World of Tanks:

Deep Dive into
Equipment 2.0 and
Relevant Game Mechanics

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Personal Statements

The purpose of this document is to show my point of view and perspective regarding equipment pieces and their value. It will be broken down into a general overview of equipment; its description, purpose, and/or application. The end of the document will highlight my personal concerns with current equipment, meta, and include suggestions/ideas for changes.

This paper was written by me and me alone.

This is a continuous work in progress and will see many revisions, edits, and updates as changes are made.

It may be incomplete in some areas; however, the release of this document implies that it is at such a level of completion that it can stand on its own.

The goal was to complete the document and proofreading was not possible. There will be spelling mistakes, errors in word usage, or straight up repetitive sentence structure. This may or may not be mended in due time.

Several words are used interchangeably in the document such as tank/vehicle. Do not be surprised if there is a change in terminology usage

The original length of this document was to be under 10 pages; however the complexity of camouflage and view range mechanics made it impossible to explain why certain new additions were powerful and why others were weak. This includes extensive analysis regarding camouflage and its relation to view range.

Do send feedback and corrections as a message to me directly through Twitch or Reddit's messenger

Don't like the document? Go write your own.

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1. **General - Category for equipment that exists in multiple categories**

    a. **Improved Ventilation (Vents)**
        i.   Overall, a jack-of-all trades piece of equipment that serves as a way to boost all aspects of the tank that is controlled by the crew members of a tank. This leads to a small bonus in reload speed, gun handling, tank soft-stats (both tank and gun), and a small boost in camo/firefighting/repairs.

        ii. Ventilation bonus of 5% translates to approximately 2.2% tangible bonus in these aspects of tanks controlled by crew members:

             Commander - view range
             Gunner - accuracy, dispersion penalties, aim time, turret traverse
             Driver - hull traverse, terrain soft-stats (soft, medium, hard)
             Radioman - radio range
             Loader - reload speed

             This percentage (5%) increase also applies to the 3 basic skills that can be trained on all crew members - camouflage, repairs, and firefighting; however, this percentage bonus only applies to crew members already trained in those skills.

        iii. This equipment is the ideal choice when a tank is sitting on a comfortable amount of view range and wishes to gain a general boost in all of its characteristics - DPM, mobility, view range, gun handling, etc.

2. **Firepower - Category for equipment that directly affects the gun or characteristics of the gun of a tank**

   a. **Gun Rammer**
      i. A must-have piece of equipment on all tanks that can equip it due to being the only equipment in the entire game that has a direct effect on damage output for a vehicle by decreasing reload time.

      ii. Rammer reload reduction time of 10% directly translates into reload time by multiplying reload time by 90% or 0.9. This can be converted into DPM by dividing 1 minute (60 seconds) by reload time and multiplying the result by damage per shot.

      $$DamagePerMinute = \frac{60}{ReloadTime} * DamagePerShot$$

      This formulation shows that the increase to DPM is an inverse function in relation to the reload reduction.

      -10% Rammer translates into a DPM increase of $\sim 11.\overline{11}\%$

   b. **Enhanced Gun Laying Drive (eGLD)**
      i. A useful piece of equipment that is used on tanks that require better gun handling but cannot mount a Vertical Stabilizer or used in conjunction with Vertical Stabilizer to maximize gun handling properties of a vehicle.

      ii. eGLD increases the aiming speed of vehicles by 10%. This is a little misleading as the actual effect of an eGLD is actually around 9% due to how the formula works. The aim time of a vehicle is calculated by dividing the circle size by its aiming speed to obtain the aim time. *Note: this is just a general equation and not the actual formulation.*

      $$Aimtime = \frac{CircleSize}{AimingSpeed}$$

      This formulation shows that an AimingSpeed increase has an inverse relationship with Aimtime.

      +10% aiming speed translates to an AimTime decrease of $9.\overline{09}\%$

c. Vertical Stabilizer (VS)

    i. A must-have piece of equipment on all tanks that can mount it. Vertical Stabilizer decreases all dispersion penalties "after firing, during movement, and turret traverse". However, this official in-game description is misleading as Vertical Stabilizer's actual effect is a decrease to ***all dispersion penalties***. The official description of this piece of equipment understates its actual value and varies depending on source.

    ii. The gist of VS is that it decreases the accuracy (or dispersion) penalties on the vehicle. When a vehicle moves, fires, or turns its turret, the aiming circle will increase in size to indicate that you are under a dispersion penalty. Vertical Stabilizer decreases all of these penalties by 20% or makes them 80% effective.

However, these are only 3 of 5 dispersion penalties that can be placed on a tank (and WG states VS functions on); 3 which are relevant all the time, 1 which is relevant on specific vehicles, and the last which exists but we forget about. These penalties are:

Hull Movement - Forwards and backwards movement of a vehicle
Hull Traverse - Vehicle turning left or right
Turret Traverse* - Movement of the gun
Firing Bloom - The penalty placed on a gun after a shot is fired
Damaged Gun - A damaged gun offers a penalty

The first 3 penalties are useful as they are relevant in all vehicles (*even turret traverse for turretless vehicles because the penalty is on gun movement not the actual movement of a turret). Firing Bloom is relevant for autoloaders as it is a balancing statistic used for autoloaders to prevent them from being fully aimed before loading in the next shell. Damaged Gun penalties are not relevant most of the time but the penalty reduction applied by VS is a nice bonus.

For all vehicles the reduction in penalty means that the aiming circle will be smaller in every use-case compared to an eGLD and will be doubly useful for autoloaders due to being the only piece of equipment that decreases firing bloom and thus allowing autoloaders to fire as soon as possible with minimal inaccuracies.

d. Improved Aiming Unit (IAU)

    i.   A new piece of equipment that decreases the size of the aiming circle. This effectively will make tanks more accurate when fully aiming which can help inaccurate vehicles hit its target more often or increase the accuracy further of sniper tanks due to its "% decrease in aiming circle size" bonus.

    ii.   There are two theoretical implementations to this piece of equipment which drastically affect how I view it and will be stated below.

           The first implementation is a decrease to the aiming circle size (5%), which according to Wargaming's official video will happen "when fully aimed". This implies that the effect of this piece of equipment is to decrease the fully aimed circle size which means its only application is on tanks that expect to be fully aimed most if not all the time or vehicles who are capable of aiming in fully quickly.

           The second implementation (actual case) is a general decrease to the aiming circle size in all scenarios stated in the first equipment 2.0 pages' description which states "reduces the size of the aiming circle… of an aiming or fully aimed gun". This will effectively allow any tank to have a smaller reticle at all times while also boosting fully aimed accuracy.

    iii.   The first implementation will only be useful to stationary or low aim time vehicles which means its only application will be for camping vehicles, vehicles with a stationary role/playstyle (sniper Tank Destroyers), or fast aim time vehicles like the Leopard 1.

           The second implementation (actual case) lends itself into an overlapping role with Vertical Stabilizer. The decrease in both base aim circle size and effective reduction in penalties (by decreasing the aim circle size after penalties are applied) means that the IAU aiming circle would act as a pseudo-VS but require the same (default) aim time to fully close.

           The IAU will find usage on tier V through VII tanks that cannot mount a VS but would like the benefit of having a smaller aim circle (VS-esque) while also wanting/needing better accuracy.

e. Improved Rotation Mechanism (IRM)

  i. A new piece of equipment that reduces dispersion penalties applied to the gun while also increasing hull and turret traverse (turning) speeds. In effect, it is a weaker Vertical Stabilizer that can also boost turning speeds for both the hull and turret. **Tier 5+ only.**

  ii. Similar to VS, the IRM will reduce dispersion penalties applied to a vehicle from moving and traversing both the hull and turret by 10%. It will also increase the turret and hull traverse by the same percentage (10%).

  This increase in turret and hull traverse in practice will almost cancel out the bloom due to dispersion penalties acting as a function of speed multiplied by penalty. This leads to two general observations:

  The first effect is a weaker VS effect - general lowered dispersion penalties leading to faster effective aim times.

  The second effect is an effectively unchanged aim circle bloom when utilizing the new maximum speed gained from the new turret and hull traverse. This means tanks will have the same effective circle size (compared to a tank not using IRM) but now have a faster acquisition time leading to faster effective aim times.

  iii. There will be little reason to be using this piece of equipment over the existing VS due to the smaller effect against dispersion penalties. It also loses to eGLD in engagements where aiming in (for a noticeable amount of time) takes priority.

  The main reasons why this equipment is so valuable in the game is that it is the first VS-esque equipment that can be mounted on Tank Destroyers and Artillery (although not as useful as eGLD in most cases).

  The IRM will find main usage on three types of tanks: **frontline TDs** where flat dispersion penalty reductions will be more useful than an aim speed increase (eGLD) and increased ability to prevent flanking/circling, **turreted TDs or vehicles with good soft stats** where turret rotation speed increases help with target acquisition, and **tier V through VII tanks that can't mount VS** but have a playstyle that encourages low exposure time (hull-down) or constant movement (such as the Cromwell).

Firepower Analysis and Theorycrafting
Credit to CrySpy from the European server for generating the graphs/images

This section primarily exists to analyze the potential applications of new firepower equipment and their specific use cases and purpose. This will analyze the various gun handling boosting equipment which includes: Enhanced Gun Laying Drive, Vertical Stabilizer, Improved Aiming Unit, and Improved Rotation Mechanism.

As it currently stands, Vertical Stabilizer is by far the strongest piece of equipment for gun handling control. The ability to remove 20% of all dispersion penalties is insane when it comes to effective aim time reduction and has been proven to be better than an eGLD in almost every possible scenario. However, this only concludes that VS is better than eGLD. The introduction of new equipment shifts focus towards the viability of IAU and IRM over the existing eGLD. There will be a critical intersecting point where eGLD becomes more viable than IAU (5% circle size reduction; no aim time change) and IRM (10% dispersion penalty reduction; weaker VS).

We will test a hypothetical example in which a Bat.-Châtillon 25t stops from full speed and aims:
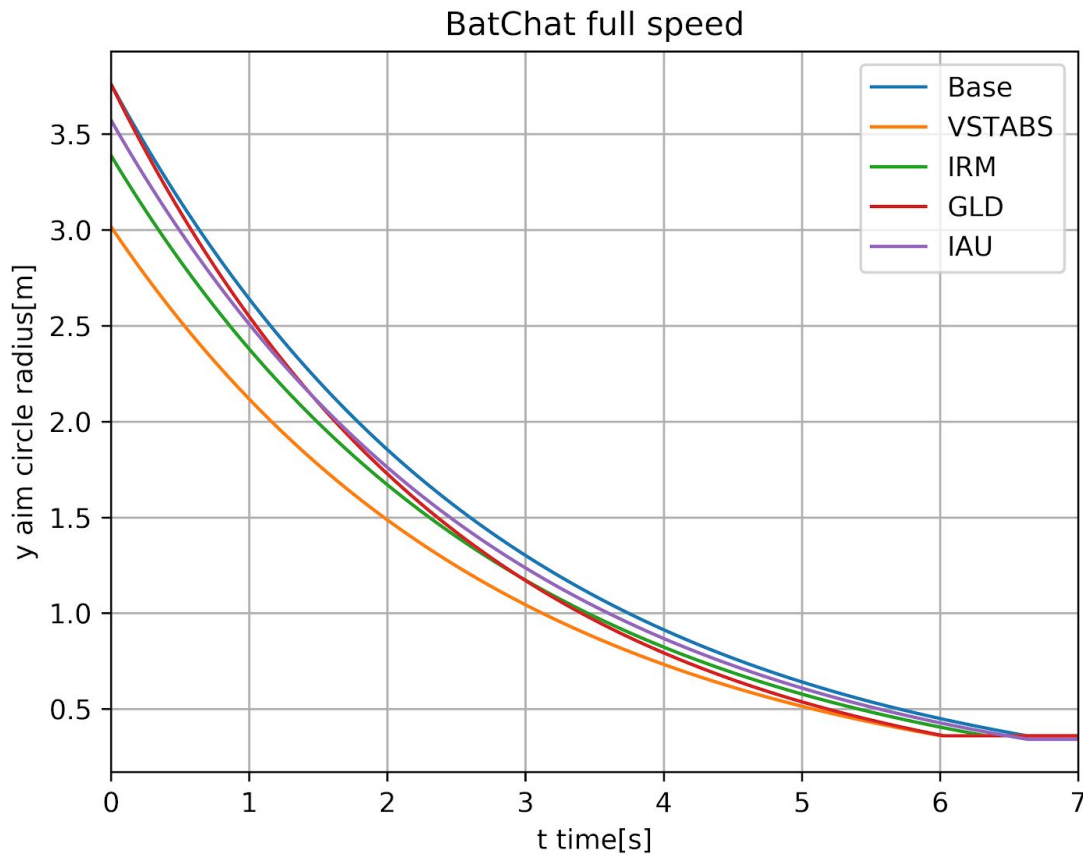
The Batchat is used due to its longer aim time leading to much wider critical point positions and having higher dispersion penalty values to emphasize equipment differences. **These graphs will apply to most vehicles in the game and will be used for future references.** *While the numbers used won't be applicable 1:1 to all tanks, the observations remain relevant for equipment analysis and general comparison.*

From this graph we can confirm that VS is indeed better than eGLD in every scenario - from stopping to fully aiming in, the VS will have a smaller effective aim circle at every point in time. However, we can see that eGLD is better than both the IAU and IRM depending on the aim time duration. **The critical intersection points between eGLD and IAU at approximately 25% aim time and eGLD with IRM at approximately 50% aim time with respect to eGLD aim time.** This means in cases where aiming in becomes priority, eGLD will still be the optimal pick for most tanks. We can estimate the general effective aim time decrease by zooming in on the section of the graph where the aim circle closes fully.

The graph shown below is a zoom-in between 5 and 7 seconds and illustrates the points at which each particular piece of equipment fully aims in:
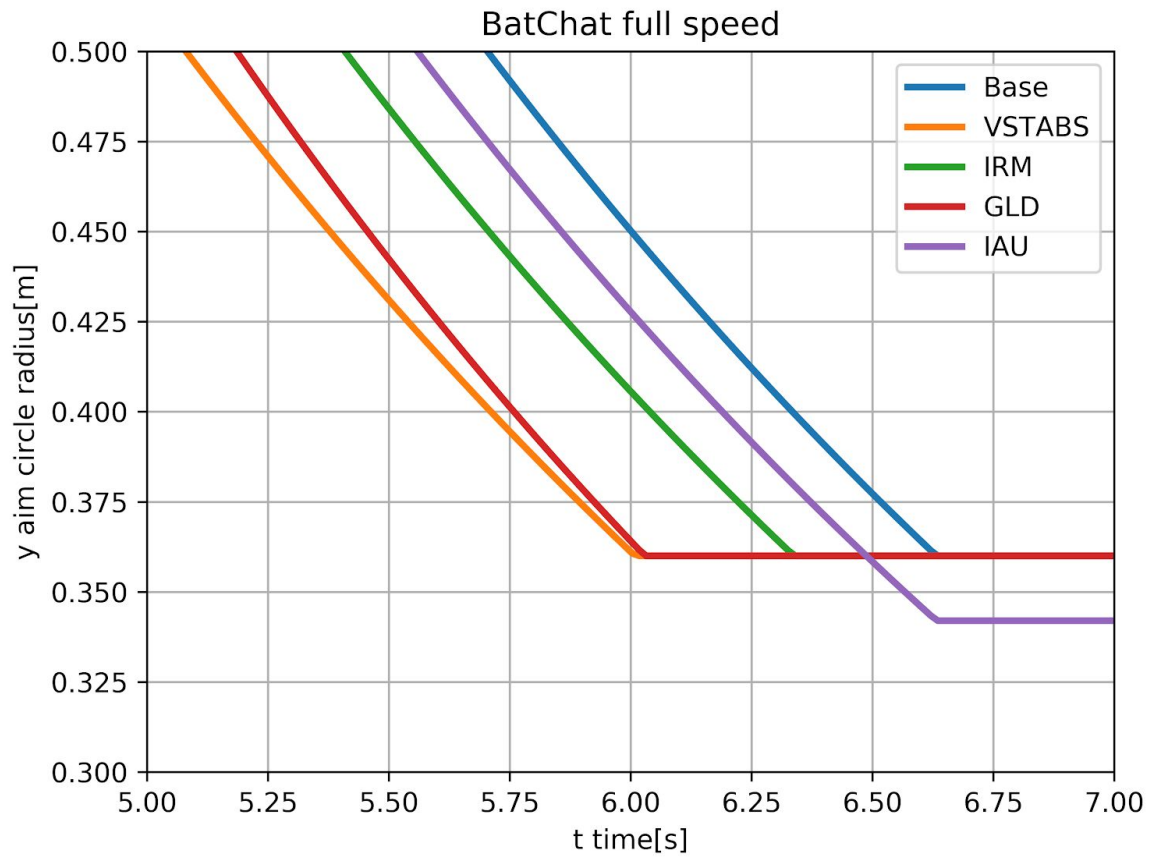
From this we can see the general effective aim time reductions each piece of equipment offers:

Enhanced Gun Laying Drive provides **9.1% (calculated previously) reduction**
Vertical Stabilizer provides approximately **9.2% reduction**
Improved Rotation Mechanism provides approximately **4.5% reduction**
Improved Aiming Unit provides approximately **2.2%* reduction**

The eGLD provides a calculated decrease of approximately 9.1% aim time and is verified from the graph.
The VS provides a slightly larger benefit than eGLD and provides approximately 9.2% reduction in aim time.
The IRM provides a decrease of approximately 4.5% in aim time which makes sense because it contains half the dispersion penalty reductions compared to VS.
The **IAU technically has no change in aim time*** because it only decreases aim circle size by 5%. We can calculate the *effective* aim time decrease by finding the point where you would have the same aim circle as without the IAU. This is approximately a ~2.2% decrease in aim time.

We can come to several interesting conclusions. There is no instance in which any equipment piece is better than VS. It is the strongest piece of gun handling equipment that is usable by vehicles and realistically has no reason to be discarded in favor of any other equipment. If a vehicle is unable to mount VS, we can see interesting use cases for the 3 alternatives:

eGLD will continue to remain a strong pick for tanks that wish to aim in for a considerable amount of time to increase damage potential. ***It's viability goes up as tank dispersion penalty values are higher (and vice-versa) relative to the IRM/IAU and this <u>viability is independent of aim time</u>***.

IRM is a weaker VS and can find use in vehicles where minimizing exposure or decreasing target acquisition time is mandatory. It is better than IAU when *final* accuracy is not required and loses to eGLD in situations where aiming fully (or near fully) is mandatory. However, it would theoretically beat eGLD in effective aim time in situations where the player would need to acquire targets quickly through turret (or hull) rotation.

IAU will be a slightly more interesting option as it decreases circle size as a pseudo-VS; however, it suffers by still requiring the full aim time to utilize this new accuracy. It is beaten by the IRM when shooting in any scenario where you are not fully aimed and is beaten by eGLD when even a minor amount of aim time is taken into consideration. The niche application of IAU can be applied to low dispersion penalty tanks (such as the M48A1 Patton) because the decrease in circle size is independent of penalties and has more impact.

What if we could mount a Vertical Stabilizer but would want to further increase gun handling? The current options to do so in the game consists of either using Vents or eGLD with VS. With IRM and IAU as potential options, which combination would be the most useful?

We will re-use the same scenario as before but now use various combinations of equipment with Vertical Stabilizer:
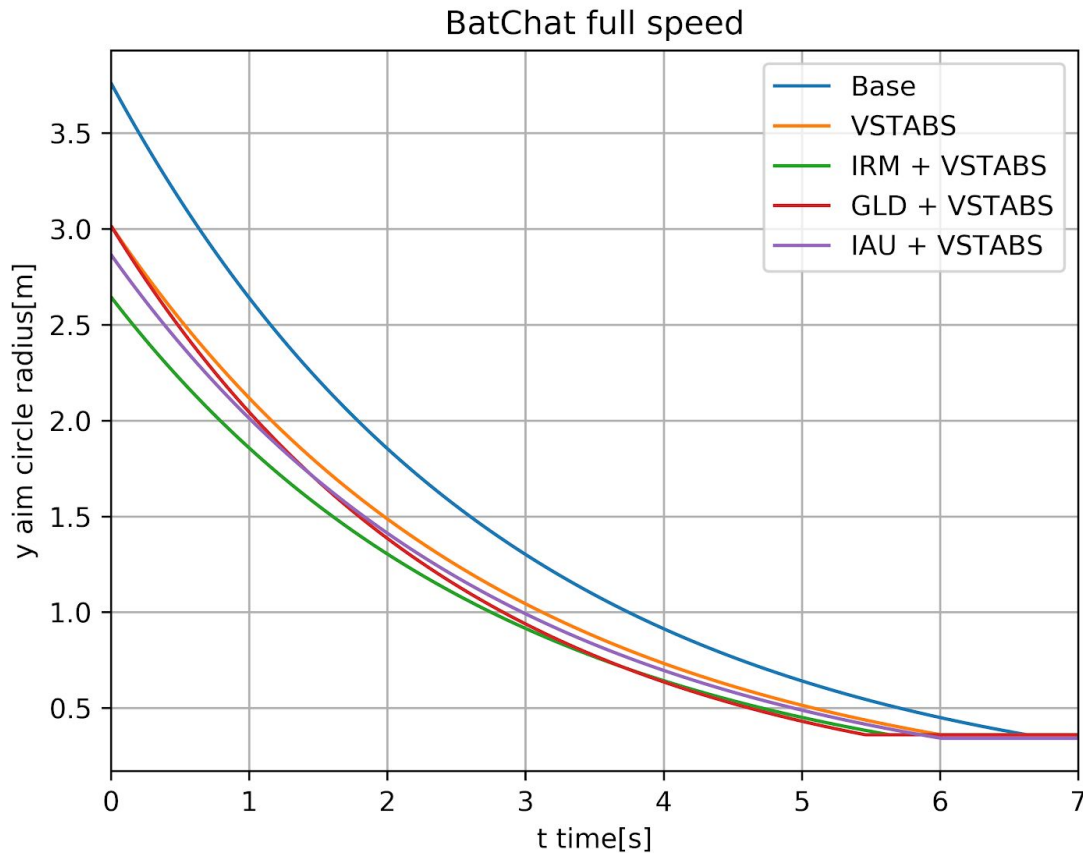
The above graph illustrates an interesting development. Despite having the same equipment; the addition of VS decreases the viability of eGLD over an IRM. There is only a small increase in the intersecting point for eGLD vs IAU which is either negligible or non-existent. However, IRM sees the intersecting point moved to approximately 65% aim time compared to the previous 50% in the independent tests. This means the general viability of eGLD decreases when compounding bonuses with VS.

