Chapter 4 Maintaining Aircraft Control: Upset Prevention and Recovery Training (**UPRT**)

**Introduction**: “The pilot’s fundamental responsibility is to prevent a loss of control (LOC). Loss of control in flight (LOC-I) is the leading cause of fatal general aviation accidents in the U.S and commercial aviation worldwide.”

**Situations That increase risk of loss of control**

* Uncoordinated flight
* Equipment malfunctions
* Pilot complacency
* Distraction
* Turbulence
* Poor risk management

**Defining an Airplane Upset:**

* An event that unintentionally exceeds the parameters experienced in normal flight.
  + Pitch attitude greater than 25 degrees nose up or 10 degrees nose down
  + Bank angle greater than 45 degrees
  + Within normal attitudes but flying at an inappropriate speed.
  + Stalls are airspeed related but are also related to AOA
* **Upset Prevention Recovery Training includes (UPRT):**
  + Slow Flight
  + Stalls
  + Spins
  + Unusual Attitudes

**Coordinated Flight**

* Generally, occurs when the pilot is proactively correcting for any yaw effects on the plane.
* Nose should be yawed into the relative wind and slip/skid ball should be centered.
* Step on the ball or step on the rudder towards the side that has a pronounced leaning feeling to it.

**Angle of Attack**

* When the critical AOA is exceeded air flow over the top of the wing separates and eddies causing a **stall** which decreases lift and tremendously increases drag.
* Stall is the result of AOA, but the term “**stall speed**” is used to denote the minimum speed that the plane would have to fly at in a given configuration to maintain its altitude.

**Slow Flight:**

* Flight at an AOA just under the one that will cause buffet or a stall warning.
* This can happen during takeoffs and approaches so pilots must be proficient.
* Object is to understand how the plane reacts to an oncoming stall such as reduced control fidelity, and difficulty maintaining altitude.
* **2 Main Elements of Slow flight Training**

1. Slowing to and maneuvering at and recovering from a speed that barely does not activate the stall warning; typically, 5 – 10 knots above the 1g stall speed.
2. Slow flying in takeoff, descent, approach and landing

* Procedure: Pitch the plane until the stall warning happens, pitch nose down until it stops and make note of the attitude
* Controls will require increased input to maintain.
* When flying slow you are below (Lift/Drag)Max and on the “backend of the power curve ” which causes speed instability. If the plane is disturbed by turbulence in this state you will have to correct it with power or AOA decrease.
* In slow flight pitch is a better way to control speed than power; power is usually used to control altitude.
* The closer the plane is to 1G stall the more rudder will be needed to correct P-factor

**Procedure:**

* **Be above 1500 AGL before you do this.**

1. **Clear the area, gradually reduce power and maintain altitude.**
2. **Note the changing sound around the plane**
3. **Trim the plane to compensate for control pressures**
4. **Extend the gear and flaps if practicing for approach**

**Maneuvering:**

* During turns it will be necessary to increase power to maintain altitude
* Abrupt movements may result in a stall.
* Practice climbs and descents by adjusting the power
* Counter any yaw tendencies caused by excessive control input
* To exit the maneuver apply forward control pressure, maintain coordinated flight, and level out the wings
* **Common Errors in Slow Flight**
  + Not clearing the area
  + Inadequate back pressure and subsequent altitude loss
  + Excessive back pressure causing a climb and airspeed loss
  + Not enough right rudder to counteract left yaw
  + Flight instrument fixation
  + Failure to anticipate AOA changes as flaps are moved
  + Bad power management
  + Poor division of attention between control and orientation
  + Bad trim
  + Poor response to a stall warning.

**Stalls**

* An aerodynamic condition that occurs as airflow over the wing is disrupted
* Occurs when the critical angle of attack is disrupted
* **Impending Stall:**
  + AOA is high enough to trigger a stall warning
  + Indicated by buffeting, stick shaker, and aural warning
* **Full Stall:**
  + Critical AOA is exceeded
  + Uncommanded nose down pitch and may roll as well
  + Full stall indication, on certain planes
  + Will cause a loss of altitude before it can be recovered

**Stall Recognition**

* **Feel**
  + Control surfaces will suffer progressively less air resistance and need more control movements.
  + Slower; more sluggish airplane reaction speed
  + Buffeting, rolling, and vibration
* **Vision**
  + Maintain pitch awareness
* **Hearing**
  + Change in the sound of air rushing along the plane as speed decreases
* **Kinesthesia / “seat of the pants”**
  + The physical sensation of change of direction or deceleration.

