



about.datadrivenucsb.com

Development Team



Arjun Vinod

Web App
PCB Design



Brian Li

PCB Design
Enclosure Design



Nicholas Tran

Firmware
Backend



Bryan Olivares

Frontend
Backend Infra



Hyun Kyum Kim

Frontend
Backend Infra



Problem Statement

Lost in Translation



Lost in Translation

Cars already talk to us with colorful and creative icons on the dash



Lost in Translation

Cars already talk to us with colorful and creative icons on the dash

But for a team, this **single stream** of information is a **bottleneck**



Lost in Translation

Cars already talk to us with colorful and creative icons on the dash

But for a team, this **single stream** of information is a **bottleneck**



Lost in Translation

Cars already talk to us with colorful and creative icons on the dash

But for a team, this **single stream** of information is a **bottleneck**

The operator of this vehicle has the additional responsibility for **gathering**, **organizing**, and **storing** this data



Lost in Translation

Cars already talk to us with colorful and creative icons on the dash

But for a team, this **single stream** of information is a **bottleneck**

The operator of this vehicle has the additional responsibility for **gathering**, **organizing**, and **storing** this data

Most importantly, to develop **insights** using this data





Proposed Solution

End-to-End Vehicle Data Tracking



End-to-End Vehicle Data Tracking

Collect live vehicle data



[12.345°N, 21.345°W, 45 mph, 70°F, ...]

[37.375°N, 19.345°W, 47 mph, 67°F, ...]

[47.342°N, 17.345°W, 55 mph, 57°F, ...]

End-to-End Vehicle Data Tracking

Collect live vehicle data

Upload it to the cloud



- [12.345°N, 21.345°W, 45 mph, 70°F, ...]
- [37.375°N, 19.345°W, 47 mph, 67°F, ...]
- [47.342°N, 17.345°W, 55 mph, 57°F, ...]

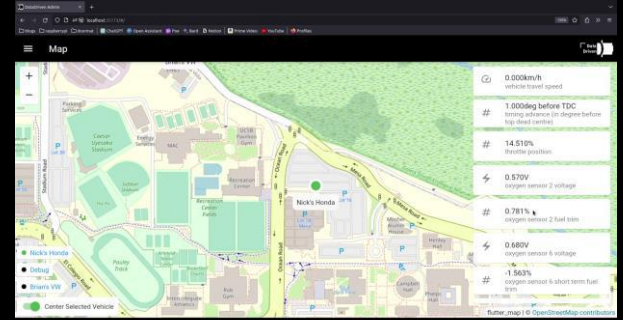
End-to-End Vehicle Data Tracking



Collect live vehicle data

Upload it to the cloud

Serve to the user



[12.345°N, 21.345°W, 45 mph, 70°F, ...]

[37.375°N, 19.345°W, 47 mph, 67°F, ...]

[47.342°N, 17.345°W, 55 mph, 57°F, ...]





Tracker Module Installation

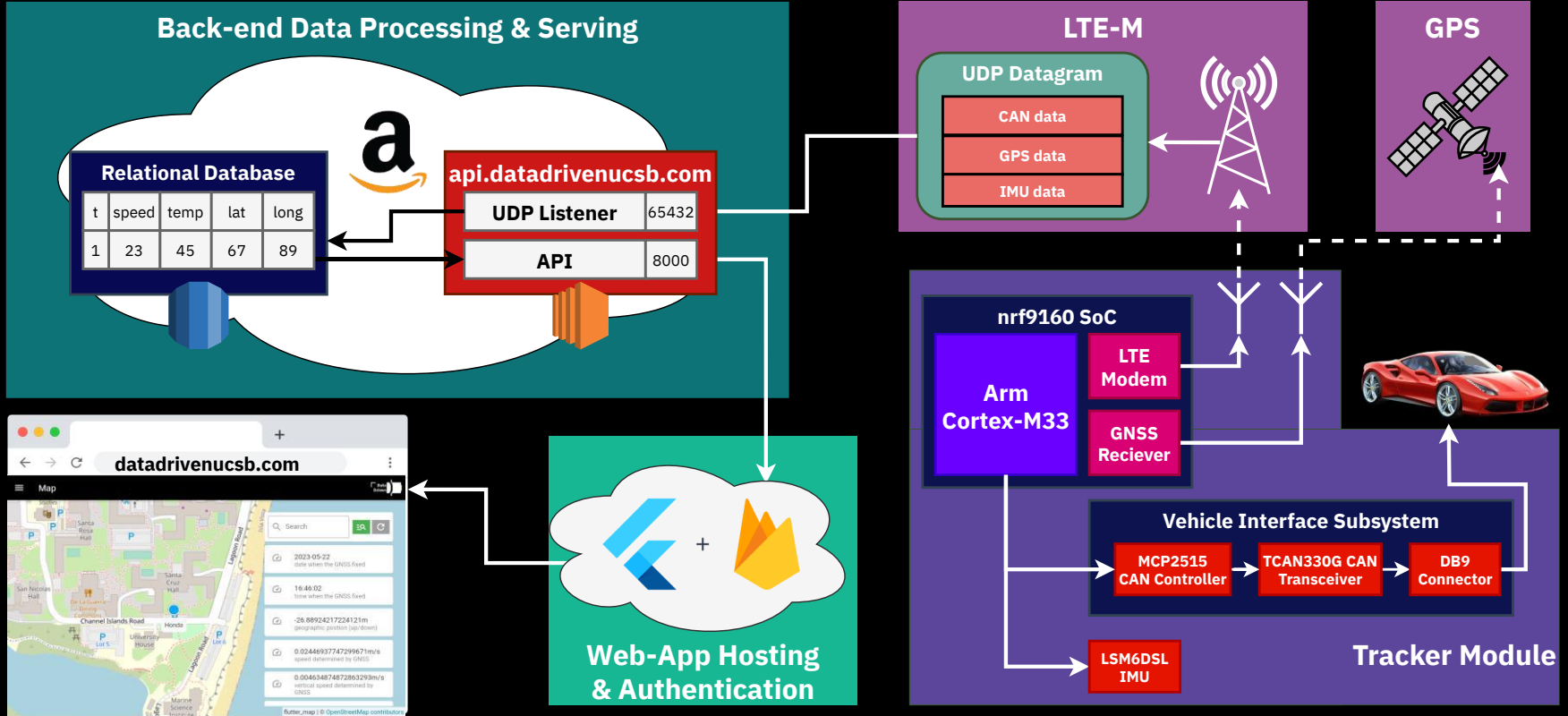


Web App Overview



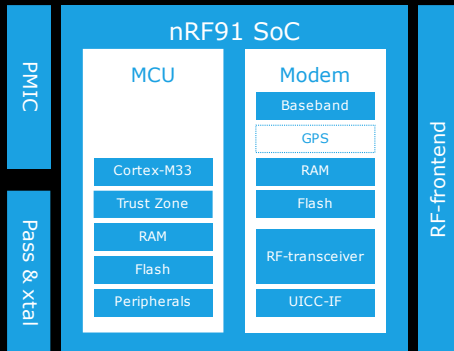
Implementation Details

System Block Diagram



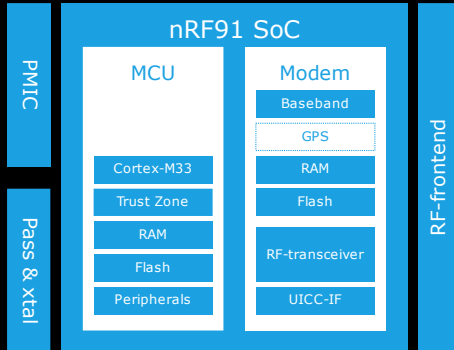
Location Data

GPS data is embedded in a PVT (Position/Velocity/Time) frame fetched periodically from the microcontroller's built-in GPS/LTE modem



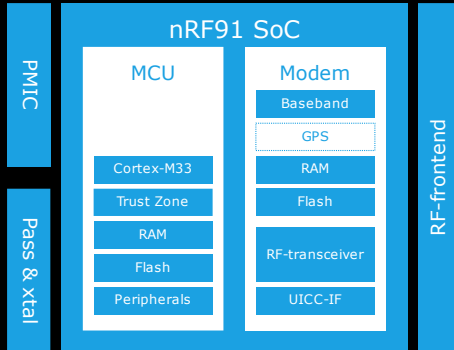
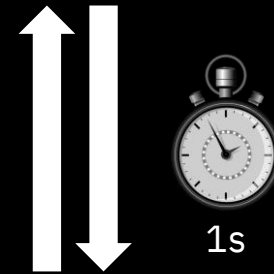
Location Data

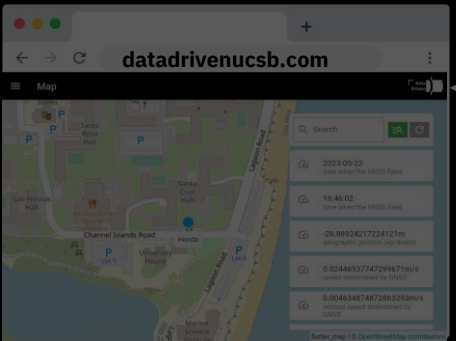
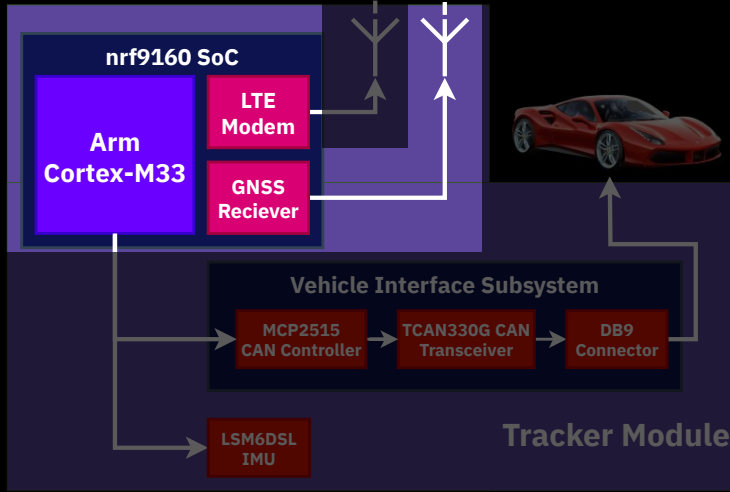
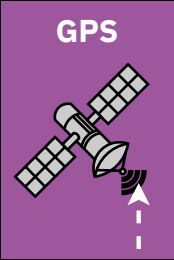
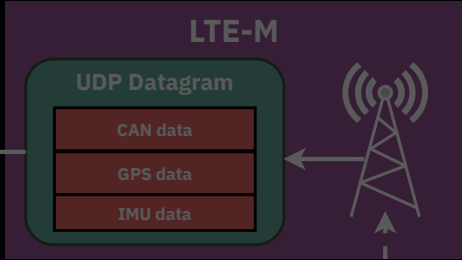
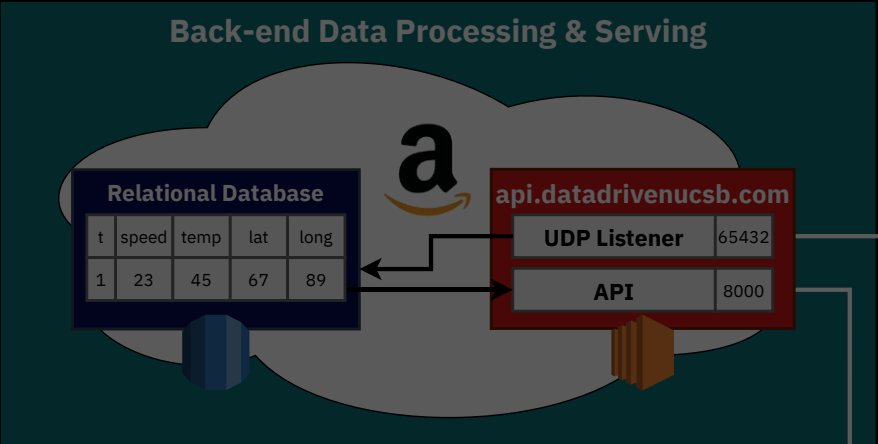
GPS data is embedded in a PVT (Position/Velocity/Time) frame fetched periodically from the microcontroller's built-in GPS/LTE modem



