Gunnery Introduction

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This is a short primer on gunnery skills and gunnery in general for use in Eve Online. It comprises of 4 steps that will walk through all the basics for efficient gunnery use:

- General Introduction
- Types of guns; Their benefits and drawbacks
- Hitting your targets; What factors play a role
- Improving the odds; how to get the most out of your guns

1. General Introduction

Eve Online is a complex game. Many concepts may, at first, seem daunting to understand. Gunnery is one that is probably on the top of the list for new players. Before going into specifics on gunnery I want to highlight a few myths and pitfalls you may encounter.

Gunnery is all about hitting your target. In Eve there is also a quality modifier to hits with your guns. This is a straight bonus or penalty applied to the base damage of your guns. For this primer I will mainly concentrate on maximizing your hit potential and leave quality of the hits as a given.

There is no ultimate gun system. Eve has been balanced extensively. While certain systems certainly are better suited for certain roles, no gun can do all of them (well)

Beware 'EFT warrior'-ing. On paper, guns always hit, enemies have no resists, ammo never has to be reloaded and the highest damage type ammo is always the best choice. Unfortunately, none of this is true (except maybe the ammo for lasers). In fact, many of the important gunnery skills to master don't change your EFT DPS at all!

The gun system has been balanced around the total package of weapons. This means that certain concepts of eve gunnery are purely there for balancing purposes and don't have a real-life equivalent. In "real" life an orbiting ship always has the advantage in hitting the target, making the faster ship the winner almost by default. Not so in Eve. Also, common sense would suggest that shooting a projectile the size of a car would give you a better chance to hit a target than one the size of a fist, but for balancing purposes this is not true in eve.

Comparing guns to missiles, guns do more damage on paper, but only in perfect circumstances. Missiles always hit within range and do consistent damage. A perfectly flown gunship versus a 'dumb' target will certainly out-damage a missile system. Unfortunately, a 'dumb' gunship versus a very skilled adversary will produce very poor results compared to missile systems.

Don't mix gun types and/or sizes. Guns, depending on the ammo, all guns have a 'sweet spot' where they perform to the best of their ability. Mixing guns will average out your DPS over a wide range and will not allow you to perform to your maximum.

Take your role into account when selecting guns and ammo. This is especially true in PvP. If you are going to be a tackler and do a lot of orbiting, it's no use taking ammo that can't hit your target at the speed and distance to the enemy you are using. This may sound very obvious, but many a fast frig or interceptor is loaded with guns and ammo that can't actually damage it's target when maxing out its speed.

2. Gun types

There are 3 general types of guns and each type has a short-range and a long-range version:

- Lasers
    - Short-range **pulse** lasers
    - Long-range **beam** lasers
- Hybrids (part projectile, part energy weapon)
    - Short-range **blasters**
    - Long-range **railguns**
- Projectile weapons
    - short-range **autocannons**
   - long-range **artillery**

Some of the lines have faded over time, but the original use of these guns was tied to the races of Eve:

- Lasers are the main weapons of the Amarr.
- Gallente like hybrid blasters as a secondary weapon to drones
- Caldari like hybrid railguns as a secondary weapon to missiles
- Projectile weapons are the main weapon of the Minmatar

Both Gallante and Caldari can use all hybrid weapons, but the bonuses on the ships usually benefit either blasters or railguns.

Within these main classes various types, sizes (small, medium and large) and qualities (meta-levels) are available, leading to a staggering amount of guns in the game. I'll try to illustrate how the various types and sizes relate using graphs and pictures. Then I'll go through the pro's and con's of each gun type.

