

Energy

Energy is the single most important concept you need to understand before you will be successful in air-to-air combat. Energy is - in its simplest form - airspeed or the ability to generate airspeed. All manoeuvring creates drag that bleeds airspeed and if you cannot counter this energy bleed you will find yourself unable to either attack or defend.

In combat the pilot with the most energy has the upper hand. They should be able to manoeuvre to an attack position while denying the enemy the chance to do the same. Once in the attack position energy is spent making your attack while your bandit spends energy avoiding it. It often costs more energy to defend successfully than is spent on the same attack.

An attacker should wisely use his energy, A quick kill spending little energy is more desirable than a kill made through wearing an opponent down. Getting a kill through energy depletion might still be a kill, but your own energy state may well make you a sitting duck for another lurking bandit.

Turn fighting often turns into a battle of energy depletion where combatants aggressively spend their energy to gain a controlling position with little regard to energy state. Energy fighting is combat where an attacker aims to keep energy up through slashing attacks at high speed coupled with manoeuvring in the vertical. Choosing which approach you will take in your engagement will depend on whether you have an initial energy advantage with relative aircraft performance being a secondary consideration.

If you have an energy advantage energy fighting is your best choice, at least initially. It keeps you safer than turn fighting and is easier to coordinate. If you have the disadvantage you want to lure your opponent into turn fighting to reduce their energy state to the point where you can move over to the offensive when you achieve energy parity.

How do you get energy?

You gain energy by accelerating. You do this by using the acceleration provided by your power plant or the acceleration provided by gravity by putting your nose down and trading altitude for airspeed.

Gravity gives you the best acceleration so it's your best source of energy. This is why having an altitude advantage is very important. You can consider altitude an energy bank that you can withdraw from whenever you need to gain energy by diving to gain airspeed.

How do you waste energy?

- Spending more energy in an ineffective attack than defender spends evading.
- Giving up altitude for no purpose.
- Defending inefficiently by giving up excessive altitude or airspeed.
- Not grabbing energy when you have the opportunity to do so.

How do you wisely use energy?

You wisely use your energy by being miserly with it. If an attack would cost you a lot of energy be patient and wait until your target is on sale.

When you're banking energy by converting it to altitude you should only bank what you can spare. You should always keep enough to defend effectively against a couple of attacks by climbing at high speed.

Gunnery

Until there is lead hitting targets it's only an airshow.

Gunnery can be as simple as getting very close to your bandit and letting fly with all weapons or with more finesse at greater ranges and higher deflection.

Greater gunnery skills provide more opportunities to bag your bandit. It also makes it harder for your bandit to defend successfully.

Firing methods

There are two types of guns attack, tracking shots and deflection shooting.

Tracking shots are when you place your gun sight on or near the bandit and fire while 'tracking' the movement of the target. Tracking shots are made on 'low aspect' targets – i.e. targets whose flight vector is close to your own.

Deflections shots are much like skeet shooting. You judge where the bandit is travelling and shoot into that area hoping that the bandit flies into the stream of fire.

Which firing method you use is dependent on two things:

- Type of armament – Higher rate of fire weapons with high muzzle velocity are better for deflection shooting than slower firing weapons because they lay a greater density of fire and have a flatter trajectory, increasing the chances of hitting the target.
- Relative manoeuvrability of your aircraft versus enemy aircraft – if your aircraft is not as manoeuvrable as the enemy's it may be difficult to get a tracking shot.

Once you have decided what kind of firing method you will use, you set your convergence accordingly. If you are going to use tracking shooting you want to use

a close in convergence setting. If you are going to use deflection shooting you want to set your convergence as far out as you can and still maintain a good grouping of the projectiles.

Some aircraft have a mix of weapons and multiple triggers. This allows those aircraft to 'mix' their convergences and the pilot can use the weapons to suit the situation.

Gravity and muzzle velocity

When a round leaves the weapons it begins to accelerate towards the earth. During the initial part of a round's flight the drop is negligible, negating the need to take it into account but as time passes and velocity bleeds the drop becomes more pronounced.

Weapons with a slower muzzle velocity will have a shorter range before the drop becomes prohibitive to accurate gunnery

The effect of range on gunnery

Range effects gunnery in the following manner:

- Round velocity decreases: To penetrate armour and the vital structure the projectiles need enough kinetic energy to do so. Kinetic energy is mass x velocity, so the faster a projectile is going the more armour it can penetrate. Some rounds use a secondary effect for their killing power – high explosive or incendiary or some mix of the two.
- The longer the shot the more the rounds will drop from gravity.
- Each round fired will travel a slightly different path – this is known as dispersion. The longer the shot the greater the dispersion of the rounds.

