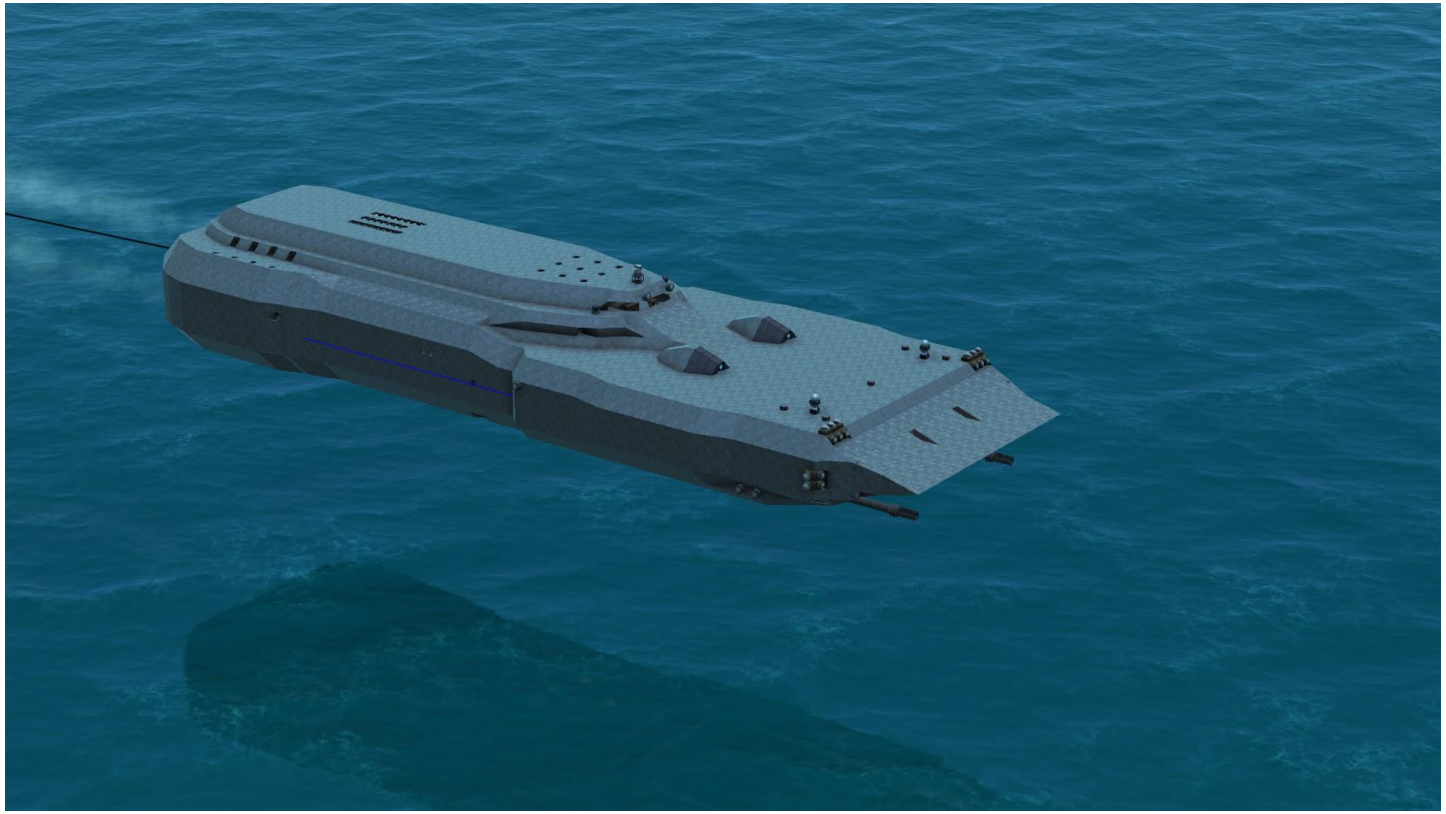
# Mass Drivers In *From the Depths*

My journey with and explanation of an unintended weapon type in my favorite game.



# *From the Depths* (FTD) – Quick Summary

An obscure Indie game that was in open access for 7 years with a small but dedicated following that is a favorite of mine.

FTD is a voxel-based combat vehicle sandbox game that allows players to build vehicles from design to implementation. Everything in a vehicle from the engine to the armor is built from the ground up.

With a variety of different weapons, engines and armor types to choose from, designing involves trade offs and deliberate choices that give the game incredible depth and complexity.

# A Mass What Now?

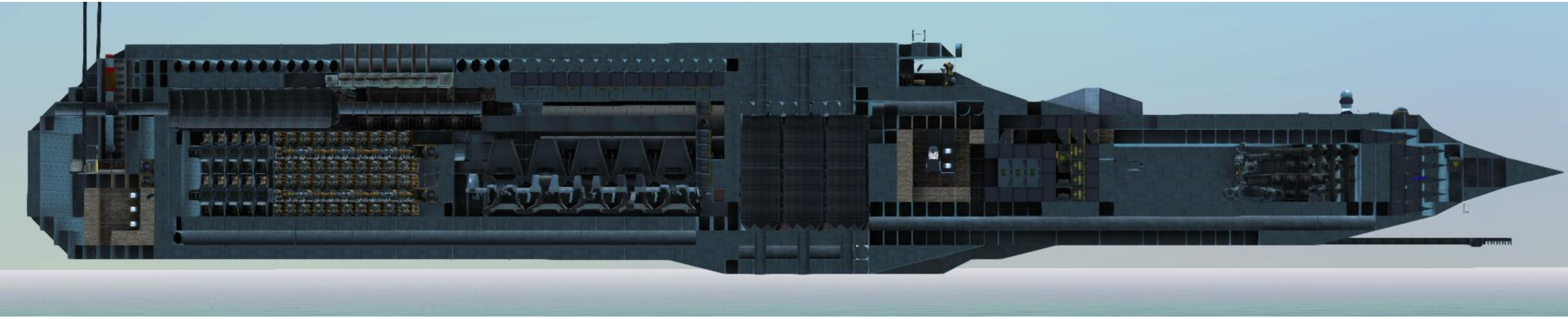
Usually its a term used in sci-fi to describe a method of using electromagnetic catapults to launch projectiles into space.

But in the case of FTD, it is the name given to a type of weapon that works by accelerating a very light projectile up to hundreds of times the speed of sound using a special niche mechanic of a weapon system in game.

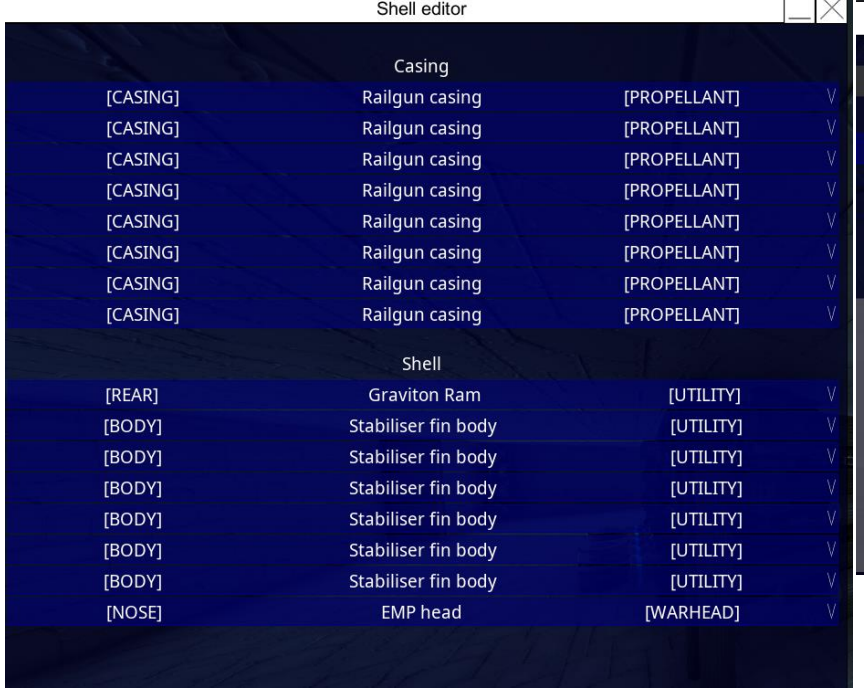
Though I didn’t create the idea of mass drivers, I did create this implementation based on the general idea of how mass drivers work in FTD.

