NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 2, 2015

Attachment 10 – Flight Crew Procedures

OPERATIONAL FACTORS

DCA13MA081

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A. National Airlines Procedures

1.0 Preflight Duties

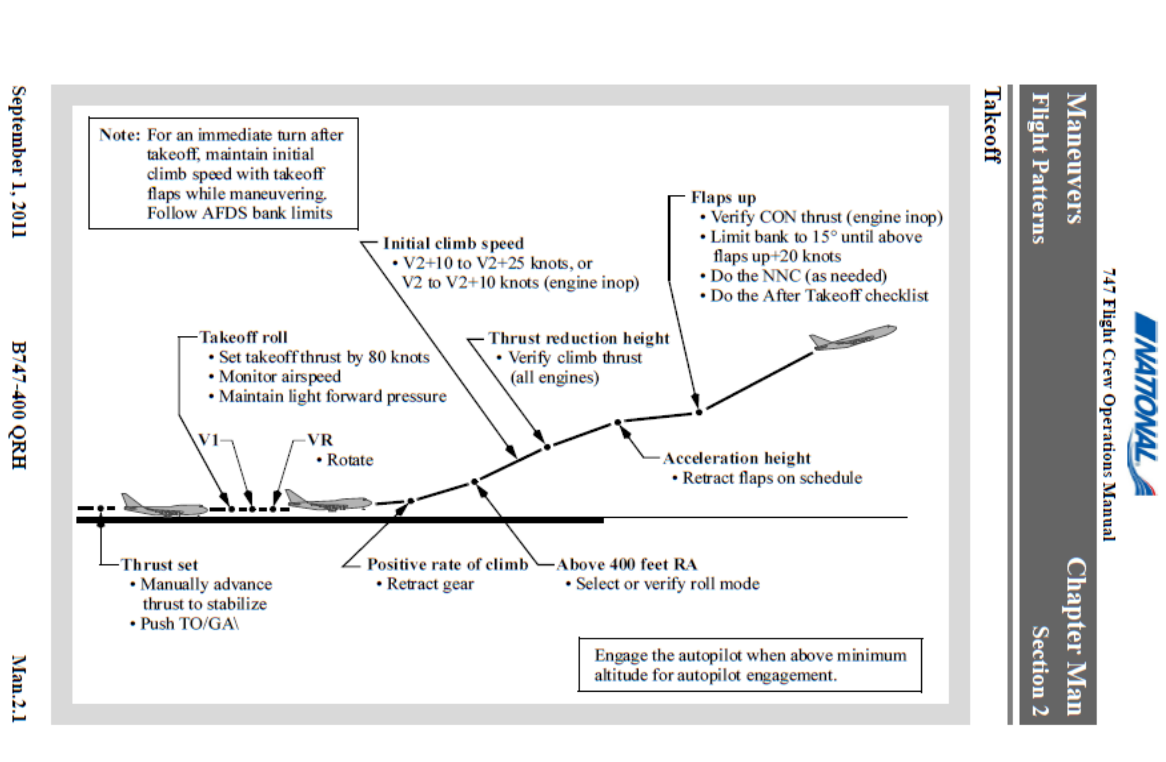
There are no preflight duties for the flight crew to inspect the main deck of the B747.

2.0 Takeoff Briefing

Takeoff Briefing

- Review of the Aircraft Log and any MEL operational limits
- Taxi routing
- CRM
- Emergencies:
  - Rejected takeoff considerations
  - Engine out procedure
  - Engine out acceleration height and turn procedure
- **INIT REF page**: GR WT
- **THRUST LIM page**: Thrust setting and N1 value confirmation (CDU & Primary Eicas)
- **TAKEOFF REF page**:
  - Flap setting, NADP, EOAH, THR reduction, V speeds
  - V1,V2 verification (PFD)
- **RTE page 1**: Departure runway
- **RTE page 2**: SID
- **LEGS page**:
  - Initial HDG or TRK
  - Waypoint and altitude constraints (if applicable)
- Roll and Pitch modes to be used (FMA)
- Initial altitude (FMA)
- **NAV/RAD PAGE**: Navaids to be used for departure
- **FIX page**: Any additional information to increase situational awareness
- **VNAV page**:
  - Clean maneuvering speed below 10,000 ft versus speed restriction
  - Transition altitude
- Minimum safe altitude and terrain
- WX or TERR selection