Location Data

GPS data is embedded in a PVT (Position/Velocity/Time) frame fetched periodically from the microcontroller's built-in GPS/LTE modem







Vehicle Diagnostic Data

Diagnostic data is extracted from the car via the OBD-II diagnostic port

Vehicle Diagnostic Data

Diagnostic data is extracted from the car via the OBD-II diagnostic port



Vehicle Diagnostic Data

Diagnostic data is extracted from the car via the OBD-II diagnostic port

Data includes:



Vehicle Diagnostic Data

Diagnostic data is extracted from the car via the OBD-II diagnostic port

Data includes:

- Speed
- Engine RPM



Vehicle Diagnostic Data

Diagnostic data is extracted from the car via the OBD-II diagnostic port

Data includes:

- Speed
- Engine RPM
- Fuel Level
- Engine Load



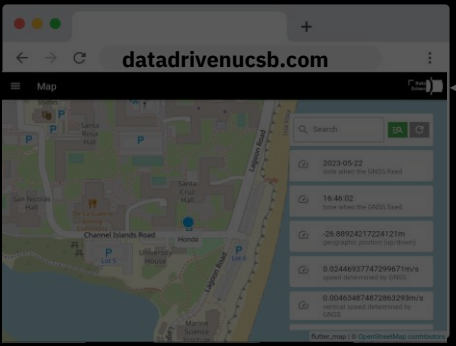
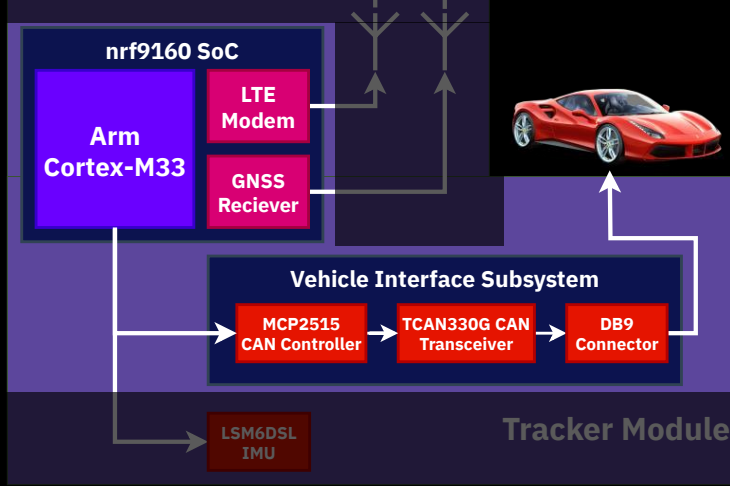
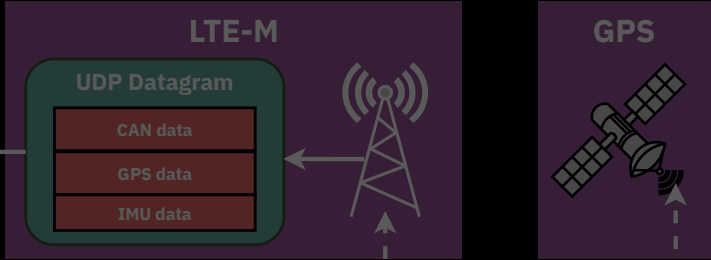
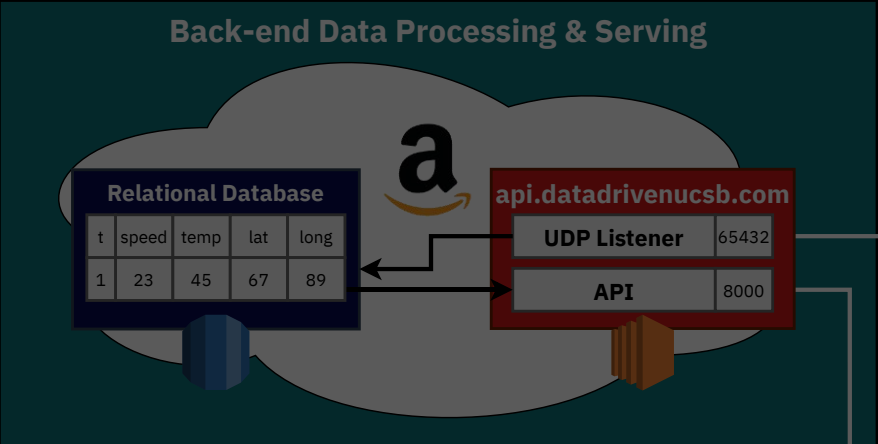
Vehicle Diagnostic Data

Diagnostic data is extracted from the car via the OBD-II diagnostic port

Data includes:

- Speed
- Engine RPM
- Fuel Level
- Engine Load
- Coolant Temperature
- Intake Air Temperature







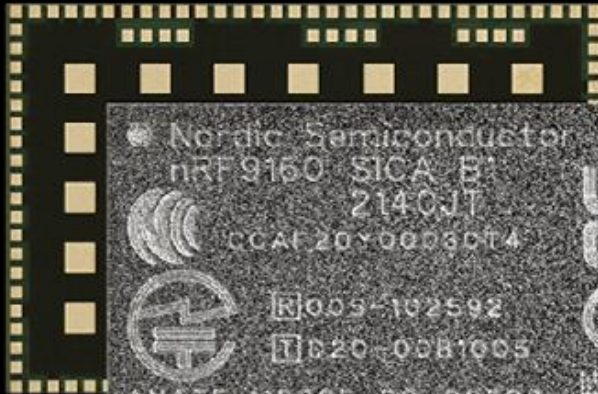
Uploading Data to the Cloud

Uploading Data

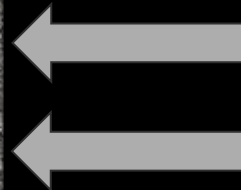


CAN Data: [0x11, 0x22, 0x33, 0x44, 0x55, 0x66]

Uploading Data



Nordic Semiconductor ASA
nRF9160 SICA B1
2140JT
CCAF 20Y00030T4
UK
CA
CE
005-102592
020-0081005
ANATEL:18295-20-08598
CMIIT D: 20200113308(M)
FCC ID: 2ANF000NRF9160
IC: 24529-NRF9160



CAN Data: [0x11, 0x22, 0x33, 0x44, 0x55, 0x66]

GPS Data: [05/22, 5:00PM, 34.41, -119.84, ...]

Uploading Data



CAN Data: [0x11, 0x22, 0x33, 0x44, 0x55, 0x66]

GPS Data: [05/22, 5:00PM, 34.41, -119.84, ...]

Accel/Gyro Data: [0, 0, 9.8] [0, 0, 0]

Uploading Data



UDP Datagram

CAN Data: [0x11, 0x22, 0x33, 0x44, 0x55, 0x66]

GPS Data: [05/22, 5:00PM, 34.41, -119.84, ...]

Accel/Gyro Data: [0, 0, 9.8] [0, 0, 0]

Uploading Data



**GPS/LTE
Modem**



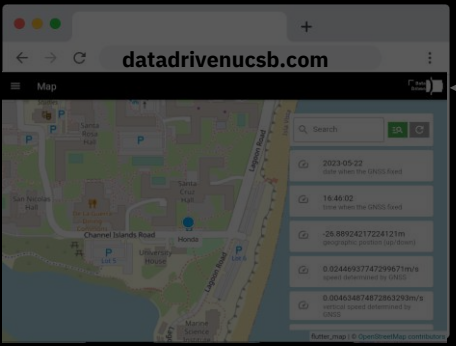
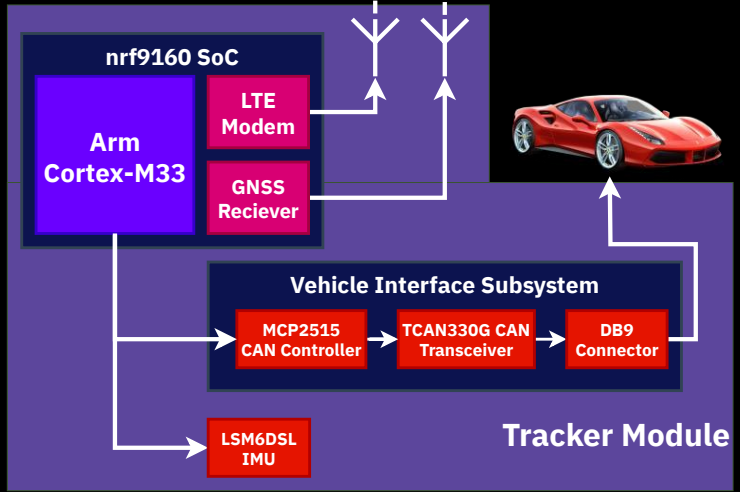
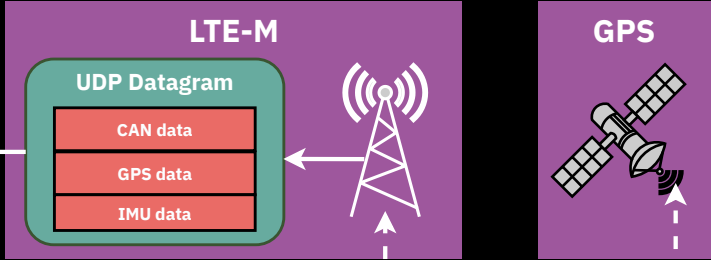
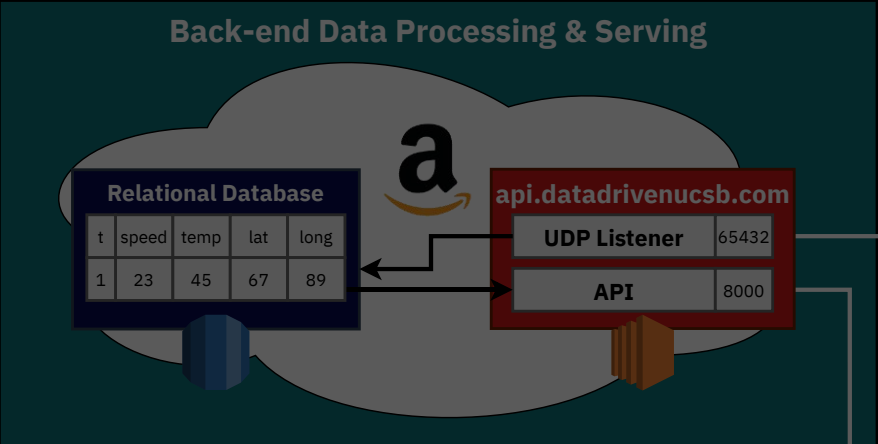
30s

UDP Datagram

CAN Data: [0x11, 0x22, 0x33, 0x44, 0x55, 0x66]

GPS Data: [05/22, 5:00PM, 34.41, -119.84, ...]

