UPSET PREVENTION AND RECOVERY TRAINING

AIRLINE PILOT
PERFORMANCE

Introduction:

Welcome to the Airline Pilot Performance Upset Prevention and Recovery Training (UPRT) Handbook. This e-book is designed to supplement your knowledge of UPRT, helping you recognize and effectively recover from upset conditions in flight.

Understanding UPRT

What is UPRT?

Upset Prevention and Recovery Training (UPRT) is a critical component of pilot training aimed at preventing and recovering from unusual attitudes or upset conditions during flight.

Upsets in flight can occur due to various factors, and it's essential for pilots to be aware of these causes to effectively prevent and recover from such situations.

What is an ‘Upset’?

Historically, an upset was defined as unintentionally exceeding one or more of the following conditions:

Pitch attitude greater than 25 degrees nose up
Pitch attitude greater than 10 degrees nose down
Bank angle greater than 45 degrees
Less than above parameters but flying at an airspeed inappropriate
for the conditions.

An upset condition is now considered any time an airplane is diverting from the intended airplane state. An airplane upset can involve pitch or roll angle deviations as well as inappropriate airspeeds for the conditions.

Aerodynamic Fundamentals Applied to Large Airplanes

Airline pilots are thoroughly familiar with airplane handling qualities under normal flight conditions. In general, if pitch is increased (the result of pulling back on the controls), altitude increases; in level flight, if thrust is increased, airspeed increases.

However, when an airplane is taken to the edges of the flight envelope, different situations result. It is possible, for example, to encounter flight conditions where an increase in thrust is needed to maintain a slower airspeed, and where an increase in pitch will decrease altitude. While airline pilots may have received training on how to use flight controls to recover from airplane upsets, they rarely, if ever, experience these conditions in line operations.

In the context of aerodynamics, the following three basic concepts should be understood:

- Energy management.
- Pitch control.
- Lateral and directional control.

ENERGY MANAGEMENT.

Three sources of energy are available to generate aerodynamic forces and thus manoeuvre the airplane: kinetic, which increases with increasing airspeed; potential, which is proportional to altitude; and chemical, which is from the fuel in the airplane's tanks.

The term "energy state" describes how much of each kind of energy the airplane has available at any given time. The critical element to realize is that pilots who understand the airplane energy state will be in a position to know what options are available to manoeuvre the airplane.

The airplane is continuously expending energy in flight because of drag. Drag is usually offset by using some of the stored chemical energy -- that is, by burning fuel in the engines. (At landing, the reverse is the case when wheel brakes [friction] and thrust reversers dissipate energy.)

During manoeuvring, the three types of energy can be traded, or exchanged, usually at the cost of additional drag. This process of consciously manipulating the energy state of the airplane is referred to as energy management. Airspeed (kinetic energy) can be traded for altitude (potential energy). Altitude therefore can be traded for airspeed, as in a dive. This trading of energy, however, must be balanced with the final desired energy state in mind. For example, when a pilot trades altitude for airspeed by descending the airplane, the descent angle must be selected carefully in order to capture the final desired energy state with the introduction of the necessary chemical energy.

This becomes especially important when the pilot wants to generate aerodynamic forces and moments to manoeuvre the airplane. Kinetic energy can be traded for potential energy (climb). Potential energy can be converted to kinetic energy. Chemical energy can be converted by engines to either potential or kinetic energy, but only at specified rates.

The objective of manoeuvring the airplane is to manage energy so that kinetic energy stays between limits (stall and placards), potential energy stays within limits (terrain-to-buffet altitude), and chemical energy stays above certain thresholds (fuel in tanks). These concepts are especially important to understanding recovery from an airplane upset.

In managing these energy states and trading between the sources of energy, the pilot does not directly control the energy. The pilot controls the direction and magnitude of the forces acting on the airplane. These forces result in accelerations applied to the airplane. The result of these accelerations is a change in the orientation of the airplane and a change in the direction, magnitude, or both, of the flight path vector. Ultimately, velocity and altitude define the energy state.

This process of controlling forces to change accelerations and produce a new energy state takes time. The amount of time required is a function of the mass of the airplane and the magnitude of the applied forces, and is governed by Newton's laws. Airplanes of larger mass generally take longer to change orientation than do smaller ones. This longer time requires the pilot to plan ahead in a large-mass airplane to ensure that the actions taken will result in the final desired energy state.