Below is a picture that illustrates the respective DPS and effective range of each gun type when fighting with small weapons versus an afterburning frigate. I've also added the basic fitting requirements for each type, which is discussed in more detail further on.
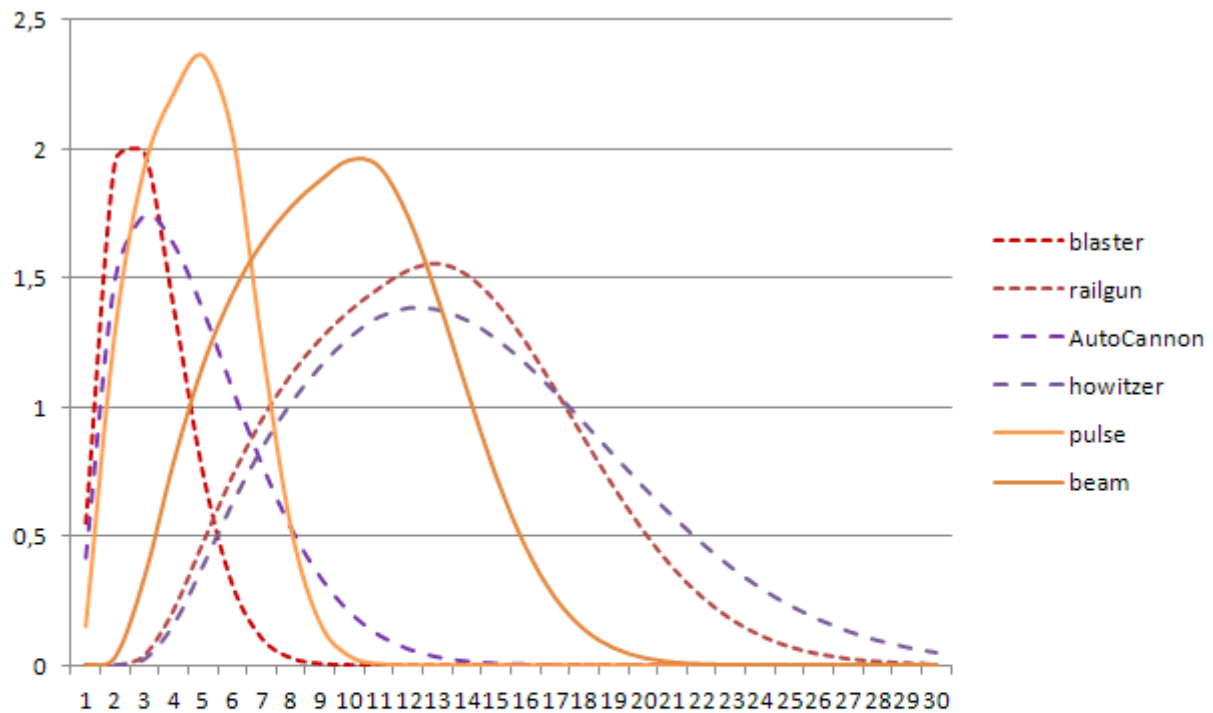
	Powergrid	CPU	Energy/s
beam laser	13	20	1,81
pulse laser	11	16	1,27
railgun	10	25	0,79
blaster	9	17	0,58
Artillery	12	15	0,00
AutoCannon	4	9	0,00

Small guntypes versus a fast frigate
no skills, no ammo modifiers
"real" DPS versus range in KM

Lasers

A first glance at the graph will give the impression that lasers are the 'best' weapon in the game. In certain ways they are. This power comes at a price though. Lasers require the most 'power grid' to fit on a ship. Furthermore they require a large amount of energy to fire, draining your ships capacitor and limiting its ability to maintain other modules like your defensive systems. Lasers do EM and thermal damage, making it very suitable to bring down enemies relying on shield tanks. Its performance versus is armor is relatively poor, though. The short range of the guns combined with the, generally, very slow Amarr ships also makes for an additional handicap when maneuvering for optimal damage.

Pro's

High tracking
High DPS
No ammo use (T1)
Very low ammo use for T2/faction ammo
Low skill needed to use initially

Con's

Short range
High power grid requirement
Large energy requirement to fire
Fixed EM/Thermal damage type
Amarr ships are generally slow

Hybrids

Hybrids are plasma weapons and are called hybrids because they blend energy weapons and projectile weapons. Because the short-range and long-range variants were originally targeted at two different races, the fitting requirements and positioning of the weapons in the chart is a bit different then you might expect. Railguns fit pretty well between beam lasers and artillery. Originally being targeted for caldari, they have low power grid requirements (relatively speaking of course) and very high CPU use. Considering that the damage is very close to projectile weapons, but without the range, many currently consider railguns the weakest gun system in the game. Blasters on the other hand are real short-range weapons. They have a very limited effective range, but when you need maximum close range damage blasters can be devastating.

Hybrids do kinetic and thermal damage. This allows them to do consistent, if average, damage to both shields and armor.

Pro's	Con's
Blasters are excelent close range	High CPU requirement
Relatively good ammo capacity	Fixed thermal/kinetic damage type
Benefits most from the various ammo types	Most effective against slow moving targets
Fast firing	

Projectile Weapons

Purely based on the gun graph, projectile weapons seem like the weakest gun platform. When used correctly they have a lot going for them, however. Projectile weapons have the longest effective range of all guns by default. Firing a projectile costs no energy at all and various ammo types can be loaded to adjust damage types delivered to the target. Because projectiles almost always reach maximum damage potential outside (untrained) optimal range, they are the most skill-intensive gun to use well. On the other hand, it's also the platform that most benefits from good skills, once trained.

