Warbirds Online Academy

Basic Course Manual

Preface

The purpose of this manual is as an accompaniment to the Basic Course taught by Warbirds Trainers in the Warbirds training arena. It is meant as a review of topics to be covered and is in no way a complete treatment of any particular maneuver or tactic. It is imperative that the serious student of virtual aerial combat study all available reference material regarding the art of aerial warfare in order to gain a more complete understanding of the complexities and challenges particular to combat in the air and the idiosyncrasies of simulated combat in the virtual environment.

The student desiring to participate in the Basic Course should review the material to be covered in the lesson prior to attending the lesson. After the lesson the student should accomplish all assigned practice drills and again review the material covered. This will help solidify the concepts for later application.

The course is designed to be accomplished in the order presented in this manual but each individual lesson is a self-contained unit and may be accomplished individually. This was done purposely to allow students the flexibility of attending parts of the course instead of requiring attendance at every session.

The goal of the course is to prepare students to be more competitive in the online arenas but, as always, the focus remains on fun. Warbirds is designed to be an entertaining, rewarding experience and that will be the focus throughout training in this course.

Good luck and Good Hunting!

Acknowledgements

During compilation of this book the author realized the extent that credit must be given to the appropriate sources. Of primary importance is an icon of the virtual aerial combat community, Robert L. Shaw. Without his work, **Fighter Combat: Tactics and Maneuvering**, this manual would not exist. The influence of this work upon this manual cannot be overemphasized. All of the tactical concepts presented here are directly drawn from Mr. Shaw's work. It is highly recommended that this work be included in any student's personal aviation library. Included in the Basic Fighter Maneuver chapter you will find several references directing the reader to Mr. Shaw's work for further study.

Also the author would like to thank all of the Warbirds trainers, past and present. All have contributed in some fashion. The following have been especially critical to the development of this manual.

=dobs= =tech= daddy= crtch= =flet= =gryf= =varg=

All of the good stuff in here is because of the folks I mentioned above. I have liberally used their words throughout this manual.

Any errors, omissions, or other nonsense is completely my fault.

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Table of Contents

Chapter 1 - Basic Maneuvers

Basic flying skills

Primary Maneuvers

The focus of primary flight training is to build the skills necessary for success in advanced qualification training in fighter, bomber or transport aircraft. The skills learned in this phase will build confidence and develop rudimentary situational awareness. A firm foundation in the basic skills presented here is essential for future success in the virtual combat arena.

Basic Aerodynamics

The main purpose of this section is to clarify the concepts of lift, drag, thrust, and weight.

It is not necessary for virtual pilots to have a complete understanding of the four forces.

The relative wind acting on the airplane produces a certain amount of force which is called the total aerodynamic force. This force can be resolved into components, called lift and drag.

Lift is the component of aerodynamic force perpendicular to the relative wind. This is also referred to as the lift vector in tactical discussions.

Drag is the component of aerodynamic force parallel to the relative wind.

Weight is the force directed downward from the center of mass of the airplane towards the center of the earth. It is proportional to the mass of the airplane times the strength of the gravitational field.

Thrust is the force produced by the engine or engines. It is directed forward along the axis of the engine (which is usually parallel to the long axis of the airplane).

For more complete information refer to the following URL(S):

http://www.ient.com/warbirds/ Select Community -- Training -- Learning Offline -- Physics of Flight Lesson. Also of interest are the lessons on Control Surfaces, Instruments and Gun Convergence

Taxi Takeoff and Landings

The information in this section is taken from the Warbirds Training pages and is placed here for review only. If you are having trouble with Taxi, Takeoff, Climbs, Descents and Landings you should arrange private training in these areas prior to beginning the Basic Course Syllabus.

Start the engine.

Slowly open the throttle all the way - watch the swing to the left - (right for the Spitfire Mk. XIV) - counter with right rudder (left for the Spitfire Mk. XIV), and roll down the center of the runway.

Use your rudder to steer with, not the joystick. Use the joystick only to counter the torque-induced roll. Most aircraft tend to yaw and roll to the left (except for the Spitfire Mk. XIV and the Yaks - their engines rotate in the opposite direction) due to the torque forces of the engine. Although current torque models in WarBirds aren't that bad, gunning the throttle in a real F4U or Spitfire Mk. XIV was bad news.

If you have a heavy load of weapons or a large aircraft on a short field, you may want to use your flaps and/or WEP on takeoff.

When your IAS (indicated airspeed) reaches about 100, start to pull back gently on the stick. The aircraft will lift off the runway. Be ready with the joystick here to counter a roll to the left (right for the Spitfire Mk. XIV and the Yaks) - possibly even before liftoff.

If you are flying an aircraft with narrow landing gear (like the Spitfire or the Bf109), be careful of dropping a wingtip onto the runway in Step 5. It'll ruin your takeoff. Counter with a bit of right stick.

Start a gentle climb.

Retract your landing gear, and make sure that your rudder is centered (and close your flaps, and switch off WEP if necessary). That's it - the takeoff is complete.

To trim your aircraft correctly (something which many pilots forget), level off, press the [X] key to autotrim the aircraft, and wait until you reach 200mph before taking back control of the plane. Your aircraft is now trimmed correctly for about 200mph.

Landing

Choose an aircraft and field from the Select menu. Ensure that you have enough fuel, take off, and fly out a few miles. Don't go above 5,000 feet above ground level.

Around three to five miles out (you should be able to zoom the map to see how the runways line up, or use your printed maps), turn and line up with the airfield.

Fly to the field - descending to 2,000 feet above ground level (AGL). The most important thing here is to set up a good approach - if you're inexperienced, a bad approach will screw up your landing.

Reduce your power to about 25% and hold your altitude - your speed will start to bleed off.

Fly over the runway - at mid field with power off (or 25%), break turn 90 degrees to the left. You should be down to 1000 AGL.

Fly out for about half a mile or a count of five, and then break left 90 degrees and enter a downwind leg.

Drop your gear (the two 90 degree break turns at low power should have bled your speed down to a reasonable gear speed). Abeam the numbers, drop some flaps. The flaps (in effect) alter the shape of the wing and create more drag (to slow you down), and lift (to enable you to fly slower without stalling). When you lower the flaps, the nose of your aircraft will drop slightly. Be ready to counter this with stick back, and keep the aircraft in a gentle (500 feet per minute) descent.

Turn 90 degrees onto the base leg and continue your 500 fpm descent. Add more flaps. Look out the left window and time your turn to final. Once you get a rhythm down, this will work as one fluid 270 degree turn from entry to downwind all the way through, rolling out on final.

Control your rate of descent with your THROTTLE, not with your elevators:

Close the throttle to lose altitude, or increase your rate of descent.

Open the throttle to gain altitude, or decrease your rate of descent.

Control your speed with your elevators:

Pull back on the stick to slow down.

Push forward on the stick to speed up.

As you cross the runway threshold, you should be at about 50 feet and 100mph. All you need to do is drop the aircraft gently onto the runway.

You do this by pulling back gently on the stick, which causes the aircraft to slow down and sink, and also sets the aircraft in the correct attitude for landing. This is called flaring.

If you are sinking too fast, add just enough power to arrest the sink rate, but do not begin a climb.

As the plane touches down, stop the engine, and start braking.

Steer the aircraft to a complete stop on the runway and exit the plane.

Refer to the following URL:

http://www.ient.com/warbirds/ Select Community -- Training -- Learning Offline -- Lesson.

Stalls and Spins

Any time you push the plane to the limits of its performance you have to be aware of the possibility of stalling the aircraft. High performance turns and maneuvers at the edge of "the envelope" of the plane's capabilities need to be performed with care. If you push the plane beyond its abilities, the plane may rebel. The experienced pilot learns the limits of aircraft and learns to "fly the edge of the envelope".

If you push the plane too hard you can stall the aircraft. A stall can cause the plane to enter a spin. The pilot has to react quickly to regain control of his aircraft, or it may well enter a spin from which the plane cannot recover.

What is a Stall?

A stall is when the wing stops generating lift. A "stall" occurs when the airflow over the wing (or other surface) is disrupted to the point where it no longer generates lift. This is measured by "angle of attack" which is defined by the angle between the chord line of the wing (the line through the cross section from the trailing edge to the leading edge) and the relative wind. When you exceed the critical angle of attack, the wing will stop making lift and stall. This can happen in any configuration, altitude or airspeed.

In simple terms, when you are flying too slow, or trying to turn or maneuver too hard, the wing may no longer be able to generate lift. A stall results.

There are three types of stalls

Power on stalls - A stall with engine power at 1 G (G = Gravitational Force)

Power off stalls - A stall without engine power at 1 G

Accelerated stalls - A stall at greater than 1 G

The critical angle of attack of a specific wing never changes. The wing will always stall when that critical Angle is exceeded. The difference is the airspeed that the wing stalls is due to the factors that play into achieving that critical angle of attack. In a 1 G power off stall the critical angle of attack is achieved at a low airspeed and a relatively low nose attitude (Usually 10-12 above the horizon)

In a power on stall in a propeller driven aircraft the critical angle of attack occurs at a much higher deck angle above the horizon because the propeller wash is generating lift over the wing, effectively lowering the angle of attack.

In an accelerated stall the wing can stall at any nose attitude or airspeed. The G force applied to the aircraft increases the angular difference between the wing chord line and relative wind thus increasing the angle of attack. Thus the accelerated stall can occur at any speed based upon the G force applied. The G force required to stall the wing is generally expressed by the following equation:

$$V_{Sa} = V_{S1}\sqrt{n_a}$$

In English the stall speed at G force **a** is equal to the Stall speed at 1 G multiplied times the square root of G Force **a**

Thus the stall speed at a constant 4 G force is approximately twice that of the 1 G stall speed.

This means that a P38 with an unaccelerated stall speed of 90 MPH will stall at approximately 180 MPH in a 4 G accelerated condition.

What is a Spin?

A spin is a stall with a component of rotation around the yaw axis. This rotation is usually initiated by entering the stall in an uncoordinated condition (too much or too little rudder). As the rotation develops the aircraft nose tends to rise as the stall condition deepens. Once the aircraft completes 2 to 5 rotations the nose attitude becomes very flat. This is known as a flat spin and is unrecoverable in some aircraft types.

Warning Signs of an Impending Stall

The Stall Horn - This is a warning horn that lets you know when you are nearing the edge of a stall. The louder it gets the closer the critical angle of attack (stall). The Stall Horn was installed for a reason - ignore it at your own risk! It is also very handy to use judgement of the volume of the stall horn to gauge how much performance you are getting from the plane in a high G maneuver.

Stall Recovery

Recognize the stall- One or both wings quit producing lift causing an abrupt downward motion

React quickly - the sooner you react to the stall the better the chances of recovery.

Push the stick forward gently - try to get the nose down to regain airspeed so that the wings can regain lift.

If rotation accompanies the stall you are in a spin. Apply opposite rudder. This may be hard to judge. Look outside. Step on the rudder on the side where the world is disappearing on the windshield. If the world is moving from left to right, right rudder is required and vice-versa. Once the spin starts to slow down, you are on your way to recovering from the spin. You can also use the slip indicator (little black ball) to gauge this. Step on the ball. If the ball is to the left of the two lines step on left rudder.

Things not to do!

Overreact! - Don't overreact to a slight stall - that may cause the stall to become worse!

Pull back on the stick! - Pulling back on the stick when you feel your plane beginning to stall is just going to make the impending stall and spin worse. No matter how tempting - don't do it! To the beginner pilot, pulling back on the stick seems the "natural" thing to do. Don't follow instinct. Follow training. Push the stick forward, get the nose down and apply opposite rudder; get that airspeed back up and regain normal flight.