Thrust, weight, lift, and drag are the forces that act upon an airplane. Manoeuvring is accomplished by variations of these forces and is controlled by the throttles and flight controls.

The lift force in pounds or kilograms generated by a surface is a result of the angle of attack, the dynamic pressure of the air moving around it (which is a function of the airspeed and density), and the size and shape of the surface. Lift varies with angle of attack for constant speed and air density. As angle of attack is increased, the lift increases proportionally, and this increase in lift is normally linear. At a specific angle of attack, however, the resulting lift due to angle of attack behaves differently. Instead of increasing, it decreases. At this critical angle of attack, the air moving over the upper wing surface can no longer remain attached to the surface, the flow breaks down, and the surface is considered stalled. The breakdown of the flow and consequent loss of lift is dependent only upon the angle of attack of the surface. This is true regardless of airplane speed or attitude. An airplane stall is characterized by any one (or a combination) of the following conditions:

- Buffeting.
- Lack of pitch authority.
- Lack of roll control.
- Inability to arrest descent rate.

These conditions are usually accompanied by a continuous stall warning. A stall must not be confused with the stall warning that alerts the pilot to an approaching stall. Recovery from an approach to stall is not the same as a recovery from an actual stall. An approach to stall is a controlled flight manoeuvre; a stall is an out-of-control, but recoverable, condition.

Flight controls give the pilot the ability to manage the forces acting on the airplane in order to manoeuvre; that is, to change the flight path of the airplane.

PITCH CONTROL.

Movement around the lateral axis of an airplane is called pitch and is usually controlled by the elevator. Given any specific combination of airplane configuration, weight, centre of gravity, and speed, all forces will be balanced at one elevator position.

In flight, the two elements most easily changed are speed and elevator position; as speed changes, the elevator position must be adjusted to balance the aerodynamic forces. Control forces required for this new position can be neutralized by adjusting the pitch trim mechanism. Typically, the pitch trim mechanism adjusts the position of the horizontal stabiliser.

An important concept for pilots to understand is that if the airplane is at a balanced, "in-trim" angle of attack in flight, it will generally seek to return to the trimmed angle of attack if upset by external forces or momentary pilot input. This is due to the longitudinal stability designed into that airplane.

Changes in airplane configuration also affect pitch control. For example, flap extension usually creates a nose-down pitching moment; flap retraction usually creates a nose-up pitch. When extended, wing-mounted speed brakes usually produce a nose-up pitching moment.

Pitch attitude can also change with thrust. With underwing engines, reducing thrust creates a nose-down pitching moment; increasing thrust creates a nose-up pitching moment. The combination of elevator and stabilizer positions also affects pitch. In normal manoeuvring, the pilot displaces the elevator by applying an elevator control force. The pilot then trims the stabilizer by driving it to a new position to remove the elevator control force.

This new stabilizer position is faired with the elevator. If they are not faired (one is down and the other is up), one cancels out the other. This condition limits the airplane's ability to overcome other pitching moments from configuration changes or thrust.

LATERAL AND DIRECTIONAL CONTROL.

Similar to how feathers on the back of an arrow make it fly straight, airplanes have a vertical stabilizer to keep the nose into the wind. The rudder is attached to the vertical stabilizer, and movement of the rudder into the airflow creates a force and a resulting rotation about the vertical axis. This motion is called yaw.

The vertical stabilizer and the rudder are sized to meet two objectives: to control asymmetric thrust from an engine failure at the most demanding flight condition (greater than V_1), and to generate sufficient sideslip for crosswind landings. To achieve these objectives, the vertical stabilizer and rudder must be capable of generating powerful yawing moments and large sideslip angles.

Motion about the longitudinal axis is called roll. Control inputs cause the ailerons and spoilers to control the airplane's roll rate. The aileron and spoiler movement changes the local angle of attack of the wing, changing the amount of lift and causing rotation about the longitudinal axis.

During an airplane upset, unusually large amounts of aileron or spoiler input may be required to recover the airplane. After input of full roll control, it may be necessary to use rudder in the direction of the desired roll. The amount of rudder required to coordinate the manoeuvre will depend on the airplane type and associated systems. An uncoordinated rudder movement results in a nose movement (yaw) in the direction of the rudder input. The yaw creates sideslip, which causes a roll in the same direction as the rudder input. The roll due to sideslip is referred to as dihedral effect.

