

325th Fighter Group (Virtual) Air Combat Maneuver and Tactics Manual



"Locare Et Liquidare"

"Locate and Liquidate"

DRAFT
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Colonel Stream

CO, 325th Fighter Group (Virtual)

15th AF, USAAF, MTO

"Checkertail Clan"

"The best individual defensive tactic is a hard and fast offensive, regardless of the odds."

Major William D. "Dinghy" Dunham, USAAF (16 victories)

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Physics of Air Combat

One may think that one must have a superior knowledge of physics in order to be successful in an air-to-air engagement. This is not true; all one requires is knowledge of the basics. In flight, you will not be able to get out your calculator and predict what is going to happen. These basic physical principals will help you know what is going on with your aircraft while in flight and if something goes wrong you can know why. No attempt will be made to qualify the reader as a fully fledged aeronautical engineer, nor is it needed. Formulae and complex equations should be left to the aircraft designer, not the pilot. With the constant information coming in to the pilot in combat, the pilot does not have time to do any math.

"Beware the lesson of the fighter pilot who would rather fly a slide rule then kick your ass!"

Commander Ron "Mugs" McKeown, USN

Roll, Yaw, Pitch

Roll is controlled by the **ailerons**, controls surfaces or fins on the wings. The ailerons increase and decrease lift on each wing. The downward aileron produces more lift, and the up going aileron produces less. The aircraft will roll along its **longitudinal axis (Figure 1)**. **Aileron Drag** is drag created by the downward aileron, against the higher pressure of the airflow below the wing, when the airplane rolls; it will yaw in the opposite direction of the roll. Rudder is applied to **coordinate** the roll.

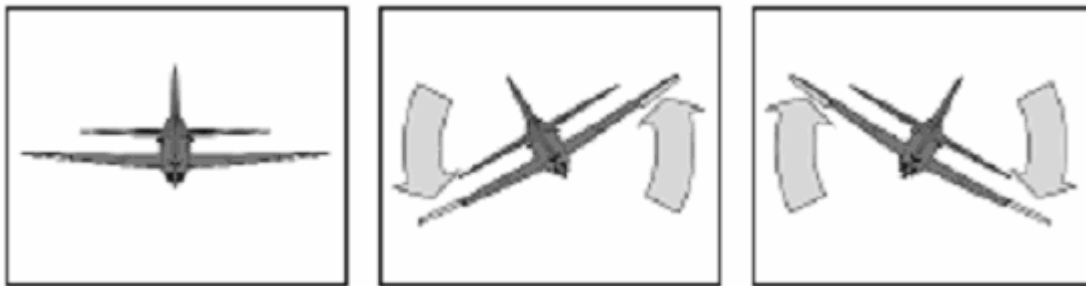


Figure 1

Yaw is controlled by the **rudder** to move the airplane side to side along its normal axis or **Vertical Axis (Figure 2)**. The rudder does not turn the aircraft as the rudder in a boat would. Yawing can cause roll, in the direction of the applied rudder. The wing on the outside of the yawing motion is faster and has greater lift, causing the airplane to roll.



Figure 2

Pitch is controlled by the **elevators** to move the airplane up or down, and to control Angle of Attack, and speed. It moves the airplane on its **Lateral Axis (Figure 3)**.

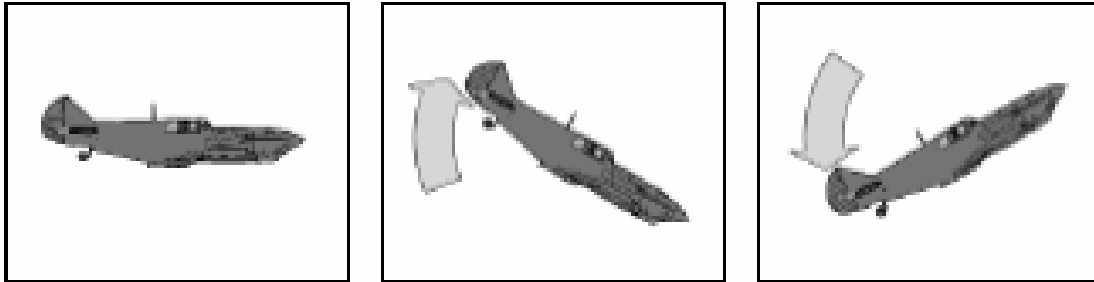


Figure 3

Each of these movements acts through a point called the **Center of Gravity (CG)**.

The Four Forces of Flight

When the four forces balance each other ($\text{Lift} = \text{Weight}$ and $\text{Thrust} = \text{Drag}$) the airplane is said to be in a state of **equilibrium (Figure 4)**. If any of the forces are unbalanced the aircraft will climb, descend, accelerate, or decelerate. The four forces are listed below, each with a description.

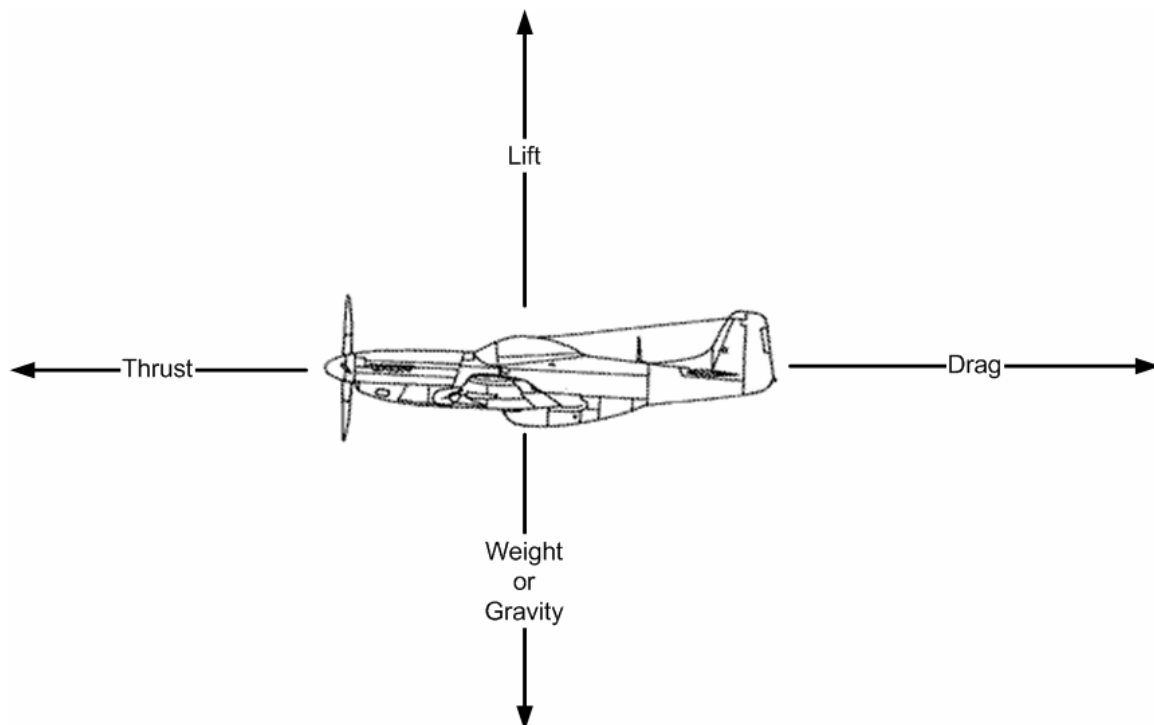


Figure 4

Lift

Lift is created mainly by the wings. The air under the wing gets delayed, while the air above the wing increases with speed. **Bernoulli's Theorem** states that if a fluid increases in speed its pressure decreases. Air essentially is a fluid. The delayed airflow below the wing is much higher in pressure than the low pressure above, and gives us lift. Generally as airspeed increases, so does lift. As **Angle of Attack (AOA)**, increases, the air below the wing becomes even more delayed, the air above increases in speed, and downwash increases, therefore total lift increases. As AOA increases to a certain point the Laminar or smooth airflow above the wing becomes more and more turbulent and the airplane starts to mush as there is little or no smooth air flowing over the control surfaces. This increases to a point which is called the **Critical Angle of Attack**. Lift is at its peak at this point, and further increase of AOA decreases lift as the airplane stalls. AOA is the angle in which the wing meets the **Relative Wind** which is parallel to the direction of flight (Figure 5). Lift opposes weight.

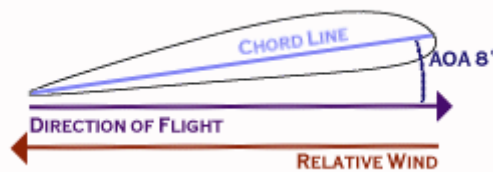


Figure 5

Gravity or Weight

Gravity is the natural attraction of masses. The larger the mass, the greater the pull is. The earth's acceleration of gravity is **32.2ft/sec²**. This means that a falling object will accelerate at a rate of 32.2ft per second, per second in a vacuum. Drag can slow this acceleration though, and the point where weight equals drag is called **Terminal Velocity** and the falling object remains at a constant speed. Gravity is perpendicular to the horizon. Gravity opposes Lift. See above.

Thrust

Thrust is power from the engine. It acts through a line called the **Thrust Datum** and is controlled by the throttle and propeller controls. It opposes drag.

An airplane's propeller creates thrust in the same way its wings create lift: air is deflected backward, so the propeller (and the aircraft) moves forward. The more powerful the engine (and the bigger the propeller), the greater the thrust, and the faster the airplane can fly.

Thrust is also the most important factor in determining a plane's ability to climb.

Drag

Drag is the rearward-pulling force due to the natural resistance of the air that opposes thrust. **Drag: rate of energy loss from the resistance of air.** As an aircraft passes through air, it gets stirred up, and heated slightly, and this energy disperses in the air until it becomes immeasurable. As speed increases so does drag. There are two main components of drag: parasite drag and induced drag.

PARASITE DRAG

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Parasite drag is caused by friction between the air and an airplane's structure. The more things there are sticking out into the airflow (antennas, landing gear, bombs, etc.), the higher the parasite drag. Your plane is designed to have as little parasite drag as possible, but the faster you go, the more there will be.

INDUCED DRAG

As you increase the angle in which the wing meets the airflow, called **Angle Of Attack**, lift pulls an airplane upward and backward. The upward component of lift is called "effective lift"; the backward component is called "induced drag." Effective lift counteracts weight to keep the airplane flying. Induced drag counteracts thrust and slows the airplane down. The slower you go (the bigger the angle of attack), the greater the induced drag. Eventually, you'll need to add more power to generate the lift necessary to remain aloft.

Playing with induced drag:

You can understand how induced drag works by sticking your hand out the car window again. If you hold your hand relatively flat (at a low angle of attack), your hand gets pushed upward and slightly backward. As you increase the angle of attack, you'll notice an increase in both the upward force (effective lift) and in the backward force (induced drag). Increase the angle too much and your hand will stall.

A few words about torque:

"Torque" is a catch-all term used to describe your plane's tendency to yaw and bank in either one direction or the other at certain power settings. A fighter's powerful engine and big propeller make this effect very pronounced, especially when the throttle's on high but the airspeed is low (as during takeoff). To counter these turning tendencies, you'll need to use the rudder and ailerons, although torque can be used to your advantage in a dogfight.

What causes torque? Four phenomena--reactive force, spiraling slipstream, gyroscopic precession, and P factor.

Reactive force:

When the powerful engine of a fighter plane turns the propeller in one direction, there is an equal and opposite force that makes the plane roll in the other direction. When your throttle's high but your airspeed's low (as during takeoff), the plane will roll in a direction opposite to the rotation of the prop. This effect is most pronounced during acceleration.

Spiraling slipstream:

A propeller's spiraling slipstream (the air mass that the propeller propels behind it) hits one side of the tail and causes the nose of the plane to yaw (rotate left or right around the vertical axis) in the same direction that the reactive force causes it to roll. The result is an even stronger tendency to turn.

Gyroscopic precession:

Because it's big and spins rapidly, your plane's propeller behaves like a gyroscope. This makes it subject to the effects of gyroscopic precession. When a force acts on a gyroscope, the gyroscope behaves as if the force were applied at a point 90 degrees in the direction of rotation. If your plane's propeller turns clockwise (viewed from the cockpit), then when the tail comes up on the takeoff run--the nose goes down--and gyroscopic precession makes the plane swerve to the left.

P factor:

A propeller is a bunch of small wings moving around a crankshaft. Each propeller blade produces a certain amount of thrust. When an airplane is flying at a high angle of attack, the downward-moving propeller

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blades have higher angles of attack and produce more thrust than the upward-moving blades. The result is asymmetric propeller loading--or P factor--which creates a yawing motion.

Drag is said to be the price we pay for lift. In level flight, Induced Drag is minimized at high speeds, and increases as speed decreases. Altitude is more valued than speed, because of the sharp increase in Parasite Drag at high speeds, but with a maneuvering airplane, both major forms of drag can be high. For example, an airplane at high speed pulling high Gs.

Positive and Negative G-Forces

As noted above, G-forces begin to have an effect as soon as you start executing high-speed maneuvers and quick changes in direction. The G stands for gravitational and 1G is the basic force of the attraction exerted by the earth. If you fly a tight, high-speed turn, your body cannot keep up with the rapid movement, and you will be forced in the opposite direction by a multiple of the force of attraction. If positive G-forces become too intense, you can blackout or even lose consciousness.

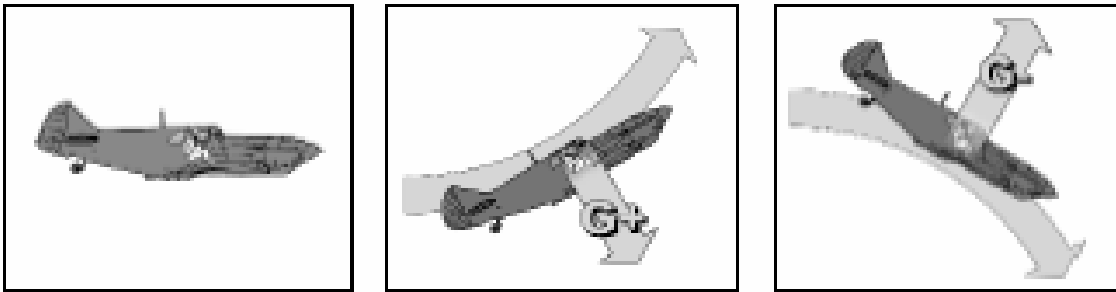


Figure 6

If you force your aircraft downwards out of level flight at high speed, you may experience the effects of negative G-forces. You will be lifted out of your seat and will be weightless for a short period of time. If you make the downward maneuver too extreme, blood will rush to your head and your vision will become tinged with red. The human body can deal with positive G-forces better than with negative Gs.

When playing Aces High, if your screen goes black or red in mid-flight, this probably has to do with the effects of excessively high positive or negative G-forces (Figure 6).

Energy

What is energy? Basically, to a fighter pilot, energy is life! Energy, for a fighter pilot is **speed, altitude, and fuel**. As an airplane climbs, it gains altitude, and if airspeed is constant, that energy is coming from **Power: the rate of doing work** or rate of energy addition to the system. As an airplane accelerates in level flight, it gains airspeed or energy and if it decelerates loses energy. Altitude and Airspeed are related. One can be transferred into the other. If you lose airspeed, you probably gain altitude; lose altitude you gain airspeed but total energy is the same. Controlling both altitude and airspeed is done using both the elevator, and throttle control, usually both together. We lose energy to drag. See Above.

"Throughout the story of air fighting runs the quest for height, for the fighter on top had control of the air battle." **Air Vice Marshal J. E. "Johnnie" Johnston, RAF**

With this in mind, it goes to show why the fighter pilot valued speed and altitude. Altitude energy has the potential to be transferred into speed energy, and vice-a-versa. Beware of the Hun in the Sun!

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Turns

Turning an airplane is almost like turning a car, as you turn your automobile, you are pushed against the side of the car to the outside of the turn. This pushing force is caused by **Inertia**. The car and your body want to continue in a straight path at a constant speed, unless acted upon by an unbalanced force. The force of the wheels turns the car, while the force of the car is turning you, pushing you into the side of the car. This is the reason you must wear your seatbelt. If your car suddenly stops, there is nothing to push back on you, a force, to slow you down.

Likewise an airplane needs an unbalanced force in order to turn. The four main forces in flight, lift, thrust, weight, and drag. What force is the easiest for the pilot to control? The answer is lift. By rolling and pulling, the pilot can direct his **lift vector** almost anywhere he wants. He can also increase its magnitude by increasing AOA. To turn, the pilot rolls his aircraft, directing his lift vector to one side. This causes an unbalanced force to the side to turn the airplane. But lift is needed to counteract weight. How can you direct your lift vector to side and maintain level flight? The answer lies with something physicists call **vector addition** which is a very simple concept to grasp. As the pilot rolls, more and more lift is needed to maintain level flight. This is because the pilot needs to maintain a 1g vertical component of lift to counteract weight. This "cancels out the effects of gravity". If the pilot rolls 90° so that his lift vector is perfectly horizontal, he is unable to cancel out gravity, as there is no vertical component of lift. The vertical component of lift counteracts gravity; while the horizontal component turns the aircraft also called **Radial G**. Turning involves all four control inputs. The pilot rolls his aircraft to direct his lift vector to the side. He adds rudder to counteract the effects of aileron drag. He pulls back to increase AOA and which in turn increases lift. Lastly, he adds a throttle to maintain airspeed, due to the increase drag caused by increased lift. It also increases acceleration, giving you more G potential.

"Know and use all the capabilities in your airplane. If you don't, sooner or later, some guy who does use them all will kick your ass!" **Lieutenant Dave "Preacher" Pace, USN**

Stalls, Spins and Rolls

Stalls

Many people believe that an airplane only stalls at a certain speed, and that when it stalls the airplane falls out of the sky. This is far from the truth. **An airplane can stall at any attitude and any speed, as long as the Critical Angle of Attack is exceeded.** Angle of Attack (AOA) as talked about above is the angle in which the wing meets the relative airflow. As AOA increases both lift and drag increase until drag exceeds lift and lift drops off. Any further increase in AOA and the airplane becomes more stalled drag increases and lift decreases. The airplane does not suddenly fall out of the sky like many may believe.

There are two types of airflow over a wing **Laminar** (smooth) and **Turbulent**. They are separated by a transition point or **Separation Point**. This Separation Point, moves forward as angle of attack increases giving us less and less Laminar airflow over the wing which is needed to produce lift. As the turbulent airflow moves forward, we get the control problems and buffeting most people associate with a stall because of the circular motion of **Eddies**. At slower and slower speeds at level flight, a greater AOA is needed to create enough lift to support the airplane. At a certain speed, called the **Stalling speed or V_{st}** , the airplane in level flight will stall as the pilot increases AOA to maintain level flight. Most airplanes do not have AOA indicators so the only reference is the **Airspeed Indicator (ASI)** but one must remember that **the airplane can stall at any speed as long as the Critical AOA is exceeded**. This is very important to a fighter pilot because of the rapid control movements and maximum performance that is needed for certain maneuvers. Stalling AOA is usually around 20° depending on aircraft design.

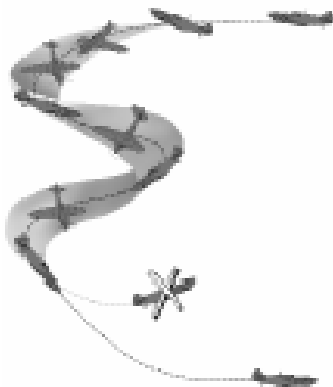
As an airplane turns it offsets its lift to the side, using lift to turn in around the corner. Greater the bank, the

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more lift is required to maintain level flight and to kick the aircraft around the turn. Therefore the pilot increases AOA. A fighter pilot may even stall the aircraft in a turn to get maximum lift, and maximum turn performance. Since drag also increases, the airplane will slow down to a point, in a Sustained Turn, but more about this later.

Spins

Spins are defined as **Autorotation**. Autorotation develops after an aggravated stall. In a spin, one wing is stalled more than the other and the aircraft spins around the more stalled wing. The downward moving wing has a greater AOA than the upward moving wing and more Induced Drag. This causes Yaw, Pitch, and Roll movements all in one, and develops into a vertical decent spinning around the more stalled wing, sometimes called a flat spin. An **Incipient Spin** is the first stage of the spin, prior to the vertical decent. The **Developed Spin** is when airspeed remains constant and the airplane spins in a decent. The **Recovery** is performed by the pilot by pushing forward on the stick to de-stall the aircraft with simultaneous rudder in the opposite direction of the spin. Spins are fun, and easy to recover from. The easiest time to recover is in the Incipient Stage. If you're proficient in stalls and spins, you can recover from them instantaneously and to an observer it would only look like you rolled the aircraft slightly. Control a stall and you will not spin at all. The best way to do this is to neutralize ailerons, and use rudder to control. If you add aileron, you can aggravate the stall and perform a Snap Roll, and to an unsuspecting pilot, can be devastating and could mean loss of the advantage or loss of life in air combat.



If spin cannot be halted in the Incipient Stage, the first step in recovering is to look outside the cockpit and determine the direction of the spin. When you have determined the direction of the spin, you can begin the spin recovery operation. Move the stick to the neutral position. Under no circumstances should you operate the ailerons (by moving the stick to one side or the other) – this only makes the spin worse! Instead you should apply maximum rudder in the direction opposite that which the plane is spinning. After that, wait for the plane to stop spinning. If you can't see any improvement, try again.

If the plane stops spinning, then recovery from the spin is almost complete. Push the stick forward slightly to establish a normal dive until the plane has picked up sufficient speed for the control surfaces to start reacting again. You can then pull back slowly on the stick to end the dive

and return to normal flight! Use extreme caution during the pullout since too aggressive a maneuver can reinitiate the spin.