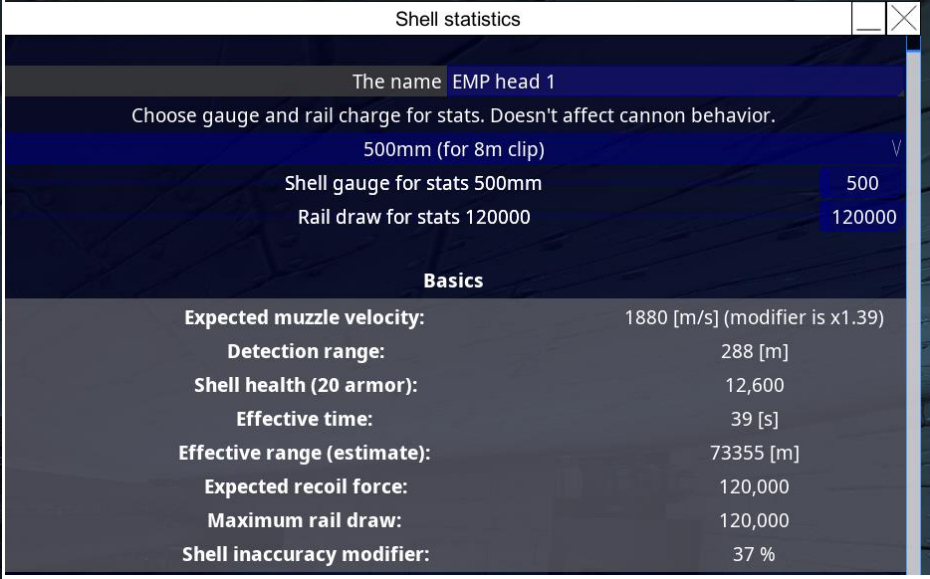
# The Goal

The whole goal of this build was to create a mass driver armed ship in a small and affordable package.

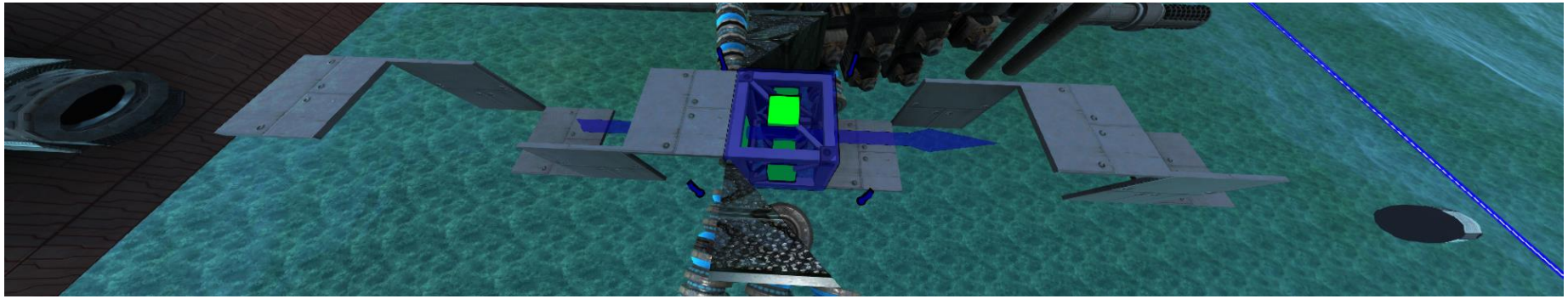


# The Principles - Ram Shells



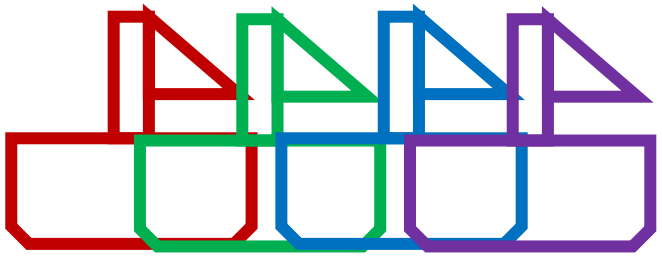




This niche mechanic is the graviton ram shell component that the “advance cannon” has access to. It takes the unmitigated recoil force of the shell and imparts that force onto whatever it hits. If a shell is min/maxed for recoil it can get over 120,000 units of recoil force. Someone else in the community had the idea of seeing what would happen if a shell like this was used on a very light and small projectile (i.e. a vehicle consisting of a couple of blocks). Due to how FTD (up until recently) calculates collision damage, a vehicle moving at such speeds caused ludicrous amounts of collision damage.



# The Principles – Vehicle Movement

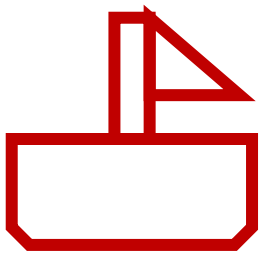
FTD runs at 40 simulation ticks a second, meaning a vehicle's movement is divided into 40 steps. FTD takes the simple approach of simply teleporting a vehicle 1/40$^{th}$ of its speed forward, usually this is fine.




But, if a vehicle is moving at 150 kilometers a second, it will teleport 3,750 meters in one tick. As can be seen below, this creates a problem for our chances of hitting a target. My options for trying to increase the chances of hitting aren't good, they all involve losing speed and fire rate for longer, slower projectiles. This will not do. We want to maximize speed to do as much damage as we can.