3.0 Normal Takeoff Profile


Maneuvers
Flight Patterns
Chapter Man
Section 2
747 Flight Crew Operations Manual
Takeoff
Note: For an immediate turn after takeoff, maintain initial climb speed with takeoff flaps while maneuvering. Follow AFDS bank limits
Flaps up
• Verify CON thrust (engine inop)
• Limit bank to 15° until above flaps up+20 knots
• Do the NNC (as needed)
• Do the After Takeoff checklist
Initial climb speed
• V2+10 to V2+25 knots, or V2 to V2+10 knots (engine inop)
Takeoff roll
• Set takeoff thrust by 80 knots
• Monitor airspeed
• Maintain light forward pressure
Thrust reduction height
• Verify climb thrust (all engines)
V1
VR
• Rotate
Acceleration height
• Retract flaps on schedule
Thrust set
• Manually advance thrust to stabilize
• Push TO/GA\
Positive rate of climb
• Retract gear
Above 400 feet RA
• Select or verify roll mode
Engage the autopilot when above minimum altitude for autopilot engagement.
September 1, 2011
B747-400 QRH
Man.2.1

4.0 Upset Recovery

PF	PM
If maneuvering is required, disengage autopilot and disconnect autothrottle. Smoothly adjust pitch and thrust to satisfy the RA command. Follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action.	
Attempt to establish visual contact. Call out any conflicting traffic.	

For a climb RA in landing configuration:

PF	PM
Disengage autopilot and disconnect autothrottle. Advance Thrust levers forward to ensure maximum thrust is attained and call for FLAPS 20. Smoothly adjust pitch to satisfy the RA command. Follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action.	Verify maximum thrust set. Position Flap lever to 20 detent.
Verify a positive rate of climb on the altimeter and call "GEAR UP".	Verify a positive rate of climb on the altimeter and call "POSITIVE CLIMB". Set the landing gear lever to UP.
Attempt to establish visual contact. Call out any conflicting traffic.	

Upset Recovery

An upset can generally be defined as unintentionally exceeding the following conditions:

- pitch attitude greater than 25 degrees nose up, or
- pitch attitude greater than 10 degrees nose down, or
- bank angle greater than 45 degrees, or
- within above parameters but flying at airspeeds inappropriate for the conditions

The following techniques represent a logical progression for recovering the airplane. The sequence of actions is for guidance only and represents a series of options to be considered and used depending on the situation. Not all the actions may be necessary once recovery is underway. If needed, use pitch trim sparingly. Careful use of rudder to aid roll control should be considered only if roll control is ineffective and the airplane is not stalled.

These techniques assume the airplane is not stalled. A stalled condition can exist at any altitude and may be recognized by continuous stick shaker activation accompanied by one or more of the following:

- buffeting, which could be heavy at times
- lack of pitch authority and/or roll control
- inability to arrest descent rate

If the airplane is stalled, recovery from the stall must be accomplished first by applying and maintaining nose down elevator until stall recovery is complete and stick shaker activation ceases.

Nose High Recovery

PF	PM
• Recognize and confirm the situation	
• Disengage autopilot and disconnect autothrottle • Apply as much as full nose-down elevator • *Apply appropriate nose-down stabilizer trim • Reduce thrust • *Roll (adjust bank angle) to obtain a nose down pitch rate • Complete the recovery: - When approaching the horizon, roll to wings level - Check airspeed and adjust thrust - Establish pitch attitude	• Call out attitude, airspeed and altitude throughout the recovery • Verify all required actions have been completed and call out any omissions

WARNING: *If the control column does not provide the needed response, stabilizer trim may be necessary. Excessive use of pitch trim may aggravate the condition, or may result in loss of control or in high structural loads.

WARNING: **Excessive use of pitch trim or rudder may aggravate the condition, or may result in loss of control or in high structural loads.

Rejected Takeoff

The captain has the sole responsibility for the decision to reject the takeoff. The decision must be made in time to start the rejected takeoff maneuver by V1. If the decision is to reject the takeoff, the captain must clearly announce "REJECT," immediately start the rejected takeoff maneuver, and assume control of the airplane. If the first officer is making the takeoff, the first officer must maintain control of the airplane until the captain makes a positive input to the controls.

Prior to 80 knots, the takeoff should be rejected for any of the following:

- activation of the master caution system
- system failure
- unusual noise or vibration
- tire failure
- abnormally slow acceleration
- takeoff configuration warning
- fire or fire warning
- engine failure
- predictive windshear warning (as installed)
- if the airplane is unsafe or unable to fly

Above 80 knots and prior to V1, the takeoff should be rejected for any of the following:

- fire or fire warning
- engine failure
- predictive windshear warning (as installed)
- if the airplane is unsafe or unable to fly

During takeoff, the crew member observing the non-normal situation will immediately call it out as clearly as possible.