Looking at a closer image of the final aim time values for the VS combination equipment testing:
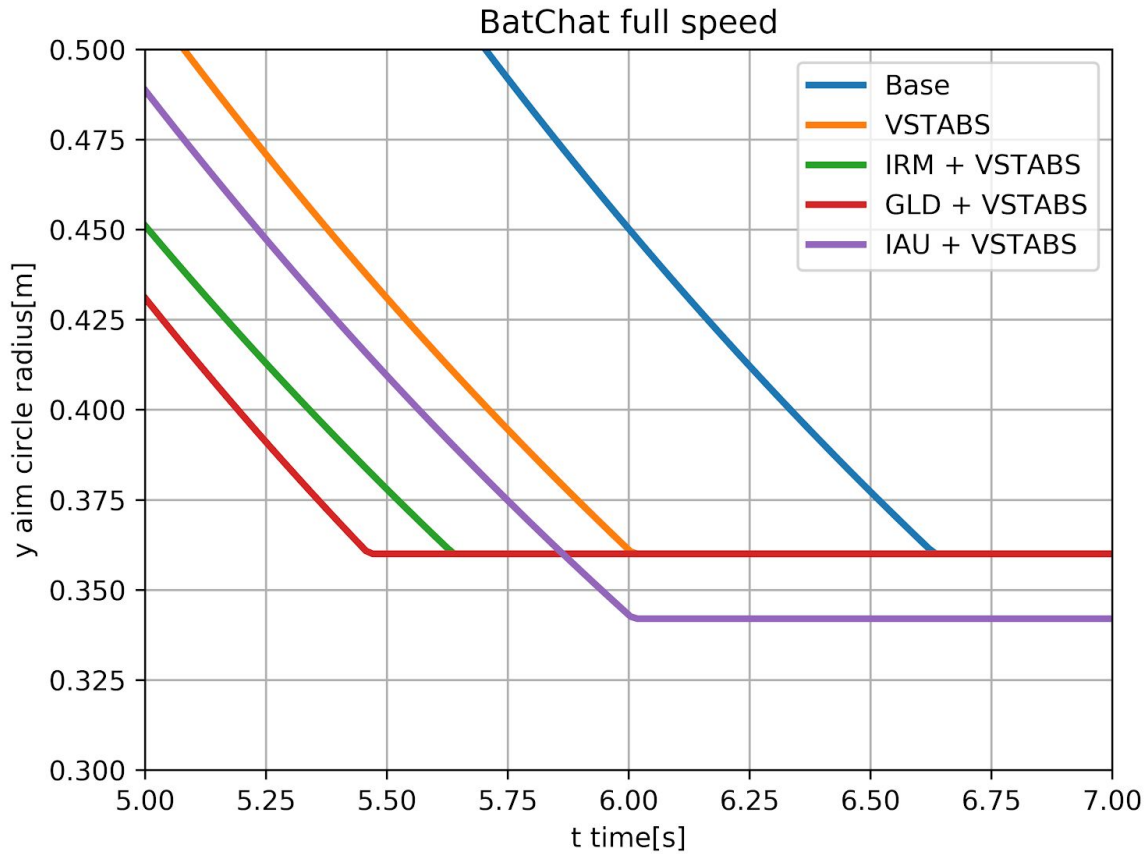
We can see a repeat of previous independent equipment test results. eGLD is the fastest, followed by IRM, and IAU in last place. However, the three final placements are much closer together. A decrease in dispersion values (from VS) leads to lower effectiveness of eGLD and higher viability of IRM and IAU in combination equipment set-ups. This is because a decrease in reticule size means eGLD will not have enough time to "catch up" to the bonuses of IRM and IAU.

Which combination of equipment is the best? When should I use a specific combination?

Enhanced Gun Laying Drive + Vertical Stabilizer:
This combination will switch from the current go-to option into a situational pick. It is best used when the tank requires most or all of its aim time to fire accurately. However, it is important to note that its ***primary benefits are on tanks with bad dispersion penalty values*** and **not** bad aim time.

Improved Rotation Mechanism + Vertical Stabilizer:
This will probably be the general go-to equipment combination for tanks focusing purely on gun handling characteristics. The decrease in dispersion penalties by 30% is significant and will find high adoption in tanks with minimal exposure playstyles - corner poking, hull-down ridgeplay, or aggressive counter shots (peeking; where firing quickly and going back into cover is a must). The increase to turret traverse further decreases effective aim time making this possibly the best equipment combination.

If IRM decreases the same dispersion penalties as VS (including firing penalties) this will be the best equipment option for autoloaders (such as the T57 Heavy). Otherwise autoloaders will consider using the IAU.

Improved Aiming Unit + Vertical Stabilizer:
One of the more interesting combinations. This would be useful for tanks that primarily want to minimize exposure time but with a weaker effect compared to IRM as a trade off for gun accuracy. This would be a fantastic option for tanks that want to have reduced dispersion penalties in minimal exposure playstyles but also a more consistent ability to snipe given the opportunity.

*This will be a must-have combination for autoloaders that rely on minimizing all dispersion penalties (**if IRM doesn't reduce firing penalties**).* It will also be used on tanks when the user wants a slight boost in gun handling and will consistently utilize the improved accuracy.

An example of eGLD vs IRM vs IAU (with VS) is the T57 Heavy

The T57H is notorious for having several problems as an autoloader; poor aim time, horrendous dispersion penalties, and a fast fire rate on its intra-drum. This puts the T57H into an odd scenario where it cannot aim in faster than it fires and thus requires both an eGLD + VS in order to (mostly) mitigate its poor handling. However, the majority of its issues comes from firing penalties in which eGLD does not help because the bloom is slightly larger than what eGLD can mitigate in the 2 second intra-drum period (more noticeable with turret movement). This is where IRM (assuming fire penalty reduction) and IAU come into play - both of these pieces of equipment would be able to decrease the effective aim circle size and be more useful than an eGLD in the short intra-drum period. This means there are interesting applications and a trade-off between the different pieces of equipment.

The eGLD would offer the best starting to stopping accuracy if fully or nearly fully aiming in the gun. This would find the most use for relocation/reposition purposes or early game movement phases.

The IRM would offer further dispersion penalty reductions and be the strongest option for clipping purposes. Firing penalties is the major reason why the T57H has difficulties emptying its drum accurately into enemies. An additional 10% reduction to penalties would fix these issues. This is the option that I would choose if I were to play the T57H.

The IAU is a hybrid of both the eGLD and IRM. It decreases the overall aim circle size which acts as a pseudo-VS or IRM. Smaller circle size would decrease the effective aim time during intra-drum clips; however, *it would not allow the T57H to aim in fully between shots (as the T57H cannot do so with VS alone)*.

AMX 50B?

On the other hand, the AMX 50B is capable of aiming fully between its shots. This would allow the AMX 50B to freely choose between any of the 3 options.

IAU would be the strongest pick because it would both decrease reticle size and increase the gun's (final) accuracy which heavily benefits the 50B's gun. The IRM is also another strong pick due to the 50B's ability to accelerate and relocate quickly. Relegating the eGLD to last place of the 3 due to the 50B's playstyle.

Firepower Conclusions

Note: All tests and theorycrafting are under the assumption of non-improved equipment.

- The discrete numbers for intersecting points will change on a tank-by-tank basis but serves to emphasize that [eGLD > IRM > IAU] in *every single situation* **when aiming is the sole consideration**.

- eGLD's viability is solely dependent on dispersion penalty values. Tanks with poor dispersion values will continue to value eGLD over any new piece of equipment. This means **SPGs will still continue to use eGLD** as the go-to option for gun handling boosting purposes.
  - This would also apply to tanks with average dispersion penalties and high speed. An example of a tank that fits this category is the Grille 15 (extremely high dispersion with high speed)
    - Most tanks falling into this category are mediums and heavies which have the superior VS at their disposal.

- eGLD's value drops considerably if used on vehicles with VS already mounted. This is because VS decreases the "size" of the reticle which means that eGLD has less time (literally) to expand the gap between itself and other equipment choices.

- The usage of improved bonuses on equipment emphasizes the benefits of the IRM and IAU by the same margin regardless of tanks. This is because IRM and IAU work as percentage bonuses on variables independent of aim time (penalty reduction and circle size reduction, respectively).
  - However, eGLD viability increases and decreases depending on the **aiming speed** of the reticule (which changes per tank). This is not "Aim time" but rather a combination of dispersion penalties "divided" by aim time. This is why **tanks with poor soft-stats (dispersion penalties) will have higher returns from eGLD than any other piece of penalty reducing equipment** regardless of "Aim time".

3. **Survivability - Category for equipment that affects a tank's ability to survive through health alteration, damage production, or module modification.**

    a. **Spall Liner**

        i. A defensive piece of equipment that largely existed to reduce High Explosive (HE) damage dealt from opposing tanks or artillery. Spall Liner increases "HE and ramming protection" of a vehicle by a noticeable percentage (50%+) while also protecting crew members from being injured.

        ii. The unfortunate truth to Spall Liner is that it is one of the worst pieces of equipment in the game if used for their primary stated purpose - reducing HE damage. The damage reduction from Spall Liner can be calculated from reading WGs formula for HE non-penetration calculation:

$$Damage = 0.5 * nominalDamage * (1 - ImpactR/SplashR) - 1.1 * nominalArmorThickness * SpallValue$$

From this formula, the only important bit about "damage reduction" comes from the last section which shows that ***damage reduction is a flat value*** based on the nominal armor thickness:

$$1.1 * nominalArmorThickness * SpallValue$$

A hypothetical best-case scenario in which a Maus is shot in the front of the turret (260 nominal armor) by a T92 HMC loading HE (1300 nominal damage):

The maximum damage of a shell is halved by a non-penetrating hit (650), this new damage must now be reduced by 1.1 times the nominal armor thickness (286) which means the expected damage would be around 364. With a Spall Liner the reduction in damage is 429 which means the expected damage would be 221; **a *decrease of 143 expected damage* or 39% reduction in damage in a *best-case scenario*.**

Of course, the above example doesn't take into account splash mechanics which allows shells to "creep" towards weaker armor zones meaning T92 HMC shells can calculate damage against the hull "roof" which has a nominal armor thickness of 50mm or 75mm with Spall Liner equipped.

The other mechanics of Spall Liner states that it also increases ram protection; this is to be taken quite literally as it has no effect on ram damage potential (barring the increase in weight from utilizing this piece of equipment). Spall Liner directly reduces the amount of ram damage taken by the stated percentage (approximately). A light tank that receives 100 damage from a ram would only take 50 damage if he had a Spall Liner (+50% protection from ram) equipped.

iii. There is little reason to be using Spall Liner for the main reason it was created - to protect against artillery. The calculation for HE damage reduction severely hampers the viability of such a piece of equipment against the vast majority of big HE hitters. Its primary use case is against low damage, low splash shells which is very counterintuitive to how most players expect Spall Liner to function.

Thus, Spall Liner should only be used in one of several scenarios:

Expectation of being damaged by several low-medium damage, low splash shells. This can come from either artillery (Object 261s, Batchat) or heavy tanks (T110E5, 60TPs, E-100s, etc). It will be useful on tanks that only expose high nominal thickness armor to its enemies (such as hull-down positions).

Crew Protection will be beneficial as it's a significant reduction in crew injury for all levels of Spall Liner. However, this is very wasteful as a Large First Aid Kit can save all crew members lost every 90 seconds and also reduces crew injury chance. This reduces Spall Liners only application to a tank which loses multiple crew members within 90 seconds of continuous engagement during First Aid Kit cooldowns.

There is an argument to be had for the reduced stun duration. However, seeing as the use case requires the tank to be stunned in the first place, the equipment will only be beneficial if there is artillery on the opposing team. On top of this, the stun duration reduction of 10% translates to 1~2 seconds of stun duration reduction. So even if it's useful, it's not greatly beneficial in a gameplay application.

iv.

b. Improved Hardening (IH)

    i.   A defensive piece of equipment whose purpose is to increase the durability of a vehicle by increasing its hitpoints and increase brawling capability by allowing full suspension repairs, increased suspension durability, and faster suspension repair times. **Unavailable for SPGs.**

    ii.   Improved Hardening is one of the more interesting pieces of equipment entered into the game because of its unique ability to directly change the hitpoint pool of a vehicle.

        In a game that utilizes a health pool as a primary characteristic to balance vehicles and being able to increase your hitpoints (by 8%) to raise your survivability is quite valuable. If rammer increases your damage output, Improved Hardening can be seen as the counter by increasing the damage output required to kill a vehicle.

        Improved Hardening also increases the suspension durability by 50% which will change the number shots required to de-track most vehicles from 1 shot to 2 shots. Additionally, any track repair returns suspension module health durability to 100% (instead of the usual 50%) which requires the aforementioned 2 shots to be destroyed again. IH also includes an increased suspension repair speed of 15% which further synergizes with the increased track durability and hitpoint increase.

    iii.   This is perhaps one of the pieces of equipment brawlers were looking for. An increase to suspension health and ability to repair to 100% increases sidescraping viability past the initial repair for shot trading purposes or close-quarters brawling.

        Increased track repair could potentially allow a single crew member to forego repair in favor of more useful skills for crew members with many choices but limited skill slots (such as the commander), though unlikely.

        Vehicle hitpoint increase has interesting implications as World of Tanks doesn't translate well into direct Time to Kill (TTK) but rather Shots to Kill (STK).

        As an extreme example, say a tank with 600 HP is shot by a tank with two tanks with 600 DPM. Tank "A" has 10 damage per shot with a 1 second

reload, while another tank "B" has 500 damage per shot with a 50 second reload. Tank "A" would take 60 shots and kill the player in 1 minute (as expected). Unfortunately, tank "B" requires two shells - a shell for 500 and another reload of a 500 damage shell to finish off the last 100 health which would take ~1.7 minutes. From this example, a small increase in health would require tank "A" to fire more shells and thus increase STK and thus TTK. On the contrary, tank "B" wouldn't care about a small increase in health because the 400 damage "overkill" from the second shell would mean the STK (and thus TTK) would remain the same.

Game based example:

	Health Points	360 Damage	390 Damage	400 Damage	440 Damage
Tank A	1700	5	5	5	4
w/ Hardening 8%	1836	6	5	5	5
w/ Hardening Bonus 10%	1870	6	5	5	5
Tank B	2200	7	6	6	5
w/ Hardening 8%	2376	7	7	6	6
w/ Hardening Bonus 10%	2420	7	7	7	6

From the above image, a theoretical (but applicable) case in which two tanks with 1700 and 2200 HP use Improved Hardening (w/ and w/out bonus) against common damage numbers to highlight STK differences.

From above, Tank A with 1700 HP would **not** fare well using IH (in tank-exclusive engagements) because the common 390 and 400 guns have the same STK/TTK and would effectively have little to no impact on the vehicle. However, Tank B with 2200 HP would find significant benefit from using IH as it increases STK against 390, 400 (bonus dependent), and 440 damage guns by 1 which translates to anywhere between 8 and 12 seconds of additional survival.

c. **Improved Configuration (IC)**
    i. A new piece of defensive equipment that combines the effects of the new Cyclone Filter, "Wet" Ammo Rack, Fill Tanks with CO2, and Toolbox. Whereas IH improves the overall external durability of tanks, IC focuses on improving the overall internal durability of tanks combined with reduced penalties, a saving throw, and improved repair speed. **Tier 5+ only.**

    ii. Improved Configuration combines 3 of the previous equipment that increase durability of internal modules. These internal modules are the engine, ammo racks, and fuel tanks and they gain an increase to their durability by 100%. On top of this increase in health, should any of these modules be destroyed and result in a destroyed engine (immobility), ammo detonation (death), or fuel tanks (fire) a saving throw is cast and the destruction of that module is negated *once*. There is also a decrease to ammo rack damage penalty (reload), engine penalty (mobility), and engine fire chance.

    To improve survivability even further, the toolbox's effect is added to IC to give the tank an additional 25% to its repair speed.

    iii. The low adoption rate of individual module protective equipment led WG to create IC which combines all internal module equipment into a single general piece of equipment (similar to the original "Module Protection" equipment).

    Unfortunately, I believe it will still see a low adoption rate because it is a "reactive" piece of equipment. Similar to Spall Liner which only functions when a tank is damaged by a specific shell type and gains extra benefits if hit by a specific shell type from a specific tank designation (SPG), **IC only gains benefits if penetrating shells hit locations where these internal modules are located and cause damage or destroy them several times in a single battle** or enough to disrupt normal gameplay (ammo rack detonations) constantly. Ammo rack detonation can largely be countered by the skill "Safe Stowage" and turn common ammo rack detonations into mere damage. Fires can be stopped by firefighting skills and the fire extinguisher. Engine damage/destruction can be stopped by using a repair kit.

Adding the previous "Improved Consumables" bonus (perhaps to a lesser degree) into IC would potentially allow it to gain higher adoption without removing the "spirit" of the equipment.

IC's philosophy in design revolves around "redundancy". Internal modules' health is doubled to decrease likelihood of destruction, decreased penalties remove the reliance on repair kit's long 90s reuse period to allow continuous contribution to a battle despite what many would consider crippling circumstances (damaged ammo rack/engine), and saving throws give tanks an opportunity to ignore the first major critical hit.

The addition of "Improved Consumables" (at a 20s/30s cooldown instead of 30s/50s) would keep the tank in line with the equipment's intended purpose and design decision. It would allow redundancy by helping the tank continuously repair its modules but also introduce an "active" aspect in the equipment by allowing players to play more aggressively due to the faster cooldowns on consumables.

The current iteration of Improved Hardening would see higher usage than Improved Configuration due to the increase in HP acting as a "reactive" measure to prolong the survival time in a match while allowing players to also use it "actively" as a tool to trade health/shots in 1-on-1 engagements.

As it stands, IC falls under the same category as Spall Liner which only acts as a piece of equipment where the goal is to receive damage but in an environment where *multiple* critical hits are few and far between in a single match.

I can see **extremely niche** picks of this equipment going towards a few existing tanks falling under very specific conditions. These conditions would require a weak ammo rack (even post-Safe Stowage), poor or compact module placement, and considerable health to have multiple critical module hits be an actual concern. Examples would be Russian and British mediums, though I doubt many would use IC even given these conditions in these tanks.

4. **Mobility - Category for equipment that directly affects the movement capabilities of a tank**

    a. **Additional Grousers (AG)**
          i. An updated equipment that is now no longer German middle-tier exclusive (few exceptions). The changes in equipment 2.0 change the reduction in terrain resistance into an increase in hull rotation and an increase in acceleration. **Unavailable for SPGs and wheeled vehicles.**

          ii. Additional Grousers has two characteristics, an increase to hull traverse speed by 15% and an increase to "acceleration" or "maintaining speed" (depending on source) by 10%.

             The increase to hull traverse is a direct translation to existing hull traverse speeds by multiplying existing values by 1.15. This is similar to applying three instances of the Clutch Braking skill on vehicles.

             The interpretation of how the secondary characteristic will be applied to vehicles will have drastic effects in its potential application:

             The first implementation is a direct increase in acceleration which would be similar to pseudo-engine power. This would allow tanks to capitalize on stop-start movement or 0 to top speed acceleration for general use.

             The second implementation is a decrease to terrain resistance (from the original grousers equipment) which also translates to better "acceleration" and speed "maintenance". It will have the same returns regardless of terrain due to the percentage increase in effective resistance reduction.

          iii. In terms of hull traverse, AG will find strong competition against IRM because the hull traverse increase (15% and 10%, respectively) exists on both pieces of equipment. Similarly, the 10% "acceleration"/"maintaining speed" bonus could be seen as a direct competition to Turbocharger's increase in engine power. Thus, AG can be seen as a **hybrid piece of equipment that specializes in general vehicle handling, responsiveness, and anti-circling capabilities**.

             The first implementation (unlikely) would lead to niche uses of AG due to specific maps favoring early high-risk, high-reward positions where speed

is valuable and acceleration is key to minimizing damage. It would also find usage in vehicles engaging around corners where acceleration is more valuable than speed.