Tick 1


Tick 2

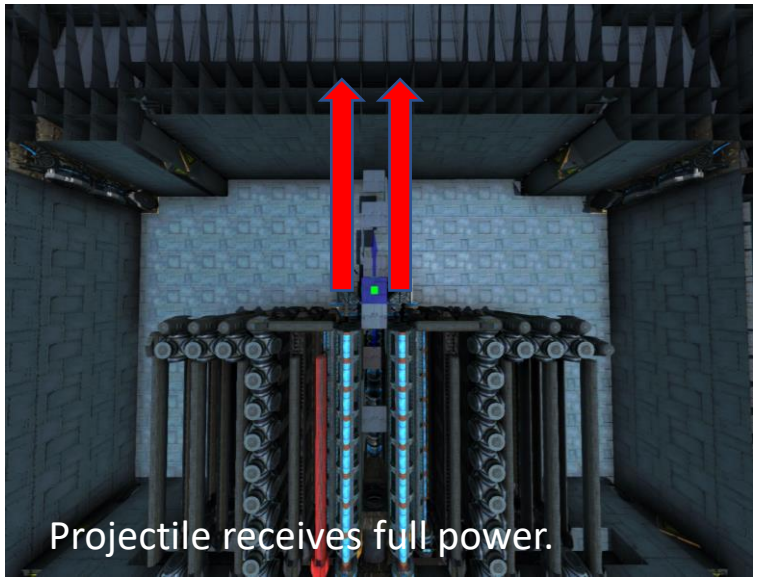

Hypothetical target

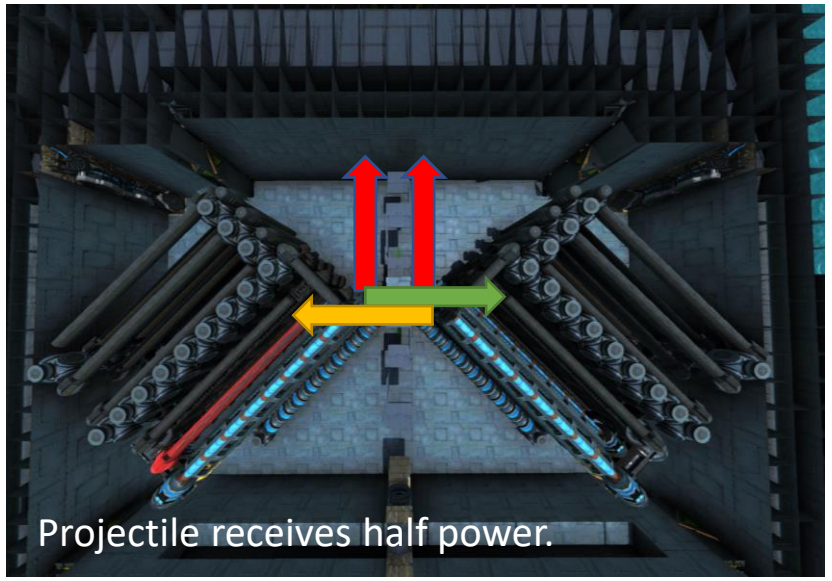

Tick 3

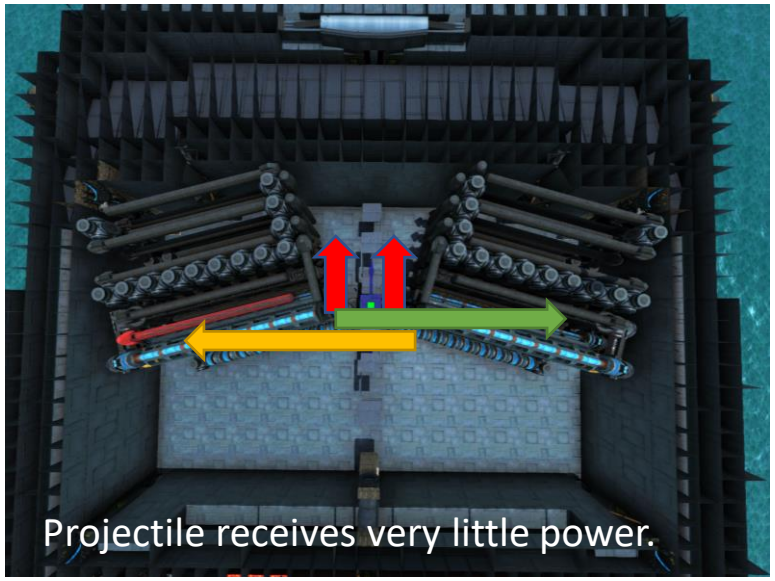

Tick 4

# The Principles – Energy Regulation

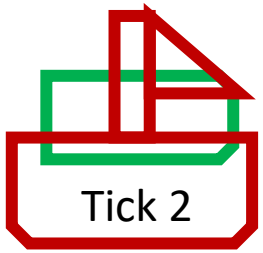
However, one option remains, regulate the amount of energy that is put into projectile. But how to do that? I can't change the projectile or energy used on the fly, so I instead use an ingeniously simple solution. Mount the graviton ram cannons on spin blocks. By doing this, part of the energy from the cannons is turned into sideways energy, and said energy is canceled out by its opposite vector from the other cannon, thus allowing very fine control over the forward energy put into the projectile.




Tick 1

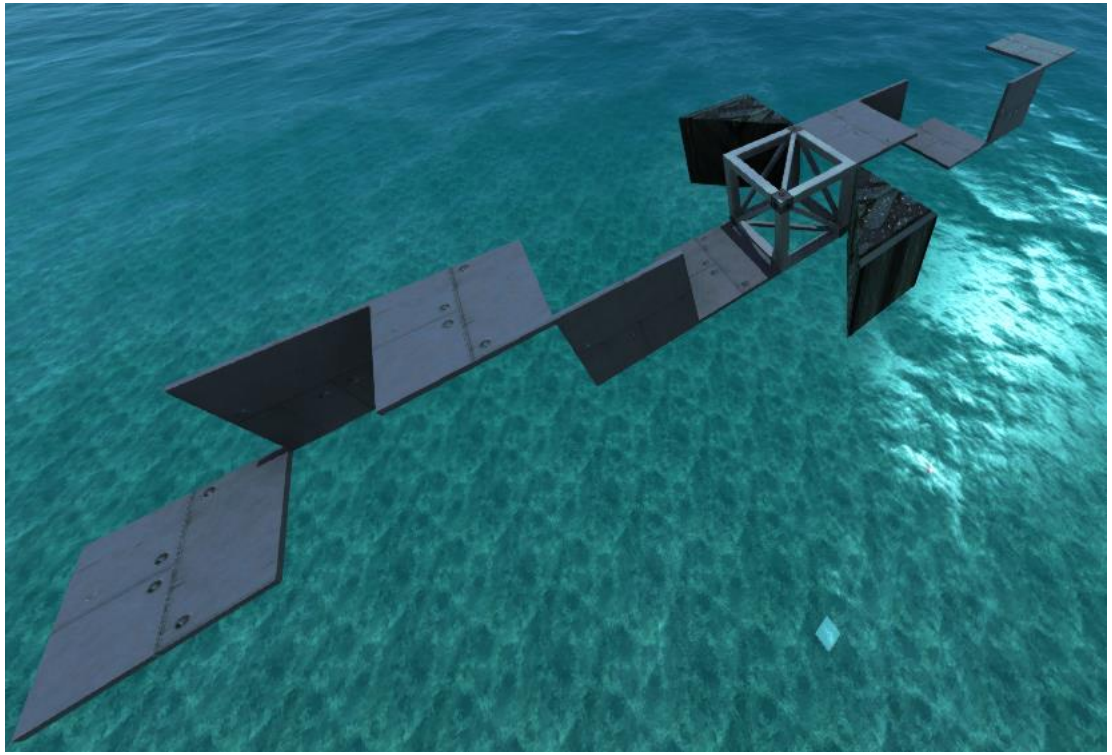



Hypothetical target

The end goal of the energy regulation is to have the projectile teleport right on top of the target in one tick.

