A110 INTRODUCTION TO AEROBATICS

OBJECTIVE: Students will understand the key differences in performance, handling, and emergency procedures between single-engine and multiengine airplanes, with a focus on OEI operations and system management.

STANDARDS: This lesson is complete when the student can explain multiengine aircraft performance, systems, V-speeds, OEI procedures, weight and balance considerations, and proper takeoff, climb, cruise, landing, and emergency operations.

This stage of your flight training is primarily devoted to the performance of aerobatic maneuvers and the further refinement of the maneuvers previously introduced.
Aerobatic flight training is essential to your development as an effective military pilot.

Experience gained through aerobatic training will increase your confidence and enhance your understanding of practical aerodynamics. Your coordination, timing, and ability to maintain spatial orientation will improve as you learn by flying the aircraft through the various aerobatic maneuvers.

The ability to perform aerobatic maneuvers skillfully is in large part due to an innate "sense of feel" which is developed through practical experience. Mechanical execution of the procedures alone will not produce the desired results. The pilot must continually analyze and make control adjustments based upon a constant flow of visual, tactile, and even aural feedback.
Increased demands will be made upon your air work as you improve your consistency and precision in the landing pattern. You will also perform angle of attack (AOA) approaches for the purpose of introducing landing procedures which are used exclusively in fixed wing Naval Carrier Aviation and to some degree in the USAF.

Aerobatic flight training is as challenging as it is exciting. Study this instruction thoroughly.
The better you prepare yourself on the ground, the quicker you will begin to develop your "sense of feel" while in the air. Careful study and preparation will ensure that you receive the maximum benefit from this training while maintaining the highest possible level of flight safety.

1. RULES AND PRECAUTIONS FOR AEROBATIC FLIGHT

Due to their unique nature, there are certain rules and precautions you must observe prior to performing any aerobatic maneuver. FRRs and local SOP will prescribe restrictions governing the airspace within which you may perform aerobatic maneuvers. Ensure that you are thoroughly familiar with these regulations. Strict compliance is mandatory.

2. AEROBATIC CRUISE

All aerobatic maneuvers will be from aerobatic cruise. This is defined as trimmed and balanced flight utilizing the maximum allowable power setting (1015 ft-bs.). Transition to aerobatic cruise by increasing power to maximum allowable and trimming for straight and level balanced flight. This will normally result in an indicated airspeed between 180 and 190 KIAS. Once the aircraft is trimmed for aerobatic cruise, leave the trim tabs where they are and do not adjust them while performing the various aerobatic maneuvers. Remember that one of the basic reasons that aerobatic training is performed is so that you may develop a "sense of feel" under constantly changing attitudes and airspeeds. The use of trim tabs would defeat this objective by altering the feel of the controls

3. AEROBATIC CHECKLIST
Prior to performing any aerobatic maneuver or series of the same maneuver, complete the Aerobatic Checklist. This will assure you that your aircraft is prepared for aerobatic flight. The checklist is as follows:

1.**Bilges** - *"*Clear of loose objects, control lock stowed (in two places)*"*
2.**Restraint harness** - *"*Locked and tight.*"*
3.**Autoignition** - *"*On, AUTO IGN light, ON.*"*
4.**Engine instruments** - *"*Checked" (for normal indications).
5.**Report** - *"*Aerobatic Checklist complete.*"*

Ensure that all loose items (checklists, charts, pubs, clips, water bottles, etc.) are secure in either the map case or a zipped pocket. Your inertial reel should be locked and the harness tight (waist and shoulder straps). The control lock should be visually checked to ensure that it is secured in both places. Check that the autoignition light actually illuminates and make a mental note to secure it once all aerobatic maneuvers and/or stalls are complete. Take the time to check each instrument for normal indications. Additionally adjust the friction knob so that sufficient pressure is applied to prevent the PCL from slipping during high G maneuvers. Taking the time and effort to do your Aerobatic Checklist correctly can prevent some unwelcome surprises.

4. SECTION LINES AND GROUND REFERENCE POINTS

The maneuver descriptions and procedures of the various aerobatic maneuvers often refer to section lines and ground reference points. Understanding how to select and utilize these geographical references will greatly enhance your ability to remain oriented during the various aerobatic maneuvers.

Much of the area you will fly over is rural farmland or beachline/waterways.
The lines which separate one "section" of land from another is called a "section line."
These lines commonly run north/south or east/west in long, straight lines and are easily identified from the air. During the various maneuvers, these section lines are utilized as a reference to maintain directional control. Since some maneuvers involve a reversal in the direction of flight, it becomes necessary to select a line which extends both in front of and behind you. Highways, utility cuts or even beachlines may also be utilized, provided they are linear and of sufficient length.

Maneuvers such as the Barrel Roll or Wingover require the use of a ground reference point which is 90 from your initial heading. Ensure that the points which you select are prominent and easily seen, remembering that you will have to relocate them rapidly as you are passing through unusual attitudes. The rate at which you must scan while performing the maneuvers does not allow the time to search for a hard-to-see reference point

5. CLEARING TURNS
During aerobatic flight, attitude, altitude and direction of flight change rapidly. You must therefore exercise extreme caution by ensuring the immediate area is clear of other aircraft and that no danger of midair collision exists. A clearing turn, as the name implies, allows you to clear the area in which you are operating. A clearing turn shall be executed after the Aerobatic Checklist and immediately prior to the performance of any aerobatic maneuver. Utilize a minimum of 45 angle of bank and turn for a minimum of 180 of heading change. Two 90 turns in opposite directions will suffice. The direction of the last clearing turn shall be in the direction in which the maneuver will be performed. Throughout the turn, check the area thoroughly for other aircraft. Continue the turn until you have the desired airspeed and sufficient ground references to maintain orientation during the maneuver. Remember 180 of turn is a minimum, not an absolute.

If the number of section lines or ground references is limited, then a teardrop maneuver is an

effective means of performing the clearing turn while positioning the aircraft for the next maneuver. This may be performed by turning to place the nose approximately 45 from the section line, timing for 10-15 seconds, and then turning back to the reciprocal of the original heading.

Common Errors

a. Failure to plan or execute the clearing turn(s) so that the chosen ground references are properly positioned to allow for adequate orientation during the subsequent maneuver.
b. Not "clearing" the area sufficiently during the turn.
c. Poor basic airwork during the clearing turn(s), resulting in the aircraft not being at the correct altitude and/or airspeed to commence the planned maneuver in a timely fashion.
d. Failure to execute the maneuver within the cleared airspace.

6. ALTITUDE LIMITATIONS

Commence each aerobatic maneuver from an altitude which is sufficient to allow a return to straight and level flight above 5000 feet AGL. You must also exercise caution to ensure that you do not exceed the maximum altitude permitted for your particular operating area. If performed correctly, all of the maneuvers (except the Aileron Roll) require approximately 1500 feet of vertical airspace. Use this figure while planning your entry altitude, keeping in mind that the minimum recommended altitude for bailout during out-of-control flight is also 5000 feet AGL. Sound judgment applies in choosing an altitude from which to commence each particular maneuver. Generally, the higher you can begin without exceeding your maximum altitude is the most logical choice. As your experience increases, you should manage your altitudes in order to control your energy states more effectively, thus increasing efficiency within the same allotted time and available fuel

7. OPERATING LIMITATIONS

Aerodynamic, acceleration and aerobatic flight limitations are contained in the Aircraft's Manual. You are required to know and operate the aircraft within these limitations. In the event that you inadvertently overstress the aircraft, you should discontinue aerobatics immediately and execute the IN-FLIGHT DAMAGE procedures in accordance with the Aircraft's Manual. Immediately after your return, you must "down" the plane so that the airframe can be inspected for damage prior to the next flight.

