QT-19 build notes

1. Summary:

I've wanted a brushless build for a while due to the mounting-pattern, and ability to target a specific RPM instead of controlling via duty cycle and reliance on motor kV specification. I was also fond of the T19/Flyshot ability to wait for a specific RPM (i.e. closed loop control) instead of controlling it via an timing approximation (open-loop) guess.

2. Components:

2.1 Motors:

- iFlight Xing-E Pro 2306
    - These are the ones I used. The bell shape was not ideal, but serviceable.

2.2 Controllers:

I used the Narfduino ESC Compleat motor from AirzoneSama, you'll likely have to contact him directly to purchase one.

Here is a link to his website, the documentation should be mostly available here - https://blastersbyairzone.com/hardware/narfduino/

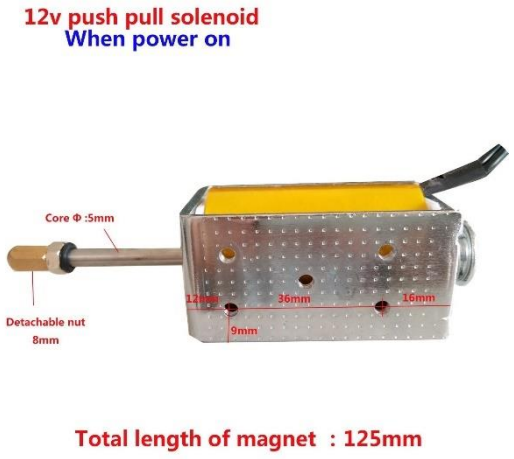
2.3 Battery:

I'm using a 3S for now, but the system is supposed to run on 4S. I'm not familiar with the issues of running on 3S (Aside from weak solenoid throws, and potential issues sourcing high-capacity batteries), but torukmakto4 has hinted at encountering other issues relying on motors with high kV to compensate for the lower voltage.

Make sure to source a battery with a reasonably high max current output to facilitate the solenoid and large brushless motors; solenoids tend to drain a surprisingly high current.

2.4 Solenoid pusher:

This generic solenoid I used was 13.27USD, whereas a Neutron solenoid is around 30USD and a FTW Hyperdrive is around 35USD.



Generic 35mm stroke solenoid

I found that the total available stroke length was less than I had hoped, having only about 30mm.

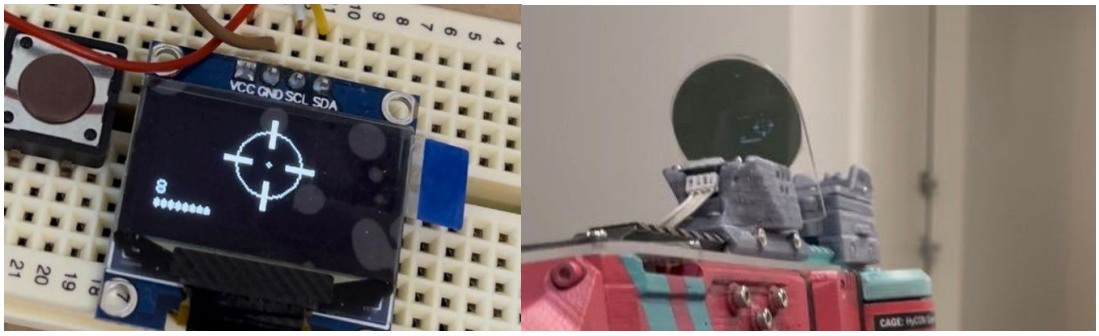
I also had to cut down a stock retaliator spring (or something similar) to replace the stock solenoid spring to create enough back-force to not get stuck on darts. Skimming over the r/Nerf discord, looks like the Ace/Hillman #94 might be promising, but I'd recommend doing your own research before buying.

Alternatively, I'm given to understand the Nerf-specific solenoids tend to be stronger than the generic 35mm, so there's some incentive to go down that potentially less-troublesome route. I'm not sure if the mounting patterns for these purpose-built solenoids are the same as the generic 35mm, but if so, it'd be nice not to have to source and mess around with turning a generic.

2.5 Screen:

White 128x64 OLED Display Module for Arduino 0.96"

I programmed the screen output to act as a HUD sight with a dynamic crosshair and ammo counter.



