# Fleet Edge System Specification & User Guide - DRAFT

## Fleet Edge Overview

Fleet Edge is an edge compute system for deployment on Amazon delivery vehicles. It will provide an in-vehicle machine learning platform for map data acquisition, route generation and driver metrics, all of which have a significant business value to the Last Mile organization. The system is being designed as a flexible edge-compute platform, and as such will have an API for development and deployment of applications developed by a number of amazon business teams.

For the first version of the Fleet Edge system a 6-core Intel CPU architecture was selected because of it's large compute capacity and the ease of development using existing AWS frameworks. Intel MyriadX VPUs were selected because their low cost and small size makes it possible to run multiple independent ML tasks in parallel. A modular VPU-card approach allows us to take advantage of next generation Intel VPU performance increases without modifying the system architecture. Future cost-down SoC based Fleet Edge systems will likely have to run more integrated tasks on a more monolithic ML processor; this multi-VPU architecture will allow us to explore the application space more freely before selecting a set for optimization.

## Compute Hardware

### PHYSICAL CHARACTERISTICS

All connectivity on one side for protection and ease of installation.
Fan-less design for reliability.
The system dimensions are 260mm x 313mm x 80mm.

## TEST SPECS

ISO16750_4.2.2 shock
IEC 60068-2

## POWER SUPPLY

Power supply input is 9-36VDC. In some vehicles the voltage may drop as low as 7V for 100ms while the engine is cranking, so the power supply must be able to maintain system performance through such events.

Power supply must be automotive-grade and able to filter noisy signal from alternator, starter, etc.

System will have a relay in-line with the +12VDC input that can be controlled by the watchdog MCU. When this relay is open, the only system that will receive power is the MCU and it's sensors.

## CPU

The FE system will work with any 35W Intel Coffee Lake CPU, in particular the i5-8500T. Amazon is working with Intel to confirm the ideal CPU for our application.

## CHIPSET

Cannon Lake Q370, recommended due to thermal operation range.

## RAM

1 SO-DIMM @2666MHz, 8G or 16G TBD, high-temp spec.

## STORAGE

M.2 SATA SSD, 512Gb or 1TB TBD, high-temp spec.
System will have 2 M.2 slots so a more cost effective solution for 1TB storage of 2x 512Gb.

## WATCHDOG SYSTEM

For reliability, the system will have a watchdog micocontroller that has the ability to cut the 12V power to the remainder of the system. This will ensure that when the system is in the off state it draws very minimal power from the vehicle battery. This microcontroller will also manage the power up and down of the system based on the tracking of the ignition power signal. The microcontroller will have control of the system power button signal so it can turn the Intel Core processor on and off.

The microcontroller will have sensors for monitoring the environment temperature, the battery voltage and the wall clock time. It can monitor these values to ensure the vehicle battery and the Fleet Edge system are protected at all times. The sensors will be logged at all times, even when the system is powered off. These logs will be pulled by the Fleet Edge OS and uploaded to the cloud.

The following parameters can be set from the Intel Core processor to the watchdog MCU via a serial interface:

- power on time delay ([0,360] seconds, 10 default)
- power off time delay ([0,360] minutes, 5 minute default)
- Low and high temperature safety limits (each [-30, - 100] range in degrees C, defaults [0-60] )
- Low voltage shutdown level ( [1-30] in volts, default 11)

Log data sensor internally when system off, store up to 7 days of data. When system powers up, CPU can use UART protocol to retrieve data logged when offline.
Keep-alive watchdog from CPU, if a heartbeat message is not received from CPU within 1 minute attempt 1 reboot PC via relay.

Watchdog MCU will have ROM bootloader and COM firmware update protocol for safe firmware updates.

### ERROR STATUS

The system will have a two-digit seven segment display that can show error codes to the installation or service technician. This display can be controlled by the systems UEFI bios while booting, then by the operating system once available. A service checklist will be produced for system or sensor service based on error codes. Refer to appendix for the error codes.