Chandelles

The chandelle is a climbing turn used to maximize altitude gain while turning. It is most often used to keep sight of the enemy while maintaining or building energy for future maneuver.

Technique is fairly simple. A roll of about 30 degrees is initiated followed by a low G pull up. This results in a climbing turn. The maximum pitch angle should be reached at 90 degrees of turn. This angle should be held for the remaining 90 degrees of turn. During the second 90 degrees of turn the bank angle is gradually shallowed until the aircraft arrives at 180 degrees of turn and should be just above stall speed. This is the technique used in training. In combat situations the chandelle may vary somewhat due to conditions and the speed at the top of the maneuver should be considerably higher to preserve maneuvering capability.

Rolls

Aileron rolls

Technique - Again fairly simple. Move the stick to one side causing the ailerons to deflect which rotates the aircraft around it's long axis. To stop the roll the stick is moved in the other direction. It will be necessary to correct slightly past center on the stick to overcome the inertia of the rolling aircraft.

Types of rolls

Quarter rolls- A 90 degree roll. Four of them get you where you started.

Half Rolls- 180 degree roll. Two of them get you where you started.

Full Rolls- 360 right around where you started.

Of course there are many different possible rolls but these are the ones we will use to define our maneuvers.

Loops

A loop is a circle flown in the vertical plane.

Full loop = Full Circle

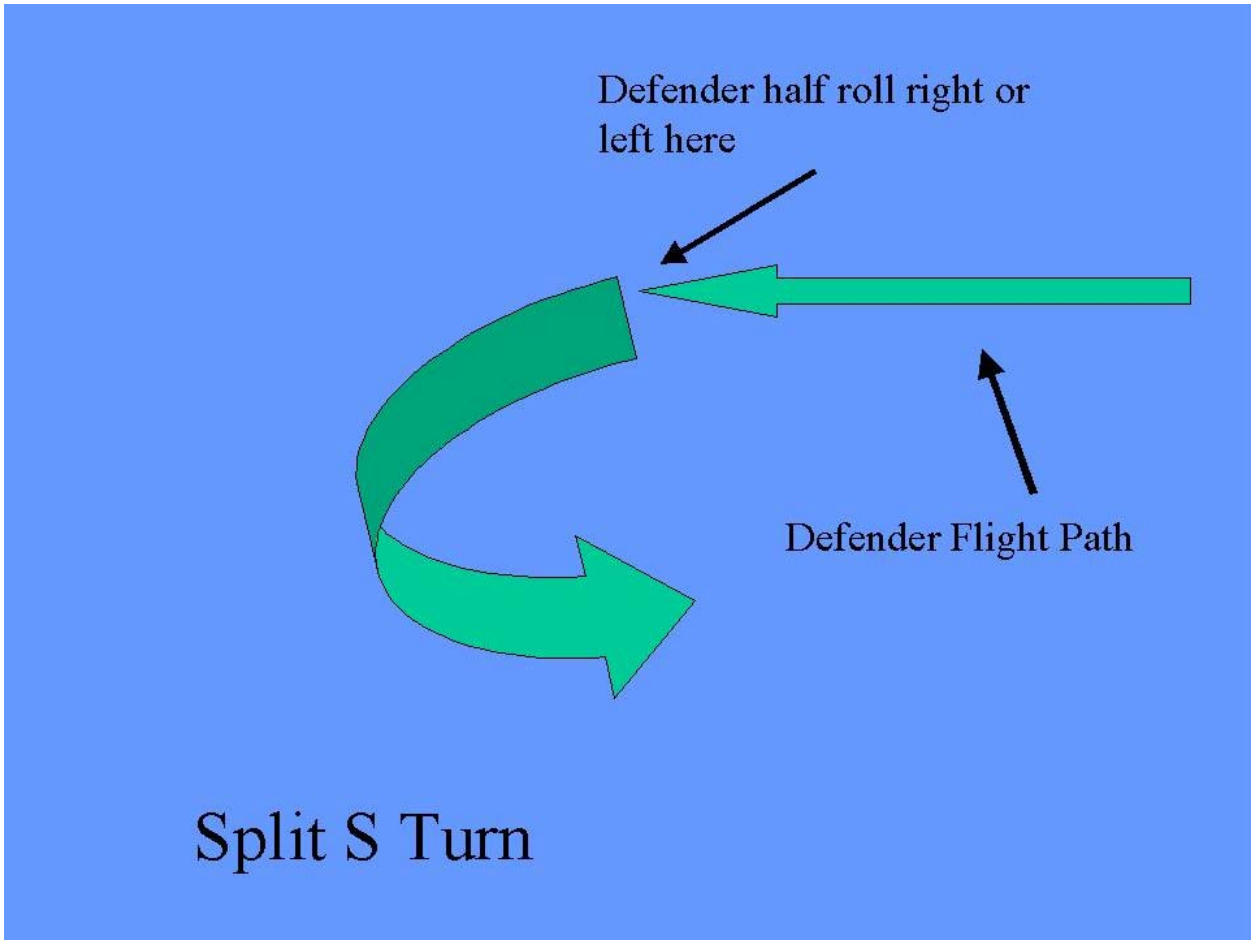
Half Loop = Half Circle

Loops may be performed up or down.

Technique for a loop is fairly simple. Just pull back on the stick. The trick is to modulate the backpressure on the stick to maintain the proper G force during the maneuver. An Airshow loop must be a perfect circle. In order to achieve that the aircraft will be at zero G as it comes over the top of the loop. In combat situations we aren't concerned with how the loop looks. We are more concerned with positioning the aircraft for the kill. But be careful. Too much G force and the aircraft will stall and spin. Also, you must have sufficient speed to complete the planned loop before you start or you will stall.

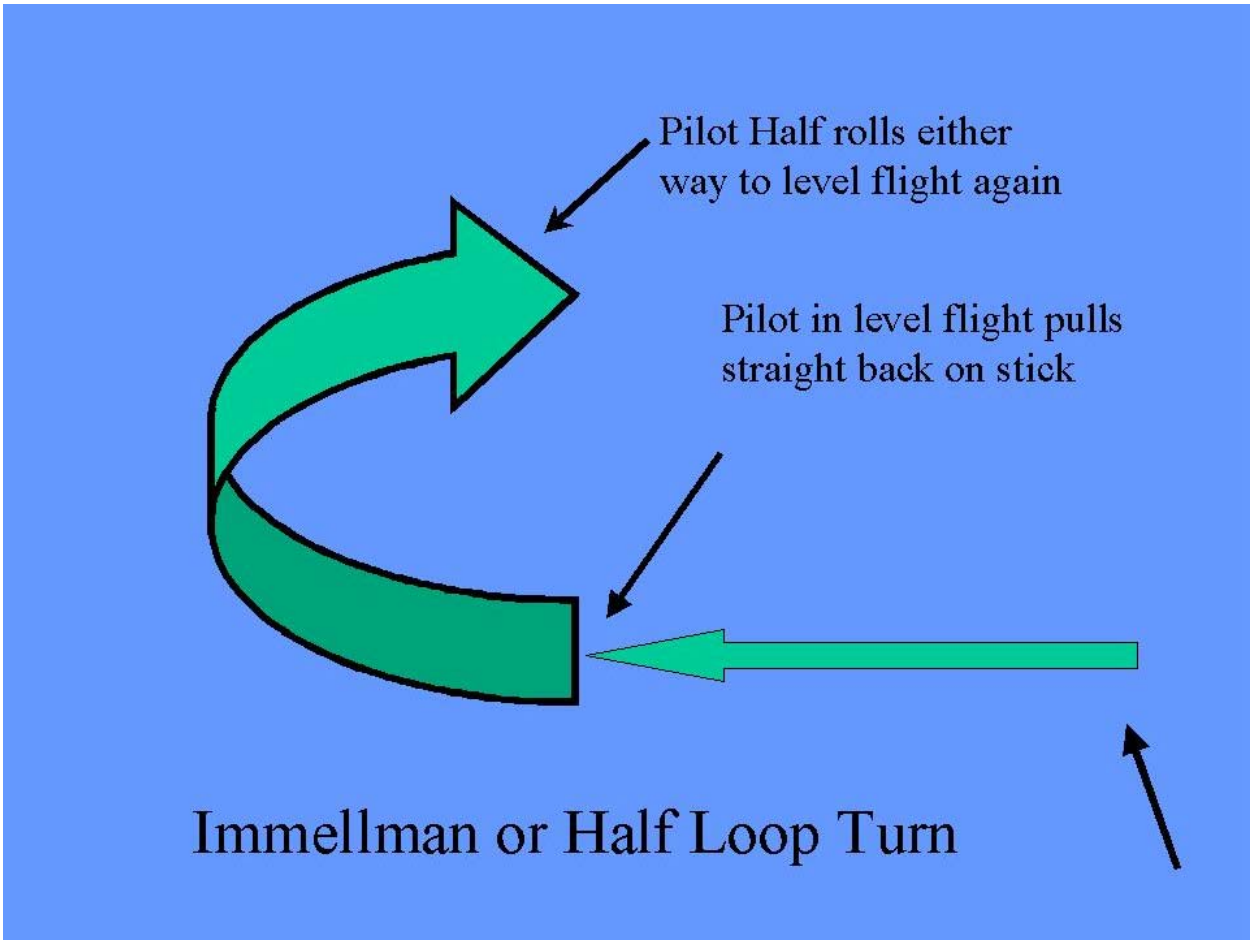
Split S

A Split S is simply a Half - Roll followed by a Half Loop. Starting from the upright position roll the aircraft upside down then pull back on the stick until in level flight again. Be careful, this maneuver requires considerable altitude to complete.



Immelman (Modern)