Remember: Level-flight 1G stalling speed is valid only

* In unaccelerated flight at 1G
* In coordinated flight
* Typically at maximum gross weight
* Usually at maximum forward CG

*Angle of attack indicators:*

* Can give some visual indication if the plane is approaching critical angle of attack
* Some may give aural warnings
* Testing should be done at different flight conditions

**Stall Characteristics**

* Different for each plane but there are some similarities for GA planes
* Most planes have wing twist along the planform (washout) to make the wing root stall before the rest of its length, making the ailerons still effective before the entire wing stalls
* Reduce the angle of attack before using the ailerons while in a stall to prevent “roll off”, which can exacerbate the stall
* In a power-off stall buffeting and shaking can be less noticeable than a power on one. Use the elevator position instead as a better cue.

**Fundamentals of Stall Recovery**

* **Consists of potentially six steps that must be done in order!**

1. Disconnect wing leveler or auto pilot (if equipped).
2. Pitch NOSE DOWN and trim if necessary.
3. Roll the wings level.
4. Add thrust/power to increase airspeed.
5. Retract speed brakes or spoiler (if equipped).
6. Apply smooth control to return to desired flight path.

* Note: In a single engine training plane you will likely only need four or five of these steps.

**Stall Training**

* Stall accidents are usually inadvertently caused by poor attitude control at low altitudes
* Power-on stalls can result from aggressive pitching right after takeoff, or during climbs and turns
* Power-off stalls can simulate what happens if you try to “stretch a glide”
* Pilot should clear the area and be at least 1,500 ft AGL before stall training
* **Impending Stalls, Power-on and power-off**
  + Pilot must pitch nose high until the slightest warnings of a stall and then apply the procedure to recover from a stall
  + Procedure complete when plane returns to the original flight path.
  + Pilot performance is ranked as poor if a full stall develops, or excessive pitch, airspeed or altitude loss occurs
* **Full Stalls, Power-Off**
  + Simulates stalls in landing or approach conditions and/or mechanical failures
  + Should be practiced with all flap settings and without high airspeed
  + **Setup**: put the plane in landing configuration with flaps and landing gear extended, carburetor heat on and retard the throttle. Pitch down to a landing attitude and maintain airspeed
  + Pitch nose high after setup to initiate a stall and keep wings levelled
  + When recovering from the stall, you may need to add right rudder to overcome engine torque at low speed
  + If a stall is simulated during an approach the pilot should perform a go around by climbing and retracting all surfaces and gear
  + Recoveries are practiced in shallow turns to simulate base-leg stalls
  + If the plane slips the outer wing can stall first and move downward
  + Usually, a turning stall is recovered within a 90 heading change
* **Full Stalls, Power-On**
  + Typically practiced in straight climbs or climbing turns (15– 20 ) in takeoff or clean configuration with maximum power
  + Simulates takeoff and go around stalls
  + **Setup**: Put plane in takeoff or climb config, slow to normal lift-off speed while clearing area of traffic, set take-off power when at desired speed, and establish climb attitude
  + After achieving climb attitude, raise the nose until stall occurs while keeping the rudder and ailerons steady
  + Reducing speed to takeoff before applying engine power is done to prevent excessive nose high attitude for too long
  + After recovering from the stall and returning to climb the pilot may reduce engine power
* **Secondary Stall**
  + Can happen before complete stall recovery by way of abrupt control inputs
  + Can also occur if the pilot does not reduce AOA sufficiently or tries to break the stall using power alone
  + Pilot must apply the same anti-stall procedure to break the second stall