Left: WIP of screen, clearer shot. Right: Implementation of HUD

Whether or not it is sufficiently bright to be practical has yet to be tested in Nerf games. If not, I'll branch off the software and convert it to a simple ammo counter.

2.6 Bolts:

This blaster is assembled with a thrown-together assortment of M3 and M4 bolts. I apologise that I have not kept track of the lengths. The stock and solenoid are held together with M4, everything else is M3. You should be able to get away with an assortment of SCSH bolts such as this:

https://www.ebay.com.au/itm/403461691176

Although I think there's a bit around the mag release that requires button head bolts due to poor placement. I think they're around 8mm length? I also had to purchase sets of 25mm and 35mm M3 bolts to hold the receiver together.

If you do end up building this, again, sorry about the mess around the bolts, I'm not proud of it. 😟

2.7 Misc:

I also used 20mm OD (16mm ID) conduit for the barrel at the front.

3. STL files:

3.1 Original files for torukmakto4's build:

https://drive.google.com/drive/folders/1cfsm5mGHDXkl9gdmkl7Z_lcq5yUasON_?usp=sharing

Early T19 build

3.1.1 Navigating torukmakto4's 3D files:

You'll find 3 different cage types:

- Common – original cage (See above).
- Delta – Long cage

Delta cage

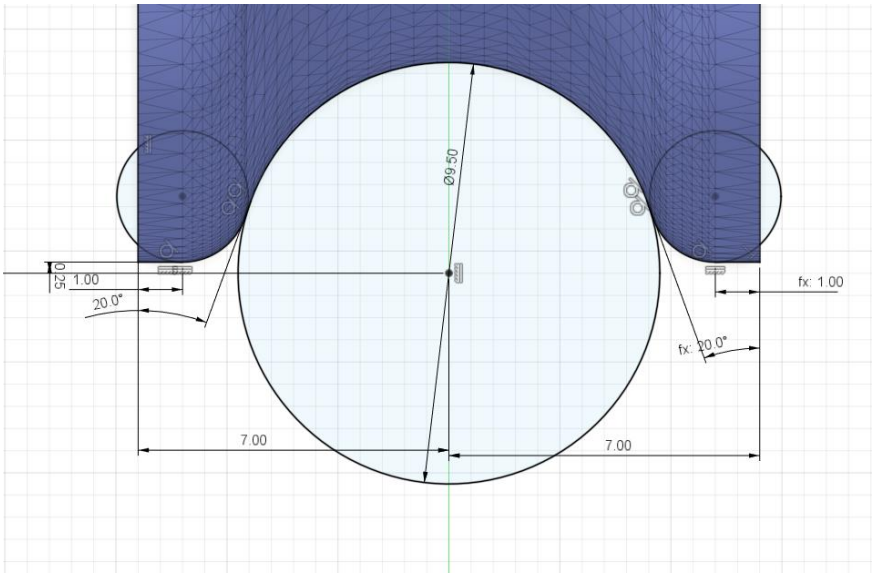
- GammaMajor – Short cage. I believe this is similar to the common cage in appearance, but has a few added features like truncated groove fillers, also present in the Delta cage.

In the repository you will find cages for these motors (See motors section for more notes):

- Emax RS2205S
    - E.g. *Crazepony 4pcs EMAX RS2205 2600KV Brushless Motor 3-4S 2CW 2CCW for QAV250 QAV300 FPV Racing Drone Quadcopter* on Amazon.

- iFlight-XingE 2207/2306 (non pro)
    - Don't mix these up with the bell-*shaped iFlight 2pcs XING-E Pro 2306 2450KV*, which I made the mistake of doing – I've posted my own flywheels which fit these. They're not ideal due to the single contact point with the wheel, instead of a full-contact flat surface, but they're serviceable.
- Racerstar-BR2207S
    - These seem somewhat accessible, I think they're the same one used in other brushless builds like the ultrastryfe, I seem to see them in abundance on eBay, Aliexpress and Banggood. Reports seem to suggest that they are functional options, but don't have the same build quality as other motors that have been recommended for the T19.
- Turnigy
    - These refer to the *Turnigy Multistar V-Spec 2205 2350kv*, and as far as I can tell, aren't available anymore, you'll likely have to get your hands on alternatives
- Blanks (For fitting your own motors)
    - There are standard sizes to brushless motors (https://www.phaserfpv.com.au/blogs/fpv-news/what-is-the-difference-between-1804-vs-2204-vs-2205-vs-2006), so I suspect that 2205/2207/2306 would fit in the cages, potentially with some light CAD work.