When encountering an angle of attack associated with the onset of stick shaker, ailerons and spoilers are still effective at controlling roll. However, as the angle of attack continues to increase beyond the angle associated with stick shaker onset, the airflow over the wing separates and airplane buffet generally begins. Without decreasing the angle of attack, the combination of ailerons and spoilers in this separated airflow may not always generate a significant force; therefore, little rotation about the longitudinal axis occurs on some models. Since the vertical stabilizer/rudder is rarely aerodynamically stalled, it is still possible to generate a force and a nose rotation with associated roll rate.

However, at a high angle of attack, pilots must be extremely careful when using the rudder for assisting lateral control. Excessive rudder can cause excessive sideslip which could lead to departure from controlled flight.

Asymmetric thrust creates a yawing and a rolling moment. An engine failure creates an undesired yaw and roll. Conversely, an intentional engine throttle up or down could create a desired yawing moment followed by a desired rolling moment.

Using asymmetric thrust to control roll is not precise because of the lag time associated with engine spool-up or spool-down and should be avoided unless no other means of roll control are available. Generally, the pilot should attempt to restore symmetric thrust conditions during an upset recovery.

Applying Aerodynamic Fundamentals to Airplane Upsets

Though airline pilots in line operation will rarely, if ever, encounter an upset situation, understanding how to apply aerodynamic fundamentals in such a situation will help 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.

STALL RECOVERY

In all upset situations, it is necessary to recover from a stall before applying any other recovery actions. To recover from the stall, angle of attack must be reduced below the stalling angle. Nose-down pitch control must be applied and maintained until the wings are unstalled. Under certain conditions, on airplanes with underwing-mounted engines, it may be necessary to reduce some thrust in order to prevent the angle of attack from continuing to increase. Once unstalled, 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 high and increasing, the kinetic energy (airspeed) is decreasing rapidly.

According to the energy management discussed earlier, the energy is actually being stored as potential energy. As airspeed decreases, the pilot's ability to manoeuvre 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 will cause an additional pitch up for underwing-mounted engines. At full thrust settings and very low airspeeds, the elevator -- working in opposition to the stabilizer -- will have limited control to reduce the pitch attitude.

In this situation the pilot should trade the potential energy of altitude for airspeed, and would have to manoeuvre 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 will result 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 to 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 on airplanes with underwing-mounted engines. The use of this technique is not intuitive and must be considered by each operator for their specific fleet types.

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 degrees, up to a maximum of 60 degrees, could be needed. Unloading the wing by maintaining continuous nose-down elevator pressure will keep 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 manoeuvre changes the pitch rate into a turning manoeuvre, 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 manoeuvre 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 will allow 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 low and going lower, the kinetic energy (airspeed) is increasing rapidly. A pilot would likely reduce thrust and extend the speed brakes. The thrust reduction will cause an additional nose-down pitching moment. The speed brake extension will cause a nose-up pitching moment, an increase in drag, and a decrease in lift for the same angle of attack. At airspeeds well above V_{MO}/M_{MO}, the ability to command a nose-up pitch rate with elevator may be reduced because of the extreme aero-dynamic loads on the elevator.

Again, it is necessary to manoeuvre the airplane's flight path back toward the horizon. At moderate pitch attitudes, applying nose-up elevator -- and reducing thrust and extending speed brakes, if necessary -- will change the pitch attitude to a desired range. At extremely low pitch attitudes and high airspeeds (well above V_{MO}/M_{MO}), 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 which is unintentionally beyond that necessary for normal flight.

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 will be required for level flight.

At bank angles greater than 67 degrees, level flight cannot be maintained within flight manual limits for a 2.5 g load factor. In high bank angle, increasing airspeed situations, the primary objective is to manoeuvre the lift of the airplane to directly oppose the force of gravity by rolling to wings level. Applying nose-up elevator at bank angles above 60 degrees 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 potential energy (altitude) is rapidly being exchanged for kinetic energy (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 degrees. This will also reduce 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 speed brakes as necessary.

