

# Commercial Vehicle Electronic Logging Device Security: Unmasking the Risk of Truck-to-Truck Cyber Worms

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# About Me: Jake Jepson

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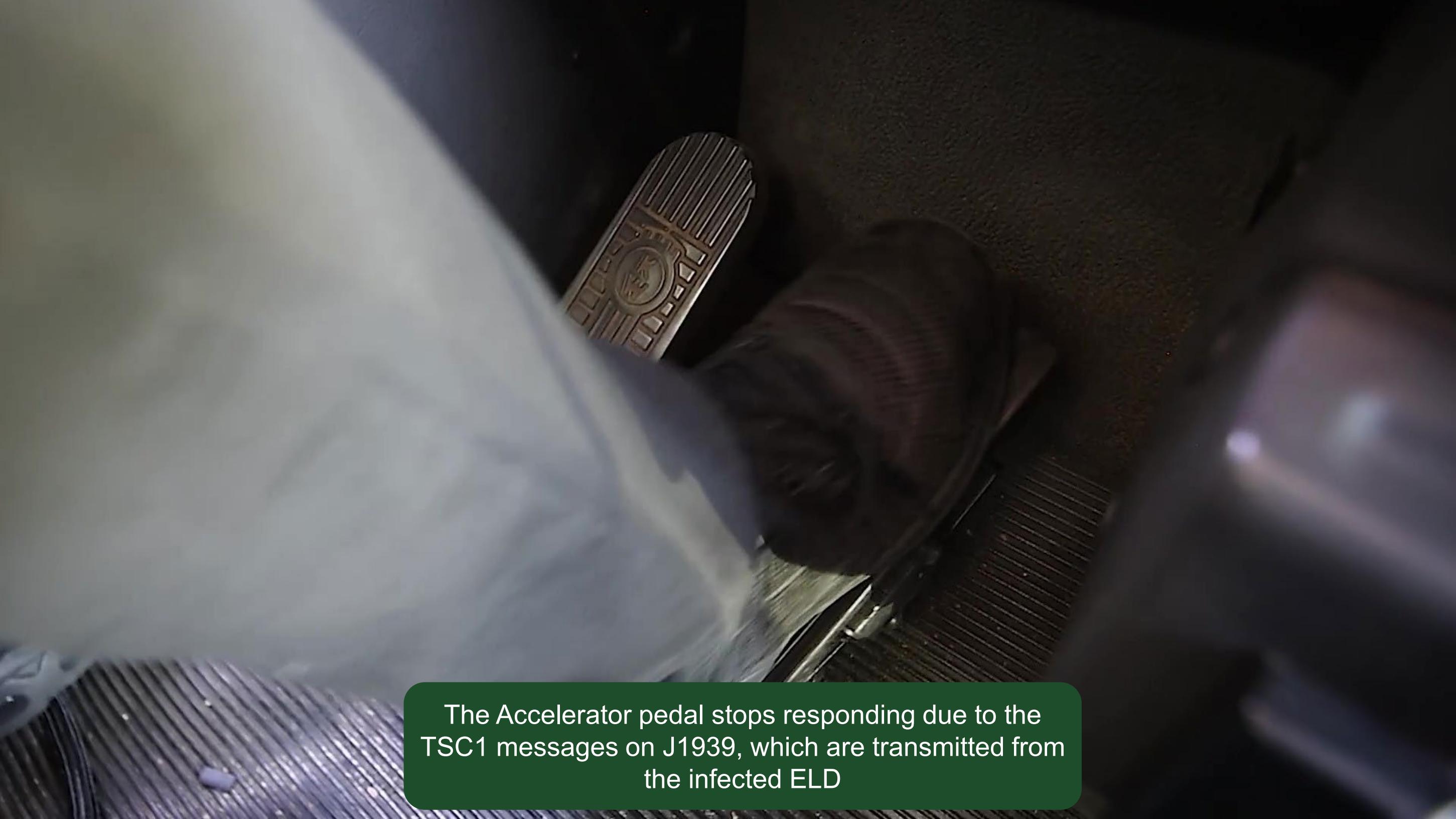
in as far as we know, the first ever  
wireless drive by attack on a truck.

A photograph taken from the perspective of a person sitting in a car, viewed from behind. The person has brown hair and is wearing a grey hoodie. They are looking out of the car window at a parking lot. In the foreground, a laptop is open, showing a software interface with various buttons and a map. The car's interior is visible, including the dashboard and a small blue and white logo on the sun visor. The scene is set during the day with clear skies.