Accel/Gyro Data: [0, 0, 9.8] [0, 0, 0]





Processing Data in the Cloud

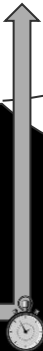
Processing and Persisting Data



UDP Listener
(Port 6543)



Amazon
EC2



GPS/LTE
Modem

UDP Datagram

CAN Data: [0x11, 0x22, 0x33, 0x44, 0x55, 0x66]

GPS Data: [05/22, 5:00PM, 34.41, -119.84, ...]

Accel/Gyro Data: [0.6, 19]

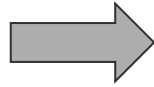
Processing and Persisting Data



UDP Listener
(Port 6543)



Amazon
EC2



Processed Data

CAN Data: [6 mph, 200 rpm, 14.22%, 44°F, 55s, 65°C]

GPS Data: [34.4094°N, 119.8434°W]

Accel/Gyro Data: [2 m/s², 0 m/s²]



GPS/LTE
Modem



UDP Datagram

CAN Data: [0x11, 0x22, 0x33, 0x44, 0x55, 0x66]

GPS Data: [05/22, 5:00PM, 34.41, -119.84, ...]

Accel/Gyro Data: [0.6, 19]

Processing and Persisting Data



UDP Listener
(Port 6543)



Amazon
EC2

Processed Data

CAN Data: [6 mph, 200 rpm, 14.22%, 44°F, 55s, 65°C]

GPS Data: [34.4094°N, 119.8434°W]

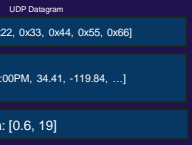
Accel/Gyro Data: [2 m/s², 0 m/s²]

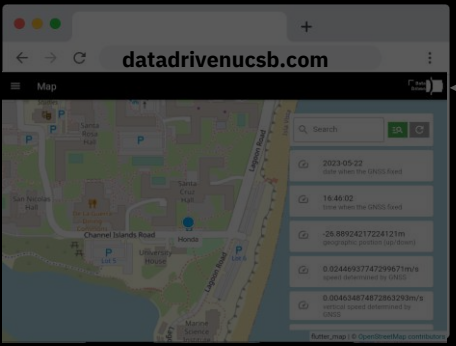
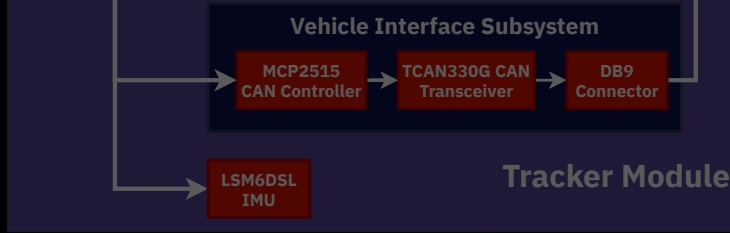
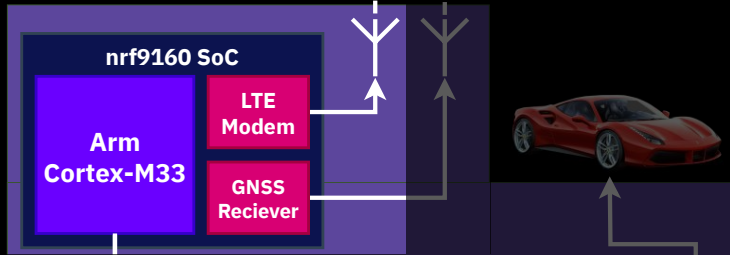
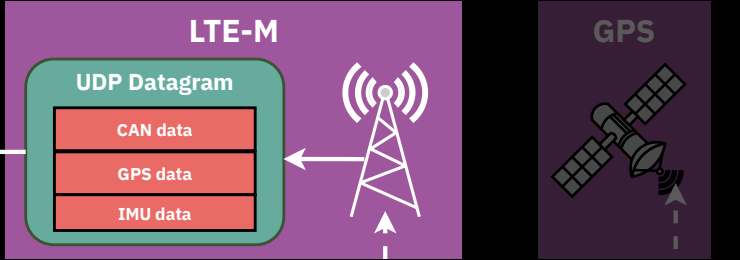
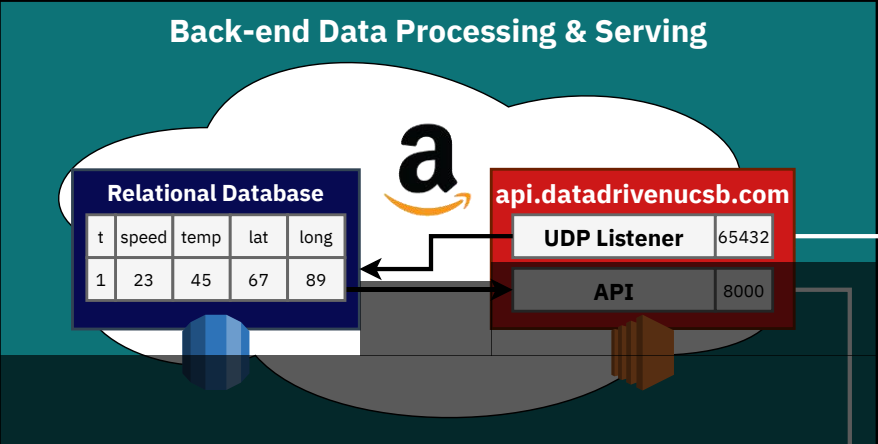