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. Boeing and Airbus believe the recommended techniques provide a logical progression for recovering an airplane. The techniques assume that the airplane is not stalled. If it is, recovery from the stall must be accomplished first.

Causes of aircraft upset:

1. **Turbulence**: Turbulence, whether from clear air turbulence (CAT), thunderstorms, or wake turbulence from other aircraft, can and have lead to unexpected attitude changes.

2. **Pilot Error**: Errors in flight operations, incorrect control inputs, misinterpretation of instruments, or failure to react appropriately to changing conditions can result in upsets.

3. **Spatial Disorientation**: Pilots can lose their sense of orientation, especially in IMC, and may inadvertently put the aircraft into an unusual attitude – more on this later.

4. **Mechanical Failures**: Malfunctions or failures in aircraft systems, such as control surfaces, hydraulics, or engines, can lead to upsets.

5. **Weather-Related Factors**: Severe weather phenomena like wind shear, microbursts, and severe turbulence can create conditions that challenge aircraft stability.

6. **Wake Turbulence**: Flying too close to a larger aircraft's wake turbulence can induce upset conditions.

7. **Icing**: Ice accumulation on aircraft surfaces can disrupt aerodynamics, potentially leading to upsets.

8. **Instrumentation Issues**: Faulty instruments can provide incorrect information to the pilot, leading to incorrect control inputs.

9**. Extreme Manoeuvres**: Aggressive or uncoordinated manoeuvres, such as abrupt control inputs, can result in upsets.

10. **Loss of Situational Awareness**: Pilots may lose awareness of their aircraft's position and attitude, especially during high workload situations.

11. **Human Factors**: Fatigue, stress, distractions, and other psychological factors can impair a pilot's ability to maintain control.

13. **Inadequate Training**: Lack of proper training in upset recovery techniques can leave pilots ill-equipped to handle such situations.

Preventing and recovering from upsets in flight requires a combination of training, situational awareness, and adherence to established procedures. Proper pilot training and recurrent UPRT can significantly reduce the risks associated with these potential causes of upsets.

Why is UPRT Important?

UPRT is essential as it enhances our ability to maintain control of the aircraft, even in extreme situations. It equips you with the skills and confidence to handle unexpected scenarios, ensuring passenger safety and aircraft integrity.

Recovering from an Upset Condition

The following actions 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 dependent on the situation.

Not all actions can be needed once recovery is under way. If needed, use minimal pitch trim during initial recovery. Careful use of rudder to aid roll control should be considered only if roll control is ineffective and the airplane is not stalled.

These actions assume that the airplane is not stalled. A stalled condition can exist at any attitude and can be recognized by one or more of the following:

Stick shaker
Buffet that can be heavy at times
Lack of pitch authority
Lack of roll control
Inability to stop a descent.

If the airplane is stalled, first recover from the stall by applying and maintaining nose down elevator until stall recovery is complete and stick shaker stops.

Signs of an Upset

Recognizing an upset condition involves being attentive to the following signs:

a. Unusual aircraft attitude (nose high, nose low, banked).

b. Unusual control inputs or instability.

c. Unusual engine sounds or vibrations.

d. Alarms, warnings, or unusual instrument readings.

Recovery Process

Nose High Recovery

<table>
<tr><th>Pilot Flying</th><th>Pilot Monitoring</th></tr>
<tr><td colspan="2">Recognize and confirm the developing situation</td></tr>
<tr><td>Disengage autopilot
Disengage 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.</td><td>Call out attitude, airspeed and altitude throughout the recovery.
Verify all needed actions have been done and call out any continued deviation.</td></tr>
</table>

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

<table>
<tr><th>Pilot Flying</th><th>Pilot Monitoring</th></tr>
<tr><td colspan="2">Recognize and confirm the developing situation</td></tr>
<tr><td>Disengage autopilot
Disengage 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.</td><td>Call out attitude, airspeed and altitude throughout the recovery.
Verify all needed actions have been done and call out any continued deviation.</td></tr>
</table>

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

One key principle of UPRT is to avoid overcontrolling the aircraft during recovery. Smooth and deliberate control inputs are crucial to prevent exacerbating the situation.

The above recovery is specific to the Boeing 737 as of September 2023. Refer to your airline's manuals for up to date information.