Note that the cage files aren't 100% comprehensive, you may have to make your own edits, mashups, and compromises. For instance, if you want to use spacing other than the standard 9mm or 9.5mm, or if you want to use the iFlight motors with a cage cover compatible with the lower gamma rail. Depending on your FreeCAD/STL editing skills, it may be worth digging through the files before sourcing motors. Don't worry though, the wheels are relatively straightforward geometrically speaking. I've made some edits for my own needs, listed under "Files for my edited build"



If you need to edit the wheels like I did, here's the contact profile.

3.1.2 Original files used:

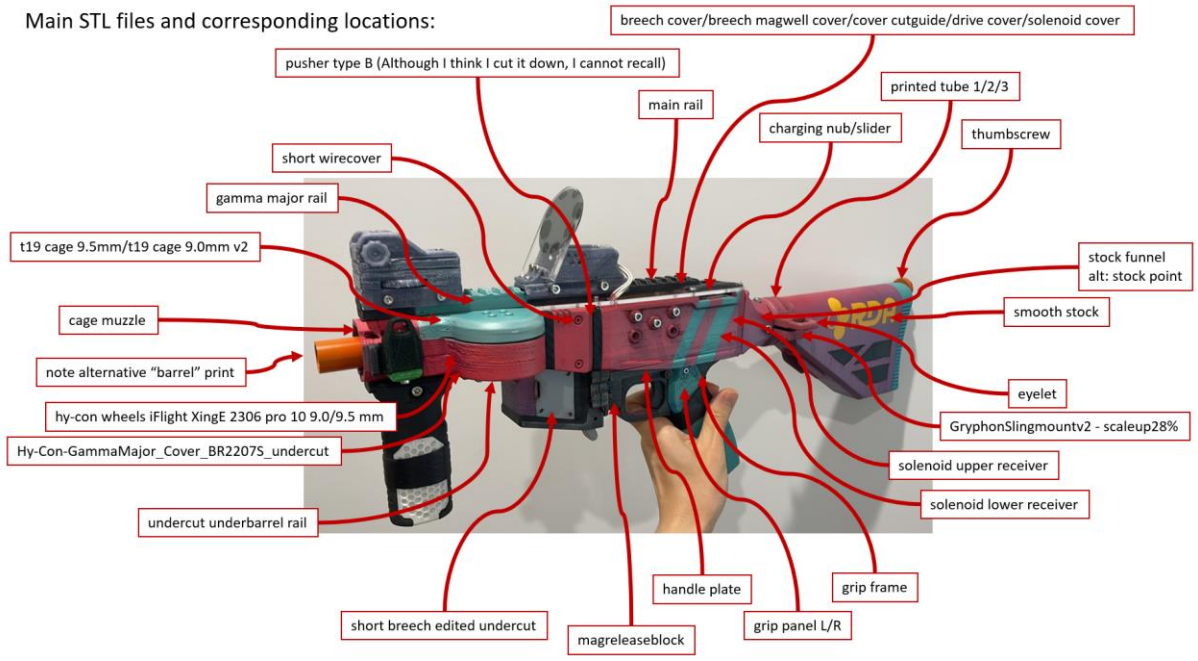
Not all files ended up edited, some were kept as the originals:

- Ribbed stock butt plate – T19E1/Common/STL/T19_ButtplateCurved
- Mag release – T19E1/Common/STL/T19_ShortMagRelease

- Trigger – T19E1/Common/STL/T19_Trigger

3.2 Files for my edited build:

Link to STL files: https://github.com/GrubbyLittleRaccoon/T19variant/tree/main/My%20stl%20edits



All the modified files in "My stl edits" folder, and their respective locations.