Amazon RDS



GPS/LTE
Modem







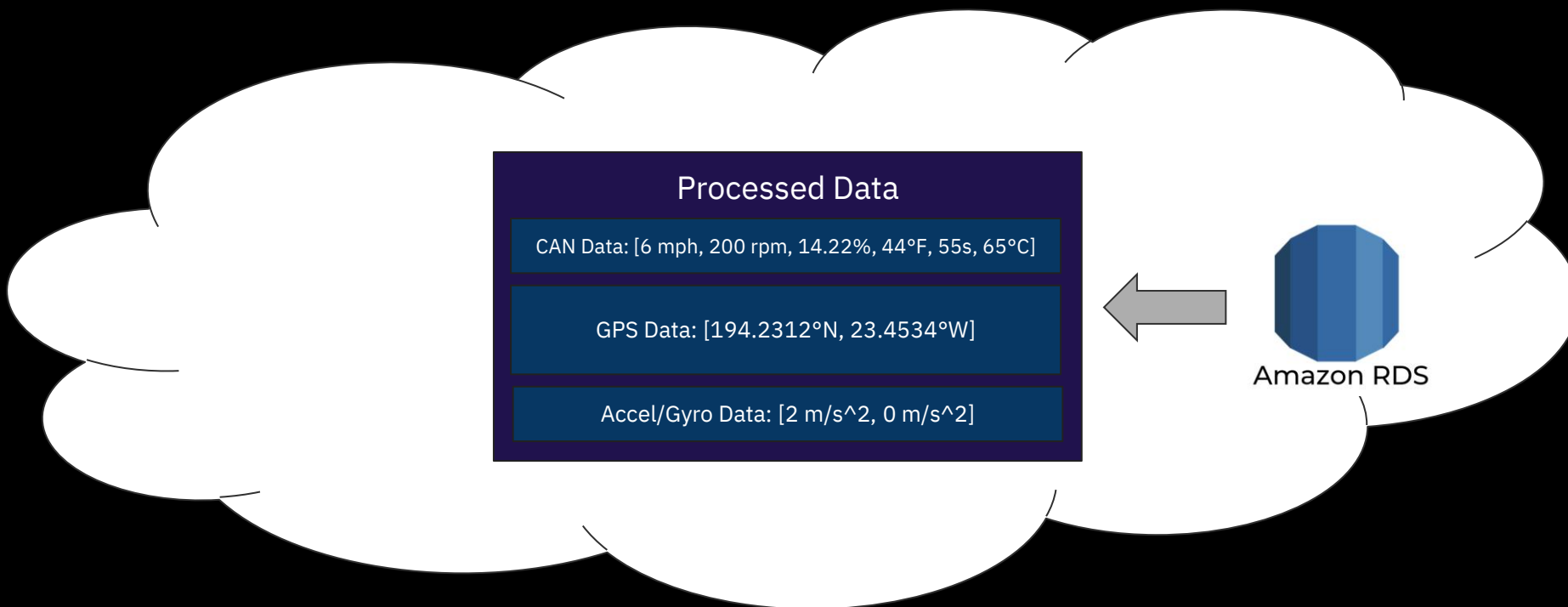
Serving Data to the User

Serving Data via API



Amazon RDS

Serving Data via API



Processed Data

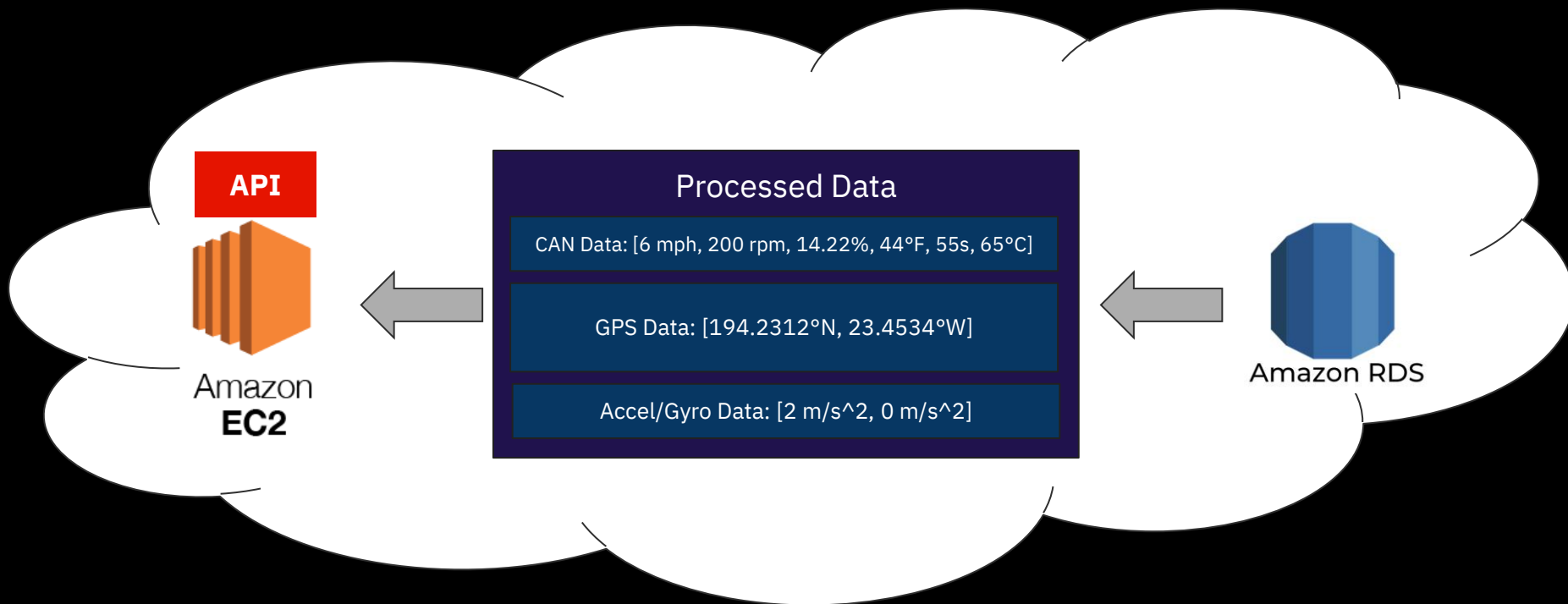
CAN Data: [6 mph, 200 rpm, 14.22%, 44°F, 55s, 65°C]

GPS Data: [194.2312°N, 23.4534°W]

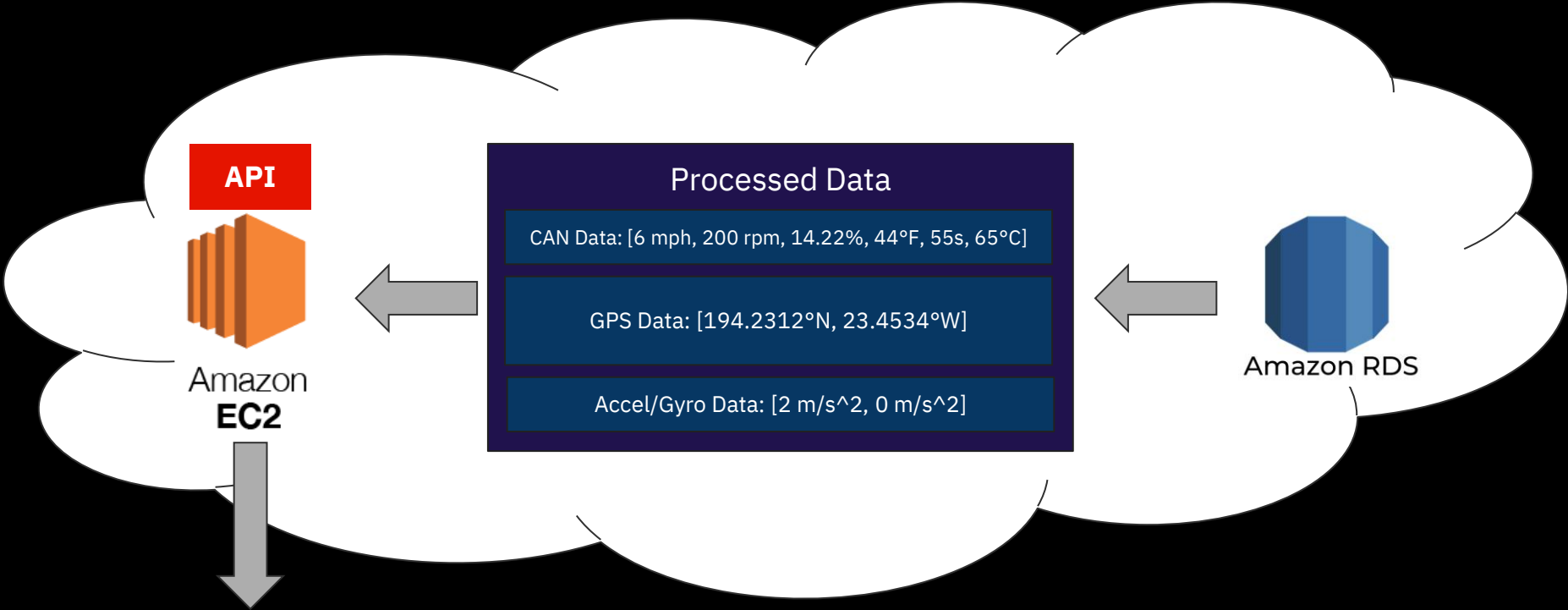
Accel/Gyro Data: [2 m/s², 0 m/s²]

Amazon RDS

Serving Data via API

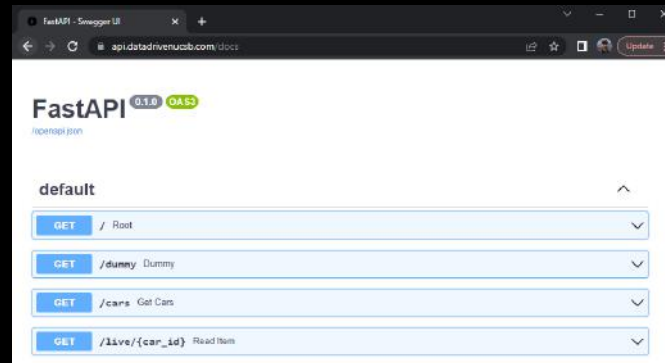
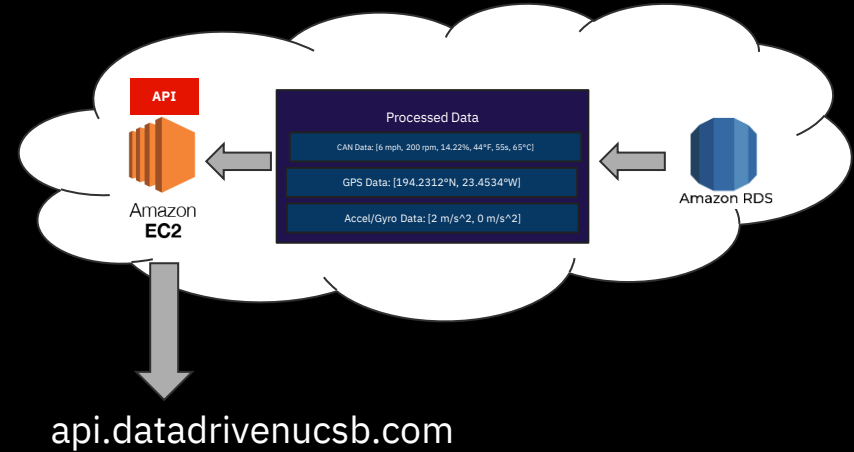


Serving Data via API

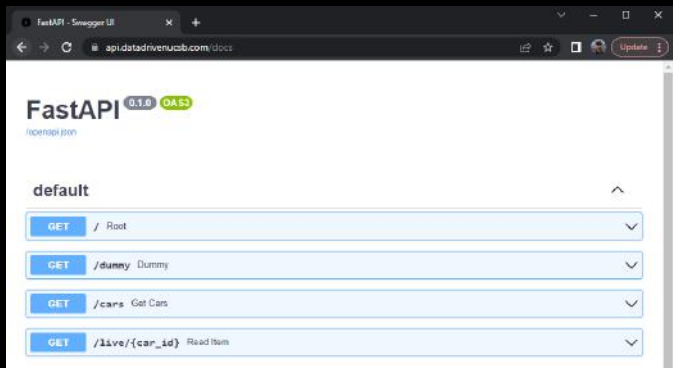
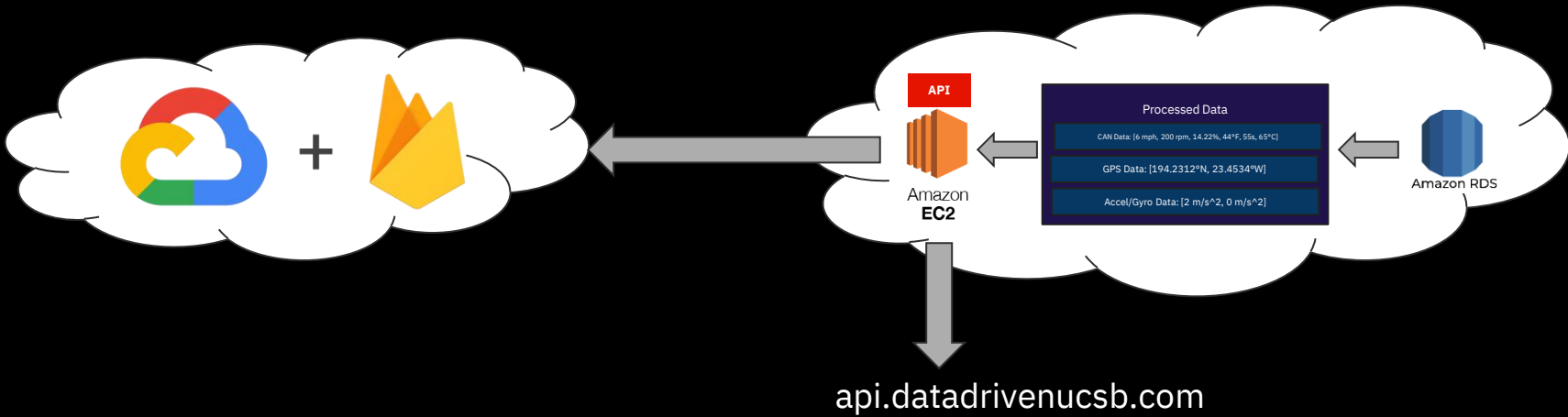