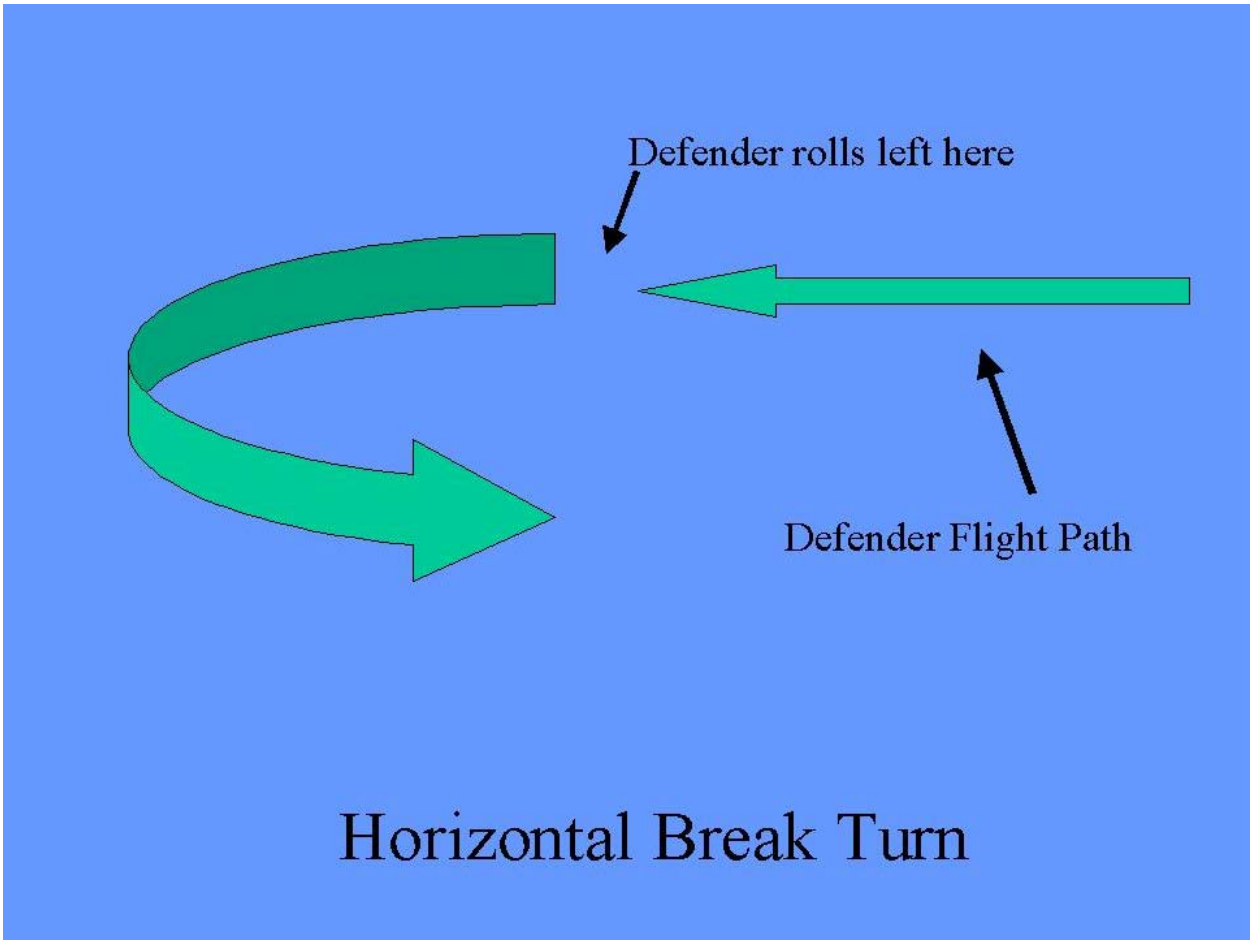
An Immelman is simply a Half Loop followed by a Half roll. From the upright position pull back on the stick performing the first half of a loop. When upside down at the top of the loop, roll the aircraft upright.



Break Turns

The simplest break turn is the horizontal break. A con is approaching from your 5 o clock at your altitude. A proper break turn means you roll the aircraft so that the lift vector is in line with the bogey and you pull on the stick. A co alt attacker means a 90 degree roll (Quarter roll) toward the attacker and pull.

This is what it looks like from the pilot seat. You spot the attacker out your six view at 5 o'clock. Stay in six view. Roll toward the attacker until he is in your slightly high six view then pull back on the stick to put him in high six view or straight up view.



Hammerhead or Stall Turn

The hammerhead turn or Stall Turn is a simple maneuver to describe but difficult to perfect. It is executed by climbing in the pure vertical (straight up) at full power. As the speed bleeds off to near zero full rudder is applied to cause the aircraft to rotate around its center of gravity and the result is the nose is pointed towards the ground.

The difficulty comes in countering the torque of the engine as the aircraft slows the gyroscopic effects as the aircraft rotates and in timing the maneuver properly.

Snap Roll

The snap roll is rotation about the roll axis of the aircraft induced by an accelerated, uncoordinated stall. To perform a snap roll the pilot applies full back stick while simultaneously applying full rudder. This causes the wing on the rudder side to stall while the opposite wing remains partially unstalled due to its greater forward speed. The end result is a very quick rotation around the longitudinal or roll axis.

The snap roll is a difficult maneuver to master but it builds confidence in stall/spin recovery technique and can be used in combat in a very desperate situation to force an overshoot.

Oblique Maneuver

Up to this point all maneuvers have been described in either the vertical or horizontal plane. Of course, there are an infinite number of maneuver planes available. The name applied to these infinite planes is oblique. Oblique maneuver is any maneuver not performed in the pure vertical or pure horizontal plane.

The chandelle is an example of an oblique maneuver.

Chapter 2 - Formation Flying

The Air Combat Learning Laboratory

Tactical Formations

Tactical formations are employed in order to bring multiple aircraft to bear upon the enemy together. Formations are the basis of all wingman and larger engagement tactics. The easiest and most effective formation to employ in the virtual aerial combat arena is the echelon and finger four formations. This is due to the lack of peripheral vision in the online simulation environment. Line abreast formations are historically more effective but more difficult to employ in the virtual world. As a result the echelon formations shown will be the primary formation for most online flying. Combat spread or line abreast formations may be used when entering a known hostile zone or upon contact with the enemy.

As we intend to employ the tactical doctrines of Double Attack, Loose Deuce and Fluid Four, our formations will be of a spread variety. Horizontal separation of aircraft should be approximately 1 to 2 turn radii.

Formation Organization

Military units are organized using specific terminology. The precise terminology will depend on the country and branch of service.

For example in the United States Army the basic unit is the soldier.

Soldiers are grouped into **Squads**

Squads are grouped into **Platoons**

Platoons are grouped into **Companies**

Companies are grouped into **Battalions**

And so on up to the Army level.

The Air Forces of the world do much the same thing with pilots and aircraft. For simplicity sake we will use a system based loosely on the USAF for training purposes.

The basic unit is one aircraft (and pilot)

2 or more aircraft will be grouped into an **Element** under an Element Leader

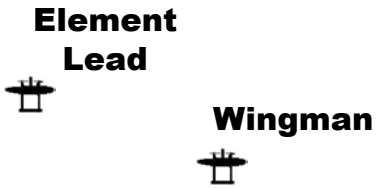
2 or more elements comprise a **Flight** under a Flight Leader

2 or more flights comprise a **Squadron** under a Squadron Commander

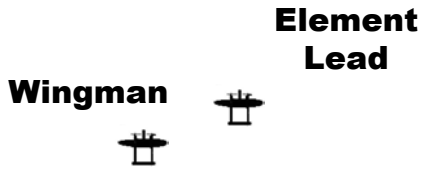
2 or more squadrons comprise a **Group** under a Group Commander

Warbirds rarely exceeds Group level operations

Below are examples of the Element Echelon formation

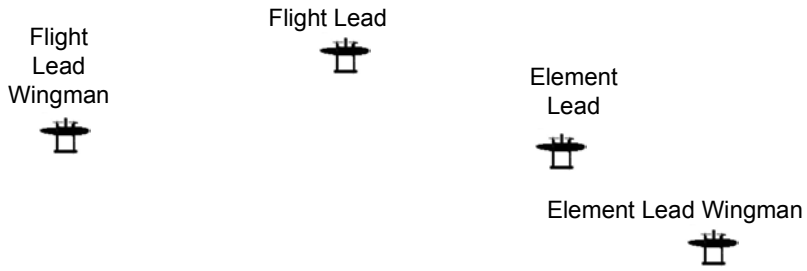


Right Echelon Formation top view (300 Yard separation)



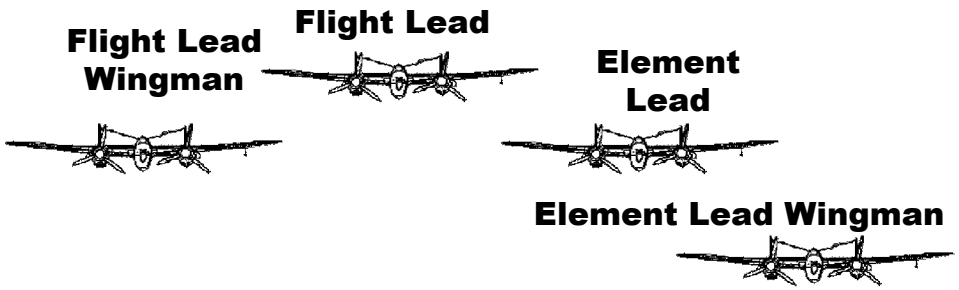
Left Echelon Formation top view (300 Yard separation)

The element formation is used to build the flight formation. Below is an example of the flight in finger four.



Finger Four Formation top view (300 Yard separation)

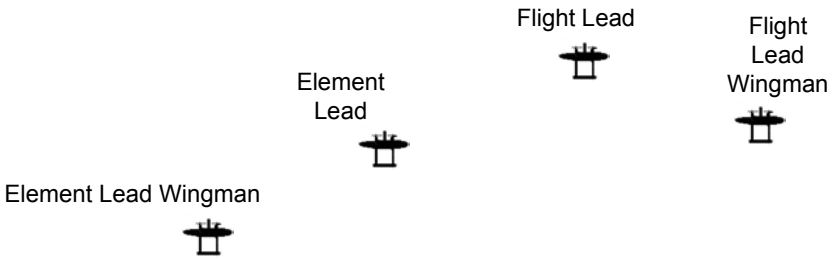
Here is a front view to illustrate vertical separation. This vertical separation is just enough for ease of maintaining station in the formation.



Finger Four Formation Front view

This view shows the proper vertical stacking.
Horizontal separation is reduced for clarity.

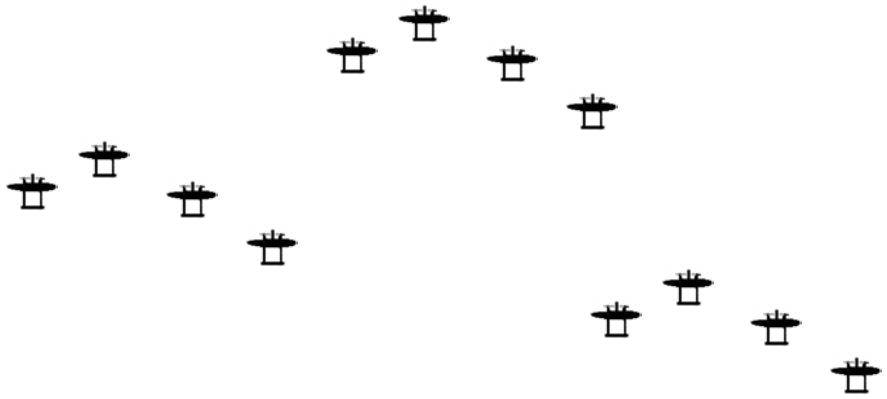
Finger four formation (named because of the resemblance of aircraft positions to the tips of the fingers) may be either left or right-hand finger four. The flight lead is always the middle finger,his wingman is index, the element lead is always the ring finger, his wingman is the pinkie.



Left Hand

Finger Four Formation

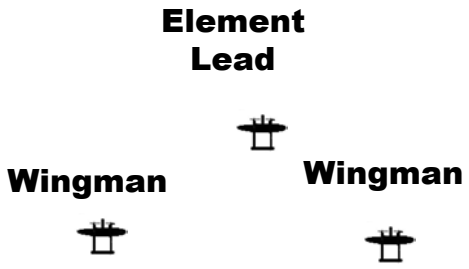
Top view (300 Yard separation)



A Squadron of three Flights heading for battle

. Above the Flights are in Finger Four and the Squadron is in Vee or Vic formation

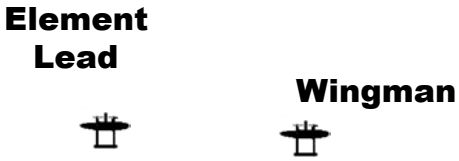
While the finger four will be the primary formation, some situations may call for variations from this formation. Here are a few examples.