8. INVERTED AND ZERO G FLIGHT LIMITATIONS

The maximum inverted flight time is 15 seconds. Inverted flight above 220 KIAS is prohibited. The maximum zero G flight time is transient.
Zero G flight is associated with a "floating" sensation. This is usually a result of relaxing too much or all of the backstick pressure and is often referred to as "unloading the aircraft." If the maneuvers are performed correctly, you will not experience this condition.

9. G-INDUCED LOSS OF CONSCIOUSNESS

G-induced loss of consciousness (G-LOC) is a fainting episode caused by gravity-induced physiological stresses on the human body. The most commonly experienced G-forces are encountered by pilots during positive acceleration maneuvers (such as pulling out of a dive or turning at high angles of bank). This type of positive G-force (+Gz) is directed from head to foot, and therefore imparts a feeling of being pressed into the seat.
The ultimate effect of these forces on the human body is a tendency for blood to pool both in the lower abdomen and the extremities. This pooling effect dramatically reduces the volume of blood available to the eyes and brain, thereby critically reducing the oxygen available to sustain vision and conscious brain function. The typical G-LOC sequence of progression is as follows:

1. Grayout -- peripheral vision is progressively impaired.
2. Blackout -- vision is lost completely.
3. Loss of consciousness.

Once G-LOC actually occurs, it typically lasts from 15-30 seconds. Once consciousness is regained, the individual usually exhibits a period of uncontrolled muscle spasms followed by disorientation or a "dream-like" state which can last from a few seconds to several minutes. Some pilots have described post G-LOC feelings of detachment, apathy and temporal distortion. Amnesia of the entire episode is a common occurrence. Impairment of piloting skills may last for as long as 30 minutes.

Navy and Air Force investigators have identified G-LOC as a probable causal factor in numerous Class A mishaps. The Air Force estimates that at least 12% of all Tac-Air pilots have experienced actual G-LOC at least once. G-loading capability in the T-38/T-7 is comparable to most tactical jets, and therefore can easily cause G-LOC among the inexperienced or unprepared pilot. Most T-38 G-LOC episodes occur during rapid G-loading of 3 to 5 G's over 2 to 5 second intervals. Pilots can prepare themselves for the physical stress of rapid accelerations and therefore prevent G-LOC by taking certain precautions:

1. Learn and utilize the proper Anti-G Straining Maneuver (AGSM), more commonly called the "HOOK Maneuver." There are two components to the recommended AGSM:
    a. The first component is a continuous and maximum contraction (if necessary) of all skeletal muscles including the arms, legs, chest, and abdominal muscles. This tensing of the skeletal muscles restricts blood flow in the G-dependent areas of the body and thereby assists in the retention of blood in the thoracic region (including the heart) and the brain.
    b. The second component of the AGSM involves repeated closing of the respiratory tract at 2.5 to 3.0-second intervals. Its purpose is to counter the downward G force by expanding the lungs and increasing the chest pressure, thereby forcing blood to flow from the heart to the brain.

The respiratory tract is an open breathing system which starts at the nose and mouth and ends deep in the lungs. It can be completely closed off at several different points, the most effective of which is the glottis. Closing the glottis (which is located behind the "Adam's Apple") yields the highest increase of chest pressure. The glottis can be closed off by saying the word "HOOK" and catching it about of the way through the word ("Hooo-"). This should be done after a deep inspiration, followed by forcefully closing the glottis as you say "HOOK." Bear down for 2.5 to 3.0 seconds, then rapidly exhale by finishing the word HOOK ("-ka"). This is immediately followed by the next deep inhalation, repeating the cycle until the G-loading is discontinued. The exhalation and inhalation phase should last for no more than 0.5 to 1.0 second. Since the blood pressure falls dramatically during this phase, its duration must be kept to a minimum.

WARNING

Do not hold your respiratory straining too long (more than five seconds) since this will prevent the blood from returning to the heart properly and may result in loss of consciousness.

Anticipate the onset of high G forces whenever possible. Skeletal muscles should be tensed prior to the onset, coupled with the "HOOK" respiratory cycle as the G-loading increases. Initiating the AGSM too early can inhibit the body's natural cardiovascular reflex responses, while beginning too late creates a deficit situation which may be difficult to overcome.

NOTE

If properly performed, the AGSM should provide adequate protection against G-LOC while performing the various aerobatic maneuvers. If you experience difficulty, or are in doubt as to whether or not you are

executing the maneuver correctly, see your squadron flight surgeon or wing Aeromedical Safety Officer.

2. Inter-cockpit communication between aircrew is imperative. Both individuals must rely on the other not to apply high G forces without first giving prior warning. Historically poor crew communication has been a major causal factor in G-LOC episodes.

3. Be prepared physically.
   a. Avoid flying if ill or extremely fatigued.
   b. Maintain an adequate fluid intake and do not skip meals.
   c. Stay in shape. The optimum fitness program for increasing G-tolerance is a combination of moderate weight training and cardiovascular aerobic exercise (running, walking, swimming, etc.) 2-3 times weekly. Avoid excessive long distance running (more than 25 miles per week) or overly intense weight training. These will typically result in lower blood pressure and heart rate which may decrease G-tolerance.