A handy acronym to remember is **PARE**:

- P** Power off
- A** Ailerons neutral
- R** Rudder opposite of the direction of spin
- E** Elevator forward to brake the stall

1. Reduce the throttle.
2. Center the stick--that neutralizes
3. Apply full rudder opposite spin.
4. Relax the back-pressure on the angle of attack and break the stall. (In some planes you'll have to "pop" the stick forward sharply.) As soon as the rotation stops, neutralize the rudder.

You may be alarmed by how much height you have lost. If you do happen to fall into a spin at low altitude, time is of the essence and you should bail out without further efforts to recover. Alternatively, you may find

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that the maneuver described above doesn't achieve a recovery from the spin. In some cases you may have fallen into a flat spin, a particularly unpleasant variety in which you find yourself spinning around your yaw axis. Recovering an aircraft which has fallen into a flat spin is nearly impossible. At that point, abandoning the plane is by far your best option.

Rolls

Aileron Roll

Purpose:

Rarely used on its own in battle, the aileron roll is worth learning because it's part of many combat maneuvers (Figure 7).

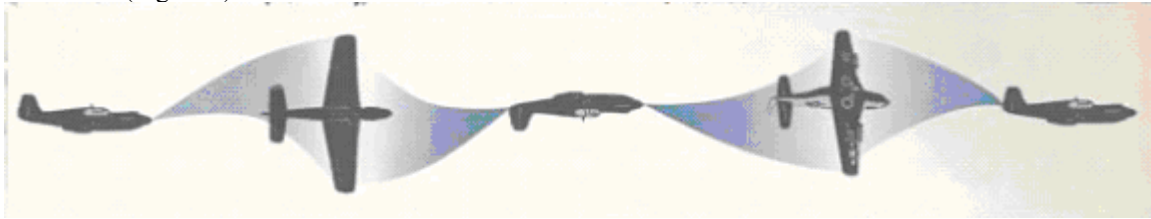


Figure 7

To perform:

Raise the nose slightly. Pick a reference point on the horizon, then smoothly push the stick all the way to one side and hold it there. Use the stick to keep the nose on the reference point, then center the stick as the wings approach level again. Practice stopping the roll partway through for a half-roll. That's an easy way to get inverted quickly.

Barrel Roll

Purpose:

This basic aerobatic maneuver can be used in combat to shake an enemy from your tail. You'll corkscrew through the sky and lose airspeed, causing your opponent to fly right past you (Figure 8).



Figure 8

To perform:

Raise the nose, bank sharply left or right, and gently pull back on the stick to maintain the roll. Hold the sideways-pressure on the stick as you roll inverted, then center it when you return to level flight. During this

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move, the stick is essentially in the left- or right-rear position. The nose will draw a circle on the horizon instead of rotating around a point, as in an aileron roll. If you do a barrel roll perfectly, you won't lose any altitude.

Loop Over

Purpose:

Commonly referred to as a "loop," this move is a way to make a vertical circle in the sky and end up back where you started (Figure 9). Practicing loops will help you get accustomed to unusual pitch attitudes, rapidly changing airspeeds, and the effects of G-forces.

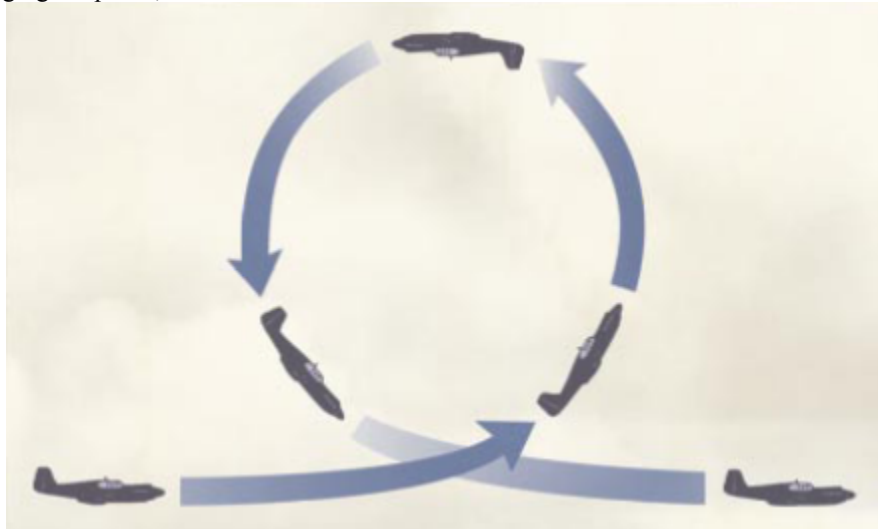


Figure 9

To perform:

Make sure you have enough airspeed or you'll stall at the top of the loop. Slowly pull back on the stick. As you climb, you'll lose airspeed. Once inverted, ease off on the stick. As you start down the back side, add a little back-pressure and reduce the throttle.

Tip: Watch your left wingtip to see where in the loop you are.

Loop Under

Purpose:

A loop under is basically a reverse loop over, but it's more useful in combat since you gain speed early (Figure 10). Your airspeed has to be high to do a loop over, but your plane has to be high to do a loop under--or you'll hit the ground! Make sure you have enough altitude before you try this one, and don't pull too many negative Gs. The negative G-loads most aircraft can handle are half that of the positive G-loads.



Figure 10

To perform:

Do a half-aileron roll to get inverted, and then pull back on the stick smoothly. You'll gain airspeed, which will let you start up the other side of the loop. As you start to climb, keep back-pressure on the stick. You'll slow down as you become inverted. Push forward on the stick slightly to stop the loop, and then finish the maneuver with another half-aileron roll. You should end up flying in the same direction and at the same altitude as when you started.

Basics of Air Combat

Air Combat may seem very complicated to you. In fact, it is quite simple. All one requires is a good knowledge of the basics. The basics provide the pilot with a way to learn, and gain experience. The basics are so simple, yet so important. If you are reading this we assume you have read about **The Physics of Air Combat**, and have experimented with your aircraft of choice to find its envelope. Experimenting is probably the best way to learn the techniques of fighter combat. It should be noted that the times given in each extended-trail figure does not correspond to any exact measurement of time, but are only used to compare relative positions at any moment in time. It should also be noted that each figure is not to scale, and are used only to explain the basic principals of air combat.

"...a fighter pilot must be free to propose improvement in tactics or he will get himself killed"

Commander Randy "Duke" Cunningham, USN

Angles

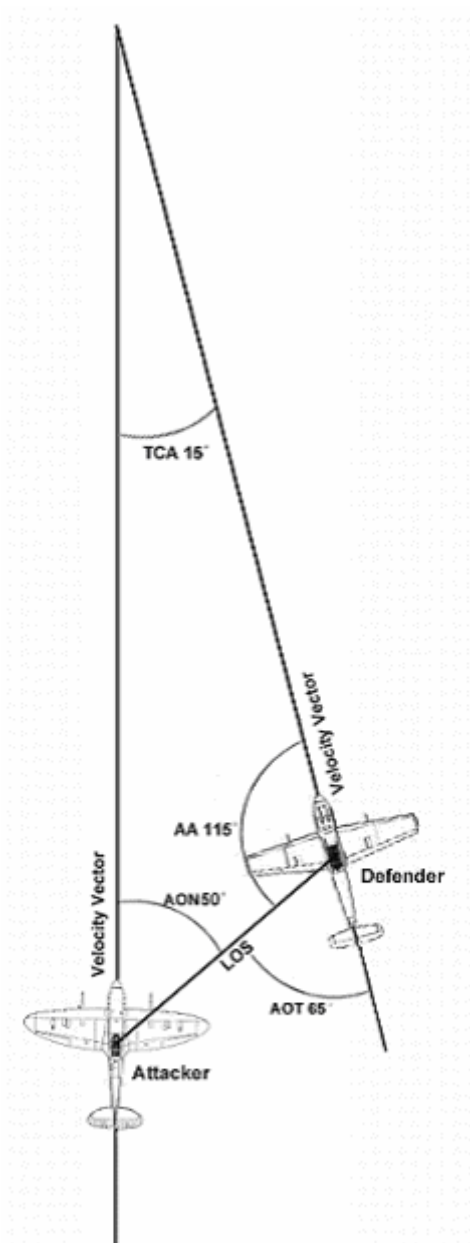
There are many angles in air combat that the fighter pilot should be able to recognize during and air to air engagement. Angle advantage is defined as the pilot who is able to get his nose on his target first due to their relative positions, and who is able to press an attack longer than their opponent.

In Figure 11, the Supermarine Spitfire (Attacker) on the bottom, obviously has the angular advantage, because it can get its nose on its target first by decreasing **Angle Off the Nose (AON)**, which is basically the O'clock position of the target, by turning 50° while the Messerschmitt 109 (Defender) has to turn 115° in order to neutralize angles. One determines the angular advantage by comparing AON with **Aspect Angle (AA)**. AA is the angular difference between the **Line of Sight or LOS** and the targets velocity vector, or simpler, the difference between the targets "o'clock" position and the targets nose. If you are looking directly at a target that is pointed directly away from you in any clock position, the targets AA is 180° and directly towards you, AA is 00° regardless of your nose position. If you are looking at a target that is flying perpendicular to your LOS, AA is 90° .

Comparing AA to AON is only half the picture; it only determines who can get in a shot first. To actually get into a better position, one must decrease **Angle Off the Tail (AOT)**. Being behind the enemy traveling in the same direction is the optimum position because it lessens **Track Crossing Angle (TCA)** decreasing the rate the target moves across your field of vision, called **LOS rate**, lessening the possibility of the attacker losing its angular advantage. Another advantage is easier to predict the targets maneuver when he is in front of you on his tail do to the targets lack of rearward visibility.

To gain the advantage using angles involves quick reactions, a lightly wing-loaded airplane, and skill in manipulating your maneuvers and even your targets maneuvers. Angles in a dogfight constantly are constantly changing with maneuvers. Describing angles statically is simple; applying it to motion is difficult and requires much practice. Simply maneuvers like a roll or a turn reversal can change angles rapidly. A fast flying airplane can have the advantage, but lose it by simply flying past its target. You see a lot of fighter pilots using their hands to describe dogfights. Try this yourself to dissect and analyze your flying. You will find that it's not as hard as it seems to figure out who has the advantage, how to retain it, or how to achieve it.

Figure 11



Lead, Pure, and Lag Pursuit

The **Lead Pursuit** is usually used to **close range** on the target or to pull ahead of the target for a gun shot. Using a Lead pursuit, even a slower aircraft can close on a faster target, by "**flying across the circle.**"

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Basically it is performed by pulling your nose or velocity vector ahead of the target, which is limited by your aircraft's frontal view. Use a Lead Pursuit, only to close the range, because it results in an increasing AA, AOT, and AON a **decreasing angular advantage**, in the targets rear hemisphere.

The **Pure Pursuit** is used to **close range** also, by pointing your nose on the target, only if your **Angle Off the Tail or AOT** (Figure 3) is not low and if the target doesn't have a significant speed advantage. Pure Pursuit results in a much slower closure rate and also a much slower increase in AA and much slower angular loss then the Lead Pursuit.

The **Lag Pursuit** is used to **stop or slow closure** on the target. It results in a steady or decreasing AOT. A faster fighter can use this tactic to remain in the rear hemisphere of a much slower, and tighter turning target. The attacker reduces turn rate by pointing his nose behind the target. It also allows the attacker to accelerate and **gain an energy advantage** over the target. The Lag Pursuit also makes it difficult for the Target to maintain sight of the attacker, and can usually cause the target to reverse and turn into the attacker, which can place the attacker at high AOT, and in a lead pursuit.

Gunnery

Gunnery is complicated but if you understand some of the basic techniques it can be much simpler. First you must estimate your LOS rate, and estimate the targets range. The best way to do this is by using the circle on your gun sight, which may be set for different ranges. This circle is set for a given wing span at a given range. For example, the circle could be set for a wingspan of 35 feet at 200 yards. When the targets wingspan equals the diameter of the circle, the target is at 200 yards. This is to determine the TCA you need for your bullets to meet the target, called pulling lead. The amount of lead required for you to pull is related to the targets AA and target crossing speed. The faster the target moves across your field of vision the more lead is required. Now its time for you to take the shot, you must know the average bullet speed, called bullet **Time Of Flight or TOF**. You want to fire ahead, so the bullets meet the target by estimating the targets crossing rate (by using **LOS** rate), AA, bullet **TOF** and range. Say the phrase "**In range, in plane (of maneuver), and in lead**" when each are satisfied. Then you may take the shot.

"Aerial gunnery is 90 percent instinct and 10 percent aim." Captain Frederick C. Libby, RFC

Another factor to consider is gravity drop, if your bullets are in the air for a TOF of one second they would have dropped 16 feet because the acceleration of gravity is **32.2ft/sec²**. Maneuvering and target maneuver are another thing to consider. If the target moves at all, all your calculations are void and you need to correct your aim. All these calculations may seem complicated but they are quite natural.

The weapon system is another thing to consider. The weight of fire, projectile type, location of the weapons, convergence, and number of rounds. In order to down an enemy aircraft, the time allowed for a shot must exceed the time required. This is where tactics and ACM come in. The weight of fire and projectile type usually equals the lethality of the weapon. The greater the weight the slower the rate of fire generally is.

The location of the weapon systems are normally forward facing in fighters, usually in the wings or in the nose. Guns in the nose are usually easier to aim, however if they fire through the propeller disk, they require synchronization which slows the rate of fire, which means less hits per TOF. Wing mounted guns require no synchronization and therefore do not suffer from the problems associated with nose mounted guns. However, they do have problems of their own.

Convergence

Wing mounted guns are usually set to meet at a point in space to make the weapons easier to aim. This point, called the **convergence**, is usually set to get the maximum lethality at an optimal range. In the

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example below (Figure 12), an aircraft with wing-mounted guns has its convergence set to 600 yards. It is firing at an aircraft that is 300 yards away. The two banks of guns are hitting different places on the enemy aircraft. This is not the optimum configuration. In this example, the convergence is set too high for this attack.

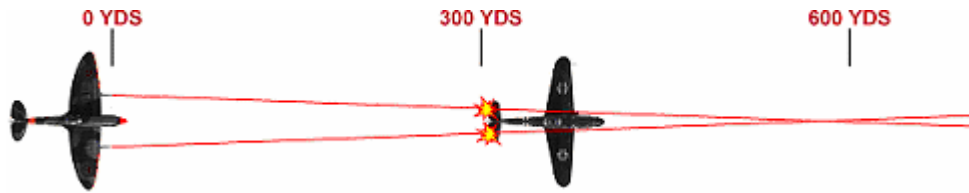


Figure 12

In the next example (Figure 13), the aircraft with wing-mounted guns has its convergence set to 300 yards. The aircraft that is being fired upon is only 300 yards away. The two banks of guns are hitting the same place on the enemy aircraft. This is the best configuration to inflict damage on the enemy.

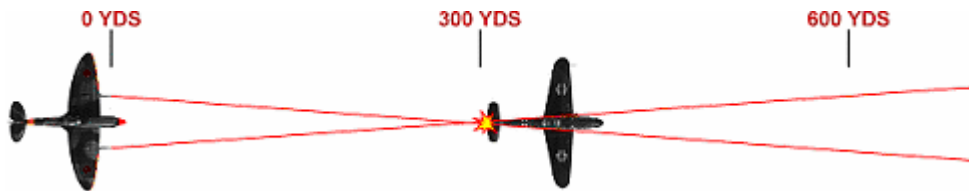


Figure 13

The example below (Figure 14) is probably the worst scenario. Here, an aircraft with wing-mounted guns has its convergence set to 300 yards. It is firing at an aircraft that is 600 yards away. The two banks of guns are hitting widely different places on the enemy aircraft. If the enemy was any further away, the two streams of fire, might actually pass either side of the enemy without hitting. If you have to fire at distances of double (or more) the set convergence, try to aim slightly to one side of the enemy. That way, one bank of guns might hit the enemy aircraft.

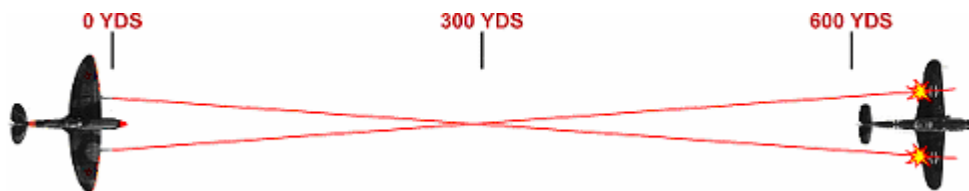


Figure 14

The last example (Figure 15) shows how little effect convergence has on an aircraft with nose-mounted guns. This aircraft has its convergence set to 300 yards. It is firing at an aircraft that is 600 yards away and still manages to achieve a fairly concentrated stream of fire on the enemy aircraft.

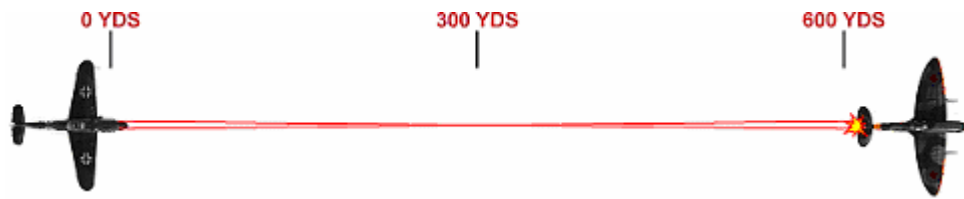


Figure 15

In Figure 16 below, notice the effect convergence has on the lethality zone. The bottom aircraft has a larger lethality zone, indicated by the vertical black lines, than the aircraft at the top.

Figure 16

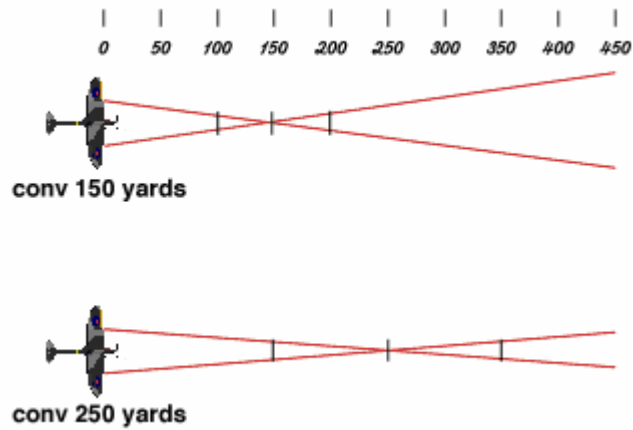


Figure 17 below shows the procedure used to set the convergence for the guns of a P-51D Mustang fighter.

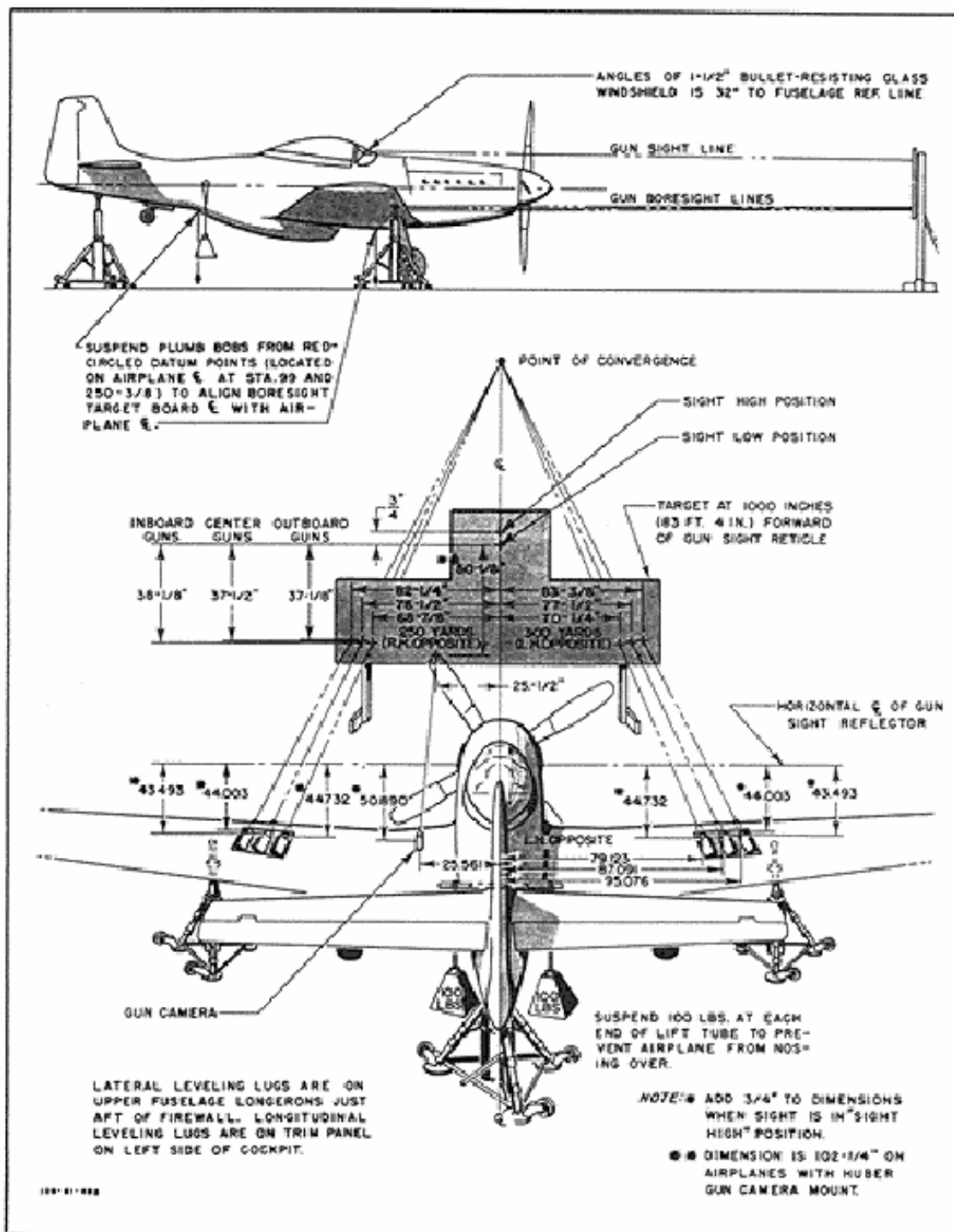


Figure 17

Tracking Shots

A steady target makes an easy shot. Line up with the target, turn with him so that he remains fixed in your windscreen, estimate lead required and just lay it on him. This is a Tracking Shot. Rarely does this ever happen if your target is paying attention to what is going on, but occasionally your target could be "asleep."