Vee or Vic Formation

Trail Formation (500 Yard separation)

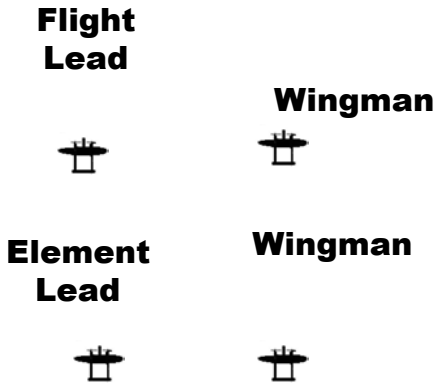
It is highly desirable for the Element to be in combat spread in hostile areas. Combat spread provides the best defensive lookout for both Lead and Wingman with each aircraft blind spot being covered by the other pilot. The disadvantage of combat spread lies in the difficulty in maintaining combat spread in the virtual environment.



Right Combat Spread (500 Yard separation)

Formation types may be mixed in a large formation.

The element might fly in combat spread with the flight flying in trail. This is a combat box.

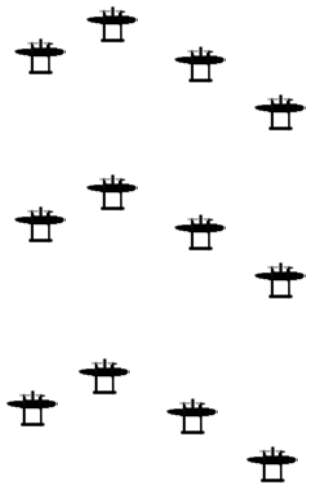


Combat Box

(Elements in Spread, Flight in Trail)

Add a combat box on either side and you would have elements in Combat Spread, Flights in Trail and Squadron in Line Abreast

Some more examples of mixing formations.



Flights in Finger Four

Squadron in Trail

The type of formation used will depend on many factors. These factors include number of aircraft, mission, planned tactics, expected enemy, experience of pilots, and other conditions.

Flight and Element Formation

Element Formation

The Element is the basic formation unit. It consists of an Element Leader and a Wingman. This 2-ship formation may also be called a wing pair, section or some other name.

Duties in Element Formation

The element lead makes the basic tactical decisions for his element and coordinates with his flight lead. The Element Lead must maintain formation station on the Flight Lead and be prepared to carry out the tactical orders of the Flight lead. He is also responsible for defensive lookout for his wingman.

The wingman in an element is responsible for defensive lookout and with carrying out the tactical orders of the element lead. The wingman must maintain proper formation station on the element lead and be prepared to execute element maneuvers when called upon.

Flight Formation

The Flight is made up of 2 or more Elements. One element lead will be designated as the Flight Lead. The preferred tactical unit is a four aircraft flight (2 elements). Three or more elements in a Flight may be desirable for certain missions or situations.

Duties in Flight

The Flight Lead retains all of the duties of an Element Lead. In addition, he is responsible for making the flight tactical decisions and for carrying out tactical orders from Flight, Group or Squadron Leads as appropriate.

The wingman in a flight lead element retains all of the responsibilities of an element wingman. Because of the high workload imposed on Flight Leads, his wingman must be extra vigilant and provide the Flight Lead with timely information.

Large Formations

There are infinite possible combinations of formation possibilities with varying degrees of command structure complexity. Fighter units should strive to keep structure flexible and loose. The ideal structure has each pilot responsible for a maximum of two command levels at any time.

For example, an element wingman has only one command level, his Lead.

The Element Lead is responsible for his wingman and responsible to his flight lead, two command levels.

Task loading in the combat environment is a primary concern and must be minimized at all times. When engaged with the enemy the ability of an individual pilot to coordinate defensive lookout responsibility, engage in tactical maneuver and keep sight of the enemy and the wingman are almost overwhelming endeavors. Any additional responsibilities would almost immediately cause task overload and result in combat losses.

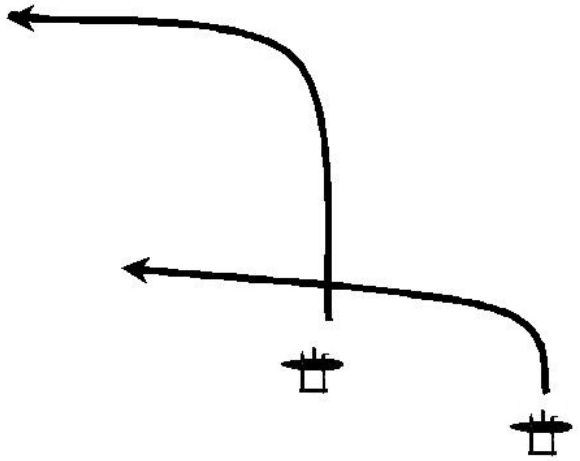
Large formations are necessary to bring force to bear upon the enemy but once engaged the individual elements must have the ability to fight as a unit. Coordination with other elements is desirable but not at the expense of element integrity. Training in large unit engagements can improve Element and Flight coordination.

For the purposes of training any formation of 2 or more flights will be considered a squadron formation with a squadron leader flying as Flight Lead in one flight.

Tactical Formation Turns

Formation turns are maneuvers designed to maintain energy and provide adequate rear quarter visibility during the turn. We will employ three types of formation turns in combat.

The Tactical Turn or TAC Ninety (Left or Right). This turn is executed in stages. The aircraft on the outside of the turn begins the turn when it is called. Aircraft delay 1 to 2 seconds and then commences the turn in order from outside of turn to inside of turn. Two TAC Ninety turns must be called to effect a course reversal.

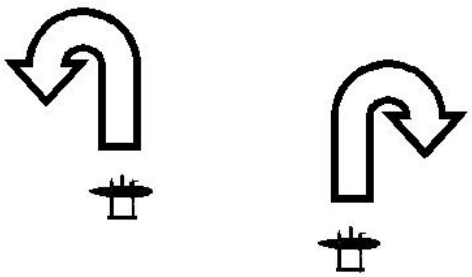


Tactical Turn Left (Tac 90 Left)

Formation start in right echelon and finishes in Left echelon

Two Tac 90 turns give a 180 course reversal

Split Turns are used to set up a bracket maneuver on an enemy spotted in the rear quarter. A split may be horizontal or vertical or oblique but wing pairs must practice the communications necessary for employment of these turns. The same applies to the cross turn.



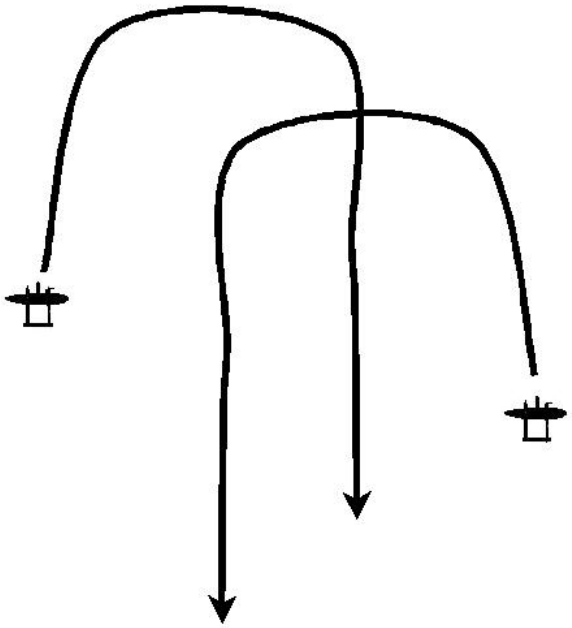
Split Turn

This turn is used to increase separation.

Normally a prelude to a bracket.

Can be done vertically or oblique as well as horizontal

Cross Turn Illustration. Again these may be horizontal, vertical or oblique.



Cross Turn

This turn is used to decrease separation.

Can be done vertically or oblique as well as horizontal

Formation Joins or Rendezvous

We have covered what formations look like and some basic formation maneuvers. What we haven't done is discuss how we get into formation and how we stay there.

There are a few different methods for organizing a formation after takeoff.

The unit should line up on the runway in element pairs. Each element lead should call the takeoff roll in order. This allows the elements to begin the flight in formation and basically cuts the number of rendezvous in half. It is also beneficial to have the elements paired up if enemy attack may be possible.

Once all elements have successfully gotten airborne the unit can begin to join up.

Elements comprising a flight should join up first. After the flights are formed the squadron can assemble in its final formation. A typical squadron formation should be complete 2 minutes after the last element takeoff.

Rendezvous Methods

There are three methods of rendezvous normally used. Running, Running Turn, and Vertical Rendezvous.

Running Rendezvous

This method is a simple straight-line speed differential overtake. The Lead must set a low enough power setting to allow prompt overtake. This power setting should be announced.

Running Turn Rendezvous

This method employs Lead Pursuit techniques to achieve rendezvous. The Lead maintains a constant turn and the overtake is accomplished by using lead pursuit to cut across the Lead pilot turn circle. The rendezvous may be accomplished at high power settings if necessary. However, rendezvous will be expedited if the Lead pilot flies at a Running Rendezvous power setting.

Vertical Rendezvous

This method is accomplished by using an altitude separation for a vertical lead turn formation join. The joining pilots orbit at altitude and the lead pilot flies to the orbit point at a lower altitude. This rendezvous is especially useful after combat engagements.

Other Methods

There are many other methods and situations to accomplish formation joins and rendezvous. All employ the concepts of the above three as well as the Basic Fighter Maneuver concepts of lead turns and pursuit curves. All fighter pilots should continually practice the rendezvous and formation join techniques in as many different situations as possible. This practice builds the foundation of all fighter tactics and maneuver as well as building efficiency and confidence in formation skills.

Lead Turns

The concept of a lead turn is probably the single most misunderstood maneuver in virtual aerial combat. Almost every pilot in the online arena uses lead turns at the initial merge. Very few know how to employ lead turns after the merge.

Military aviation organizations use formation flying as a beginner's laboratory for aerial combat. In the virtual arena, we use formations but rarely as a training tool. A little practice drill called formation joins can work wonders for your BFM skills.

The goal of every virtual fighter ace is to arrive 'in the saddle', that magical place where you are locked up on the bandit's six and he can't shake you. The saddle is simply a close trail formation on the bandit.

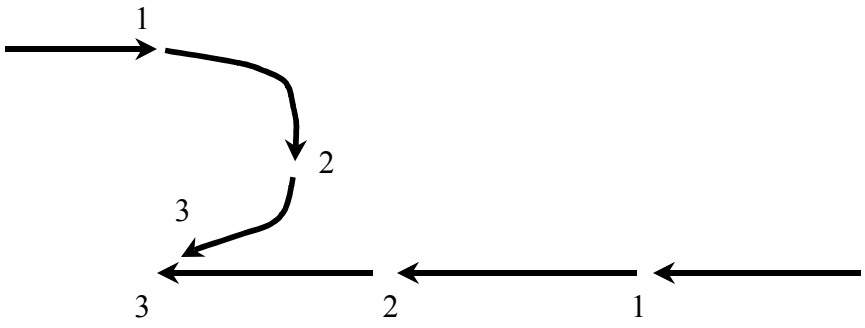
Arriving 'in the saddle' means predicting the bandit flight path and maneuvering your aircraft to arrive there when the bandit does. When you predict the bandit's flight path and act on your prediction you are lead turning. The further ahead you can predict the bandit's flight path the easier your job becomes.

Lead turns have nothing to do with Lead Pursuit.

You can lead turn in lag pursuit. In fact, most pre-merge lead turns are lag maneuvers.

The classic pre merge lead turn.