One specific feature of artillery that needs mentioning is the concept of the "alpha strike". Artillery fires very slowly compared to any other gun type. However, once fired a very high peak damage is delivered to the target. This can be useful when firing at passively tanked ships as you can bring the ship past 'peak recharge' in a single volley. Also, when the enemy is using remote repair support, alpha strikes leave the enemy guessing which of the ships will need remote repair support until a massive damage peak strikes the selected target, possibly destroying it outright before the repairs land on the target. This gives artillery a psychological advantage in some PvP situations.

Pro's	Con's
Long range	Very small ammo magazines
Damage types can be modified	Most skill intensive gun type
Low fitting requirements	Poor tracking by default
No capacitor used when firing	
Effective with most ammo types	

3. Hitting the Target

As mentioned in the introduction, hitting the target is what gunnery is about. In this chapter I want to the discuss the factors that will cause you to miss when using guns. The 3 factors taken into account are:

- – Firing your gun beyond optimal range
- – Can the gun 'lock on' to the target effectively?
- – Is the turret fast enough to track the target?

The last two factors interact. If you can very effectively lock on to the target, you need less tracking speed. If you can very effectively track the target, locking on can be less of a problem. If both tracking and locking ability is high, these factors have almost no effect on your chance of hitting the target. If both are low they may reduce your chance to hit to 0%.

For the hit chance the negative factors from both sides are added up to come to the final chance to hit. You can never have a positive effect that increases your chance to hit! If you and your target are stationary within optimal range of your guns your chance to hit is 100%, in any other situation your chance to hit is less.

Range factors

I have already mentioned optimal range above. Every gun has two range properties: **optimal** and **falloff**.

Barring any other factors, your guns have a 100% base chance to hit within your optimal range. At optimal + falloff, your guns have a 50% base chance to hit. At optimal + 2x falloff your chance to hit begins to approach 0%. The exact curve can be found in the picture below.
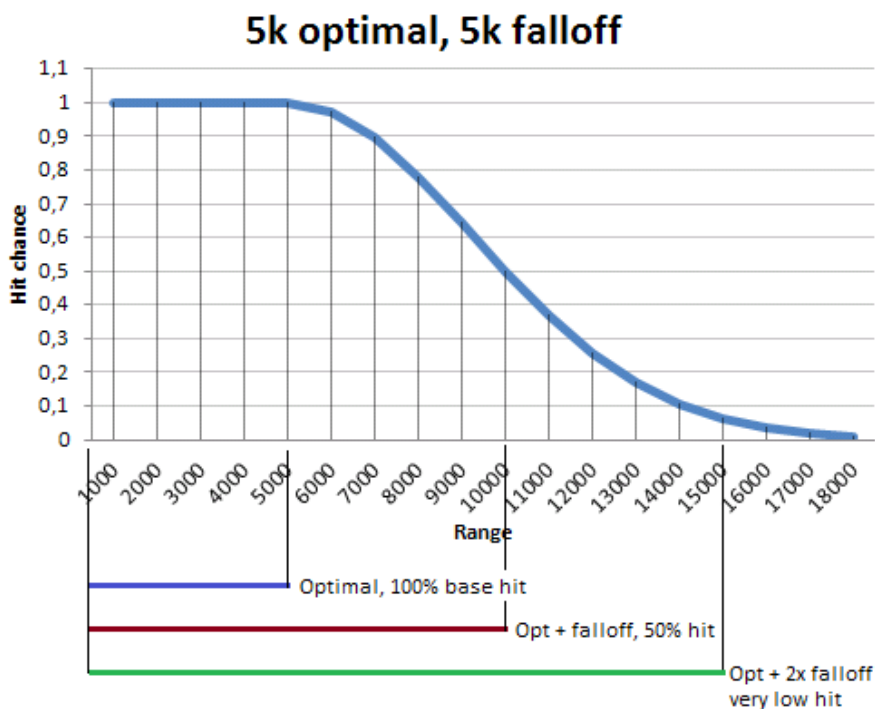
The optimal and falloff stats of your guns can be influenced by skills, the ship you fly, modules, ammo, etc. However, once you are past your calculated optimal range your hit chance will start dropping below 100%, regardless of any other factors and even if you and your target are perfectly stationary.

Gun Signal Resolution versus Target Signature Radius

This can be a confusing concept sometimes. I have found it is easier to understand if you use different terms than the ones Eve uses:

Signal Resolution (gun property): how good is my gun sensor? What can i lock on to?
Signature Radius (target property): How big is my target?

In short, guns in eve have have a stat called signal resolution. If the target you are shooting at is larger than the resolution you gain a bonus to track your enemy. A target that is smaller than the resolution incurs a penalty to your chances of tracking the enemy. In that case your gun can't effectively 'lock on' to the target and predict where it will move next. The signal resolution is fixed for every gun size and cannot be changed in any way. The gun resolution follows the default signature radius for targets of the intended gun, so normally this factor only comes into play when firing at a smaller or larger target than the gun was intended for.