C	F/O
Without delay, simultaneously: • Close thrust levers. • Disconnect autothrottles. • Apply maximum manual wheel brakes or verify operation of RTO autobrakes. **Note:** RTO autobrake function does not operate below 85 KTS. If above 85 KTS with RTO autobrakes selected, apply manual wheel brakes if deceleration not adequate or AUTOBRAKES message displayed. Raise reverse thrust levers to idle detent and apply reverse thrust, as required, on symmetrical engines consistent with conditions.	Verify actions as follows: • Thrust levers closed. • Autothrottles disconnected. • Maximum brakes applied. • If speedbrake lever not UP, call • "NO SPEEDBRAKES". • Reverse thrust applied symmetrically. • Call out any omitted action items. • If AUTOBRAKES displayed on EICAS, call "AUTOBRAKES OFF"
Field length permitting: Initiate movement of Reverse Thrust levers to reach reverse idle detent by taxi speed.	Call out 80 knots. Communicate reject decision to control tower as soon as practical.
When the airplane is stopped, perform procedures as required. Review Brake Cooling Schedule for brake cooling time and precautions (refer to Performance Inflight chapter). Consider the following: • the possibility of wheel fuse plugs melting • the need to clear the runway • the requirement for remote parking • wind direction in case of fire • alerting fire equipment • not setting parking brake unless passenger evacuation is necessary • advising the ground crew of the hot brake hazard • advising the passengers of the need to remain seated or evacuate • completion of the Non-Normal checklist (if appropriate) for conditions which caused the RTO	

5.0 Non-normal Checklist Use

Non–Normal Checklist Use

If a checklist or a step in a checklist is not applicable to all airplanes, airplane effectivity information is included in the checklist. Airplane effectivity can be listed by airplane number, registry number, serial number, or tabulation number. If a checklist is applicable to some but not all airplanes, airplane effectivity is centered below the checklist title. If a step in a checklist is applicable to some but not all airplanes, airplane effectivity is included above the step. If a checklist or a step in a checklist is applicable to all airplanes, airplane effectivity information is not included.

Non–normal checklist use starts when the airplane flight path and configuration are correctly established. Only a few situations need an immediate response (such as CABIN ALTITUDE or Rapid Depressurization). Usually, time is available to assess the situation before corrective action is started. All actions must then be coordinated under the captain's supervision and done in a deliberate, systematic manner. Flight path control must never be compromised.

When a non-normal situation occurs, at the direction of the pilot flying, both crewmembers do all memory items in their areas of responsibility without delay.

The pilot flying calls for the checklist when:

- the flight path is under control
- the airplane is not in a critical phase of flight (such as takeoff or landing)
- all memory items are complete.

The pilot monitoring reads aloud:

- the checklist title
- as much of the condition statement as needed to verify that the correct checklist has been selected
- as much of the objective statement (if applicable) as needed to understand the expected result of doing the checklist.

The pilot flying does not need to repeat this information but must acknowledge that the information was heard and understood.

For checklists with memory items, the pilot monitoring first verifies that each memory item has been done. The checklist is normally read aloud during this verification. The pilot flying does not need to respond except for items that are not in agreement with the checklist. The item numbers do not need to be read.

Non-memory items are called reference items. The pilot monitoring reads aloud the reference items, including:

- the precaution (if any)
- the response or action
- any amplifying information.

The pilot flying does not need to repeat this information but must acknowledge that the information was heard and understood. The item numbers do not need to be read.

The word "Confirm" is added to checklist items when both crewmembers must verbally agree before action is taken. During an in-flight non-normal situation, verbal confirmation is required for:

- an engine thrust lever
- a fuel control switch
- an engine or APU fire switch, or a cargo fire arm switch
- a generator drive disconnect switch
- an IRS mode selector

With the airplane stationary on the ground:

- the captain and the first officer take action based on preflight and postflight areas of responsibility

With the airplane in flight or in motion on the ground:

- the pilot flying and the pilot monitoring take action based on each crewmembers's Areas of Responsibility

After moving the control, the crewmember taking the action also states the checklist response.

The pilot flying may also direct reference checklists to be done by memory if no hazard is created by such action, or if the situation does not allow reference to the checklist.