At time one the attacker begins the lead turn. At time 3 gun parameters are reached



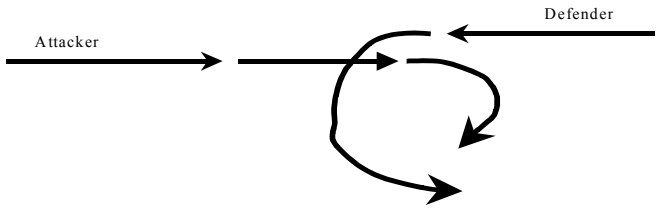
This is a lead turn executed with flight path separation of 2 times the turn radius of the attacker. Obviously, the defender is not looking, as he makes no reaction. At time one the attacker predicts the future position of the bandit and begins a maneuver to put his aircraft there. A close study of the above diagram reveals that the defender could use the attacker's lead turn against him. Lead turn timing is critical. A lead turn too early could mean giving the opponent positional advantage. A lead turn too late could mean an overshoot and loss of the offensive.

Nose to Nose and Nose to Tail Turns

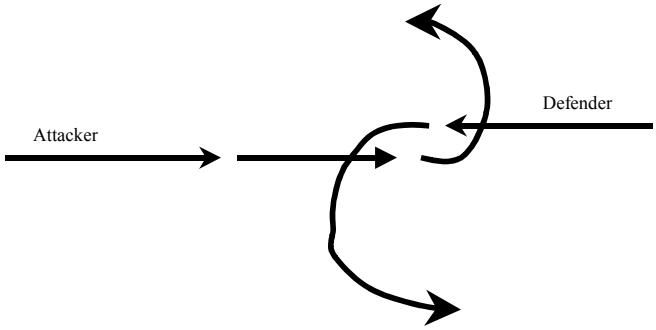
The names for these two turns are actually descriptions of the maneuver. They describe the relationship of the attacker to the defender in the turn. If you turn towards your opponents nose you are nose to nose. Turning towards his tail is nose to tail geometry.

Some illustrations.

Nose to Nose Geometry



Nose to Tail Geometry



Each type of geometry has its advantages and disadvantages. Nose to Nose geometry is advantageous to the fighter with smaller radius of turn. Conversely, nose to tail can benefit a fighter with greater turn radius but it will not generate an immediate offensive position. A fast fighter can use nose to tail geometry on a slower fighter to induce him to turn harder, bleeding his energy. If a fighter has a **Turn Rate** advantage nose to tail geometry can result in an offensive position.

See Fighter Combat: Tactics and Maneuvering Shaw, Robert L. pp. 77-82 for further discussion.

Chapter 3 - Basic Fighter Maneuvers

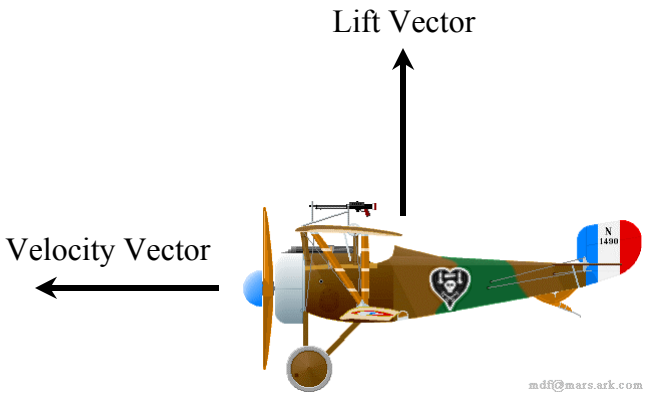
The primary tools of the fighter pilot

Primary Maneuvers

In primary flight training basic aerobatic maneuvers and formation flying built the foundation for Basic Fighter Maneuver or BFM training. The purpose of BFM is to position your aircraft to kill the opponent. All successful BFM requires a good understanding of the geometry of the fight. Maybe you did not think so in class but those Geometry lessons were actually fighter pilot school.

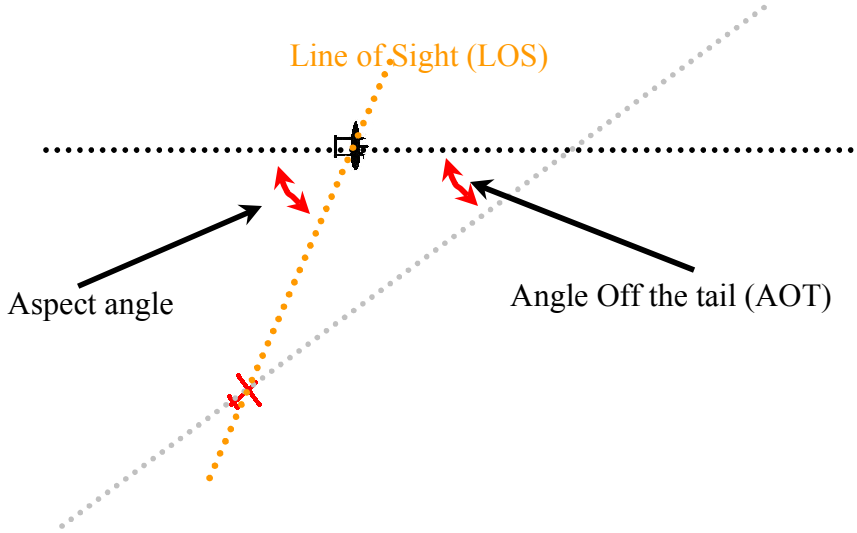
Velocity Vector- The direction the aircraft is going. Since we do not have an accurate indication of velocity vector, the gun sight position or nose position will do as a substitute. Actually, the velocity vector and nose position will always differ by the Angle of Attack of the wing.

Lift Vector- This is the direction of lift of the wing. The fighter pilot uses a line drawn from his rear end through the top of his head continuing off into space to define the lift vector. In Warbirds, the straight UP view has the pilot looking along the lift vector line.



Angle Off Tail (AOT)- The angular difference between your velocity vector and the target velocity vector. This is the angular relationship between you and the targets tail. If you are on the bandit's tail at the classic 6 O'clock position you are at 0° AOT. If the bandit is on your six you are at 180° AOT. Off his wingtip is 90° AOT. Note this is irrespective of your nose position.

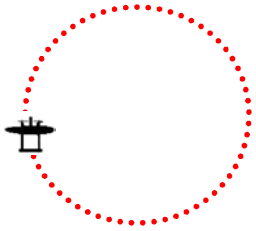
Aspect Angle- This is the angular relationship between the target velocity vector and your line of sight (LOS) to the target. If the target is pointed at you the aspect angle is 180°. If you are looking at the opponent's tail, the aspect angle is 0°. If you are looking at the wingtip of the target that is 90° aspect angle. Again, notice this relationship does not factor in your velocity vector, only your LOS to the target.



Closure Velocity (V_c)- The rate at which the range to the target is changing

Turn Circle- The circle drawn by the flight path of an aircraft in a maximum performance turn

Turn Circle



Reference: Robert L. Shaw **Fighter Combat: Tactics and Maneuvering** pp. 8-61 1985

Fight Geometry

The fight exists in the respective turn circle of the aircraft involved. You cannot kill the bandit until you are on his turn circle and he cannot kill you until he is on yours.

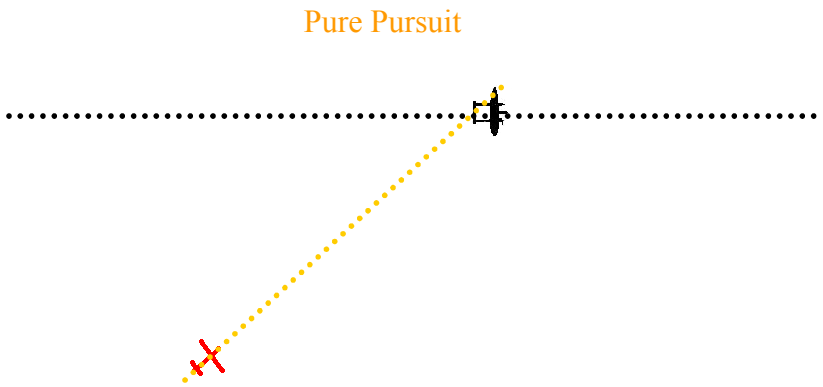
The key to successful BFM is what you do to get into the bandit's turn circle, what you do while you are there and how you exit.

Arriving in the Bandits Turn Circle - Pursuit Curves

Pursuit curves are the method the fighter pilot uses to solve the geometry problems associated with the fight. There are three types of pursuit curves.

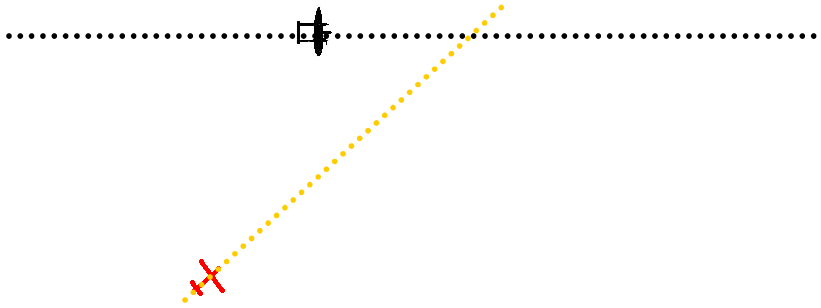
- Lead Pursuit
- Lag Pursuit
- Pure Pursuit

The illustrations below demonstrate each type of curve.



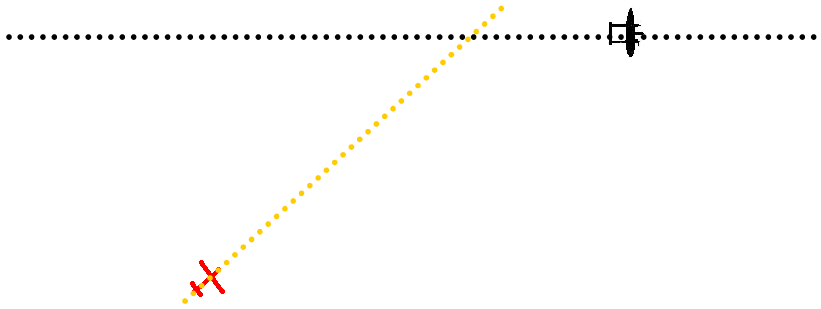
Pure pursuit is quite simple. All that is required is for you to point your velocity vector (nose) at the target.

Lead Pursuit



Lead pursuit is simply placing your velocity vector ahead of the target. Lead pursuit is necessary for all gun kills. This is because it takes time for the bullets to travel through space. If you shoot where the target is right now the target will no longer be there when the bullets arrive. Therefore, you must predict the future flight path of the target in order to put the ammunition into the target. This is the essence of aerial combat. The ability to predict where the target will be in the future is crucial to all facets of aerial combat.

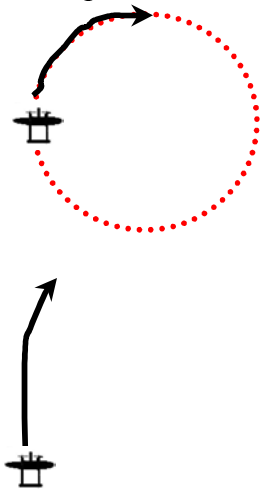
Lag Pursuit



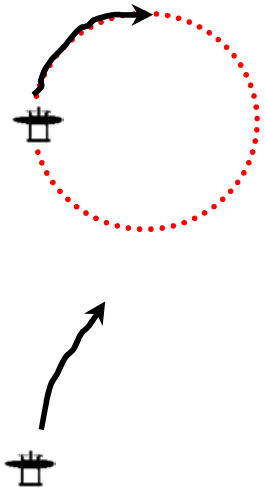
Lag pursuit is simply placing your velocity vector behind the target.