The second implementation (likely) is powerful as the percentage decrease in terrain resistance yields the same returns for vehicles moving in all terrain. *This implementation is likely because of the key phrase "all terrain" in the first equipment 2.0 description.*

The previous implementation of grousers decreased terrain resistance in soft and medium terrain; it wouldn't be outlandish to assume this new iteration of AG to do the same, now with the inclusion of hard terrain.

World of Tanks has 3 different terrain "types". These types can be broken down into:

Soft/Poor Terrain - marsh, swamp, submerged (water)
Medium/Off-Road Terrain - grass, dirt, sand
Hard/City Terrain - roads, pathways

The order of resistance goes from [soft > medium > hard] which means soft terrain has a larger impact in movement *penalties* than medium and hard terrain. This makes sense as swampy/marshy terrain should make your tank move and react more slowly compared to city roads.

AG is the only option to **decrease terrain resistance on hard terrain** outside of increasing driver proficiency levels, it can be seen as the first piece to directly improve performance of vehicles operating on roads and pathways.

The decrease in terrain resistance will lead to better acceleration and increased hull traverse capabilities which has high synergy with the existing hull traverse bonus already built into AG, effectively making AG one of the **strongest hull traverse (anti-circling) or active angling pieces of equipment in the game**.

b. Turbocharger (Updated for Iteration 3)

    i.   A new mobility equipment that drastically changes how vehicles operate. It increases the engine power produced by a vehicle which directly affects hull traverse speeds, acceleration, and ability to maintain speed. It also combines the effects of the "Additional Forwards Transmission" and "Additional Reverse Transmission" which increases the maximum forward and reverse speeds. **Unavailable for wheeled vehicles.**

    ii.   Turbocharger increases the engine power of a vehicle by 7.5%. This directly translates into an increase in acceleration, an increase in hull traverse in all terrain types by the same percentage (7.5%), and a better ability to maintain speed when moving on inclines.

        The increase to forward and reverse top speed (4 and 2 km/hr, respectively) means tanks will enjoy the benefits of the engine power increase by not having the existing top speed limits act as a "limiter" to the increased horsepower.

    iii.   This is a game changing piece of equipment on par with Improved Hardening. Both forward and reverse top speed parameters and acceleration values for vehicles are characteristics which are widely used to balance vehicles between one another.

        The static increase to top speed means there is a higher benefit to slower vehicles than faster ones. A 60 km/hr tank would see a 6.7% increase in top speed and an 18 km/hr tank would see a 22% increase. This is fine as it gives this piece of equipment more viability on slower, bulkier tanks.

        The reason this has potential game changing properties is due to the fact that it not only increases a tank's ability to reach their top speed, but also increases their top speed even further while boosting acceleration by a noticeable margin. This will impact maps where early high-risk high-reward positions are played and speed is key to reaching and controlling positions. Maps such as Mines, Karelia, Malinovka, etc.

        It also has high potential in vehicles which enjoy minimal exposure gameplay - ridgelines or pokes on the side of buildings means the increased reverse speed can minimize potential damage intake.

Mobility Personal Analysis and Theorycrafting

To understand the value of mobility equipment. There has to be a very strong understanding of why mobility improvements are valuable.

Increases to mobility has significant implications in two major aspects:

Early positioning and faster rotations will be possible with the increase in top speed (not acceleration). Positions relying on speed (Karelia, Mines) have starting locations that allow players to reach top speed incredibly fast meaning top speed limitations hinder hill climb timings. Similarly positions relying on acceleration (Ruinberg, Himmeldorf) have locations where the ability to reach higher speeds faster (either on straight roads or hill climbs) can generate massive returns due to the ability to diminish potential incoming damage and take strong positions.

Ridge pokes and corner battles will become more "efficient". Both types of exposure have two common requirements to maximize damage output and minimize damage intake. Acceleration allows tanks to reach higher speeds around corners and over hills to minimize the amount of time spent exposed to enemies and top speed (reverse speed, especially) is the controlling factor into how "fast" a tank is able to return to cover. When fighting tanks in localized positions, the ability to consistently "control" engagements (or trades) is based on your tank's ability to accelerate forward against the opposition's ability to accelerate backwards for aggressive plays(and vice-versa for defensive plays). When acceleration is a non-concern it becomes a battle of forward acceleration (offensive) vs reverse top speed (defensive). This makes increases to reverse top speed incredibly valuable in conjunction with increased acceleration.

Thus, the value of Turbocharger and (to a lesser extent) Additional Grousers cannot be overstated. It's important to note that these types of engagements are situational and heavily based on map and positioning. Many maps have hull-down corridors (or sniper fights) which decrease the value in acceleration for brawling/trading and shifts value towards relocating and positioning.

Hull Traverse of Turbocharger and Additional Grousers

As I stated in the hull traverse section, increases in engine power also increases hull traverse. This is evident when analyzing the formula that calculates effective hull traverse.

$$HullTraverse_{effective} = \frac{EnginePower_{new}}{EnginePower_{old}} * HullTraverse$$

This formula indicates that the **increase in HullTraverse is proportional to the increase in engine power**. This explains why vehicles have increased responsiveness when upgrading to a more powerful engine.

We can use this to state that **a % increase in engine power from Turbocharger yields the exact same % increase to hull traverse**.

However, this formula can be expanded to include terrain resistance:

$$HullTraverse_{effective} = \frac{EnginePower_{new}}{EnginePower_{old}} * \frac{TerrainResistance_{hard}}{TerrainResistance_{applied}} * HullTraverse$$

*Note: this is merely an **approximation** that returns a close value to the expected result.*

This formula indicates that the **increase in HullTraverse is proportional to the decrease in TerrainResistance**.

We can use this to determine that **a 10% decrease in terrain resistance (assuming this is the case) from Additional Grousers yields approximately ~11% in hull traverse.** This increase in hull traverse from reduced terrain resistance is cumulative with the existing hull traverse increases which means AG will offer ~25% increase in hull traverse speed.

Turbocharger Analysis (*addressed in iteration 3*)

To understand why Turbocharger's increases to top speed and reverse speed is game-changing we have to analyze how WG game balancing is done.

There are three generalized aspects of a vehicle that can be modified (and nerfed); armor, gun characteristics, and mobility.

Armor is typically left untouched as WG is more prone to changing armor values of weakspots rather than changing armor profiles as a whole.

This means the **two major areas where vehicles face nerfs are in gun stats and mobility**.

Oftentimes, gun stat nerfs refer to significant soft stat (dispersion penalties) changes, aim time increases, uncommon reload time increases, and extremely rare elevation/depression decreases.

Mobility nerfs refer to changes in **engine power,** hull traverse, terrain resistance, **top speed,** and, most importantly, **reverse speed**.

Turbocharger undos many nerfs to vehicles that were primarily balanced through mobility. Several examples of mobility nerfs to problematic tank destroyers:

- Grille 15
    - Engine power decrease from 900 to 850 (5.6% decrease)
    - Reverse speed decrease from 20 to 15 km/hr (5 km/hr)

- FV4005 Stage II
    - Traverse speed (hull traverse) decrease from 30 to 26 deg/s (4 deg/s)
    - Forward speed decrease from 35 to 32 km/hr (3 km/hr)
    - Reverse speed decrease from 12 to 8 km/hr (4 km/hr)

- Object 268 Version 4
    - Engine power decrease from 1,500 to 1,350 (10% decrease)
    - Traverse speed (hull traverse) decrease from 23 to 22 deg/s (1 deg/s)
    - Forward speed decrease from 55 to 50 km/hr (5 km/hr)
    - Reverse speed decrease from 22 to 18 km/hr (4 km/hr)

As you can see, significant nerfs to vehicle mobility characteristics primarily involved a decrease to engine power or a significant decrease to reverse speed. This decrease to reverse speed heavily limited each vehicle's ability to play aggressively against enemies on ridgelines or corners and retreat relatively unscathed. The reduction to engine power only increased the difficulty in reaching the front line or accelerating quickly into cover even further.

If we were to compare a pre-nerf Object 268v4 against the current one utilizing Turbocharger:

	Pre-nerf Object 268 Version 4	Post-nerf Object 268 Version 4 w/ Turbocharger	Difference
Engine Power	1500.0	1451.3	-48.8
Forward Speed	55.0	55.0	0.0
Reverse Speed	22.0	21.0	-1.0

As you can see, it's possible to reach near pre-nerf levels of mobility with the use of Turbocharger on these vehicles. This applies to each of the listed TDs and to any vehicle who has seen similar mobility nerfs in the past.

To rebalance the Turbocharger, the only changes I would apply is a decrease to the reverse top speed because it is disproportionately high compared to the increase in forward top speed. It would be balanced if the reverse top speed increase was dropped by 1~2 km/hr.

Turbocharger issues have been addressed as of iteration 3 in equipment 2.0

5. **Scouting - Category for equipment that directly affects view range or modifies camouflage characteristics**
   a. **Binocular Telescope (Binocs)**
      i. A niche equipment that increases a vehicle's view range but only if stationary for a short period of time. This view range boost only works while the equipment is active and will not be functional if the vehicle is moving or not stationary for at least 3 seconds. **Unavailable for wheeled vehicles.**

      ii. Binocs increase view range by 25% if a vehicle is stationary for 3 seconds or more (and remains active as long as stationary). This bonus does not stack on the other view range boosting equipment Coated Optics.

      iii. Binocs are typically used for two tank playstyles.

         Passive Tank Destroyers find Binocs useful because it allows the tank destroyer to spot opposing tanks before they can spot in return. This ensures that a TD has the advantageous 1st shot opportunity when spotting its own targets.

         Passive Scouting (Light Tanks) will utilize Binocs if "passively" scouting. This involves finding an aggressive forward position to spot enemy vehicles and gain view range control over an important central position or vulnerable relocation area.

         Binoc's view range calculations are multiplicative *after* all view range boosting effects are included (barring Coated Optics equipment and Optical Calibration directive). This means binoc's value scales directly with any view range boosting skill (Recon, Situational Awareness, Brothers in Arms), equipment (Improved Ventilation), and consumable (food).

         Most importantly, **excess view range reduces camo effectiveness.** When the view range of tanks exceeds the spotting limit of 445m, the formula used to determine spotting range remains the same. This has an interesting side effect where **increasing view range doesn't change the spotting range of vehicles (445m limit); however, the amount of camo required to stay hidden at any range goes up**. Looking at it from another angle, increased view range decreases camo effectiveness.

b. Coated Optics (Optics)

     i.   One of the potential must-have pieces of equipment for tanks in the game. It offers an increase in view range which allows tanks to spot enemies at longer distances and allow more opportunities to dish out damage or gather information.

    ii.   Coated Optics increases your view range by 10%. This increase to view range is not limited to just the base view range but rather the "final" view range after all crew skills and equipment are factored in. *This does not include consumables (food)* in the final calculations.

    iii.   Coated Optics has incredibly high value for two reasons:

        It allows vehicles to reach max spotting range which makes it possible to maximize the distance at which vehicles will be seen by your vehicle. Many vehicles that have low view range (upper 300s) will find use in Optics when gun handling is not an issue and the ability to see enemies at longer distances will contribute to better performance and flexibility in its possible roles (generalization/"rounding out"). This is evident in fast middle or high tier mediums where acting as a spotter/scout is a possibility and enemy view range is similar, if not worse, making it possible to line up a shot or reposition favorably for the 1st shot due to the time gained from spotting the enemy earlier.

        Permanent increase to view range. The view range bonus offered by Optics is an active, permanent increase to view range. It does not require any special circumstances to be active on vehicles. For the same reason binocs is useful for passive vehicles, optics is useful for active vehicles (where being stationary/passive is not the main goal).

        Many players consider the 445m view range the minimum value for high tier gameplay. This is because it allows tanks to spot enemies if they fire at the maximum spotting range without having any potential blindspots. This is correct; being able to guarantee spotting at the maximum distance possible against low camo tanks means tanks will be taking advantage of spotting mechanics and, to a lesser extent, minimum view range control.

    iv.

Excess View Range Camo Negation Mechanics

Due to the advanced nature of camo negation it will have its own page below view range boosting equipment.

As with camouflage mechanics, the value in camo reduction from *excess* view range can be determined using the same formula:

$$SpottingRange = ViewRange - CamouflageValue_{enemy} * (ViewRange - 50)$$

This formula will plot a straight line with a negative slope. If we plug in values for ViewRange against a range of CamouflageValues, we can see exactly how much camouflage will be negated by determining the camouflage required to intersect the graph at 445m (max spotting range).

For a graph where ViewRange = 445:
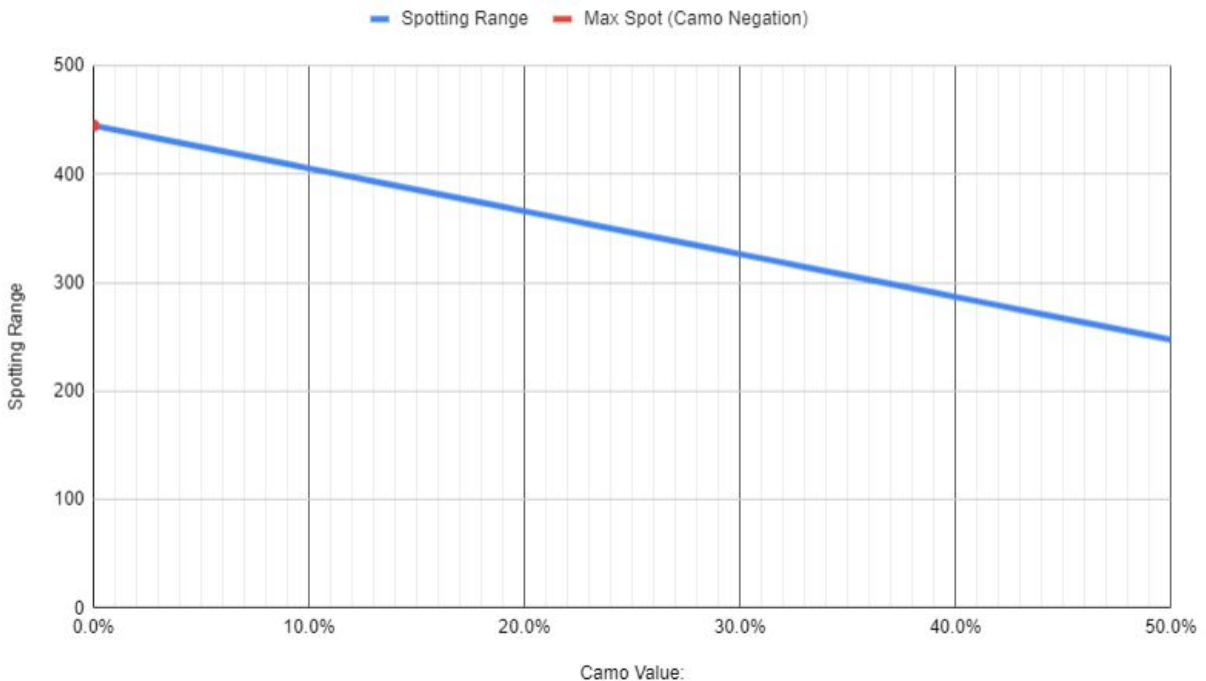
As you can see from the graph. If your view range is exactly 445m, you will only spot a tank at the maximum distance of 445m if they have a camouflage value of 0%. This makes sense from an intuitive and mathematical standpoint.

For a graph where the vehicle has Coated Optics equipped, ViewRange = 445*1.1 = 490:

Spotting Range vs Camo Value
@ 445m Spotting Range
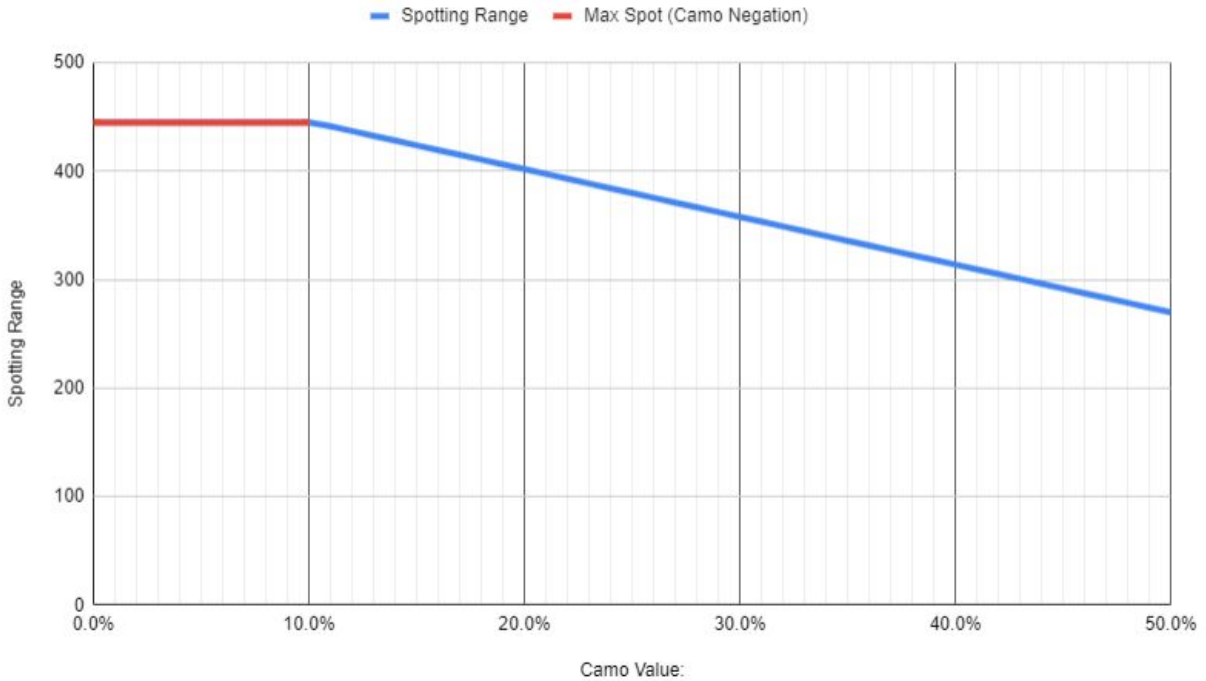
From this graph we can now see how effective an increase of ~45m view range over the maximum spotting range can be when used against camouflage. This shows that a vehicle with 10% or less camo will be spotted at the 445m spotting limit against a vehicle with a view range of 490m.

An interesting thought is whether or not this reduction in camo is proportional to an increase in view range. If view range increase is doubled, is the reduction in camo also doubled?

If Optics was replaced with Binocs instead, view range will increase by 25% (Binocs). A quick assumption would be a 2.5x (25%/10% = 2.5) increase of Optics' camo reduction. Thus, it might be assumed that Binocs would negate 25% of camo.

For a graph where the vehicle has Binocs equipped, ViewRange = 445*1.25 = 556:

Spotting Range vs Camo Value
@ 445m Spotting Range
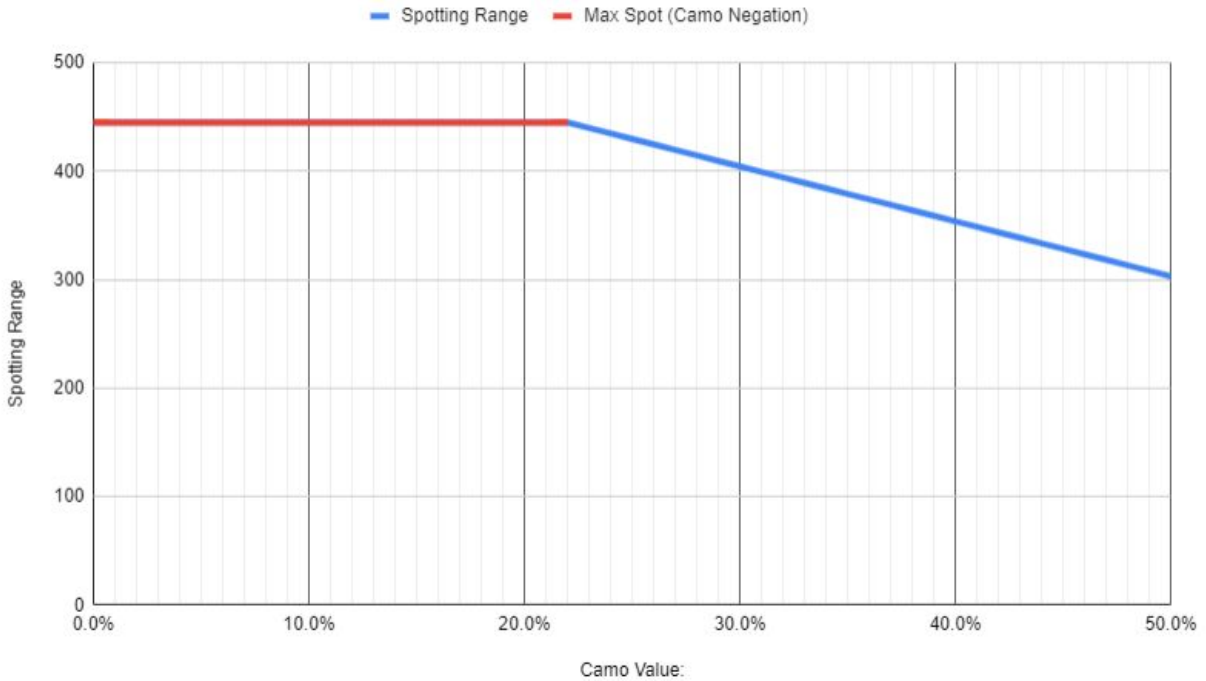
We can see that an increase in view range by ~111m led to a further detection range against camouflaged vehicles. Vehicles with 22% or less camouflage will be spotted at the 445m spotting limit against vehicles with a view range of 556m.