**Accelerated Stalls**

* These simulate stalling at speeds greater than the 1G load factor
* In normal config the plane can stall at high indicated airspeeds when turning, pulling up, or any abrupt maneuvers.
* Typically happens in stall and spin recoveries, pullouts from steep dives, or landing overshoots during base to final.
* Never practice accelerated stalls with flaps/gear extended or when above the manufacturers designed maneuvering speed VA
* Perform with a bank angle of approximately 45
* **VA:**
  + Relates to the airplanes weight
  + “Is the max speed at which the max positive load limit can be imposed by gusts or full one sided deflection with one control surface without causing structural damage”
  + VA can be reached before the critical AOA damaging the plane before a stall
* **Method 1 to perform an Accelerated Stall: (Most common)**
  + Start in steady level flight at or below VA
  + ­Roll plane into a steep turn and apply back elevator pressure until a stall.
* **Method 2:**
  + Achieve VA first and roll the plane into a steep turn
  + Increase AOA using the elevator while in the turn until a stall occurs
* Take recovery action immediately as a prolonged accelerated stall can develop into a spin

**Cross-Control Stall**

* This represents stall behavior in uncoordinated flight conditions
* The effects can surprise a pilot, effects such as nose pitching down, bank can suddenly change, or even overbanking into unintended inverted flight and a spin
* Occurs when aileron and rudder pressure are applied in opposite directions
* Skidding cross-control stalls are likely during a base to final turn overshoot, if the pilot tries to correct by overbanking and pulling back hard
* Pilot should not use a bank angle greater than 30 at the low altitude of the base to final leg turn to avoid a potential spin
* Before practicing this stall, get to safe altitude for spin recovery
* **Setup:** Lower landing gear, close throttle, and maintain altitude until normal glide speed. Trim for normal glide and roll the plane into a medium bank that overshoots a base to final turn.
* Apply rudder in the opposite direction as the turn and pull back on the elevator to induce a cross-control stall
* To recover from the stall push nose down to eliminate the stall warning, then remove rudder pressure and level the wings.

**Elevator Trim Stall**

* Can happen when the pilot applies full power for a go around and doesn’t maintain positive control of the airplane.
* May occur during a go-around from a normal or forced landing approach, or right after takeoff with the trim set to approach glide setting at idle power.
* Pilot may have to overcome strong trim forces provide smooth power application to prevent this stall
* **Setup:** After clearing the area and altitude, retard the throttle and extend landing gear and extend flaps to half or full position. Close the throttle and maintain altitude until normal glide speed
* Trim the airplane nose up for an approach glide, then advance the throttle to full to induce an elevator trim stall
* Prop wash from the engine will combine with the elevator trim to force the nose up and to the left.
* If taken to the full stall, the plane will require significant nose-down force to reduce the AOA below critical.

**Common Errors in the Performance of Intentional Stalls**

* Not clearing the area
* Over-reliance on airspeed and slip-skid indicators
* Pulling to fast on the controls causing an unintended accelerated stall
* Not recognizing and impending stall
* Failure to act quickly enough to stop a stall
* Inconstant bank angles during turns
* Poor rudder coordination throughout stall and recovery
* Recovering before reaching the critical AOA
* Not disconnecting wing leveler or autopilot
* Lack of pitch control an AOA awareness
* Not maintaining nose down long enough to eliminate stall warning
* Attempting to level wings before reducing AOA
* Trying to add power before reducing AOA
* Not rolling wings level after reducing AOA
* Inadvertent secondary stall
* Excessive forward-elevator pressure
* Too much airspeed during recovery
* Losing situational awareness

**Spin Awareness**

* A spin is an “aggravated stall”
* Typically comes from a full stall with the plane in a yawed state which causes the outboard wing to be less stalled than the inside one
* Plane follows a corkscrew like path going down
* The plane is stuck descending, rolling, yawing and pitching in a spiraled path
* Less stalled wing has a decreasing AOA while the descending wing has an increasing AOA
* Less stalled wing has an increasing relative lift and decreasing drag while the descending wing has the opposite
* Airplane can yaw into a spin because of adverse yaw, prop effects(p-factor, torque, spiraling slipstream, gyroscopic precession), wind shear, and turbulence
* A slipping or skidding turn plus a stall can cause a spin in the direction of the direction of the rudder application.