Snap or Deflection Shots

With Snap Shots, the target is within your aim for only a brief few seconds allowing you to get a few rounds off. You find this type of shot more often when your target is alert or in a high G maneuver. Snap Shots are sometimes called deflection shots, because of the high angle involved.

"I am not a good shot. Few of us are. To make up for this I hold my fire until I have a shot of less the 20° deflection and until I'm within 300 yards. Good discipline on this score can make up for a great deal."

Lt.Col John C. Meyer, USAAF

The best position to attack a plane is from 6 o'clock astern with a deflection no greater than 20° degrees. What does "a deflection no greater than 20°" mean? Assuming that 6 o'clock astern equals zero degrees then a 20° deflection would be 20° degrees from that point or from 5 to 7 o'clock. The same applies to a frontal attack (11 to 1 o'clock) but since the aircraft are approaching each other at high speed the optimal time to fire is very short.

Once the angle of deflection goes beyond 20° degrees a number of factors come into play and the pilot has to judge his speed, the speed and direction of the enemy and make the appropriate adjustments to his angle of attack before firing. For instance, if he is attacking from the 9 o'clock position, it would be necessary to "lead" the enemy aircraft in order to hit it. In other words he shouldn't shoot directly at the airplane because by the time the bullets get there the airplane will have flown ahead of that point. He should fire at a point in front of the enemy airplane so that by the time the bullets get there the enemy plane will also have reached that point. Combine this with factors such as whether he is above or below the enemy airplane, approaching from in front or behind and whether the enemy is taking evasive action and you begin to understand some of the difficulties in performing a successful snap or deflection shot.

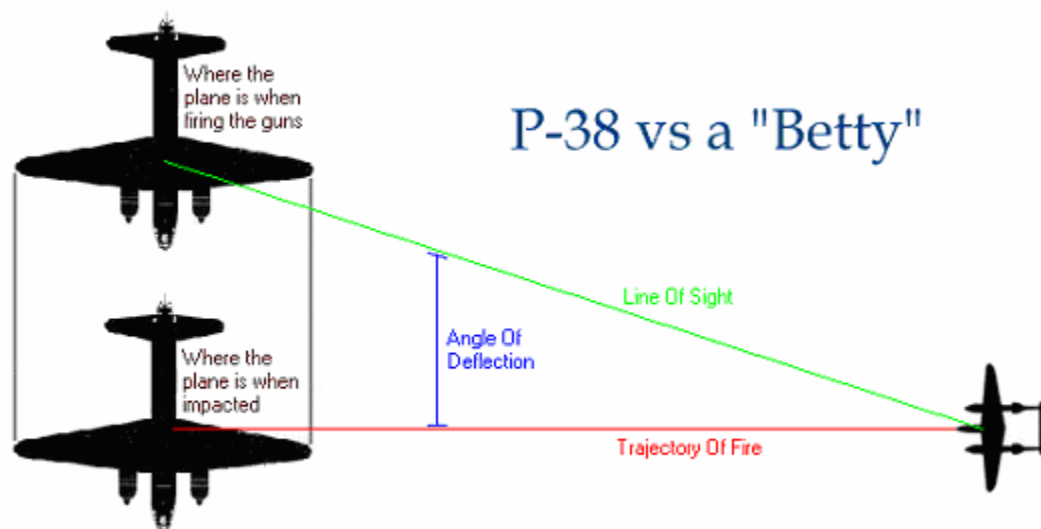


Figure 18

Another factor that came into play was something called the "cone of fire". All fighters with machine guns in the wings have those guns aligned so that when they fire all the trajectories will converge at a point about 200-300 yards away (see Convergence above). At this point will be the highest concentration of bullets. Beyond that the bullets start to diverge and lose effectiveness. In addition, since the wings were mounted below the center-line of the airplane, it is necessary to "pull the nose through the enemy plane" when firing thereby losing sight of the target while firing. The pilot then has to drop the nose in order to reacquire the target and see if any damage had been done.

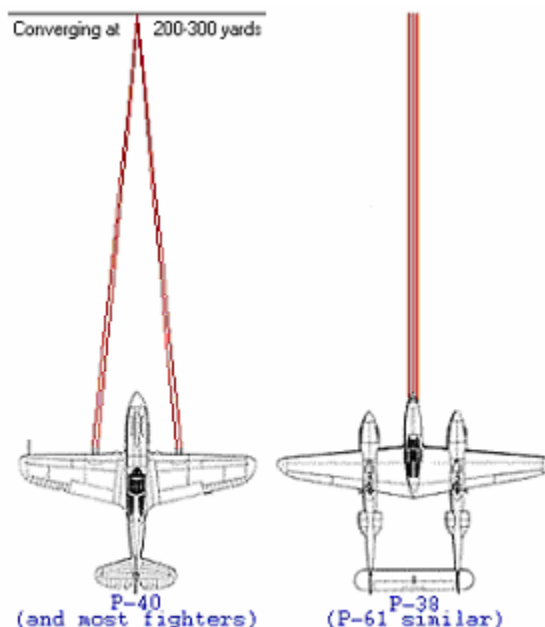


Figure 19

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The one plane that is different is the P-38 Lightning (Figure 19). All the machine guns are mounted close together in the nose and therefore its cone of fire is fully concentrated all the way out. Taking all this into consideration, you can see that it is incredibly difficult to shoot down another warplane. That's what makes the accomplishments of the aces so remarkable.

If you think gunnery is too hard for you, there is one last thing you can do. Just get in close and just lay it on! It is the most effective technique.

"I opened fire only when the whole windshield was black with the enemy... at minimum range...it doesn't matter what your angle is to him or whether you are in a turn or any other maneuver." **Colonel Erich "Bubi" Hartmann, Luftwaffe**

Theory of Lead

To understand clearly the theory of lead it must be remembered that to obtain a hit, the bullet and the enemy airplane must arrive at the same point simultaneously. It takes a certain period of time for the bullet to travel the distance between the two airplanes. The center line of the bore of the gun, if extended, should not pass through the target, but should strike at some point along the apparent line of flight of the target at an appreciable amount in front of the enemy airplane.

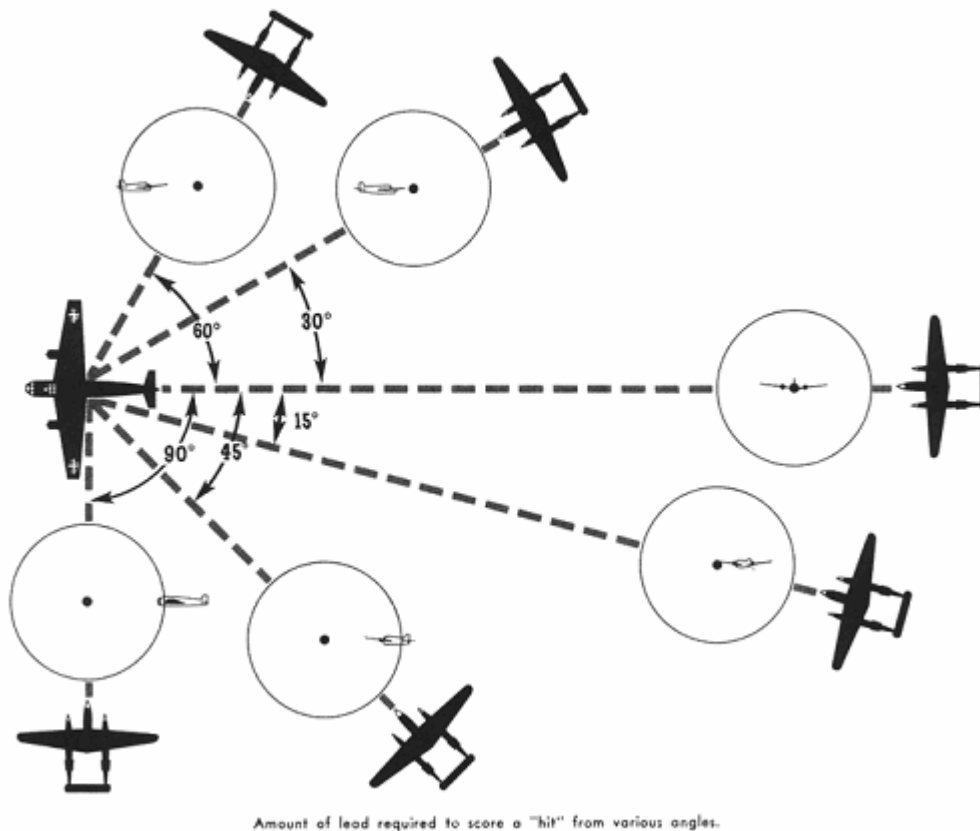
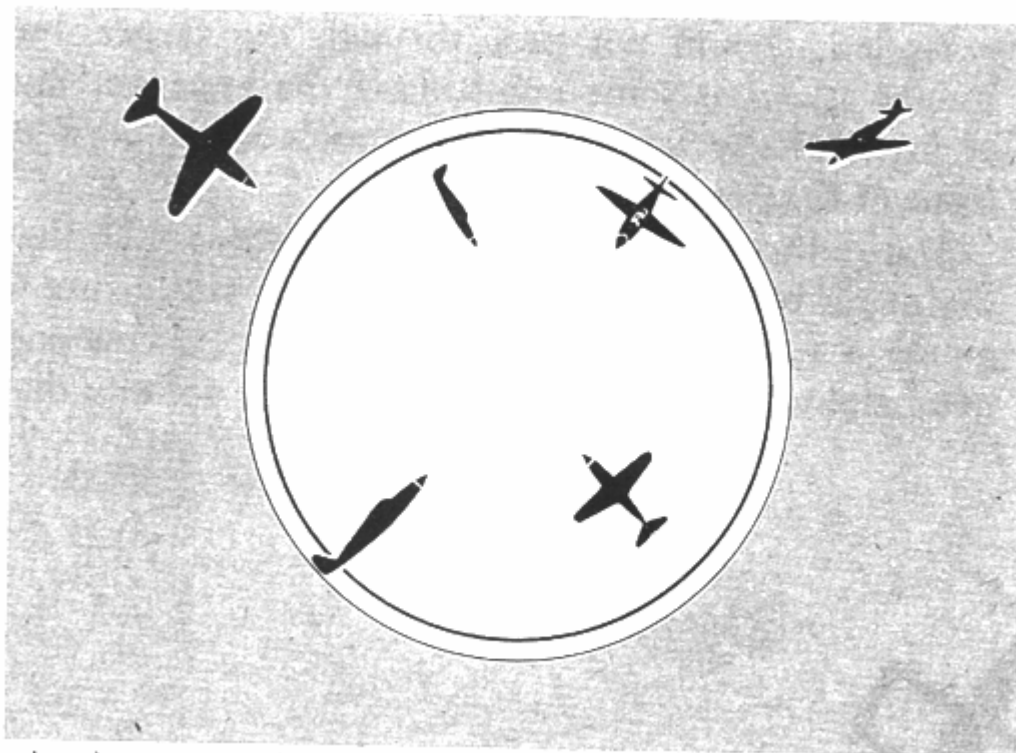


Figure 20

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The radius of the larger ring of a sight is such that the angle between the edge and center of the ring is, equal to a definite lead angle. In the case of ring and bead sights the gunner's eye must be a definite distance (usually 8 inches) from the ring. This angle may be expressed in terms of mils, or in terms of miles per hour of relative speed perpendicular to the line of sight. That is, a 150-mile-per-hour ring establishes the proper lead angle at the gunner's eye when the target is traveling at a relative speed of 150 miles per hour perpendicular to the line of sight. This is exactly true for one particular range only, usually 400 yards. However, if the relative speed perpendicular to the line of sight is constant, then the change in the lead angle is small as the range changes.

Reflex Sights



Lead required when target approaches from various angles.

Figure 21

The basic principle of all optical sights is the projection of the image of a reticule of some form out to infinity so that the gunner can aim the gun by moving the sight until the reticule appears to be superimposed on the target. The reticule size is computed so as to be an aid in range estimation. With this sight it is not necessary for the gunner to hold his eye very steadily at a fixed distance from the sight while lining up a pair of reference points with the target. When the distance between the gunner's eye and the sight is too great, it is possible that part of the reticule will not be seen. This is purely a function of the size of the reticule and the physical diameter of the lens system used and does not affect the use of the sight so long as the reticule can be seen. When the complete reticule can be seen, it can be used to estimate lead or range.

NOTE: Check your sight lamp before take-off.

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DISTANCE TRAVELED BY TARGET AIRCRAFT BETWEEN SUCCEEDING PROJECTILES

(Armor Piercing Ammunition – 90° Deflection Shooting)
Computation based on 300 mph speed of target

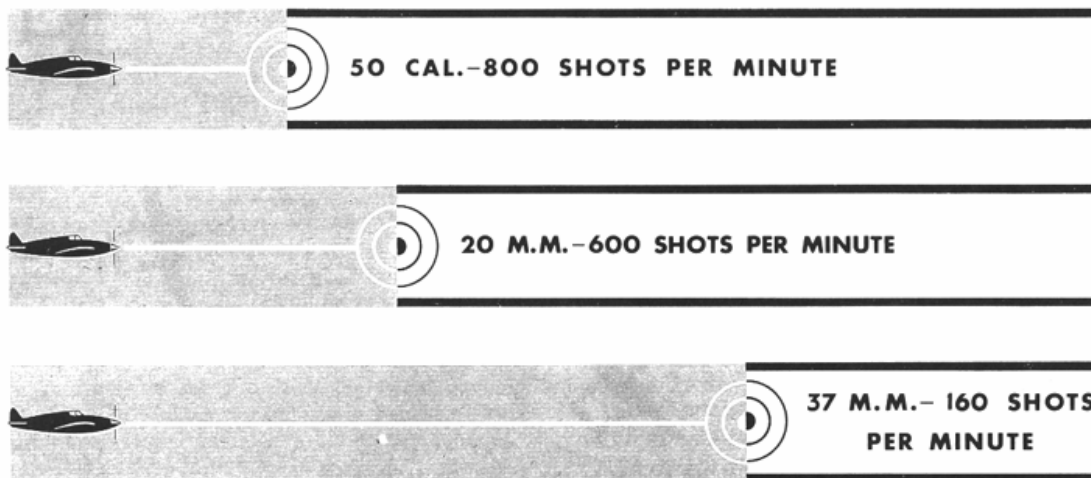


Figure 22

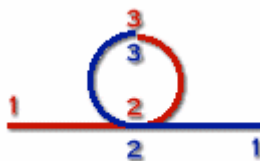
REFERENCE: Technical Order No. 11-35-1, dated September 18, 1942.

Merges

One-Circle Turn

In the One-Circle Turn (Figure 23), two opposing aircraft approach head on. At the point in which they meet or merge, both turn in the same direction at Time 2 and continue the turn and meet head-on again, inscribing a circle as the name states. In figure 3.1, neither aircraft came out with an advantage at Time 3.

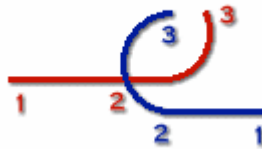
Figure 23



To win in the One-Circle Turn you can either turn tighter, bleeding off more energy than the target which he can use against you, or add separation or Turning Room (Figure 24). Turning Room allows for a **Lead Turn** or early turn towards the target and also prevents a possible collision, however, any Turning Room you can use the opponent can use also. If he is awake the merge will more likely be neutral. Generally the

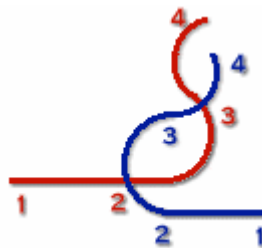
One-Circle Turn gives the greatest angle gain per knot of airspeed loss, and should generally not be used against a tighter turning target making the One-Circle Turn a contest of **turn radius**. In Figure 24, the blue aircraft added some Turning Room to the bottom of the page at Time 1; lead turned at Time 2 with almost 90° advantage. The aircraft in blue pressed this advantage and come out with 90° on the target at Time 3. The aircraft in the blue can reverse his turn the other way at Time 3 with the advantage, and a possible shot.

Figure 24



Because of the attackers high angle on the target, he will likely overshoot before time 4 (Figure 25), allowing the target to reverse his direction of turn and begin the Flat Scissors, covered below in the ACM section, which is a contest of pilot ability, turn radius, and quickness of reversals. If the defender continues his direction of turn at Time 3, the attacker will overshoot, but will be in a lag pursuit behind the defender maintaining his advantage.

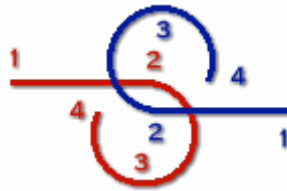
Figure 25



Two-Circle Turn

In the Two-Circle Turn (Figure 26), two opposing aircraft approach head on. At Time 2 they merge turning into each other and continue the turn, tracing two circles in the sky. At Time 3 notice that both aircraft are on parallel yet opposite headings meaning no advantage has been gained. If they both continue turning they will meet again head on with no advantage gained.

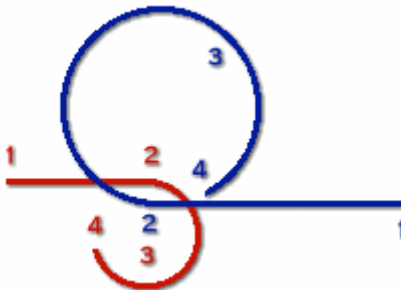
Figure 26



To win in the Two-Circle Turn one must turn faster than the opponent. To do this he must keep his speed up, pulling maximum G. As speed called **Corner Speed** is very important to a fighter pilot. At this speed, limited by structural or pilot factors, the pilot pulling maximum G will be turning at maximum rate. Since most aircraft are unable to maintain speed at high G the pilot may want to lower his nose to obtain more speed for the Two-Circle Turn.

In Figure 27, the aircraft in blue is at its corner speed while the aircraft in red is well below its corner. Both turn into each other at merge, pulling maximum attainable G. The red aircraft is slower and has a corresponding advantage in turn radius however it is of little value to it. Therefore the Two-Circle Turn is a contest of turn rate. At Time 3, the aircraft in blue with a faster rate of turn is able to gain some angle advantage on the opponent and continues to gain. At Time 4 the blue aircraft has 90° of advantage on the red fighter. The difference in turn radii is exaggerated but still serves its purpose of showing how a turn radius advantage is of little value in the Two-Circle Turn. Although the Two-Circle Turn allows a fighter with a faster turn rate to gain on an opponent it is not as efficient as the One-Circle Turn. By Time 4 both fighter could be very slow, resulting in less maneuverability.

Figure 27



Basic Fighter Maneuvers

BFM, Basic Fighter Maneuvers, is just that...basic offensive and defensive maneuver flown by one aircraft against a single opponent. BFM is intended to teach the basics of 3D maneuvering with emphasis on spatial relationships and control of airspeed...which is a fancy way of saying that the maneuvers are intended to keep your opponent out in front of you or, if he is behind you, the maneuvers are meant to deny him a firing opportunity, or even better, make him overshoot and become defensive. BFM is 1v1 set piece maneuvering to a desired end result.

ACM, Air Combat Maneuvers, is the next step in the building block concept of air-to-air training. ACM involves a pair of fighters solving a defensive or offensive problem being presented by a single opponent. ACM is 2v1 and involves the practice of initial defensive or offensive moves. As in BFM, the maneuvers are set piece, are begun from a visual set up, and are flown to a pre-briefed conclusion. ACM is not free play...the fighters follow a script to a desired learning objective using BFM maneuvers to defeat the single opponent.

ACT, Air Combat Tactics, is what most often referred to as “dog fighting”. The numbers of participants is not limited...everything from 1v1 to many v many. There is no script in that no specific objective is mandated. ACT involves the blending of BFM and ACM techniques into free play. DACT is Dissimilar ACT, meaning the opponents fly different types of aircraft. ACT is the final building block in air-to-air training.

Five Stages of Aerial Combat

1. Detect

Find the enemy before he finds you, so that you have the advantage of surprise. Most pilots who are shot down never see their attackers.

2. Close

Once you’ve detected the enemy, move into a position close enough to shoot him down without being discovered.

3. Attack

When you’re close enough to shoot the enemy, commence the attack. If you fire too soon you’ll waste ammunition, and he might see you coming. Remember: your weapons don’t move. To aim, you must move your entire plane and use a deflection angle. If you fail to defeat your enemy, you’ll need to maneuver.

4. Maneuver

Dogfighting is a test of skill in which each opponent tries to get into a position to fire.

Maneuvering means dogfighting. Many novice combat pilots think that dogfighting is the way all aerial combat occurs, but combat veterans will tell you that dogfighting should be avoided if possible.

If you’re successful at detecting, closing in on, and attacking your enemy, you won’t need to dogfight with him. You should maneuver when any of the following occurs after the attack:

- Neither side has gained an advantage during detection.
- The enemy sees and successfully evades during your closing.
- Your attack fails to down the enemy aircraft.

5. Disengage

Disengaging means putting space between you and the enemy so you are out of the fight. You can disengage on purpose or by accident. Be careful though: just because you want to leave doesn't mean the fight will end.

Air-To-Air Combat Strategies

Forget about the old "knights of the air" mythology. In air-to-air combat, it's fast, dirty work that is often over in seconds. The loser has usually lost before they knew what hit them. You must gain the dominant position above and behind the enemy through surprise or by the use of maneuvers.

