FRC 5026 Iron Panthers: Driver Station in a Box

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Overall view of the Driver Station in a Box after the 2025 World Championship event

Goals

- Keep all the parts (laptop, 2 XBox controllers, cables) together while travelling so the kit is complete for practice and competition
    - We fly to some regionals, so should be flight-compatible
    - Needs to fly as carry-on to include the laptop
- Include a modern-enough performant laptop with non-USB Ethernet port
    - Mid-range CPU launched within the last 5 years; bonus within 3 years
    - We experienced match-impacting latency issues in the previous few seasons:
        - Some that seem to come from CPU performance with the driver station software not responding to the robot in a timely manner
        - Some from USB Ethernet dongles that seem to overheat and throttle
- Internal packaging must protect controllers and laptop during travel while enabling quick setup between matches during competition
- Bonus space for VH-109 Radio in AP mode and potentially a data-logging computer (Raspberry Pi or similar)
- Total cost a complete kit < $1

Our Implementation

We chose to build the Driver Station into a carry-on Pelican Case. The original version was built from a bare Framework 13 motherboard and screen built into the case lid, though the final revision is built around a Lenovo Thinkpad T14 laptop. More details of this progression below. The laptop sits on a hinged shelf that allows access to the controller pockets and bonus space divided by 3D printed structure. An extra weight is needed to prevent the case from tipping over when the laptop is pivoted up.

Driver Station CAD:
https://cad.onshape.com/documents/f3b8300b142efee5b4d3072d/w/f6d4b8525904794992f26ebb/e/2abed157bcfda699ac06be91?renderMode=0&uiState=683bec27999b6e5e6b87f719
Framework Case CAD:
https://cad.onshape.com/documents/554dfdbb7ef486868c6a6c7e/w/659e6b7d900c732bb6499a24/e/ba3694bfdfbb7ee63de6dfa0?renderMode=0&uiState=683bece63848326299463895

Key Features

- Pelican Case that fits within flight carry-on and Driver Station dimension limits
- Laptop shelf with zip tie mount points for cable strain relief per port
    - Laptop chosen with on-board Intel NIC and touchscreen
    - Laptop attached to shelf with 3M Dual Lock in case it needs to be removed
    - Keeping the laptop level with the case opening allows easy keyboard usage
- Foam-padded controller pockets (and bonus feature: controller pocket insert)
- Ethernet port pigtail to reduce strain on on-board port
- Space for extra accessories in the box:
    - Laptop (and more) power supply & USB Mouse (by student request)
    - VH-109 Radio as Access Point (removed at competitions)
- Velcro on the case bottom to stick to Field and Robot Cart

Bill of Materials

Item - Description	Cost	Qty
Box - Pelican 1485 Air Case	$185	1
Laptop - Lenovo T14 Gen 3 Intel i5-1250P Touch	$390	1
XBox Controllers & Cables	--	2
Ethernet Port Pigtail	$5	1
Dividers, Laptop Shelf Frame, and Other Parts - 3D Printed from Red Bambu Labs PLA	--	--
Shelf - ¼ in Smoke Polycarb (WCP-0295)	~$12	1
Shelf Pivot - ¼" x ½" x 10-32 Shoulder Bolt	$6	2
Shelf Pivo - ⅜" Nut Strip 10-32 (WCP-1554)	$10	2
Foam - 10mm Thick EVA Sheets	$5	--
Double-sided Tape - VHB ½ in	--	~ 7 ft
Weight - Stainless Steel ¾ x 3 x 4 in Flat Bar	$27	1

Assembly Photos

Issues Encountered and Revisions

The final Driver Station in this guide is the 3rd major revision used over the course of the 2025 FRC season. Each revision improved the stability of functions needed to drive the robot such as having a stable network connection.

