

Factual Report – Attachment 28
Atlas Air Upset Recovery Guidance

OPERATIONAL FACTORS

DCA19MA086

**Standard Maneuvers and
Configurations
Upset Recovery****Chapter SMAC****Section 132****General**

An upset is an inadvertent aircraft attitude occurring as a result of such things as turbulence, instrument failure, distraction, spatial disorientation, or transition from VMC to IMC. 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 at an airspeed inappropriate for conditions.

In most cases, upsets are mild enough that reestablishing the proper attitude for the desired flight condition and resuming a normal instrument scan will ensure recovery. In all cases, however, successful recoveries are based on a distinct pattern of actions - recognize, confirm, and recover.

Top priority should be given to early recognition and rapid correction of attitude excursions. It is important to transition to instrument references any time disorientation occurs or outside visual references become unreliable.

The recovery techniques used must be compatible with the severity of the upset, the characteristics of the aircraft, and the altitude available for recovery. Though flight crews rarely, if ever, encounter an upset situation, understanding how to apply aerodynamic fundamentals in such a situation will help control the aircraft. The following aerodynamic principles and considerations apply:

- Elimination of bank in a dive aids pitch control.
- Use of bank in a climb aids pitch control.
- Thrust and drag devices, used properly, aid airspeed control.

Recognition and Confirmation

An upset is recognized by an unexpected presentation on the attitude display and/or conflicting indications on the performance instruments (airspeed display, vertical speed display, altitude display, etc.). Regardless of how the upset is recognized, verify that an upset has occurred by comparing control and performance instrument indications prior to initiating the recovery on the attitude display. This is to prevent aggravating the upset as a result of making control movements based on erroneous instrument indications.

February 1, 2017

SMAC.132.1

During the recognition process, the attitude must be correctly interpreted. Cross-check other attitude indicating sources (e.g., other pilot's attitude display, standby attitude indicator) to determine if an attitude display failure might be the cause. With an inoperative attitude display, early recognition of failure is critical because spatial disorientation may become severe. Therefore, it is essential that the PF's attention be directed toward an operative attitude display while cross-checking the performance instruments during the recovery.

Upset Recovery Techniques

There are two basic upset scenarios, nose high and nose low; however, potential exists for high bank angles in each scenario. The recommended techniques provide a logical progression for recovery and represent a series of options to be considered 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 aircraft is not stalled.

WARNING: Excessive pitch trim or rudder inputs applied too quickly or held too long may aggravate the upset or result in loss of control or structural damage.

During recovery, coordinate the amount of bank and thrust used with the rate at which airspeed and pitch are being controlled. The application of bank, thrust, and control pressure must be compatible with aircraft and engine characteristics. Higher than normal control forces may be required to recover. Be prepared to use firm and continuous force on the control column and control wheel to complete the recovery. If the aircraft is stalled, recovery from the stall must be accomplished first. Once stall recovery is complete, upset recovery actions may be initiated and thrust reapplied as needed.

Nose Low

If diving, adjust thrust and/or drag devices as appropriate while rolling to a wings level, upright attitude. Correct to a wings level condition on the ADI by applying ailerons and spoilers (full control displacement if necessary) toward the nearest horizon. It may be necessary to unload the aircraft by decreasing back pressure to improve roll effectiveness. Use caution if adding back pressure while rolling to wings level since rolling (asymmetric) load limits are less than wings level (symmetric) limits. Use speedbrakes as necessary.

Airspeed increases rapidly if the pitch attitude is more than 10° nose down and going lower. A normal reaction is to reduce thrust and extend the speedbrakes. Keep in mind that thrust reduction causes an additional nose-down pitching moment and 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 aircraft's flight path back toward the nearest 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.

Nose High

If climbing, use thrust as required and bank to assist pitch control and to avoid negative G forces. In an extreme nose-up trim situation, for example, using bank to avoid an excessive nose-high attitude may be the key to a safe recovery. On the ADI, as the aircraft symbol approaches the horizon bar, adjust pitch, bank, and thrust to complete the recovery and establish the desired aircraft attitude.

Airspeed decreases rapidly if the pitch attitude is more than 25° nose-high and increasing. As airspeed decreases, the ability to maneuver the aircraft 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 the situation, as airspeed decreases, a normal reaction is to make a large thrust increase, causing an additional pitch up. At full thrust and low airspeeds, the elevator, working in opposition to the stabilizer, has limited ability to reduce pitch.