General tactics

1. In the first pass, it is usually best to make an overhead attack from behind. In a situation where you are able to make an overhead attack from behind, but instead carry out an overhead attack from the front, maneuvering for the second pass will be comparatively difficult and you may end up in a disadvantageous position. Furthermore, if your altitude is insufficient, it is best to pursue from the lower rear rather than head-on.
2. In close combat, achieve mastery of those tactics which are your own strong points. After gradually reaching proficiency, you will discover your own characteristics in battle. When you fight with your favorite tactics, victory will be easy. When you become aware of these tactics, study and master them at once. When in battle, it is important to entice the enemy into your favorite battle tactics, and make them fight on your terms.
3. When you are suddenly head-on with the enemy, plan to be resolute in the attack. Never abandon the line of fire too soon to start maneuvering for the second pass.
4. During air combat it is essential to maintain altitude. However, do not mindlessly concentrate on the altitude, thereby making essential maneuvers impossible because your airspeed has dramatically dropped during a climb. It is particularly important to pay attention to selecting the opportune time to make changes of altitude and speed while approaching the enemy.
5. Air combat is generally easy against an enemy who is fighting and losing altitude. The enemy who fights while maintaining his altitude by skill in maneuvering at lower speed is formidable. (In a rough and tumble fight it is essential to maintain all your speed.) When you advance on a second enemy or when you go to the aid of an ally, keep in mind the fact that altitude is better than a stout heart.

Counter-attack

When you have been attacked by the enemy plane, unless the performance of the enemy plane is inferior or the pilot's ability very poor, it is difficult to regain your position in one counter-attack. However, always try to regain your position while continuing your counterattacks.

Disrupt the enemy's firing line as much as you can by diving. After avoiding their first pass, maneuver so that you will be under the enemy.

As soon as the enemy plane starts his run, start a steep dive immediately and cause the enemy's firing angle to be depressed. The enemy will break off the attack because his speed is excessive and firing is difficult; as soon as you see him pulling out, turn toward him and maneuver so that you are in pursuit.

When you find yourself under attack, use the following formulas for counter-attack:

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- Against the overhead attack from behind. When the enemy tries to make a run at you, gun your engine and avoid the line of fire by turns or abrupt maneuvers just before the approaching enemy reaches effective distance, and strive to regain gradually the advantage.
- Against the belly attack from behind. Though you can counter-attack by means of a slanting loop, you are often a good target for a long period when in a climbing position, so twist away as soon as possible.
- Against a belly attack from the front. By utilizing maximum climbing power, seize the dominant position above the enemy and counter-attack with an overhead attack from behind.

When you have tried to counter-attack and have been unsuccessful because of the enemy's maneuvering skill, or when as in training, ideal counter-attacks cannot be made because of their danger, it is important that you hang on, and strive with your utmost to regain the advantage while keeping the enemy from attacking, and then make a sound counter-attack.

Coming in under the enemy

When there is a large altitude difference, make attack impossible by climbing; take a position beneath the enemy (almost directly below), and match your flight pattern with the enemy's flight. By following the enemy's maneuvers you can ordinarily make it impossible for the enemy to half-roll and attack, and you can recover the altitude difference gradually. When the enemy turns, maneuver by flying somewhat to his outside so that he cannot see you. You can also recover the altitude difference by heading the same way.

Important: If you're attacking bombers, be very aware of where their gunners are. The gunners are positioned to protect the bomber against attacks from any side.

Measures to take when you are being closely pursued:

1. First, always have as your principal object the avoidance of the line of fire, and by the use of your total capacities and abilities strive to extend the interval between the planes gradually. In this situation, straight-line maneuvers should be absolutely avoided!
2. Ordinary aerobatics will have little effect. By making particularly good use of the rudder, maneuver exaggeratedly and confuse the enemy.
3. Even if you gradually extend the interval, consider the turning radius and do not plan to pursue until the situation is such that an even battle can be expected from the start.
4. Remember, if you are getting hit, whatever you are doing is wrong. Do something radical and do it fast! It can't make things worse.

Level Dogfighting

In this type of battle particularly, incomplete turning maneuvers have a fatal consequence. The plane, which must be perfectly controlled while it turns continuously, will step-by-step close in on the enemy and finally be able to seize the dominant position. If you learn the following tips, you can follow through to success:

- Keep in mind that although you have been pounced upon from somewhere to the rear, you will never be fired upon when the sights and eyes of the enemy are not aligned. When an enemy is behind you but to one side or the other in a level dogfight always turn toward your enemy, even though that brings you in front of his guns. If you turn toward him, you give him the most difficult possible shot and increase the chance he will overshoot. If you turn away from him, you give him the perfect opportunity to fall in behind you for an easy shot.

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- When you are about to shift to vertical dogfighting from level dogfighting, lower the plane's nose slowly, accelerate, and maintain your turn. When the enemy plane follows and starts to dive, still maintain your turn, climb steeply and make a slanting loop. In case the turns become very sharp when you are wide open, there are many situations where you must pull back on the control column with both hands and increase the turning speed. In this situation, changing the angle of inclination of the tail elevator (trim tabs), that is, putting them at a "down" position, generally makes piloting easier.
- During turns, aiming and firing are usually difficult, but when you get an opportunity, shift to aiming and shoot immediately. When it is difficult to fire, shift your attention to turning maneuvers without letting the enemy plane escape.

Vertical Dogfighting

Your fighting ability will be shown for what it is in this type of combat. The so-called "ace" is often made in this type of warfare. It is easy to get into a disadvantageous position and lose altitude if you maneuver clumsily and are fooled by the deceptive maneuvers of the enemy. Keep the advantage by learning the following strategies well enough to do in your sleep:

- When you try to shoot down the enemy plane with one pass, do not be anxious to pursue the track of the enemy plane too strictly. Keep in mind that the quickest method of shooting down the enemy is to wait for a firing opportunity by maneuvering little by little into a superior position.
- Although it is difficult to size up a situation instantly, do not yield a foot when coming face to face with the enemy.
- Getting out of a bad situation by means of a true loop is generally difficult. You should use the slanting loop. A skillful "twist" in the middle of a slanting loop is extremely effective. It is important that you understand it through practice and experimentation.
- The key to vertical dogfighting lies in closing in on the enemy's rear by degrees while deceiving the enemy with changes of the plane's fore and aft line, and banking.

Basic Air Combat Maneuvers

Barrel Roll

The Barrel Roll is a defensive maneuver. It is a more complex maneuver in that one needs to have a very good foundation in the basics, particularly the yoyo, before you can master it. The Barrel Roll is very similar to the lag roll, but it is defensive in nature. Hence it will be done with greater urgency.

The barrel roll is defensive because its goal is to force the overshoot of an attacker who is closing fast. The idea is not so much to slow your plane down in airspeed, but to shorten the distance you cover in a straight line by adding lateral movement.

Think of it this way. An attacker is closing on your six o'clock from a higher altitude. He is traveling from point A (Your six o'clock position) to point B (a position leading your flight path at 12 o'clock). By pushing your flight path to the side in a barrel-shaped circle, you lengthen the time it takes you to travel to point B while your attacker is already closing upon point B with great speed as it is. Also the complexity of the movements is able to defeat a guns resolution in the short term (Figure 28).

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Figure 28

To perform:

Step 1 - Roll 45° right or left and begin a shallow climb. This will create the lateral movement you'll need to begin the roll. Many make the mistake of excluding this first step and they only perform a corkscrew which is easy to gun down. You need this first step to the side to create a larger, barrel shaped, circle.

Step 2 - The next step is to roll back the opposite direction 90° and pull again. So if you rolled 45° to the right and pulled up into the start of a yoyo, you then roll 90° (45° until you are level, and 45° more to get set for a left yo-yo) and pull (just like a yo-yo) in the opposite direction. You will not need to be anywhere near a stall as you want to conserve energy for a kill (Step 4 below). If you did Step 1 correctly you won't have to work that hard at this.

Step 3 - Then you may watch for the overshoot. The attacker should over at a high rate of speed. To begin with you will move him from your dead six view to your six high view and finally to your straight up view. Once he is in the straight up view, you have him. This is also your lift vector, and any time a plane gets in front of that you are moving over to the offensive. Rotate around your enemy simply by using the straight up view. Rotate so that you are rolling toward his flight path.

Step 4 - When he moves out of the up view to a more forward view, shoot.

The Break Turn

The standard evasion against attack from astern is to turn as hard as possible in the direction of the attacker, to increase deflection quickly, and make yourself a harder target to hit.

Drawbacks:

This move is a momentary solution to getting out of harm's way, but it drains your plane of any airspeed, making you a sitting duck if you're not careful. Also, if your attacker can turn into you, breaking does you no good. If your attacker is in a more maneuverable aircraft than yours, the break is a temporary solution at best.

To perform:

Throttle back so you can turn tighter, roll toward the direction



of your attacker (if he's coming from your right, roll right), and turn as tightly as you can into him. Pour on the gas if you lose too much airspeed. If you find that you have lost momentum after the sharp turn, lower your nose to gain more speed. Keep breaking into the attacker if you have to.

The Chandelle

The Chandelle, in very simple terms, is a climbing turn. That turn can range from 90° to 180°. It is a low-G move, and aims to conserve as much energy as possible.

To perform:

Execute the Chandelle by banking to one side to start the turn, and pull the stick back gently to climb while you're turning. Once you have finished the turn, you will be at a higher altitude than you were, and at a different heading.

Center the stick and recover to straight and level flight to complete the Chandelle.

1/2 Cuban 8

This is a great way to turn around fast, and not lose any "E" or speed.

To perform:

1. Go into a 45° climb or more.
2. At the top of the climb when you slow down to above stall speed, roll inverted.
3. Pull towards the ground.
4. Pull out level, and you will be at the same height, same speed, but heading 180 degrees the other way.



Hammerhead/Flip Turn

The Hammerhead or Flip Turn is a great way to surprise someone coming up your tail with less Energy at maybe d500 to d700. If you can stay above him in the vertical, then you both stall and flip over, but you stay in control. You will be on his six o'clock. Some call this a pure "Rope-a-Dope". There are other variations like the Climbing Spiral mentioned below where you climb until the bogey stalls out and then pounce on him as well.

To perform:

1. Have speed. If necessary, dive down.
2. Pull straight into the vertical. Pull up and looking out your left and right sides to hold it in perfect vertical perpendicular to the horizon. Also, use the rudder to keep the wing tips level with horizon.
3. Hang on the prop and wait. Wait until you "feel" the plane get mushy. You can tell this when the plane rolls by itself because of the torque. It just begins to roll left in the Spitfire, then immediately reduce power to idle to avoid the torque moving you anymore. You still stay vertical for a bit, then if you apply no rudder, it will stall and flip over, usually towards the ground and you can regain control of the plane once speed

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increases. To do the hammerhead, you kick in the rudder at the last moment, so you will control which direction you will flip over.

Note: The Air Show hammerheads are powered and make perfect arcs around a stationary lower wing tip at the top of the zoom, but the idea of flipping at the top is the same and its a useful ACM to know and it doesn't have to look good.

Lag or Vector Roll

Sometimes when you're rolling in on someone you'll notice you're coming in at a sharp angle off their tail. If the situation allows, just pull in behind them and shoot. If it's crowded and you don't want to blow a lot of your "E" (energy), simply roll wide to the outside of the turn, pull under, and swoop in behind them. This does a couple of things for you:

1. It reduces the AOT (angle off of the tail) giving you a better shot.
2. If you're above the bogey when you start your attack, it gives you a boost of speed that you can use during and after your attack.
3. Sometimes it confuses the bogey when you roll away from him and he relaxes a bit. If you can get a bit below him, then the fun really begins.

Essentially it's a maneuver you use when you see you're going to over shoot the target either because you're too steep in your AOT and closing too fast. It's not a maneuver you use too close in, but something you use it to adjust your attack parameters as you're closing. Try it on the bomber drones, they're very cooperative about it.

Loop

Disadvantage:

You must make sure that you have enough speed to complete the Loop. This goes along with "Knowing Your Aircraft". On some aircraft, such as the P-38, you can use Flaps to help you over the top of a Loop.

To perform:

Execute the Loop by pulling back on the joystick and maintaining back pressure as the aircraft climbs, inverts, dives, and then returns to level flight. At this point center the stick and recover to straight and level flight to complete the loop.

Rolling scissors

How do you get into rolling scissors?

When a fast, high plane attacks a lower plane, the lower plane (if he is smart) will pull up to face the attacker. After they pass, the fast fighter will either extend, or he will pull up to trade speed for altitude. While the fast fighter is pulling up, the slow fighter is pulling down to get his speed up for the next pass. They have entered the rolling scissors, basically two planes following each other in a barrel roll.

How do you win the rolling scissors?

Conserve energy. The first plane to run out of juice is the first one to either stall or flatten out and fly straight.

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If you are the faster fighter, you want to conserve energy by pulling up with your wings level to the horizon, and making your turns while vertical. Extend up in the vertical until you get to a comfortable speed to quickly turn back down (don't get too slow).

If you are the slower fighter, you want to minimize the vertical part of your scissors to keep your speed up. Use your slower speed and tighter turns to your advantage, but keep your speed up at all costs.

If both planes have equal speed, it is a contest for who is smoothest on the stick and can keep their speed up. In this case, the enemy plane often will seem "locked", you will see it out the same direction of your cockpit through the entire roll.

This one takes a bit of practice, but when done properly it is a wonderful sight. Your opponent will spend the entire time looking at you but not able to get one shot off until you land on his 6.

Scissors

The Scissors is a series often forcing your plane into your enemy's. The Scissors occurs when both pilots are attempting to gain advantage over the other. The Scissors tends to happen when both planes are parallel, moving in the same direction. Each plane attempts to turn into the other.



This is a very aggressive move. If you try to use it, it's important that you think aggressively. People often perform the Scissors to gain the advantage back or return to a neutral fight. Then they reverse a turn, and turn away - giving back the advantage.

Drawbacks:

The slower, more agile plane will usually win this fight, if its pilot knows what he's doing. The maneuver can be very disorienting though, and is dangerous to perform at low altitudes.

To perform:

The steps to execute the Scissors are fairly simple, and with practice it's an extremely reliable move. In explaining this maneuver, we'll assume that you are defensive with a bogey on your six at D6 to D7. If he is farther out, use short turns to get him close, but don't let him get a good tracking shot at you. Once he is in the proper position, execute the following steps.

Begin with a fairly hard turn, held long enough that you force him to roll and turn to keep you in his sights. You usually start by going left to let the engine torque assist you.

Once he enters the turn, he will usually lose sight of you either to the left of his view or in his cockpit frame work. Now roll your aircraft in the opposite (right) direction, and execute a hard turn to the right, slightly nose low to conserve your "E" (energy).

It's important to fly this fight entirely in the rear view. Switch from rear to top/rear always keeping the bogey in sight so you can react quickly. When you see his wings start to roll right to answer your turn, quickly roll back in the opposite direction (left), and turn back to the left again, nose low.

He'll see you and react by trying to follow, and again when you see his wings roll, you reverse and go into him... etc.

Usually two to three turns and he'll have lost his angle advantage, and he'll be starting to wonder what happened. This is the critical point of the fight.

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At one point you will see he has lost his angle, (he'll be more in the top view than in the rear view) and you'll have the chance to go after him. Be aggressive and do it. By the time he realizes what is happening, you'll be on his six o'clock.

Skid

A skid is a lateral slide with a gradual loss of altitude. Commonly used as a defensive maneuver to throw off an attacker's aim.

It can be performed without incurring a large increase in speed or change of direction, while trading in only a small amount of altitude.

To Perform:

Execute the Skid by dipping one wing and applying opposite rudder. The aircraft will skid in the direction of the dipped wing.

While in this maneuver, the aircraft will sink, or lose altitude. Because your actual direction of travel is different to the direction that your aircraft is pointing, it will throw off your attacker's gunnery. The loss in altitude helps to mess up his guns resolution further.

Sliceback

Have plenty of smash (airspeed) which is always wise in an "E" fighter and pull up into what might be considered the initial stages of a hi yo-yo ... a climbing turn, not too steep although in some circumstances (the need to bleed speed that would otherwise overshoot you too far beyond your target is a good example) you might want to be steep here ... and hold the rudder over in "top rudder" position, this will slew your nose UP and you'll be climbing a little sideways to your real flight path.

In other words, your nose will be HIGHER than your real vector indicates, so in a climbing LEFT turn you hold down RIGHT rudder in the climbing turn, or vice versa.

This is how a rally driver approaches a turn on dirt where he is going to "flick" the car around the apex, shortening the corner. He sets the car up going RIGHT on entry to a LEFT turn so he can "flick" it around the apex violently, rather than going smoothly around the radius of the corner.

So, you are climbing to the left, holding down right rudder to have your nose pointing higher than your climbing turn. You are skidding the plane a little as you climb in the turn, away from the direction you are going to turn in. This may seem un-natural (and does) to a lot of pilots, because it is the opposite of your instincts, i.e.: turning INTO the turn not away from it. The Barrel Roll Attack is the same, it is an un-natural set-up but that is why it works so well.

As you approach the "apex" of the climbing turn, where you are going to turn into and come down the other side, much like the rally car steering back into the corner from the initial set-up to the wrong side ... you mash "bottom rudder" and pull down, violently skidding the plane around the bottom or inside wingtip in a sort of "flick spin" for a brief moment, and what you have is a plane that was climbing (in this example) to the left, its nose held high by opposite (top) rudder ... when the time comes to go down from the highest point of the yo-yo, the apex or "corner" as it were, you throw in rudder to the complete opposite side (into the turn now) and pull the plane down into the descent side of the turn, and because of your rudder input changing sides violently, and timed to match you pulling the plane around with the ailerons slightly ... you "spin" the plane around the inside (down side) wingtip ... which is what a rally driver does when he "flicks" the car around the apex having set it up pointing the wrong way to the turn at the entry point. He'll do a full

blown slide around the apex and exit going damn near straight after the "flick around". This is what you're doing with your airplane but in 3 dimensions not 2 like the rally driver.

You have a vertical element (the 3rd dimension) where the rally driver has only 2 being wholly in the horizontal plane of maneuver.

This should help you, it is hard to describe but the 3d ribbon diagram in the book (page 54) should make it clearer if this explanation has helped at all. Note that in that diagram, there are TWO exit strategies after the apex "flick turn" ... depending on the bandit you are dealing with and what they elect to do as a counter to your "Luftwaffe Stomp."

Remember, stay fast, 400kph is probably a little slow to pull this off properly. Think 500kph or even a little more as ideal.

Snap Rolls

Snap rolls are used to shake off a guns solution. Recovering is good to learn so you won't fall into accelerated spins. It's also a quick way to flip the plane upside down and right side up. You must first be at cruising speed.

1. Using the rudders rock the plane side to side getting the widest yaw you can.
2. When the yaw is at the widest swing. (Full rudder) Pull up hard. The plane will flip on its back and even come back level.
3. Release all controls immediately. If you hold it in the wing stalled state you could go into an accelerated stall and a spin from which it is hard to recover.
4. Repeat until it becomes something you can control.

Spiral Climb

You'll see the spiral climb mentioned from time to time by Luftwaffe pilots who extol this maneuver's merit. They like it, of course, because in many cases the Bf109 can out climb many of its adversaries. Historically, the spiral climb was used as a means of disengagement and frustrated the Brits until they improved the Spitfire with a variable pitch prop. The Spiral Climb can be used whenever you have a climb rate advantage over your opponent. I like the spiral climb because it's one of the finesse maneuvers, something that takes air combat beyond thrash and clash.

The concept of the spiral climb is not hard to understand. Implementing the tactic is hard, though, because it requires experience in timing and observation and a healthy dose of advanced SA. Here's how it works. You use superior energy in the form of either speed or altitude, to position yourself in a slow, spiral climb. (This is one point where SA comes into play. You have to set this up from the beginning by recognizing what's going on around you. For instance, it's kind of hard to set this one up if you have bogeys above you, eh?) There is a fine point of execution where you can maneuver to conserve your own energy but bleed the enemy if there is a bogey around that threatens your position. Make him turn or climb more radically than you and you've got a start on beating him. This all becomes more complicated when you blend in different types of aircraft with different performance ratings.

OK, so you've got a couple guys below you climbing hard to attack. The three things you have to govern carefully are your speed, angle of attack and the angle off your tail of the nearest bogey. You have to balance your climb rate with your speed while observing how aggressively the bogey is climbing and

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turning. You want to stay away from the bogey and continue to climb but you can't lose too much speed or you lose maneuverability. If you think about it, if you set yourself up with a little altitude advantage and fairly equal energy, the bogey is going to have to work hard to close on you and you can make it difficult, if not impossible, if you manage your aircraft properly. Again, SA is an important element here as you have to watch for other threats entering the area and you have to know your aircraft and your opponent's aircraft to know how to play out the balancing act.

As you observe the bogey and his pursuit of you, you want to carefully read how dynamically he is trying to climb, his speed and his angle off your tail. If you have sufficient vertical separation and he starts to close on you, you can reduce your climb (this helps keep your speed up) and turn a little more sharply into the side the bogey is on. This will force the bogey to try to turn sharper and reduce his climbing ability. As he starts to fall back a little, you can go back to a gentle climb. If the bogey over commits to pulling lead on you or pushes his angle of attack too high, you'll notice his nose start to wobble up and down meaning he is losing control due to too low a speed or too high an angle of attack. If the bogey persists in flying in that condition, you can use this opportunity to continue to climb and increase your separation or go level, turn back on him and possibly get a chance to dive on him for a gun pass. If timed properly, you'll force him down severely if you don't kill him outright, thus improving your position.

If you are using the spiral climb defensively and are trying to disengage, you want to emphasize your direction back to friendly lines. Eventually, you'll encounter some friendlies and the bogey, being at a slow speed will most likely break off and try to evade the new threat to him, thus, you can complete your escape. Another alternative, of course, is to wait for him to try to make his break and pounce on him :)

The spiral climb can also be used as a planned offensive maneuver. You enter an area of operations with a speed advantage, pick a victim and entice him to follow you up as you do the circular climb. Watch as described above until your adversary gets too slow to maneuver effectively and then dive on him. This is a variation of the 'rope a dope' tactic. Sometimes the bogey will find he is enticed into an engagement from which he finds it difficult to survive.