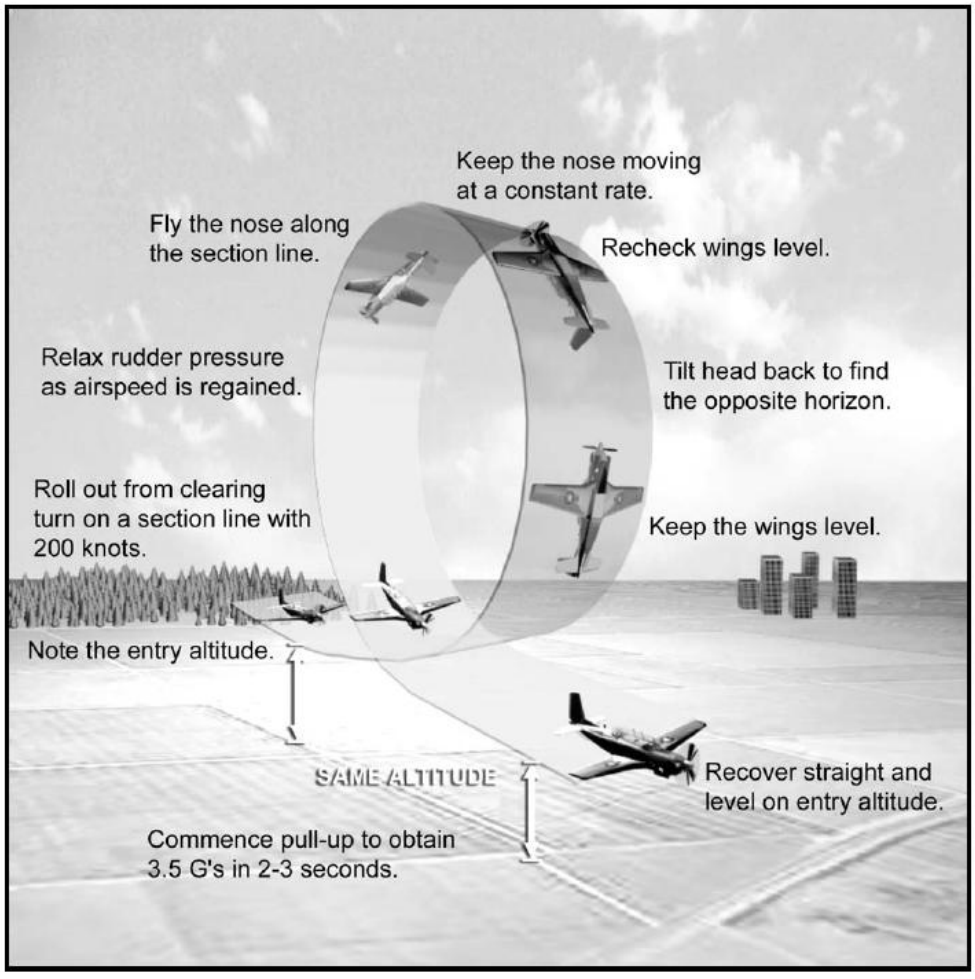
4. A "G-warmup sequence" is recommended for any pilot who anticipates performing high G maneuvers. This may be accomplished by performing the following procedures:
   a. Transition to aerobatic cruise and complete the Aerobatic Checklist. Notify the other crewmember that you are going to commence the G-warmup sequence.
   b. Clear the area. Initiate three-second verbal countdown. On "1," apply the AGSM and on "0," smoothly roll into a 60 AOB turn at 2 G's for 90 of heading change. Maintain altitude with nose attitude. Continue to perform the AGSM until step 4 is completed.
   c. Clear the area. Using the one-third rule, reverse the turn for 90 of heading change at 60 AOB and 2 G's. Maintain altitude with nose attitude.
   d. Clear the area. Using the one-third rule, reverse the turn for 90 of heading change at 90 AOB and 2.5 to 3.0 G's. Maintain altitude with nose attitude.

10. VFR UNUSUAL ATTITUDES

1. **General**. The diverse and demanding missions performed by military aircraft often require maneuvers which involve unusual attitudes. An effective military pilot must therefore be trained to quickly recognize and then safely recover from unusual attitudes. This must often be accomplished while relying almost exclusively upon the interpretation of visual cues from outside the cockpit. In this stage of training you will perform the procedures for recovery from various unusual attitudes utilizing what is primarily a scan of visual references located outside the cockpit.
2. **Procedures**
   a. The instructor will transition to AEROBATIC CRUISE, complete the AEROBATIC CHECKLIST and perform a CLEARING TURN.
   b. The instructor will then smoothly maneuver the aircraft so as to place it in an unusual attitude.
   c. Once directed by the instructor, assume the controls and recover the aircraft in accordance with the Manual Unusual Attitude Recovery procedures. Recovery shall be accomplished by 5000 feet AGL.
3. **Common Errors**
   a. Not rolling aircraft upright first.
   b. Pulling through like a Split-S

11. AEROBATIC MANUVERS

1. **THE LOOP**.
   a. The Loop is a 360 turn in the vertical plane. During the Loop the aircraft is rotated at a constant rate of pitch about its lateral axis
   b. The Loop is one of the most rudimentary aerobatic maneuvers, yet one which requires skill and practice to consistently perform well. Since the Loop is executed in a single plane, the elevator is the principle control surface utilized. The nose pitch rate should be constant, but the aft stick force required to obtain this will vary with airspeed and "G" loading. Directional control is maintained by adjusting rudder input as the airspeed varies, there by maintaining balanced flight. Aileron is used only in making corrections to maintain the wings parallel with the horizon throughout the entire maneuver.
   c. When the Loop is performed correctly, positive "G" loading and constant nose pitch movement should be maintained throughout the maneuver. As airspeed varies, the resulting transcribed arc will also vary in radius, therefore backstick pressure will vary in order to maintain constant nose pitch movement. The result will produce a Loop that has an egg-shaped appearance when viewed on the horizon. Remember to select a long, well defined section line which extends behind as well as in front of you.



d. **Procedures**

i. **CONFIGURATION**: Transition to aerobatic cruise. **CHECKLIST**: Complete the aerobatic checklist. **CLEARING TURN**: Commence a clearing turn. During the last 90 of turn, lower the nose slightly and accelerate to 200 KIAS. Roll out of the clearing turn on or parallel to a section line with 200 KIAS. The increased airspeed will require a slight amount of left rudder to maintain balanced flight.

ii. Recheck the wings level and clear the airspace above you. Just prior to entry, check and report the entry altitude over the ICS. Commence the AGSM and immediately start a smooth straight pull up accelerating to 3.5 Gs within two to three seconds. Do not use the aileron.

iii. Recheck the wings level as the nose passes through the horizon. Adjust stick pressure as necessary to keep the nose moving at a constant rate. Increase right rudder pressure as airspeed decreases.

iv. Shortly after passing the vertical position, tilt your head back and visually locate the opposite horizon. Correct with aileron as necessary to maintain the wings parallel to the horizon. Check the nose in relation to the section line and correct directional deviations as necessary by adjusting the rudder input.

v. Airspeed will reach its slowest point at the top of the Loop. The greatest amount of right rudder input will therefore be required at this point in order to maintain balanced flight. The amount of aft stick force required to maintain a constant nose pitch rate will have decreased significantly from the initial pull-up. Maintain positive "G" loading and wings parallel to the horizon.

vi. Allow the nose to fall through the opposite horizon, adjusting the amount of aft stick pressure to maintain a constant pitch rate. Fly the aircraft's nose along the section line, relaxing right rudder pressure as airspeed is quickly regained.

vii. Continue to relax right rudder pressure as the airspeed increases in the dive and smoothly increase aft stick pressure as necessary to maintain a constant pitch rate. The recovery will again require approximately 3.5 Gs, so remember to resume the AGSM. Quickly scan the altimeter during recovery in order to return to straight and level flight at approximately the same altitude, airspeed and heading from which the maneuver was initiated.

e. Common Errors

i. Failure to check and report the altitude prior to entry. It is hard to recover on the same altitude when you do not know what it is.

ii. Poor directional control caused by failure to maintain balanced flight with the proper amount of right rudder as airspeed is lost and then regained. Poor rudder control is easily detected by checking the alignment of the nose and the section line. Remember that the required rudder input varies as airspeed varies. Almost constant rudder adjustment will be required during the maneuver.