The following is an illustration of pursuit curves as they relate to the target turn circle.

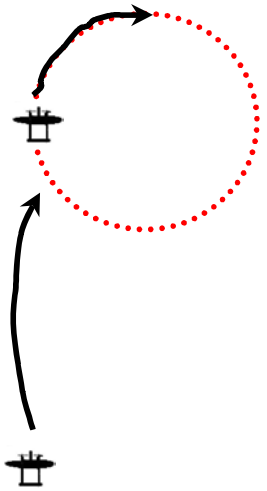
Pure Pursuit -Nose pointed at Bandit continuously



Lead Pursuit -Nose pointed ahead of Bandit continuously



Lag Pursuit -Nose pointed behind Bandit continuously



Application of pursuit curves

How do I use each one and under what circumstances?

This, of course, is not easily answered. Each pursuit curves has advantages and disadvantages and each does a different job. It is up to the fighter pilot to apply each correctly. We can provide a description of each and provide some examples of the employment of each.

Lead Pursuit

Lead pursuit involves predicting where the bandit will be at a future time. Lead pursuit does the following things when employed against a turning target.

- Increases closure velocity.
- Decreases range to target
- Increases angle off the tail
- Increases aspect angle

Against a target flying a straight path, Lead Pursuit does the following:

- Decreases range
- Increases closure

Lead pursuit may be used in the following situations:

- ✓ To get into the turn circle of a target with poorer turn performance
- ✓ To use geometry to decrease range on a target attempting to extend or disengage
- ✓ To set up a high angle snapshot opportunity
- ✓ As a prelude to a lag roll or barrel roll attack

Pure Pursuit

Pure pursuit is simply pointing your nose at the target. It has very limited usefulness.

Against a turning bandit is does everything that lead pursuit does, only slower. What it does not do is set up lead for a shot opportunity. Pure pursuit against a turning target is only useful as a potential scare tactic. It will make the target break into you while you maintain energy for a disengage after the overshoot.

Against a straight-line target, pure pursuit can be used to decrease range on a slower target.

Lag Pursuit

Lag pursuit places your velocity vector behind the tail of the target. This does the following against a turning target:

- Decreases aspect angle
- Decreases Angle Off
- Decreases Angle off the tail
- Increases or maintains range
- Decreases or maintains closure velocity

Against a straight line target Lag Pursuit does all of the above but to a much greater degree.

Lag pursuit is very useful. Here are a few examples.

- ✓ Lag pursuit puts you on the target turn circle allowing either a quick kill or a follow up BFM
- ✓ Useful in Loose Deuce tactics to create predictable target flight path for your wingman
- ✓ Handy for stopping high closure velocity and preventing overshoots

Applying Pursuit Curves

If one examines the turn circle diagrams for the pursuit curves above, one can easily see the following:

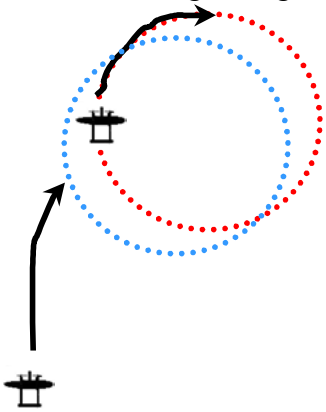
Lead pursuit will put the attacker inside the target turn circle and may present a snapshot opportunity.

Pure Pursuit will put the attacker inside the target turn circle but will not lead to a shot opportunity.

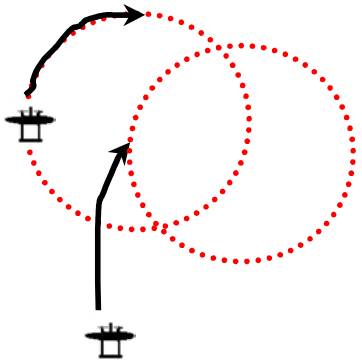
Lag pursuit will put the attacker **ON** the target turn circle and could lead to a tracking shot opportunity or "the saddle". You are saddled up when you have achieved firing position on the target six and can maintain it.

In order to achieve the saddle we must align turn circles.

Lag Pursuit leading to aligned turn circles



Lead Pursuit leading to misaligned turn circles



Reference: Robert L. Shaw, **Fighter Combat: Tactics and Maneuvering** pp. 62-67

Dobs Tactical Forum http://www.4anidea.com/333rd/forums/dobs/

What if the attacker turn circle is larger because of a difference in speed or aircraft capabilities?

That is where follow on BFM comes in. We use pursuit curves to put our aircraft on the target turn circle. Now we use follow on BFM to stay in the saddle and control the fight.

Maneuvers

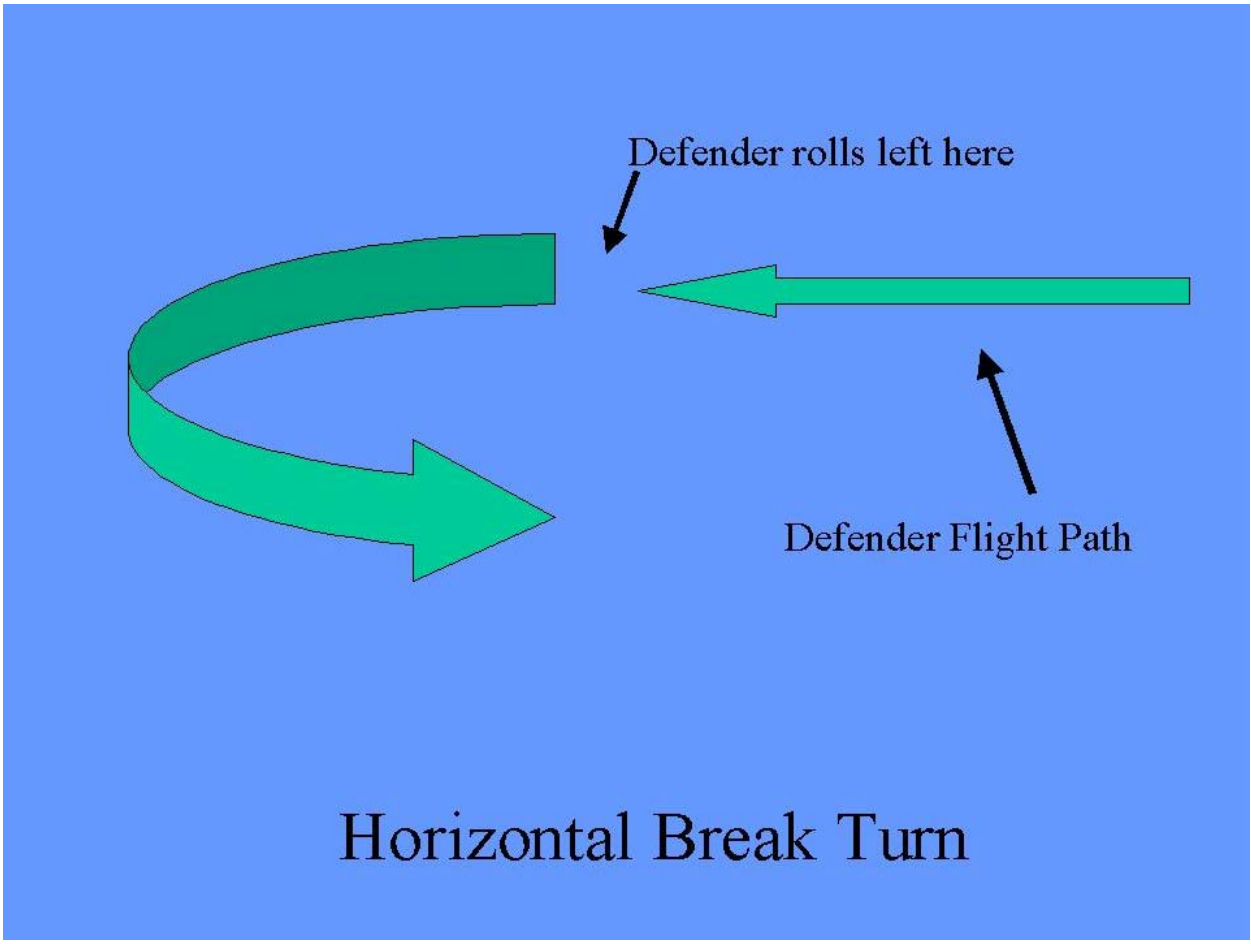
The following are the basic BFM maneuvers that we will discuss:

- High Yo Yo
- Low Yo Yo
- Lag Pursuit Rolls
- Flat Scissors
- Rolling Scissors
- Defensive Spiral
- Break Turns
- Nose to Nose Turns
- Nose to Tail Turns

Break Turns

The simplest break turn is the horizontal break. A con is approaching from your five o clock at your altitude. A proper break turn means you roll the aircraft so that the lift vector is in line with the bogey and you pull on the stick. A co alt attacker means a 90 degree roll (Quarter roll) toward the attacker and pull.

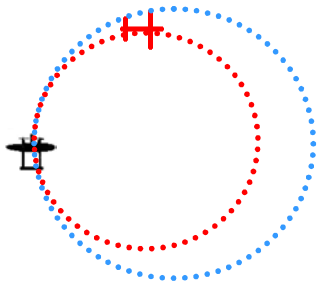
This is what it looks like from the pilot seat. You spot the attacker out your six view at 5 o'clock. Stay in six view. Roll toward the attacker until he is in your slightly high six view then pull back on the stick to put him in high six view or straight up view.



High Yo Yo

The following illustration shows the relative turn circles of an attacker reaching the turn circle of a slower or more agile bandit.

Turn circle comparison-Faster attacker



Obviously, the attacker in this case cannot shoot the target because his speed has made his turn radius larger than the target. Even if the attacker has the turning ability to pull lead, this is very wasteful. The energy lost pulling hard may be sorely missed if the shot is no good or a second bandit enters the fight.

Therefore, the question to be answered is how do I solve my geometry problem while maintaining energy levels and preventing overshoot.

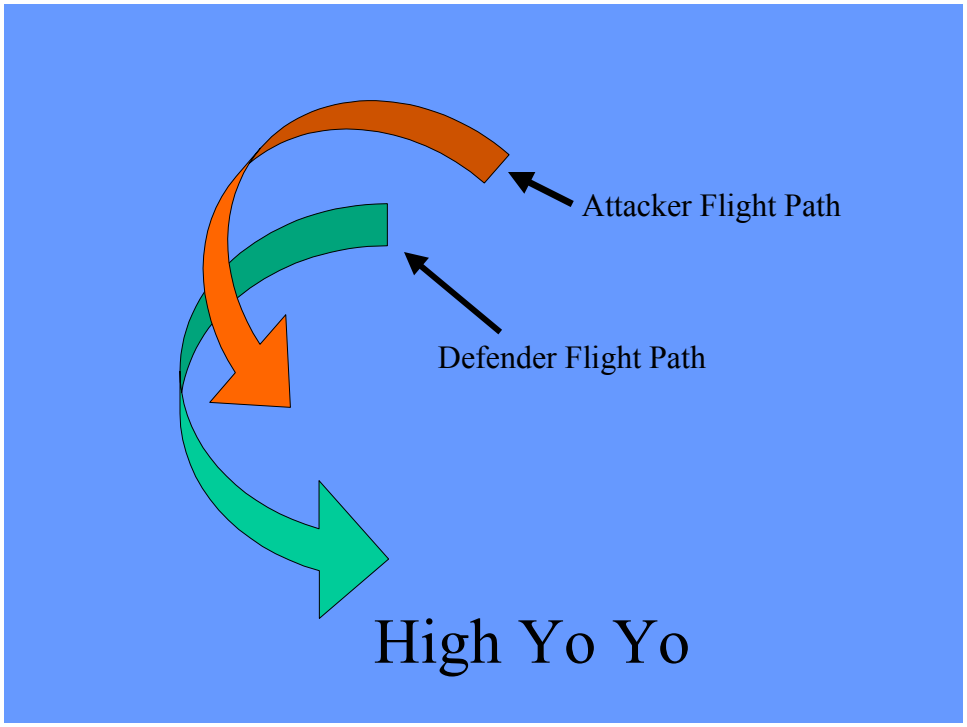
First, energy conservation. Energy may be maintained by trading speed for altitude. So we must do a nose high maneuver.