Take note. You should watch for this tactic being used on you. Refuse to accept the bait by tracking the bogey and don't be too aggressive about trying to close the vertical space between you. Be patient. The bogey will recognize that you are not falling for the ploy. As you track the bogey, try to position yourself as close to directly below the bogey as you can. If he does dive on you, he will not get a gun solution without his momentum carrying him below you. By evading a couple of these attacks without giving up your altitude, the bogey will eventually find that you are co-energy with him and you will be in a much better position to exploit the situation.

Split-Ess

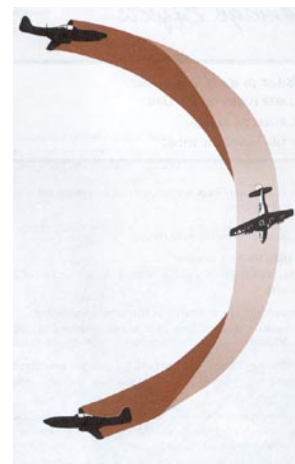
The Split-Ess is a half-roll so that you are inverted (upside-down), and a half-loop to bring you back into straight and level flight.

Drawbacks:

You'll need altitude to perform the Split-S, and if you dive too fast, you might damage your control surfaces.

To perform:

If you find an attacker at your six o'clock, roll your plane inverted and pull back hard on the stick. Throttle back as your plane dives to avoid gaining too much airspeed. As the horizon appears in front of you, increase power and be ready to turn back into your attacker. If you find that you're still at a disadvantage, consider performing another Split-S or, if you have the momentum, use your superior speed to put distance



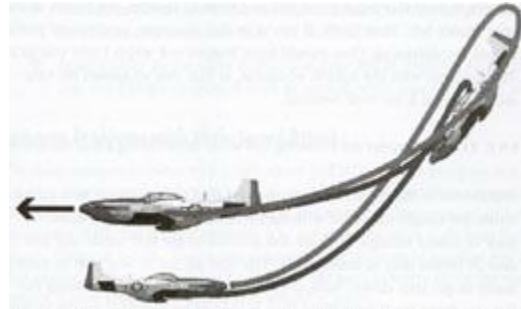
between you and your attacker. But whatever you do, don't fly straight-and-level!

Wing Over

The Wing Over is a common maneuver for attitude and position recovery after a diving attack especially on a ground target.

To perform:

Start this maneuver by entering into a climb. Close to the top of the maneuver, the aircraft should be just above its stall speed (BUT NOT STALLING). Rather than use the elevator to perform the 180 degree turn, apply full rudder in the direction of the turn to yaw the plane over until the nose of the aircraft is pointing down in the opposite direction of original climb. Make sure the aircraft doesn't roll over on to its back when in the yaw motion.



Once your nose is pointed down, center the rudder, and enter back into a dive. This is a tricky maneuver, but it comes in handy after a diving attack, and sets up for a quick second run.

Lead Turn

The Lead Turn is a "first move" to gain an advantage on your opponent by out-turning him.

Drawbacks:

Begun too soon, the Lead Turn can put you in front of the enemy. Also, it's somewhat predictable, easy to counter, and does not present you with an immediate shot. Timing is key. Do not perform this maneuver unless you're certain your ship can turn with or out-turn your foe's plane, or if his speed is so great that he can't turn tightly.



To perform:

As you are merging, begin turning early into the enemy to gain a "snap shot," then follow through with the turn to put yourself on his six o'clock. Ease off the throttle to maintain a tight turn. Keep an eye on the enemy using view commands-he should be in your upper canopy view. When you're in the tightest turn possible, apply full throttle while keeping the stick back as far as you can get it without stalling.

Up and Under

This maneuver will put your fighter in the best position to attack a bomber right in its most vulnerable area-the belly. It's also effective for bouncing unsuspecting fighters.

Drawbacks:

Climbing reduces your airspeed and makes you more of a target yourself. Pilots attacking enemy bombers are vulnerable to the bombers' defensive fire.

To perform:

From a point at or above the bomber's altitude and behind it, dive to gather speed. Once under the enemy aircraft, pull your nose up into the belly of the target and attempt to stay in the target's blind spot.



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Hi Yo-yo

The Hi Yo-Yo is useful if you're carrying too much speed to turn into your enemy's breaking move. This maneuver can also enable a plane with a wider turning radius to cut into a breaking bandit and get a shot in. The name yo-yo comes from the man who perfected the maneuver, a Chinese pilot named Yo-Yo Noritake



Drawbacks:

This maneuver is fairly difficult to perform as it requires good timing to get a lead on the target. Also, it's somewhat difficult to maintain sight of the target throughout the maneuver.

To perform:

Pull up out of your enemy's breaking turn, climb to reduce speed and then roll back down inverted toward him to either lead or lag pursuit. Keep an eye on the enemy to make sure he's continuing in his turn. Remember that by climbing, you're trading airspeed for altitude and you'll slow down. This will enable you to turn more tightly.

Lo Yo-Yo

The opposite of a Hi Yo-Yo, the Lo Yo-Yo allows you to gain energy while turning into your opponent. This is useful when you're close to stalling and need to pick up speed.



Drawbacks:

Again, timing is the key to performing this maneuver. Your foe might also be able to gain an attitude advantage over you.

To perform:

Drop nose-down into the bandit's breaking turn, gain speed in a diving turn and then bring your nose up into him. As you do this you should have the throttle on full and be turning as tightly as you can. Ideally, you should gain extra lead on your foe so that when he pulls his nose up he turns into your guns. Keep in mind that if you're already moving at well above stall speed, you're going to gain speed, which will make your turn wider.

Energy Management

It's pretty simple really. Energy exists in two forms:

- Potential
- Kinetic

Good "energy fighting" is knowing when and how to utilize and convert between these two states. If you are 5k above a bandit and going the same speed, you have the advantage in potential energy. If you are "co-alt" (equal in altitude) with a bogey but 150 mph faster than he is, you have the advantage in kinetic energy.

As an energy fighter, the best position to put you in is for a "high side" guns attack. To achieve this you want to begin your attack from a higher altitude than the bandit. This will ensure you have a much higher

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kinetic energy state. You want to dive behind and below the bandit and enter into a shallow climb and shoot him from below (Figure 29).

***Dive below the bandits 6 and shoot him as you enter into a shallow climb.
If he spots you, you have several options.
You can level into a straight ahead high speed extension.
You can continue in a steady state climb to regain "E".
You can zoom climb into a pitch back maneuver.***

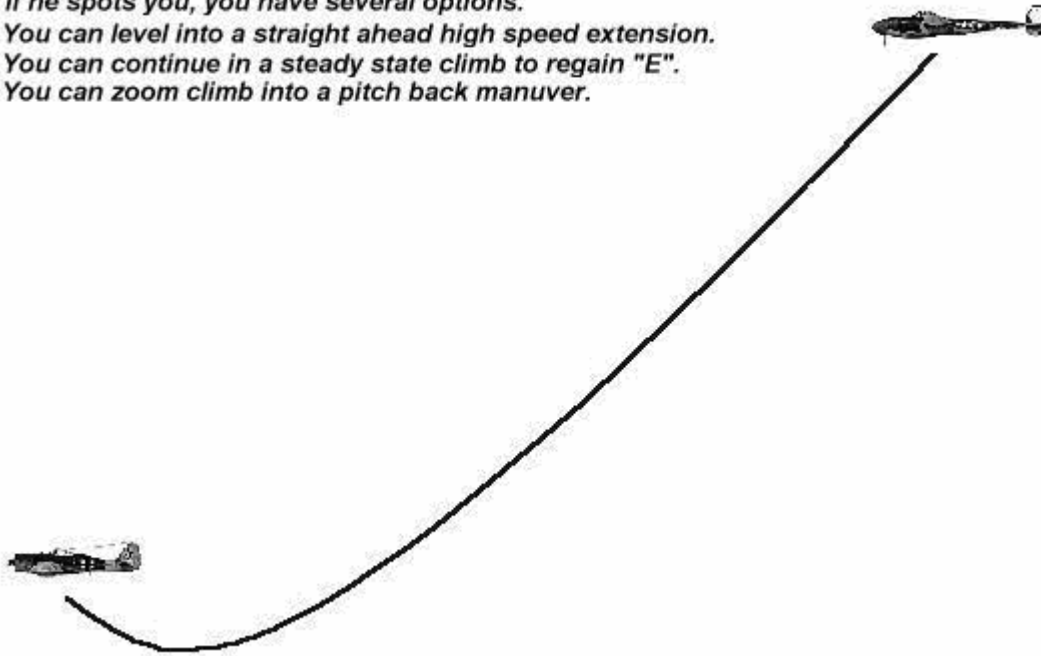


Figure 29

You have several options at this point. Should the bandit avoid your initial pass he "used up" some of his own kinetic energy.

1. You can level into a straight ahead high speed extension.

However, this will give the bandit a greater chance to recover. To avoid the giving the bandit a snapshot opportunity turn just a bit in the opposite direction of the bandits break. This is your classic hit and run tactic. It's not terribly effective unless the bandit doesn't spot you. In most instances he will spot you and enter into a break turn with his nose at a slight down angle. This will put him below your wing and out a view as you blow past.

2. You can continue on a steady state climb to regain your altitude.

This is the ideal choice if you are in an area with a high concentration of enemy.

3. You can Zoom climb in order to set up a "pitch back" maneuver.

This is will keep the pressure on the bandit. With experience you will learn how quickly to reverse. By keeping up the pressure and managing your energy eventually you will get the kill. As your skill improves you can cheat a little here and there. For example, on your initial pass as the bandit breaks you can turn with him just enough to give you a better guns solution. After all you are using your energy skills to get the kill not just for making high speed passes in order to bore your opponent to death. When you trade energy for a better positional advantage you better be certain to get the kill, especially, against an angles fighter.

An angles fighter is looking to improve his position with each pass. Your objective is to force the bandit to "use up" or bleed away more energy after each pass until he can no longer avoid your guns. By flying an aircraft in a way that highlights its strengths, almost any fighter can defeat any other. However, the ability to judge where one aircraft has an advantage over another comes from many hours of experience. Even then you will find yourself at times in disbelief at what you may see, mostly because of the variation in pilot ability. As the abilities of the competition improve, we must fly to every possible advantage. To be successful we must push our aircraft to the limit of its performance capabilities. In dissimilar aircraft engagements, we must understand and know how to exploit the weaknesses of our opponent's aircraft.

Evasive Action

We are going to deal here specifically with being attacked by an enemy with a greater energy state than you. There are three possible things you are trying to do with your evasive action.

1. Escape and live to fight another day.

You are basically trying to create some separation so you can extend away safely. A good example of this is a split-ess. Nine times out of ten, a split-ess effectively takes you out of the fight completely. But it allows you the best opportunity to trade altitude for speed and you end up extending in the opposite direction of the attacker. Also negative "G" maneuvers can add in creating separation. Basically this involves pushing the stick to the upper left (or upper right) and add some rudder in the same direction. You are basically doing a diving oblique "outside loop". What should happen as the bandit closes on you at high speed you slip down below his nose and he will "red out" trying to follow. If he continues straight and climbs he will have lost visual on you. Now if you continued this till you are near vertical you can roll and slip away in the opposite direction. Another trick to this is to use a little rudder toward the direction you intend to break. You will skid just a bit then enter your "outside loop". This is a quick maneuver you don't want to enter it too soon or the bandit will have no trouble maintaining a visual and setting up for his next pass.

2. Reverse and take the advantage.

You are trying to force the attacker into a situation where by he bleeds his energy advantage. The key here is to preserve your own "E" while he depletes his. It's crucial not to get in a situation where you are low and slow. You will want to keep your speed above 250 or be at a high enough altitude that will allow you to dive away.

Let's suppose that you're at 12k and a bandit is moving into position at your high 12 o'clock. Now since the bandit is higher than you when he attacks he will be moving much faster. With his speed advantage if he misses his pass expect him to climb into a pitch back maneuver. As he closes roll to the left and give your stick some back pressure. You want to time this just right so the bandit doesn't have a chance to get a shot at you. Depending on the enemy's armament and on there rate of closure, d800 is when you begin this. Now the attacker may cheat a little and try to follow your turn for a second to get a better guns solution. What you want to do is start a barrel roll back in the opposite direction. Keep your barrel roll tight enough so as the bandit blows through you will roll onto his 6 o'clock and in range for a snapshot. Now if you miss him he will climb and you will be in an even worse position. However, if you time it right, you get the kill.

You may also try to sucker him into giving up his energy advantage. If you spot him in enough time you can start a shallow dive bringing up your speed. As the bandit closes begin to slice left (perform a descending 180 degree turn). You only want your nose slightly down and start your turn wide tightening it as the bandit closes. You want to keep your speed up as much as possible through the turn but don't give up all your altitude. Now an experienced pilot will probably spot this and climb into a pitch back maneuver. If you are lucky the bandit will try to follow bleeding some of his "E" to get a guns solution. Once the bandit misses

go level and extend away watching what he does. If he goes into a flat turn to follow you begin a shallow climb or extend some more. Now you have the advantage.

3. Survive long enough for your Squad mates to clear your six o'clock (better known as "Drag & Bag").

First DON'T PANIC!

OK, bogie is at your six and tracers are flying past your cockpit. Don't give up, but don't panic, either. And don't make it harder on your wingman to clear you. Remember: gunnery is difficult and it doesn't take much to spoil your enemy's shot, without tracing a hard-to-follow path through the sky. Here are a few quick things you can do to throw off an enemy's shot, and buy precious time for your wingman to clear your six o'clock, without gyrating wildly:

1) Jinks: these are short, sharp banks and turns of a few degrees; but don't commit to the turn; instead reverse your path again, so you end up with a similar heading. Don't be predictable. Make some turns longer than others, and don't just alternate. Left! Level out. Left! Right (pause) Left! Right! Left! Level and left again! Add a tiny bit of dive or climb in there for variety. Time your jinks for right after the enemy sends a burst your way that misses, and jink while he's correcting. Small, energy conserving moves are the key.

2) Skids: slight nose down, slight bank to one side and lots of rudder into the bank. Or bank one way and add reverse rudder. You can slip right out of a guy's gunsight that way. Careful, this trick bleeds energy and you don't want to slow down very much.

3) Banks: Roll at less than your maximum rate to one side...hang there...and then don't turn. Roll back the other way. Or continue the roll all the way under to the other side. Sell the turn...but don't actually do it. An anticipating enemy may bite on the move and take himself out of position.

4) Bunt: this move hurts, but can buy a few seconds. Shove both the stick and rudder into one of the forward corners; you'll probably red out; but if your opponent follows, so does he. Don't overuse this one because if your opponent sees it once too often, he'll be ready to nail you on the next one. And, while you recover from the effects, you're helpless yourself.

5) Barrel roll: the all-time favorite, "out-of ideas" evasive. Pull the stick back and to one side slightly. Then execute a very sloppy roll to the other direction with heavy rudder and some delay in it; don't just rotate quickly about your axis; throw your self around the sky a bit as you complete the full roll, but unpredictably. Keep your same heading, and when you're in the nose down part of the roll, use it to gain a little speed.

Advanced Air Combat Maneuvers

ACM stands for Air Combat Maneuvers, however, here we will talk about more advanced Air Combat Maneuvers. Study these very carefully. Advanced maneuvers are complicated, however, once mastered, they can be very effective.

"If you are thoroughly conversant with [tactics], you will recognize the enemy's intentions and the have many opportunities to win." **Miyamoto Musashi, Samurai Warrior**

High Side Attack

Purpose

This maneuver gets you very close to your target and forces your opponent to dip his nose to return fire, thus risking a head-on collision (Figure 31).



Figure 30

Drawbacks

You need to have lots of room to execute your dive and maintain a fast speed so that the enemy won't get a shot at you before and after the attack.

To perform

Start your attack from well above and ahead of the bandit. The dive starts about 1,000 feet to one side of the target. Get in a steep dive abeam of the target so that you're shooting at a 45-degree deflection angle both in the vertical plane and at the four o'clock or eight o'clock position (figure your target's nose is pointed at twelve o'clock.) You should be above and to one side of your target. After firing, make your recovery beneath the target, using the speed you got from the dive to zoomback up to get ahead--and in position--for the next run.

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Overhead Attack

Purpose

The overhead attack gives you the best chance of hitting your enemy without taking any damage yourself. This slashing attack requires precision and a proper setup before you make your run. This attack is the safest way to attack a bomber and avoid the bomber's multiple gunners (Figure 32).



Figure 31

Drawbacks

Getting set up above your enemy is key. A smart opponent won't let you do this easily, and he may climb toward you. Once you make this run, you'll have a second or two at most to get your shot off before you get by him.

You need to fly this maneuver quickly--a slow or tentative overhead attack gives an opponent a chance to turn onto your tail. Also, make sure you don't dive and pull out too fast. Your controls can lock up, and you can black out if you pull up too quickly. If you find yourself blacking out or losing control of the aircraft, relax the backpressure, and reduce throttle to reduce your airspeed.

To perform

Climb to at least 2,000 feet above your opponent, and then roll onto your back before pulling through into a vertical dive. At about 600 feet, open fire, making sure you lead your target as necessary. Then pull out smoothly to get back above your target. Don't pull up so quickly as to give your opponent a quick shot at you—remember to get clear of his guns before pulling up

More Scissors

The scissors (Figure 33) is a very complicated maneuver, however, once learned it is a very effective defensive and even offensive maneuver. The main goal for the attacker is to cross his opponents extended 6 o'clock position at the lowest possible TCA in his rear hemisphere and thereby maintaining his offensive position at low AOT. The main goal of the defender is to try to turn into his opponent to get him to cross at a high TCA at a high rate of closure. The scissors usually develops after one turn of the One Circle verity. In fact the scissors is a series of One Circle turns therefore the tactics and techniques in the One Circle turn apply to the scissors. The defender turns into his opponent to maximize the attackers TCA and AOT at the **overshoot (crossing the defender's extended 6 o'clock position)**. The defender now has to things going for him. The attacker is now closing at a high rate, and his target is crossing his horizontal field of vision at the highest possible LOS rate. This can effectively degrade the attackers aiming solution. The preferred TCA is at 90° to the attacker, which generates a high LOS rate for the attacker. Any further turning can actually help the attackers aim by decreasing LOS rate. Pulling to this high angle should decrease the defenders speed relative to the attacker causing him to close even faster, increasing the likelihood of a large overshoot. If the attacker does overshoot, a reversal is in order, to maintain sight and for AA considerations. Because of the defenders hard break into the attack, there is a great likelihood that he is slower and turning tighter. He may be able to turn inside the attacker after the overshoot. If he does turn inside, another reversal is in order to decrease TCA at the overshoot, which needs to be timed perfectly. Too early and he could fly out in front of the attacker; too late and the Two Circle may be induced by the attacker which will be at his advantage because of his faster speed. If the overshoot isn't large, the defender now has gained the upper hand and is now the attacker. The new attacker job is to try to minimize TCA in each turn of the scissors. When TCA becomes low enough, the attacker should be able to turn **in-phase** with the defender terminating the scissors.

Figure 32



"When he saw me behind he began to whip back and forth, left and right, as violently as he could. I followed, but it was hard to line him up for a shot. Finally, as we kept whipping back and forth, right and left, I began to shoot before he whipped and he had to fly through my fire." **Major Robert S. Johnson, USAAF**

It should be noted, however, that the defender may not be able to gain the advantage in one or two turns in the scissors, and that each turn subjects the defender to a snap shot which can be very deadly. The defender may want to make each turn nose low, then nose high to avoid a snap shot and to make his future position unpredictable. The scissors is most effective against an opponent in an inferior turning fighter (high wing loading). It is very dangerous against a superior turning opponent and should not be considered as a viable option. The scissors could be made nose high to decrease the horizontal component of his flight path, and to decrease speed to turn tighter. Quickness is important in reversals as roll rate is very important in changing your lift vector's position to gain an advantage or to force an overshoot.

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The best counter to the scissors is to refuse to turn with the opponent. Either pull up to gain energy (altitude) or lag roll above each reversal. The lag roll allows you to maintain an energy advantage above and behind the opponent. However, the Lag roll (see above) should not be done too high because it could allow for the opponent to unload and extend away to escape.

The Head-on

Never joust an enemy fighter; it's just plain stupid. It is never worth it to give up a shot while taking a shot. You're rolling the dice unnecessarily. And the other guy could be a better shot than you. Wait until you're on his six o'clock before you blaze away. Still, some pilots will take any shot they can and will come straight for you rather than do the work to set up a better gun pass. So, your problem now becomes how to get past the head-on without taking a round to the head or damage to the engine.

1) Pick a side. Create some lateral separation as the bogie approaches about d3000. The side doesn't matter. What you don't want is an enemy centered right in your windscreen. Set him off to at least 11 o'clock or 1 o'clock. If you have enough room, sometimes a rudder kick and a skid will get the job done. Or you may have to make a short S-turn. Now watch as the enemy closes in. At just inside d2000 or when you can clearly see the "dot" sprout wings, watch for the bogie to bank toward you to establish the straight-on aspect.

2) Go for the "cold side". Time it well, but what you want to do is get to his "cold side": the area under his wings, not above them. Under his wings means under his nose, where he can't see you, and will red-out if he presses the shot. Over his wings is his gunsight and where he can pull towards you. As soon as the enemy commits to a bank, roll in the opposite direction and get to the cold side. If the enemy is diving on you, you may have to also dive. If it's a true level head-on sometimes a barrel roll is necessary to ruin a persistent foe's shot. If you move too early, and the enemy rolls back into you, tighten your roll and stick the nose down for a second. Or if you have even more time, reverse your turn again. Simply get out of the way and avoid the shot.

3) Recover UP if at all possible. After the head-on artist passes by, wasting ammo, recover your bearings and pull UP moderately hard (about 30 degrees), unless you entered the joust with very low energy. Then, immediately check behind you. If the enemy has broken horizontal, or kept diving, you have won, and have likely taken the advantage in the fight. What you *don't* want to see, but might, is that your enemy has also pulled up, and might be using his energy advantage to loop or curve back in towards you. That is not so good. If he's not closing fast, make your climb shallower, and continue away from him while you plan your next move. If he's really close, it might be time to drop flaps, roll over and head earthward.