We were successful in this attack.  
The car drove up along side it.



begins to slow down  
and the car pulls out ahead.



The Accelerator pedal stops responding due to the TSC1 messages on J1939, which are transmitted from the infected ELD

# Background



# Why: Heavy-Duty Commercial Trucks?

- Part of the Heavy Vehicle domain which is critical infrastructure
- 14 million+ medium and heavy-duty trucks in the US [1]
- Move 72.6% of the nation's freight by weight [2]
  - Toilet Paper shortage – good demonstration of the impact of supply shortages.
- Packed full of technology:
  - Loads of sensors
  - Network(s) of connected computers
- Highly homogenous and interoperable

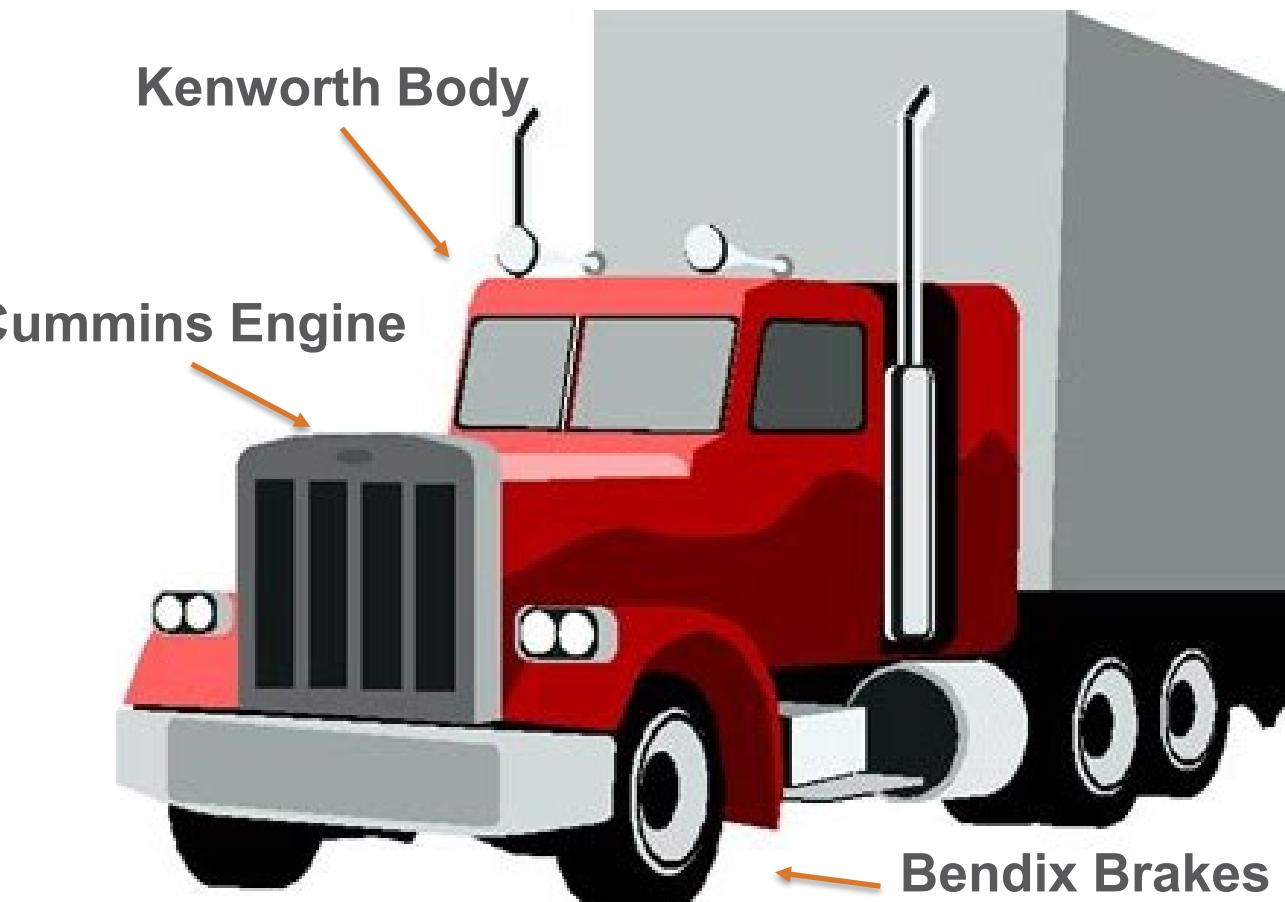
# Under the Hood: Computers & Networks

- Network(s) of computers on wheels – Electronic Control Units (ECUs)
  - ~15 to ~150 ECUs per vehicle [3]
  - Control functions from engine management to entertainment [3]
- Common network protocols:
  - CAN, CANFD, LIN, and Automotive Ethernet
- J1939 - Standard for communication and diagnostics in Heavy Vehicles [4]
  - Spans multiple OSI layers. Built on top of CAN
  - Governs how ECUs talk to each other
  - Vital for interoperability among manufacturers
  - Like CAN - No standardized protocol level security



Example ECU

Possible Truck Configuration



# Electronic Logging Device (ELD)

- Automatically record a driver's Hours of Service (HOS)
  - Compared to traditional paper-based logs.
- ELD Mandate – Made ELD usage mandatory for most commercial drivers since 2017 [5]
  - Goal: Reduce accidents caused by driver fatigue