**Spin Procedures**

* Make sure the plane is approved for spins in the AFM/POH before practice
* Clear the area and be above 1,500 ft for recovery
* There are four phases to a spin

1. **Entry Phase:**
   * Pilot provides the elements for the spin, similar to a power-off stall
   * **Setup:** Slowly reduce power and raise the nose up into a stall, then apply rudder in the direction you wish to spin
2. **Incipient Phase:**
   * Occurs between the stall and the plane starting to rotate into a full spin
   * Takes usually two to four turn in most planes
   * Turn coordinator airplane will show the spin direction, not the inclinometer (slip/skid ball)
   * Pilot should try to recover before completing a 360 rotation
   * Apply rudder in the opposite of the direction of rotation to cancel
3. Developed Phase
   * Plane’s angular rotation rate, airspeed, and vertical speed are nearly stabilized in a near vertical flight path
   * Aerodynamic and inertial forces are in balance and airplanes motions are repeating
   * Note: some training planes can enter a spiral phase instead of a developed spin. A spiral involves an accelerating movement and forces
4. **Recovery Phase**
   * Rotation ceases and AOA is reduced below critical
   * This may be done in one or many turns
   * Pilot needs to disrupt the spin equilibrium and unstall the wing
   * Retract all gear and flaps before starting
   * **Technique**:
5. Reduce power to idle
6. Position ailerons to neutral
7. Apply full opposite rudder against rotation
8. Apply some brisk forward elevator
9. Neutralize the rudder after rotation stops
10. Apply back elevator to return to level flight

**Intentional Spins**

* Spin practice authorization can be checked in 3 sources
  + Type certificate data sheets or aircraft specifications
  + The limitations section of the FAA approved AFM/POH
  + On a placard in theplane; visible to the pilot that may say (NO ACROBATIC MANEUVERS INCLUDING SPINS APPROVED)
* Planes, with placards prohibiting spins, usually are unrecoverable from a spin
* **Weight and Balance Requirements Related to Spins**
  + A plane could operate normally with normal CG loading but can exhibit different spin resistance based on the weight arrangement.
  + Large weights aft of CG can make recovery difficult
  + Lighter utility aircraft can recover faster than larger ones

**Common Errors in Performing Intentional Spins**

* Failure to apply full rudder to initiate and recover
* Failure to use full elevator up to down
* Not fully stalling prior to developing a spin
* Slow full rudder application
* Waiting for rotation to stop before applying full elevator down
* Not neutralizing the rudder after the rotation stops
* Slow control movement
* Excessive back elevator after rotation stops
* Insufficient back elevator to recover

**Upset Prevention and Recovery**

**Unusual Attitudes vs Upsets**

* An upset is defined as an attitude that is:
  + Pitch > 45 nose up
  + Pitch > 10 nose down
  + Bank > 45
  + Within the above parameters but at an inappropriate airspeed
* The top four causal/contributing factors for upsets and LOC-I

1. **Environmental Factors**
2. **Mechanical Factors**
3. **Human Factors**
4. **Stall-related factors**

* **Environmental Factors:**
  + Includes turbulence and vibration in wind velocity over short distance
  + **Types of turbulence:** include Clear air turbulence, Mountain waves, Wind Shear, Thunderstorms or microbursts.
  + **Icing:** Can also degrade lift over an airfoil and increase drag
* **Mechanical Factors:**
  + Includes malfunctions such as asymmetrical flaps, binding controls, or even runaway trim
  + Misuse of Autopilot systems can also cause upsets
  + Primary instrument failures, remind the need for good partial panel and secondary instrument use proficiency
* **Human Factors:**
  + **VMC to IMC:** Continued use of Visual meteorological conditions flight rules into Instrument meteorological conditions is a common source of loss of control.
  + **Diversion of Attention:** Inflight anomalies or malfunctions can distract a pilot, leading to an upset.
    - Failing to monitor or over relying on automated systems; with incomplete knowledge of them will lead to an upset
    - Trying to set avionics or navigation equipment while flying can also distract a pilot
  + **Task Saturation:**
    - **Margin of Safety:** The difference between task requirements and pilot capabilities
    - If requirements exceed capabilities the pilot could accidently cause an upset
    - Mounting equipment failures, fatigue, unusual operating conditions/maneuvers, and weather can overload a pilot
    - Don’t “show off” and perform acts outside of your skill level
  + **Sensory Overload/Deprivation:**
    - Too many visual, auditory, and tactile warnings can overwhelm a pilot.
    - Practice separating time-critical info from distractions and increase knowledge of airplane systems to reduce this
  + **Spatial Disorientation:**
    - Data from 2008 to 2013 show about 200 accidents caused by spatial disorientation 70%of which were fatal.
    - False sensory illusions can affect a pilot when flying at night or in poor visual conditions
    - **Three common forms of spatial disorientation on the pilot:**