api.datadrivenucsb.com

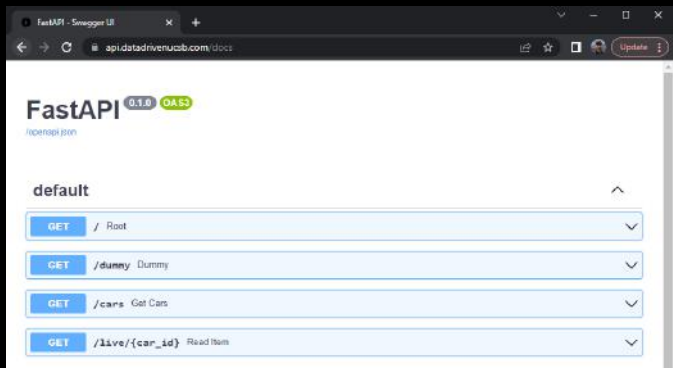
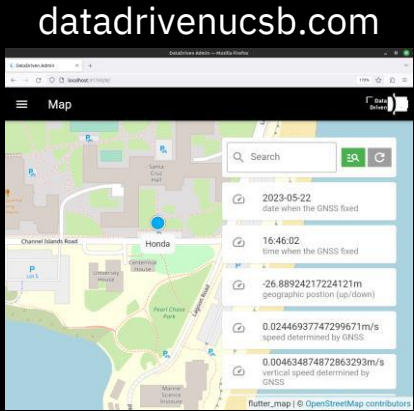
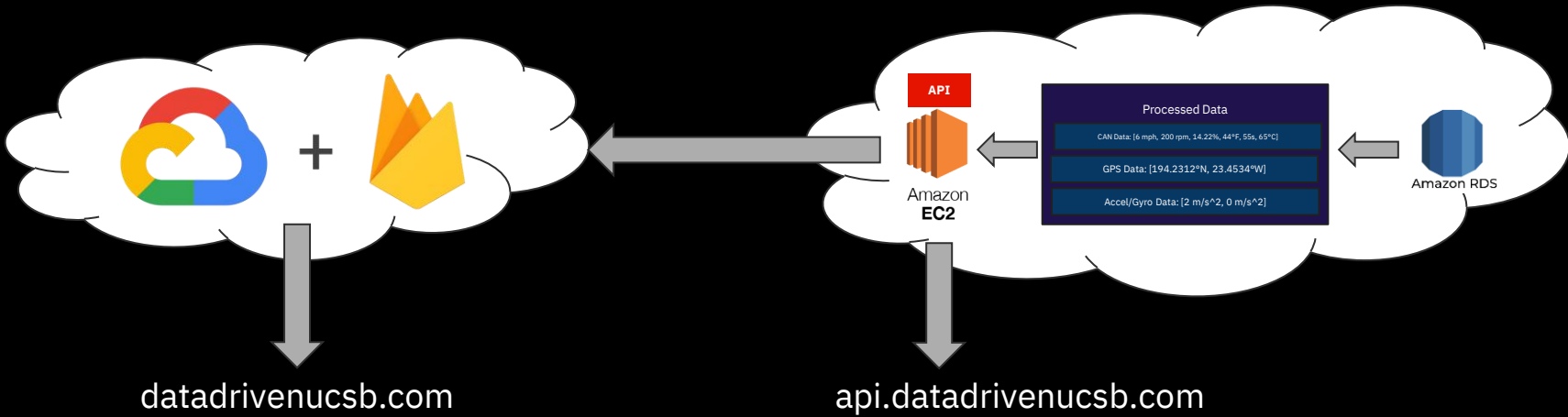
Serving Data to the Front-End

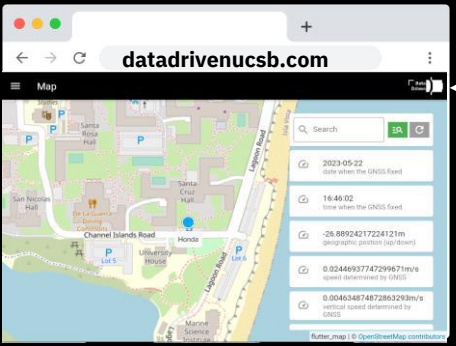
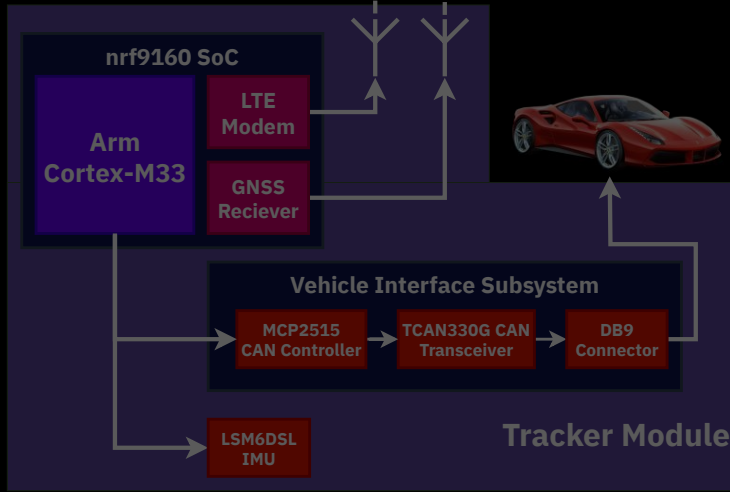
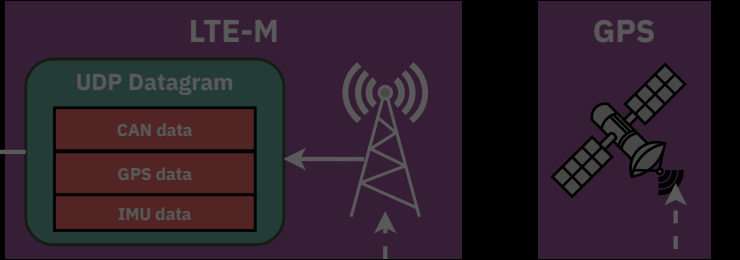
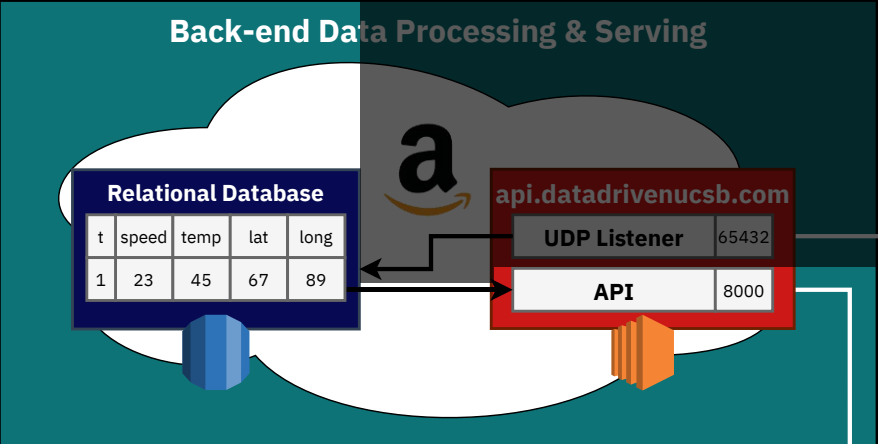


Serving Data to the Front-End



Serving Data to the Front-End







Web App

Web App: Live Tracking



Map

Search

2023-05-23
date when the GNSS fixed

11:27:51
time when the GNSS fixed

↶ 3.2237987518310547m
geographic position (up/down)

📏 0.022741438820958138m/s
speed determined by GNSS

📏 -0.01122748851776123m/s
vertical speed determined by

flutter_map | © OpenStreetMap contributors

Center Selected Vehicle

Nick's Honda

Brian's VW

Best Buy

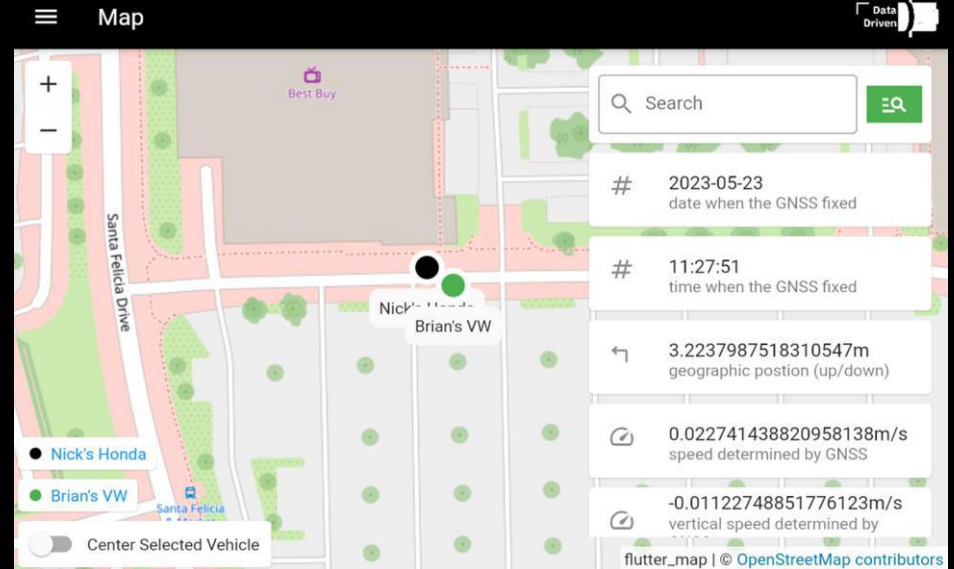
Santa Felicia Drive

Santa Felicia

Web App: Live Tracking



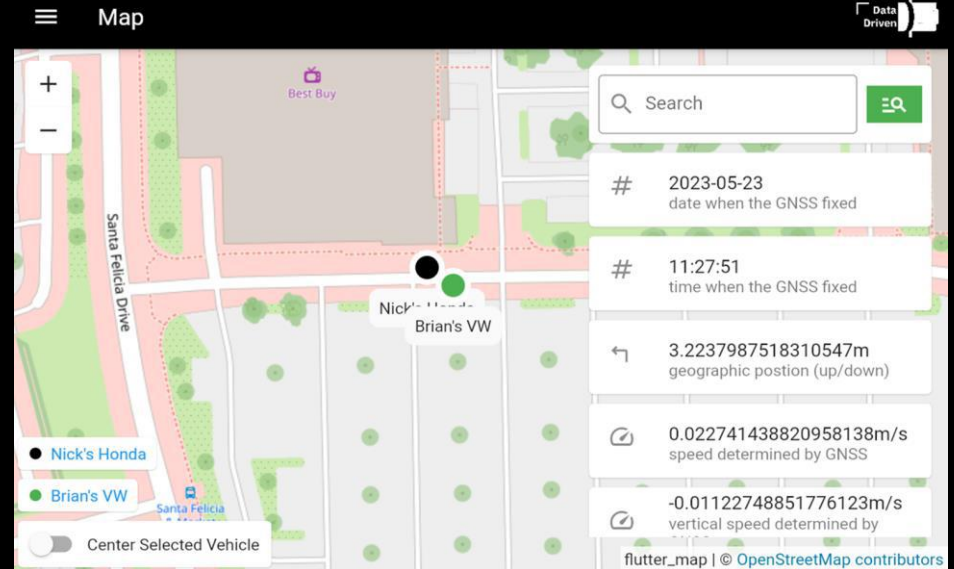
- **Track** vehicles live on an interactive map