  - No mention of security
  - Registration Required:
    - Self-certify compliance process
    - ~880 registered ELDs [6]
- Acquire data through communication with vehicle's engine control module (ECM)
  - Connected via the diagnostic port
  - Requires read and write access to get all required data
- Common Wireless interfaces include Wi-Fi, Bluetooth/BLE, GPS, and Cellular

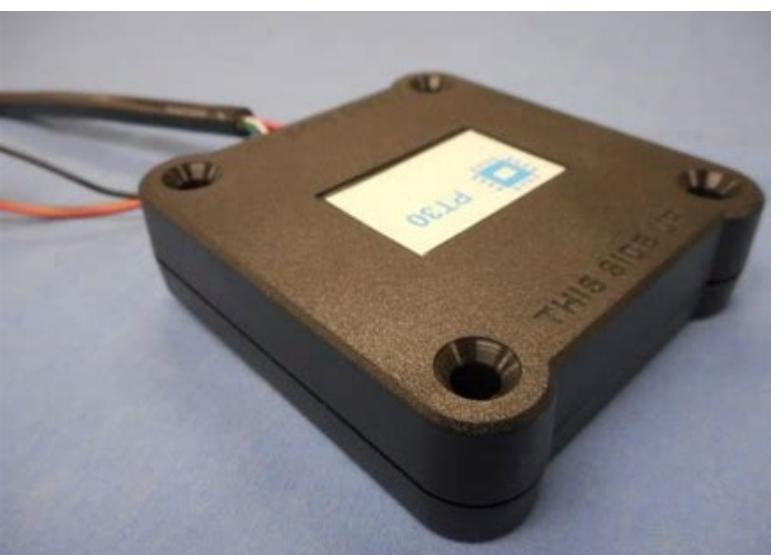


Image Credits: [7], [8], [9], [10]



\*DALL-E/Photoshop  
ELD shown\*



# System Definition

- Composed of Semi-Truck and ELD
  - Akin to passenger vehicle w/ telematics unit
  - Heavy truck: dynamic operational platform with mechanical and electronic components
  - ELD: electronic vehicle attachment mandated for data logging, regulatory compliance.
- Integration:
  - *Could* enhance operational capabilities
  - Widens attack surface / introduces new threat vectors
  - *Could* introduce potential vulnerabilities

# Preliminary Cyber-Physical Threat Assessment

- Attacker's Goal: Compromise wireless device connected to vehicle's network(s) → Send bad messages.
  - Not new (I.e., Insurance dongles, Jeep hack)
- ~880 Registered ELDs: Successful large-scale attack requires compromising ELDs from multiple companies
- Modern trucks contain diagnostic gateways functioning like firewalls to block malicious traffic
- Disconnecting the ELD halts an attack
- Typical cyber-physical control threat scenarios
  - Proximity-based wireless attack (e.g., via Wi-Fi or Bluetooth)
  - Long range access via cellular network interface