Convergence and gun placement

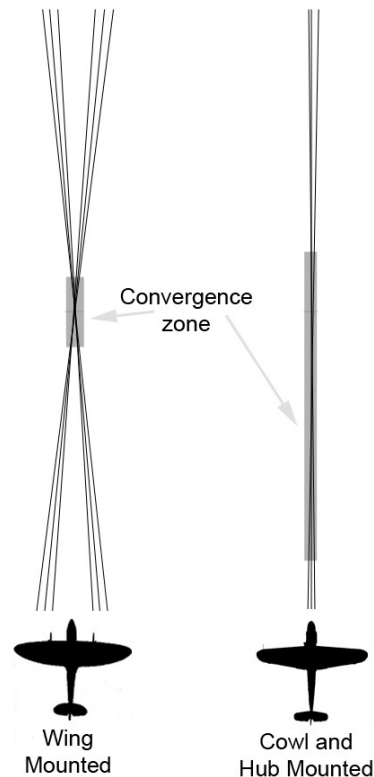
Weapons on a fighter are usually placed in one of three places, on the wings, on the engine cowling and firing through the propeller hub.

The wings are the most common as there is no need for extra equipment to allow the weapons to fire through the propeller arc. However this leads to the issue of the firepower being too spread to inflict an effective hit. This issue is solved with convergence.

The guns are set so that their trajectories overlap at a set distance – creating a convergence zone. Any aircraft caught in that convergence zone will take serious – if not fatal – damage as they would be hit by all the weapons the aircraft can bring to bear.

Aircraft with cowling and propeller hub mounted weapons do not suffer from this issue, however due to limited space their weapons load will be made of fewer weapons, and if large calibre – slower rate of fire and more limited ammo. Additionally the rate of fire may be affected by propeller rpm if the weapon fires through the prop blades.

The remaining difference between wing and cowl/hub mounted weapons are not as effective outside their convergence zone due to spread (either before or after the convergence zone) whilst the cowl/hub combination extends directly ahead in a long corridor.



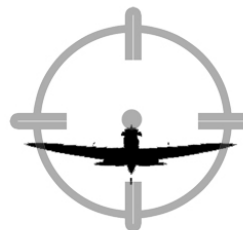
Angle off

Angle off is the amount of degrees difference in relative headings of target and attacker. Low angle off is when the difference in heading is negligible and only a small amount of leading the target is necessary and little effort is required to maintain a tracking shot. Medium angle off is when the difference in relative headings is sufficient to require a judging of how much lead to give and initiating a tracking shot might require further manoeuvring whilst a deflection shot that follows the track of the bandit may yield good results. High angle off is when the difference in headings is sufficient to make a tracking shot impossible and a deflection shot is likely to only yield a low number of hits.

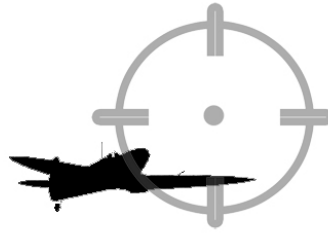
How to judge the angle off

The easiest way to judge angle off is to compare the placement of the rudder to the wing in the horizontal.

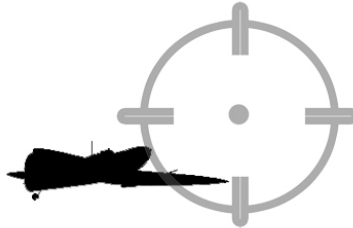
Low – if the rudder is in line with the fuselage the target is at low aspect. Put the pipper on or slightly above the bandit. This is a perfect position for a tracking shot.



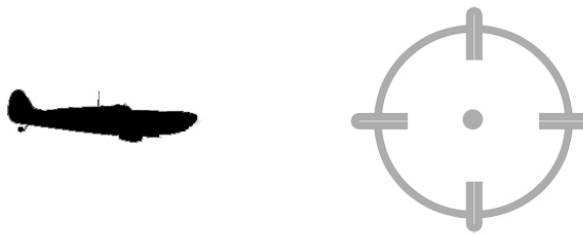
Medium – if the rudder is halfway along the bandit's wing then the target is at medium aspect. Place the pipper just inside the closest wingtip and adjust for the bandit's pitch. You will be able to get a short tracking shot from this aspect.