Web App: Live Tracking



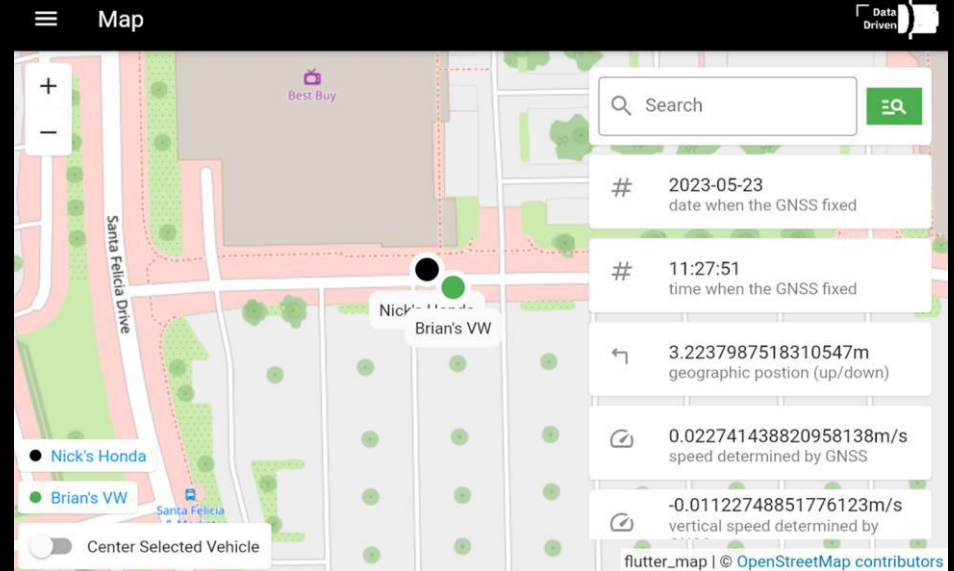
- **Track** vehicles live on an interactive map
- **Monitor** vehicle parameters live by selecting individual vehicles on the map



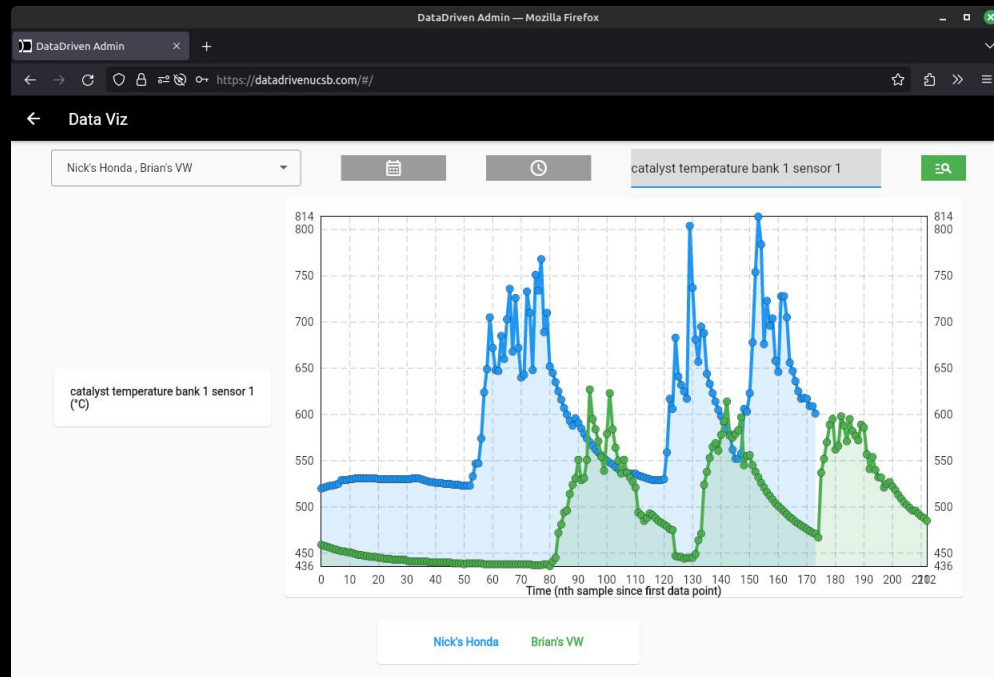
Web App: Live Tracking



- **Track** vehicles live on an interactive map
- **Monitor** vehicle parameters live by selecting individual vehicles on the map
- **Search** for parameters available from the dynamically populated sidebar



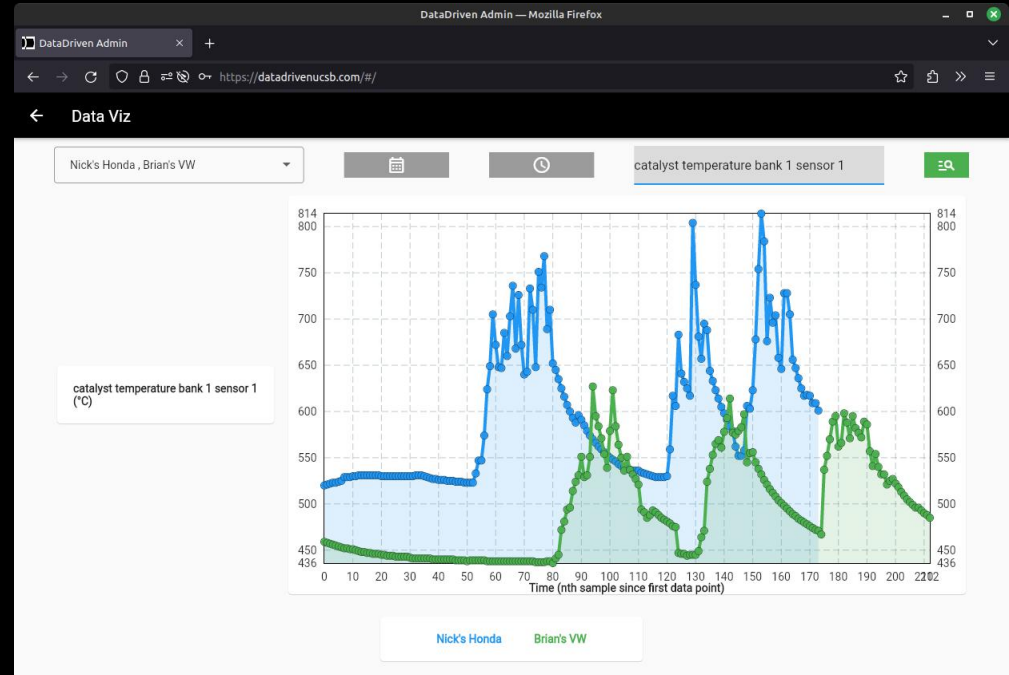
Web App: Data Visualization



Web App: Data Visualization



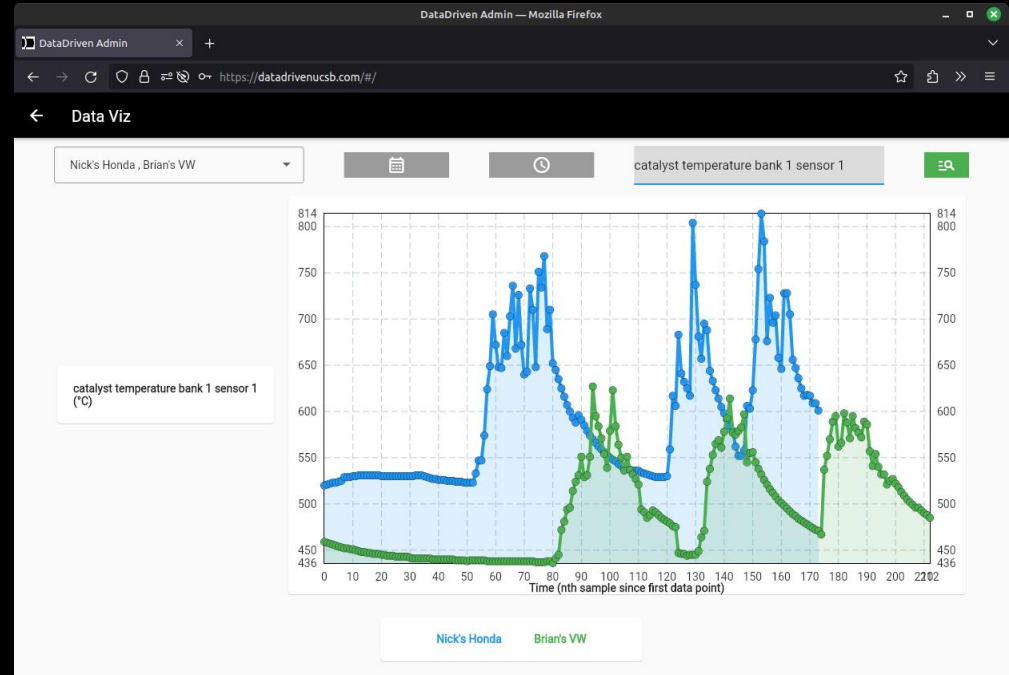
- **Plot** vehicle data parameters



Web App: Data Visualization



- **Plot** vehicle data parameters
- Supports selecting **multiple vehicles** for **comparing** data parameters in a date range