From here, we can see that an increase of 250% in view range did not lead to a 250% increase in camo reduction. In fact, increasing view range by 2.5x only reduced camo by 22% compared to the expected value of 25%.

The question then becomes: why?

The answer will be found by dissecting the original Spotting Range formula.

Camouflage Negation Formulation (WARNING: Math)

We can rearrange the Spotting Range formula as a function of CamouflageValue instead of SpottingRange:

$$\frac{ViewRange - SpottingRange}{ViewRange - 50} = CamouflageValue_{negated}$$

We can further limit the complexity of the equation (removing a variable) by solving for CamouflageValue when determining maximum SpottingRange of 445m:

$$\frac{ViewRange - 445}{ViewRange - 50} = CamouflageValue_{negated}$$

We can then use partial fraction decomposition/expansion to rewrite and simplify the formula:

$$1 - \frac{395}{ViewRange - 50} = CamouflageValue_{negated}$$

From this formula you can see an interesting relationship between ViewRange and CamouflageValue. The amount of camouflage negated is proportional to the difference between 1 and the inverse of ViewRange. As ViewRange increases, the result of its fraction decreases; however, because it is the difference from 1 we will find that a decrease in the difference will lead to an increase in the result (CamouflageValue).

Interestingly, while ViewRange increases lead to an increase in the CamouflageValue, the inverse nature of the function causes this increase to decrease over time. **For any increase in view range, the view range effect on camouflage negation has *diminishing* returns; any point increase in view range is less valuable than the last.**

Additionally, the original formula shows that the decrease in spotting range can be determined by the negative slope which is the product of camouflage and view range. When view range or camouflage increases, the gradient of the slope increases which means **spotting range is reduced more aggressively (per camo %) when camouflage overcomes the negation of camo from excess view range.**
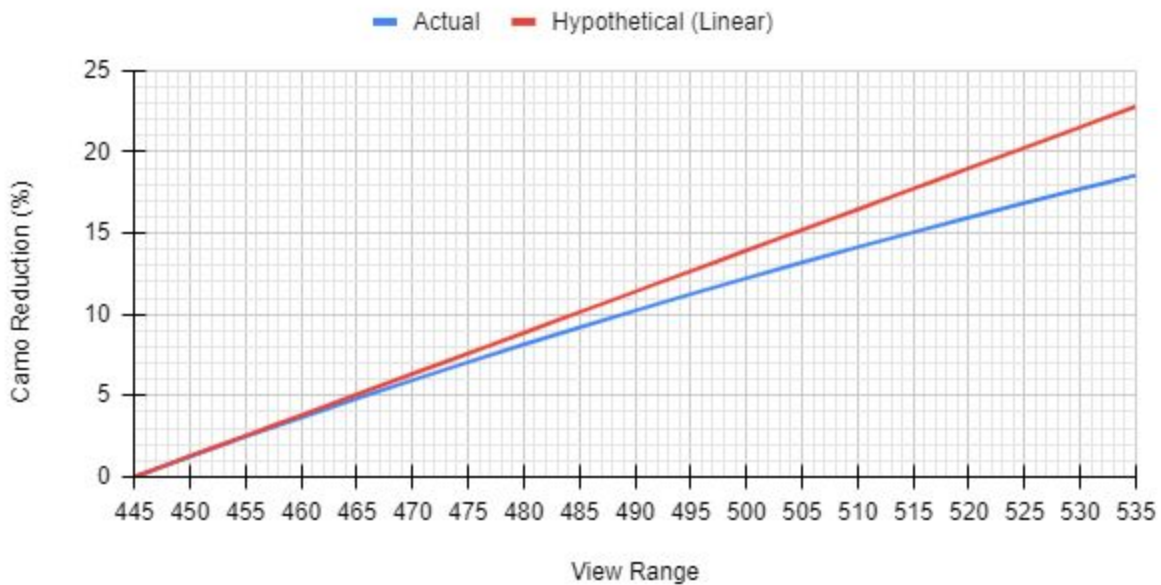
Excess View Range Camouflage Negation Conclusion
Credit to Flame9998 for assisting in verifying my findings

We can see below the interesting interaction of the reduction of camo as a function of view range using the formula created from the previous page:

Note: this graph uses ~535m View Range as the maximum because ~532m is the highest possible value achieved with Optics. Binocs increases the max possible view range to ~605m.

While these particular calculations/graphs are created by utilizing 445m spotting range as the baseline, this trend is consistent regardless of the spotting range used.

The red line illustrates the theoretical line that view range was to follow if it decreased camo proportionally, i.e., doubling the view range increase would double the camo reduction. The blue line shows the actual impact of view range on camo reduction which illustrates the diminishing returns of view range on camo.

Small increases in view range over 445m yield almost linear returns per view range increase. When view range begins reaching values over ~480m the diminishing returns become more apparent. This emphasizes the importance of a high base view range as it optimizes the value per point of view range (highest returns) *without wasting an equipment slot on Coated Optics.*

c. **Camouflage Net (Camo Net)**

    i.   Similar to binocs, another niche piece of equipment that increases the camouflage value of a tank by a flat percentage based on vehicle type. This bonus to camouflage is only applied if a vehicle is stationary for 3 seconds or longer and remains stationary for the effect of Camo Net to continue.

    ii.   The bonuses of Camo Net by vehicle type are as follows:

Heavies, SPGs - +5%
Lights, Mediums - +10%
Tank Destroyers - +15%

As we can see above, the value of Camo Net is dependent on the tank classification. Heavy tanks gain little benefit from using Camo Nets whereas TDs find tremendous benefits in using Camo Nets.

    iii.   The differences in bonuses offered by Camo Net pigeonholes its viability to TDs and niche Light tank playstyle.

The 15% increase to camouflage for TDs means it is a highly valuable piece of equipment when supporting frontline vehicles that can lead to potentially compromised positioning if spotted. It can be used in long range support positions (sniping) by minimizing the possibility of being spotted by active scouts or an aggressive enemy team. Additionally, it can be used on the frontline to lock-down lanes by limiting the enemy's ability to spot your vehicle (mid~end-game strategy). This is an alternative method of gaining a 1st shot advantage similar to Binocs.

Light tanks may find extreme niche usage of Camo Net if used with Binocs. This would further increase the difficulty of being spotted which allows for safer passive scouting gameplay in aggressive positions. However, the value of Camo Net is somewhat negated by the Low Noise Exhaust System for Light and Medium classed tanks.

Note: the camouflage bonus is additive and not multiplicative. This bonus will be the same regardless of how much or how little camo the tank of a particular classification has by default (no scaling).

d. Low Noise Exhaust System (LNES)

    i.   A new camouflage-boosting piece of equipment that competes with the existing Camo Net. It offers slightly lower camo bonuses as a trade-off to being active regardless if a vehicle is moving or stationary.

    ii.   Low Noise Exhaust System offers varying levels of camouflage bonus depending on the vehicle type as follows:

Heavies, SPGs - 3%
Lights, Mediums - 6%
Tank Destroyers - 5%

Unlike the Camo Net, LNES is designed to be more useful for active playstyles instead of passive ones. This is evident in the lower camouflage bonus, an increase in effectiveness for mobile vehicles (Lights, Mediums), and the ability to be active at all times.

    iii.   While LNES is a strong piece of equipment, it will not be as useful as Coated Optics. This is because the enemy's spotting range reduced by camouflage (from LNES) will rarely be higher than the increase to view range from Optics. Thus LNES will be a piece of equipment that works well with view range boosting equipment to emphasize view range control playstyles.

The small disparity in camouflage bonus for Lights compared to Camo Net means that this will enable both active and passive spotting for scouts. One of the issues with passive scouting with Camo Nets was the lack of camo bonus while moving into position and the requirement to be stationary to be active. This led to becoming spotted when repositioning and potential issues when waiting 3 seconds for Camo Net to become active (against active enemy scouts).

Note: the camouflage bonus is additive and not multiplicative. This bonus will be the same regardless of how much or how little camo the tank of a particular classification has by default (no scaling).

Camouflage Mechanics and Camo Equipment Viability

Due to the complexity of camouflage mechanics, it will have its own page underneath the relevant camouflage boosting equipment.

An increase in camo for a vehicle does not cleanly translate into a universal static bonus unlike many other vehicle characteristics.

The formula where camouflage comes into play is related to Spotting Range:

$$SpottingRange = ViewRange - CamouflageValue_{enemy} * (ViewRange - 50)$$

As you can see, **the impact that camouflage has in reducing view range is dependent on the view range of the tank it is applied against.** CamouflageValue is the percentage of camo a vehicle has (fortunately the camo value shown in-game is already given as a percentage). Most importantly, the relevant portion for determining the view range reduction is in the second half of the equation:

$$CamouflageValue_{enemy} * (ViewRange - 50)$$

This means that any **camouflage value scales directly in regards to the vehicle's view range** (minus 50) **it is being used against**; higher view range means higher reduction and lower view range means lower reduction. Thus every % increase in camo has its value dependent on enemy view range and not any statistics of your own vehicle. **For any *given* view range, camouflage has *linear* returns; any increase in camouflage percentage is just as valuable as the last.**

We can use this view range reduction to find the critical point in which the view range reduced on enemy vehicles would have theoretically exceeded the view range gained from either Coated Optics or Binocs. By doing so, we are able to find which pieces of equipment are optimal for view range control gameplay.

This is possible because both LNES and Camo Net are additive bonuses to a vehicle's camouflage value, similar to the camouflage bonus gained by using camo paint. We can plug these numbers directly into the reduction portion of the formula to return the effective decrease in enemy view range. **If the effective reduction in enemy view range is lower than the increase in view range gained from other pieces of equipment then the camouflage equipment is inferior from a view range control gameplay perspective.**

This can be witnessed in the table below:

Enemy View Range	View Range Reduction from Camouflage			
	LNES w/out Bonus (6%)	LNES w/ Bonus (8%)	Camouflage Net LTs + MTs (10%)	Camouflage Net TDs (15%)
400	21.0	28.0	35.0	52.5
405	21.3	28.4	35.5	53.3
410	21.6	28.8	36.0	54.0
415	21.9	29.2	36.5	54.8
420	22.2	29.6	37.0	55.5
425	22.5	30.0	37.5	56.3
430	22.8	30.4	38.0	57.0
435	23.1	30.8	38.5	57.8
440	23.4	31.2	39.0	58.5
445	23.7	31.6	39.5	59.3
450	24.0	32.0	40.0	60.0
455	24.3	32.4	40.5	60.8
460	24.6	32.8	41.0	61.5
465	24.9	33.2	41.5	62.3
470	25.2	33.6	42.0	63.0
475	25.5	34.0	42.5	63.8
480	25.8	34.4	43.0	64.5
485	26.1	34.8	43.5	65.3
490	26.4	35.2	44.0	66.0
495	26.7	35.6	44.5	66.8
500	27.0	36.0	45.0	67.5
505	27.3	36.4	45.5	68.3
510	27.6	36.8	46.0	69.0
515	27.9	37.2	46.5	69.8
520	28.2	37.6	47.0	70.5
525	28.5	38.0	47.5	71.3
530	28.8	38.4	48.0	72.0
535	29.1	38.8	48.5	72.8

The left hand column highlights possible enemy view range values. The corresponding view range reduction values are shown in the other 4 columns for various camo % increases from the equipment types. The "Enemy View Range" numbers are used from a range of 400m (for lower tiers) to 535m (the max is ~532m with Optics) which are realistic view range values one would expect from tier 8 to 10.

The assumptions here are that we will be using Coated Optics for competitive purposes. Binocs would be the best for view range but are heavily limited by positioning and playstyle.

We can assume that most tanks utilizing Coated Optics will reach a bonus to their view range of 40m (for the sake of comparison). We can see that both the basic LNES (6%) and the bonused LNES (8%) will never be more useful than Optics at any level.

Camo Net offers noticeable view range reduction over basic LNES. It offers a slightly higher bonus than the LNES (with bonus); however, this bonus is marginal considering the limitations required to utilize Camo Nets. In the case of TDs, Camo Net is by far the strongest piece of view range reducing equipment available in the game, reducing at least 50m of view range from enemy tanks.

For these reasons, we can find that the tradeoff to use LNES over Camo Nets depends heavily on the use cases for the vehicle (although Camo Net only applies to extremely restrictive passive scouting and sniping roles). TDs would still benefit from Camo Net due to the raw view range reduction but loses to Binocs (not shown, but offers at least 90m of view range) for view range control. LNES would typically lose to Optics in many cases which is why it would **work well as a supplement to Optics and not as a direct competitor**.

Note: non-bonused LNES would require enemies to have over 720m view range to beat Optics and 550m with bonused LNES; this assumes the view range from Optics isn't higher than 40m (which it usually is).

There is a scenario in which LNES would offer more useful benefits over Optics (as a competitor). Cases where the vehicle has more than enough view range to spot enemies but would require camouflage to reach an aggressive position (with foliage cover) and limit counter spotting against numerous tanks. An example would be a position outside of the Murovanka forest (strong vegetation), where you are in close proximity to the enemy tanks rendering any increase in view range as excessive but an increase in camouflage would decrease the likelihood of being spotted.

The increase in camouflage added by LNES would also decrease spotting ranges by a flat value due to the additive nature of the camouflage increase from LNES which means no scaling (with regards to its view range negation). This decrease in spotting range becomes more competitive on a LNES with the bonus (8% vs 6%) but is dependent on enemy view range to increase viability. Seeing as LNES only becomes competitive when the opposition has impossibly high levels of view range, **Optics is the better option when competing against LNES *in general.***

e. **Improved Radio Set (IRS)**

    i. A new piece of scouting equipment that merges the effect of the "Jamming Device" into the "Improved Radio Set" and decreases the potency of both of their effects. It increases the time enemy vehicles will remain spotted (by you) and decrease the time your vehicle will be visible to the enemy after exiting their view range. **Unavailable to Heavies, TDs, and SPGs. Tier 8+ only.**

    ii. World of Tanks has a separate mechanic for vehicles that are no longer within spotting range. Vehicles that leave spotting range will continue to be visible for ~10 seconds.

    The IRS increases the time enemies will continue to remain spotted and decreases the time that you remain spotted by 1.5 seconds. Once enemies *spotted by you* are out of the spotting range of your vehicle, they will remain visible for ~11.5 seconds. This also applies to when your vehicle is spotted by enemies; you will reduce the time you are spotted down to ~8.5s.

    iii. Improved Radio Set is one of the more interesting new pieces of equipment. Generally, scouting can be loosely defined as battle of map control through the collection of information. This "information" can be collected by spotting tanks piloted by players on the opposing team or limited by increasing the difficulty at which you are spotted in response.. As such, most existing equipment prioritizes this raw information gathering by raising view range (maximizing reach) and increasing camo (minimizing reach).

    The IRS changes this interaction by now modifying the amount of time that you are exposed to enemies after reaching hard or soft cover. It also increases the time enemies will be exposed after being spotted.

    We can analyze the two effects separately and their impact:

    The increased duration to enemy spotting by 1.5s is fairly strong in theory. Spotting enemy vehicles and forcing them to remain spotted for longer durations can lead to two effects. The first is a longer exposure time for enemies in potentially compromisable positions - this can refer to enemies attempting to relocate or enemies that are spotted in primarily soft

cover positions (bushes, trees, minimal physical obstructions, etc.). The second is offering a false sense of security against aggressive enemies. There is a strategy employed by players to wait ~10 seconds before repositioning, relocating, or re-exposing themselves. Increasing this spotting duration to ~11.5 seconds may lead to more accurate information gathering or higher levels of preparation for your team.

It's important to note that the skill Designated Target increases the duration for enemy vehicles spotted within 10 degrees of your reticule by 2 seconds. Many players do not consider this as a concern and do not re-evaluate their play due to the rarity of the skill. A similar occurrence will happen with the IRS if there is a low adoption rate or predictable usage of the equipment.

The decreased duration to being spotted by the enemy by 1.5s is an alternative method to limit the information enemies will be able to operate on. The time a vehicle remains visible outside spotting range can directly translate to potential incoming damage in a 1:1 fashion. Every second you are visible to the enemy translates to an extra second the enemy can reposition, aim, and fire. By limiting this duration, you can directly impact the amount of damage that you will receive.

Similar to LNES, the **IRS will work as a fantastic supplement to existing view range control options.**

Improved Radio Set vs Camouflage for Survival Viability

The real question becomes whether or not the IRS is a viable piece of equipment to replace Optics or LNES (as previously shown). IRS is difficult to evaluate in traditional terms due to the fact that it only works after being spotted which is the antithesis to view range control. Traditional comparisons will not work because equipment used to manipulate spotting cannot be compared to equipment that works *after* being spotted.

Alternatively, IRS can be viewed as a piece of "survival" equipment due to its ability to decrease your vehicle's "visible time" (this terminology will henceforth be used to describe the ~10s visible duration upon leaving spotting range). A new comparison must be made to substantiate the value of this decrease in visible time.

A decrease in visible time means there must be a direct decrease in actual visibility time or an *effective* decrease in visibility time—simply translated to "leaving" spotting range. The only equipment that can manipulate the range at which a player leaves spotting range would therefore be camo boosting equipment. This leaves LNES and Camo Net as the only two options that can indirectly relate to IRS; however, the likelihood of a player utilizing Camo Net *after* being spotted is extremely unlikely (...I mean, really?) which leaves LNES as the only competitor.

Now that we have a baseline for what will be used in the comparison, we must **find a way to directly compare an increase in camouflage to a decrease in visibility time**. In a previous discussion regarding LNES viability, a table was used to illustrate the effective view range reduction gained from an increase in camouflage. The conversion of camouflage into a unit of distance offers an interesting perspective in analyzing IRS. If the IRS is "activated" by exiting the spotting range, we can convert this unit of time into a unit of distance by utilizing vehicle speed.

And thus a direct comparison can be made between LNES and IRS by matching the reduction in enemy view range to the distance travelled in your vehicle. **If the distance travelled by a vehicle during the visibility time decrease from IRS is lower than the reduction in spotting range from an increase in camouflage from LNES, we can then state IRS is inferior to LNES from a survivability perspective.**

Below is a simplified version of the table used in the LNES camouflage section:

	View Range Reduction from Camouflage	
Enemy View Range	LNES w/out Bonus (7%)	LNES w/ Bonus (9%)
400	24.5	31.5
410	25.2	32.4
420	25.9	33.3
430	26.6	34.2
440	27.3	35.1
450	28.0	36.0
460	28.7	36.9
470	29.4	37.8
480	30.1	38.7
490	30.8	39.6
500	31.5	40.5
510	32.2	41.4
520	32.9	42.3
530	33.6	43.2

To reiterate, LNES view range reduction is based on the view range of the enemy.

We will take a competitive stance in public matches for enemy view range — we can expect enemies in high tier vehicles will be utilizing view range at a minimum value of 445m. This means LNES (no bonus) translates to a *minimum* of ~27m in view range decrease.

If a vehicle is able to travel a distance of ~27m or more in 1.5 seconds, it will have a higher benefit towards using IRS over LNES for survivability. **In order to find the distance in meters a vehicle travels, we will need to convert the given top speed in km/hr into units of m/s.**

We can use a conversion formula to convert the top speed of vehicles from km/hr into m/s:

$$TopSpeed\frac{kilometers}{hour} * \frac{1000\,meters}{kilometer} * \frac{hour}{3600\,seconds} = TopSpeed\frac{meters}{second}$$

Below is the recalculated speed of vehicles using the previous formula:

Vehicle Speed (km/hr)	Vehicle Speed (m/s)	Distance Travelled (m)	
		IRS w/out Bonus (1.5s)	IRS w/ Bonus (2s)
60	16.7	25.0	33.3
65	18.1	27.1	36.1
70	19.4	29.2	38.9
75	20.8	31.3	41.7
80	22.2	33.3	44.4
85	23.6	35.4	47.2
90	25.0	37.5	50.0
95	26.4	39.6	52.8

The range of vehicle speeds used are from 60 km/hr to 95 km/hr, this is relevant to the majority of vehicles (Light tanks) that will be utilizing IRS. Surprisingly, the table shows that **vehicles with a speed of at least 65 km/hr will benefit more from IRS over LNES when minimizing** *visibility time.*

While this decreases visibility time, **this does not necessarily translate into survival**. The theoretical scenario where two vehicles each utilized 1 of the respective pieces of equipment does not produce equal results. The reality is that LNES would only allow enemy vehicles to spot by closing this (~27m) distance to *maintain* spotting. On the other hand, the IRS would require players to compensate for this ~27m gap by driving that distance within 1.5 seconds. This is possible but **assumes there is no loss in speed; this means no suboptimal pathing, speed loss from turning, and other events that can lead to a speed decrease (damaged engine, dead driver, track destruction, etc.)**. Vehicles with higher top speeds have more leeway in regards to speed loss or suboptimal pathing.