Small guns: Signal resolution 40 (Frigate base radius is 40; Destroyer base is 80)
Medium guns: Signal resolution 125 (Cruiser base radius is 125; Battlecruiser base is 240-300)
Large guns: Signal resolution 400 (Battleship base radius is 400)

Gun Signature resolution versus target Signature Radius

Gun "radar" — No bonus, no penalty

Penalty to acquire target

Bonus to acquire target
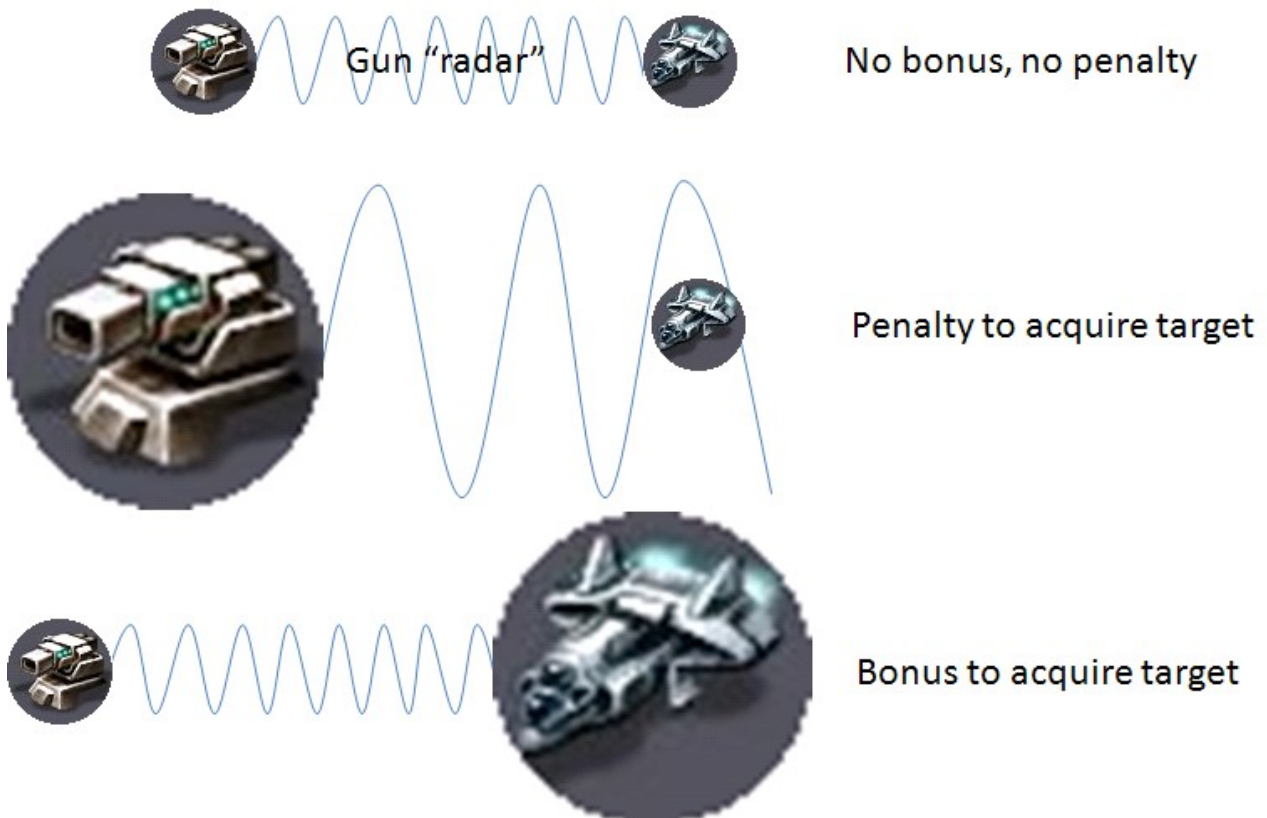
As mentioned in this chapters introduction this factor influences your chance of tracking your target effectively (tracking is discussed in the next topic). It mainly factors when large ships are trying to hit smaller ships and it balances the use of microwarpdrives.

Side topic:
If you look at the properties of a microwarpdrive (MWD) you will note that it will increase the signature radius of the ship when activated. By default a MWD makes the ship go 5x times faster, but it will also make the ship 5x larger. This means that, without further skills, adding a MWD to a ship will NOT decrease your chance to be hit by guns! You become 5x harder to track as you go much faster, but you become 5x easier to hit as well because the guns can now track a much bigger target. This is assuming you orbit the target at full speed. If you fly straight towards an enemy, or use an orbit too small for your speed, you will even become easier to hit!