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# Corrective Insights

- Only a few tens of distinct ELDs; most are rebranded clones
- Significant code reuse in ELD models from single manufacturers (i.e., Cellular vs non-cellular versions)
- Gateways became popular in the early 2020s, but trucks have long operating lifespans
- Like ECUs, Gateways are susceptible to:
  - Configuration errors which permit risky actions, like in-motion brake diagnostics (brake chuffing)
  - Diagnostic protocol flaws
- Legal requirement for ELD usage reduces likelihood of device removal...except during vehicle diagnosis by technician, further obscuring the problem
- We introduce a novel 'Truck-to-Truck Worm' threat scenario that propagates between trucks en route
  - Local wireless technology → long range access

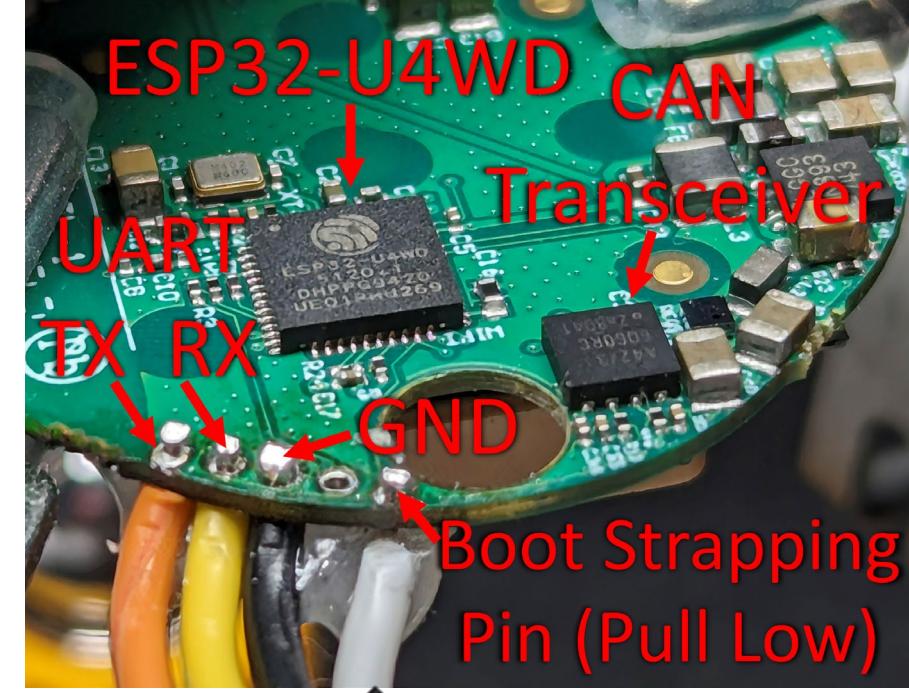
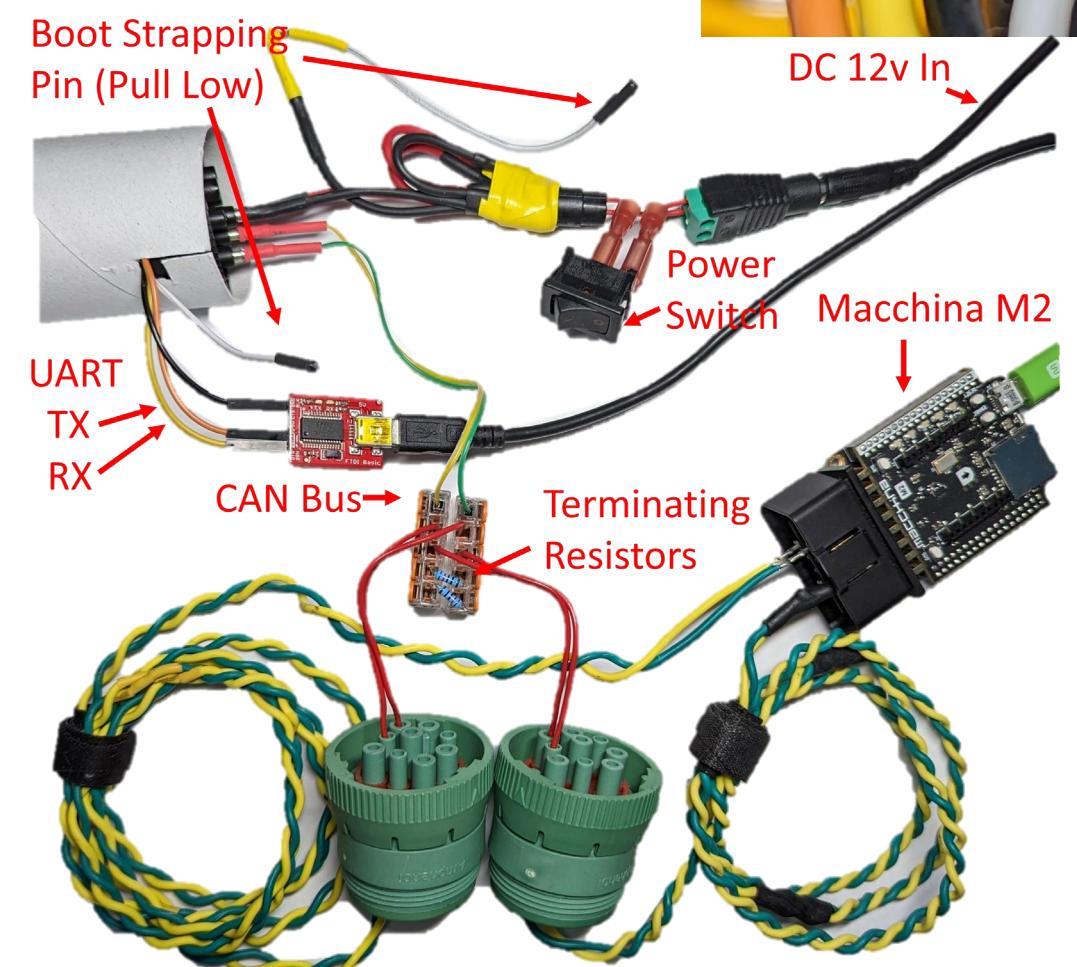
# Unveiling the Vulnerabilities – A Research Journey