Formation Training and Tactics

Formations

Welded Wing

This is the formation we often think of when we visualize a two man team in flight. One is designated the lead the other wing, and the wing man's position is anterior and defensive. During the war this was also a mentor role for younger more inexperienced pilots to gain combat experience at the side of a veteran. The lead's primary tasks are navigation, forward hemisphere search for attack planning and engaged maneuvering and he has the secondary responsibility of rear-hemisphere visual coverage. The Wing man flies a rather loose formation on the leader. His primary task is maintaining a rear hemisphere defensive look out and he has secondary forward hemisphere duties. During WWII the separation was normally 600 ft. My suggestion would be a range of 6 showing over your lead and with some alt to the wingman's advantage to close on any bogey that drops on the lead's tail. Traditional the wing was in the right echelon position, at about 4 o'clock.

Pros:

- 1) Mentor for new pilot
- 2) Releases lead for dedicated attack
- 3) Requires less discipline and training
- 4) A reserve ac is always there to be called in when needed

Cons:

- 1) Who watches the wingman's six?
- 2) Only one aircraft is engaged in dedicated attack so there is less pressure on enemy
- 3) May frustrate the more experienced wingman to do more chasing than killing

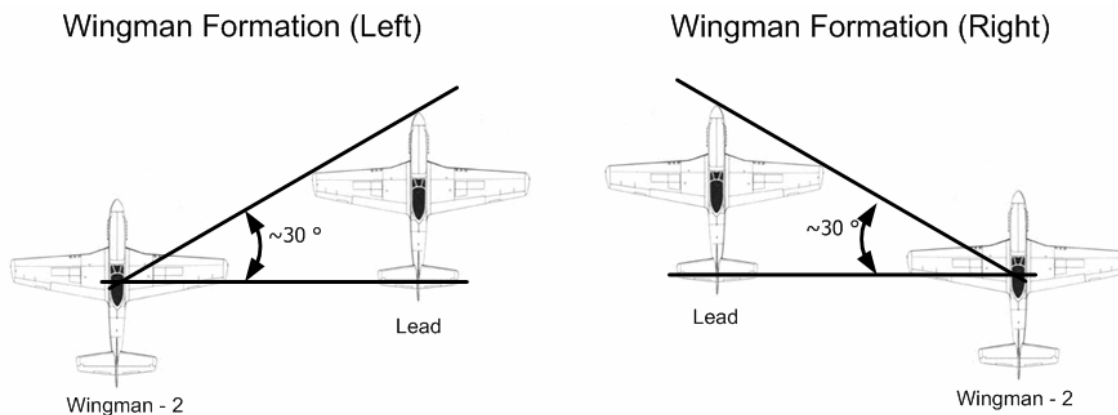


Figure 33

Wingman Coverage

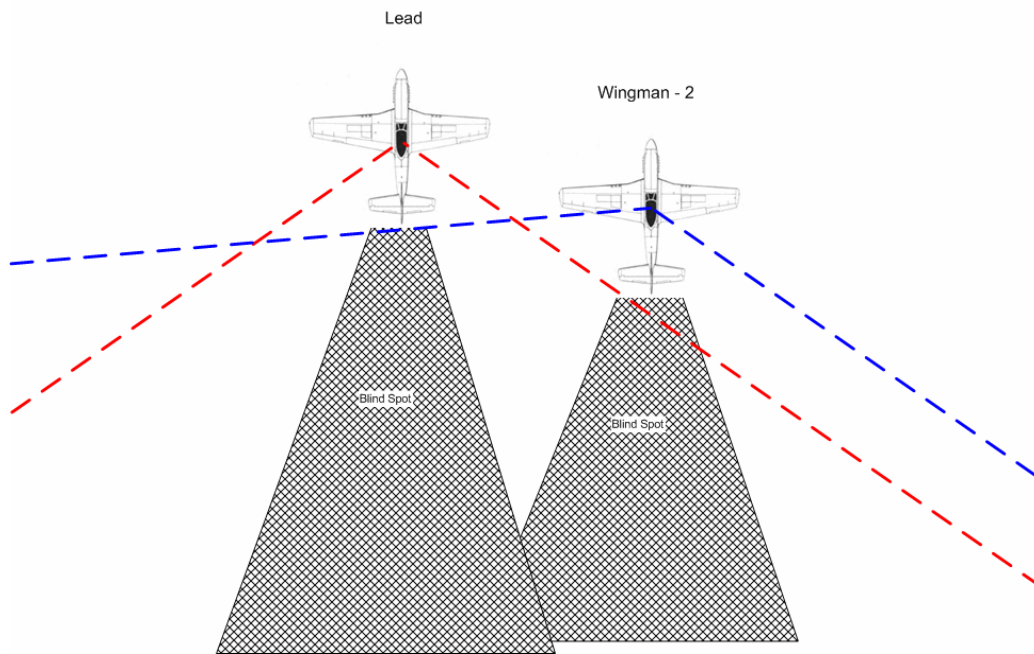


Figure 34

Finger Four Formation

The "finger four" is one of the basic combat formations. The flight of four aircraft is split into two 2-plane elements. The first element is lead by the flight leader. Each element fights as a single unit - engaging together, covering each other.

Finger or Fluid Four Formation

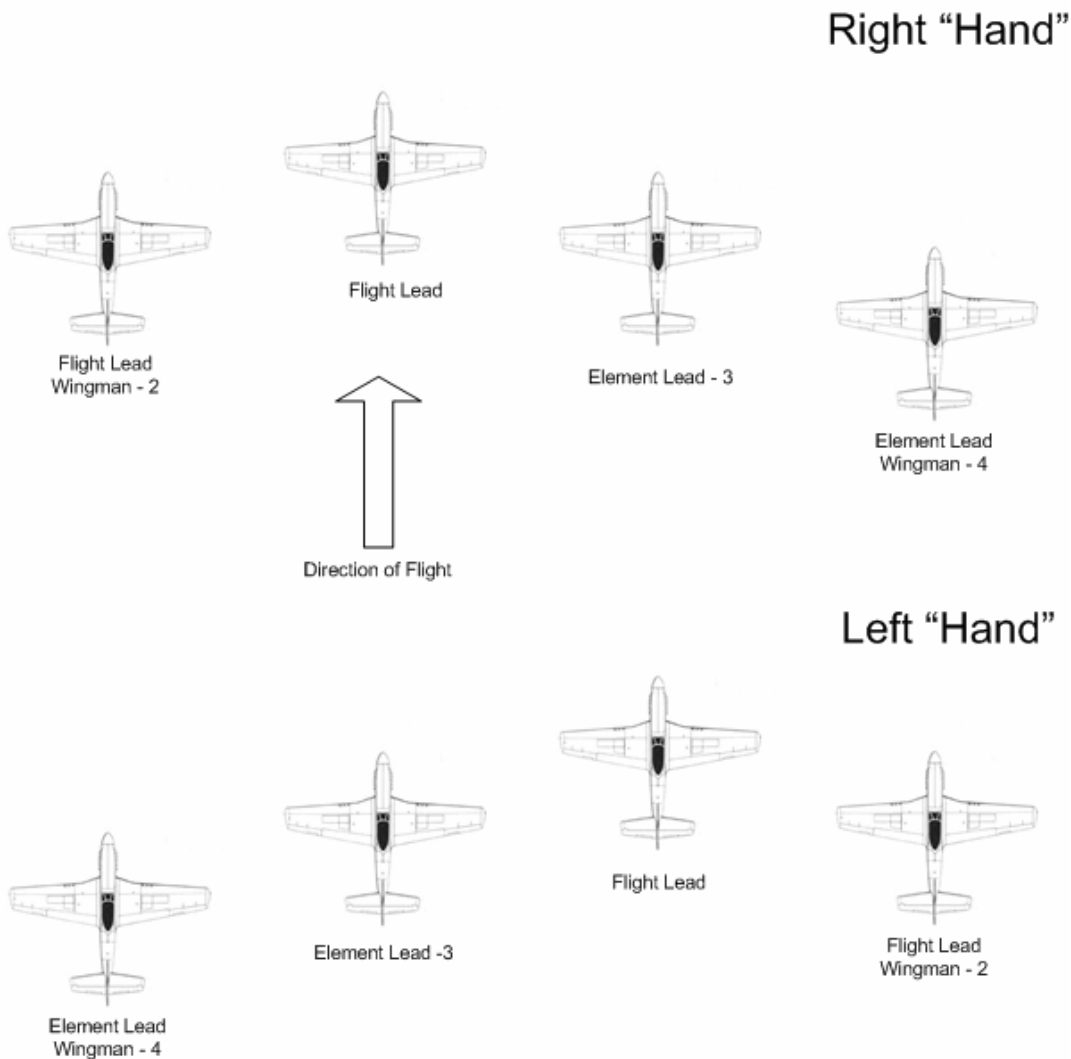


Figure 35

Navigation Turns while in the "Finger Four"

Making navigational turns while in the finger four formation is best accomplished by executing a tactical turn, or Tac turn. Instead of trying to maintain the exact entry formation the Tac turn creates a mirror formation upon exiting the turn.

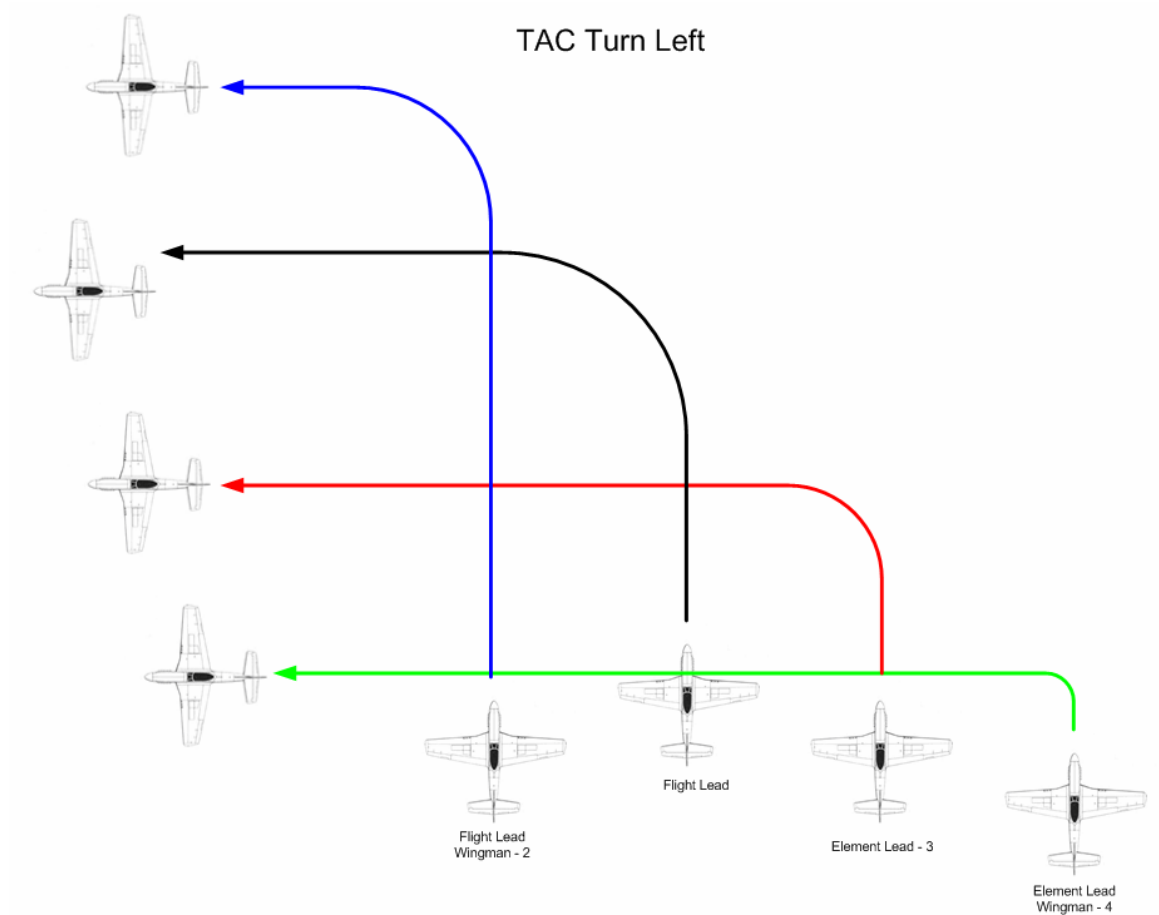


Figure 36

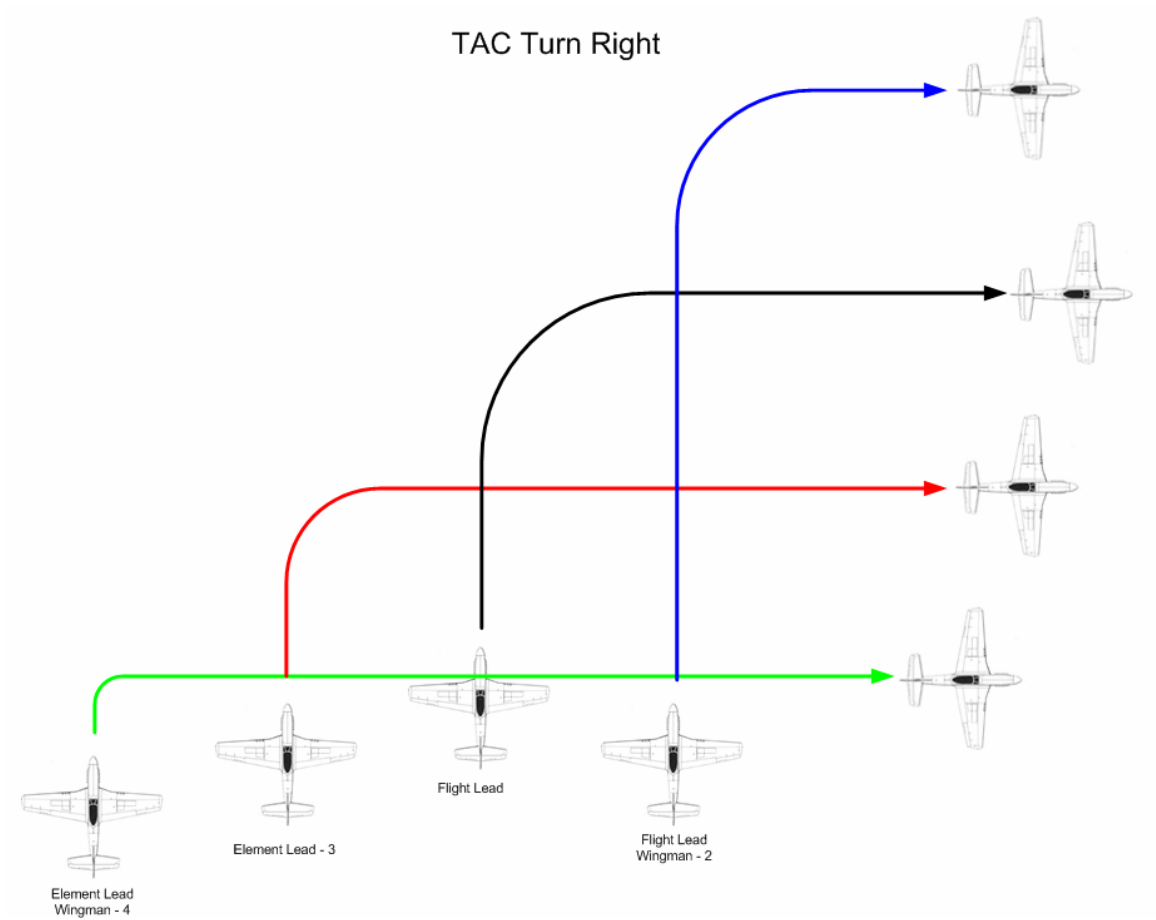


Figure 37

Line Abreast Formations

This formation places both planes at 90 degrees with each other of the three and nine o'clock respectively. A great combat spread is required, perhaps in the area of d500 to d750. This offers several defensive and offensive maneuvers against an approaching enemy. There is the "Offensive Split" the "Defensive Split" the "Beam Defense" "High-Low Split" "Bracket". What these maneuvers do, and we can cover them in a later post, is they seek to commit the enemy to pursuit of one of the two offensive planes so that the free plane can maneuver for the kill. As mentioned above, this requires a great deal of discipline and much trust in the gunnery and maneuvering proficiency of the partner pilot's abilities. Would you offer yourself to sucker in the enemy if you thought your partner could gun him down quickly when you needed him to do it?

Pros:

- 1) This things kills them dead....it works
- 2) When enemy is in pursuit he becomes predictable, and thus dead
- 3) It keeps the maximum pressure on thus leaving the initiative with you

Cons:

- 1) To apply this doctrine requires a high proficiency between both pilots
- 2) It requires discipline in terms of familiarity with maneuvers and execution of them
- 3) It suckers the enemy in, but the fish may swallow the bait before you reel him in