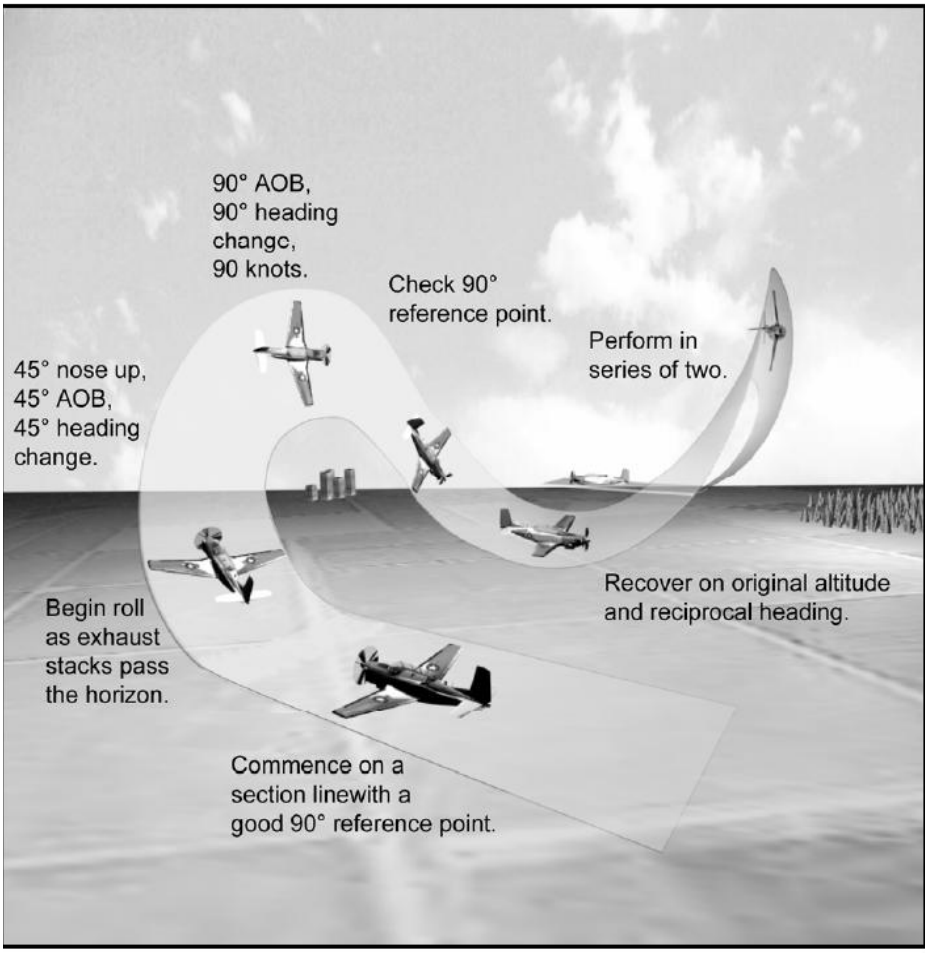
iii. Poor directional control caused by failure to keep the wings parallel to the horizon throughout the maneuver. The most common tendency by far is to pull the stick slightly to the right when pulling the nose up during the 3.5 G entry. Keep the stick centered longitudinally as the entry input is made. Check and correct the wing attitude often.

iv. Poor execution of the initial pull-up with respect to G loading and/or timing. Remember, 3.5 Gs in two to three seconds. Scan the accelerometer. Excessive G-loading and/or loading the aircraft too quickly will cause an excessively rapid deceleration, and may result in overstress. Insufficient G-loading, or taking too long to obtain the correct acceleration, will deplete the aircraft's energy state, resulting in a stalled or near-stalled condition when approaching the inverted position.

v. Relaxing too much backstick pressure while passing through the inverted position at the top of the Loop. This will result in a "floating" sensation. Remember to maintain some positive G-loading throughout the entire maneuver. Conversely, failure to relax sufficient backstick pressure over the top will result in excessive angle of attack and rudder shakers. If this occurs, relax the backstick pressure slightly.

vi. Failure to initiate the pull-out soon enough during the second half of the Loop. This results in excessive airspeed and recovery below the initial altitude.

2. **WINGOVER**
   a. The Wingover is a 180 reversal in the direction of flight accomplished by combining a smooth climbing turn for 90 with a smooth diving turn for 90. Recovery should be on the same altitude and approximately the same airspeed at which the maneuver was started
   b. The Wingover will develop your ability to smoothly control the aircraft in balanced flight through constantly changing attitudes and airspeeds. It is a slow and gentle maneuver when properly executed. No abrupt control movements are necessary. The maneuver may be initiated in either direction and is always performed in a series of two. You should therefore complete the series on the same heading that the first Wingover was initiated. Flying the maneuver in series will enable you to develop a "feel" for the changing control pressures and the rhythm of the maneuver. Successive Wingovers, when continued without interruption, serve as clearing turns for the next series.
   c. When your instructor first demonstrates the Wingover, it is of primary importance that you acquire a mental picture of the path through which the aircraft is flying. Notice the appearance of the nose and the wings in relation to the ground and the horizon at various points during the maneuver. Once you are able to visualize this, the Wingover is merely a matter of flying the aircraft in balanced flight through this pattern. Since you are learning to fly the aircraft in a predetermined pattern, keep your scan primarily outside of the cockpit. Use your instruments only for an occasional reference to crosscheck your sensory impressions.
   d. The rate of roll should be constant throughout the maneuver. The nose should always move at a constant rate in relation to the horizon as it describes arcs, first above and then below the horizon. Remember that in turns to the right, torque and slipstream effect must be offset with a greater amount of rudder input than in turns to the left. Proper performance of the maneuver demands smooth coordination of control pressures to maintain balanced flight. The rate of pitch and roll during the Wingover is relatively slow, therefore the resultant increased G-loading is relatively slight. It should not be necessary to exceed 2.0 Gs at any time during the maneuver.



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e. Procedures

i. CONFIGURATION: Transition to aerobatic cruise. CHECKLIST: Complete the Aerobatic Checklist. CLEARING TURN: Commence a clearing turn and roll out on or parallel to a section line. Pick a prominent reference point on the horizon 90 to either side of the nose, in the direction you intend to perform the maneuver.

ii. Recheck the wings level and clear the airspace above you. Just prior to entry, check and report the entry altitude over the ICS. Commence the maneuver by smoothly raising the nose while keeping the wings level. As the exhaust stacks pass the horizon, start a roll towards the 90 checkpoint. Control the pitch and roll rate so as to reach 45 nose up and 45 AOB simultaneously. The aircraft's heading should also have changed approximately 45 at this point.

iii. Continue to roll towards 90 AOB as the nose inscribes an arcing path downward towards the horizon. Maintain orientation by concentrating on your outside reference points. Control the pitch and roll rate so as to arrive at 90 AOB with the nose aligned with the 90 reference point. Airspeed should be approximately 90 KIAS at this point. Do not exceed 90 AOB.

iv. Allow the nose to fall through the horizon, then commence the recovery by smoothly rolling and pulling out of the diving turn. After approximately 135 of turn, the nose will be approximately 45 below the horizon and the angle of bank should again be 45. Scan the section line for longitudinal alignment and the horizon for pitch and roll rates. Crosscheck the altimeter. Control the pitch and roll rate so as to recover on the original altitude and reciprocal heading.

NOTE

When the maneuver is completed at the same altitude it was initiated, there is a tendency to gain about 10 KIAS.

v. Repeat steps 2 through 4, performing the second Wingover in the opposite direction. Upon completion of the series, the aircraft should once again be established in level balanced flight, on the original heading and altitude.

f. Common Errors

i. Rushing the maneuver. Remember, the Wingover is a relatively slow and gentle maneuver.

ii. Failure to obtain 45 nose up and 45 AOB simultaneously. This is usually caused by an excessive roll rate and/or insufficient backstick pressure during the initial pull-up. Once the AOB exceeds 45, it is difficult to raise the nose any higher. This type of error will result in excessive airspeed (i.e., greater than 90 KIAS) at the 90checkpoint. After the exhaust stack passes the horizon, keep the roll rate slow and constant. As the aircraft rolls, smoothly increase the backstick pressure so as to obtain 45 nose up simultaneously with 45 AOB. The required backstick pressure reaches a maximum at approximately this point. You must then continue to roll towards the 90 checkpoint at a constant rate while beginning to relax the back stick pressure. By the time you reach 90 AOB you should only have enough backstick to keep from feeling light in your seat (i.e., slight positive G-loading).

iii. Exceeding or not fully reaching 90 AOB.