Checklists include an Inoperative Items table only when the condition of the items is needed for planning the rest of the flight and the condition is not shown on EICAS. The inoperative items, including the consequences (if any), are read aloud by the pilot monitoring. The pilot flying does not need to repeat this information but must acknowledge that the information was heard and understood.

Consequential EICAS alert messages can show as a result of a primary failure condition (such as FUEL IMBAL 1-4 as a result of FUEL LEAK ENGINE) or as a result of doing a non–normal checklist (such as HYD PRESS ENG as a result of doing the HYD OVHT SYS 1, 2, 3, 4 checklist). The flight crew should do the checklists for consequential EICAS alert messages, unless the statement "Do not accomplish the following checklists:" is included. All consequential EICAS alert messages may not show while doing the primary checklist, depending on operational circumstances.

After completion of the non–normal checklist, normal procedures are used to configure the airplane for each phase of flight.

When there are no deferred items, the DESCENT, APPROACH, and LANDING normal checklists are used to verify that the configuration is correct for each phase of flight.

When there are deferred items, the non-normal checklist will include the item "**Checklist Complete Except Deferred Items.**" The pilot flying is to be made aware when there are deferred items. These items are included in the Deferred Items section of the checklist and may be delayed until the usual point during descent, approach, or landing.

The deferred items are read aloud by the pilot monitoring. The pilot flying or the pilot monitoring takes action based on each crewmember's area of responsibility. After moving the control, the crewmember taking the action also states the response.

When there are deferred items, the Deferred Items section of the non-normal checklist will include the Descent, Approach, and Landing normal checklists. These checklists should be used instead of the usual DESCENT, APPROACH, and LANDING normal checklists. If a normal checklist item is changed as a result of the non-normal situation, the changed response is printed in **bold** type. The pilot flying or the pilot monitoring responds to the deferred normal checklist items based on each crewmember's area of responsibility. However, during the deferred Landing normal checklist, the pilot flying responds to all deferred normal checklist items.

Each checklist has a checklist complete symbol at the end. The following symbol indicates that the checklist is complete:

■ ■ ■ ■

The checklist complete symbol can also be in the body of the checklist. This only occurs when a checklist divides into two or more paths. Each path can have a checklist complete symbol at the end. The flight crew does not need to continue reading the checklist after the checklist complete symbol.

After completion of each non–normal checklist, the pilot monitoring states "___ CHECKLIST COMPLETE."

Additional information at the end of the checklist is not required to be read.

The flight crew must be aware that checklists cannot be created for all conceivable situations and are not intended to replace good judgment. In some situations, at the captain's discretion, deviation from a checklist may be needed.

Non–Normal Checklist Legend

Redirection Symbol

▶▶

The redirection symbol is used in a non-normal checklist with the word "Go to", to direct the flight crew to a different checklist or to a different step in the current checklist.

Separator Symbol

The separator symbol is used in two ways:

- In the Table of Contents of a system section, to separate the Quick Action Index checklists from the checklists that are not in the Quick Action Index.
- In a non-normal checklist, to separate the memory items from the reference items.

Task Divider Symbol

The task divider symbol is used to indicate the end of one task and the beginning of another task.

Decision Symbol

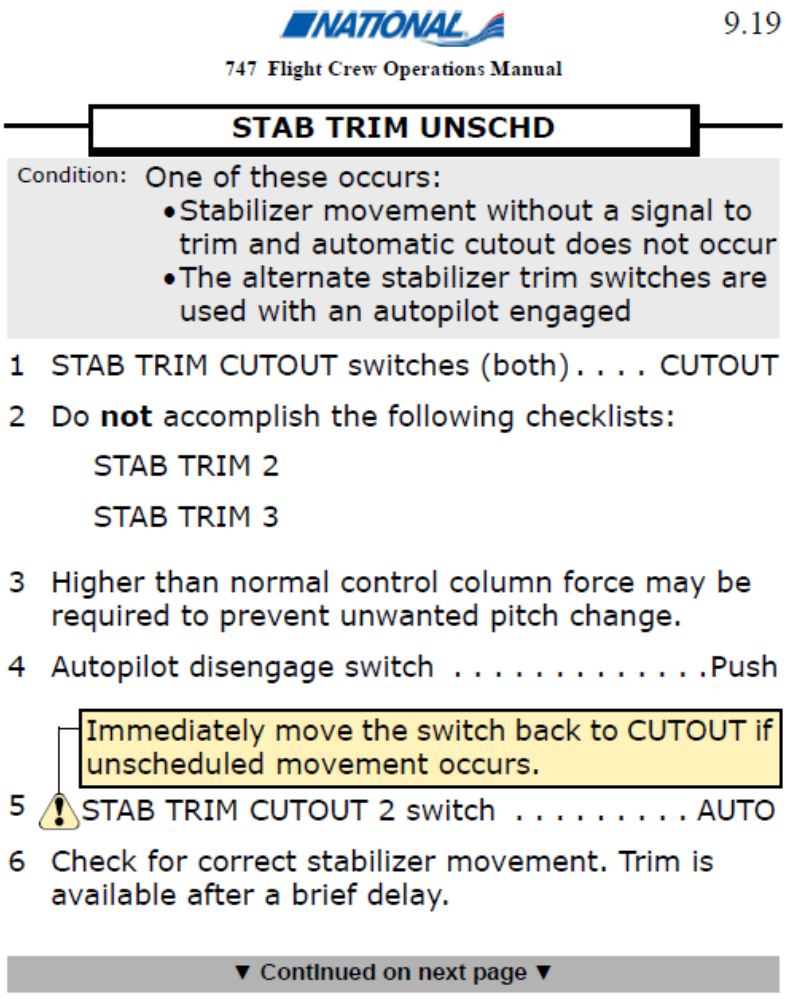
Choose one:

The decision symbol is used to identify possible choices.

Precaution Symbol

The precaution symbol is used to identify information the flight crew must consider before taking the action.

6.0 STAB TRIM UNSCHD Checklist



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747 Flight Crew Operations Manual

STAB TRIM UNSCHD

Condition: One of these occurs:
- Stabilizer movement without a signal to trim and automatic cutout does not occur
- The alternate stabilizer trim switches are used with an autopilot engaged

1 STAB TRIM CUTOUT switches (both) . . . . CUTOUT

2 Do **not** accomplish the following checklists:

STAB TRIM 2

STAB TRIM 3

3 Higher than normal control column force may be required to prevent unwanted pitch change.

4 Autopilot disengage switch . . . . . .Push

Immediately move the switch back to CUTOUT if unscheduled movement occurs.

5 STAB TRIM CUTOUT 2 switch . . . . . AUTO

6 Check for correct stabilizer movement. Trim is available after a brief delay.

▼ Continued on next page ▼

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7.0 Brake Temp

BRAKE TEMP

Condition: One or more brake temperatures are high.

Objective: To allow the brakes to cool.

1 Choose one:

◆In **flight**:

When extending or retracting the landing gear, do not exceed the gear EXTEND limit speed (270K/.82M).

Landing gear lever. . . . . DN

This allows cooling air to flow around the brakes.

When the BRAKE TEMP message blanks:

Wait 8 minutes. This ensures sufficient cooling time.

Landing gear lever. . . . UP, then OFF

■ ■ ■ ■

◆On the **ground**:

Refer to the Brake Cooling Schedule in the Advisory Information section of the Performance Inflight chapter for the required cooling time.

Minimum cooling time is 70 minutes.

■ ■ ■ ■

ADVISORY INFORMATION

Recommended Brake Cooling Schedule

Reference Brake Energy per Brake (Millions of Foot Pounds)