Second, match the target turn radius. We do this by using the vertical to reduce the horizontal component of our turn.

The high Yo Yo is born. The high Yo Yo is simply a nose high out of plane turn. Out of plane means our maneuver is outside the target maneuver plane. In this example, our target is maneuvering in a purely horizontal plane. We could choose a pure vertical maneuver or loop but this would not put us on the target turn circle for a kill. The other choice is an oblique maneuver plane.

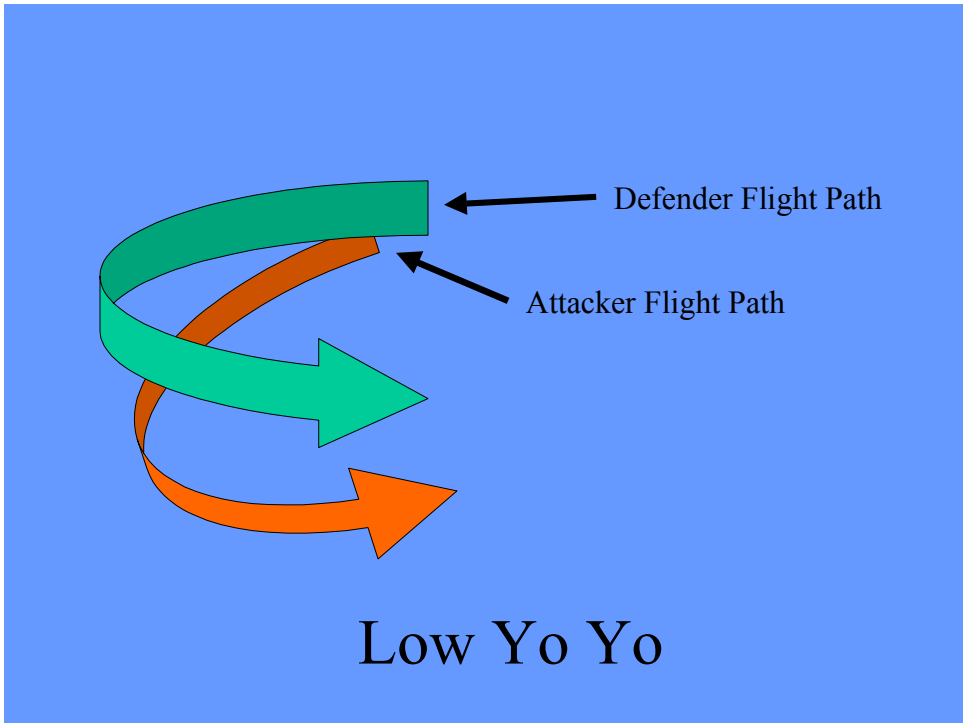
To execute the high Yo Yo is quite simple. Establish lag pursuit until you reach the target turn circle. Closure velocity should be fairly high. Once you reach the bandit turn circle go nose high about 20 degrees and roll to keep the target in sight. As you go past the 90-degree bank, start easing the nose down for the shot opportunity.

An illustration.



Low Yo Yo

In the case of the High Yo Yo, the attacker had excess closure velocity and speed. In the case of the Low Yo Yo the attacker has better turn radius but is short on closure velocity and speed. The attacker needs to "cut 'em off at the pass". The attacker trades altitude for speed and uses the vertical to cut the corner across the target turn circle.



An Illustration.

Lag Pursuit Rolls

From the earlier discussion we learned the value of lag pursuit in arriving on the bandit turn circle. Until now, we have only discussed pursuit curves in one dimension. We will now add the third dimension.

The high and low Yo Yo introduced a new concept. Energy management. A simple definition of energy as it relates to aerial combat is as follows:

Altitude + Airspeed = Energy

It is not that simple however. Altitude and airspeed inter-relate with countless other factors in a highly complex, dynamic combat situation. This inter-relation transforms the topic of energy from science to art. An art we constantly try to master.

For now, we take a small step in our understanding.

In the high Yo Yo situation we had excess closure velocity and are basically co-altitude with the bandit. Speed is **kinetic** energy, the energy of motion. Energy we have right now. Only problem is we have too much. Therefore, we have to reduce our kinetic energy.

We could reduce kinetic energy by reducing power to the engines, lowering high drag devices (flaps, gear, and speed brakes), or increasing G load on the aircraft to a level above maximum sustained G.

However, all of those choices reduce our total energy in the equation above.

Therefore, we choose to reduce our kinetic energy by climbing. We slow when we climb but in the process, we increase our **potential** energy. Altitude is potential energy.

Potential Energy + Kinetic Energy = Total Energy

Altitude + Airspeed = Total Energy

We always want to keep our total energy at a high level. We know it instinctively but it is a hard rule to live by.

Lag pursuit rolls are a method of maintaining our total energy state.

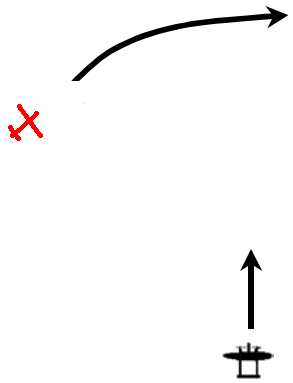
So how does a lag pursuit roll work?

First the conditions for application.

- High closure velocity
- Low angle off the tail (less than 30°)

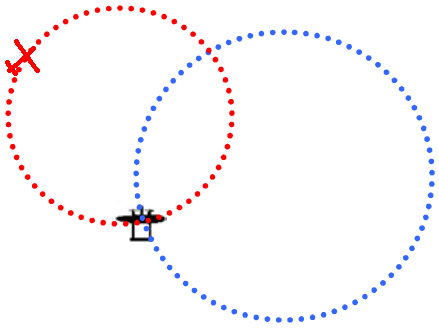
An illustration of this situation.

Lag Pursuit roll initial setup



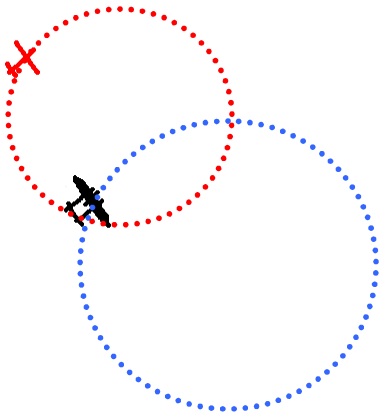
The bandit at our 10 O'clock is turning right. We are in lead pursuit. If we continue we will overshoot and the bandit will gain an angular advantage. We can examine the relative turn circles of the situation.

Lag Pursuit roll setup-Turn circles



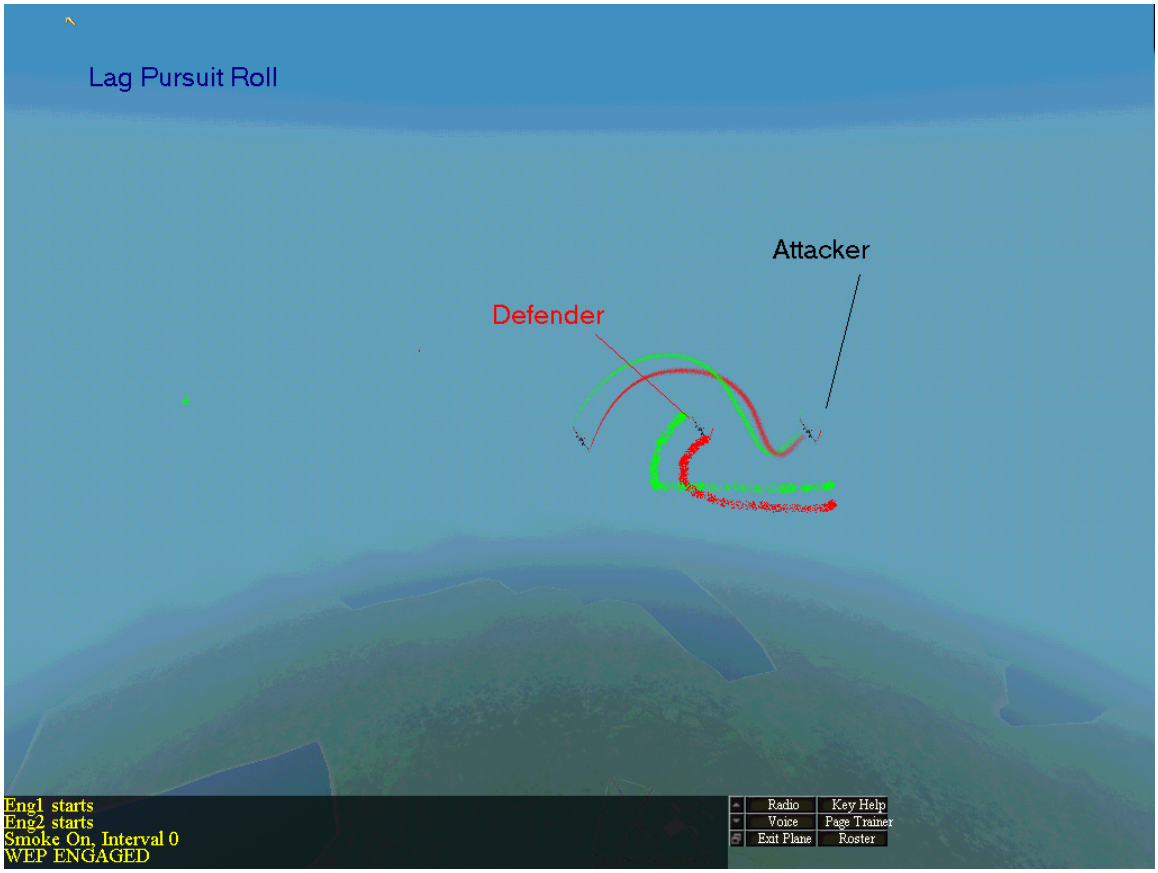
Our high speed makes our turn circle larger and we have a serious alignment problem. We can fix both with a lag pursuit roll. The first thing we do is pull more lead to get the picture like the illustration below.

Lag Pursuit roll setup-Increase the lead



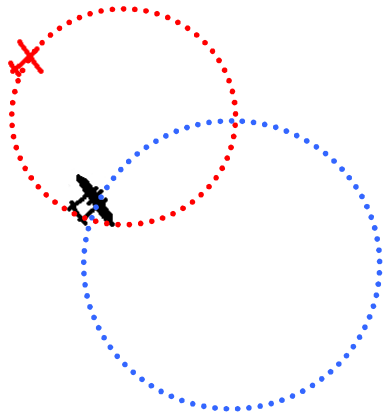
This excess lead is necessary to allow us to keep sight of the bandit and to arrive in the proper position at the end of the maneuver. The next step is to pull the nose high. The nose high pull reduces the closure by reducing our speed. It also reduces closure because some of our speed is being used vertically; further reducing the horizontal distance traveled in the direction of the target. After the nose high pull a roll is executed TOWARDS the bandit.