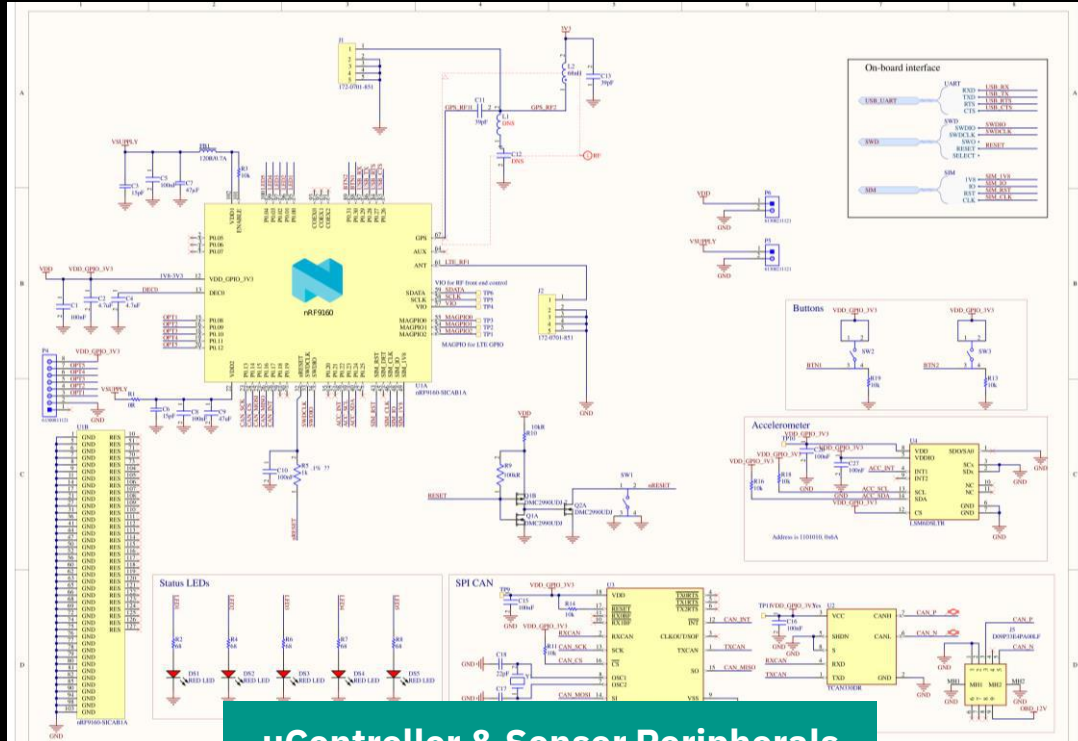


PCB Design

Schematics

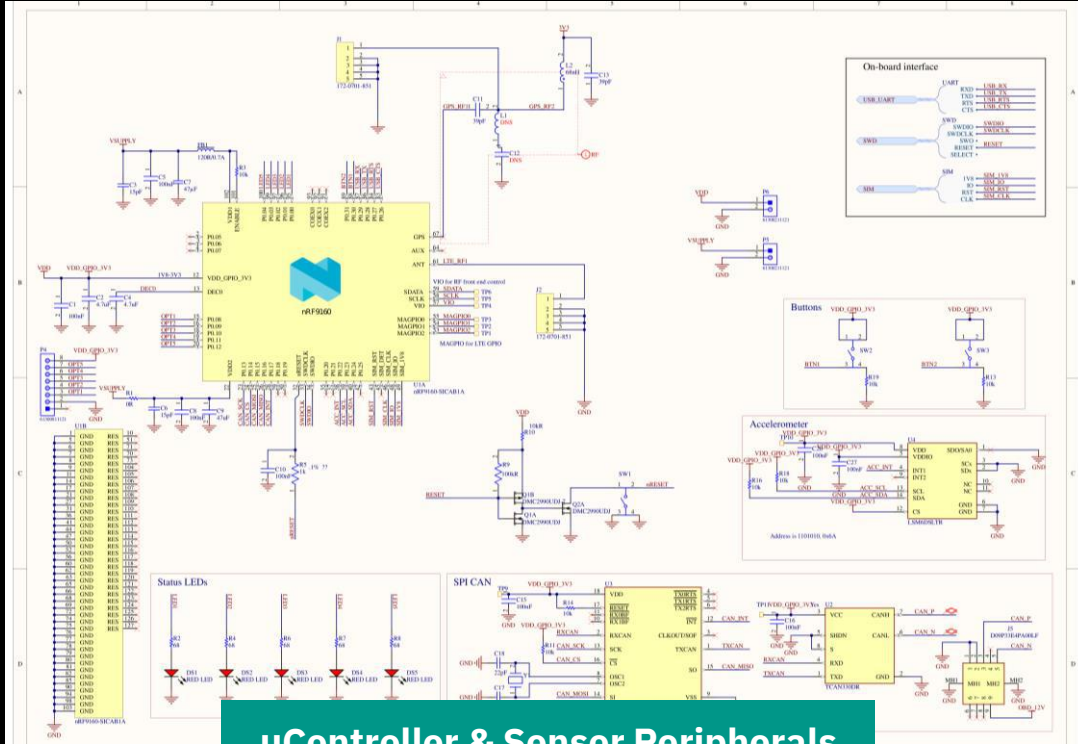


Schematics

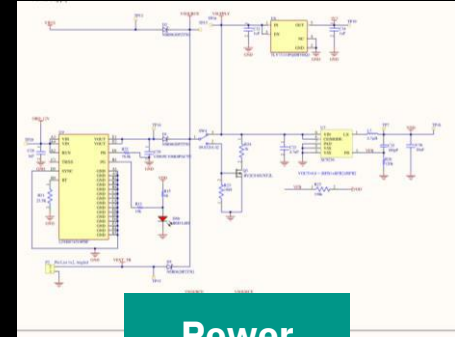


µController & Sensor Peripherals

Schematics

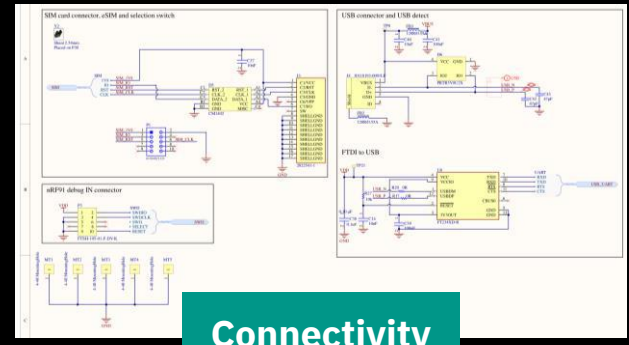
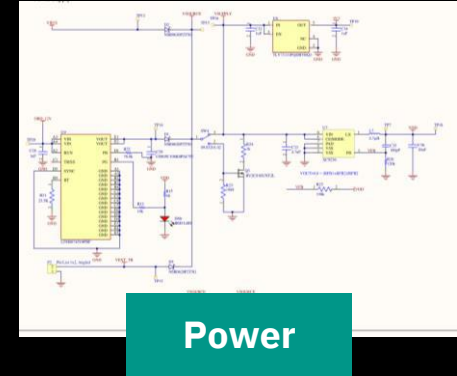
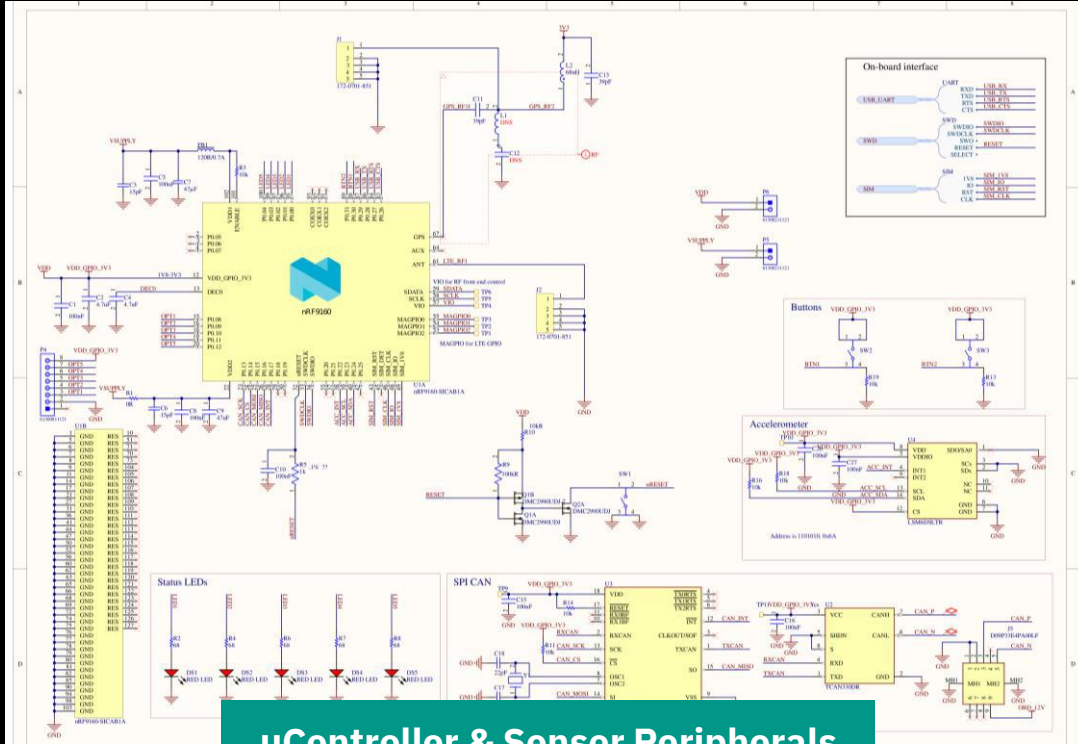


µController & Sensor Peripherals

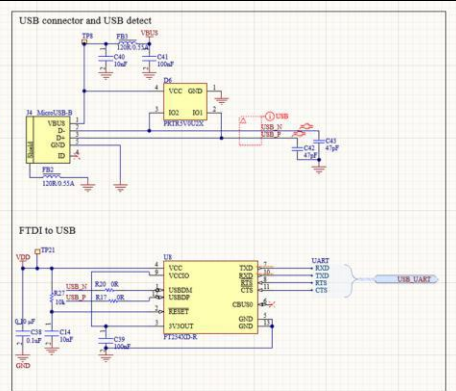
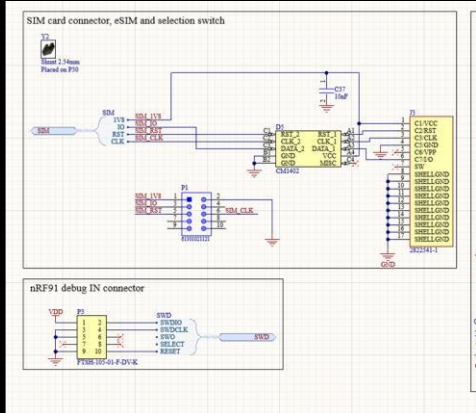
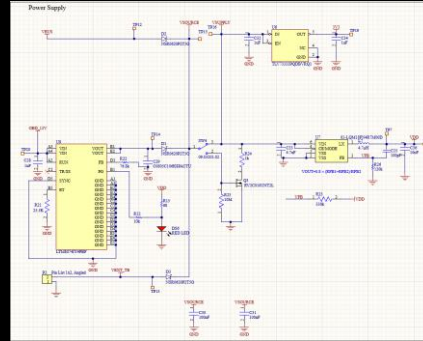
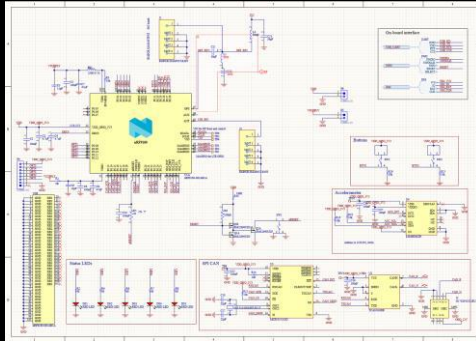