WEIGHT (1000 KG)	OAT (°C)	BRAKES ON SPEED (KIAS) 80 PRESS ALT 0	80 PRESS ALT 4	80 PRESS ALT 8	100 PRESS ALT 0	100 PRESS ALT 4	100 PRESS ALT 8	120 PRESS ALT 0	120 PRESS ALT 4	120 PRESS ALT 8	140 PRESS ALT 0	140 PRESS ALT 4	140 PRESS ALT 8	160 PRESS ALT 0	160 PRESS ALT 4	160 PRESS ALT 8	180 PRESS ALT 0	180 PRESS ALT 4	180 PRESS ALT 8
450	0	22.0	24.2	26.7	32.0	35.6	39.7	43.5	48.7	54.6	56.2	63.1	70.9	69.4	77.9	87.4	82.5		
	15	23.0	25.4	28.0	33.6	37.4	41.8	45.7	51.1	57.5	59.0	66.1	74.5	72.7	81.5	91.5	86.3		
	20	23.4	25.8	28.5	34.1	38.0	42.4	46.4	51.9	58.4	59.9	67.2	75.6	73.9	82.7	92.9	87.5		
	40	24.2	26.7	29.6	35.5	39.6	44.3	48.5	54.3	61.1	62.7	70.4	79.1	77.4	86.7	97.2	91.7		
	60	24.2	26.8	29.6	36.0	40.2	44.9	49.6	55.6	62.5	64.5	72.5	81.4	79.8	89.5	100.0	94.8		
400	0	20.0	22.0	24.2	29.1	32.3	36.0	39.4	44.0	49.3	50.9	57.0	64.2	62.9	70.5	79.4	74.9	83.9	94.1
	15	21.0	23.1	25.5	30.5	33.9	37.8	41.4	46.2	51.9	53.4	59.8	67.4	65.9	73.9	83.1	78.4	87.7	98.3
	20	21.3	23.4	25.8	31.0	34.4	38.4	42.1	47.0	52.8	54.2	60.8	68.4	67.0	75.0	84.5	79.6	89.0	99.8
	40	22.0	24.2	26.7	32.2	35.8	40.0	43.9	49.1	55.1	56.7	63.6	71.6	70.2	78.6	88.4	83.4	93.2	104.2
	60	22.0	24.2	26.7	32.6	36.3	40.5	44.8	50.2	56.3	58.2	65.4	73.5	72.2	81.1	90.9	86.1	96.4	107.4
350	0	18.1	19.8	21.7	26.1	28.9	32.1	35.3	39.3	44.0	45.4	50.8	57.1	56.1	63.0	70.8	67.0	75.1	84.5
	15	18.9	20.7	22.7	27.4	30.3	33.7	37.0	41.3	46.2	47.6	53.3	59.9	58.9	66.0	74.3	70.2	78.7	88.4
	20	19.2	21.0	23.1	27.8	30.8	34.3	37.6	41.9	47.0	48.4	54.1	60.9	59.8	67.1	75.5	71.3	79.9	89.8
	40	19.8	21.7	23.9	28.9	32.0	35.7	39.2	43.7	49.1	50.6	56.6	63.8	62.6	70.3	79.0	74.7	83.7	93.9
	60	19.6	21.6	23.6	29.1	32.3	36.0	39.9	44.6	50.0	51.7	58.1	65.2	64.4	72.4	81.2	77.0	86.4	96.7
300	0	16.1	17.5	19.1	23.1	25.5	28.2	31.1	34.6	38.5	39.9	44.5	50.0	49.3	55.2	62.1	58.9	66.1	74.3
	15	16.8	18.3	20.0	24.2	26.7	29.6	32.6	36.3	40.5	41.8	46.7	52.4	51.7	57.9	65.2	61.8	69.3	78.0
	20	17.1	18.6	20.4	24.6	27.2	30.1	33.2	36.8	41.3	42.5	47.5	53.3	52.5	58.8	66.2	62.8	70.3	79.2
	40	17.5	19.1	20.9	25.5	28.1	31.3	34.5	38.4	43.0	44.4	49.6	55.8	55.0	61.6	69.4	65.7	73.7	82.9
	60	17.3	19.0	20.7	25.6	28.3	31.4	34.9	39.0	43.5	45.2	50.7	56.8	56.3	63.3	71.0	67.6	76.0	85.2
250	0	14.2	15.3	16.7	20.2	22.1	24.4	26.9	29.8	33.1	34.2	38.1	42.6	42.1	47.0	52.8	50.3	56.3	63.4
	15	14.8	16.1	17.5	21.1	23.2	25.6	28.2	31.3	34.8	35.9	40.0	44.8	44.2	49.4	55.5	52.8	59.1	66.6
	20	15.0	16.3	17.7	21.5	23.6	26.1	28.7	31.8	35.4	36.5	40.7	45.6	44.9	50.2	56.4	53.6	60.0	67.6
	40	15.4	16.7	18.2	22.1	24.4	26.9	29.7	33.0	36.7	38.0	42.4	47.5	46.9	52.4	59.0	56.1	62.9	70.7
	60	15.1	16.5	17.9	22.1	24.4	26.9	30.0	33.4	37.1	38.6	43.2	48.3	47.9	53.7	60.3	57.5	64.6	72.6
200	0	12.4	13.4	14.4	17.3	18.9	20.7	22.7	25.0	27.7	28.5	31.6	35.2	34.6	38.5	43.1	40.9	45.7	51.3
	15	13.0	14.0	15.2	18.2	19.8	21.8	23.8	26.3	29.1	29.9	33.2	37.0	36.3	40.4	45.3	42.9	47.9	53.9
	20	13.2	14.2	15.4	18.4	20.1	22.1	24.2	26.7	29.6	30.4	33.7	37.6	36.9	41.1	46.1	43.6	48.7	54.9
	40	13.5	14.5	15.8	19.0	20.7	22.9	25.0	27.6	30.6	31.5	35.0	39.1	38.4	42.8	48.0	45.5	50.9	57.2
	60	13.1	14.2	15.3	18.8	20.7	22.6	25.1	27.8	30.8	31.9	35.5	39.6	39.0	43.6	48.8	46.4	52.1	58.4

To correct for wind, enter the table with the brakes-on speed minus 0.5 times headwind or plus 1.5 times tail-wind.