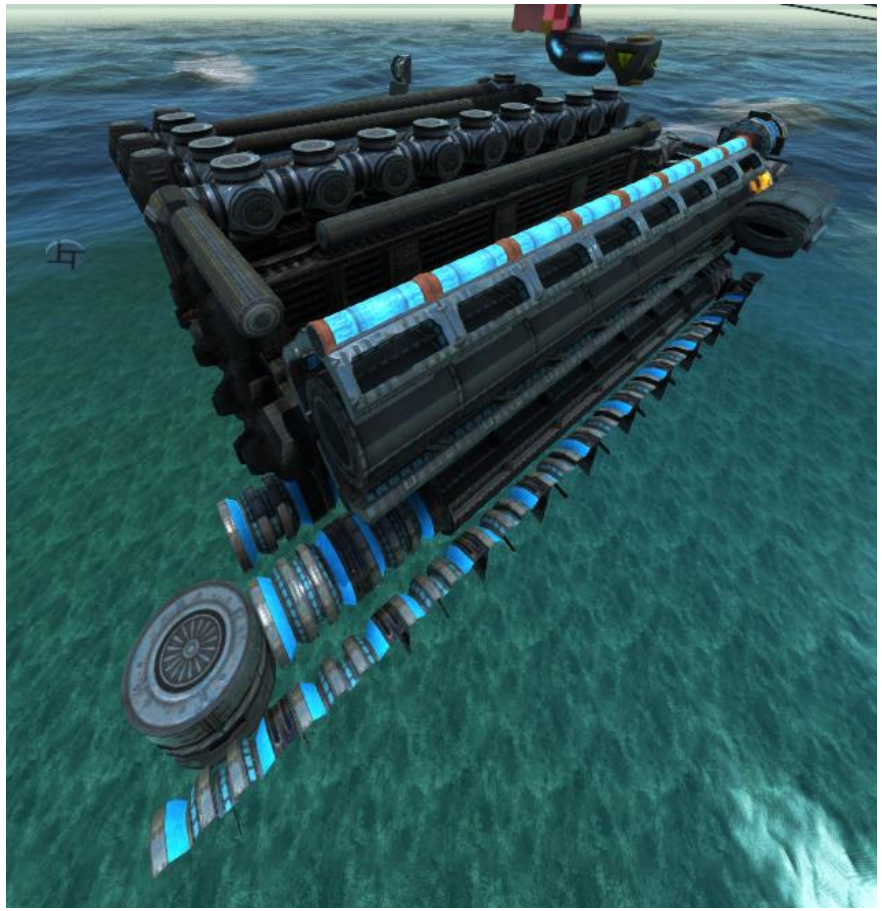
# The Design – Projectile

Now let's see these principles in action. The first thing I'll look at is the projectile itself.



The odd shape helps the projectile be as long as it can be while minimizing its weight. This maximizes the chances of hitting a target. The spiral shape is made of the lightest block in the game (light alloy plates). It clocks in at a weight of 33 units. The center block isn't a plate to maintain equal drag on all sides of the projectile. The 2 slopes attached to the center block are where the graviton ram rounds hit the projectile. They must be made of rubber, which is immune to collision damage. The slopes touch the cannon parts of the mass driver and would otherwise suffer collision damage thus, destroying the projectile before it could be shot.

# The Design – Drivers



The drivers are max gauge advanced cannons mounted on spin blocks. They are roughly square in shape as to not waste room when they rotate. If they are too long, they would make the craft unnecessarily wide. Too wide, and the room to house them would become excessive. There is no need for traverse or Artificial Intelligence (AI) control, so the design can be focused on compactness. This driver fits 120,000 units worth of railgun capacity and 115,700 units worth of absorption capacity in a compact volume of 384 m^3. This comes at the cost of rate of fire. Attempting to make a mass driver fire faster than 2 rpm comes at the cost of greatly increased ship size. This would go against my goal of creating a small and affordable mass driver armed vehicle.

# The Design – Targeting Controls


Let's break this mess down.

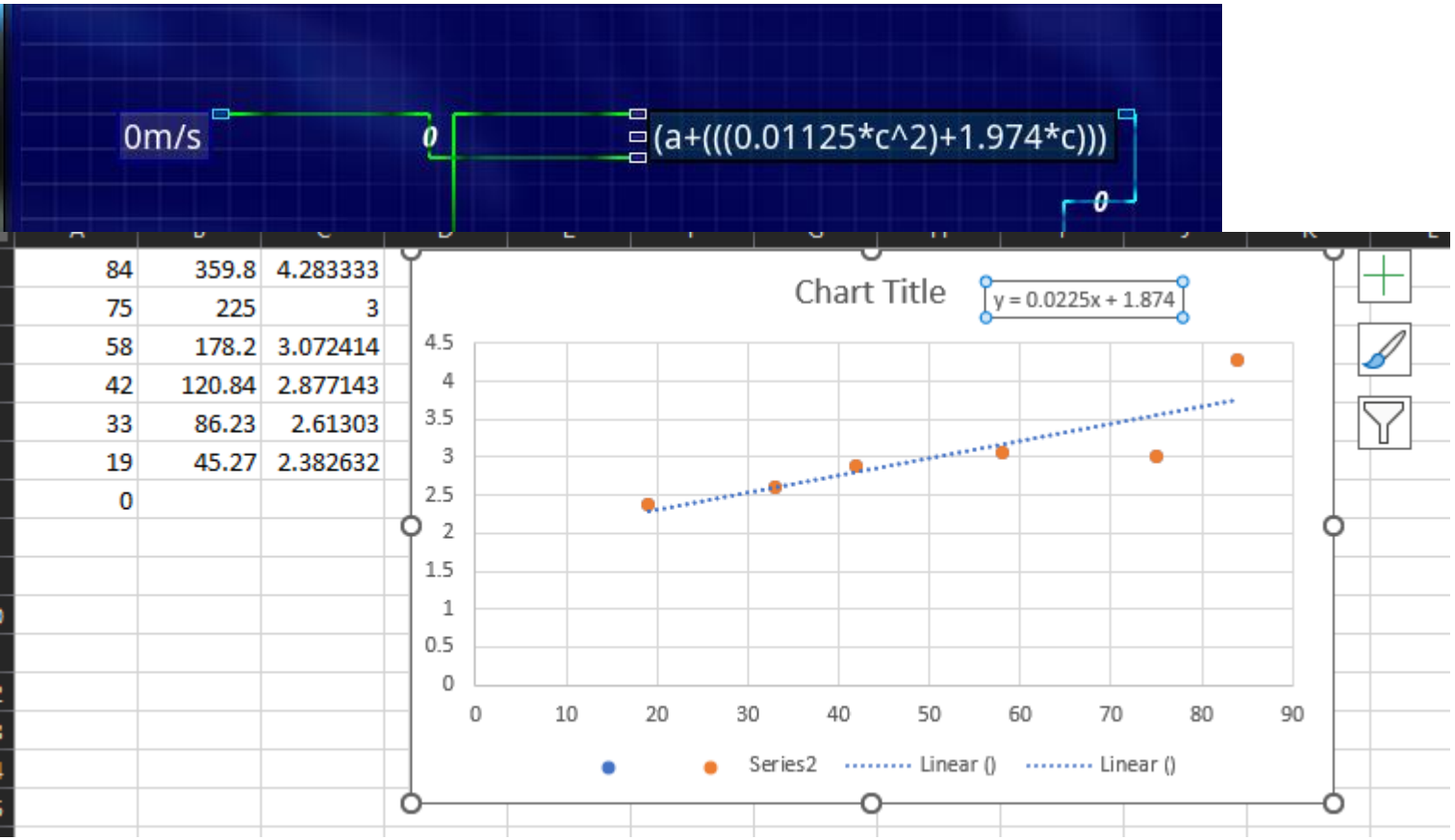
The yellow box contains the equation that governs the angle of the drivers. Arcsine is used to get an angle (in degrees) that is then turned into a value between 0 and 0.5 which is fed into the spin blocks.

The green box is for engaging targets beyond the one tick range. By dividing the range that is fed into the yellow box, the projectile will use 2 ticks to reach its target instead of 1.

The red box is compensating for the backwards movement of the vehicle which for some reason, unknown to me, is not a 1 to 1 relationship. More will be described about this in the next slide.