Tracking

Definition and transversal
Tracking is the ability of your gun to turn fast enough to follow a target that has a sideways motion compared to your ship. This may sound a bit awkward, but if you and the target fly in a straight line towards or away from each other, tracking does not come into play, regardless of the speed of either movement. Only the sideways movement compared to a straigth line between you and your target counts for tracking. In eve this is referred to as the **transversal velocity** of your target and can be added to your **overview.** In case a target is orbiting you, its full speed translates into transversal speed. Therefore an orbiting target is the hardest to track.

Radial motion
The transversal velocity is only the first part of the story. Whether an object is easy to track not only depends on the speed, but also on the distance it is away from you. Imagine looking at a plane straight above you cruising in the sky. An average plane will fly with a velocity of around 150m/s. Yet, the plane will be very easy to follow and will appear to move across your field of view very slowly. Now imagine standing on a curb close to the road and an ambulance rushes by with 20m/s. The ambulance is going very slowly compared to the plane, yet you need to turn your head very fast to follow (track) it's movement.

Tracking of guns in eve is expressed in radians per second (rad/s). There is 2*pi radians in a circle (roughly 6.28). This means that a gun with a tracking stat of 0,1 rad/s can turn a full circle in 62.8 seconds (yes, the fastest turrets in the far future still take 15 seconds to do a full circle; I warned you there would be some oddities).

Let's look at the plane again. Let's assume it's at a height of 5km. With it's speed of a 150 m/s you will need to turn your head at a rate of 0.03 rad/s to follow the plane. Say the ambulance from before passes you at 2 meters distance. You will now need to turn your head at a rate of 1,5 rad/s to follow the ambulance! This rate is called the **angular velocity**. Eve also allows you to add the angular velocity of your target to the overview.

Impact on gunnery
In eve, all other factors being discounted, you have a 50% chance to hit a target if the target's angular velocity is equal to the tracking of your guns.

The following picture puts together the various concepts

0.15 rad/s turret tracking an enemy going with a speed of 250 m/s at 500 and 2000 meters
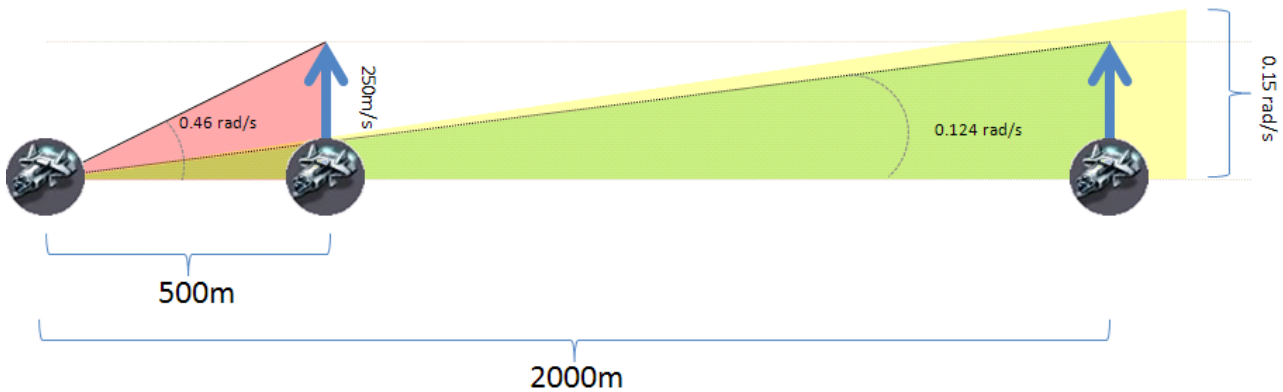
When the target is at 500m it has an angular velocity 3 times the tracking speed of the gun. In this case your gun has a chance of less than 1% to hit the target. At 2000m the angular velocity has been reduced to 0,124 which is slower than the gun can track. In that case chance to hit will be around 60%.

Putting it all together

So what if, in the previous picture, you were flying a frigate and it was not a frigate passing at 500m distance but a battleship? Then the 'resolution vs radius' factor comes into play. A small gun has a resolution of 40, the battleship has a radius of, for example, 400. This means that you have a bonus to tracking of 10x. The battleship is still 3 times faster than your gun can track, but the total factor taken into account is: 10 x 0.333 = 3.33. So you can hit the battleship as if your gun tracks 3.33 times faster than the battleship is going. This results in a final 83% chance to hit.