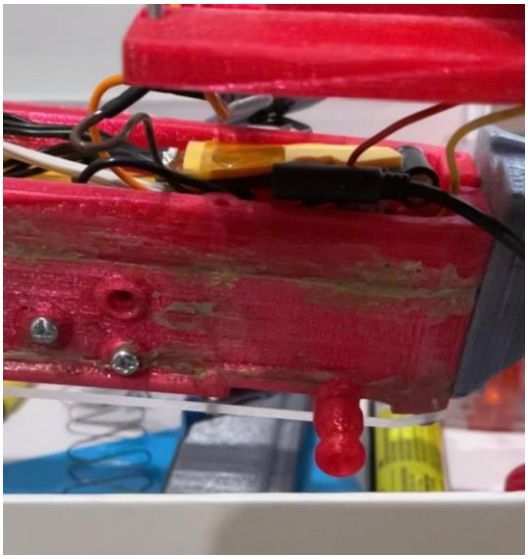
3.2.1 Other depicted attachments:

- "Quick Point Sight – Open" by TimeETraveller8
  - https://www.thingiverse.com/thing:4887523
  - I haven't tested this at games, but it looks about the right height for my GUI sight
- QT19 GUI sight
  - https://github.com/GrubbyLittleRaccoon/T19variant/tree/main/GUI%20sight
- "Shade Vertical Foregrip" by TheLoneWolf052
  - https://www.thingiverse.com/thing:3892164
  - This is optional, but I think it looks nice

3.2.2 My changes:

- Overall stylistic changes
  - Removed nearly all the ribbing for subjective taste reasons. I tend to lean more into conventional sci-fi, less so the original brutalist style.
  - Added a little bit of greebling everywhere to further that sci-fi feel. I'm still getting the hang of those little Gundam-esque flourishes, though.
- Created an iFlight Xing-E Pro variant cage based on the BR2207S files
  - This cage is more sealed off for protection, I was afraid my fingers would bump the exposed flywheels. There's still a small slit, but it's too small to poke your fingers into. Hopefully ventilation isn't an issue.
  - I added an underbarrel rail that is compatible with the shaft holes in the BR2207S files – I found that the shafts stuck out a little bit past the cage cover, so I had to add covering features to the rail accommodate that.
  - The underbarrel rail also has an additional block to cover the magwell, necessary due to the cage now hanging over the magwell

    - The cage cover also has an additional cutout to accommodate interference with the magwell
- Magwell
    - The magwell has been altered to fit the solenoid receiver
    - I've shifted the cage placement over the magwell to compensate for low stroke length, this indents the top segment backwards
- ESC cover trimmed down
    - I'm using the Narfduino board with integrated ESCs, so bulges on the side for ESCs are not necessary.
- Main body uses solenoid pusher instead of the NEMA-17.
    - This required a longer, narrower receiver shape, and bolts on the side
    - The solenoid introduction also allows the addition of a charging handle (purely aesthetic). I ended up removing it from my build because it didn't quite work as well as I'd hoped, but the files and the slot at the side of the receiver.



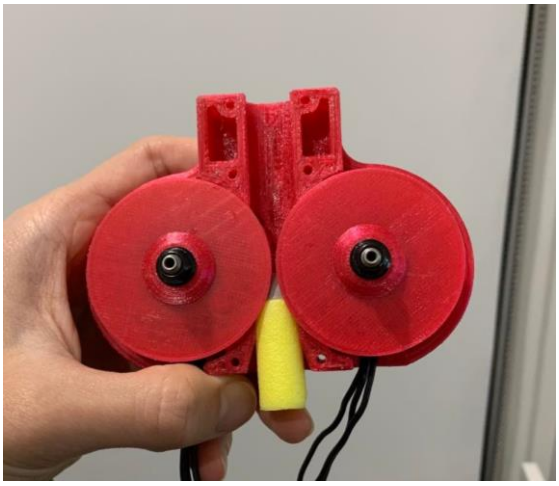
Charging handle mounts to/reciprocates with the back of the solenoid arm

- Main body electronics housing has been changed since I'm using the Narfduino board here instead of the Arduino/Stepper driver combo of the original.
- Curved handle added
    - I like the way curved handles feel, Toruk's original ribbed straight handle should still be compatible with the new body with very minor edits and vice versa

Size reference for the grip – I think I've managed to make it relatively comfortable

- Note that I've used the sling mount from the Gryphon (a similar 3D printed blaster), this needs to be scaled up by 28% as the buffer tube is larger in this build.