Note: this is assumes that the goal is to disengage from the enemy and break contact, there are other "spotted" scenarios which are more nuanced and outside the scope of this analysis

There is a distinction that must be addressed regarding the difference from spotting time and visibility time. **Visibility time is only applied once spotting is not actively occurring**. This does not mean that a player must strictly leave enemy spotting range, but rather that spotting must be obstructed or is no longer possible. Spotting can be disrupted by obstructing vision from yourself or the opposition with vegetation, physical objects, terrain, etc. In these conditions, the decrease in visibility time becomes more valuable because it becomes controllable. **In scenarios where your vehicle will be spotted regardless of camo value, a decrease in visibility time has significantly more value than an increase in camouflage for survivability.**

There are 3 use cases which would maximize Improved Radio Set (IRS):

Exceedingly fast vehicles will maximize both the aggressive and defensive applications of the IRS. As shown in the table earlier, tanks will gain more benefits if they have a higher speed because of their ability to effectively exit spotting ranges as an alternative to using camo-boosting equipment. This is especially relevant on EBR 90s and EBR 105s due to their top speed and low base view range; a playstyle that encourages spotting by closing distance rather than view range control.

Maps with large amounts of vision obstruction such as Prokhorovka, Murovanka, or any other favorable "active scout"-focused maps will benefit lights much more than any others. These maps will allow lights to minimize damage received significantly from the reduced exposure time granted from the 1.5s drop in visibility time. This is useful because limiting spotting lanes and breaking sightlines can be done on demand through the extensive use of vegetation/foliage cover.

Passive scouts will find the IRS as one of the stronger pieces of equipment to optimize their playstyle. The additional visibility time added to enemy vehicles has high synergy with the high view range, high camouflage area control playstyle. Many vehicles spotted by passive scouts will often retreat immediately, increasing the value of added visibility time over spotting time.

f. Commander's Vision System (CVS) [Updated as of 8/19/2020]

    i. A new piece of scouting equipment that will exist as the primary competitor to Optics. It reduces the camouflage value of enemy vehicles if "they are moving or behind vegetation". **Tier 8+ only.**

    ii. The Commander's Vision System has two effects. The first effect is a 10% decrease to camouflage of moving enemy vehicles. And the second effect is a 15% decrease to camouflage for enemy vehicles behind foliage.

    This decrease to camouflage is a percentage decrease to camouflage for both moving vehicles and foliage cover. If a vehicle has a camouflage value of 20% while moving then CVS will decrease that camouflage value to 18% (10% decrease). Similarly, bushes that offer 50% camouflage value will be decreased to a value of 42.5% (15% decrease).

    It's important to note that the camouflage decreases to moving vehicles and foliage can stack and are active simultaneously. A vehicle moving behind foliage will have both the movement and foliage penalty applied to it.

    iii. Previously, camouflage was described as a quirky mechanic for one simple reason: the effect of camouflage bonuses to your vehicle was dependent on the view range of the opposition. Effectively, equipment such as LNES and Camo Net had variable impacts depending on the view range and equipment set-ups of the enemy—a stat that was within your control had variable returns outside of your control.

    The same quirkiness can be applied to CVS due to the fact that the effectiveness of camouflage reduction against vehicles and foliage are dependent on the moving camouflage value or foliage camouflage. Because this equipment decreases the enemy's camouflage, **CVS is a piece of equipment that scales with your vehicle's view range but has variable returns based on the camouflage of the enemy**.

    Due to unique mechanics, CVS will completely replace Optics as the best "bush spotting" equipment in the game. In general "open spotting" (will be used hereafter to refer to isolated vehicle spotting) Optics will continue to exist as the best option.

Scouting Personal Analysis and Theorycrafting (Commander's Vision System)

To understand the full picture of the relationship between camouflage and view range, there has to be an understanding of the individual relationship between camouflage's view range negation and view range's camouflage negation. As we have discussed both mechanics extensively, we can come to a surprising conclusion:

- **View range has diminishing returns against camouflage**
- **Camouflage has linear returns for any *given* view range**

From this, we can say that **camouflage has increasing returns against view range**.

This allows us to not only accurately evaluate CVS, but also gauge its effectiveness compared to Optics.

There is a method to explain this through elaborating on formulas but instead we will explain this intuitively and practically using the above observations as guidelines.

In theory, it would be possible to calculate the view range gained from the reduction of the opposition's camouflage. However, this would not be accurate due to the spotting limitation of 445m and the variable returns of CVS. **This makes it a requirement to change the comparison from view range control to spotting range. We can also extend this to directly compare Optics and CVS by calculating the difference in the spotting range for the two pieces of equipment.**

As CVS has two different effects, this theorycraft will break down CVS into its individual components (moving and foliage).

Competitive Baseline for Optics

We can start by first establishing the camouflage negation baseline from Optics by using a previously solved formula to find the effective decrease in camouflage.

Solving for the following formula:

$$1 - \frac{395}{ViewRange - 50} = CamouflageValue_{negated}$$

We can use this formula to solve for the amount of CamouflageValue that is negated by using Optics on specific vehicles:

A 400m base view range vehicle with Recon, Situational Awareness, Vents, and BiA will have a view range increase from 440m to 484m (+44m Optics) which translates to slightly more than 10% camo negation (~10.3% actual).

A 420m base view range vehicle with Recon, Situational Awareness, Vents, and BiA will have a view range increase from 462m to 509m (+47m Optics) which translates to slightly less than 10% camo negation (~9.8% actual).

This shows that any vehicle with a view range between 400 and 420m will see an additional ~10% camo negation from Optics. We can see that although the higher base view range vehicle has a higher view range increase from Optics, it offers less camo negation than the lower base view range vehicle. This falls in line with view range's diminishing returns.

Note: Camouflage negation refers to the first x% of camouflage on vehicles that will be rendered useless and is not a reductive value. A vehicle with a camouflage value of 40% will not see their effective camouflage value reduced to 30% if the camo negation is 10%. Instead, any vehicle **under** *the calculated camouflage negation (added to the original negation prior to optics) will effectively have 0% camouflage. This explains why high camouflage is mostly unaffected by theoretically high "camo negation by view range".*

Analyzing Spotting Range Formula

Established earlier in the document was the idea that the formula for spotting range had a negative slope for the product of camouflage and view range:

$$SpottingRange = ViewRange - CamouflageValue_{enemy} \cdot (ViewRange - 50)$$

This formula generally follows the pattern y = mx + b where m (slope) is usually calculated with either CamouflageValue or ViewRange as a given constant (otherwise it creates a hyperbolic paraboloid which is outside the scope of this analysis).

From this, we can derive that any scaling (percentage change or multiplier) that is applied to CamouflageValue or ViewRange changes the steepness of the negative slope. What's interesting is **all view range skills and equipment apply this scaling; however most camouflage boosting equipment and skills do not** *except for CVS.*

This means two things:

- An increase in view range from Optics (and Binocs) means it should theoretically yield a lower SpottingRange at some point compared to a flat decrease or increase in CamouflageValue.
- A decrease to camouflage value from CVS means it should theoretically yield greater SpottingRange at some point compared to both standard and view range boosted vehicles.

We can also plot the effective spotting ranges of a vehicle with specific view ranges to visually illustrate the differences between the two pieces of equipment and also illustrate the effects of Optics and CVS (and their differences) using various view range values and come to a few interesting observations.

We can take the spotting formula a step further to show why CVS becomes more impactful as camouflage increases.

If we dissect the spotting range formula further, we can see that the reduction of 50 view range in the latter half of the equation is representative of the "proxy spotting range" as it would make little sense for camouflage to apply in scenarios where you are automatically spotted. Thus we can rewrite the equation as:

$$SpottingRange = ViewRange - CamouflageValue_{enemy} \cdot (ViewRange - ProxyRange)$$

If we remove ProxyRange and only consider the equation for which camouflage can be applied then we can simplify the equation even further and see why ViewRange becomes meaningless in a particular scenario:

$$SpottingRange = ViewRange - CamouflageValue_{enemy} \cdot ViewRange$$

This can be rewritten to:

$$SpottingRange = ViewRange \cdot (1 - CamouflageValue_{enemy})$$

What you can see from the above formula is that as CamouflageValue of vehicles reach high values, no amount of ViewRange will allow you to spot them from *any* increased distance. This is why stacking view range equipment and view range skills are relatively meaningless when it comes to spotting foliage covered enemies. **The value of ViewRange decreases as camouflage goes up and the value of camouflage removal (CVS) becomes an invaluable asset.**

Commander's Vision System Open Spotting (Moving)

The first graph will illustrate both equipment for vehicles with 380m view range:

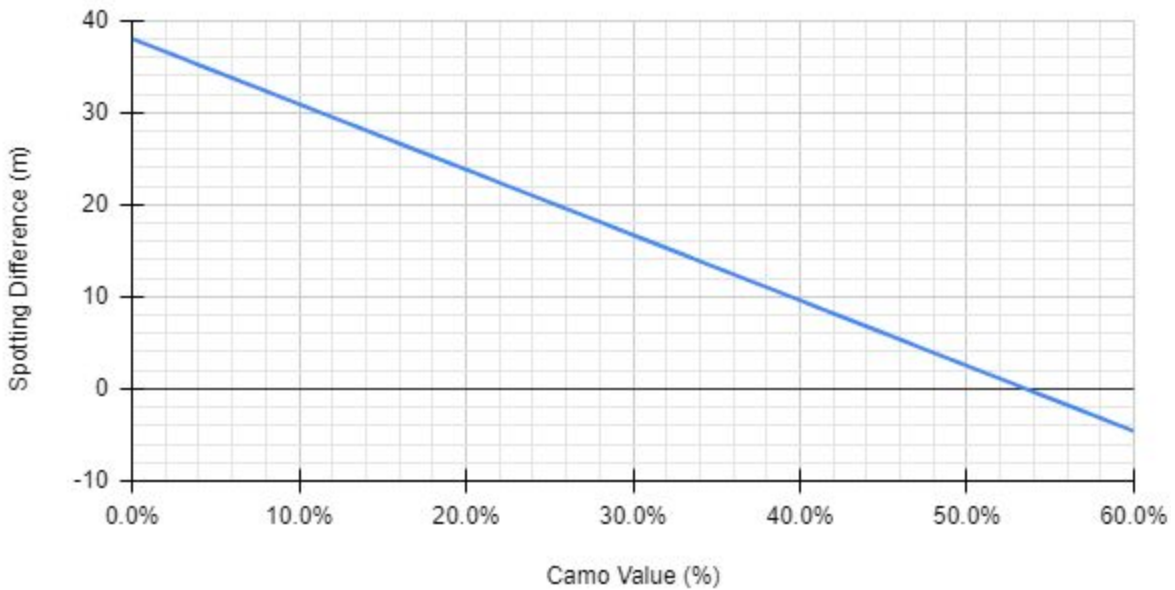

Spotting Range vs Camo Value
@380m View Range
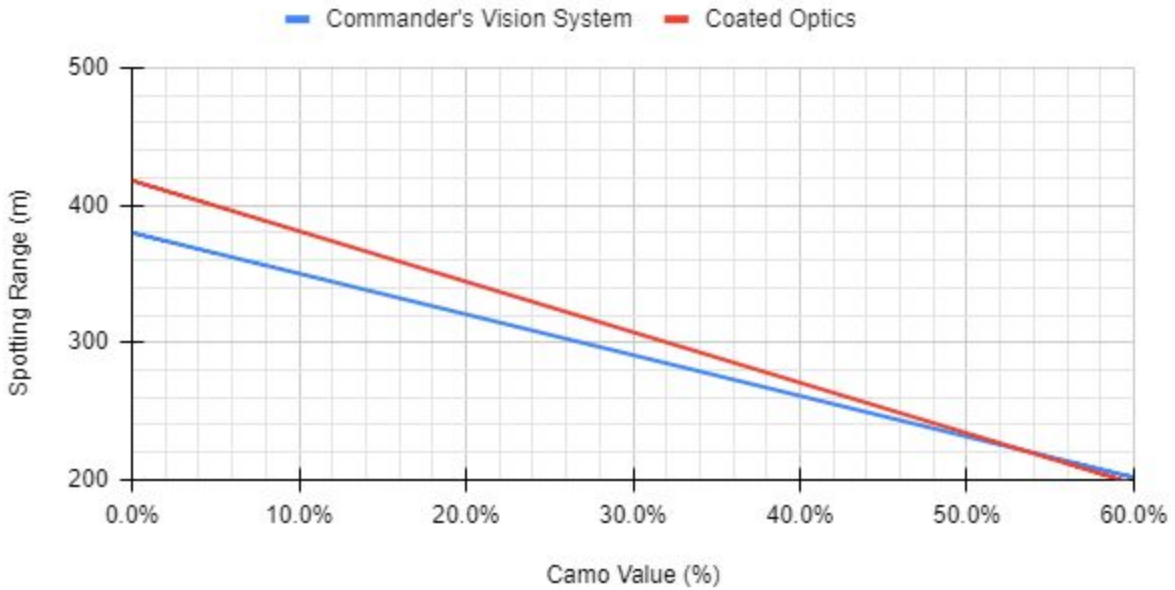
We can plot the advantage Optics has over CVS for each particular % of camo:
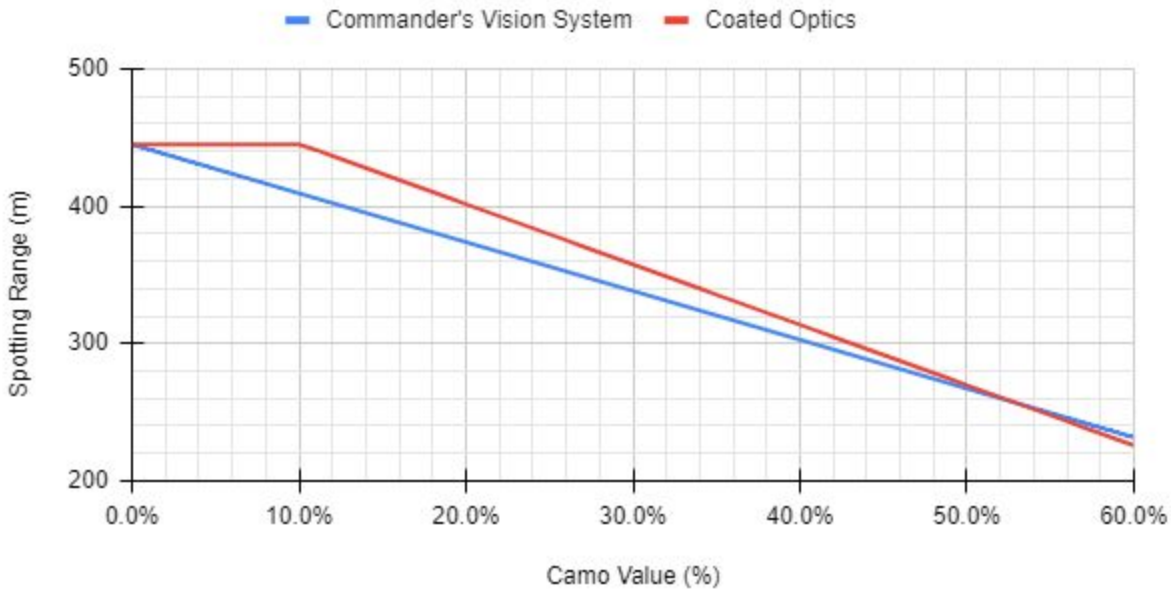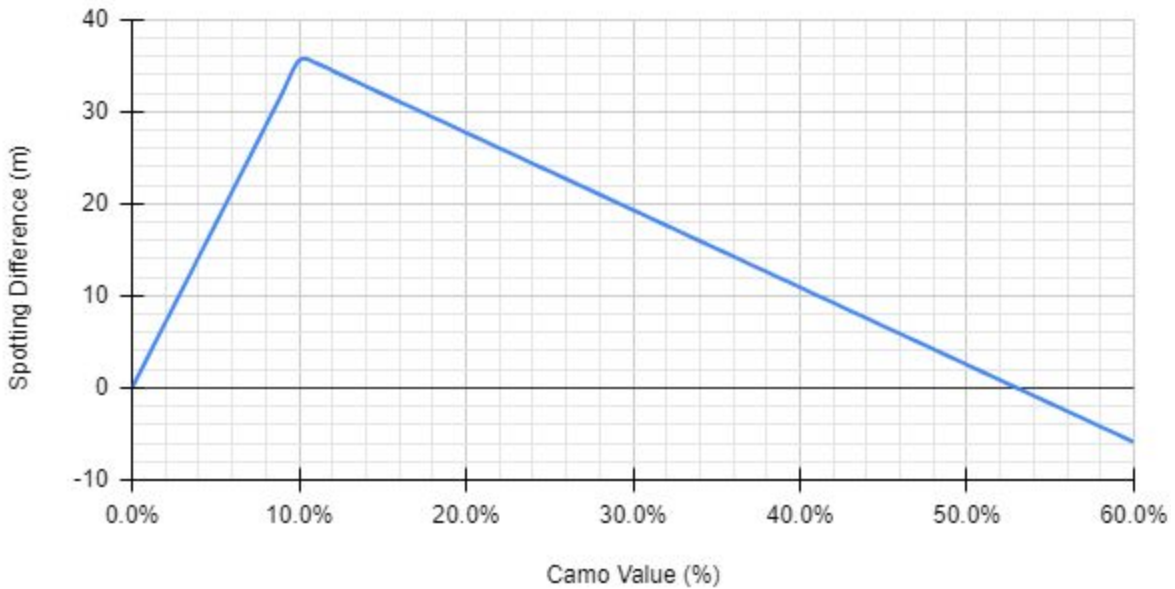

Optics Spotting Range Advantage
@380m View Range

We can do this again for vehicles with exactly 445m view range:

And again plot the Optics advantage over CVS:

From the graphs we can make some conclusions:

- **The critical point (camo value) is relatively unchanged (marginally decreases) as view range increases**
- **CVS never beats Optics when it comes to open spotting moving vehicles**

This is not surprising. Due to the percentage decrease of CVS, it will never be able to remove camouflage to any meaningful levels when the camouflage value of enemies are at non-existent or low values. **Notice that the critical point at which CVS becomes better than Optics lies around 52% camouflage. This level of camouflage is impossible for any *moving* vehicle in the game to obtain which means there is no scenario in which CVS is better than Optics for open spotting.**

The reason why CVS eventually catches up to Optics is due to the fact that CVS acts as a camouflage removal tool rather than a camouflage negation tool. CVS decreases the camouflage value of vehicles by 10%, this can be seen as a reduction of camouflage by subtraction (40% becomes 36%) which gives view range more "weight" when it comes to spotting higher camouflage targets. On the other hand, Optics attempts to brute force itself through camouflage (hence the 0 to x% camouflage negation) which creates a problem later down the road due to increasing the influence of each camouflage percentage on spotting range reduction.