High – if the rudder is in line with the tip of the wing place the pipper outside closest wingtip and adjust for the bandit's pitch. The tracking shot will be fleeting.



Extreme – if your target is side on you must lead the target by a large amount. Your best option is to set a near collision course on approach and shoot at extremely close range.



Similarly, the vertical lead mirrors the above. Once you get used to horizontal lead you will be able to judge vertical lead by placement of the elevators in relation to the nose.

Setting up the shot

In the end it all comes down to gunnery. Excellent airmanship will keep you alive and put you in the position to shoot down an opponent, but unless you know how to shoot you'll not be effective in combat and will take too long to shoot an opponent down.

A common mistake made is to shoot too early without the shot being set up properly. You should aim for your first burst to be a killing one.

You begin your shot quite some time before pulling the trigger.

1. Judge the flight path of the target – you can do this by looking at the orientation of the enemy aircraft.
2. Trim your elevator on the approach so you aren't fighting the aircraft when aiming.
3. Set up a collision course with your bandit – this will ensure you are in the right position for your shot when you are close enough.

4. Adjust your aim point. If the angle off is low and the enemy is unaware of you, close in while aiming for a wing root or mid-wing. If the enemy aircraft is offset aim in front of their cowling with the aim of raking your fire down their fuselage and through the cockpit.
5. Do not start firing until you are almost at your convergence range.
6. If at any time you determine you cannot take the shot immediately begin your repositioning for your next attack.

Machine gun versus cannon

The types of weapon typically carried by fighters can be classed as either machine gun or cannon.

The principle difference is the diameter of the round. Equal to or less than .50 cal (1/2 inch in diameter) are classed as machine gun, while larger are classed as cannon.

Machine guns rounds usually have a smaller casing, allowing more ammunition to be carried. They usually have a higher rate of fire. Machine guns themselves are smaller than cannon, weighing less and being less bulky. This allows the typical fighter to carry more of them.

Cannon rounds can be relatively small to downright huge, and can have varying warhead types. These include:

- Ball – a solid round relying on kinetic energy for the kill.
- Armour Piercing – hardened tips assist in armour penetration and allow the round to penetrate into the aircraft structure, causing kinetic damage.
- High Explosive – a thinly walled shell packed with explosive. Damage is done through explosive force. This type of round is particularly effective against lightly armoured targets.
- Incendiary – similar to the explosive round, but containing chemicals designed to set fuel, oxygen systems or hydraulics on fire.
- Combination – the warhead types can be combined, such as High Explosive Armour Piercing or High Explosive Incendiary.

Rate of fire

The rate of fire is a description of how many rounds per minute a weapon is capable of firing. A pilot often only has a short opportunity to fire. A higher rate of fire will allow the pilot to put more lead into his target in that short opportunity.

For deflection shooting a high rate of fire will decrease the chances the target will fly through the bullet stream untouched.

When an aircraft is armed with multiple machine guns they are frequently set to fire in sequence, creating a stream of fire with only small gaps in it. This assists with deflection shooting.

Sight Types

Various sighting mechanisms were used during WW2, from simple ring and bead iron sights to lead calculating gyroscopic sights at the end of the war.

Sights might include various markings, generally to mark off set milliradians (or mils) - a finer definition of angle than degrees. These markings are used to calculate range and allow you to adjust for drop. If you know the wingspan of your target and the mils marked on your sight you can calculate the range. This in head math is best done prior to flight, calculating how many mils a target's wingspan will be at your convergence setting. Later aircraft included adjustable sights where the operator can select the wingspan or aircraft type of the target and have the sights adjust to match that wingspan.

You will need to refer to the documentation for the sight installed in your aircraft for specific details.

Iron sights – simple circular rings, sometimes with a bead mounted on a rod in front to provide orientation. These sights are completely static.

Reflector sights – an image reflected off a glass plate. Being able to see this reflected image provides sight orientation. This type of sight can often be adjustable.

Gyroscopic reflector – a reflector sight coupled with a gyroscope that adjusts to the aircraft's own flight path and automatically calculates the lead required to hit a target at a given range. Usually it takes some time for the sights to stabilise while you 'track' a target. If you can hold the pipper on a target that flies a continuous path for as long as it takes for the sight to stabilise you should have a very good chance of hitting. When defending against an aircraft equipped with such a sight you must be aware of extreme range shots when you've kept a constant flight path.