APPENDIX 3-B
Airplane Upset Recovery Briefing

Figure 3-B.1

AIRPLANE UPSET RECOVERY
Industry Solutions for Large Swept-Wing Turbofan Airplanes Typically Seating More Than 100 Passengers Briefing
Airplane Upset Recovery

Figure 3-B.2
Causes of Airplane Upset

Figure 3-B.3
Airplane Upset Recovery

Figure 3-B.4
Upset Recovery Training Objectives

• To increase the pilot’s ability to recognize and avoid upset situations.

• To improve the pilot’s ability to recover control, if avoidance is not successful.
Upset Recovery Training Will Review

- The causes of airplane upsets
- Swept-wing airplane fundamentals
- Airplane upset recovery techniques
What is “Airplane Upset?”
Causes of Airplane Upset Incidents Are

- Environmentally induced
- Systems-anomalies induced
- Pilot induced
- A combination of all three
Environmental Causes of Airplane Upset Include

- Turbulence
- Clear air turbulence
- Mountain wave
- Windshear
- Thunderstorms
- Microbursts
- Wake turbulence
- Airplane icing

Figure 3-B.9
Turbulence Is Primarily Caused by

- Jet streams
- Convective currents
- Obstructions to wind flow
- Windshear
Clear Air Turbulence (CAT) Is Characterized by Marked Changes in

- Pressure
- Temperature
- Wind direction
- Wind velocity
Windshear

Figure 3-B.13
Thunderstorms

Figure 3-B.14
Microbursts

Figure 3-B.15
Wake Turbulence

Figure 3-B.16
Airplane Icing

Figure 3-B.17
System-Anomalies Induced Airplane Upsets Primarily Involve

- Flight instruments
- Autoflight systems
- Flight controls and other anomalies
System-Anomalies Induced Airplane Upsets
Flight Instruments

Figure 3-B.20
Autoflight Systems

Figure 3-B.21
Flight Control and Other Anomalies

Figure 3-B.22
Pilot-Induced Causes of Airplane Upset Include

- Instrument misinterpretation or slow cross-check
- Inattention and distraction from primary cockpit duties
- Vertigo or spatial disorientation
Instrument Cross-Check

Figure 3-B.24
Distraction

Figure 3-B.25
Vertigo or Spatial Disorientation

Figure 3-B.26
Improper Use of Airplane Automation

Figure 3-B.27
Causes of Airplane Upsets—Summary

1. Environmental:
   - Turbulence, CAT, mountain wave, windshear, thunderstorms, microbursts, wake turbulence, and airplane icing

2. Systems anomalies:
   - Flight instruments, autoflight systems, and flight control anomalies

3. Pilot induced:
   - Instrument cross-check, inattention and distraction from primary cockpit duties, vertigo or spatial disorientation, and improper use of airplane automation
Swept-Wing Airplane Fundamentals
Will Overview

- Flight dynamics
- Energy states
- Load factors
- Aerodynamic flight envelope
- Aerodynamics
The Three Sources of Energy Available to the Pilot Are

1. Kinetic energy, which increases with increasing speed
2. Potential energy, which is approximately proportional to altitude
Energy Relationships

Kinetic energy → Aerodynamic forces, maneuver capability

Potential energy

Chemical energy
Load Factors—Four Forces of Flight

Lift = 1 x weight

Figure 3-B.33
Load Factors—Airplane in Pull-Up

Flight path is curved.