In the first "spotting range advantage" graph, we can see there is no situation in which the spotting range of CVS will surpass Optics. However, the second graph highlights one major downfall to Optics through a spotting mechanic in World of Tanks—a 445m spotting limit. This creates an advantage for CVS because Optics has "wasted" its view range. **In a gameplay application, when there is a minimum of 445m view range, CVS is not penalized *as heavily* for spotting low camouflage targets compared to Optics.** This applies to low camouflage heavies or vehicles that have fired. **As your view range goes up, the difference between Optics and CVS decreases and increases the viability of CVS (though it never surpasses Optics for open spotting).**
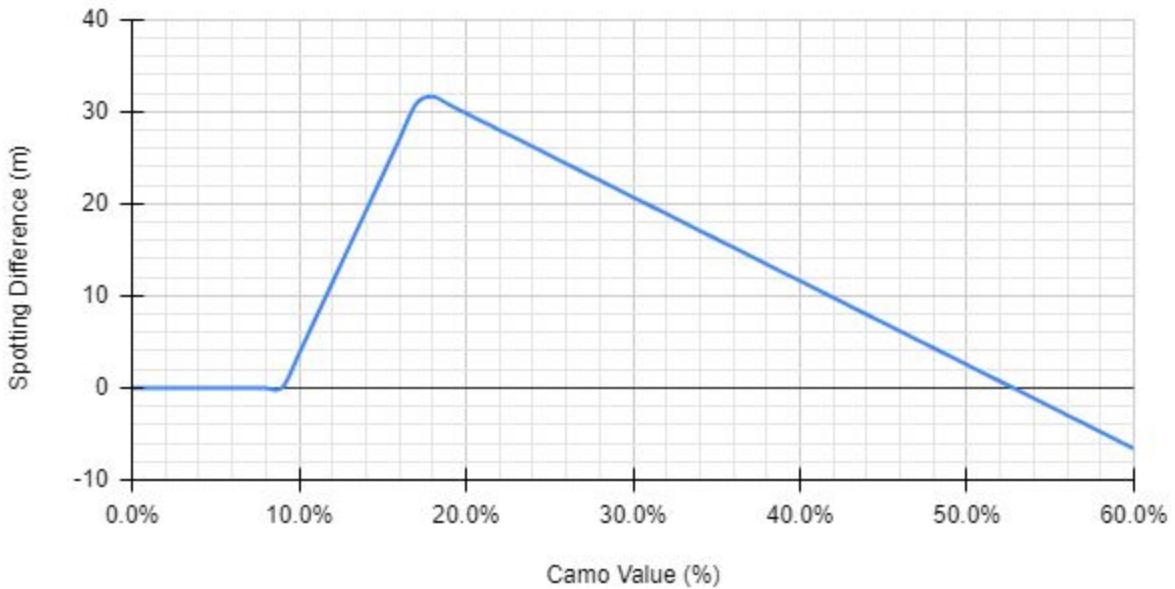
We can showcase an example using 480m view range (highest possible without optics):

Spotting Range vs Camo Value
@480m View Range
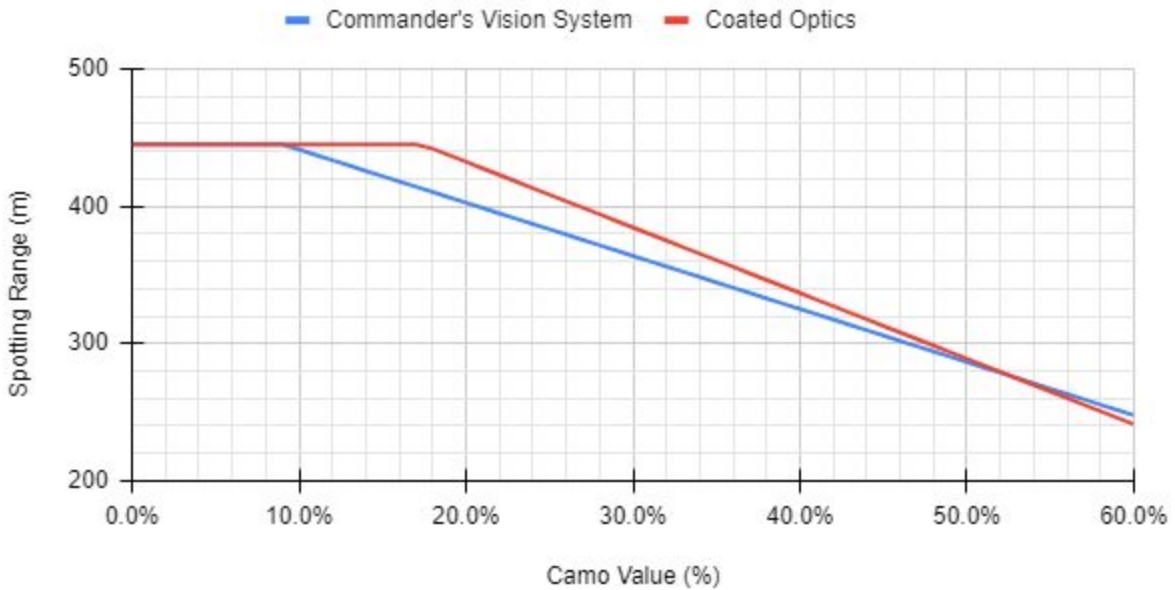
We can also show the difference graph:

Optics Spotting Range Advantage
@480m View Range

Notice how higher view range reduces the problems CVS has against spotting low camo targets due to the spotting limit working against Optics (and the lower "peak" on the graph).

Critical Point (Moving) Formulation (Warning: Math)

We can create a formula to solve for the critical point between Optics and CVS (moving; 10% decrease) for a given view range.

The critical point exists when the spotting ranges for both pieces of equipment intersect:

$$SpottingRange_{Optics} = SpottingRange_{CVS}$$

Substituting the equations where CV = CamouflageValue and VR = ViewRange:

$$1.1 \cdot VR - CV(1.1 \cdot VR - 50) = VR - (0.9 \cdot CV)(VR - 50)$$

Expanding:

$$1.1 \cdot VR - 1.1 \cdot VR \cdot VR + 50 \cdot CV = VR - 0.9 \cdot CV \cdot VR + 45 \cdot CV$$

Simplifying:

$$0.1 \cdot VR = 0.2 \cdot CV \cdot VR - 5 \cdot CV$$

Rewrite:

$$0.1 \cdot VR = CV(0.2 \cdot VR - 5)$$

Solve for CV:

$$CamouflageValue_{critical} = \frac{0.1 \cdot VR}{0.2 \cdot VR - 5} = \frac{VR}{2 \cdot VR - 50} = \frac{1}{2} + \frac{25}{2 \cdot ViewRange - 50}$$

From prior graphs we know that any value higher than the critical CamouflageValue will yield greater returns on spotting range compared to Optics. We can also see that **this value will never drop below 50%**. The formula also shows that this critical point will exist somewhere between 52.1% and 53.5% for the highest view range (605m) and the lowest view range (380m), respectively. **This conclusively shows why CVS will never surpass Optics in open spotting scenarios.**

Single Foliage Camouflage Value Calculations
Credit to Flame9998 and Bayleaf154 for assisting in verifying my findings

Now that we have calculated the effectiveness of CVS against vehicles behind no foliage, we can do our calculations against vehicles behind foliage. **In this case we need to define the general foliage behaviors when running these calculations.**

In World of Tanks, camouflage value from foliage, Camo Net, and camo paint are *cumulative*. **They are summed into one final camouflage value to use in the spotting range calculations.** In a scenario where vehicle and foliage camouflage are considered, we can expand the formula as the following:

$$SpottingRange = ViewRange - (Camouflage_{vehicle} + Camouflage_{foliage}) \cdot (ViewRange - 50)$$

We can also rewrite this formula to solve for the camouflage value of any given foliage in the game:

$$Camouflage_{foliage} = \frac{ViewRange - SpottingRange_{enemy}}{ViewRange - 50} - Camouflage_{vehicle}$$

If the known values are the range at which enemies are spotted (SpottingRange), the camouflage value of the enemy vehicle (shown in garage), and your vehicle's view range then it is possible to solve for the camouflage provided by any given foliage.

Using this formula, I was able to determine that the two most common types of foliage offered *exactly* 25% or 50% camouflage. Note that trees were not tested extensively and neither was tall grass.

Generally:

25% Camouflage Foliage - leafless trees and dead bushes/shrubs
50% Camouflage Foliage - leaf-covered trees and lush bushes/shrubs

There is a strong association with the camouflage provided with the amount of greenery that exists on foliage.

Note: this test was conducted on new maps such as Berlin, there may be some discrepancy on these values for older maps.

Commander's Vision System Single Bush Spotting (Foliage)

Now that we have established the baseline for the amount of camouflage foliage provides, we can factor in CVS' application against single bush scenarios. For each of these graphs, we will have multiple calculations based on the camouflage that foliage offers (25% or 50%), whether or not the enemy vehicle is moving (CVS stacks reductions), and for various view ranges.

The camouflage provided by foliage offers a static increase to the total camouflage during spotting range calculations. For this reason, the only variable that matters is the camouflage value of the vehicle *behind* the foliage. The graphs will not change regarding the x-axis nor the y-axis and will have the camouflage from foliage applied behind-the-scenes. Thus a vehicle camouflage of x% on the graph can be read as the vehicle camouflage (x) summed with the foliage camouflage stated on the graph.
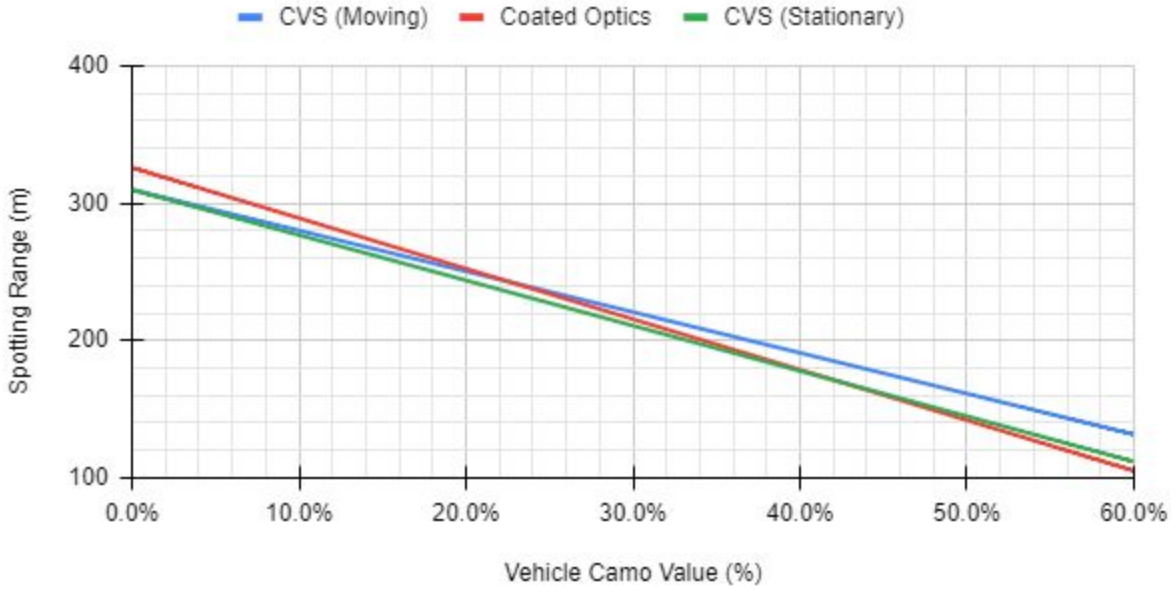
The information will be presented in graphs in the following structure:

- 25% camouflage foliage
  - 380m view range
  - 445m view range
  - 480m view range
- 50% camouflage foliage
  - 380m view range
  - 445m view range
  - 480m view range

An additional line will be present on each graph to represent a scenario in which CVS is removing camouflage provided by foliage but not against vehicles (stationary). A secondary graph similar to previously used ones will represent the "Optics advantage" in these scenarios.
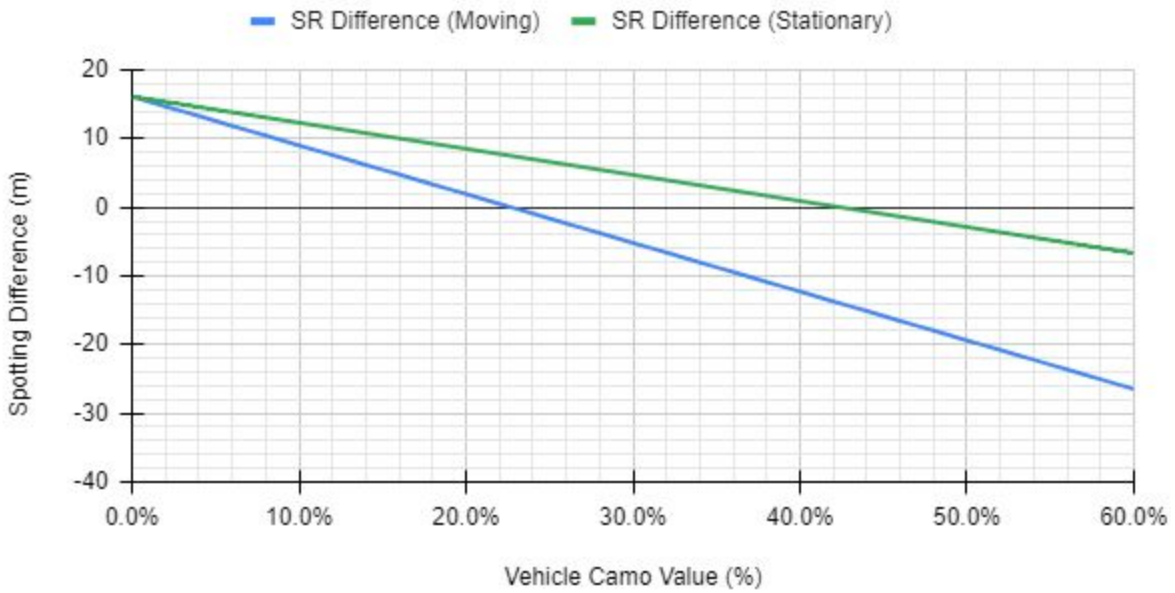
25% Camouflage Foliage
380m View Range

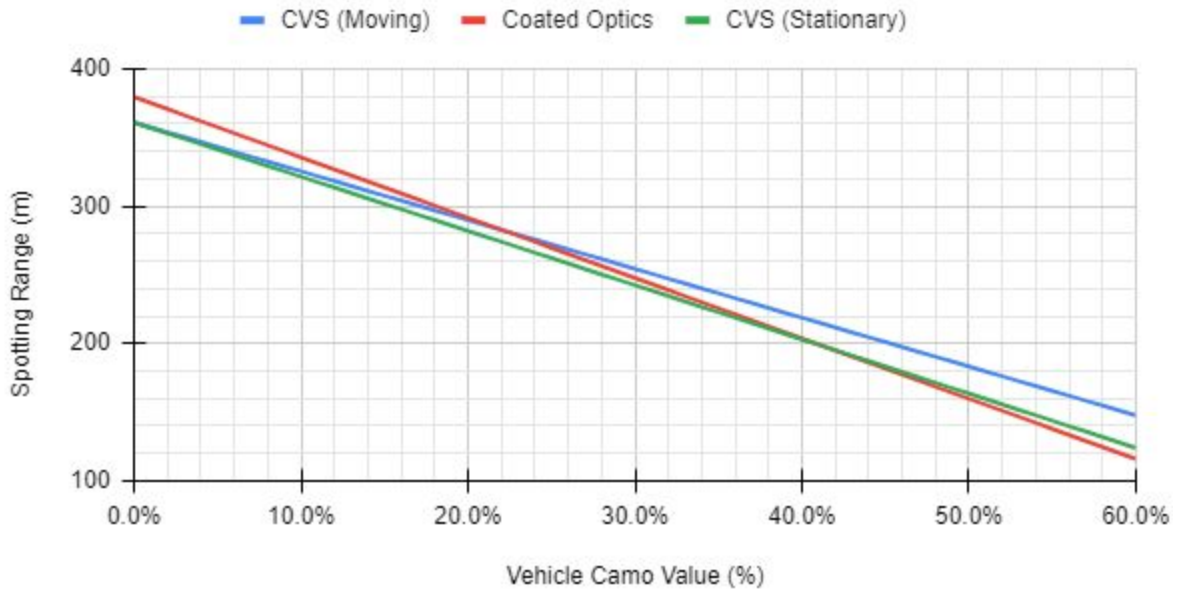Spotting Range vs Camo Value w/ 25% Camo Foliage
@380m View Range

Optics Advantage:

Optics Spotting Range Advantage w/ 25% Camo Foliage
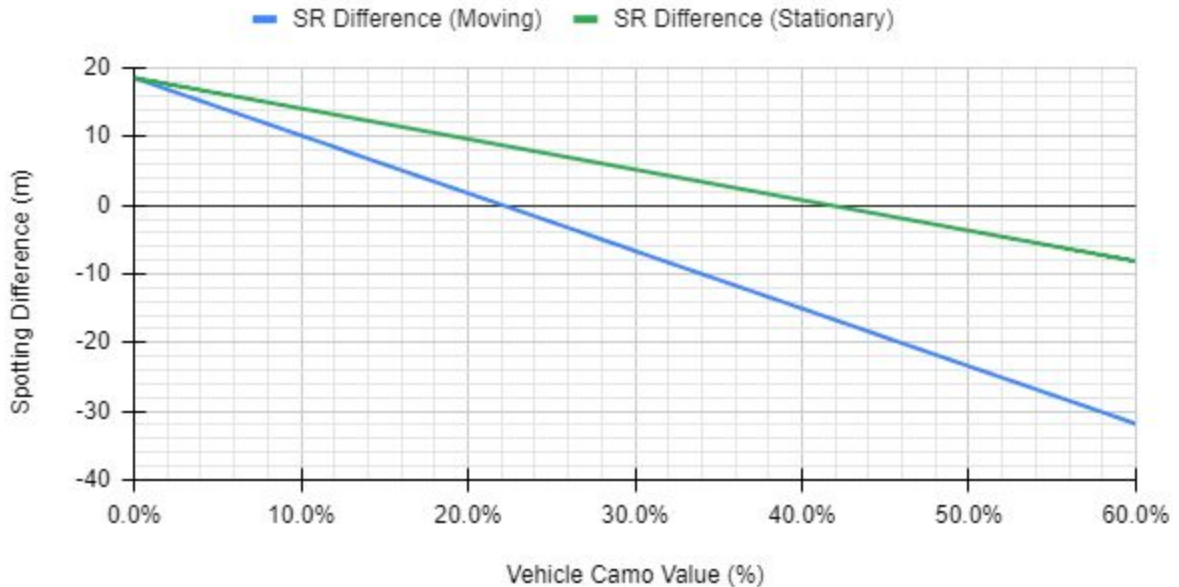@380m View Range

445m View Range

Spotting Range vs Camo Value w/ 25% Camo Foliage
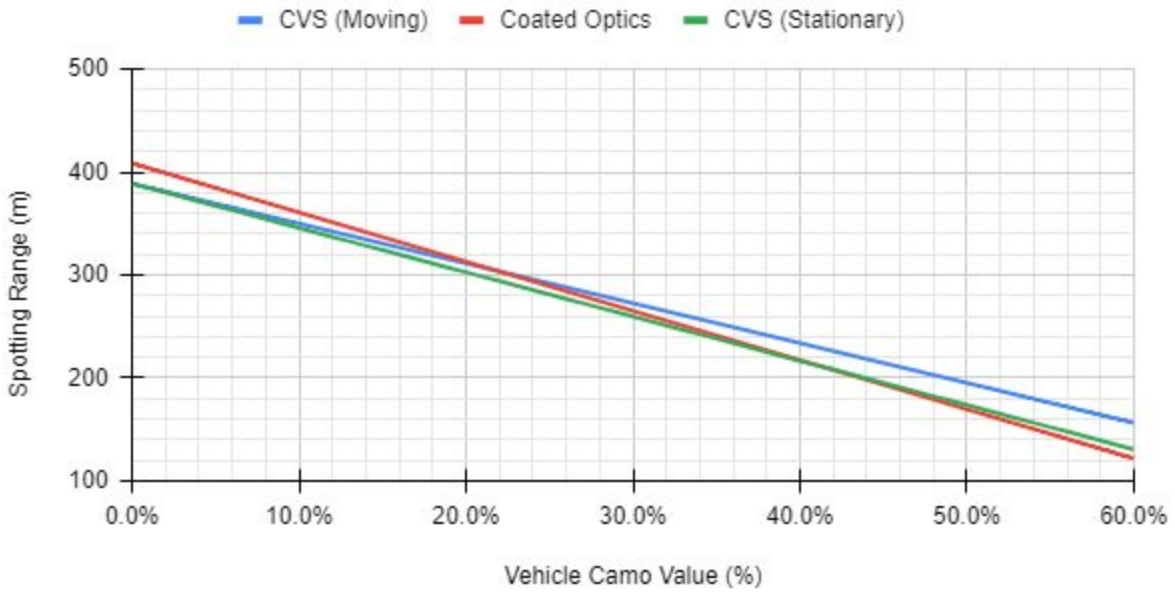@445m View Range

CVS (Moving) — Coated Optics — CVS (Stationary)

Optics Advantage:

Optics Spotting Range Advantage w/ 25% Camo Foliage
@445m View Range

SR Difference (Moving) — SR Difference (Stationary)

480m View Range

Spotting Range vs Camo Value w/ 25% Camo Foliage
@480m View Range

Optics Advantage:

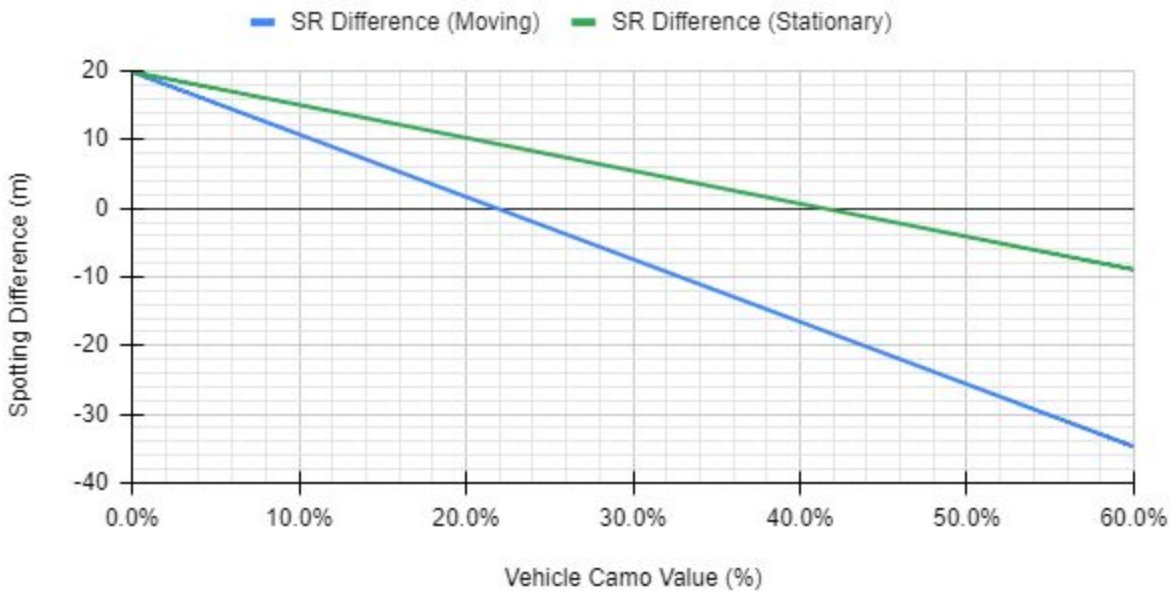Optics Spotting Range Advantage w/ 25% Camo Foliage
@480m View Range