The original Driver Station with Framework 13 Mainboard (11th Gen Intel i7-1165G7) was based around an in-kind donation of these motherboards from Framework with the concept of turning it

into a ruggedized laptop-in-a-box. This may still be possible to construct, though it did not work well enough for us to continue refining.

The Framework and Thinkpad AMD CPU revisions side-by-side.

With Framework Mainboard

This version of the Driver Station went to offseasons including Madtown Throwdown (2024), Ventura Regional (2025), and AZ East Regional (2025). The Mainboard does not have an ethernet port, though it does have an M.2 E-key slot for a WiFi card, so we added an Ethernet NIC in this slot. We had previously made a 3D-printed Mainboard case for another project, though this did not have a spot for an M.2 card. The case linked above has a spot for the card and the non-standard cable that comes out of it. The also (just barely) fits on a Bambu X1 or Prusa i3 print bed.

We wanted to use an Intel i210 NIC, though this would not enumerate in Windows or Linux. Instead we used an RTL8111H NIC which did enumerate in both Windows and Linux and was functional most of the time. On several occasions, Windows reported that it did not have any network port hardware connected. In some of those cases, rebooting the machine a few times would result in the port appearing again. As a result of this behavior, we played a few matches at AZ East with a USB Ethernet dongle and started to carry one for backup. All of the port loss events were during match load in or start of the day, though it seems we got lucky that it did not result in lost match time.

It wasn't clear to us if the cause of this network port loss issue was the mechanical assembly - the 3D-printed case design sandwiches the motherboard and M.2 card between case parts - or the specific NIC and related driver. Based on several discussions with the CSA at AZ East we decided to purchase used Thinkpad laptops with on-board Ethernet ports.

With T14 Gen 3 AMD Laptop

This version of the Driver Station did not go to any competitions, though we used it for practice at home before the 2025 World Championship.

Our first take at purchasing Thinkpad laptops was to pick up a Gen 3 AMD model. These models seemed to offer ~30% more CPU performance at the same price. However, they differ in network peripherals too. Where the Intel CPU models have an Intel WiFi card and Intel Ethernet NIC the AMD CPU models have a MediaTek WiFi card and Realtek NIC. The specific NIC (and driver combination) in this model did not seem to know how to wake the port up from sleep after the laptop was put to sleep (such as closing the lid) and woken back up again. Disabling and then Enabling the port from Windows seemed to recover functionality, so our guess is that this is a driver support issue. To avoid needing to disable sleep or constantly work around this issue we purchased the Intel CPU model of the same laptop instead.

Bonus Features

These features were requested over the course of competitions though only added after our last competition of the year - they haven't been field tested yet.

(Left) Laptop lid tabs to hold the case lid open when the laptop is open. (Center, Right) Controller pocket inserts that hold the controllers up to avoid resting on and straining the USB connector.

In Conclusion

The Driver Station is a vital piece of operating equipment for every FRC team. Having it remain functional through every match played is as important as robot functionality. With a careful selection of parts it is possible to have top tier functionality and performance without breaking the bank.
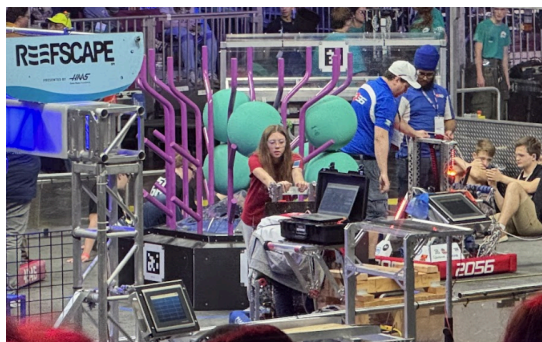
Beyond the Driver Station

The Driver Station is one piece of off-robot infrastructure amongst a set that we worked on building up this year. Other related pieces include:

- Practicing with a Radio as Access Point - practice with the same interfaces used at competition
- Adding a shelf for the Driver Station on our Robot Cart - *seen in use at left during field calibration*