Note:



Approximating overhang requirements

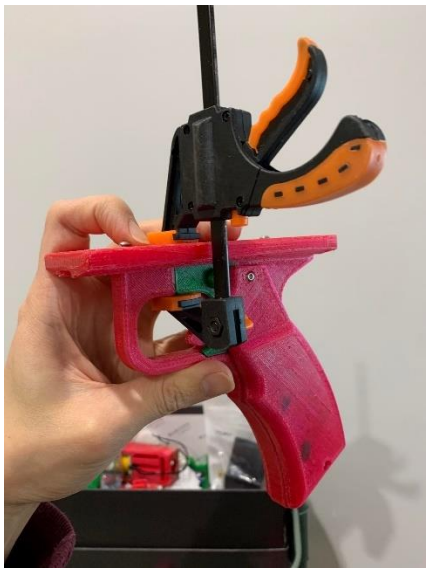
The wheels don't really grip the darts until they are somewhat into the cage, hence why I designed the cage to overhang the magwell. The reduced need for stroke length allows the 30mm stroke from the solenoid to be viable.

3.3 Assembly notes:

Hole size -The bolts used are M3 for the most part, some M4 near the back + solenoid mounting

The stock is held together with M4, everything else is M3.

The linked assembly instructions from torukmakto4's original build provide a good reference for how to conduct assembly. https://torukmakto4.blogspot.com/2019/01/t19-build-guide-part-1-3d-printed-parts.html

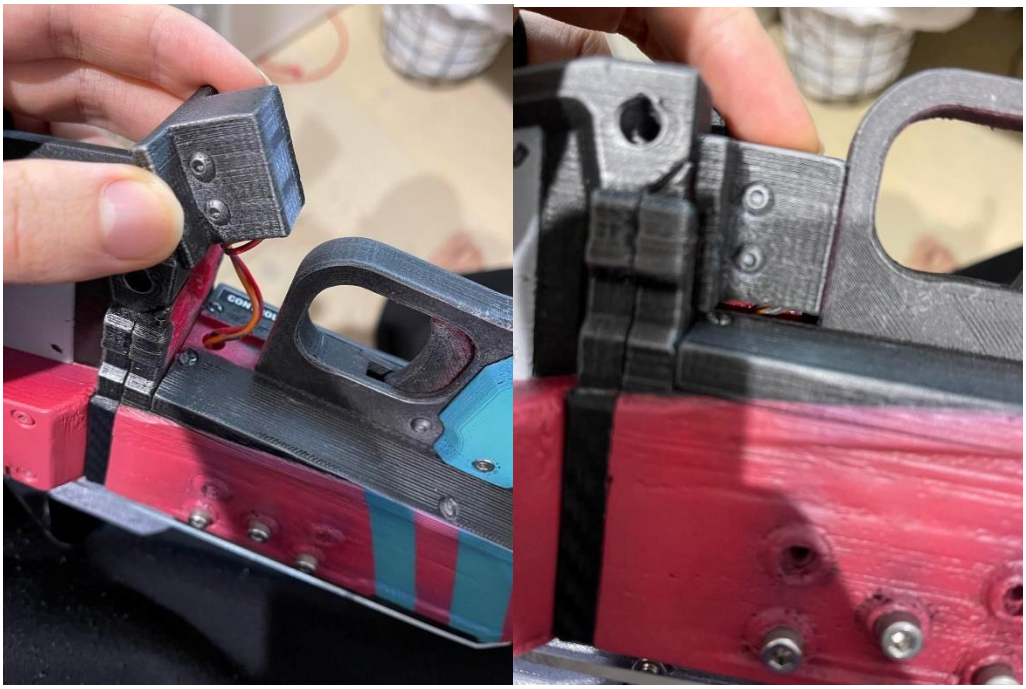


I found it difficult to get the handle in the handle plate while aligning it, I found clamps to assist after partially bolting it in somewhat helpful

I was too lazy to drive to the hardware store and get my hands on tubing, so I threw together some prints. Note that I wanted to print it lengthways to avoid layer separation issues.