### AUTOMOTIVE GPIO

The system will have general-purpose IO (GPIO) connections for monitoring vehicle functions or controlling peripherals. For example, an input may be used to track the state of a vehicle door via a simple switch, or . Alternatively, the fleet edge system could control an indicator light on the vehicle dashboard via a GPIO output.

4 GPIO Inputs and 4 GPIO outputs will be available for monitoring or driving vehicle systems. All GPIO connections will be isolated from the mainboard. Inputs should track the digital state of the input as either 0V for FALSE or 7-20V for TRUE. GPIO Outputs should have relays capable of switching 20A@12V up to 200k cycles.

### OTHER I/O

- CAN (currently via DB-9 connector, Amazon will review). 250kbps or 125kbps
- HDMI-out for system bring up and test only.
- 4x USB ports
- 1 Automotive ethernet port via Marvell 88Q2122 and TE MATENET 9-2304372-9 connector
- 1 Standard ethernet port (or drop and use usb→ethernet for npi?)

## System Power-on Timing

### hardware components

There are several hardware components involved in the power-on sequencing of the Fleet Edge system:

**supervisor MCU -** The supervisor microcontroller (MCU) is directly connected to the vehicle battery and is always on. It has very low power sleep modes and hardware watchdog monitoring to ensure it does not crash or deplete the vehicle battery. The supervisor MCU has several input sensors from which it can determine the status of the vehicle and as an output it controls a virtual power button to the main compute portion of the motherboard. Therefore it can monitor the vehicle state and turn on or off the high power compute subsystem based on the vehicles status. Two examples of this control are powering down the computer when the battery voltage is low or deciding to not power up the computer because the air temperature is too high.

**Ignition signal -** The ignition signal is a wire connected to the vehicle that supplies 12V when the key is in the active state.Note that it is possible to engage the ignition with the key without starting the engine. This ignition signal is connected to the supervisor MCU. The state of the ignition signal is also connected to the Fleet Edge mainboard, so the operating system can monitor the state of the ignition switch and make decisions independent of the supervisor MCU.

**Battery voltage -** The Superisor MCU and the operating system can monitor the battery voltage directly via a analog-to-digital converter. The supervisor MCU uses this voltage to make decisions on powering up or down the compute subsystem, and the Operating System monitors this voltage and can decide how to manage it's power consumption. The Operating System derives a state from the battery voltage being over 13.8V that indicates that the engine is running and the alternator is working correctly. Only in this state will the full compute resources be engaged. When the engine is off but the ignition switch is on — for example when the vehicle is being loaded with the radio playing— the OS will keep the system in a 'low power' state for some time before powering down.

### TIMING PARAMETERS

There are several configurable timings that control the power-on sequencing. They are described here with their current default values. Note that these values can change as the project evolves.

**Igntion on to system power on (10 second default) -** this is the amount of time between assertion of the ignition signal and the supervisor MCU pressing the virtual power button on the compute subsystem. The intent of this timing is to allow the vehicle some time to get up and running before applying the load of the Fleet Edge system. Specifically, on ICE vehicles this timer will prevent the system from powering on while the engine is cranking.

**Ignition off to system power down (3 minute default) -** the time from when the vehicle ignition is switched off to the time the supervisor MCU pushes the virtual power button to deactivate the compute system. This parameter is important for keeping the Fleet Edge system from powering down when the vehicle is parked briefly between delivery stops. An analysis of average package delivery interval determined that around 90% of all stops would be covered with a 3 minute interval.

**Overnight system wake time (0200 default) -** the supervisor MCU has the ability to wake the compute system at a certain time of day. The compute system would be able to see that the ignition was not enabled and therefore stay in a low-power mode. It can also track the ICE battery voltage to ensure the battery is not drained below safe limits.