The orange box contains the yaw controller, which uses the target bearing relative to the vehicle data from the primary target info box (the one with NA on it) to keep the vehicle pointed at its target at all times. This is also where the distance to target is introduced

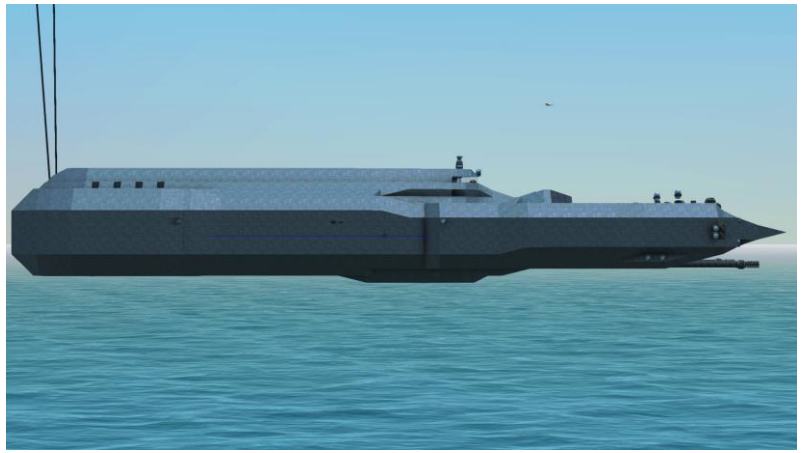
# The Design – The Red Box

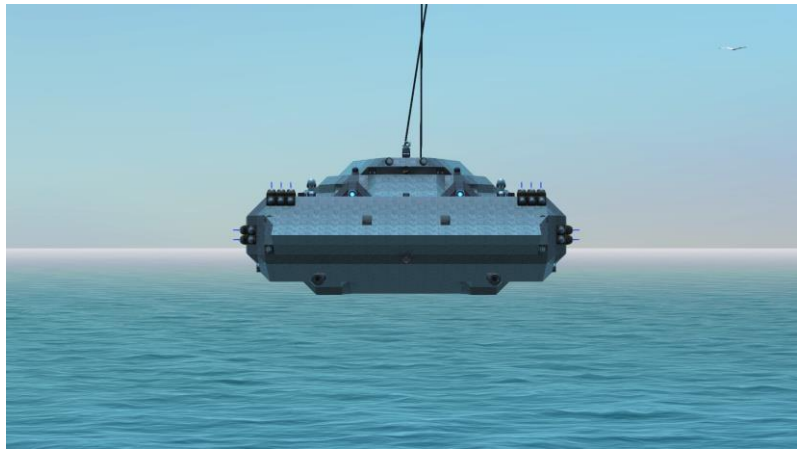


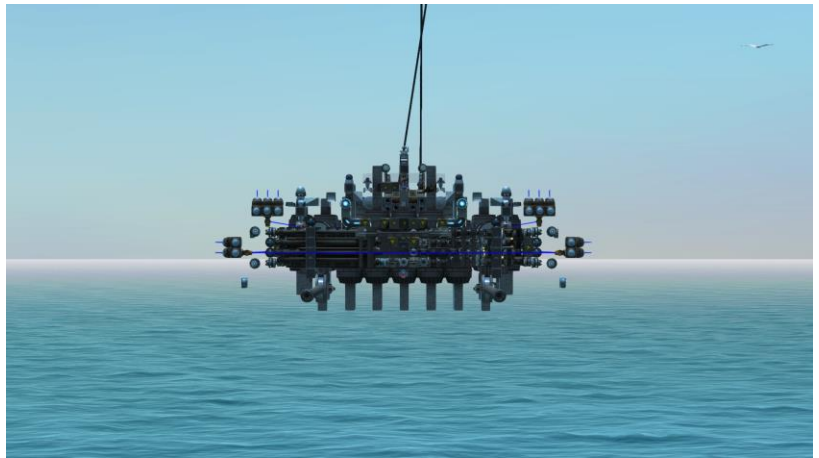

During my testing, I noticed whenever my vehicle was moving backwards, it consistently undershot its target greatly. At first, I though it was a simple 1 to 1 relationship. If the vehicle was moving 80 m/s backwards, then aim 80m further forward.

However, it proved to not be this simple. I tested different targets that all caused different backward velocities then measured the distance between the driver projectile and the center of the target. I took these values and divided the extra distance by the speed and plotted the product against the speed. This shows for any given speed, the multiplier needed to calculate the extra distance. If one integrates this equation, it results in a parabolic equation that (somewhat) accurately gives the extra distance needed based on the speed.

# The Vehicle – Design Philosophy

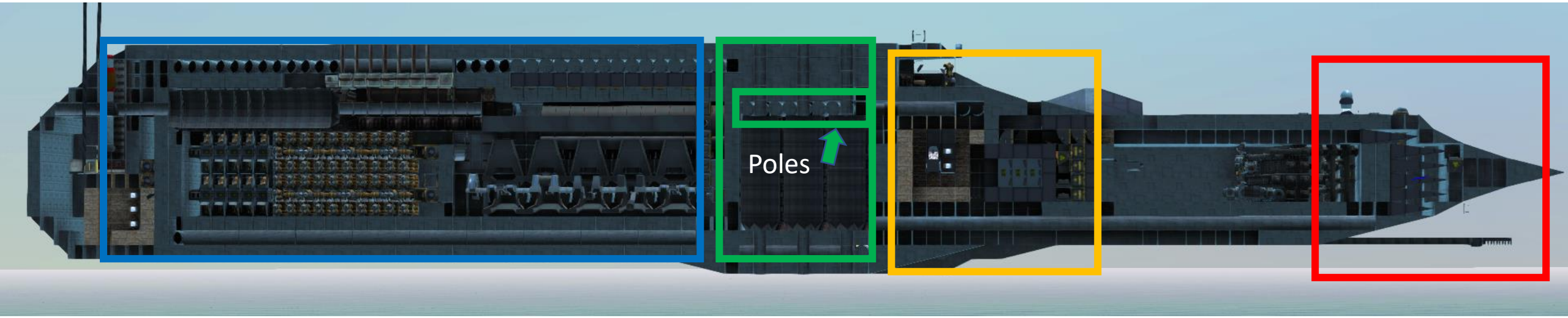






The whole goal of this build was to create a mass driver armed ship in a small and affordable package. The type of vehicle I chose was a frontsider, which as the name implies, always keeps its front towards the enemy. This type of vehicle is a good fit for a mass driver weapon. It is easier to point the whole vehicle at the enemy then to bother with a space-hogging turret. A frontsider also allows the concentration of armor on the front of the vehicle. Notice how long it is compared to its width. This allows for thicker armor at a lower price, which helps protect the delicate components of the mass driver.

# The Vehicle – Armor




## Blue:

The rear armor is the least likely place to get hit on the vehicle and is therefore the thinnest. The sides are only 4m to 5m thick. The top is the thickest due to be being exposed during combat by the downwards pitch of the vehicle. Heavy armor is near the engines to give them extra protection.

## Green:

The armor around the turbines here is very thick because the last thing we want is to fall into the water during combat. Notice the use of poles in the armor, they act as an air gap which catches the spall from High Explosive Anti Tank (HEAT) warheads.

## Yellow:

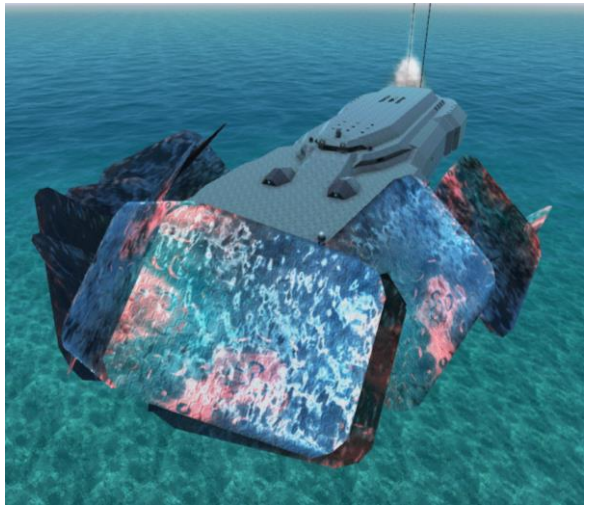
This is where the brains of the ship and ammo are both stored. The AI and ammo are also both wrapped in heavy armor. The AI and the automated control blocks for the mass driver are wrapped in a layer of stone and surge protectors for EMP attacks.