Lift > 1 x weight

Weight

Figure 3-B.34
Aerodynamic Flight Envelope

Figure 3-B.35

Maximum operating altitude

Stall speed*

Load factor

V_{S1} = flaps up 1-g stall speed
V_A = design maneuver speed, flaps up
V_C = design structured cruising speed
V_D = design dive speed

M_{MO} = maximum operating Mach number
M_{DF} = maximum flight-demonstrated Mach number
V_{MO} = maximum operating airspeed
V_{DF} = maximum flight-demonstrated airspeed

* Function of airplane configuration and load factor.
Angle of attack is the difference between pitch attitude and flight path angle (assumes no wind).
Stalls

Figure 3-B.37
Camber

Figure 3-B.38

Symmetrical Airfoil

Modern Aft-Cambered Airfoil

Cambered Airfoil

Mean camber line

Leading edge

Trailing edge

Chord line
Trailing Edge Control Surfaces

Figure 3-B.39
Spoiler Devices

Flaps Up

Flaps Down

Figure 3-B.40
Trim

Smaller additional deflection available, this direction

Deflected trim tab holds surface away from neutral position

Larger additional deflection available, this direction

Maximum deflection

Figure 3-B.41
Lateral and Directional Aerodynamic Considerations

The magnitude of coupled roll-due-to-sideslip is determined by several factors, including:

- Wing dihedral effects
- Angle of sideslip
- Pilot-commanded sideslip

Figure 3-B.42
Wing Dihedral Angle
Angle of Slideslip

Left rudder, right aileron/spoiler

“Cross-controlled”

Sideslip angle

Airplane velocity

Relative wind

Spoilers up

Aileron down

Aileron up

Rudder deflected left to hold sideslip angle

Figure 3-B.44
High-Speed, High-Altitude Characteristics

Figure 3-B.45
Static Stability

Stable
When ball is displaced, it returns to its original position.

Unstable
When ball is displaced, it accelerates from its original position.

Neutral
When ball is displaced, it neither returns, nor accelerates away—it just takes up a new position.
Maneuvering in Pitch

![Diagram of an airplane with various forces and distances labeled]

\[
(Moment)_{\text{Tail}} + \ (Moment)_{\text{Lift}} + \ (Moment)_{\text{Thrust}} + \ (Moment)_{\text{Wing-body}} = \text{Total pitching moment}
\]

\[
(Tail \ lift \ast \ Tail \ distance) + (Wing \ lift \ast \ Wing \ distance) + (Thrust \ast \ Engine \ distance) + (Moment)_{\text{Wing-body}} = \text{Total pitching moment}
\]
Mechanics of Turning Flight

Additional lift required so that vertical component still equals weight

Horizontal component produces curved flight path = turn

Load factor, g’s

Bank angle, deg

Figure 3-B.48
Lateral Maneuvering—Roll Axis

Figure 3-B.49
Lateral Maneuvering—Flight Dynamics

Figure 3-B.50
Directional Maneuvering—Yaw Axis
Flight at Extremely Low Airspeeds
Flight at Low Airspeeds and Thrust Effects
Flight at Extremely High Speeds

Figure 3-B.54
Summary of Swept-Wing Fundamentals

• Flight dynamics: Newton’s laws
• Energy states: kinetic, potential, and chemical
• Load factors: longitudinal, lateral, and vertical
• Aerodynamic flight envelope: operating and demonstrated speeds
• Aerodynamics: the relationship of angle of attack and stall

Figure 3-B.55
Airplane Upset Recovery

Figure 3-B.56
Situational Awareness During an Airplane Upset

“Recognize and confirm the situation” by the following key steps:

• Communicate with crew members
• Locate the bank indicator
• Determine pitch attitude
• Confirm attitude by reference to other indicators
The Miscellaneous Issues Associated With Upset Recovery Have Been Identified by

- Pilots who have experienced an airplane upset
- Pilot observations in a simulator-training environment

And they are associated with
- The startle factor
- Negative g force
- Full control inputs
- Counter-intuitive factors
Startle Factor

Figure 3-B.59
Negative G Force

Figure 3-B.60
Use of Full Control Inputs

Figure 3-B.61
Nonintuitive Factors

Figure 3-B.62
Airplane Upset Recovery Techniques Will Include a Review of the Following Airplane Upset Situations:

• Nose high, wings level
• Nose low, wings level
• High bank angles:
  – Nose high
  – Nose low
• And a review of recommended upset recovery techniques based on two basic airplane upset situations:
  – Nose high
  – Nose low
Airplane Upset Recovery Techniques

- **Stall characteristics**
  - Buffeting
  - Lack of pitch authority
  - Lack of roll control
  - Inability to arrest descent rate
Nose-High, Wings-Level Recovery Techniques

- Recognize and confirm the situation
- Disengage autopilot and autothrottle
Nose-High, Wings-Level Recovery Techniques

- Apply as much as full nosedown elevator
Nose-High, Wings-Level Recovery Techniques

- Roll to obtain a nose-down pitch rate
Nose-High, Wings-Level Recovery Techniques

- Reduce thrust (underwing-mounted engines)
Nose-High, Wings-Level Recovery Techniques

- Approaching horizon, roll to wings level
- Check airspeed and adjust thrust
- Establish pitch attitude

Figure 3-B.69
Nose-Low, Wings-Level Recovery Techniques

- Recognize and confirm the situation
Nose-Low, Wings-Level Recovery Techniques

- Disengage autopilot and autothrot-
Nose-Low, Wings-Level Recovery Techniques

- Recover from stall, if necessary

Figure 3-B.72
Nose-Low, Wings-Level Recovery Techniques
Recover to Level Flight

- Apply noseup elevator
- Apply stabilizer trim, if necessary

Figure 3-B.73
Nose-Low, Wings-Level Recovery Techniques

- Adjust thrust and drag, as necessary
High-Bank-Angle Recovery Techniques

- Recognize and confirm the situation
- Disengage autopilot and autothrottle

Figure 3-B.75
High-Bank-Angle Recovery Techniques

- Reduce the angle of attack
- Adjust bank angle to achieve nosedown pitch rate
High-Bank-Angle Recovery Techniques

• Complete the recovery:
  – Approaching the horizon, roll to wings level
  – Check airspeed; adjust thrust
  – Establish pitch attitude

Figure 3-B.77
High-Bank-Angle Recovery Techniques

- Recognize and confirm the situation
- Disengage autopilot and autothrottle
High-Bank-Angle Recovery Techniques

- Reduce the angle of attack, if necessary

Figure 3-B.79
High-Bank-Angle Recovery Techniques

• Simultaneously reduce thrust and roll the shortest direction to wings level
High-Bank-Angle Recovery Techniques

- Recover to level flight:
  - Apply noseup elevator
  - Apply stabilizer trim, if necessary
  - Adjust thrust and drag, as necessary

Figure 3-B.81
Summary of Airplane Recovery Techniques
Nose-High Recovery

Figure 3-B.82
Summary of Airplane Recovery Techniques
Nose-High Recovery

- Recognize and confirm the situation
- Disengage autopilot and autothrottle
- Apply as much as full nosedown elevator
Summary of Airplane Recovery Techniques
Nose-High Recovery

• Use appropriate techniques:
  – Roll (adjust bank angle) to obtain a nosedown pitch rate
  – Reduce thrust (underwing-mounted engines)
Summary of Airplane Recovery Techniques
Nose-High Recovery

• Complete the recovery:
  – Approaching the horizon, roll to wings level
  – Check airspeed; adjust thrust
  – Establish pitch attitude
Summary of Airplane Recovery Techniques
Nose-Low Recovery

Figure 3-B.86
Summary of Airplane Recovery Techniques
Nose-Low Recovery

- Recognize and confirm the situation
- Disengage autopilot and autothrottle
- Recover from stall, if necessary
Summary of Airplane Recovery Techniques
Nose-Low Recovery

• Roll in the shortest direction to wings level:
  – Bank angle to more than 90 deg; unload and roll
Summary of Airplane Recovery Techniques
Nose-Low Recovery

• Recover to level flight
  – Apply noseup elevator
  – Apply stabilizer trim, if necessary
  – Adjust thrust and drag, as necessary