50% Camouflage Foliage
380m View Range

Spotting Range vs Camo Value w/ 50% Camo Foliage
@380m View Range

Optics Advantage:

Optics Spotting Range Advantage w/ 50% Camo Foliage
@380m View Range

445m View Range

Spotting Range vs Camo Value w/ 50% Camo Foliage
@445m View Range

Optics Advantage:

Optics Spotting Range Advantage w/ 50% Camo Foliage
@445m View Range

480m View Range

Spotting Range vs Camo Value w/ 50% Camo Foliage
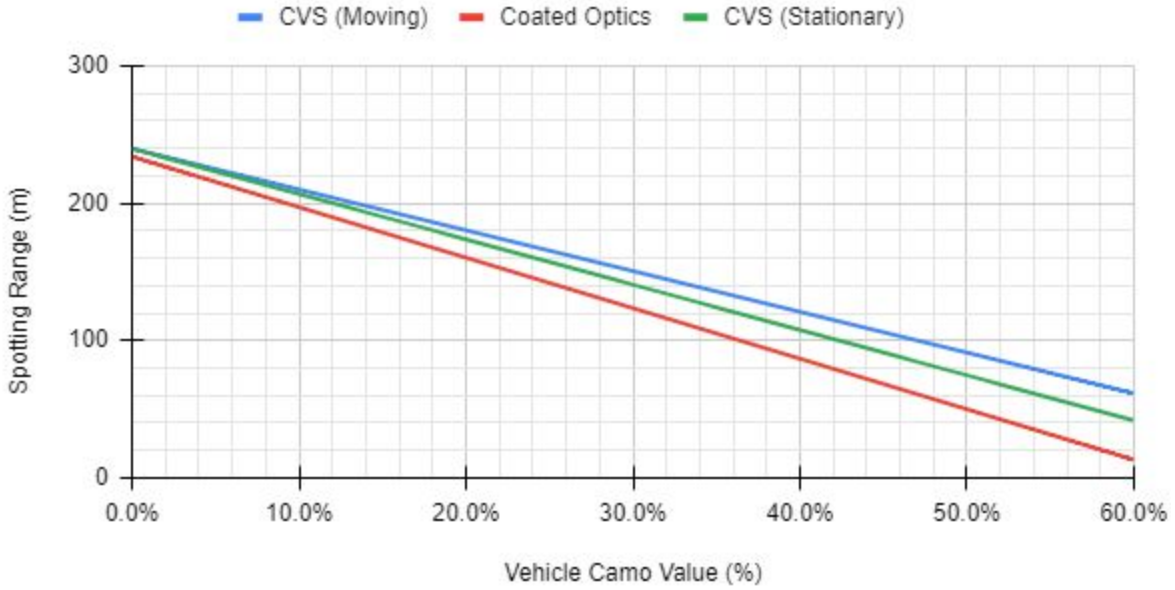@480m View Range

Optics Advantage:

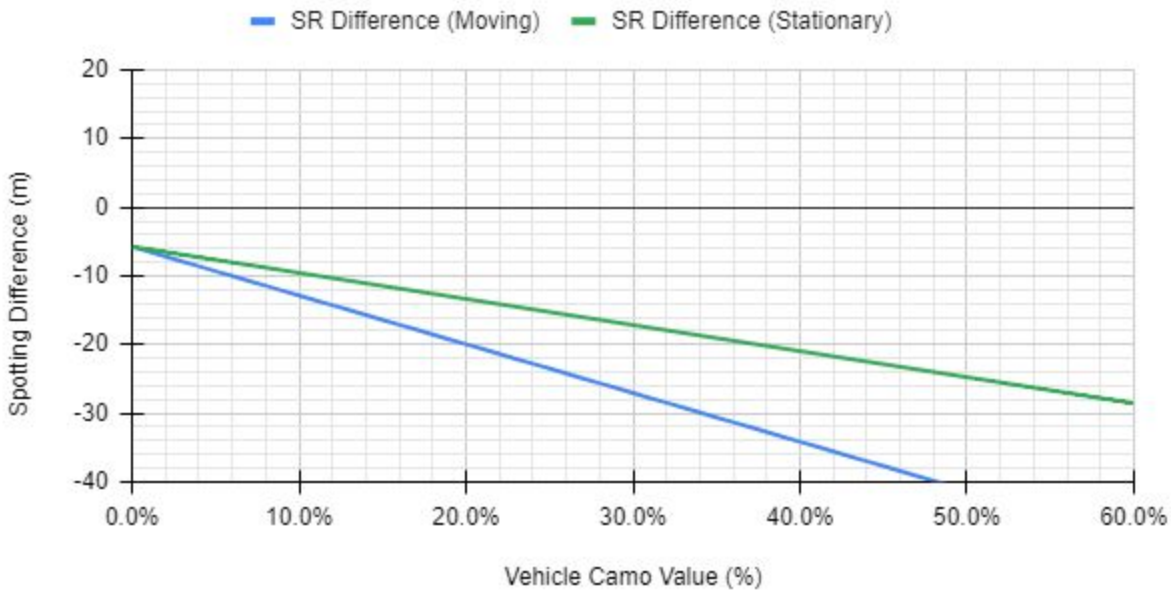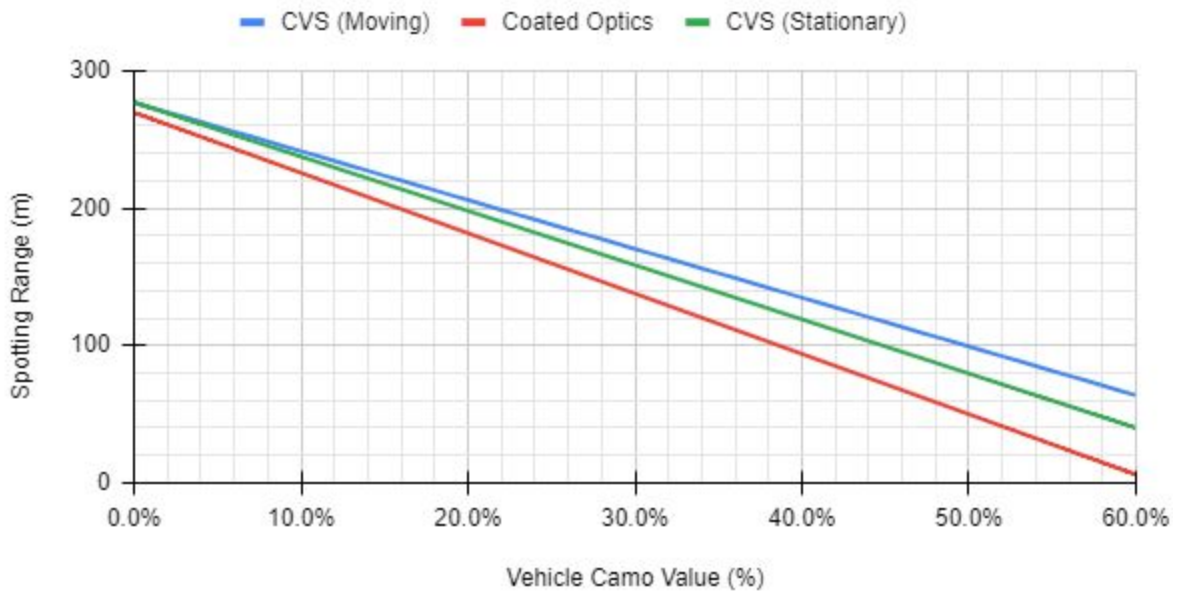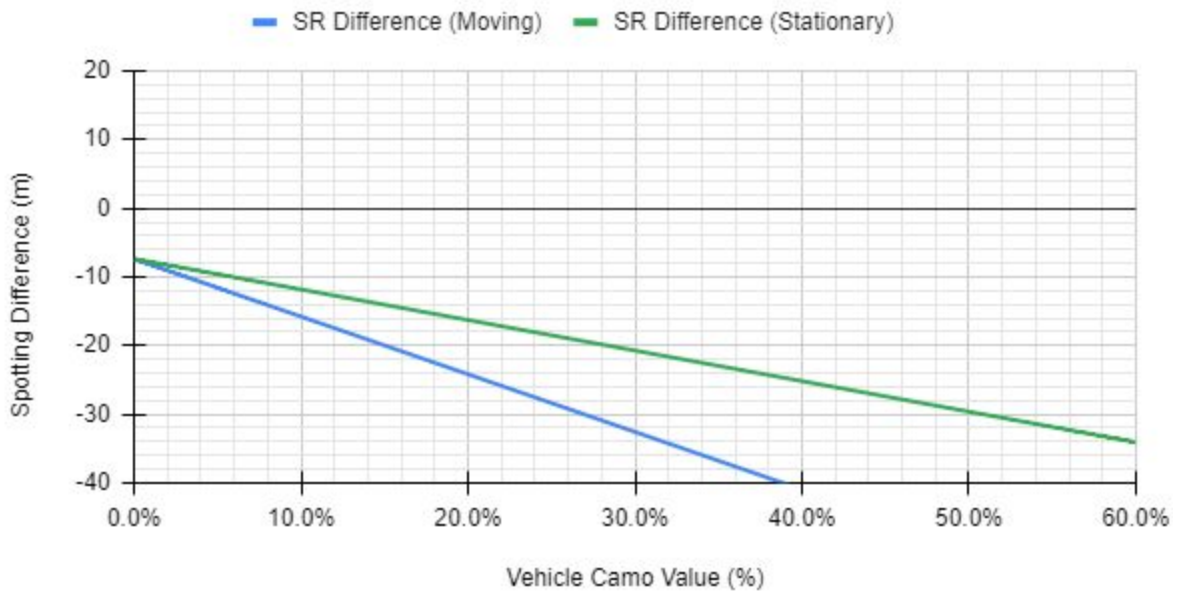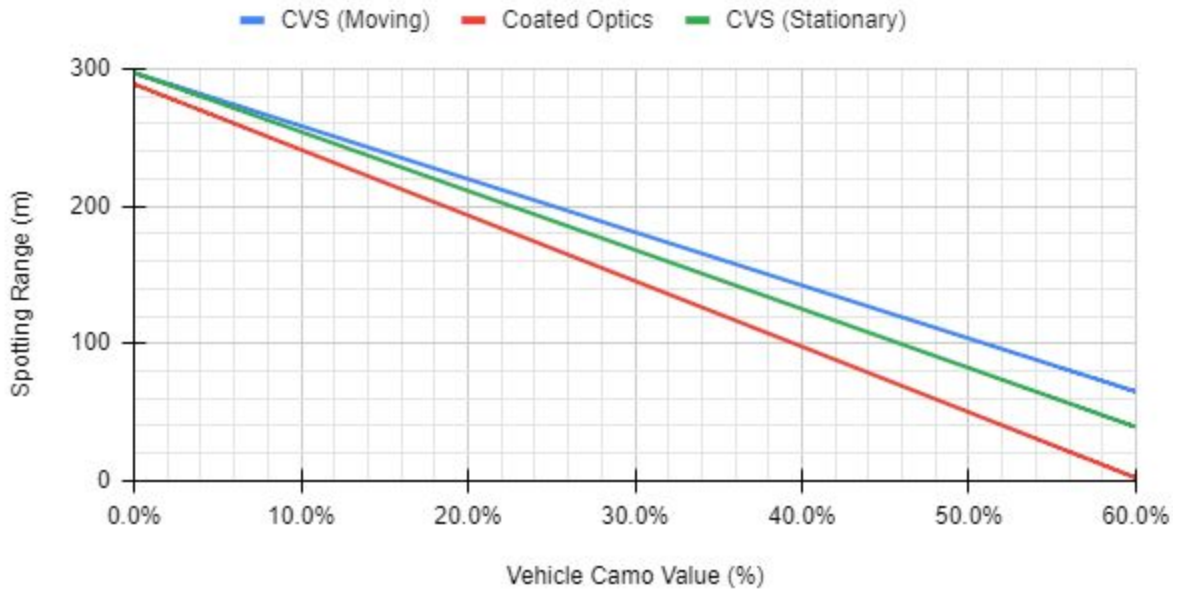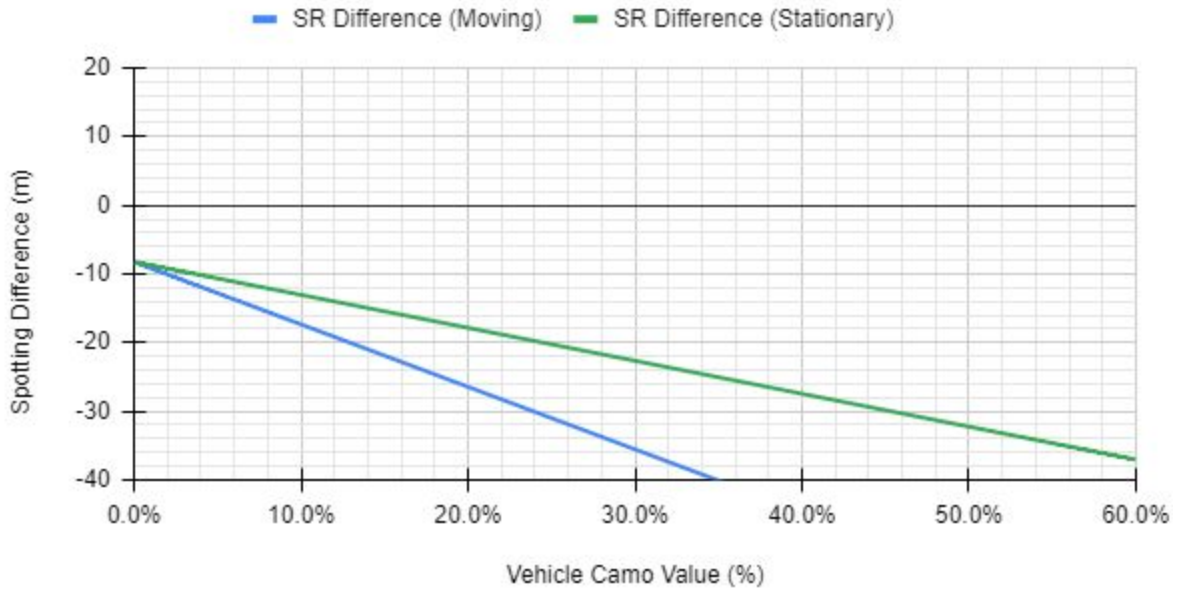Optics Spotting Range Advantage w/ 50% Camo Foliage
@480m View Range

Critical Point (General) Formulation (Warning: Math)

We can create a general formula that can be applied to any situation with variable Optics, CVS, vehicle camouflage, and foliage camouflage.

The critical point exists when the spotting ranges for both pieces of equipment intersect:

$$SpottingRange_{Optics} = SpottingRange_{CVS}$$

Substituting the equations where Camo = CamouflageValue, VR = ViewRange, Optics = Optics bonus, and CVS = camouflage removal:

Due to the length of the equations we will expand each side of the equation:

Optics:
$$SpottingRange_{Optics} = (1 + Optics) \cdot VR - (Camo_{vehicle} + Camo_{foliage})((1 + Optics) \cdot VR - 50)$$

CVS:
$$SpottingRange_{CVS} = VR - ((1 - CVS_{vehicle})(Camo_{vehicle}) + (1 - CVS_{foliage})(Camo_{foliage}))(VR - 50)$$

If we solve (we will not do a line-by-line solution as that would take several pages) for the camouflage value of a vehicle (as we have done previously) where f = foliage and v = vehicle:

$$Camo_{critical} = \frac{((1+Optics) \cdot ViewRange \cdot Camo_f) - ((1-CVS_f) \cdot ViewRange \cdot Camo_f) - (50 \cdot CVS_f \cdot Camo_f) + ViewRange}{(1-CVS_v) \cdot (ViewRange-50) - (1+Optics) \cdot ViewRange + 50}$$

This solves for the critical vehicle camouflage value required for CVS to surpass Optics for any given set of variables.

You can see that the **numerator shows that the critical vehicle camouflage is *heavily influenced by the amount of camouflage provided by foliage***; larger values of foliage camouflage leads to lower critical camouflage values (this makes CVS better than Optics).

Similarly, the **denominator indicates that CVS being applied to a moving vehicle (or not) has a *significant* impact** on the viable scenarios for which CVS is better than Optics. This explains the large discrepancy between the two lines of stationary vs moving vehicles from the previous graphs.

General Takeaways

- Against low camouflage coefficient foliage (25%), CVS is rarely more useful than Optics
  - CVS becomes competitive against Optics if vehicles are *moving* behind low camouflage foliage

- Against high camouflage coefficient foliage (50%), CVS is always more useful than Optics
  - Optics will never be able to spot earlier than CVS when dealing with high camouflage foliage
  - 50% foliage is the *most common* foliage in the game and this increases the usability/viability of CVS in many scenarios

- The general formula indicates that the two variables that influence CVS (spotting advantage) the most are:
  - Camouflage of foliage
  - Whether or not the enemy vehicle is moving behind foliage

Advanced Scouting Theorycrafting

This is an additional section to examine more nuanced game mechanics involving spotting, scouting, and camouflage. This section will go into the extreme ends of game mechanics and how they build upon each other to create a high level meta-game.

The following will be discussed in this section:

- Foliage Camouflage Limitations

- Order of Calculations (CVS interactions)

- Countering or Optimizing CVS on Vehicles

Foliage Camouflage Limitations is about the hidden mechanics behind how camouflage summation works behind excessive amounts of soft cover.

Order of Calculations will discuss when and how CVS is applied and the implications and reasoning for why it matters

Countering or Optimizing CVS on Vehicles is further theorycrafting about the requirements to maximize and determine a vehicle's ability to utilize CVS.

Foliage Camouflage Limitations

In order to understand what this means, we have to go back and look at single bush camouflage calculations to explain how camouflage from foliage is applied to vehicles. Using a previous formula:

$$SpottingRange = ViewRange - (Camouflage_{vehicle} + Camouflage_{foliage}) \cdot (ViewRange - 50)$$

We can see that camouflage from foliage is cumulative with any existing camouflage of the vehicle. This can extend to any number of foliage utilized by the player. In theory, this would mean that it would be possible to add two or more 50% camouflage bushes (such as Prokhorovka) to yield 100% or more in camouflage, making your vehicle unspottable unless proxy spotted.

The summation of camouflage foliage can be represented by:

$$Camouflage_{foliage} = \sum_{x=1}^{n} Camouflage_x$$

Where camouflage foliage is the sum of the camouflage values of all foliage between your vehicle and the enemy's.

In reality, there is a limitation on the amount of camouflage that can be provided by foliage. This limitation is 80%. If the sum of camouflage foliage is greater than 80%, no matter how great, it will always be reduced to a max total of 80% camouflage provided to your vehicle.

This is why the optimal number of foliage for "double bush" scouting or sniping is oftentimes set at a minimum of two bushes (although this is perhaps developed from game experience rather than game mechanic deconstruction). It can also explain how players were spotted from further than proxy range despite an excessive amount of foliage existing between themselves and the enemy.

Order of Calculations

From the previous page, we have learned that the highest amount of camouflage that is offered by foliage is 80%. We also know that CVS offers a 15% reduction in camouflage offered by foliage.

This begs the question: how is CVS applied to multiple pieces of foliage?

The theoretical application is to apply a 15% reduction to each bush individually for this scenario and then complete the summation calculations. If this were the case, this means that it would still be possible to achieve a camouflage value of 80%. Through testing, this is not the case. **CVS does not decrease the individual camouflage offered by foliage.**

CVS' camouflage reduction is applied to the camouflage of foliage *after* the summation has occurred (even in single foliage cases). In other words, the game first calculates the amount of camouflage a vehicle gains from the soft cover between itself and the enemy and then applies the percentage reduction.

This may not seem like a significant difference in application; however, **because there is a hard limit of 80% camouflage from foliage which CVS is applied to, there is a lowered ceiling for the amount of camouflage a vehicle can receive.**

In this case, a 15% reduction in camouflage from foliage means that there is now only a maximum of 68% camouflage offered by foliage. An effective decrease of 12% camouflage to *all* vehicles utilizing excessive soft cover.

Note: this maximum is lowered further to 64% when CVS is utilizing its bonus on light tanks (20% foliage reduction)

This change to one of the core mechanics is why CVS is capable of spotting vehicles through several bushes and why it has become more difficult to hide on certain maps.