Monitor and Assess

After initiating recovery, continuously monitor the aircraft's attitude, altitude, and airspeed. Ensure that the aircraft is returning to stable flight.

A word on Spatial Disorientation

Spatial awareness defines our natural ability to maintain our body orientation and/or posture in relation to the surrounding environment (physical space) at rest and during motion. Genetically speaking, humans are designed to maintain spatial orientation on the ground. The three-dimensional environment of flight is unfamiliar to the human body, creating sensory conflicts and illusions that make spatial orientation difficult, and sometimes impossible to achieve.

Spatial orientation in flight is difficult to achieve because numerous sensory stimuli (visual, vestibular, and proprioceptive) vary in magnitude, direction, and frequency. Any differences or discrepancies between visual, vestibular, and proprioceptive sensory inputs result in a sensory mismatch that can produce illusions and lead to spatial disorientation.

Good spatial orientation relies on the effective perception, integration and interpretation of visual, vestibular (organs of equilibrium located in the inner ear) and proprioceptive (receptors located in the skin, muscles, tendons, and joints) sensory information.

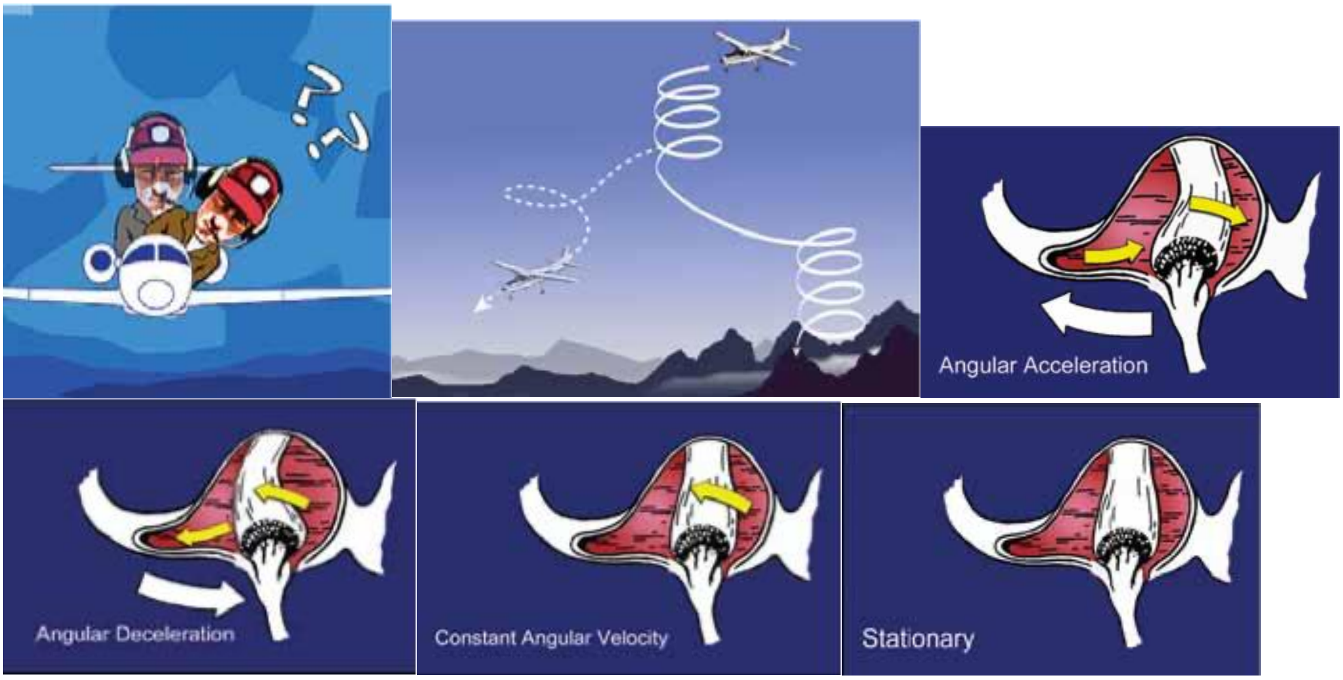
Vestibular Aspects of Spatial Orientation

The inner ear contains the vestibular system, which is also known as the organ of equilibrium. About the size of a pencil eraser, the vestibular system contains two distinct structures: the semi-circular canals, which detect changes in angular acceleration, and the otolith organs (the utricule and the saccule), which detect changes in linear acceleration and gravity.