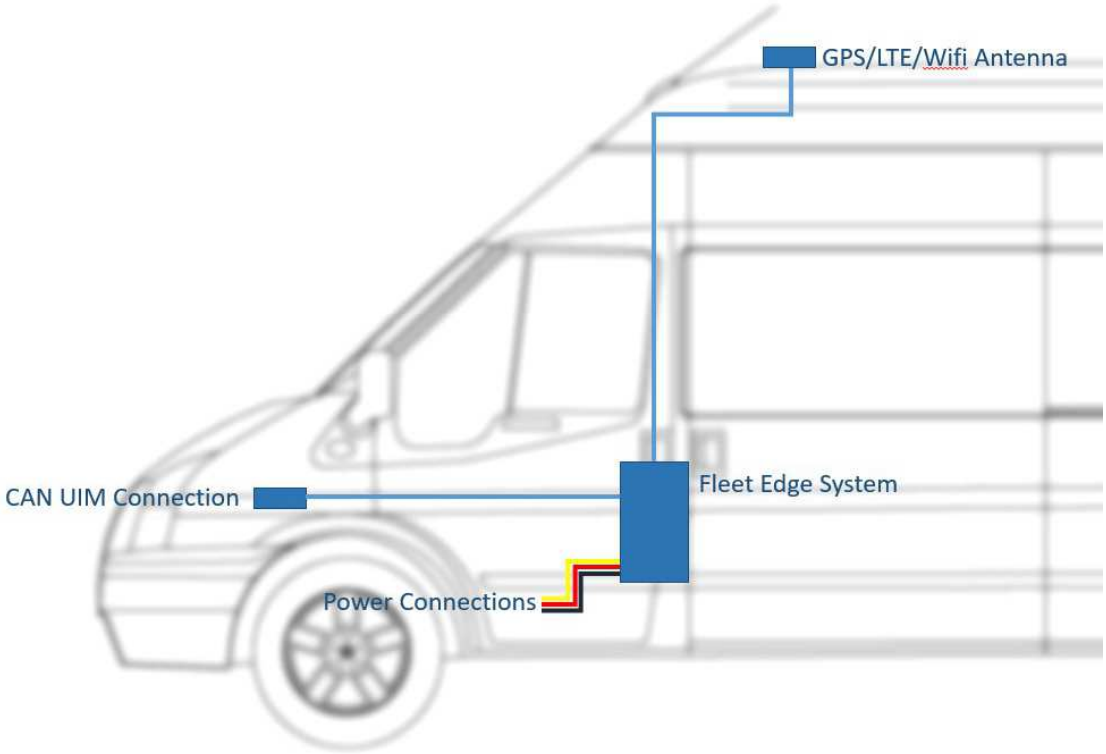
## AI Hardware

The Fleet Edge system will include hardware processors specifically designed for machine-learning tasks. To achieve the system design goal of allowing for multiple independent ML tasks running on the system, multiple small Visual Processing Units (VPUs) are preferred over a single monolithic GPU-style processor.

## GPS Interface

Fleet Edge uses a Precision GNSS module from Swift Navigation.

GPS module antenna connectors will be routed through the motherbaord and terminated with Fakra connectors on the interface panel.




**CAN**

The preferred CAN interface for 2020 will be to use the custom UIM firmware developed by the OEM to provide a private CAN network for Amazon devices. This configuration would supply all the information required by the Fleet Edge system while ensuring vehicle safety and reliability. If present, the Amazon private interface connector will be located in the dashboard in front of the passenger seat. A CAN-certified shielded twisted-pair cable will be run from that location to the PC's DB-9 connector. The private Amazon network is currently being explored for Ford vehicles, and the same interface will need to be developed for other OEMs.

For installations that occur before the Amazon-private network is ready, the Fleet Edge system can connect directly to the UIM module in Ford vehicles. The UIM location is the same as the Amazon private network hub so the only wiring change would be the connector.