\*\*\* ELD vulnerabilities discussed are currently involved in a **responsible coordinated disclosure** effort with CISA and the manufacturer. Therefore, the manufacturers name among other information will be left out. \*\*\*

# Device Overview

- Acquired popular ELDs from popular Ecommerce site for analysis
  - All small, handheld devices
  - Connects to vehicles diagnostic port
- Quickly became apparent that multiple ELDs were clones with minimal changes
  - Same device sold by 50+ brands
  - Wireless networks not rebranded
  - Uncovered that this is commonplace in the ELD industry
- Manuals indicates:
  - Bluetooth Low Energy (BLE) and GPS connectivity
  - Companion app for data logging, monitoring, diagnostics, etc.
- Discovered password protected Wi-Fi network, not stated in manual

Tabletop Lab Setup



ELD PCB Up Close

Booting ... version %s (IDF %s) [reset cause %u  
 Debug  
 Upgrade  
 Data  
 BTLE  
 Socket  
 Analog

**SSID Format**  
**WIFI Password**  
**Upload Key**

```
ELD: %02X%02X%02X%02X%02X%02X
Created SSID: %s
d [REDACTED] 7
ELD
About to connect
@ [REDACTED]
```

POST /upload.php HTTP/1.1
 Suspending tasks ...
 Starting OTA ...
 upgrade
 E (%d) %s: OTA END: %u
 E (%d) %s: Boot partition activated: %s
 E (%d) %s: Failed to activate boot partition
 Flash Successful! %lu.%02lu seconds
 Upload Firmware
 Flash success and closing socket
 Error flashing! Code %u [%u]
 Flash error and closing socket
 RESETTING
 GET / HTTP/1.1
 <html><head><title>Upload Firmware</title></head><form enctype="multipart/form-data" action="http://192.168.4.1/upload.php" method="post">Serial: %02X%02X%02X%02X%02X%02X<br>Version: %s (%s)<br>Key: <input name="key" type="text"><br>File: <input name="fw" type="file"><input type="submit" value="Send File"></form><br>Buffer: %ld,%u,%u,%u</body></html>

**Upload Endpoint**  
**Webserver IP**  
**Upload Key**  
**Input**

Failed to write flash at address 0x%08lx, error %d [%u] %0
 Recv error %d (%u)
 Content-Length:
 Content-Type: multipart/form-data; boundary=1 [REDACTED] 6
 So far we have %lu bytes of the content, total %lu bytes
 Flashing error: %08X
 Received %d bytes (%lu/%lu)
 Subtracted %u from currcontentlength: buflen %u
 Recv error %d (%u/%u)
 http\_basic\_response %s:%s [%d %d]