Here is a crude illustration.

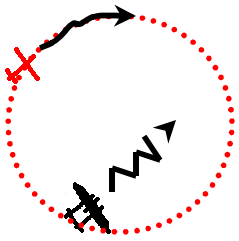


Using diagrams we can see why the maneuver works.

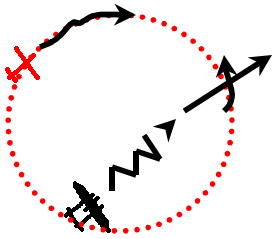
Lag Pursuit roll setup-Increase the lead



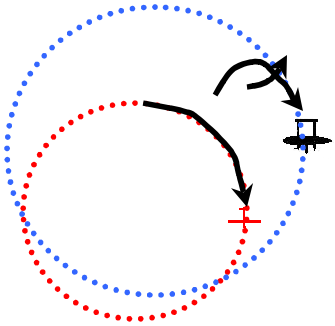
Lag Pursuit Roll -Initiate climb



Lag Pursuit Roll -Barrel Roll towards bandit



Lag Pursuit Roll-Position after roll



I hope that through careful study of the diagrams the maneuver can be visualized. Once mastered the lag roll technique can be applied to a wide variety of tactical situations.

Reference: Robert L. Shaw, **Fighter Combat: Tactics and Maneuvering** pp. 67-71

Lead Turns

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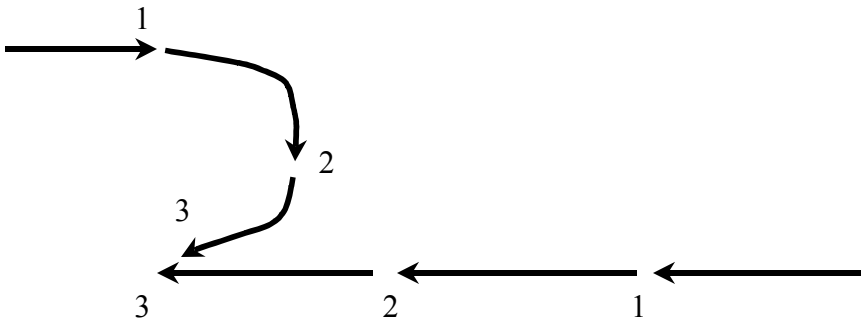
The classic pre merge lead turn.

At time one the attacker begins the lead turn. At time 3 gun parameters are reached



This is a lead turn executed with flight path separation of 2 times the turn radius of the attacker. Obviously, the defender is not looking, as he makes no reaction. At time one the attacker predicts the future position of the bandit and begins a maneuver to put his aircraft there. A close study of the above diagram reveals that the defender could use the attacker's lead turn against him. Lead turn timing is critical. A lead turn too early could mean giving the opponent positional advantage. A lead turn too late could mean an overshoot and loss of the offensive.

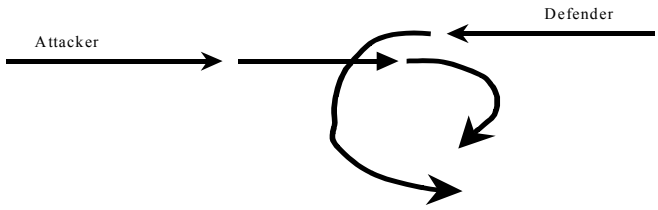
Reference: Robert L. Shaw, **Fighter Combat: Tactics and Maneuvering** pp. 74-75

Nose to Nose and Nose to Tail Turns

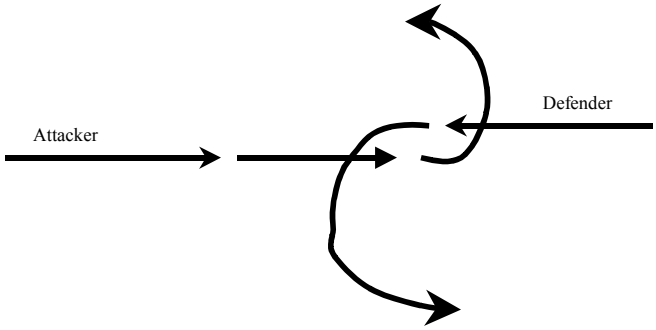
The names for these two turns are actually descriptions of the maneuver. They describe the relationship of the attacker to the defender in the turn. If you turn towards your opponent's nose you are nose to nose. Turning towards his tail is nose to tail geometry.

Some illustrations.

Nose to Nose Geometry



Nose to Tail Geometry



Each type of geometry has its advantages and disadvantages. Nose to Nose geometry is advantageous to the fighter with smaller radius of turn. Conversely, nose to tail can benefit a fighter with greater turn radius but it will not generate an immediate offensive position. A fast fighter can use nose to tail geometry on a slower fighter to induce him to turn harder, bleeding his energy. If a fighter has a **Turn Rate** advantage nose to tail geometry can result in an offensive position.

See Fighter Combat: Tactics and Maneuvering Shaw, Robert L. pp. 77-82 for further discussion.

Reference: Robert L. Shaw, **Fighter Combat: Tactics and Maneuvering** pp. 77-82

Flat Scissors

Closely related to the nose to nose geometry discussion is the flat scissors maneuver. The flat scissors is simply a series of nose to nose lead turns while using maximum deceleration. The critical part of proper performance of the flat scissors is timing of the turns. Ideally, the reversals are executed at the instant the bandit reacts to match your turn. This is called keeping the fight out of phase.

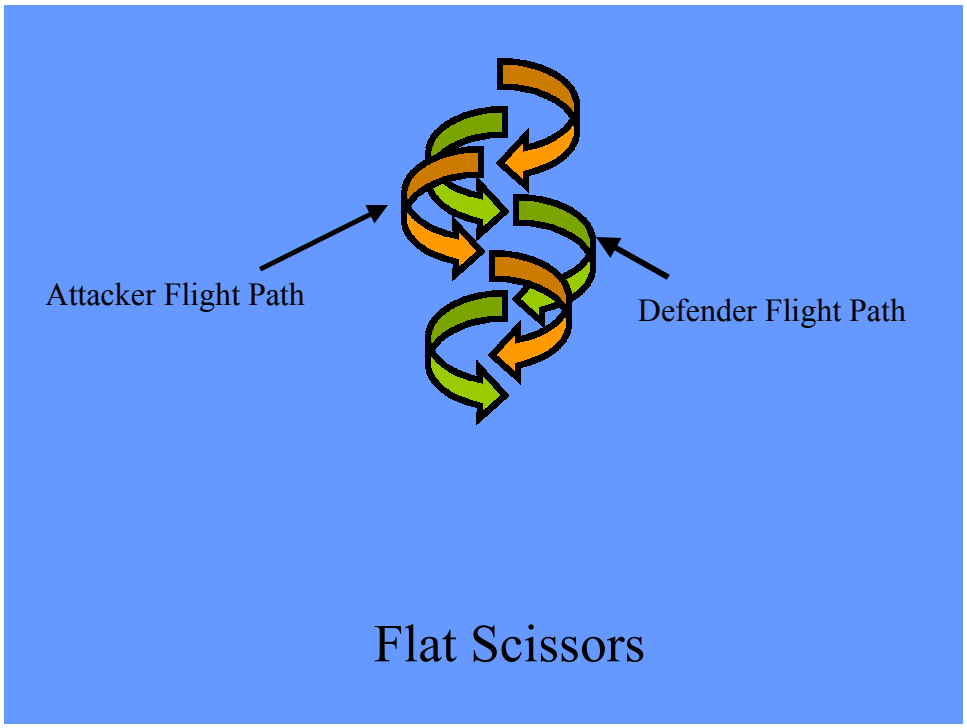
Phase refers to the alignment of lift vectors. Two aircraft flying in formation have aligned lift vectors and are in phase.

If one makes a 90-degree bank the two aircraft are then 90 degrees out of phase.

Two aircraft flying canopy to canopy (like Maverick and the "Mig" in Top Gun) are 180 degrees out of phase. The flat scissors reversals are time to keep the fight as close to 180 degrees out of phase as possible. This out of phase geometry maximizes the overshoot potential while minimizing exposure to the enemy guns.

Tactical situations appropriate for the Flat Scissors are horizontal overshoots at slow speeds due to a successful break turn. It is most properly used against a poorer turning bandit (either he is faster or in a poor turn performance aircraft).

Start with a flat break turn. Chop the throttle and drop flaps as quickly as they will go down. Watch the bandit. As soon as he reacts to match your break turn use maximum roll techniques to reverse the turn and flat break the other way. It is critical to be able to fly while looking backwards for this maneuver. Once the bandit reacts again to match your turn break back into him. Try to break slightly out of plane to avoid his snapshots.



Reference: Robert L. Shaw, **Fighter Combat: Tactics and Maneuvering** pp. 82-86

Rolling Scissors

The rolling scissors is appropriate in a high speed overshoot or a vertical overshoot from high to low. Once the bandit overshoots below the defender goes nose high and rolls to maintain visual on the bandit. The bandit will react by rolling and pulling toward the defender. The two aircraft will corkscrew through the sky canopy to canopy as they both execute barrel rolls at fairly high G levels. The key to winning the rolling scissors is to minimize horizontal distance traveled and to predict the bandit's position.

To minimize horizontal distance traveled the defending fighter should maximize his nose high position before rolling for the downward portion of the roll. The defender brings his nose to near vertical and rolls to place his lift vector in lead pursuit (ahead of the bandit on his predicted flight path). At this point the defender pulls for the bandits rear quarter to force the bandit to continue his roll, preventing the bandit from getting his nose vertical. If separation is insufficient for the defender to avoid an overshoot he should go pure vertical down. He then performs another roll to place his lift vector in lead pursuit and pull up to the vertical again.

By performing vertical climbs and descents, the defender minimizes horizontal distance traveled. This causes the bandit to overshoot in the horizontal plane.

Reference: Robert L. Shaw, **Fighter Combat: Tactics and Maneuvering** pp. 89-93

Defensive Spiral

The defensive spiral is a combination of the techniques used in the flat and rolling scissors.

In the defensive spiral, the defender goes radically nose low to avoid an attacker (Split S or similar maneuver). The attacker continues the pursuit and forces the defender to react to prevent a tracking gunshot. The defender continues rolling maneuver as in the rolling scissors to prevent the shot. Both fighters enter a very steep nose down rolling scissors. Obviously the duration of this maneuver is limited severely by the available altitude.

The question is how to force the attacker to overshoot vertically (downward)? The answer is to minimize the descent rate while maintaining a very tight rolling spiral towards the ground.

This means using every means available to slow the plunging aircraft. All of the techniques in the flat scissors are appropriate with one addition. Chop throttle; deploy drag-producing devices like flaps, gear, or dive brakes. In addition, maintain high angle of attack to maximize the induced drag that comes from the production of lift. In other words, get the stall horn as loud as you can while maintaining a nearly vertical descent.

The attacking aircraft should have a greater descent rate and should overshoot below the defender leading to good rear quarter position for a gun shot. At the worst the defender has rear quarter position while the attacker extends away wondering what happened.

Reference: Robert L. Shaw, **Fighter Combat: Tactics and Maneuvering** pp. 93-97