## ANTENNA

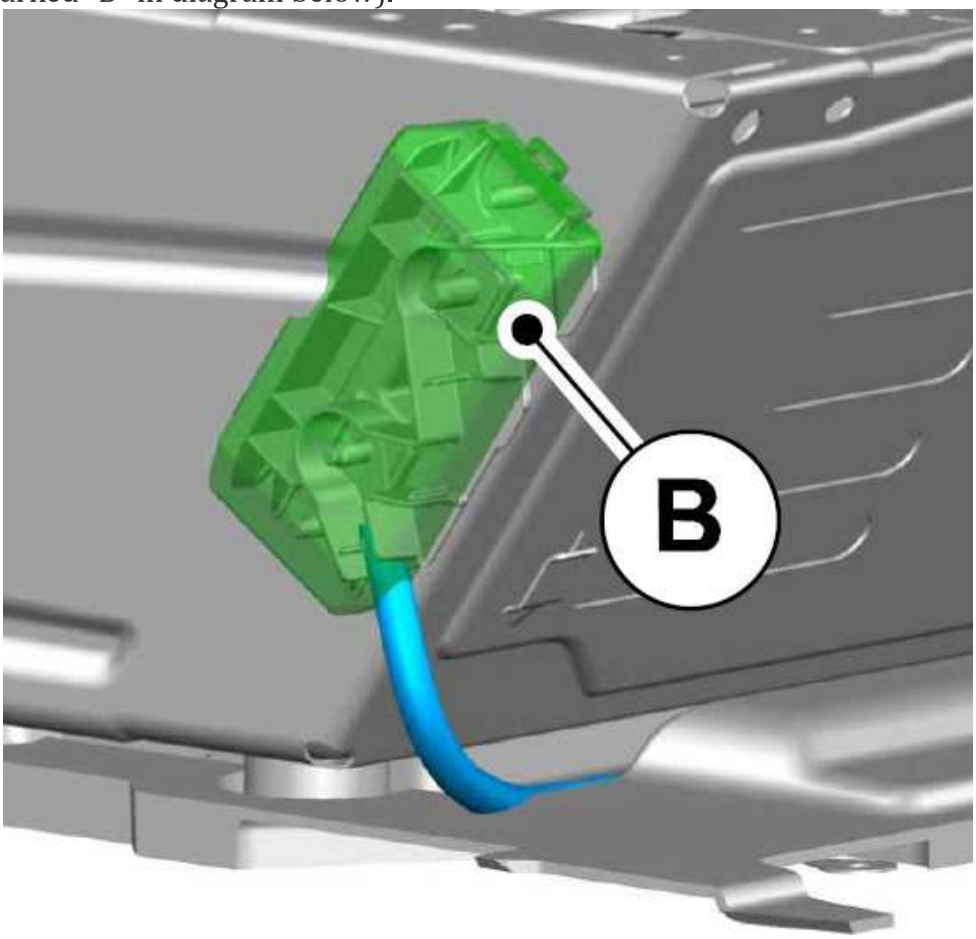
The antenna will be roof-mounted for best GPS performance in urban environments. The mounting procedure requires drilling of a 1" hole in the sheet metal roof, the sealing of the exposed metal, feeding the cables through the hole and tightening with adhesive. The Fleet Edge team is working with the vehicle OEM and upfitters to ensure the integrity of the installation.

For best performance, the GPS antenna should be mounted on a flat surface, parallel to the ground. If separate, the LTE antenna should be mounted as flat as possible, but it does not have the same importance as the GPS antenna. If separate, the two antennas will need to be spaced apart by some minimum amount.