At 500m optimal range is very unlikely to play a role, but let's assume you are firing at the battleship with a gun that has 250m optimal and 250m falloff. You would be firing at the battleship at optimal + falloff for a ranged based chance to hit of 50%. In such a case the two factors are multiplied: 83% chance based on tracking, 50% chance based on range, for a final chance of 41.5% to hit.

The Overview
So what to put in the overview to make sure you perform to the best of your abilities? Angular velocity is the most obvious choice, as it is the easiest to match to the tracking speed of your guns. However, because the numbers are so small, you may find yourself counting zero's a lot. So some people may prefer putting in the raw transversal velocity number in the overview and work out at what range and what transversal the DPS is still acceptable. Both methods work and there is nothing stopping you adding both indicators to your overview.

4. Improving Your Gunnery

Now that we covered all the basic concepts of gunnery it is time to look at the possibilities to improve your damage output and at the various systems and ammo available to the gunner.

As many factors overlap it is hard to find the best order in which to discuss the various improvements that are available to enhance your performance.

I have settled for the following order:

- – Guns and Ammo
- – Skills
- – Mods and rigs

Guns and Ammo

I have chosen to start with guns and ammo as it will be easier to demonstrate later why skills and mods are important to maximize your performance.

In the chart below there are six graphs. The top three graphs contain the DPS at various ranges against a slow frigate using all three small railguns available in the game: the 150mm railgun 1, the 125mm railgun 1 and the 75mm gatling rail 1. Each colored line in each of the graph represents an ammo type. The bottom three charts contain the same information, but now versus a fast afterburning frigate. DPS is based on an unskilled character using the guns.

I will use these charts to illustrate some key elements to take into account when fitting your ship.
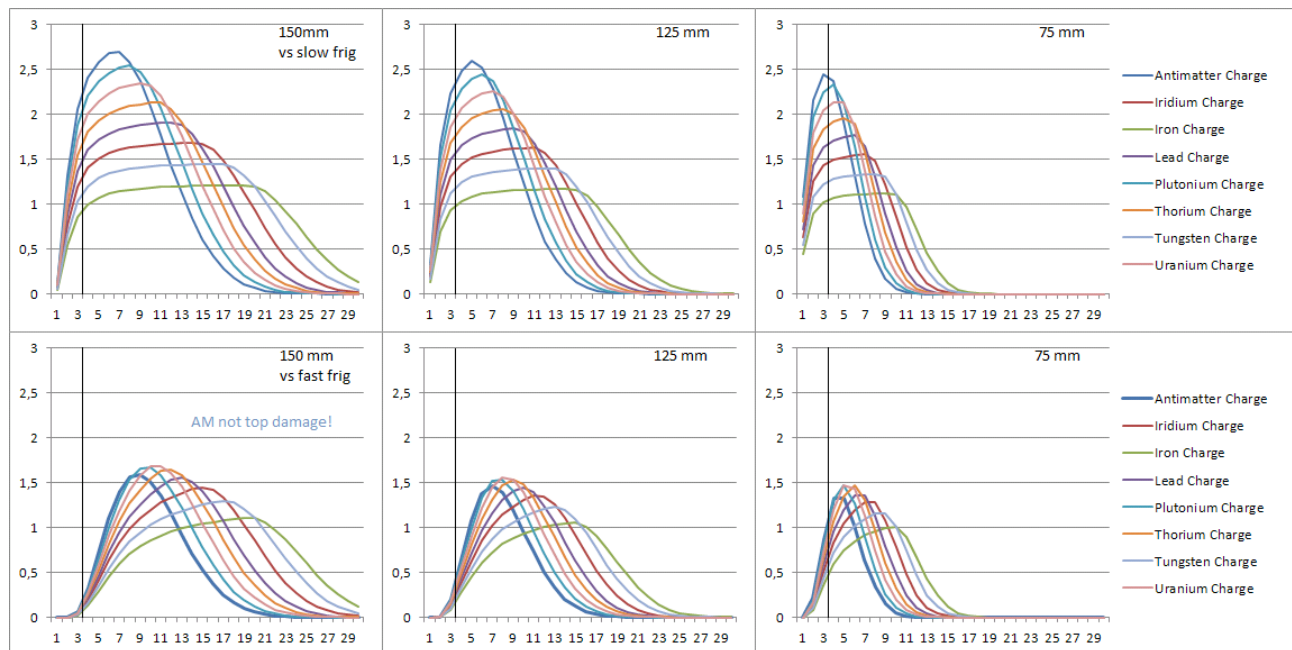
First, let's examine the performance of the three guns. Despite what many people think, the largest gun does not significantly out-DPS its smaller brothers. Top DPS only drops about 15% between the largest (hardest to fit and fire) gun and the smallest one. There are some other differences though. You will notice that the smaller guns do their top DPS closer to the ship. If your role requires damage at relatively close range, the smaller guns might be a better match for your needs.