DEBUG: ENGINE STOP DETECTED 3 %lu (%lu) - %lu (%lu)
 DEBUG: ENGINE STOP BLOCKED BY IGNITION 3 %lu (%lu)
 DEBUG: VEHICLE WAKEUP DETECTED %ld → %ld (%d) V, %
 DEBUG: ENGINE START DETECTED 3 %lu (%lu)
 debug
 192.168.4.1 [REDACTED]
 Client connected
 %02X %02X %02X %02X %02X %02X %02X %02X
 %02X %02X %02X %02X %02X %02X %02X %02X
 SSID: %s
 Pass: %s
 Skipping backup due to no vehicle connection
 Found flash save partition with good signature
 RBT\_READ: failed @ %06lx → %02X ≠ %02X [%lu]

Serial: [REDACTED]
 Version: [REDACTED]
 Key: 1 [REDACTED] 6
 File: Choose File firmware-mal.hex
 Send File

# Technical Inspection

- Firmware Extraction & Acquisition:
  - Utilized ESPTool.py for firmware extraction via serial to USB on the ELD's programming port
  - Discovered credentials and endpoints using GNU strings command
  - Obtained newer firmware from update servers by reverse engineering mobile apps with JADX
- Employed Ghidra with ESP32 plugins for analysis
- Default Wi-Fi credentials easily accessible online
- Using default Wi-Fi credentials mapped Wi-Fi network using Nmap to identify open ports and associated services
  - Service on port 22
  - Telnet on port 23
  - HTTP server on port 80

# Vulnerabilities

- Default Network Security Weaknesses:
  - Hardcoded weak password
  - Unnecessary simultaneous use of Wi-Fi & BLE
- Web Server & OTA Updates:
  - Default-enabled web server, seemingly unused by resellers
  - OTA update mechanism with a weak password
  - Firmware update not signed
  - Downgrade attack susceptible
- Debugging & APIs:
  - Unnecessary debug thread open on port 22
  - Unauthenticated Telnet API (port 23) and BLE exposing critical device control, including arbitrary CAN message handling and OTA updates, without security measures.
  - While API provides the ability to configure the device to a more secure state, we did not find it used by the reseller applications we examined

```
43 ble_message = strncmp((char *)recv_message, "0x0000000000000000", 16);
44 if (ble_message == 0) {
45     puVar7 = &command_handle_output;
46     bus = 0x6a4;
47     pcVar6 = "Dbg";
48     pcVar5 = dbg_thread;
49 LAB_401162c6:
50     xTaskCreatePinnedToCore(pcVar5, pcVar6, bus, puVar7, 5, 0, 1);
51     return (int *)0x1;
52 }
53                                     command might start a thread to stream back data */
54 ble_message = strncmp((char *)recv_message, "0x0000000000000000", 16);
55 cmd_parameter = baud_rate_1;
56 if (ble_message == 0) {
57     memw();
```

## ~ Code for other Commands ~

```
573             /* if it doesn't equal any of the above commands then it goes to this routine
574             if (is_streaming == '\x01') {
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578             The streaming
579             command, must
580             be sent first
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```
586     if ( ) {
587         [REDACTED]
588     );
589     if ( ) {
590         if ( ) {
591             if ( ) {
592                 if ( ) {
593                     return recvd_message;
594                 }
595                 if (first_char != 6) {
```

## ~ Code for other CAN Bus Channels ~

```
679     debug_printf("CAN1: Requesting @%08lX %u bytes\r\n",id,length);
680     bus = 0;
681 }
682 send_can sends the message to the CAN bus
683 send_can(bus,id,0,0,0,0,length,&can_data,0,0,100,&command_handle_output,0);
684 return (int *)0x64;
```



## What's the Impact?

- Wirelessly send/receive arbitrary CAN messages
- We created a malicious firmware to reduce a truck's speed through a strategy known as the "Petal Jam" technique, utilizing:
  - Placed in the debug thread function
  - TSC1 messages telling engine to go to 0% torque
  - To find more info about this attack and others visit: [systemscyber.engr.colostate.edu](http://systemscyber.engr.colostate.edu)
- Wirelessly re-flashed the device during a simulated drive by attack (on a private airfield)
  - Firmware flashing ~12 seconds, total operation ~30 seconds.
- Developed and demonstrated a self-replicating worm on ESP32 devices, exploiting their dual-mode (station and access point) capability.
  - ~120ft range in dense parking lot with PCB antenna



Thank you *and come by to  
see the demos!*

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Colorado State University

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