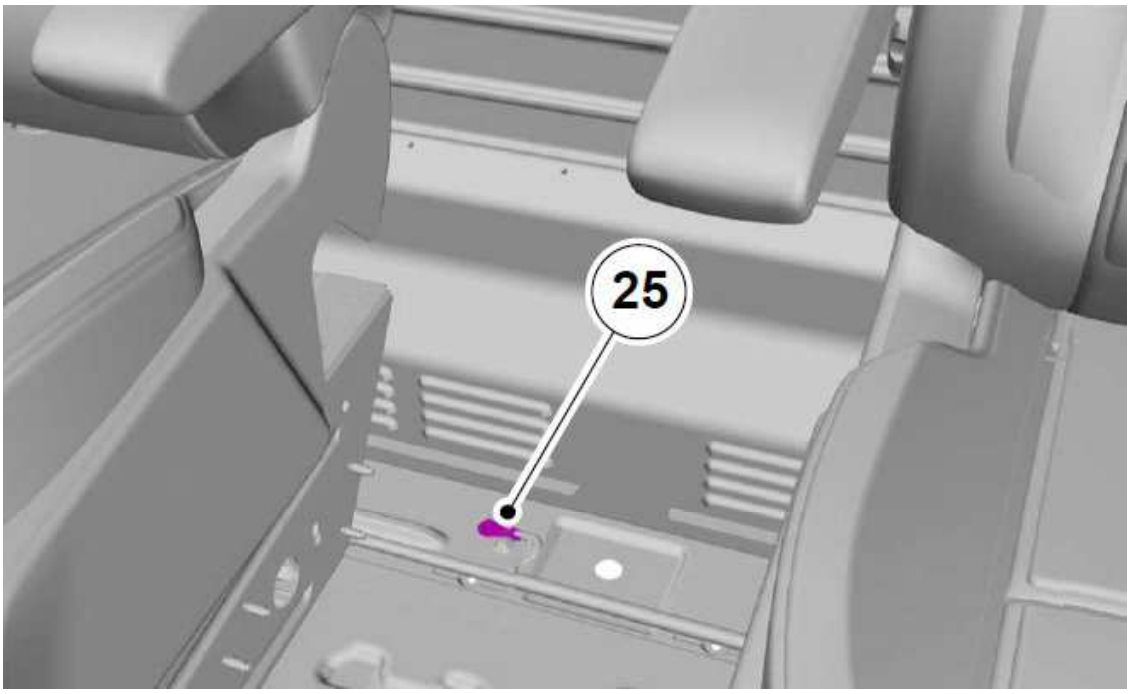
## POWER

The power interface consists of three signals, +12V, Ground and Ignition.

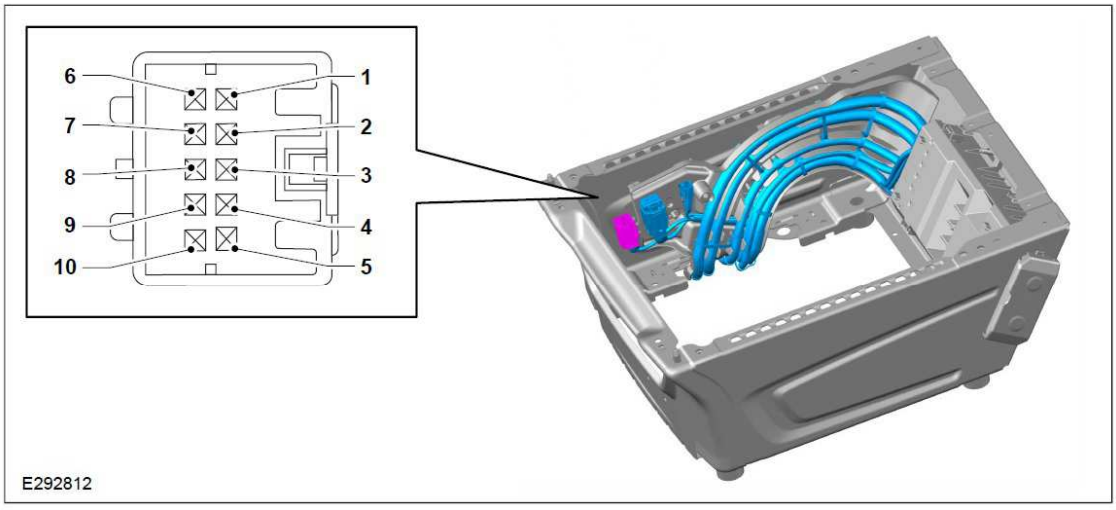
All of the vehicle types provide a +12V stud connection for use by upfitter applications. The Fleet Edge wiring harness includes a power wire a 6mm ring terminal for interfacing with the +12V CCP1 post (marked “B” in diagram below).




The ground wire will have a similar eyelet connector for connecting to one of the vehicles provided ground studs.