## Red:

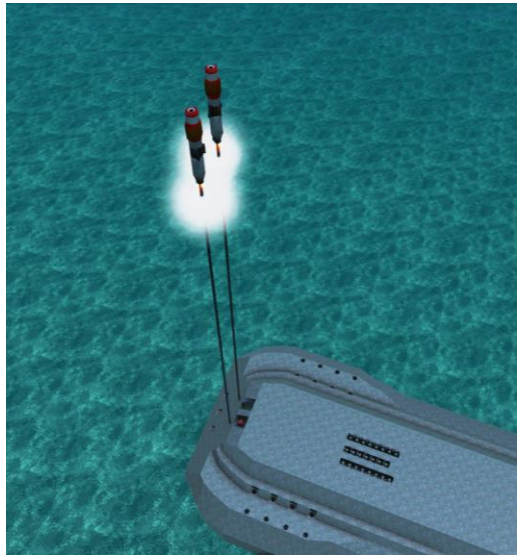
The front armor uses heavy armor wedges which are highly effective against armor piecing rounds and chemical warheads.

# The Vehicle – Active Protection

Active protection is any system that seeks to protect the vehicle by destroying or otherwise deflecting munitions directed at the vehicle. Here are all of the ones on this vehicle.



Planar Shields:
Planes of energy that deflect incoming projectiles and reduce laser weapon's armor pierce factor. The deflection chance increases as angle of attack decreases. Shields are most effective at extreme angles. As a frontsider, this vehicle only has shield coverage on the front.



Decoys:
Using a harpoon part in a dumb fire missile, one can create a missile that will stay a set distance away from the vehicle. Load them up with radar target simulators and they become effective missile decoys.


Laser Anti-Munition System (LAMS):
A versatile and powerful system, it is the core of any good layered active protection system. A good LAMS has a large energy buffer. Since a LAMS isn't engaging a target 100% of the time, the downtime can be spent filling the buffer to allow for quicker destruction of munitions. This vehicle has its LAMS nodes concentrated in the front with 2 groupings on each side.

# The Vehicle – Active Protection

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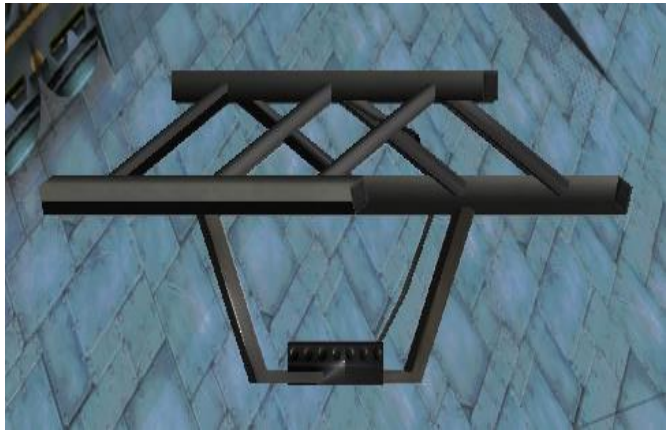
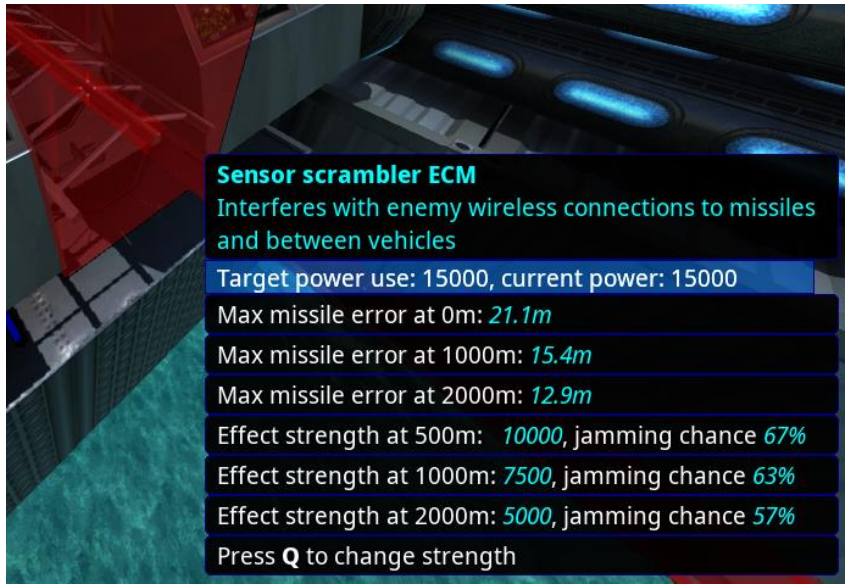
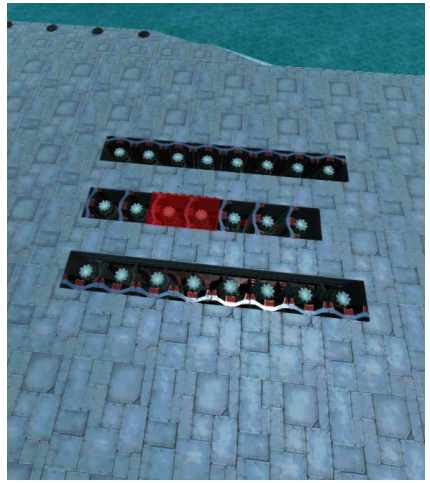


Electronic Countermeasure (ECM) jammer:
A quick and easy way to disrupt missiles provided there is enough spare engine power to run them. They may not be too effective on their own but they can be stacked together with other counter measures.



Missile interceptors:
Missiles that destroy other missiles. They are highly effective against swarms but, unless a ship is equipped with a massive battery of interceptors, they lose their effectiveness against more continuous bombardment.

# The Vehicle – Secondaries

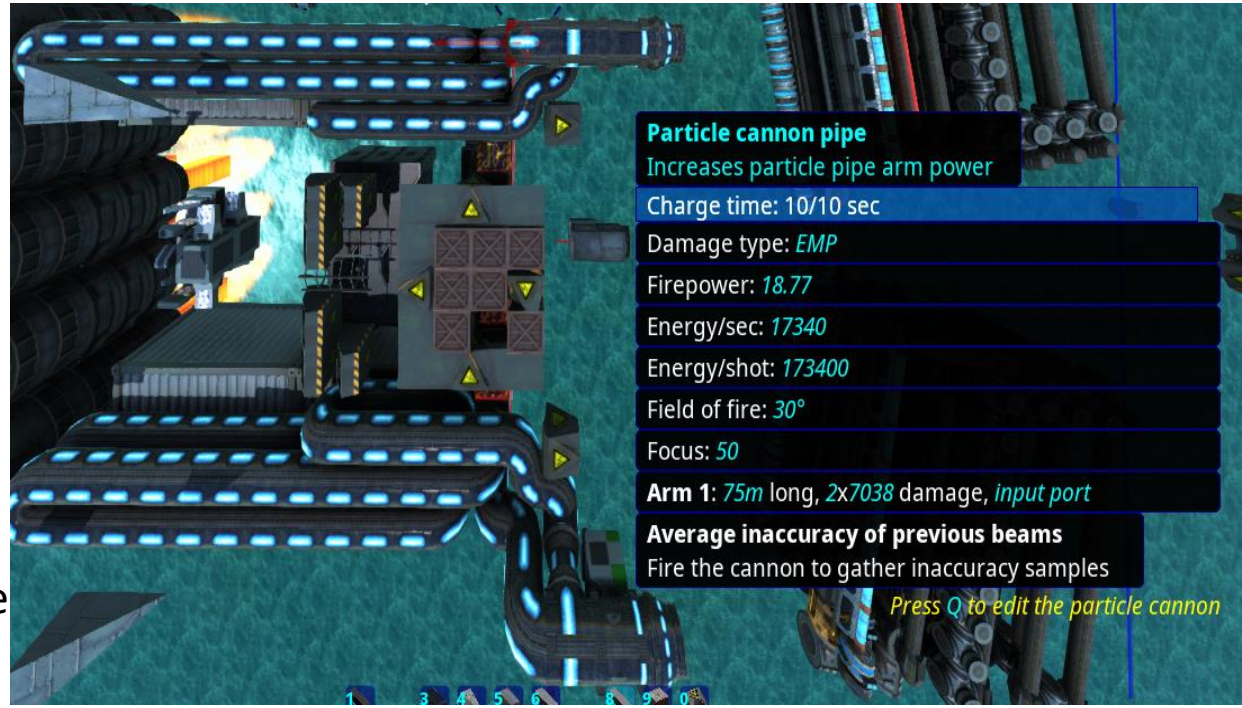
We don't want to rely upon the mass driver alone, so the vehicle is equipped with 2 secondary weapon systems.