1. **Recognized Spatial Disorientation:** Pilot predicts the oncoming upset and is able to safely correct the situation
2. **Unrecognized Spatial Disorientation:** Pilot is unaware of an upset developing or occurrence and fails to take corrective actions
3. **Incapacitating Spatial Disorientation:** Pilot is unable to affect a recovery, because of lack of understanding, skill, or physiological/psychological inability to cope with what is happening
   * **Startle Response:** Uncontrollable muscle reflex, raised heart rate, blood pressure etc., caused by sudden event that violates pilot expectations.
   * **Surprise Response:** Unexpected event that can affect the pilot’s mental state and processes used to respond to it
     + Startle may or may not lead to a surprised response

**Upset Prevention and Recovery Training (UPRT)**

* Untrained pilots often react to an upset with abrupt inputs and non-intelligent responses which aggravates upsets
* **Upset prevention:** refers to actions to avoid a divergence from the desired plane state.
* **Recovery:** refers to pilot actions that return a plane that is diverging in altitude, speed, or attitude.
* UPRT stresses that the first step is recognizing any time the plane begins to diverge from the intended flight path.
* Pilot should perform cross-checks as soon as the instrument deviate from expected readings
* UPRT can help a pilot react more quickly, decisively and calmy during upset
* This should be conducted in both visual and simulated instrument conditions
* Additional considerations in airplane suitability and instructor training must be made for training in recovery from extreme maneuvers such as 90 turns.
* UPRT is different from aerobatic training

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| --- | --- | --- |
| Aspect of Training | Aerobatics | UPRT |
| Primary Objective | Precision maneuvering capability | Safe, effective, recovery |
| Secondary Outcome | Improved manual handling skills | Improved manual handling skills |
| Aerobatic Maneuvering | Primary training | Supporting training mode |
| Academics | Supporting role | Fundamental component |
| Training Resources | Aircraft | Aircraft or flight simulator |

* UPRT builds on three supportive components

1. Academics
2. Airplane based Training
3. Use of Flight Simulated Training Devices (FSTDs)

**Academic Material (Knowledge and Risk Management)**

* Academic material should emphasize concepts, principles, procedures, and techniques for recognizing and mitigating upsets
* The relationship between AOA, G-Load, Lift, and energy management should be studied along with consequences of mismanagement
* Aircraft decision making (ADM) and risk management (RM) should be stressed

**Prevention through ADM and Risk Management**

* This happens in a time-scale of minutes or hours leading up to any upsets
* Involves effective analysis, awareness, resources management, interruption of an error chain, and sound judgement.
* Pilots should look for increased scenarios that require high risk management such as low – altitude, visibility, increased load factors, steep turns in a pattern, etc..
* Crew Resource Management (CRM) and Single Pilot Resource Management is important, *See FAA Pilot Handbook for details*
* A Crew must:
  + Communicate and confirm situations clearly and concisely
  + Transfer control to the most Situationally aware crew member
  + Use standardized interactions, work as a team, manage stress, and mitigate fear.

**Prevention through Proportional Counter-Response**

* Proportional counter response: the timely manipulation of flight controls and thrust to manage a plane’s unintended attitude or flight envelope
* Time scale for this is on the order of seconds or fractions of a second.
* Do not to panic and overreact to the developing upset

**Recovery**

* Structured practice must be carried out after academic research.
* Upset recovery follows the same procedure as stall recovery,
  + Disconnect autopilot 🡪 apply forward pressure 🡪 Roll wings to the nearest horizon (aka level)

**Common Errors in Upset Recoveries**

* Not disconnecting wing leveler or autopilot
* Failure to unload the wing
* Not rolling in the correct direction
* Bad airspeed management

**Roles of FSTDs and Airplanes in UPRT**

* Flight training devices and full flight simulators are not always a suitable substitute
* Only level C and D flight simulators are appropriate stand ins for a plane
* Training should only be reinforced using simulators after plane practice.

**Airplane-Based UPRT:**

* The airplane vs the simulator forces the pilot to overcome fear in an upset.
* Your training is limited by the plane and instructors’ capabilities.
* An instructor must also conduct training correctly and professionally to prevent negative learning of the student

**All-Attitude/All-Envelope Fight Training Methods**