Both the semi-circular canals and the otolith organs provide information to the brain regarding our body's position and movement. A connection between the vestibular system and the eyes helps to maintain balance and keep the eyes focused on an object while the head is moving or while the body is rotating.

The Semi-circular Canals

The semi-circular canals are three half-circular, interconnected tubes located inside each ear that are the equivalent of three gyroscopes located in three planes perpendicular (at right angles) to each other. Each plane corresponds to the rolling, pitching, or yawing motions of an aircraft.



Each canal is filled with a fluid called endolymph and contains a motion sensor with little hairs whose ends are embedded in a gelatinous structure called the cupula. The cupula and the hairs move as the fluid moves inside the canal in response to an angular acceleration.

The movement of the hairs is similar to the movement of seaweed caused by ocean currents or that of wheat fields moved by wind gusts. When the head is still and the airplane is straight and level, the fluid in the canals does not move and the hairs stand straight up, indicating to the brain that there is no rotational acceleration (a turn).

If you turn either your aircraft or your head, the canal moves with your head, but the fluid inside does not move because of its inertia. As the canal moves, the hairs inside also move with it and are bent in the opposite direction of the acceleration by the stationary fluid (A). This hair movement sends a signal to the brain to indicate that the head has turned. The problem starts when you continue turning your air- craft at a constant rate (as in a coordinated turn) for more than 20 seconds.

In this kind of turn, the fluid inside the canal starts moving initially, then friction causes it to catch up with the walls of the rotating canal. When this happens, the hairs inside the canal will return to their straight up position, sending an erroneous signal to the brain that the turn has stopped–when, in fact, the turn continues.

If you then start rolling out of the turn to go back to level flight, the fluid inside the canal will continue to move (because of its inertia), and the hairs will now move in the opposite direction, sending an erroneous signal to the brain indicating that you are turning in the opposite direction, when in fact, you are actually slowing down from the original turn. This has been a leading cause of aircraft upsets.

Vestibular Illusions (Somatogyral - Semicircular Canals)

Illusions involving the semi-circular canals of the vestibular system occur primarily under conditions of unreliable or unavailable external visual references and result in false sensations of rotation. These include the Leans, the Graveyard Spin and Spiral, and the Coriolis Illusion.

The Leans. This is the most common illusion during flight and is caused by a sudden return to level flight following a gradual and prolonged turn that went unnoticed by the pilot.

The reason a pilot can be unaware of such a gradual turn is that human exposure to a rotational acceleration of 2 degrees per second or lower is below the detection threshold of the semi-circular canals.

Levelling the wings after such a turn may cause an illusion that the aircraft is banking in the opposite direction. In response to such an illusion, a pilot may lean in the direction of the original turn in a corrective attempt to regain the perception of a correct vertical posture.

The Graveyard Spin is an illusion that can occur to a pilot who intentionally or unintentionally enters a spin. For example, a pilot who enters a spin to the left will initially have a sensation of spinning in the same direction. However, if the left spin continues the pilot will have the sensation that the spin is progressively decreasing. At this point, if the pilot applies right rudder to stop the left spin, the pilot will suddenly sense a spin in the opposite direction (to the right). If the pilot believes that the airplane is spinning to the right, the response will be to apply left rudder to counteract the sensation of a right spin. However, by applying left rudder the pilot will unknowingly re-enter the original left spin. If the pilot cross checks the turn indicator, he/ she would see the turn needle indicating a left turn while he/she senses a right turn. This creates a sensory conflict between what the pilot sees on the instruments and what the pilot feels. If the pilot believes the body sensations instead of trusting the instruments, the left spin will continue. If enough altitude is lost before this illusion is recognized and corrective action is taken, impact with terrain is inevitable.

Conclusion:

Aircraft upsets can occur for a wide variety of reasons and UPRT is a fundamental skill for airline pilots, ensuring that you can safely and confidently handle upset conditions in flight. By understanding what UPRT is, recognizing the signs of an upset condition, and following the recovery process, you'll be able to competently manage the unexpected challenges that may arise.

Remember, practice and training are essential for mastering UPRT. Stay vigilant, stay safe, and never stop learning!