We can graph the difference between Optics, CVS (bonus), and CVS (non-bonus) against maximum camouflage foliage to illustrate the differences. We will be using a view range of 445m as the baseline and vehicles will be stationary:

Spotting Range vs Camo Value w/ Max Camo Foliage (80%)
@445m View Range
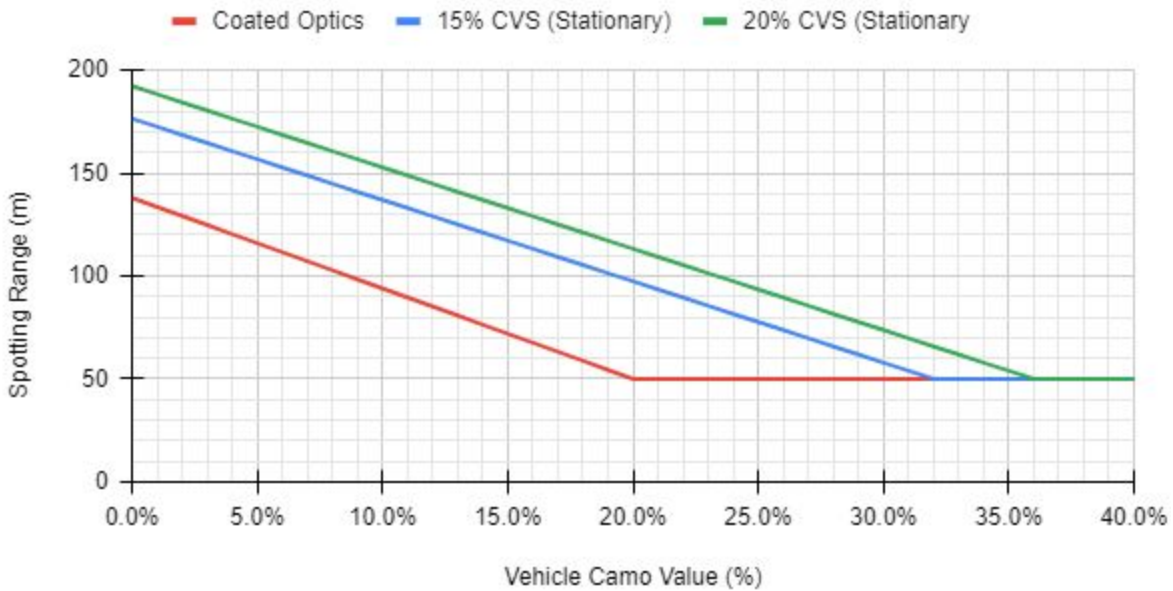
From the above graph you can see that view range is negated completely when enemies are at proxy range (50m). We can come to several observations:

● View range is completely negated when the total camouflage value is 100% or more.

● Optics is completely negated when the vehicle camo value is at 20% or higher

● CVS is completely negated when vehicle camo values are at 32% and 36% with 15% and 20% CVS, respectively
    ○ This was calculated previously where the max camo provided from foliage with CVS was 68% (15% CVS) and 64% (20% CVS)

We can create another graph illustrating the CVS advantage over Optics. CVS advantage will be used because Optics will never be more useful than CVS in high camo situations.

We can plot both the 15% and 20% CVS equipment into the same graph to see the relative advantage they will have against Optics:

CVS Spotting Range Advantage w/ Max Camo Foliage (80%)
@445m View Range
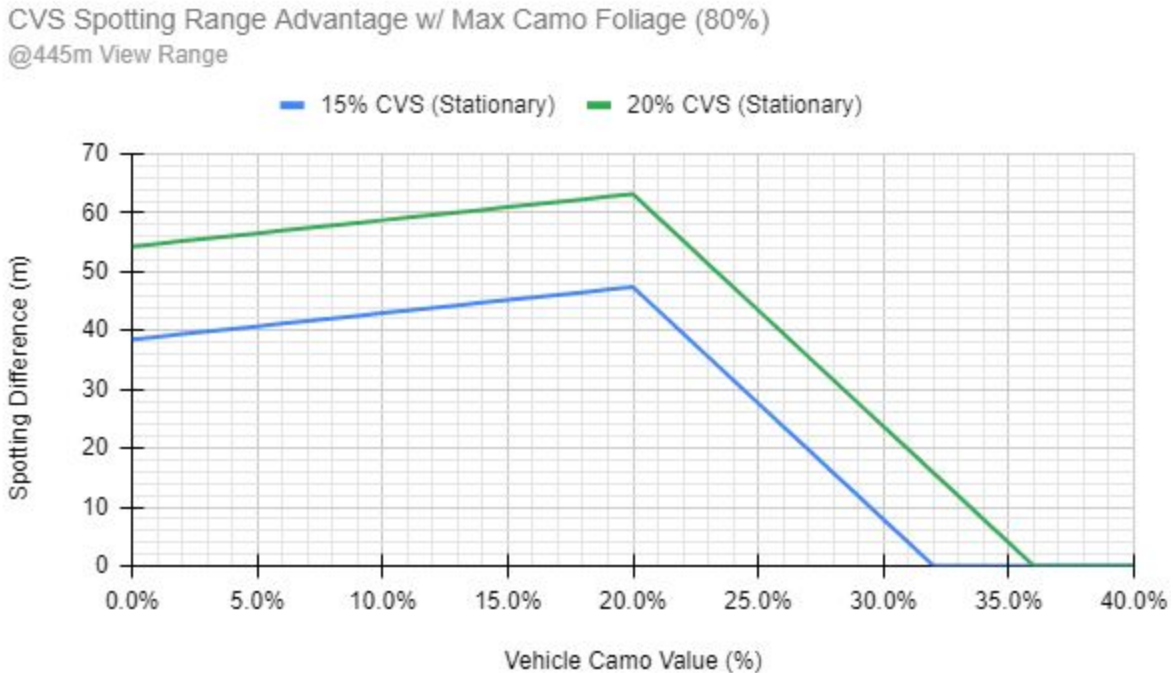
This is the same as the graph from before but with an alternative interpretation:

- Against any vehicles with 20% or less camouflage, CVS will always have around 40m (15%) or 55m (20%) spotting range advantage

- Against vehicles with more than 20% camouflage, CVS will continue to have a noticeable advantage between 10~40m (15%) or 25~60m (20%) of spotting range compared to Optics
    - This is relevant because the majority of high camo mediums and tank destroyers that may snipe in heavy bush cover will have around 20~30% camouflage.

Note: This spotting range advantage can be translated into raw spotting by adding 50m to the value. If a vehicle has 10% camouflage and is in max camo foliage, then a 20% CVS will spot them at 59m+50m = 109m if they have 445m view range.

View range has an impact by increasing these values further so there is merit towards increasing view range (Optics) in conjunction with camouflage removal (CVS).

Countering or Optimizing CVS on Vehicles

It is possible to calculate the best light tank or scout that can optimize the usage of CVS. In this case, we will assume that CVS is on a light tank with a bonus active (-20% foliage/-12.5% moving).

As stated previously, **CVS will decrease the maximum amount of camouflage provided by foliage down to 64%. In order to overcome this decrease in camouflage completely, a vehicle will need to provide the missing camouflage which is a total of 36% camouflage.**

We can find the light tanks that fit this description. Under the assumption that they had Improved Ventilation, Brothers in Arms, maxed camouflage skills, and food, we would discover that light tanks with at least 17% base camouflage would be able to hit a camouflage value of 36% after all camouflage improving items were applied.

For tier 10, this means the viable tanks to use CVS are:

- EBR 105 (21.15%)
- Manticore (20.52%)
- T-100 LT (19.84%)
- AMX 13 105 (18.18%)

Unfortunately, this is not entirely true. Assuming 36% vehicle camouflage is the goal, this would suffice; however, **this does not take into account the stacking penalties to camouflage that is applied by CVS to moving vehicles.** Thus, the above 4 vehicles would only work if **stationary**.

We can solve for the required value of vehicle camouflage by solving the simple equation:

$$Camouflage_{total} = Camouflage_{vehicle} + Camouflage_{foliage}$$

Where the total camouflage is 100% and the total camouflage offered by foliage is 64%:

$$Camouflage_{vehicle} = 100\% - 64\% = 36\%$$

This is how the calculation of 36% vehicle camouflage came to be. The resulting 36% camouflage does not take into account the vehicle camouflage while moving and instead just iterates that 36% camouflage is required of the vehicle to remain completely camouflaged.

If we take the previous equation and apply a moving penalty of 12.5% to the vehicle's camouflage:

$$(1 - CVS_{vehicle}) \cdot Camouflage_{vehicle} = 36\%$$

We can now solve for the new camouflage value required.
Substituting CVS variable:

$$(0.875) \cdot Camouflage_{vehicle} = 36\%$$

Solving:

$$Camouflage_{vehicle} = \frac{36\%}{0.875} = 41.143\%$$

From this we can see that a vehicle must have at least 41.15% in order to completely negate CVS when active spotting. **In order to achieve this value on moving vehicles, a light tank must have at least 19.5% base camouflage.**

Using the previous list of tier 10 lights:

- EBR 105 (21.15%)
- Manticore (20.52%)
- T-100 LT (19.84%)

These would be the best contenders for countering CVS users (and therefore be the best users themselves). It's important to note that due to the lower view range of the EBR 105, it will not be able to spot low camo targets from a further distance than the Manticore and T-100 LT which have 400m and 390m view range, respectively.

This gives a slight advantage to the Manticore and T-100 LT for traditional scouting roles on maps such as Prokhorovka. This advantage is pushed further in the Manticore's favor due to its higher base camo (0.7% higher) which allows it to reach the necessary camouflage threshold without utilizing the food consumable and giving it a slight edge in single-bush cases. The Manticore also has a 10m advantage in spotting but the actual advantage it provides for spotting through foliage is marginal compared to a T-100 LT.

For competitive *traditional* scouting:

Manticore > T-100 LT > EBR 105 > AMX 13 105

Commander Vision System Conclusions

- Commander Vision System decreases the max amount of camouflage provided by foliage
  - This changes one of the core mechanics of the game and gives light tanks a method of countering "hard camp" situations on specific maps

- CVS offers a noticeable spotting advantage over Optics when spotting through high amounts of foliage
  - Doubling or tripling the distance a player would typically spot enemies

- There is a minimum requirement of camouflage for a light tank to be an "optimal" user of CVS in competitive scenarios
  - This accounts for extreme high end gameplay where countering the opposition is more important to securing a victory for the rest of the match
    - The T-100 LT and EBR 105 will still be the best two scouts in the game despite the Manticore theoretically being the best user of CVS and Optics

- CVS viability is dependent on heavy foliage on maps which makes the equipment's usage dependent on the maps in the game or your current map rotation
  - Malinovka
  - Prokhorovka
  - Steppes
  - Pilsen
  - Westfield
  - etc.

Equipment 2.0 Conclusion

The introduction of these pieces of equipment are interesting. Each section emphasizes specific aspects of a vehicle that have already existed in some form through crew skills (Additional Grousers), consumables (Turbocharger), or existing equipment (Improved Rotation Mechanics). Each equipment has a "twist" or specialization that offers greater benefits for specific vehicles or scenarios/circumstances more so than others.

Unfortunately, it does not address the existing problems with the current equipment meta nor does it have equal impact on all vehicles in the game.

Equipment Tier List

Varies by vehicle class and type

TODO (may scrap)

Feedback (Equipment Changes)

*Remember that this entire analysis was written in the context of **non-bonused equipment**. Any bonuses further amplifies the aspects of the equipment being addressed and discussed.*

- Nerf turbocharger by 1~2 km/hr reverse speed (*WG addressed as of iteration 3*)

Stated on the mobility theorycraft section, many vehicles primarily find themselves nerfed in regards to gun handling and mobility. Many mobility nerfs fall into a decrease in engine power, top speed reduction in both forward and reverse, and hull traverse reduction. Turbocharger *effectively* undos these nerfs due to its high engine power increase (which increases hull traverse), forward speed increase, and most notably, reverse speed increase. Reverse speed is proportionally higher than forward speed on the basis that many vehicles do not have a 5:3 or 6:4 top forward:reverse speed ratios. To balance this, the Turbocharger should have its reverse speed increase slightly nerfed.

- Buff to Improved Configuration by possibly adding reduced consumable cooldown time

Stated under the Improved Configuration section, the concern about the adoption rates of module boosting equipment is the primary argument for why all module equipment was merged into a single super piece of equipment. Unfortunately, I cannot see a high adoption rate due to its viability hinging on poor module health and placement on vehicles. It also sees fierce competition due to the (realistic) fight against Improved Ventilation, Optics, and a whole slew of new additions for the 3rd equipment slot. It may see use in middle tiers where module destruction is more common. I suggested adding the previous "Improved Consumables" at a lower value (20~30s) to offer an "active" role in the equipment.

Feedback (Mechanic Changes)

- Balance the bonus from bond/bounty equipment to match existing category bonus

The current system proposed offers a further increased bonus for bond/bounty equipment. The value of these bonuses should not be higher than the existing bonuses gained from using equipment with the categorical bonus.

An example with Vents:

Equipment	Improved Ventilation	Venting System
Without Bonus	5%	8.5%
With Bonus	6%	8.5%

As you can see, the bond version of Vents offers a greater bonus compared to Vents with bonuses. Bond equipment also has value because the effects provided do not care about whether or not the equipment is in a category slot or not.

Bond equipment has two "bonuses":
1. **Stronger effect compared to standard equipment**
2. **Does not require a category slot to have improved effects (built-in)**

My suggestion is to allow standard equipment with the categorization bonus provide the same effects as improved equipment. This means it's possible for regular players to have 1 out of 3 equipment be on par with bond equipment and leaving its primary bonus be that it provides improved stats regardless of slots.

- Remove slot categories by vehicle type

This is an idea to encourage certain vehicle types to use specific pieces of equipment. Unfortunately, it means many vehicles are pigeonholed into what type of equipment they should be using based on the assumption that they will capitalize or require an equipment piece in said category. This is not a great idea due to many vehicles in the game specializing in specific roles under each vehicle classification. As an example, the Bat.-Châtillon 25t (Batchat) which plays a hybrid role of firepower, mobility, or scouting would be limited to only gaining bonuses from a mobility piece of equipment. The same could be said towards the vast majority of heavies which would not all benefit equally from utilizing survivability equipment.

Wargaming states the reason for decreasing equipment categories from 2 to 1 was, and I quote, "some commanders believed the categories of slots forced them to choose the equipment corresponding to the slot, which seemed like an additional limitation". Furthermore, WG continues to state that "there were also concerns some tanks had the wrong role".

By decreasing the category slots from 2 to 1 but retaining the slot category types, the problem is not resolved but rather shifted from being compelled to use 2 specific pieces of equipment down to 1. The underlying issues still remain and the previous argument can be applied to this single slot.

Ironically, the current equipment additions which encourage choices and specialization is hindered by Wargaming's idea of what your vehicle should specialize in.

The vehicle specific slot categories should be removed in favor of a single **universal category** that grants bonuses to any equipment in that slot.

Existing Problem(s)

In order to properly understand the underlying issues with equipment and why many of these pieces of equipment are not seen favorably or "metashifting", the existing system must be examined.

- High adoption rates of specific equipment

There are two pieces of equipment that have extremely high adoption rates due to their ability to significantly alter a tank's performance for the better.

The first piece is the Gun Rammer which decreases reload speed by 10%. It is the only piece of equipment (barring Improved Ventilation) which can increase the fire rate, and by extension, the DPM of a vehicle. There is no realistic scenario in which a player would willingly sacrifice their ability to destroy enemies more quickly (which is the primary goal of the game).

The second piece is the Vertical Stabilizer which decreases all dispersion penalties by 20%. It is currently the only existing piece of equipment that is capable of both increasing on-the-move accuracy and decreasing effective aim time (as good if not better than eGLD). There is no realistic scenario in which a player would avoid increasing their ability to acquire and target enemy vehicles more accurately—effectively decreasing their time to kill enemy vehicles and ability to deal more consistent damage.

It can be extrapolated that every vehicle loses a "free" equipment slot for each of the above pieces of equipment that are available to be equipped. Which leads to:

- Equipment 2.0 impacts specific vehicles more than others

If we extend the previous "free" equipment slot idea, we can come to the conclusion that if a vehicle cannot mount a Gun Rammer or Vertical Stabilizer then it is equivalent to having an extra equipment slot. This extra equipment slot means greater variability among these specific vehicles.

For existing vehicles, the assumption was that Rammer and VS would always be chosen. This meant the majority of the analysis assumed that the 3rd slot would be the main source of competition which would be Vents or Optics(the entirety of the scouting section was viability *against* Optics). For future reference, this was a "free" slot which means many traditional vehicles have at least 1 free slot.

We can now count how many free slots vehicles have by equipment available:

TDs and SPGs have an interesting position due to many vehicles under this classification having an open-top (meaning no Vents). The inability to mount a VS increases their free slots by 1. This means many TDs and SPGs have at least 1 (2 if open-topped) free equipment slots to mount anything of their choosing.

Autoloaders cannot mount Rammers. This increases their number of free equipment slots to 2. This is not exact as several autoloaders in the game gain tremendous benefits from Vents which puts autoloaders in a grey area where they have more freedom than traditional vehicles but is case dependent.

Light tanks are different due to the necessity of at least 1 view range boosting equipment. This means that a light tank will have no free slots (Optics, Rammer, VS). Due to their inability to realistically compete in firepower against any other class, it's not uncommon to see specialization by removing VS and with equipment 2.0—the removal of rammer. I would not be surprised to see both unchanged equipment loadouts and extreme specialization in public and competitive modes.

This means there is higher impact from equipment 2.0 for vehicles that are not currently limited by equipment availability.

Ideas

There is an idea to fix the above issue with the game in regards to equipment problems:

- **Removal of Gun Rammer or Vertical Stabilizer**

This is an interesting idea as it removes one or both pieces of equipment that exist as must-haves for vehicles in the game. As stated previously, the mere existence of these pieces of equipment effectively decreases the number of available equipment slots on vehicles for which they are available.

Removing Rammer or VS and accommodating the loss in stats by buffing vehicles to compensate for the removal would give vehicles that currently use these two pieces of equipment an equipment slot while not changing any vehicle performances. In theory, we would give preference to Rammer due to its higher adoption rate compared to VS.

While seemingly reasonable, this itself has many problems on its own:

We can treat the removal of a piece of equipment as a direct buff to vehicles to which it applies. On the other hand, this also means it indirectly nerfs vehicles which do not have these changes.

Removing Rammer would buff all vehicles that can mount one. **This would apply to all vehicles except autoloaders.** This would indirectly nerf autoloaders as they are not able to be compensated for the Rammer they never had.

Similarly removing VS would buff all vehicles that can mount one. **This would apply to all vehicles except TDs and SPGs** and indirectly nerf these vehicles (TDs + SPGs).

Any of these would be reasonable if the intended outcome was to indirectly nerf the affected vehicles. In the state of the current game, removing VS (despite Rammer being marginally more impactful) would be the better option due to TDs and SPGs being much larger problems than autoloaders.

Unfortunately, while this may seem like a clear and relatively sound solution, it does not solve the existing problems and merely moves the goalpost.

If one or both of these pieces of equipment are removed then the next issue will be how to deal with the next most problematic pieces of equipment. The existence of these pieces of equipment in and of itself can be seen as a balancing mechanic by *limiting user choice*.

If removing Rammer and VS is no longer viable due to shifting the problem. Then it must be addressed directly which leads to:

- **Balancing (nerfing)**

The main issue with Rammer and VS is not that they are must-haves—this is merely the symptom of the problem. The real reason is that they are too strong. Their ability to influence vehicles to the extent they have changes their existence from an option or choice into a requirement. This is evident in the firepower theorycrafting section where I illustrate that **Vertical Stabilizer is the strongest gun-handling boosting equipment in the game.** Rammer is as simple as increasing your ability to kill and deal damage faster which aligns with the goal of the game.

The solution to stopping the existing overuse of these pieces of equipment is to decrease their effects to the point that they become competitive with alternative pieces of gear. This can be as simple as reducing Rammer's reload reduction from 10% to 5%. In the case of VS, adding additional limitations or restrictions in which it becomes active.

This itself may be troublesome because it goes back to the issue before where nerfing or removing pieces of equipment shifts focus to the next most problematic pieces, though to a lesser extent. In theory this would work if equipment was near perfectly balanced with one another.

This leads to the final idea:

- **Specialization (Pros/Cons)**

If the goal of equipment is to specialize vehicle capabilities then it makes sense to give players the options of specifying which parts of their vehicle to focus on improving. Unfortunately, it can be seen as improving the existing parts of a vehicle to optimize victory and not the vehicle (many vehicles don't use Spall Liner because the goal isn't to take high explosive damage). Again, this focuses on Rammer and VS to damage enemies as much as possible.

An alternative way to encourage specialization is with the introduction of penalties. By adding a downside to equipment, it forces players to make a choice about how they wish to improve their vehicle.

As an example for how this could look:

	Pros	Cons
Gun Rammer	+10% loading speed	-5% accuracy
Vertical Stabilizer	-20% dispersion penalty	+5% aim time
Gun Laying Drive	-10% aim time	+10% dispersion penalty
Turbocharger	+10% engine power	-5% hull traverse

As you can see from the example, there would be noticeable downsides for players specializing in firepower equipment. Using equipment such as the Rammer and VS together would decrease your accuracy and increase your aim time. Similarly, equipment can be made to cancel the negative effects of one another and provide an overall boost with no downsides with the exception of a wasted equipment slot. Equipment like Vents would remain the same as the equipment that offers a small boost with no downsides.

This can be done as long as there is an analogy to the pros of the piece of equipment.

- "You can fire faster but more inaccurately"
- "You can move faster but have worse turning/handling"
- "You have less dispersion penalties but aim time (or accuracy) decreases"

This would encourage true specialization of vehicles without encouraging generalization that exists now but introduces another balancing level between the pros and cons and their individual values itself.