This is a small advanced cannon that isn't mounted on a turret which saves space. There is a second copy of this gun on the opposite side of the ship. It shoots an AP-HE round theoretically capable of punching through 9 meters of metal which makes it effective against heavy targets. This allows constant damage to be done to enemy ships while the mass driver is reloading. It has ejectors and its shells are equipped with ejection fuses so any damage to the gun won't cause a catastrophic explosion.

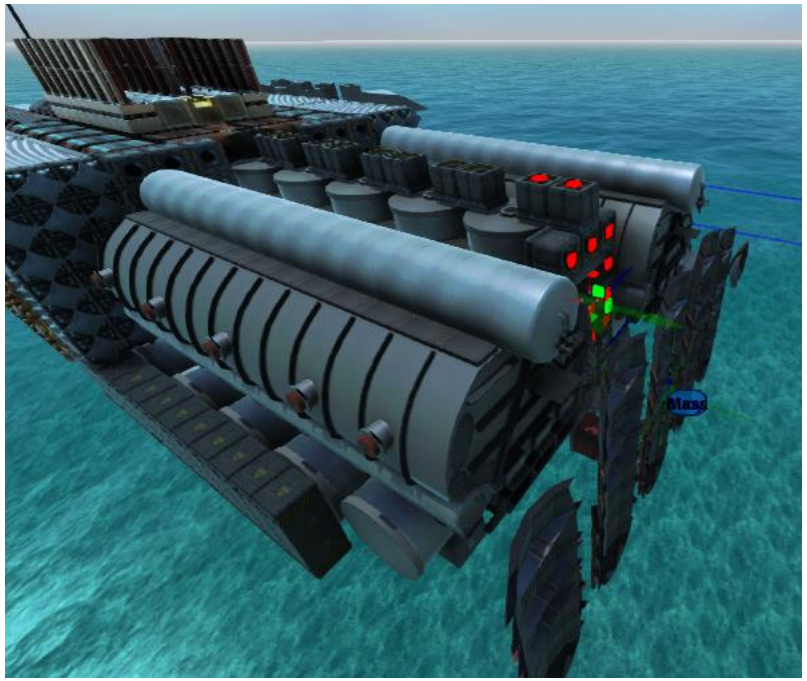
Weapon slot: *All*
Shells available: *33/33* (*956.1* materials)
Shell speed: *1777m/s* (including *191m/s* from rails)
Inaccuracy: *0.2°*
Azimuth range: *-47°* to *47°*
Elevation range: *-6°* to *6°*
Cannon using 131 components
Gauge: *444mm* (*8* gauge increasers available)
Recoil: *35463* (4926/s). Absorption: *42094*/42094 (4988/s)
Rail use: *7200* (1000/s). Capacity: *10000*/10000 (1000/s)
Inaccuracy from instability
Firepower: *24.16*
Shell power: *173.93*
Material use: *4/s*
Rate of fire: *8.3 RPM* (7.2s/shot)
Autoloader limit: 8.3 RPM
Ammo intake limit: 10.1 RPM
Cooling limit: 8.5 RPM (+0.24 RPM/cooler)
Barrel cooldown: 7.1s (31 coolers)

| | | |
|---|---|---|
| [REAR] | Base Bleeder | [UTILITY] |
| [BODY] | Penetration depth fuse | [FUSE] |
| [BODY] | Emergency ejection defuse | [FUSE] |
| [BODY] | HE warhead body | [WARHEAD] |
| [BODY] | HE warhead body | [WARHEAD] |
| [NOSE] | Sabot head | [CAP] |

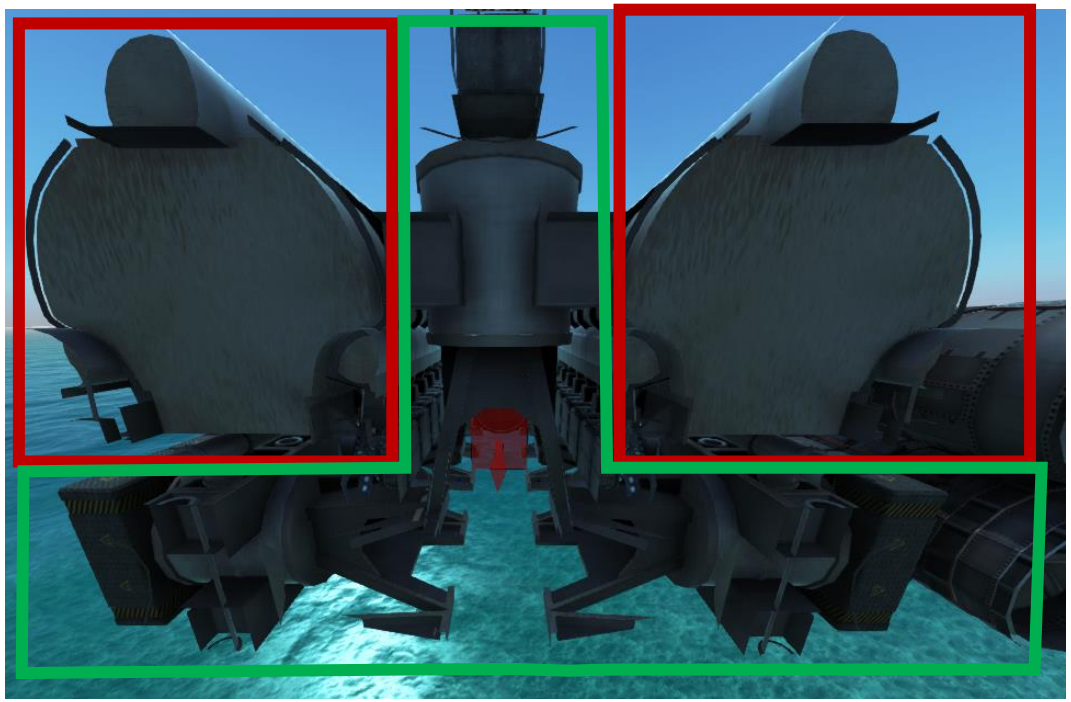
Taking the free space left in the middle of the ship, I put in a small particle cannon. Using an input port instead of a pipe terminator allowed for better range. The damage type is set to EMP, in an effort to damage enemy detection and weapons to reduce the effectiveness of return fire



# The Vehicle – Engine



Due to the power demands of this craft and the options of power production in game (no nuclear), steam was the obvious choice to me because of its power to density ratio. The cost of running all the weapon and protection systems adds up, and in the compact design of this ship, steam was the logical choice.