If ground speed is used for brakes-on speed, ignore wind, altitude and OAT effects, and enter the table at sea level and 15°C.

8.0 Boeing Procedures – Upset Recovery

Pilots should maintain situational awareness since TCAS may issue RAs in conflict with terrain considerations, such as during approaches into rising terrain or during an obstacle limited climb. Continue to follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action. Windshear, GPWS, and stall warnings take precedence over TCAS advisories. Stick shaker must be respected at all times. Complying with RAs may result in brief exceedance of altitude and/or placard limits. However, even at the limits of the operating envelope, in most cases sufficient performance is available to safely maneuver the airplane. Smoothly and expeditiously return to appropriate altitudes and speeds when clear of conflict. Maneuvering opposite to an RA command is not recommended since TCAS may be coordinating maneuvers with other airplanes.

Upset Recovery

For detailed information regarding the nature of upsets, aerodynamic principles, recommended training and other related information, refer to the Airplane Upset Recovery Training Aid available through your operator.

An upset can generally be defined as unintentionally exceeding any of the following conditions:

- pitch attitude greater than 25° nose up
- pitch attitude greater than 10° nose down
- bank angle greater than 45°
- within above parameters but flying at airspeeds inappropriate for the conditions.

General

Though flight crews in line operation rarely, if ever, encounter an upset situation, understanding how to apply aerodynamic fundamentals in such a situation helps them control the airplane. Several techniques are available for recovering from an upset. In most situations, if a technique is effective, it is not recommended that pilots use additional techniques. Several of these techniques are discussed in the example scenarios below:

- stall recovery
- nose high, wings level
- nose low, wings level
- high bank angles

- nose high, high bank angles
- nose low, high bank angles

Note: Higher than normal control forces may be required to control the airplane attitude when recovering from upset situations. Be prepared to use a firm and continuous force on the control column and control wheel to complete the recovery.

Stall Recovery

In all upset situations, it is necessary to recover from a stall before applying any other recovery actions. A stall may exist at any attitude and may be recognized by continuous stick shaker activation accompanied by one or more of the following:

- buffeting which could be heavy at times
- lack of pitch authority and/or roll control
- inability to arrest descent rate.

If the airplane is stalled, recovery from the stall must be accomplished first by applying and maintaining nose down elevator until stall recovery is complete and stick shaker activation ceases. Under certain conditions, it may be necessary to reduce some thrust in order to prevent the angle of attack from continuing to increase. Once stall recovery is complete, upset recovery actions may be taken and thrust reapplied as needed.

Nose High, Wings Level

In a situation where the airplane pitch attitude is unintentionally more than 25° nose high and increasing, the airspeed is decreasing rapidly. As airspeed decreases, the pilot's ability to maneuver the airplane also decreases. If the stabilizer trim setting is nose up, as for slow-speed flight, it partially reduces the nose-down authority of the elevator. Further complicating this situation, as the airspeed decreases, the pilot could intuitively make a large thrust increase. This causes an additional pitch up. At full thrust settings and very low airspeeds, the elevator, working in opposition to the stabilizer, has limited control to reduce the pitch attitude.

In this situation the pilot should trade altitude for airspeed, and maneuver the airplane's flight path back toward the horizon. This is accomplished by the input of up to full nose-down elevator and the use of some nose-down stabilizer trim. These actions should provide sufficient elevator control power to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Pilots should not fly the airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen. This use of stabilizer trim may correct an out-of-trim airplane and solve a less-critical problem before the pilot must apply further recovery measures. Because a large nose-down pitch rate results in a condition of less than 1 g, at this point the pitch rate should be controlled by modifying control inputs to maintain between 0 g and 1 g. If altitude permits, flight tests have determined that an effective way to achieve a nose-down pitch rate is to reduce some thrust.

If normal pitch control inputs do not stop an increasing pitch rate, rolling the airplane to a bank angle that starts the nose down should work. Bank angles of about 45°, up to a maximum of 60°, could be needed. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible. With airspeed as low as stick shaker onset, normal roll controls - up to full deflection of ailerons and spoilers - may be used. The rolling maneuver changes the pitch rate into a turning maneuver, allowing the pitch to decrease. Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to induce a rolling maneuver for recovery.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Because of the low energy condition, pilots should exercise caution when applying rudder.