In this situation, trade altitude for airspeed and maneuver the aircraft's flight path back toward the horizon. This is accomplished using up to full nose-down elevator and some nose-down stabilizer trim. These actions should provide sufficient elevator control to produce a nose-down pitch rate. It may be difficult to determine the amount of stabilizer trim to use; care must be taken to avoid excessive trim inputs. Do not use stabilizer trim to fly the aircraft and stop trimming nose-down when G forces or required elevator forces lessen.

Because a large nose-down pitch rate results in less than 1G, at this point the pitch rate should be controlled by modifying control inputs to maintain between zero and 1G. If altitude permits, reducing thrust is an effective way to achieve a nose-down pitch rate.

If normal pitch inputs do not stop an increasing pitch rate in a nose high situation, rolling the aircraft to a bank angle that starts the nose down may be effective. Approximately 45° of bank, up to a maximum of 60°, may 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 initiate a rolling recovery. Because of the low energy condition, 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, reduce angle of bank with normal lateral flight controls and return the aircraft to normal flight.

High Bank Angles

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°. If bank angle is greater than zero, lift created by the wings is not being fully applied against gravity, and more than 1G is required for level flight.

At bank angles greater than 67°, level flight cannot be maintained within load factor limits. With high bank angles and increasing airspeed, the primary objective is to maneuver the lift of the aircraft 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. A smooth application of up to full lateral control should provide enough roll control power to establish a positive recovery roll rate. If full roll control application is not satisfactory, it may be necessary to apply a slight amount of rudder in the direction of the desired roll.

If the bank angle exceeds 90°, it may be necessary to apply nose-down elevator to limit the amount of lift, which will be acting toward the ground. 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 speedbrakes may be extended as needed.

October 16, 2014

SMAC.132.4

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. Nose-down elevator must be applied and bank angle adjusted 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 aircraft to level flight.

A nose low, high angle of bank upset requires prompt action as altitude is rapidly being exchanged for airspeed. Even at altitudes where ground impact is not an immediate concern, airspeed can rapidly increase beyond design limits. Simultaneous application of roll and adjustment of thrust may be necessary.

Rudder Use

For transport category aircraft, the use of full rudder for control of engine failures and crosswind takeoffs and landings is well within the structural capability of the aircraft. For other phases of flight, however, it is important to use the rudder in a manner that avoids large sideslip angles and the resulting excessive roll rates.

Furthermore, if the reaction to an abrupt roll onset is a large rudder input followed by a large rudder input in the opposite direction, the resulting yaw amplitude oscillations may be beyond the structural design limits of the aircraft. There are no flight crew procedures that require such inputs.

It is strongly recommended that the rudder not be used in stall, upset, or unusual attitude recoveries. Ailerons/spoilers should provide adequate rolling moment. If, however, the application of full lateral control (ailerons and spoilers) is not sufficient, it may be necessary to judiciously apply some rudder in the direction of the desired roll.

Rudder input is never the preferred initial response for events such as an upset or unusual attitude recovery, wake vortex encounter, windshear, or to reduce bank angle preceding an imminent stall 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.

WARNING: Excessive use of pitch trim or rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.

Upset Recovery Procedure

Nose High Recovery

PF	PM
Recognize and confirm developing the situation.	
Immediately and simultaneously: - Disengage the autopilot. - Disengage the autothrottle. Recover: - Apply nose-down elevator. Apply as much elevator as needed to obtain a nose down pitch rate. - 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 needed actions have been done and call out any continued deviation.

WARNING: *Excessive use of pitch trim or rudder can aggravate an upset, result in loss of control, or result in high structural loads.

Nose Low Recovery

PF	PM
Recognize and confirm the developing the situation.	
Disconnect autopilot. Disconnect autothrottle. Recover: • Recover from stall, if needed • Roll in the shortest direction to wings level. If bank angle is more than 90 degrees, unload and roll* Complete the recovery: • Apply nose up elevator • Apply nose up trim, if needed* • Adjust thrust and drag, if needed	Call out attitude, airspeed and altitude throughout the recovery. Verify all needed actions have been done and call out any continued deviation.

WARNING: *Excessive use of pitch trim or rudder can aggravate an upset, result in loss of control, or result in high structural loads.