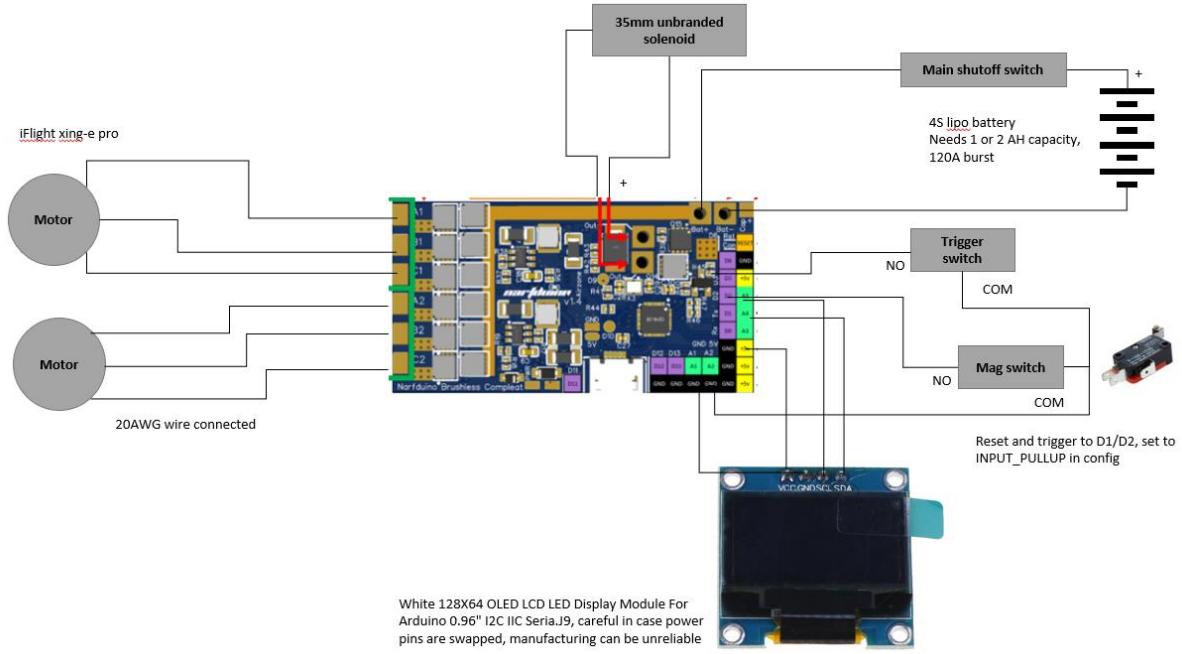
Printed tube

The switch holder for the magazine release is a little awkward, too. After you attach the trigger plate to the receiver, mount the switch inside the holder/bracket. Then push it down slowly, and to avoid the wires sticking out, I tucked them in with a flathead screwdriver as I pushed down. Then I bolted the holder/bracked to the blaster body with a couple of 8mm cap-head M3 bolts.



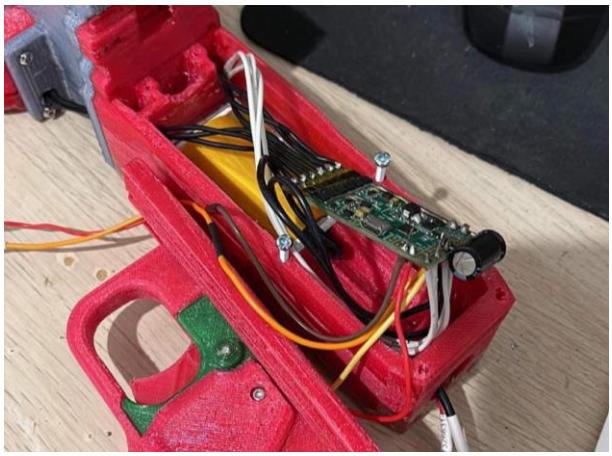
Left: Assemble the switch holder. Right: Push it down slowly, tucking/prodding wires in.

4. Wiring:



Blaster circuit diagram

Note: Careful about which version of the Narfduino Compleat board you have – the v1.2 and v1.4 have slightly different pinouts.