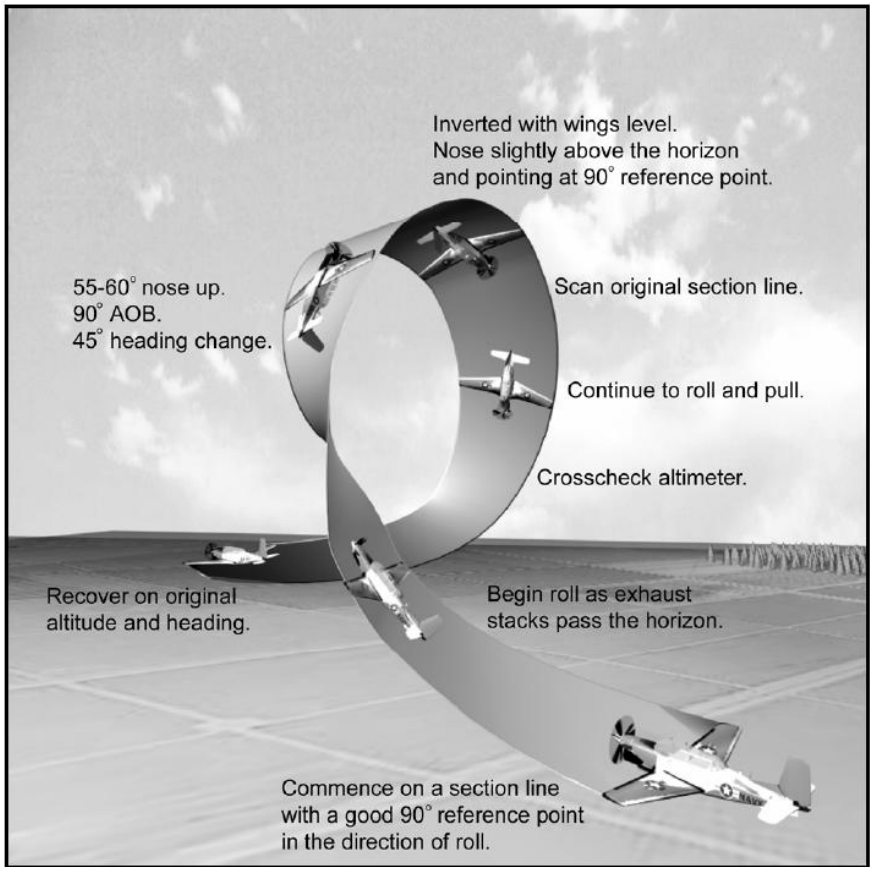
iv. Holding excessive backstick pressure at the 90 checkpoint, thereby "pulling" the nose through and obtaining the reciprocal heading too early during the recovery. Conversely, releasing all of the backstick pressure, thereby inducing a zero or negative G state.

v. Poor timing of the roll and pitch rate during recovery. The wings should come level simultaneously as the nose reaches the level flight attitude.

vi. Commencing the second Wingover in the series off airspeed, heading, altitude, etc. Expeditiously make the necessary corrections prior to initiation of the next Wingover. There is no point in practicing the maneuver if the entry parameters are incorrect

3. BARREL ROLL

a. The Barrel Roll is a maneuver in which the aircraft is rolled 360 about an imaginary point which bears 45 off the nose of the aircraft



b. The Barrel Roll will help develop your confidence, coordination and "sense of feel" while flying the aircraft through rapidly changing attitudes and airspeeds. Since attitude, heading, etc. change so rapidly, this is an excellent maneuver for developing your ability to maintain orientation.

c. Procedures

i. CONFIGURATION: Transition to aerobatic cruise. CHECKLIST: Complete the Aerobatic Checklist. CLEARING TURN: Commence a clearing turn and roll out on or parallel to a section line. Pick a prominent reference point on the horizon 90 to either side of the nose, in the direction you intend to perform the maneuver.

ii. Recheck the wings level and clear the airspace above you. Just prior to entry, check and report the entry altitude over the ICS. Commence the maneuver by smoothly raising the nose while keeping the wings level. As the exhaust stacks pass the horizon, roll and pull so that the nose travels around in an arcing path towards the selected 90 checkpoint. After 45 of turn, the angle of bank should be 90 and these will be at its highest point during the maneuver (approximately 55-60 degrees above the horizon).

iii. Continue rolling the aircraft at a constant rate until in a wings level, inverted attitude, heading directly at the 90 reference point on the horizon. Your nose should be slightly above the horizon and the airspeed between 90 and 100 KIAS. Fly the aircraft through the inverted position and continue rolling at a constant rate, completing the maneuver on the original heading and altitude at aerobatic cruise airspeed. Maintain a positive "G" load throughout the maneuver. If performed properly, 2.0 Gs should not be exceeded at any time during the maneuver.

iv. The nose should appear to make an arcing path about the imaginary point on the horizon 45 from your original heading. The last half of the arc will, therefore, be the same distance

below the horizon that the first half is above the horizon. Remember, as the airspeed decreases towards the top of the maneuver, it will be necessary to increase the deflection of the ailerons, rudder, and elevator to maintain a constant rate of pitch and roll. Conversely, as the airspeed increases towards the bottom of the maneuver it will be necessary to decrease the deflection of the ailerons, rudder, and elevator to maintain a constant rate of pitch and roll. Notice that this roll is started as a climbing turn, which then becomes a continuous roll at a constant rate.

v. Maintain orientation throughout the maneuver by concentrating on your reference points. Maintain a constant rate of roll and nose movement. Inscribing a small arc above the horizon in the first half of the maneuver and a larger arc below the horizon in the last half will result in too great an airspeed at the completion of the maneuver or unnecessarily high "G" forces to recover on airspeed. During the roll out to the original heading, adjusting the backstick pressure will enable you to recover on altitude and at aerobatic cruise airspeed.

d. Common Errors

i. Failure to raise the nose high enough during the first 45 of turn. Generally, this will result in a correspondingly nose low attitude and proportionally high airspeed when recovery is made.