On the other hand, the larger guns do consistently more damage over a wider range.

Moving on to the ammo, there are some more myths to bust. Looking at the top 3 graphs, DPS progresses pretty much as you would expect with the ammo used. Anti-Matter does top DPS, in a very narrow band of ranges. This is also what programs like EFT will tell you. Now, let's examine the bottom three charts. The only difference is that the target now moves significantly faster, using a MWD or afterburner with high skills. Suddenly, Anti-Matter moves to 4th place on the damage chart. This large shift is mainly caused by the fact that the gun is used by an untrained gunner. However, even when used by highly skilled gunners, the highest damage ammo will usually not be top DPS in high speed fights as I will demonstrate later. Also keep in mind that the highest damage ammo will only perform at maximum efficiency in a very tight band of ranges. Changing out ammo types and/or the time to get into the optimum range can all reduce your real DPS while using top-damage ammo.

Skills

So how do skills help you improve your performance? Obviously there are skills that improve your bare damage per shot. However, gunnery is mainly about hitting first. Before going into details about the various skills let's look at the graph below and see how skills help, looking at one of the scenario's presented in the guns and ammo chart above.
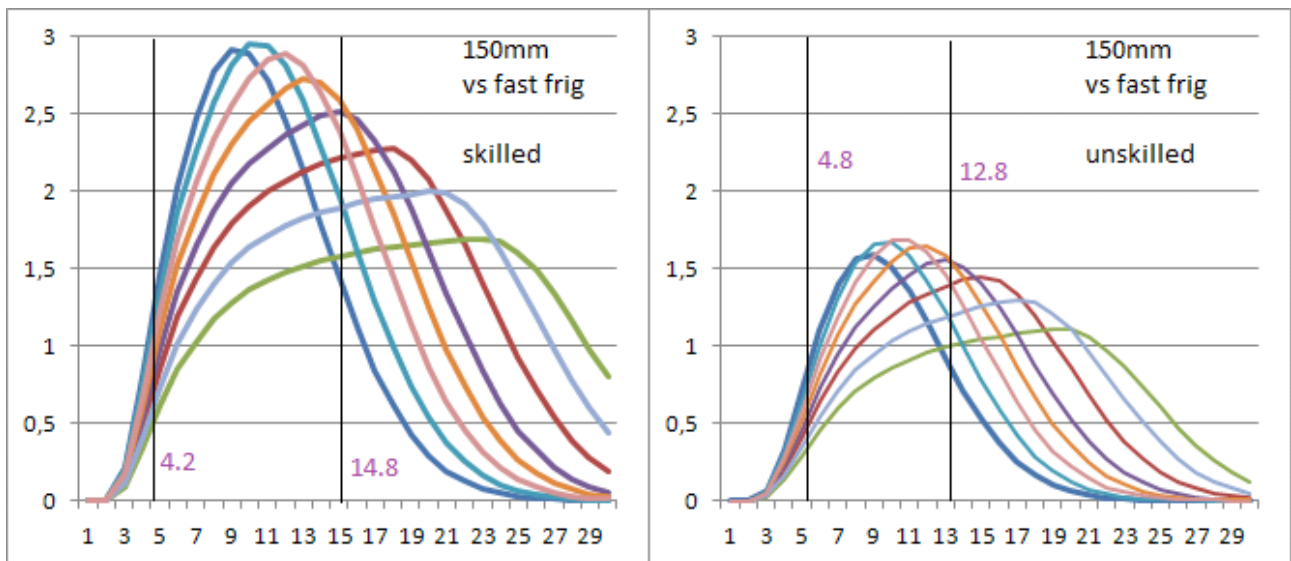
The left-hand chart is a '150mm railgun 1' used by a skilled pilot, the right-hand chart corresponds with the bottom-left chart of the gun-and-ammo picture. One of the first things to note is that with the skilled player, AM ammo (dark blue line) has moved to second place in DPS again. Skilled players can use high damage ammo more efficiently in difficult situations. The 2 vertical lines in both graphs represent the ranges at which AM ammo does 50% of maximum damage. As you can see (purple numbers) skilled players can maintain high damage over a wider range. Finally, top DPS has nearly doubled for the skilled player compared to an unskilled one.

Gunnery Skills – Damage

Gunnery (1) – 2% to turret firing speed per level
    Cheap skill to improve DPS, prerequisite for many advanced gunnery skills; increases cap drain on lasers and hybrids

Motion Prediction (2) – 5% to tracking speed per level
    Critical to improve short-range efficiency of all guns. Key skill for projectile weapons

Rapid Firing (2) – 4% to turret firing speed per level
    A good way to increase DPS but keep in mind: faster firing is more cap use for lasers and hybrids!