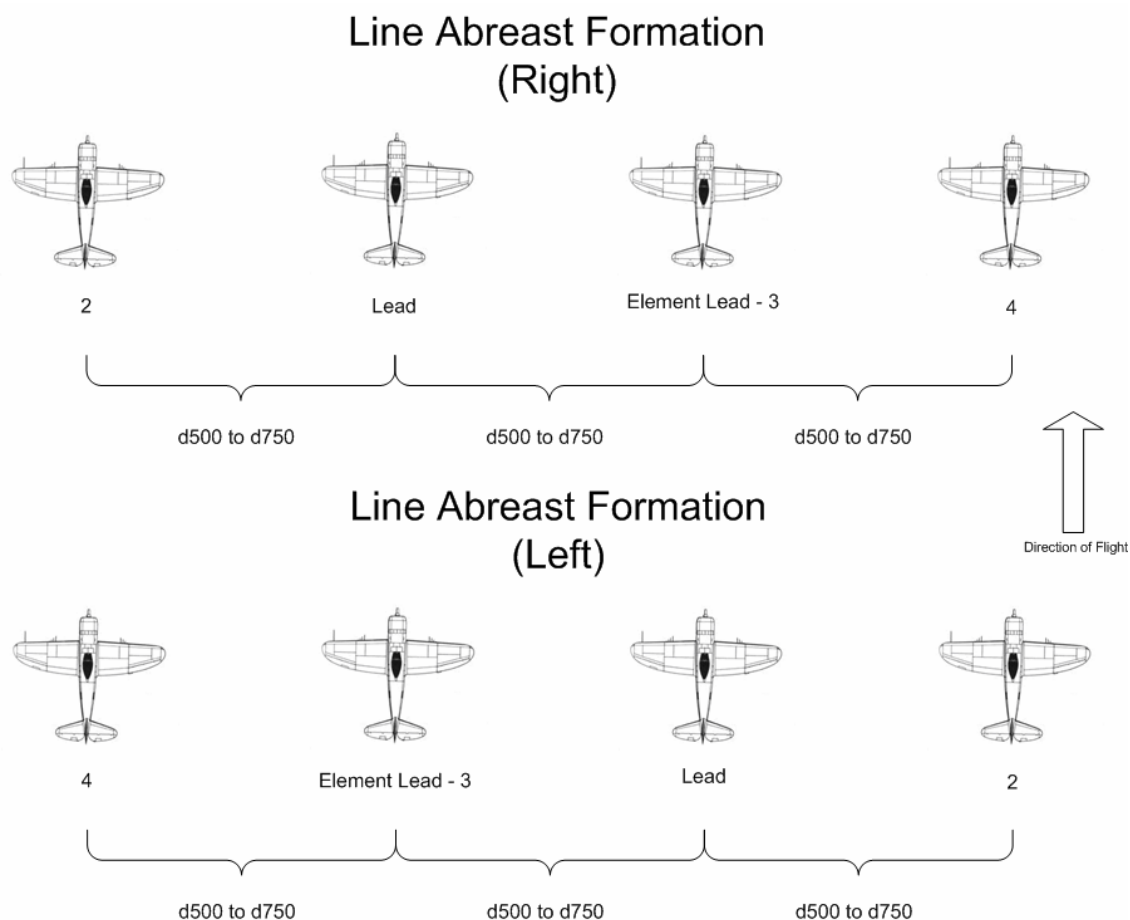


Figure 38

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Line Astern Formation

Line Astern or “Trail” Formation

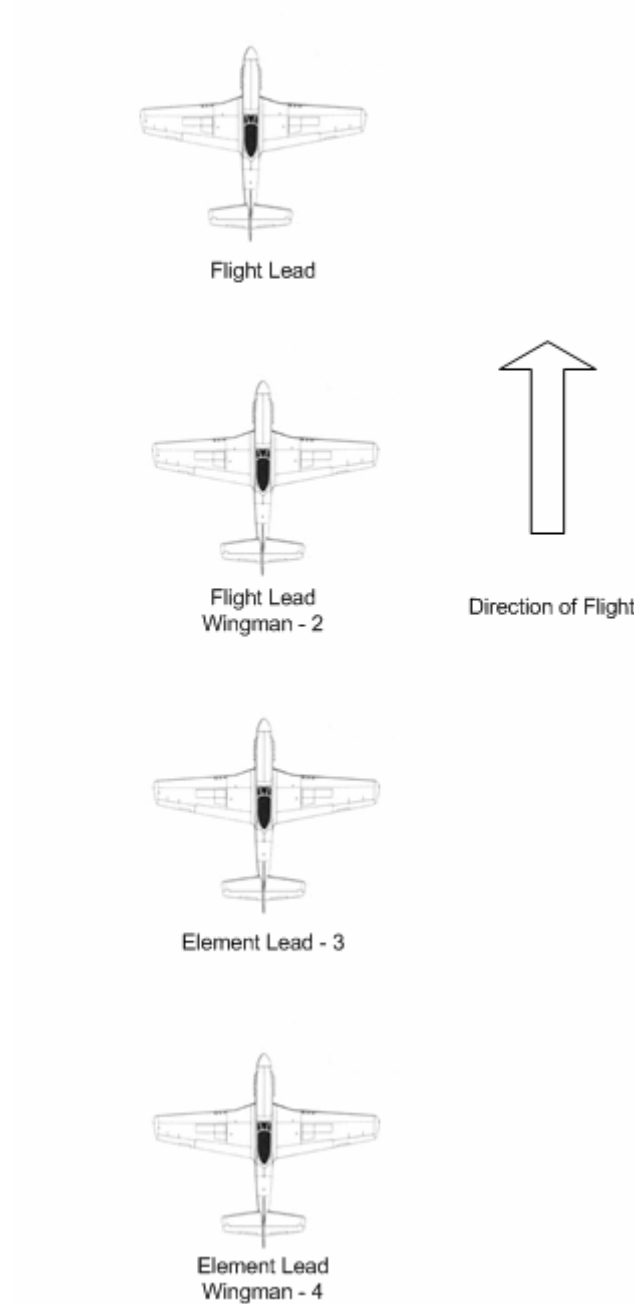


Figure 39

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Kudos Turns

Kudos Left from Line Abreast

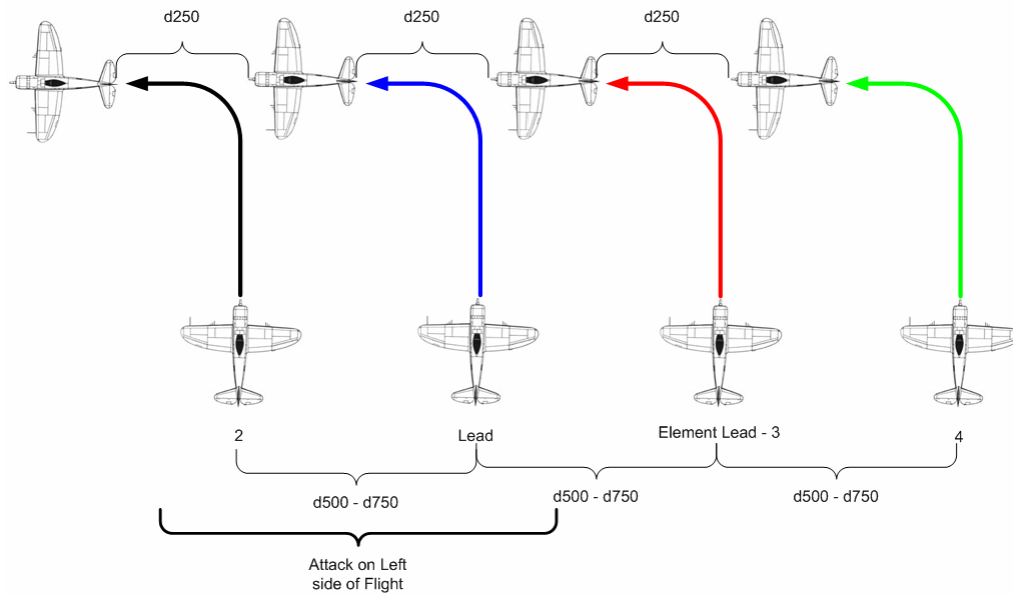


Figure 40

Kudos Right from Line Abreast

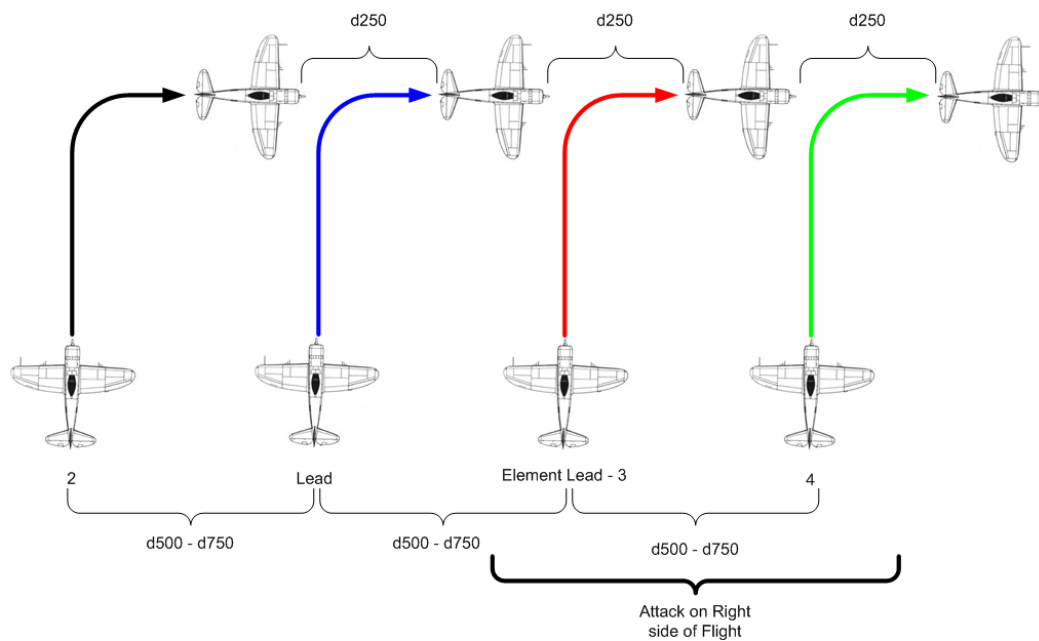


Figure 41

Crossover Turn

Crossover Turn

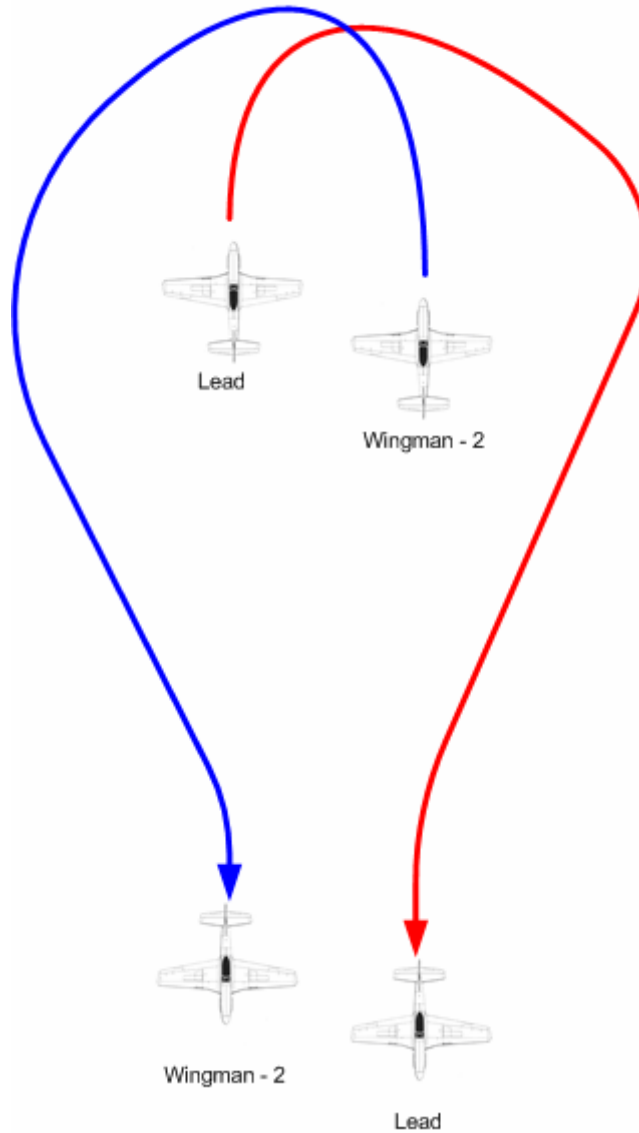


Figure 42

Wingman Tactics 2 v 1

***** ACKNOWLEDGEMENT: Many of the diagrams below were taken from "Fighter Combat: Tactics and Maneuvering" by Robert L. Shaw. If you've read this far and don't own a copy of this book, you probably should seriously consider buying one*****

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Offensive Tactics

Remember that you're not flying in formation because it's pretty. You're there to KILL and enjoy better security while doing it! Formations are never defensive. They are offensive at all times.

Bracket Attack

The most basic 2v1 maneuver is called the Bracket. It's fairly self explanatory given the name. You and your wingman bracket the enemy between you and force him to make his first of two critical decisions. That first decision is to run or engage. The two fighters perform an offensive split slightly away from each other in order to get the bogie to chase one or the other. If he runs then you have him unless he is faster than you but then at least your have a moral victory. If he decides to engage, then he must make the second of his decisions - who to attack.

Whoever he decides to attack is called the engaged fighter. The other wingman is the free fighter. The engaged fighter maneuvers so that the enemy exposes himself to the free fighter. The free fighter's job is simple - aim true and deliver the coup d' grace quickly..

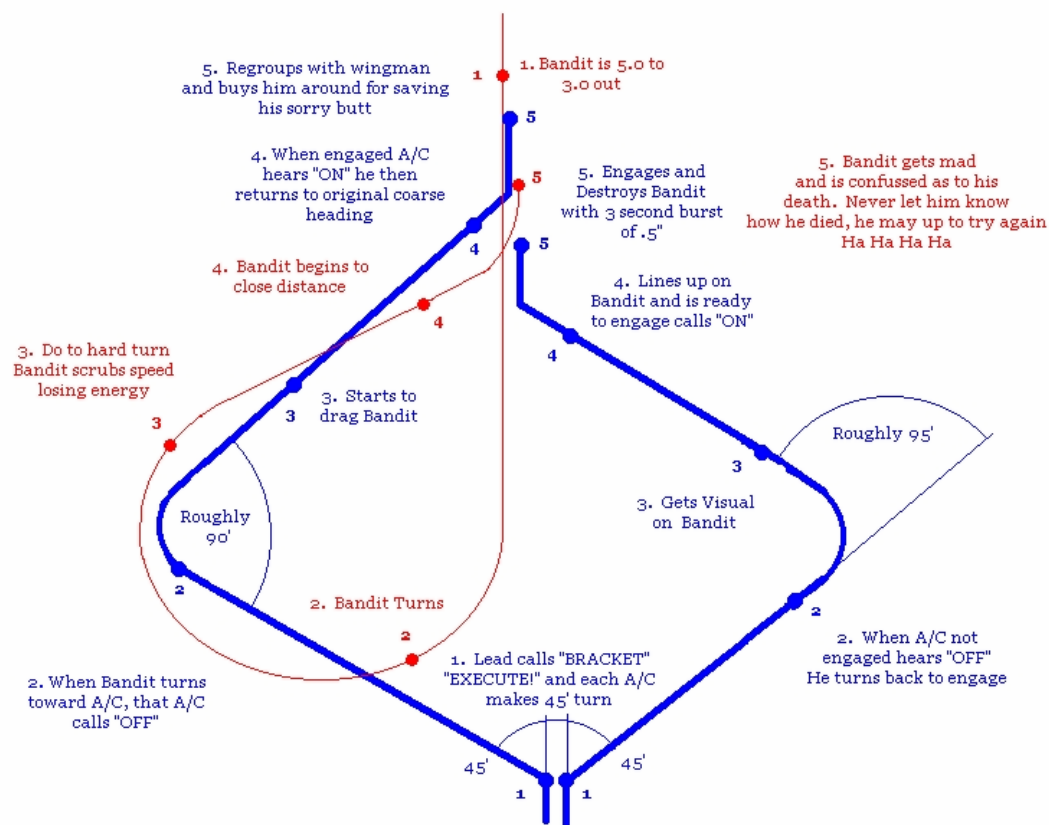


Figure 43

After the bogie makes his decision on which plane to attack, the engaged fighter turns back toward his opponent creating a head on pass (the object is not to give the opponent a shot) the free or non-engaged fighter turns toward the bogie using lead to close gap quickly as bogie attacks his wingman, and as the first two fighters pass the free fighter should end up on the attacking bogie's six o'clock. Following the pass, the more offensive fighter (free fighter) should assume the role of Lead. The bogie must choose to defend

against one or the other of the attackers but he cannot defend against both. If the fight does not end quickly, keep working with separation, and use drag & bag tactics as necessary to kill the enemy

In Figure 43, prior to Time 1 you and your wingman are spread out to bracket the enemy. At Time 1 you split more to force the enemy to pick one of you, which in this case is the lower fighter. Once you see who he has picked the engaged fighter moves so that the enemy isn't given the room for a lead turn (keep the separation low). By doing this at Time 2 the free fighter can then make an easy turn into the enemy for a deflection shot at Time 3.

Loose Deuce Attack

The "Loose Deuce" is basically a form of "*tag team fighting*". The tight wing formation can be abandoned in favor of a more loosely spaced combat spread of the section. The wingman does not need to stay closely behind the leader in this formation as he will be a more active member of the attack. This is a widely used tactic between wingmen, and it can be very effective. Distances between aircraft in the section can also be enlarged. Usually a spread of d750 to d1000 is acceptable to keep within turning distance of your wingman. This separation allows the wingman the opportunity to get his guns trained on the enemy upon engagement.

In this attack doctrine the closest fighter or the fighter with the best position for the shot assumes the role of lead and is "in" on the bogie. The other pilot assumes the wingman role and positions himself to both cover his wingman and if the opportunity presents itself, get a good shot on the bogie. The wingman should be above the fight, but close enough to assume the lead if the leader loses the advantage.

The job of the "in" pilot is to maneuver for a shot, and if this cannot be achieved, to bleed the enemy's energy or force him into a disadvantageous position. He then calls, "Out" and disengages. The other pilot, formerly the "out" or "perch" pilot can then dive in and engage the bogie while the other pilot climbs to regain energy, reestablish SA and perform the duties of the perch. The idea is usually for only one plane to be committed at one time; the other, on the perch, is there to ensure the SA for the pair and to watch the six o'clock of the "in" pilot, who can concentrate his full attention on shooting the bogie.

The wingmen alternate roles until the bogie is killed or the overall tactical situation changes. At that point, it usually becomes necessary for the pair to either escape or extend away from the action to regain their SA before moving on to the next bogie.

Double Attack

Double Attack is a more aggressive derivative of Loose Deuce. There are still the "in" and "out" pilots, but the "out" pilot is more actively involved in the attack, not just waiting on the perch until the engaged pilot calls him down. When the "out" pilot feels he has a good angle on the bogie he can dive and engage. This approach demands *very* close communications and is not recommended if voice radios are not working properly. The Loose Deuce is used more often than the Double Attack which is reserved for situations where it is reasonably sure that there will be no reinforcements to undermine the SA of the pair.

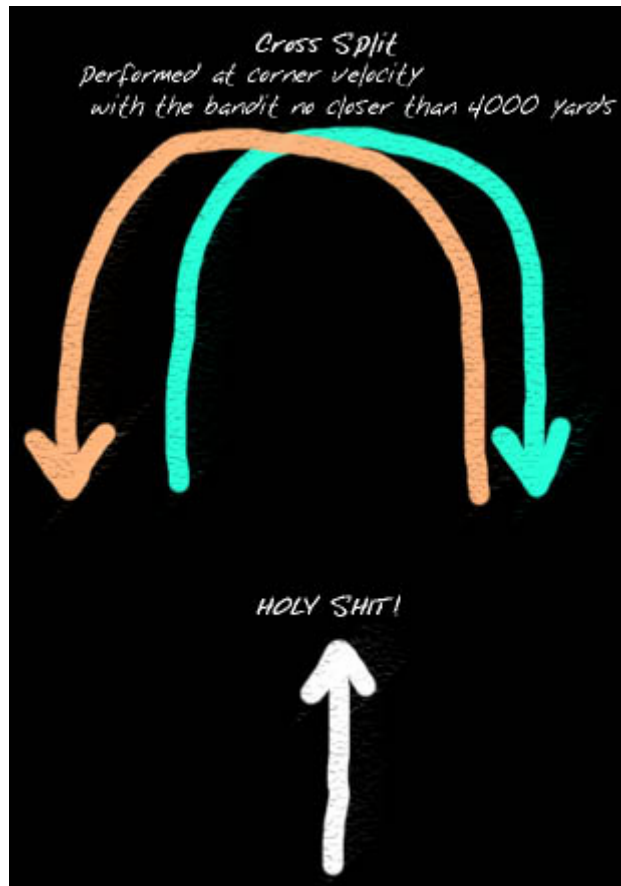
Defensive Tactics

Defensive tactics are only used to neutralize the enemy's advantage and transition to the offensive. If unable to attack safely, disengage.

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Cross Split

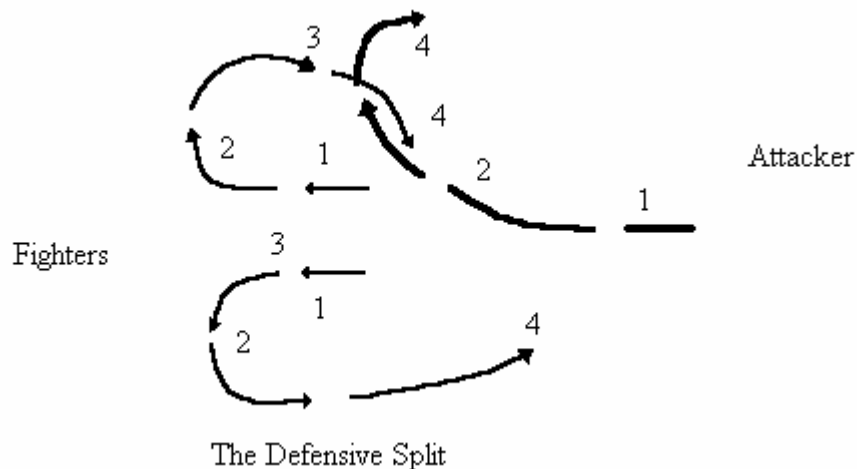
This maneuver allows a swift transition to the attack. The element spots an enemy aircraft at their six o'clock. The enemy's energy state may be negative, neutral or superior. It doesn't matter - you will turn the table on him regardless. Break toward your wingman, making a sustained turn to maintain E and sufficient separation. The bandit must choose between the wingmen for his attack. He cannot attack both. The engaged fighter may need to perform guns defense while the free fighter convert to the bandit's six o'clock position.



If the enemy is not killed quickly and the tactical situation allows for engaged maneuvering, make sure to continue working the bandit from different directions in order overtax or break his SA. If he breaks off combat, let him go unless you feel entirely safe to pursue and/or are in a position to kill him swiftly.

Defensive Split

The defensive split can be used when an attacker has not as of yet selected an aircraft to attack. In this tactic, both leader and wingman turn away from each other, forcing the attacking bogey to choose one or the other. Non-level planes of turns may be used, but you must remember to attempt to retain as much energy as possible. The engaged fighter should turn to meet his attacker head on. Then after passing should regain E and disengage from fight. The non-engaged teammate may attempt a hi yo-yo to get around faster, once he learns that he is not under attack. By choosing one fighter over the other, the attacking bogey will lose sight of the free fighter who after making his turn will be able to enter the fray on the bogey's six o'clock position.



Half Split

This maneuver is used in the same situation as the defensive split. This time only the wingman peels off some 45 degrees or enough to keep the bandit in sight, while standing by to turn back immediately if the bandit goes after the Lead. Perform guns defense if necessary. In case of the bandit going after the wingman, the Lead turns in and disposes of him. Depending on relative E-states, the engagement may lead to a classic sandwich or a bracket fight as described above.

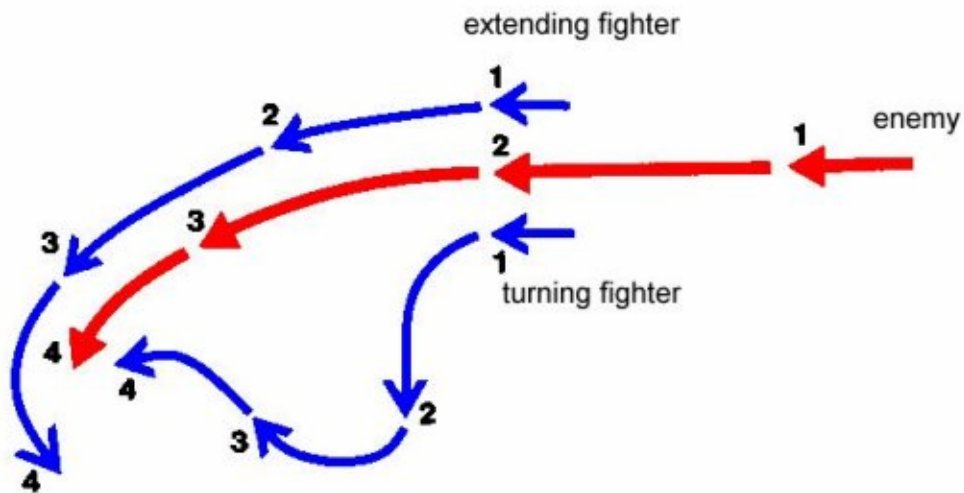


Figure 44

Drag & Bag

Dragging is an art. Most pilots think situational awareness only relates to the knowing where and what the enemy is. With the Icon system in Aces High most pilots have no idea what the friendly pilots around them are flying. You may find yourself a situation where you are in a position to clear a friendly pilot's six o'clock and at the last moment before you get a guns solution the friendly pilot breaks hard into you.

Leaving you in the position of having to force a shot and bleed your “E” or go into a pitch back maneuver. Most of the time, the friendly pilot will be killed before you get around in a hi yo-yo to clear him.

Flying in a squad with other pilots who fly the same planes makes "dragging" and "clearing" much easier. When performing evasive actions you must be aware of the abilities of the plane and pilot trying to clear you. Never turn into him cutting his angle. Communicate with the pilot clearing your six o'clock. With the VOX in Aces High and TeamSpeak 2.0 it makes it easier to communicate. Think in terms of "setting up" the bandit not just in avoiding his guns (Figure 43). Always turn away from your help and keep an eye on his position. If you see him closing fast, take the bandit on your vertical 6 o'clock. When running never run away from your help. Know where you are, where help is, and where that lovely friendly Ack is.