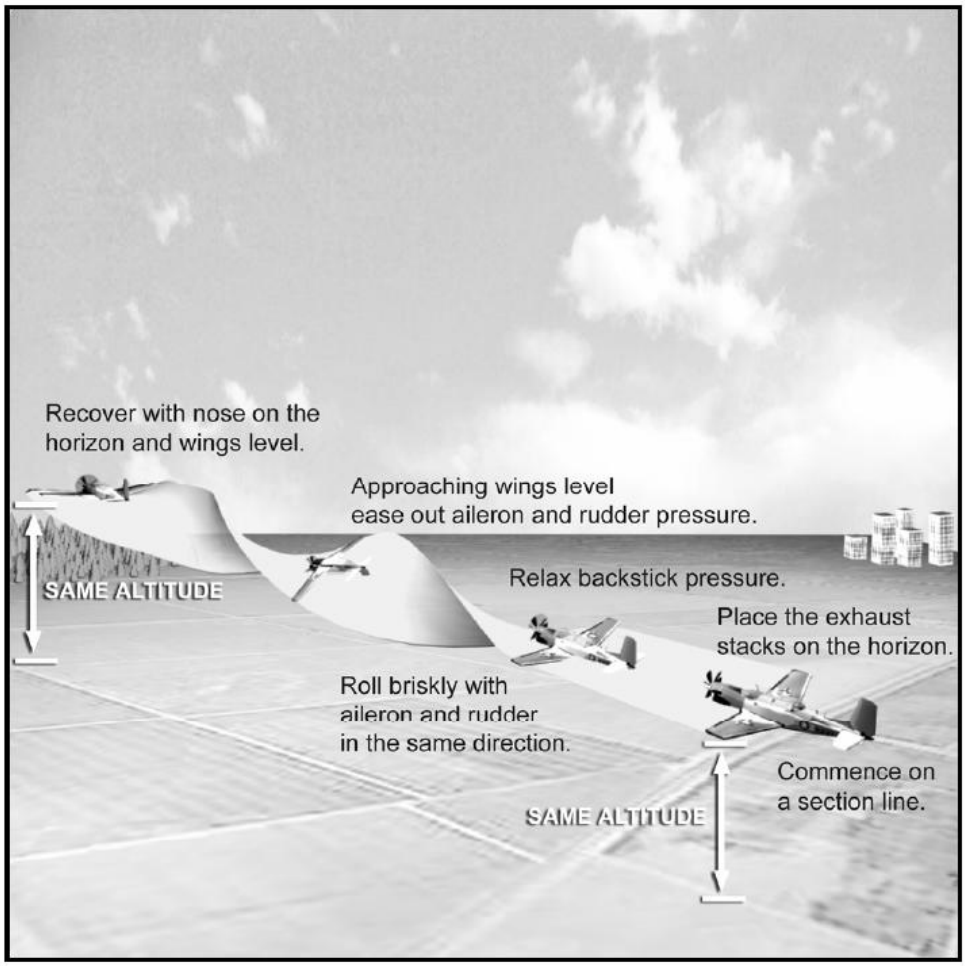
ii. Improperly coordinating the rate of roll with the rate of pitch. An insufficient roll rate will result in an overshoot of the intended recovery heading while an excessive roll rate will result in an undershoot. A common tendency is to allow the roll rate to accelerate after passing the inverted position.

iii. Failure to maintain balanced flight. Too much or too little rudder will produce essentially the same results as too fast or too slow a rate of roll, respectively.

iv. Failing to scan ahead for the reference point and/or section line and thereby losing orientation.

4. AILERON ROLL

a. The Aileron Roll is a 360 roll about the longitudinal axis of the aircraft



b. Plan your clearing turn so as to roll out on a good section line or with the nose aimed at a prominent reference point. When performing the maneuver make your control inputs smooth, brisk and positive.

c. Procedures

i. CONFIGURATION: Transition to aerobatic cruise. CHECKLIST: Complete the Aerobatic Checklist. CLEARING TURN: Commence a clearing turn and roll out with the required ground references.

ii. Commence the maneuver by smoothly raising the nose to place the exhaust stacks on the horizon while keeping the wings level. Stop nose movement by relaxing backstick pressure.

iii. Roll briskly in either direction by applying lateral stick deflection and rudder in the same direction. The amount of stick deflection will determine your rate of roll. If the rate of roll is too slow, the nose will fall below the horizon and a rolling pullout will result.

iv. As you approach the wings level attitude, ease out aileron and rudder pressure to recover with the wings level and the nose attitude reset for level flight.

d. Common Errors

i. Failure to relax the back stick pressure prior to rolling. Backstick pressure is required only to set the initial nose high attitude. Failure to relax the backstick pressure will cause the nose to follow an arcing path rather than having the aircraft roll about its longitudinal axis. It will also cause the nose to drop rapidly while passing the inverted position.

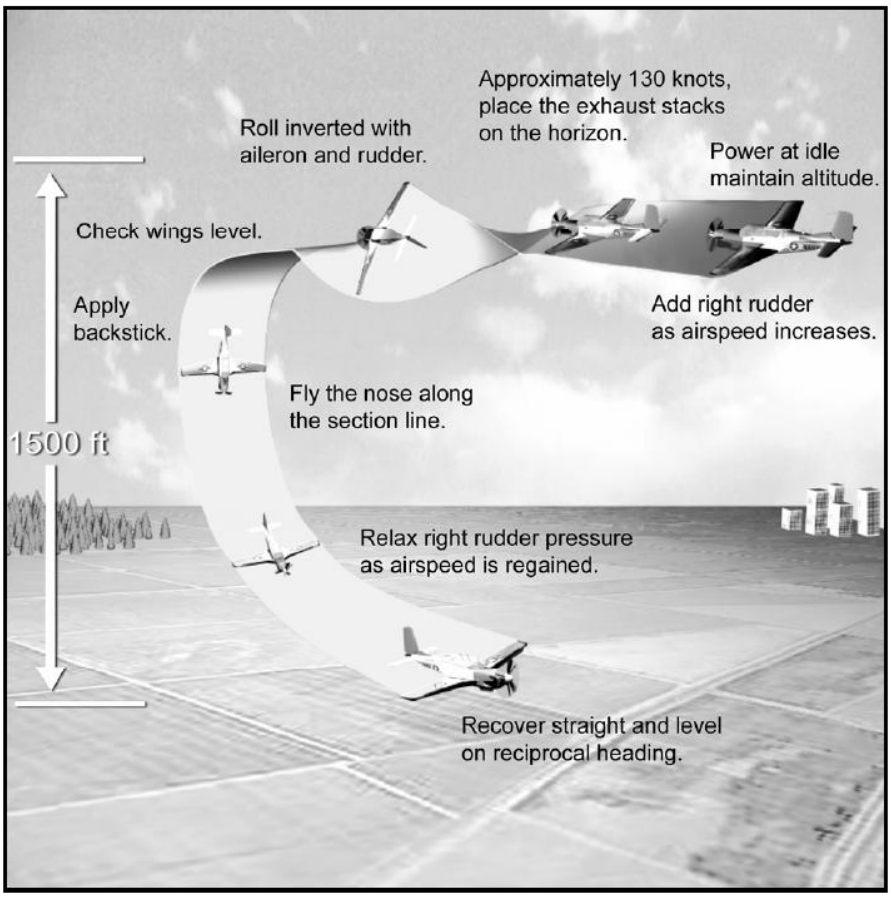
ii. Delaying initiation of the roll once the nose high attitude is set. This causes excessive airspeed decay, which results in a sluggish roll performance.

iii. Failure to input sufficient rudder in the direction of roll. The high roll rates required for the Aileron Roll generate considerable adverse yaw. This must be compensated for with

sufficient rudder in order to maintain balanced flight

5. SPLIT S

a. The Split-S maneuver combines the first half of an Aileron Roll with the last half of a Loop



NOTE

Student solos are strictly prohibited from performing the Split-S, Immelmann Combination Maneuver, and intentional sustained inverted flight maneuvers. Failure to comply with this safety related restriction is considered sufficient grounds for attrition from flight training.