The ignition signal will come from a vehicle-specific connection point. For Ford vehicles it can be reached via the 10-pin connector located under the driver seat. Fleet Edge systems provisioned for Ford Transit vehicles will be shipped to the installer including this connector for quick installation.



## Appendix: Power on procedure and Error Codes.

**Power on procedure:**

1. Connect Fleet Edge box with ethernet cable and LTE/Wi-Fi Antenna then turn on the PC power switch.
2. Wait approximately 3 minutes for DV units for completion of the initialization process as indicated by the code. If 'U9' is shown, the system initialization has already been successfully and no issue detected as part of diagnostic process.
3. If a code other than U9 is shown follow the debugging guide for the correction procedure. Log the error code for reporting to Amazon.
4. Turn off the PC during repair. After a repair has been completed, turn the system on again and repeat from step 1.

**Error Codes:**

| Code | Description | Action |
|---|---|---|
| H1 | Failed to detect GNSS Module on Fleet Edge system | GNSS_MODULE_FAIL |
| H3 | Fleet edge system is able to detect GNSS Module but failed to read any data from socket. | GNSS_MODULE_FAIL |
| H4 | Failed to detect LTE Module on Fleet Edge system | LTE_MODULE_FAIL |
| H5 | Failed to detect SIM inside LTE Module | SIM_NOT_PRESENT |
| H6 | SIM is not activated | REPLACE_SIM_CARD |
| H7 | SIM is active but Fleet Edge is not able access internet via LTE Module | REPLACE_SIM_CARD |
| H8 | Fleet Edge system is not able to access internet. | NO_INTERNET_ACCESS |
| H9 | Fleet Edge system is not able to access TPM Module or unable to take the ownership. | TPM_MODULE_FAIL |
| HA | Failed to detect Wi-Fi module on Fleet Edge system | WIFI_MODULE_FAIL |
| HB | Fleet Edge system is not able to explore any Wi-Fi network using Wi-Fi Module | WIFI_MODULE_FAIL |
| HC | Failed to detect VPU on Fleet Edge system | VPU_MODULE_FAIL |
| HD | Fleet Edge system detected hard disk error during deep checks. | SSD_MODULE_FAIL |
| HE | Fleet Edge system unable to update software and currently in unstable state. | RE_INSTALL_OS |
| L1 | Intermediate error code. | Wait for final status |

**Error Corrections:**

- **GNSS_MODULE_FAIL:** The PC is unable to communicate with GNSS module. Suggested action is replacing the GNSS module or verify internal connection.
- **LTE_MODULE_FAIL:** The PC is unable to communicate with LTE module. Suggested action is replacing the LTE module or verify internal connection.
- **SIM_NOT_PRESENT:** The PC is unable to detect SIM card in LTE module. Suggested action is to verify if SIM card is present in LTE module or not. If it is present then replace the SIM card.
- **REPLACE_SIM_CARD:** The PC is unable to communicate with SIM card using LTE module. Suggested action to replace the SIM card.
- **TPM_MODULE_FAIL:** The PC is unable to communicate with TPM module. Suggested action to replace the TPM module on main board. If there are no issue with TPM then clear the TPM using BIOS and reinstall Amazon OS.
- **WIFI_MODULE_FAIL:** The PC is unable to communicate with Wi-Fi module. Suggested action to replace the Wi-Fi module or verify internal connections.
- **VPU_MODULE_FAIL:** The PC is unable to communicate with Movidus module. Suggested action to replace the Movidus module or verify internal connections.
- **SSD_MODULE_FAIL:** The PC has detected critical errors while performing deep checks on SSD. Suggested action to replace the SSD and reinstall Amazon OS image again.
- **RE_INSTALL_OS:** Fleet Edge box is currently in unstable state. Suggested action to reinstall Amazon OS again and connect to internet again
- **NO_INTERNET_ACCESS:** Fleet Edge box is not able to access internet. Suggested action to check ethernet connection and reboot the machine.

# Federal Communication Commission Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

**FCC Caution:**

- Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.
- This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

**This device meets all the other requirements specified in Part 15E, Section 15.407 of the FCC Rules.**

**Radiation Exposure Statement:**

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.