Sharpshooter (2) – 5% bonus to optimal range per level
    An improved optimal range let's you shoot at targets without penalty farther.

Surgical Strike (4) – 3% to turret damage per level
    Very expensive skill to improve your damage, get this one last

Trajectory Analysis (5) – 5% to falloff per level
    Adds to the falloff, allowing your to fire confidently past optimal range. Key skill for projectile weapons

Small X Turret (1) – 5% bonus to small turret damage per level
    This skill allows you to use the selected small turret of your choice, cheap to train but only improves the selected turret

Medium X Turret (3) – 5% bonus to medium turret damage per level
    This skill allows you to use the selected medium turret of your choice, only improves the selected turret

Large X Turret (5) – 5% bonus to large turret damage per level
    This skill allows you to use the selected large turret of your choice, only improves the selected turret

Small X Turret Specialization (3) – 2% bonus to T2 small short-range / long-range turret
    This skill only improves T2 turrets of the selected sub-type, learn "weapon upgrades" before T2 turrets (see below)

Medium X Turret Specialization (5) – 2% bonus to T2 medium short-range / long-range turret
    This skill only improves T2 turrets of the selected sub-type, learn "weapon upgrades" before T2 turrets (see below)

Large X Turret Specialization (8) – 2% bonus to T2 large short-range / long-range turret
    This skill only improves T2 turrets of the selected sub-type, learn "weapon upgrades" before T2 turrets (see below)

Gunnery Skills – Support

Controlled Bursts (2) – 5% less capacitor use to fire weapons per level
    This skill helps to offset the increase in capacitor use because of increased firing speed; critical for laser weapons

Weapon Upgrades (2) – 5% reduction in CPU need to fit a weapon per level
    This upgrade allows you to increase CPU availability on your ship; prerequisite for advanced weapon upgrades

Advanced Weapon Upgrades (6) – 2% reduction in Power Grid need to fit a weapon per level
    Very important skill to master for many fits. Mastering this skill is required to fit T2 guns on many ships

Supporting skills – Gunnery related

Long Range Targeting (2 – electronics) – 5% bonus to targeting range per level
    Having long range weapons is useless without the ability to target your enemy

Signature Analysis (1 – electronics) – 5% increased targeting speed per level
    Faster targeting allows you to do damage more quickly, very useful once you reach larger ships

Targeting (1 – electronics) – Can lock 1 additional target per level (up to ship capacity)
    More targets locked allows you to chain targets faster. Also great for salvaging after missions

Supporting Skills – Indirect

Engineering (1 – engineering) – 5% bonus to power grid per level
>Gun systems require a lot of power grid to fit, use this with 'advanced weapon upgrades' to fit the largest guns

Electronics (1 – electronics) – 5% bonus to CPU per level
>Together with the 'weapon upgrades' this increases CPU available to you to complete your fittings

Energy Systems Operation (1 – engineering) – 5% reduction in capacitor recharge time per level
>Capacitor is important for everyone, but even more so with capacitor using gun systems

Energy Management (3 – engineering) – 5% increase in capacitor capacity per level
>Capacitor is important for everyone, but even more so with capacitor using gun systems

Modules

Gun Support Modules – Direct

There are 3 modules available that will directly improve your guns' performance.

Gyrostabilizers, Heat Sinks, and Magnetic Field Stabilizers
>Low slot mods that enhance damage and rate of fire. Each type enhances one type of gun: projectiles, lasers or hybrids

Tracking Enhancers
>Low slot mods that enhance optimal, falloff and tracking. Mainly interesting for sniper fits, little used in PvE

Tracking Computers
>Mid slot mods that enhance tracking, optimal and falloff; can be scripted. Mainly for snipers, less used than enhancers

Gun Support Modules – Indirect

Target Painters
>Mid slot e-war module that increases the apparent size of the target to allow for easier tracking.
>Harder to train for than a webifier, but with much extended range

Stasis Webifiers
>Mid slot module with a short range that slows the target, making it easier to hit. Mainly used on tackling and blaster fits

Tracking Links
>Basically a remote tracking computer that can be used to support other ships

Rigs

Although rarely used for missioning, rigs exist that enhance performance of turret weapons for a penalty to power grid requirements. In case you use gunnery rigs it's highly recommended you train up the associated rig skill to reduce the penalties. Gun rigs are popular for sniper fits and speed-tank fittings that don't need the power grid to fit a "tank". In general they are used most often with projectile weapons, but fits for hybrids and, even less commonly, lasers do exist.