b. The Split-S provides a means of rapidly converting the potential energy of altitude into airspeed while reversing the direction of flight. Once the pull is commenced from the inverted position, airspeed builds rapidly and altitude is quickly lost. If performed correctly, the altitude loss should be approximately 1500 feet. Remember to select a long, well defined section line which extends behind as well as in front of you.

c. Procedures

i. CONFIGURATION: Transition to aerobatic cruise. CHECKLIST: Complete the Aerobatic Checklist. CLEARING TURN: Commence a clearing turn. After rolling out of the clearing turn, reduce power to idle and maintain altitude while slowing to130 KIAS. Increase right rudder pressure as the aircraft decelerates in order to maintain balanced flight.

ii. Raise the nose to place the exhaust stacks on the horizon, relax the backstick pressure and roll in either direction using aileron and rudder to the inverted position.

iii. Once inverted, neutralize the ailerons and apply slight forward stick pressure to momentarily maintain straight and level flight. Quickly verify that the wings are level by referencing the horizon and correct as necessary. Apply back stick pressure, pulling the nose through the horizon and flying the aircraft along the section line as in the last half of the Loop. Decrease right rudder pressure as the aircraft accelerates to recovery airspeed.

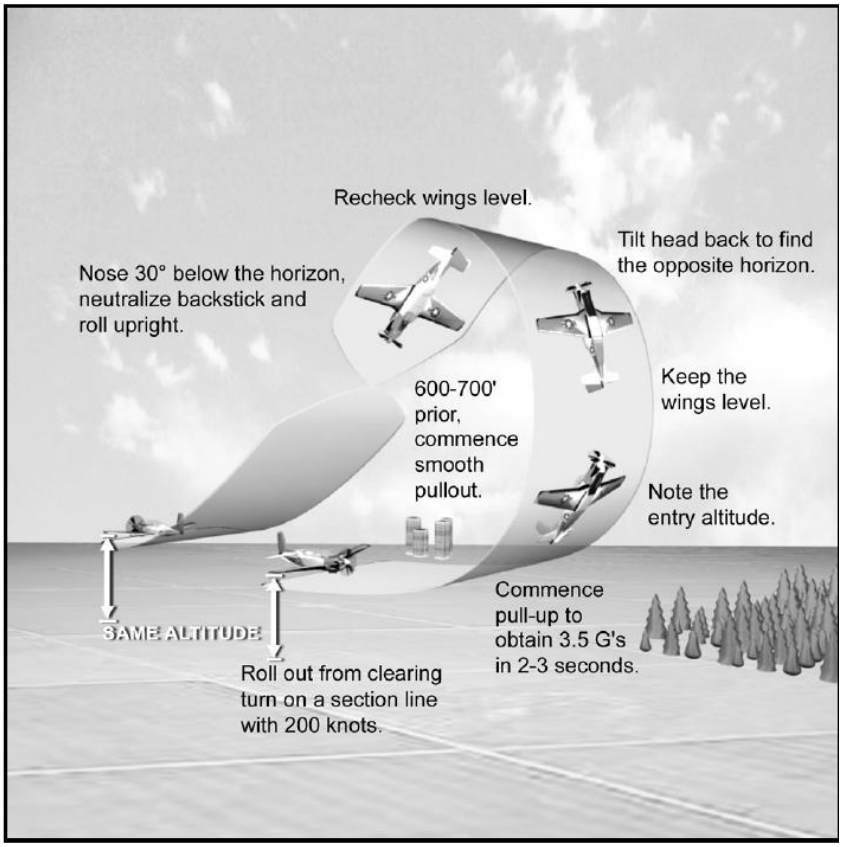
iv. Check oil pressure within normal limits. Reset aerobatic cruise power and report the oil pressure over the ICS.

d. Common Errors

i. Failure to maintain altitude and/or balanced flight during the deceleration.
ii. Delaying roll initiation, airspeed decay causes difficult lateral control.
iii. Failure to obtain, check and/or correct wings level prior to the pull-out. This results in disorientation and a rolling pull-out.
iv. Pulling too much backstick before sufficient airspeed has been gained resulting in anear-stalled AOA.

6. ONE-HALF CUBAN EIGHT

a. The One-Half Cuban Eight combines the first 210 of a Loop, a half roll to the upright position, and a 45 diving pull out to level flight on the original altitude and reciprocal heading



b. Procedures

i. CONFIGURATION: Transition to aerobatic cruise. CHECKLIST: Complete the Aerobatic Checklist. CLEARING TURN: Commence a clearing turn. During the last 90 of turn, lower the nose slightly and accelerate to 200 KIAS. Roll out of the clearing turn on or parallel to a section line with 200 KIAS. The increased airspeed will require a slight amount of left rudder to maintain balanced flight.
ii. Recheck the wings level and clear the airspace above you. Just prior to entry, check and report the entry altitude over the ICS. Commence the AGSM and immediately start a smooth straight pull-up, accelerating to 3.5 Gs within two to three seconds. Do not use the aileron.
iii. Recheck the wings level as the nose passes through the horizon. Adjust stick pressure as necessary to keep the nose moving at a constant rate. Increase right rudder pressure as airspeed decreases.
iv. Shortly after passing the vertical position, tilt your head back and visually locate the opposite horizon. Correct with aileron as necessary to maintain the wings parallel to the horizon.

Check the nose in relation to the section line and correct directional deviations as necessary by adjusting the rudder input.

v. Airspeed will reach its slowest point at the top of the Loop. The greatest amount of right rudder input will therefore be required at this point in order to maintain balanced flight. The amount of aft stick force required to maintain a constant nose pitch rate will have decreased significantly from the initial pull-up. Maintain positive G-loading and wings parallel to the horizon.

vi. Allow the nose to fall through the opposite horizon, adjusting the amount of aft stick pressure to maintain a constant pitch rate. As the nose approaches a point 30 below the opposite horizon, slow the nose movement by releasing backstick pressure and commence a roll in either direction, using aileron and rudder. During the roll, it will take slight forward stick pressure as the aircraft passes wings vertical to hold the heading and allow the nose to continue pitching downward to a position 45 below the horizon.

vii. Commence a smooth pullout to straight and level balanced flight 600-700 feet prior to the original entry altitude. Recover on the original altitude and reciprocal heading.