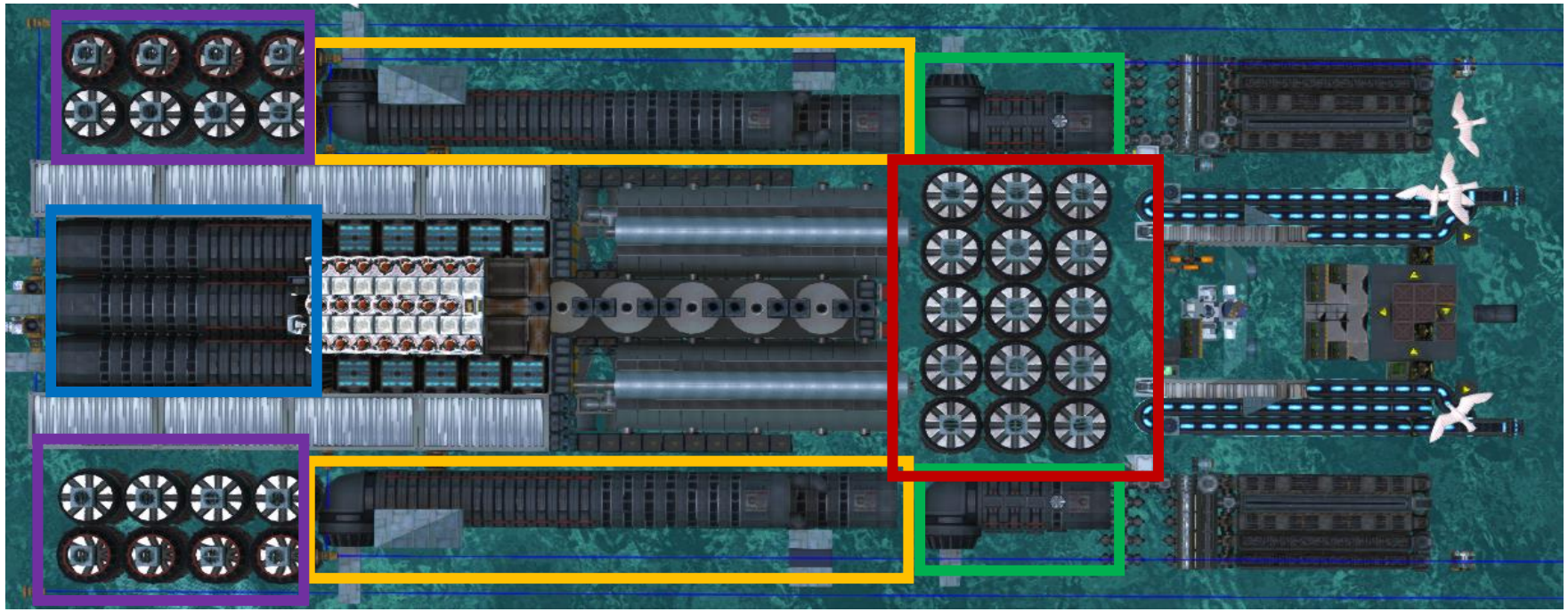


The design of the engine is quite simple. There are 15 pistons with 3 pistons per crank piece with the space bounded by the pistons occupied by the boilers, a simple but effective design.

# The Vehicle – Propulsion

This vehicle is maneuverable because it is propelled entirely by custom jets which can produce large amounts of thrust.

Blue: The backwards jets. There are 3 jets because 1 jet that could produce the equivalent thrust would be too long to fit. This vehicle hits a top backwards speed of 91 m/s.



Purple:
Pitch and roll jets. 2 banks on either side with jets facing up and down for maximum redundancy and easy upwards and downwards pitch. They are also positioned at back to maximize leverage.

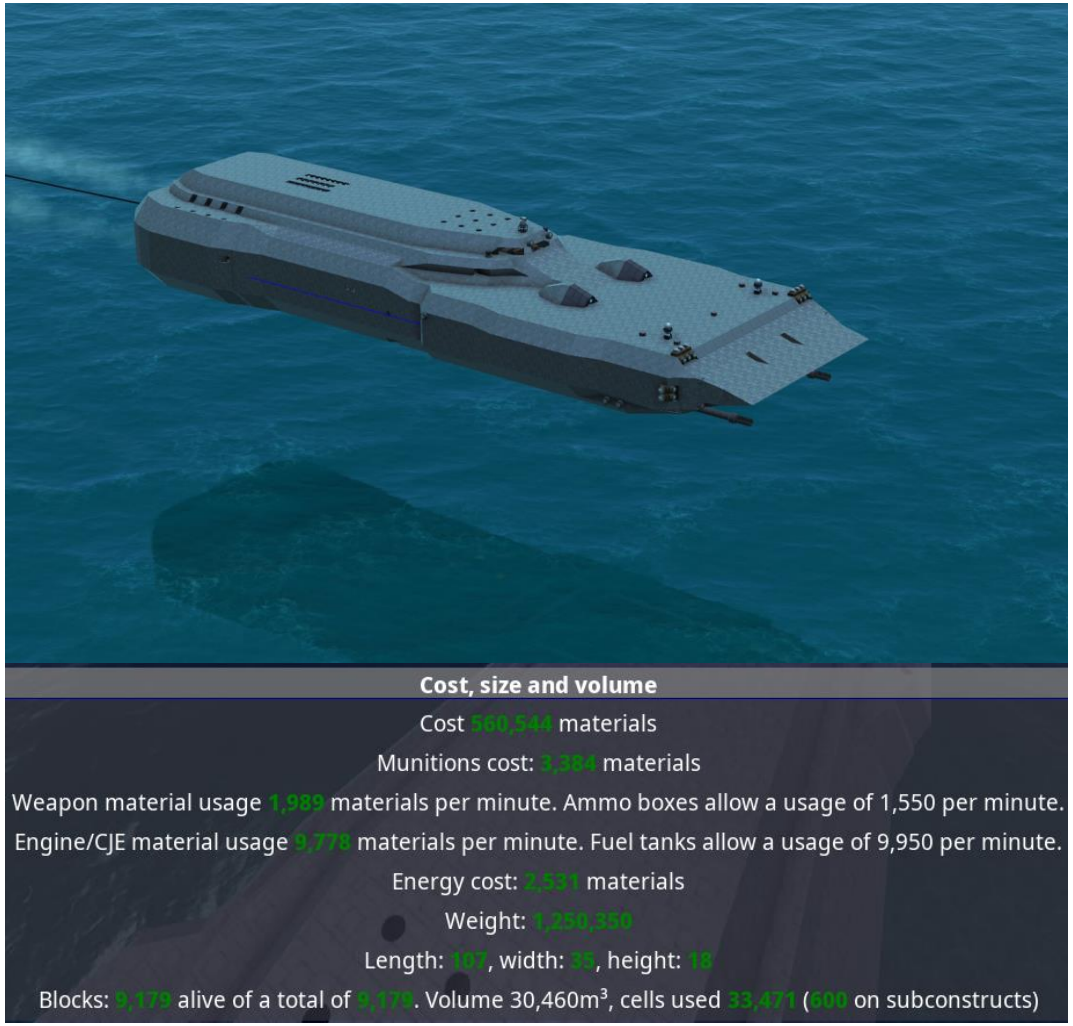
Yellow:
The forward and yaw jets. Unlike the other jets, they must be long enought to produce the large amount of thrust required from them. This vehicle hits a top forward speed of 117 m/s.

Red:
The hover jets. These allow the vehicle to stay airborne. They are positioned on top of the center of mass so that they don't induce much pitching when they activate.

Green:
Strafe jets. In line with the center of mass, they allow the vehicle to move side to side. Space was limited so they are small.

# An Overall View

So, did I accomplish my goal with this design?




Underside of ship hit by a mass driver round

As a whole, I believe I did. This vehicle comes in at a reasonable 560,544 units of material and can punch well above its weight fighting surface vessels. The ship pictured above (with a massive hole in it) costs over twice as much and has twice the volume. Despite that, it has been thoroughly wrecked. Though there are some flaws with my design such as the front armor being a bit thin and the strafe thrusters not nearly strong enough, it still does its job very well. This vehicle represents the culmination of my experiments of mounting a mass driver onto a ship over 3 iterations. Each version has taught me much about what not to do. This ship encapsulates everything I love about FTD, the designing, experimenting, testing and fine tuning an idea until it works flawlessly.