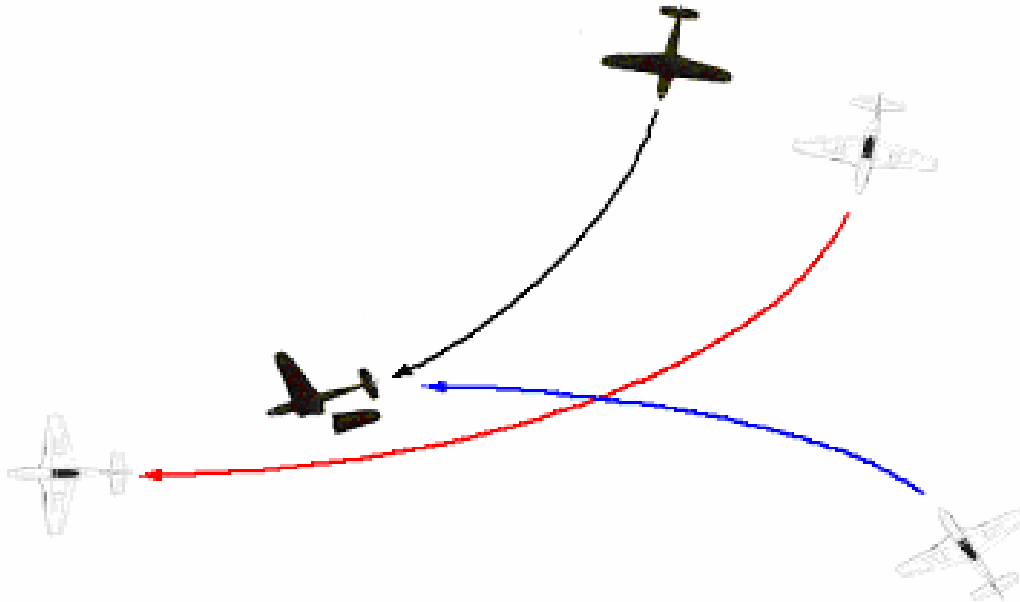


Figure 45

The biggest thing to learn about evasive actions is timing. Knowing when and how fast or slow to perform a maneuver will determine whether you live or die. As you get better, your objectives will shift from "how do I survive" to "how do I kill". Many pilots prefer to work from the defensive but never go into a situation expecting to die. Keep a clear head and take what you get until you either die or you reverse.

Thach Weave

USN pilots used the Thach Weave from early in WWII when it was Wildcats vs. Zeros right up to the end even though they had more powerful and maneuverable fighters like the Hellcat and Corsair. The engaged fighter does a series of turns (Figure 46) that gives the free fighter multiple deflection shots. Keep the turns nose-low so that you keep your speed up and prevent high-G stalls.

Primarily used when the team is too far from each other to perform any of the above, or wish to exit the general area and still defeat the bandit. Depending on energy state and the need to put distance behind you, scissor the bandit to death by reciprocating S-turns. Note that this is NOT an individual flat scissors, but a TEAM scissors which opens and closes - with the bandit in the middle. The picture shown here is not totally correct in that regard. In a true Thach Weave, you will want to make more pronounced turns.

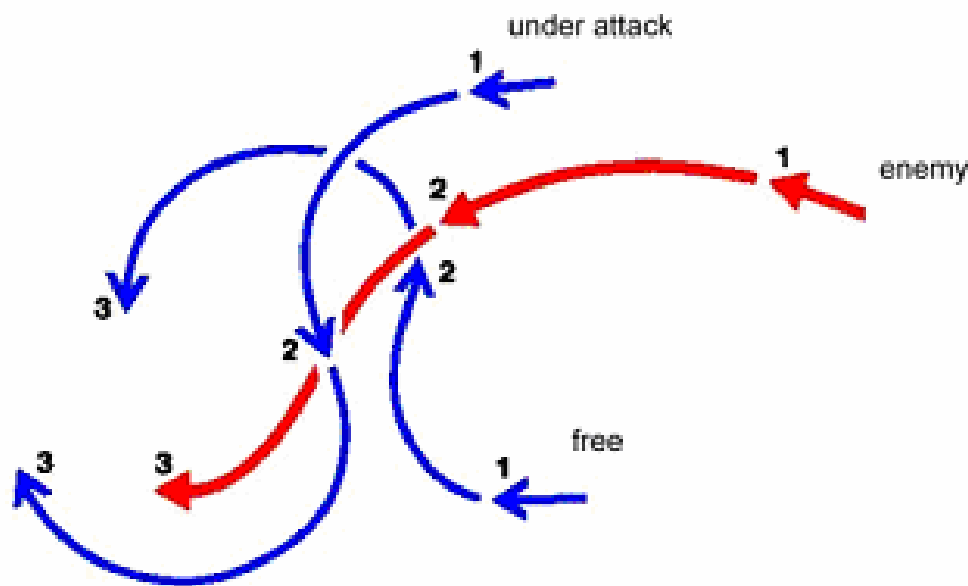


Figure 46

Note that this is NOT an individual flat scissors, but a TEAM scissors which opens and closes - with the bandit in the middle. The picture shown here is not totally correct in that regard. In a true Thach Weave, you will want to make more pronounced turns.

In high speed fights where you wish to extend, the turns are small unless the bandit is in firing range (which will force guns defense and lead to a 2v1 situation). Open up separation and then close it again to let yourself or your wingman gain angles. The bandit will be at a significant disadvantage if you keep the radius small yet sufficient to gain angles, whereas you will risk head-on shots if you make big turns. Whenever the bandit stops tracking one of you (due to having to perform guns defense), he's meat on the table.

The Sandwich

The sandwich (Figure 47) can be the most effective way to deal with an attacker who wishes to attack a two-ship unit. In this instance the attacking bogey will usually line up on one plane or the other (Time 1). When this occurs, the best thing to do on the "break" is for the attacked pilot to turn away from his wingman. The non-engaged free fighter should also turn in the same direction as his wingman (in the picture both fighters break in the same direction). If the attacking bogey continues to press his attack on the first fighter as shown here, the turn will place the free fighter right on the attacker's six o'clock position where he will then become sandwiched (Time 2).

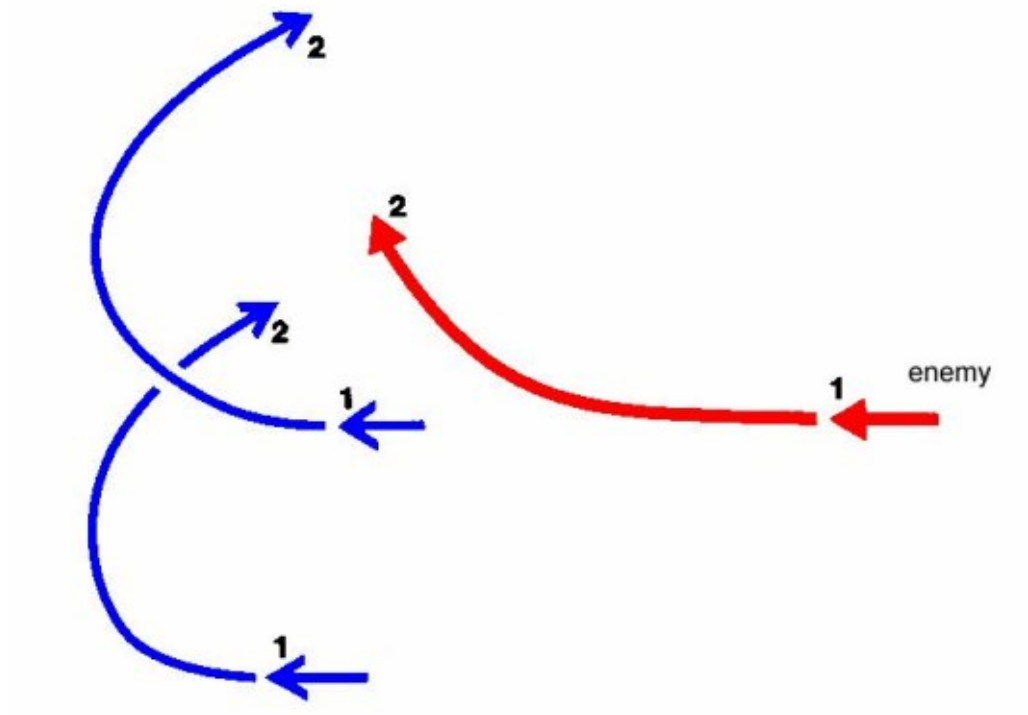


Figure 47

Common Mistakes or “the Seven Deadly Sins” in Wingman Tactics

"Never break your formation into less than two-ship elements. Stay in pairs. A man by himself is a liability; a two-ship team is an asset." **Maj. Thomas B. "Tommy" McGuire USAF,**
Second Leading U.S. Ace, WW-II, 38 Victories

1) NO ASSIGNED LEADER

Trading off the lead in your tactics is acceptable. However, it is critical to always have a designated Lead! If the Lead runs out of ammo, the wingman can assume the Lead, and roles are then reversed. For example, the Lead overshoots and the wingman picks up the attack etc. However, always determine who is the active Lead and will be calling out the ACM (air combat maneuvers) or which bogies to chase and destroy at any particular point in the fight.

2) FULL THROTTLE CRUISE

If you are the Lead, you have less work to do to preserve the formation. In most situations, your task is offensive. Reduce your manifold or boost to 90% or even 75% of maximum so that your wingman can maintain formation.

3) ONLY LOOK STRAIGHT AHEAD

The biggest challenge to flying wing is keeping track of your wingman. Wings must get used to flying in the off angle views and be able to track their wingman quickly and smoothly. In this way, one will always be able to cover your wingman's six o'clock.

4) COMMUNICATE TOO LITTLE

You cannot be radio shy for wingman tactics to work. Set up the correct squad channel on TS and in Aces High. Ignore most of the other messages once you are in the thick of battle. Initial radio chatter will include: load out for the mission, destination, altitude, and formation (traditional, line abreast, loose deuce). The wingman will also call out the distances, manifold and RPM settings so that proper spacing can be maintained.

Whoever sees the contact first will call it out. Then the Lead will choose bogie to target. Wingmen will acknowledge with the designated call-sign. This completes the communication loop, and then there is no worry about missed assignments. Major maneuvers should also be signaled by the Lead (e.g. - pitch back (or Immelman), split-ess, break right, left and left turn, right turn, etc.)

When it is time to extend away, you may hear: "Bingo fuel!" or "Winchester!" which means one of the wingmen is ready to depart. The Lead will order the break off of the attack and both pilots will egress the area.

5) LONE WOLF SYNDROME

Wingmen are eager for combat too. But in a real fight, any target fixation can become dangerous, especially when both Lead and wing are locked on a different enemy's six o'clock. The Lead's first priority will be offense; traditional wingman's priority will be defense. (Once again, line abreast, and loose deuce offer other advantages.) The Lead can be selfless and call on the wingman for a shot if he finds it too hard to pull sufficient "lead" to do so himself. Also, the Lead can be traded on alternating missions. As one ace said, "To lose your wingman is to lose 75% of your fighting power." Stick together! It's critical to your survival in aerial combat. If you get killed, or damaged, wait on the runway for your wingman to return.

6) FAIL TO CHECK YOUR OWN SIX

The Lead, if he knows the caliber of his wingman, and trusts his dedication, can spend less time checking his own six o'clock, and more time tracking bogies than his wingman. The wingman has a clear view of his

Lead's six o'clock. A good trail distance is d350 to d500. Any bogie that gets in between you and your Lead can be dealt with from this distance.

However, as a wingman, checking your own six is essential and a greater workload for you than for the Lead. Don't just hit the six o'clock view from time to time, but do the twists, the turns and the inverts, to get a good view of your own six o'clock low position as well. In all likelihood, your death will lead to your Lead's death soon after. Also, be aware that you will often be the first target in a flat out pursuit.

7) FAIL TO MAINTAIN ALTITUDE

Altitude equals life. Contrary to popular belief, E (energy) does not mean speed. It is the potential to make speed. To accomplish this, you need to maintain your altitude. Unless strategy dictates, do not get drawn into a low energy, turning fight. If you do get into a turning fight, keep your nose up or you will put both your wingman and yourself in jeopardy.

Air Combat Maneuvering - Rules to Live By!

Don't Climb into a Fight! -- If you find yourself climbing into a fight, you are usually in the process of making a big mistake. The enemy is sure to have the advantage in energy-state. It is generally very unwise to "force" an engagement from an inferior energy state.

Attack with the advantage! -- Air Combat is War! It's about using all the advantages that God gave you to shoot down other planes without being shot down yourself. Plan your attacks carefully. Move into a favorable attack position first -- don't just "jump into" the "furball"! Take advantage of "blind spots" and distractions to score quick kills

Attack with surprise on your side! -- Try setting up a surprise attack on a target whenever possible in the game. Look for situations where the target may have poor SA (situational awareness), move into blind spots and sneak up on the target

Higher energy state "go high"/ lower energy state "go low" -- If you have the better energy state you generally have the advantage. Stay above your opponent if possible. After completing a gun pass it is usually a big mistake to "go low" to re-engage. Going high conserves energy. Going "low" is good when on the defensive. When you are in trouble, the most important factor is to keep your airspeed up. If you are in an inferior energy state, attempting to "go high" will make you a sitting duck. Keeping your airspeed up allows you to maneuver more crisply. Your opponent could make a mistake, which you could exploit with that extra maneuverability. Try to fly near corner speed whenever possible.

When it Doubt - Go Vertical! -- In air combat, it's a good idea to use the vertical as much as possible. If you have the energy to "go high", it's rarely a mistake to do so. Don't stick to "flat" turns in a dogfight! It leads to very high insurance premiums.

Lose sight...Lose fight! -- The most important factor in Air Combat is to see the opponent! Spot him first (and his friends!). Keep him in sight at all times. Whatever system you use for views, memorize it forwards and backwards! Scan your views once every few seconds even in a "quiet" sky. Otherwise the first indication of danger could be bullets ripping through your plane.

Know your limitations! -- Don't attack outnumbered unless you have the energy advantage. The more outnumbered you are the bigger the advantage should be. If you are badly outnumbered you only have to miscalculate the energy state of one of the enemy to end up in a "silk letdown".

Calculate firing lead before opening fire! -- Don't fire first and ask questions later! Try to gauge the "Kentucky Windage" before you pull the trigger. Otherwise you might find yourself flying around without ammunition real fast. It also lets the enemy know you're there and they can take evasive maneuvers.

Short Range! Short Bursts! -- Don't try to "walk" the tracers into the target plane, because ammo doesn't grow on trees! Short bursts initially, then if you really have the range down, fire for effect! Generally shots over 300-500 meters are a waste of time against a hard maneuvering plane. Get in close and hit hard! Remember that cannon shells will "drop" faster than machine guns at long range.

Get "Out of Plane" when being fired upon! -- No! That doesn't mean bail out! When evading fire think aileron and rudder -- not just elevator! The infamous "flat break turn" is the easiest defensive move to track with guns. That is an "in plane" maneuver, the easiest maneuver on which to maintain a gun solution! Make the other pilot work for it. Instead use "jinking" rudder moves and

aileron rolls to evade fire. If you can force the other pilot to pull negative G's to fire, so much the better. He will be seeing "red" real soon.

Avoid "Dead Six"! -- It's generally wiser to attack slightly from the side than to attack from a dead-on six o'clock position. The target presents a very small cross section from "Dead Six", which makes for a difficult shot except at point-blank range. At ranges over 150 meters, try to attack slightly from the side. This presents a much larger cross section and involves a minimal gun deflection angle. It also helps avoid those nasty collisions!

Think Energy, Not Stick -- "Average pilots think stick -- the best pilots think energy!" Even when in a tight "furball" always keep relative energy states in mind. This will allow you to evaluate what he can do, and what you can do with more accuracy. Always try to keep that last ounce of energy in your back pocket as your "Ace in the Hole". You may need to play the card sooner than you think!

Turn into the attack, not away! -- By turning "into" the attack you are maneuvering to avoid allowing the other pilot to get on your "six". By turning "away" you are giving it to him.

Lead turns -- They are not just for the horizontal! -- Many pilots know that in the eternal battle for "angle", the "lead turn" is a useful tool, but they forget that lead turning is also permitted in the vertical, not just the horizontal. Vertical separation can be exploited just as easily with a lead turn as lateral separation.

Remember the "Rule of 45" when B and Zing! -- When making an energy based rear quarter attack with a fair amount of closure on a target, follow the target for only about 45 degrees of "break". If you haven't killed him by then it is time to zoom away and setup another pass! Following that break turn too far will surrender your energy advantage, or could lead to a disastrous overshoot. It's generally a poor idea to follow an "out of plane" break down if you have a fair amount of closure on the target. If he breaks into a Split-S or similar maneuver (such as a slice-back) it is usually a bad idea to follow, since your high speed will actually work against you as the target breaks low. Instead establish a lag pursuit situation or go vertical to establish a dominant altitude advantage with vertical separation. Then close in for another pass. Remember it often takes several energy passes to "wear down" the target's energy state to the point where the kill is assured, all the while maintaining your own energy.

Lag Pursuit with superior Energy, Lead Pursuit with equal or inferior Energy! -- When attempting to gain gun angle on a target use geometry to close on a target who has equal or higher energy by "cutting the corner" of his turn. Anticipate his flight path and "lead" it. Lag Pursuit avoids problems with gun deflection and closure. Instead of flying straight at the target and taking a high deflection shot at his turning plane with a large amount of closure, simply "lag" out side his turn. Often you can deliberately turn outside his circle, going into a high yo-yo or lag roll to conserve your energy advantage and set up a more promising shot.

Always Fly Aggressively! -- When in the air, always think aggressively -- even when you are on the defensive. One of the skills of all successful pilots is a basic killer instinct. Flying in a tentative or indecisive fashion will get you killed. A good pilot will use your hesitation against you. The good pilot is the master of the calculated risk. Building the judgment to know when a risk is justified is a key to success.

Know your plane and your enemy's! -- Understand the strengths of your plane, and the planes you are flying against. Their strengths and weaknesses should be etched in your mind. A good pilot knows how to exploit the strong points of his ride, and exploit the weak points of his target to get the victory. Don't fly "against" your plane by asking it to do something it is not capable of.

Basic Stuff

Avoid stalling or entering into an unrecoverable dive. To avoid spinning:

Watch your airspeed.

If your airspeed is low and you are following a slightly faster plane with a better rate of climb than your aircraft, be very careful trying to follow him in a climb, he is probably trying to stall you out.

If you are doing a head-on with an aircraft higher than you, don't try to shoot him as he goes over you unless you have enough speed to do a half loop (Immelman).

Zoom and Boom - you will see this being used by pilots flying planes inferior in maneuverability to yours. These pilots will always start out climbing to gain height advantage. They often commence with a head-on attack in a swoop style. When you try to get behind them, they continue to fly away from you and climb again. They are conserving energy and are very hard to catch, especially if they are flying a faster airplane.

Tactics:

Reverse Half-Cuban Eight - conserving energy in reversals is critical and this turn is one of the best ones when traveling fast.

American Fighter Tactics - CAA-NRC Committee on Selection and Training of Aircraft Pilots, 1942

Know your airplane

Every aircraft has strengths and weaknesses. Make sure you know yours and those of the enemy aircraft you're most likely to encounter. Knowing you can out-climb, out-accelerate, out-turn, or out-gun your foe changes the way you fly. So does knowing your own plane's vulnerabilities.

Keep your head on a swivel

Visualizing the positions and movements of fast-moving objects in a three-dimensional space is difficult. But it's what separates fighter pilots from fighter aces. Being a good shot is a useless skill if you can't keep track of the enemy.

Use the element of surprise

When you come in from behind or below the enemy he can't see you. But dropping in from above gives you the potential for greater speed. While you're closing in, use the enemy's blind spots to your advantage. Come out of the sun or the clouds with your guns blazing so you can shoot him down before he even knows you're there.

Stay one move ahead of the enemy

A good fighter pilot's actions in the present are dictated by his prediction of the future. If you merely react to your opponent's actions you will be shot down. If you anticipate his actions and respond intuitively without hesitation, you will emerge the victor.

Trade altitude and airspeed

Are you flying too fast? Pull back on the stick and you'll slow down as you climb. Be careful though: pulling up to shake the enemy off your tail is a dangerous move! Your airspeed will drop quickly, and a slow ship under fire is a sitting duck.

Are you flying too slowly? Nose your ship over into a dive to gain some airspeed. Trading altitude and airspeed is an essential part of all aerial combat maneuvers.

Fly slower to turn faster

When you ride a bicycle around a corner quickly you want to go fast, but not too fast-it's the same with your aircraft. At fast speeds, centrifugal force causes the plane's turn radius to increase and its turn rate to decrease. Every ship has a speed at which maximum-performance turns are possible. In general, though, a slower-flying aircraft will out-turn a faster-flying one.

Turn into your opponent

Turning into the enemy's direction of movement increases the angle between your movement and his guns, making you harder to hit. Turning away decreases the angle, making you an easier target-and making it much easier for him to get on your tail.

Use "deflection shooting"

Attacking an enemy aircraft from in front or behind is easy. Just aim and shoot when you're close enough to hit the target. Attacking from other angles is more complicated. You must coordinate your shooting with your speed, and fire ahead of the target so that he runs into your bullets. This difficult skill is called "deflection shooting," and it is the mark of a good combat pilot. Learning it is essential to your success.

Don't shoot until he fills your windscreen

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Wait until you're so close that you're sure you'll hit him-you'll save ammunition. This strategy takes less concentration than deflection shooting, but it isn't always practical-especially if you're meeting the enemy head on!

Never stop an attack once you've initiated it

If you run away when you're within range of the enemy, it's easier for him to get a shot at you. Courage is not the absence of fear; it's action in the face of fear. If you've decided to attack, be courageous and follow through. Cowardice at close range will get you killed.

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