c. Common Errors

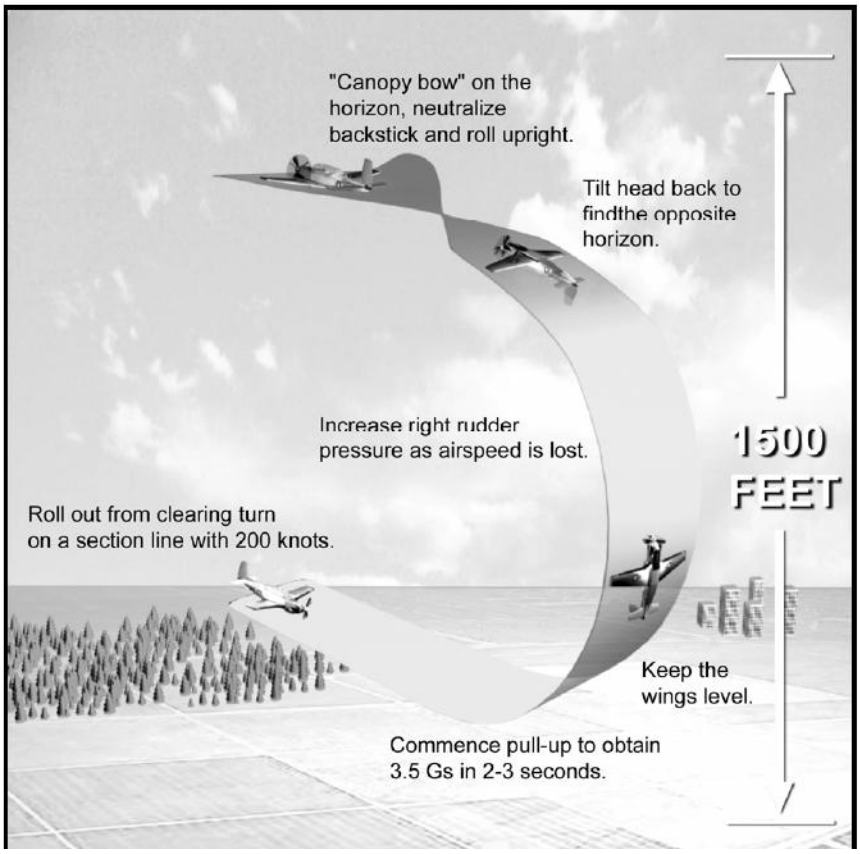
i. Same common errors as the first half of a Loop.

ii. Improper forward stick application during roll resulting in less than the desired 45 nose down attitude.

iii. Failure to initiate the pull-out 600-700 feet prior.

7. IMMELMANN

a. The Immelmann combines the first half of a Loop followed by a half-roll to the wings level attitude. It achieves a 180 change of direction of flight and a gain in altitude of approximately 1500 feet



b. This maneuver offers a quick means of reversing the direction of flight while trading excess airspeed for increased altitude. Remember to select a long, well defined section line which extends behind as well as in front of you.

c. Procedures

i. CONFIGURATION: Transition to aerobatic cruise. CHECKLIST: Complete the Aerobatic Checklist. CLEARING TURN: Commence a clearing turn. During the last 90 of turn, lower the nose slightly and accelerate to 200 KIAS. Roll out of the clearing turn on or parallel to a section line with 200 KIAS. The increased airspeed will require a slight amount of left rudder to maintain balanced flight.

ii. Recheck the wings level and clear the airspace above you. Just prior to entry, check and report the entry altitude over the ICS. Commence the AGSM and immediately start a smooth straight pull-up, accelerating to 3.5 Gs within 2 - 3 seconds. Do not use the aileron.

iii. Recheck the wings level as the nose passes through the horizon. Adjust stick pressure as necessary to keep the nose moving at a constant rate. Increase right rudder pressure as airspeed decreases.

iv. Shortly after passing the vertical position, tilt your head back and visually locate the opposite horizon. Correct with aileron as necessary to maintain the wings parallel to the horizon. Check the nose in relation to the section line and correct directional deviations as necessary by adjusting the rudder input.

v. As the nose approaches a point 20 above the opposite horizon ("canopy bow" on the horizon,) slow the rate of nose movement by neutralizing backstick pressure. Commence a roll in either direction to the upright position using aileron and rudder. Anticipate the need for slight forward stick pressure as the aircraft passes 90 of roll.

vi. The maneuver is complete when the aircraft is once again in the level flight attitude on the reciprocal heading. The airspeed should be approximately 100 KIAS. The nose attitude will therefore be slightly high.

d. Common Errors

i. Same common errors as the first half of a Loop.
ii. Commencing the roll to upright attitude either too early or too late.
iii. Utilizing improper rudder and/or poorly coordinated rudder inputs during the roll

12. COMBINATION MANEUVER

1. Description. A Combination Maneuver is nothing more than combining a series of aerobatic maneuvers into a single evolution. A maximum of FOUR maneuvers may be "linked" together.
2. The aerobatic training you receive is NOT intended to prepare you for the airshow circuit. As previously discussed, aerobatic training IS taught to allow you to make the aircraft perform precise and controlled maneuvers, flying the aircraft throughout more of its envelope.
3. By combining maneuvers, you will need to plan ahead to the second maneuver while completing the first half. As always, maintain a constant and vigilant scan, especially during the maneuvers.
4. Energy management should be a part of the discussion so as to plan maneuvers to maximize airspeed/altitude, while staying within assigned airspace. This should be a major consideration for which maneuvers are linked together and in what order.
    a. Example: One-Half Cuban Eight - Barrell Roll - Immelmann - Split-S3.
        i. Procedures. Perform all maneuvers IAW the procedures previously set forth for the maneuvers you intend to fly. The SP shall pre-plan his/her Combination Maneuvers and thoroughly brief his/her intentions to the IP during the pre-flight briefing. While modifications are authorized during the flight, the intent is that impromptu and non-briefed Combination Maneuvers NOT be accomplished.

13. INVERTED FLIGHT

1. Description. The Inverted Flight maneuver is the intentional flying of the aircraft in the inverted wings level attitude for the maximum time as outlined in the aircraft's operating limits. Review specific aircraft manuals regarding inverted flight.
2. Inverted flight is a natural part of many aerobatic maneuvers you will perform during this stage (Loops, Barrel Rolls, etc.). While students will never intentionally fly inverted as a separate maneuver, this demonstration will give you the experience and confidence to handle the aircraft throughout a full range of pitch attitudes. This demonstration will acquaint you with the inverted flight attitude (nose high-not level), feelings of sustained negative G's(normally -1 G), and proper entry and exit control inputs.
    a. It is imperative that you tighten your restraint harness to the maximum extent possible (without cutting off your circulation.). The reason being that regardless of how tight you think your belts are, once inverted and stabilized, you will have the sensation of being pulled from the aircraft. You will stretch to the limits of your belts and may feel like you are "hanging in the straps. "First, RELAX; you are not going anywhere. Second, notice the nose attitude.
    b. Reference points that may be used to keep the aircraft from changing altitude while inverted are:
        i. Front Cockpit = OAT gauge on or about even with the horizon.
        ii. Rear Cockpit = The middle canopy bow on or about even with the horizon.

Your instructor will be pointing out this attitude as well as watching the oil pressure and clock remain within limits. Ensure the rudder pedals are within reach in this attitude. Since you will not be flying this maneuver, you can crank the rudder pedals towards you.

NOTE

This is a "demonstrate only" maneuver and shall not be performed by the student.

3. Procedures

a. CONFIGURATION: Establish the aircraft at 150 KIAS in the clean configuration. CHECKLIST: Perform the Aerobatic Checklist. CLEARING TURN: Perform a clearing turn and roll out on a suitable section line

b. Raise the nose to place the exhaust stacks on the horizon and roll the aircraft in either direction using rudder and aileron to the inverted position. Once inverted, neutralize aileron and rudder and utilize slight forward stick pressure to maintain altitude. Immediately note the clock sweep second hand and check the oil pressure. Return to normal flight immediately if oil pressure is not in the normal range.
c. Prior to 15 seconds inverted, utilize coordinated aileron and rudder to roll the aircraft back to the upright flight attitude. Recheck the oil pressure in the normal range

4. Common Errors

a. Failure to maintain straight-and-level flight while inverted.
b. Poor coordination of control inputs during the roll to the inverted and/or upright position