The reduced pitch attitude allows airspeed to increase, thereby improving elevator and aileron control effectiveness. After the pitch attitude and airspeed return to a desired range the pilot can reduce angle of bank with normal lateral flight controls and return the airplane to normal flight.

Nose Low, Wings Level

In a situation where the airplane pitch attitude is unintentionally more than 10° nose low and going lower, the airspeed is increasing rapidly. A pilot would likely reduce thrust and extend the speedbrakes. Thrust reduction causes an additional nose-down pitching moment. Speedbrake extension causes a nose-up pitching moment, an increase in drag, and a decrease in lift for the same angle of attack. At airspeeds well above VMO/MMO, the ability to command a nose-up pitch rate with elevator may be reduced because of the extreme aerodynamic loads on the elevator.

Again, it is necessary to maneuver the airplane's flight path back toward the horizon. At moderate pitch attitudes, applying nose-up elevator, reducing thrust, and extending speedbrakes, if necessary, changes the pitch attitude to a desired range. At extremely low pitch attitudes and high airspeeds (well above VMO/MMO), nose-up elevator and nose-up trim may be required to establish a nose-up pitch rate.

High Bank Angles

A high bank angle is one beyond that necessary for normal flight. Though the bank angle for an upset has been defined as unintentionally more than 45°, it is possible to experience bank angles greater than 90°.

Any time the airplane is not in "zero-angle-of-bank" flight, lift created by the wings is not being fully applied against gravity, and more than 1 g is required for level flight. At bank angles greater than 67°, level flight cannot be maintained within AFM load factor limits. In high bank angle increasing airspeed situations, the primary objective is to maneuver the lift of the airplane to directly oppose the force of gravity by rolling in the shortest direction to wings level. Applying nose-up elevator at bank angles above 60° causes no appreciable change in pitch attitude and may exceed normal structure load limits as well as the wing angle of attack for stall. The closer the lift vector is to vertical (wings level), the more effective the applied g is in recovering the airplane.

A smooth application of up to full lateral control should provide enough roll control power to establish a very positive recovery roll rate. If full roll control application is not satisfactory, it may even be necessary to apply some rudder in the direction of the desired roll.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control or structural failure.

Nose High, High Bank Angles

A nose high, high angle of bank upset requires deliberate flight control inputs. A large bank angle is helpful in reducing excessively high pitch attitudes. The pilot must apply nose-down elevator and adjust the bank angle to achieve the desired rate of pitch reduction while considering energy management. Once the pitch attitude has been reduced to the desired level, it is necessary only to reduce the bank angle, ensure that sufficient airspeed has been achieved, and return the airplane to level flight.

Nose Low, High Bank Angles

The nose low, high angle of bank upset requires prompt action by the pilot as altitude is rapidly being exchanged for airspeed. Even if the airplane is at a high enough altitude that ground impact is not an immediate concern, airspeed can rapidly increase beyond airplane design limits. Simultaneous application of roll and adjustment of thrust may be necessary. It may be necessary to apply nose-down elevator to limit the amount of lift, which will be acting toward the ground if the bank angle exceeds 90°. This also reduces wing angle of attack to improve roll capability. Full aileron and spoiler input should be used if necessary to smoothly establish a recovery roll rate toward the nearest horizon. It is important to not increase g force or use nose-up elevator or stabilizer until approaching wings level. The pilot should also extend the speedbrakes as needed.

Upset Recovery Techniques

It is possible to consolidate and incorporate recovery techniques into two basic scenarios, nose high and nose low, and to acknowledge the potential for high bank angles in each scenario described above. Other crew actions such as recognizing the upset, reducing automation, and completing the recovery are included in these techniques. The recommended techniques provide a logical progression for recovering an airplane.

If an upset situation is recognized, immediately accomplish the Upset Recovery maneuver found in the non-normal maneuvers section in the QRH.

Windshear

General

Improper or ineffective vertical flight path control has been one of the primary factors in many cases of flight into terrain. Low altitude windshear encounters are especially significant because windshear can place the crew in a situation which requires the maximum performance capability of the airplane. Windshear encounters near the ground are the most threatening because there is very little time or altitude to respond to and recover from an encounter.

Airplane Performance in Windshear

Knowledge of how windshear affects airplane performance can be essential to the successful application of the proper vertical flight path control techniques during a windshear encounter.