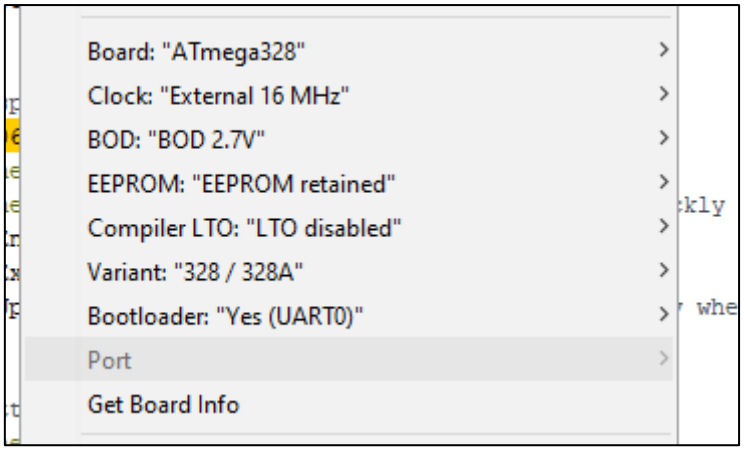
Soldered narfduino compleat

5. Programming:

5.1 Installation

Airzone's website contains instructions for uploading software in the "getting started" tab.
https://blastersbyairzone.com

Note: If you're using the Narfduino v1.4, you may need to install certain board managers: https://mcudude.github.io/MiniCore/package_MCUdude_MiniCore_index.json (Install the MiniCore board)



Arduino Upload board settings

5.2 My software:

Link to my software (Upload using Airzone's instructions):
https://github.com/GrubbyLittleRaccoon/T19variant/tree/main/qt19software

This is based on the Airzone's NBC library, it's intended as a 2-round burst functionality, with the usual "wait for motor to rev up" functionality that the NBC library creates from Toruk's Flyshot SimonK implementation. It also controls the OLED board with a 15-round ammo counter (reset on mag change) and dynamic crosshair (expands on firing, retracts slowly) influenced by popular FPS game design.

Altering the values of the ammo count, target RPM and crosshair should be reasonably easy – just find the relevant variables and change them, I'd like to think my drawing functions are somewhat modular.

I'll likely update this software soon – I'm having intermittent issues, wherein the software will sometimes have trouble distinguishing the rising from falling edge ISR due to a lack of debouncing and state monitoring, resulting in a slight "binary trigger" effect. There's also the fact that the reflected GUI is somewhat hard to see in daylight, so I'll likely revert to a conventional under-sight ammo counter (i.e., direct display instead of reflected)

6. More documentation:

In case you wanted to know where to find more information about the underlying tech,

6.1 Airzone's other stuff:

Github – https://github.com/airzone-sama

YouTube – https://www.youtube.com/@AirzonesBlasters

6.2 torukmakto4's other stuff:

Blog – https://torukmakto4.blogspot.com

YouTube – https://www.youtube.com/c/TheDartZone

7. Final statements (Possible future development):

Looking back on the design, I could've accounted for several factors better:

- Assembly

    - The pieces are bolted together from the front/back. I could probably have converted these to be bolted from the side, like the Gryphon, this would likely have made the build process somewhat easier.
    - The bottom plate where the handle is mounted was a little hard to bolt together and feels a little reliant on a thin section of plastic. I'm not sure how to address this, but perhaps I could look to other mainstream designs for influence.
- Printability
    - Expanding the length of the receiver group for the solenoid made that segment prone to warping, I found, since I'm using PETG. Perhaps I could've made split that body, taken influence from Captain Slug's later designs, wherein each piece fits onto a small build plate, thus removing that difficulty for less tuned printers. This also applies to the stock. However, that could've diminished the battery storage space, so additional thought would be required.
- Finishing touches
    - By the time I got to the stock, I was somewhat unmotivated, so I cut a few corners with the ID specifications while experimenting with materials. You'll note that the diameter of the stock and the stock point are not identical, this was an oversight on my part.
- HUD sight
    - The HUD sight ended up being somewhat problematic – it doesn't work with just a regular piece of acrylic, due to the double-image, so I've had to use a scrap piece of tinted glass to reflect only a single image, or alternatively a PET sheet glued onto a perforated plastic piece (file included in repo), which feels a little sloppy.
    - The OLED screen also does not emit sufficient light for outdoor use. I'll likely alter the build to use the screen as a simple ammo counter, in lieu of the dynamic reticle I wanted it to be.
    - It was a fun experiment at the very least, another pitfall for others to avoid or amend.
- Software
    - The software is somewhat unreliable at this stage – I've managed to get the 2-round burst working most of the time, but on occasion it'll act as a binary trigger, firing both press and release. This is due to the way the ISR is triggered without debouncing. I'll likely simplify the software to full auto if I can't amend this.

And if you'd like to help me justify spending time making more free designs… https://www.buymeacoffee.com/Jyang