Power

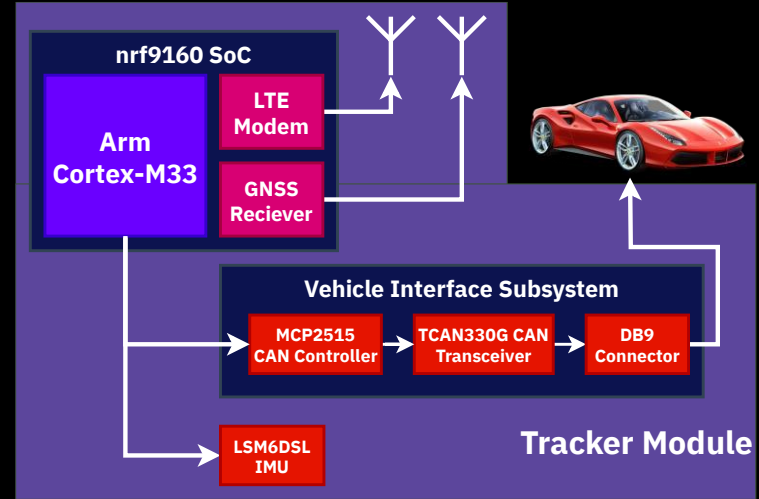
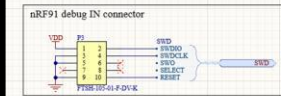
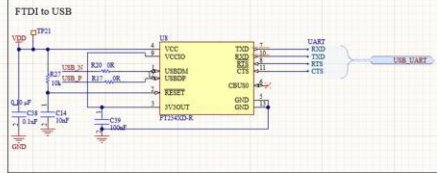
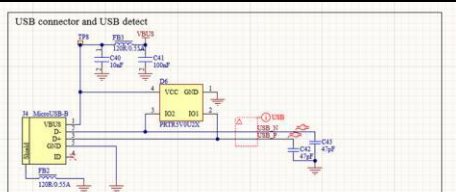
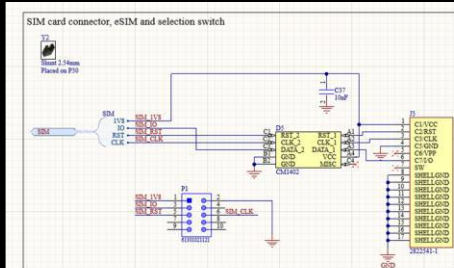
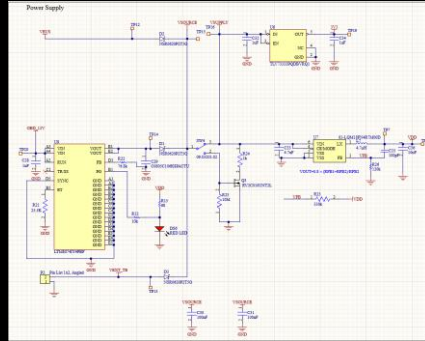
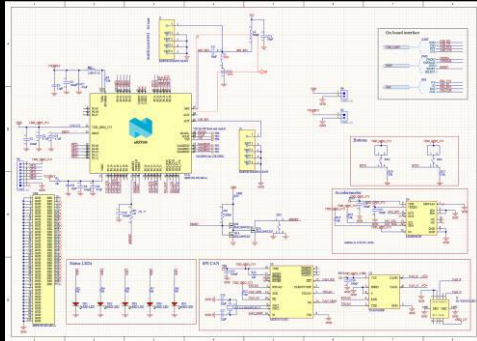
Schematics



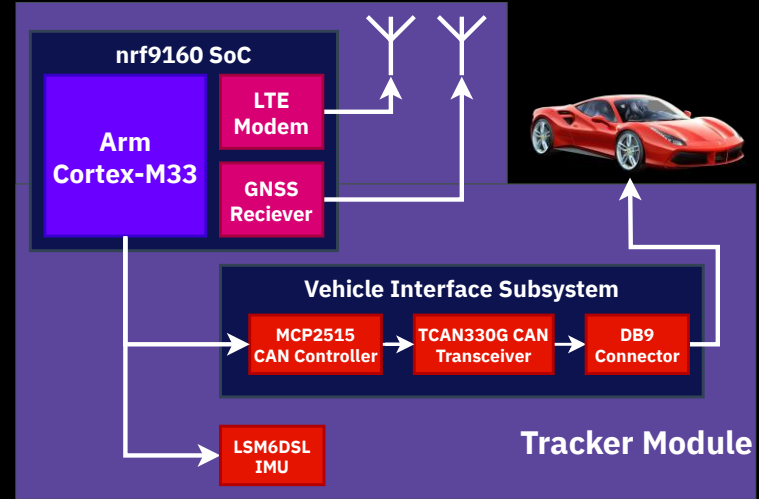
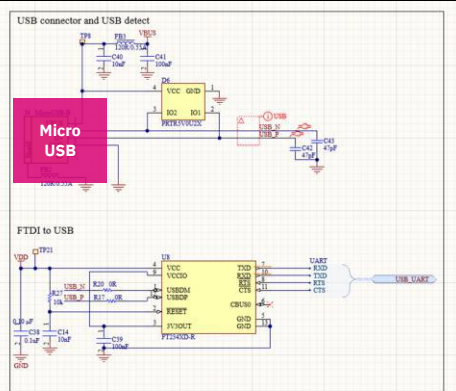
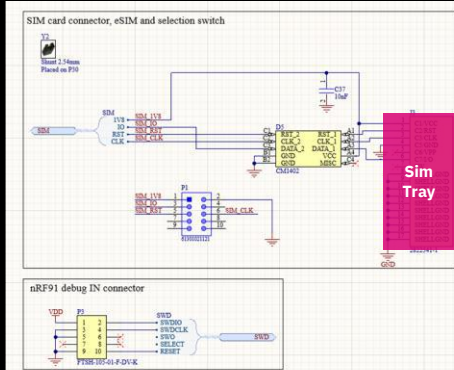
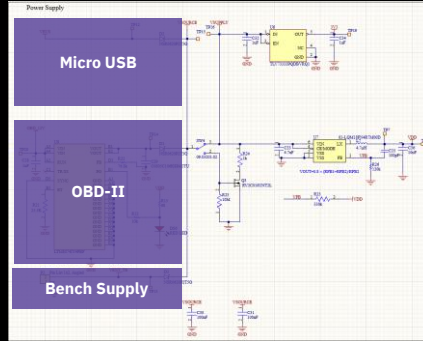
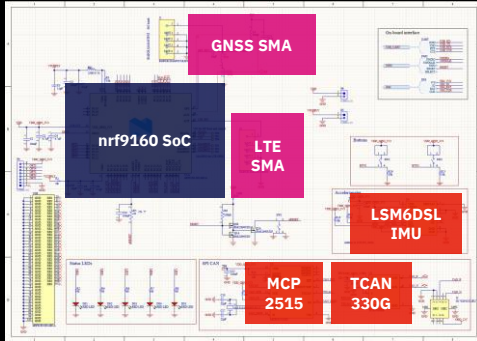
Schematics



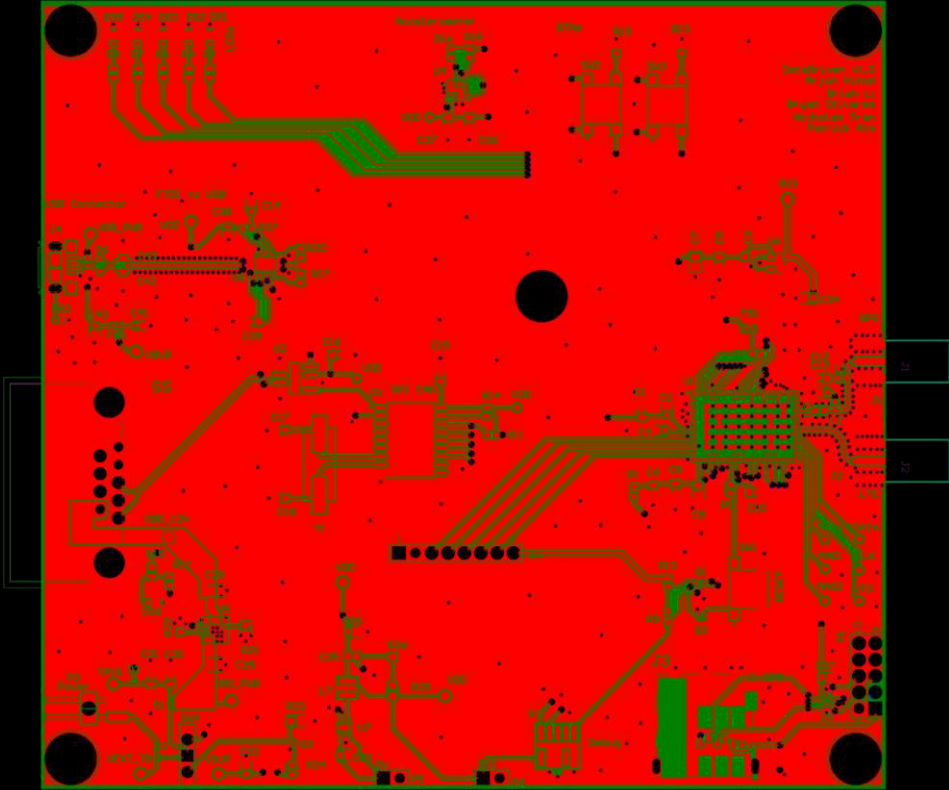
Schematics



Schematics



Layout



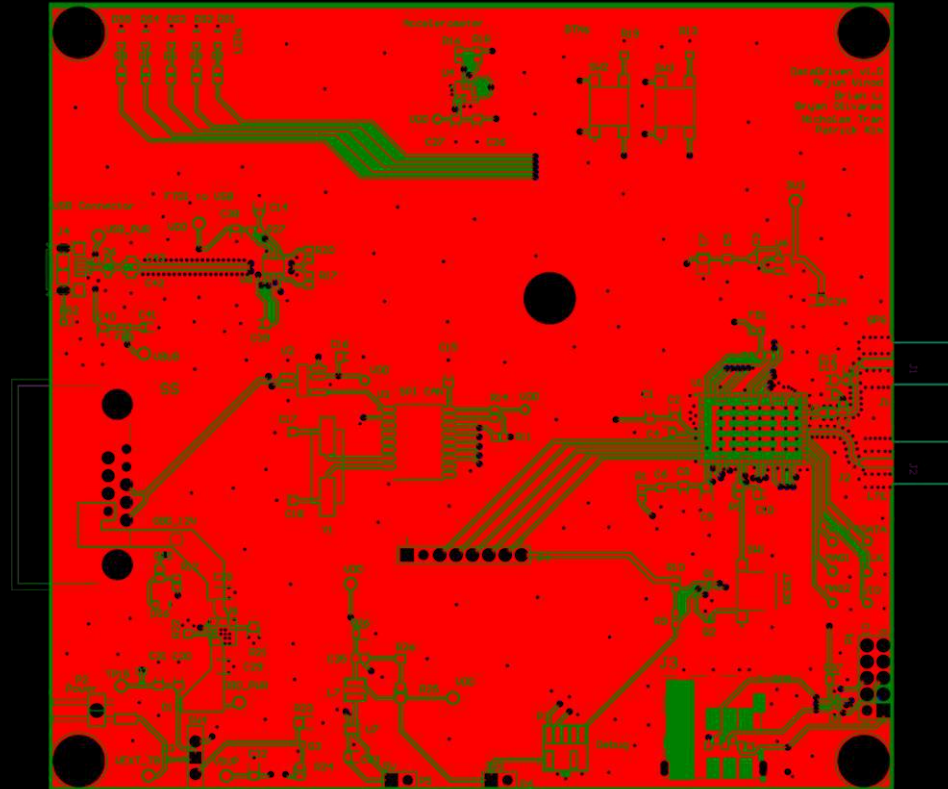
Layout



4-layer PCB

- Top Layer
- GND
- PWR
- Bottom Layer

131 components



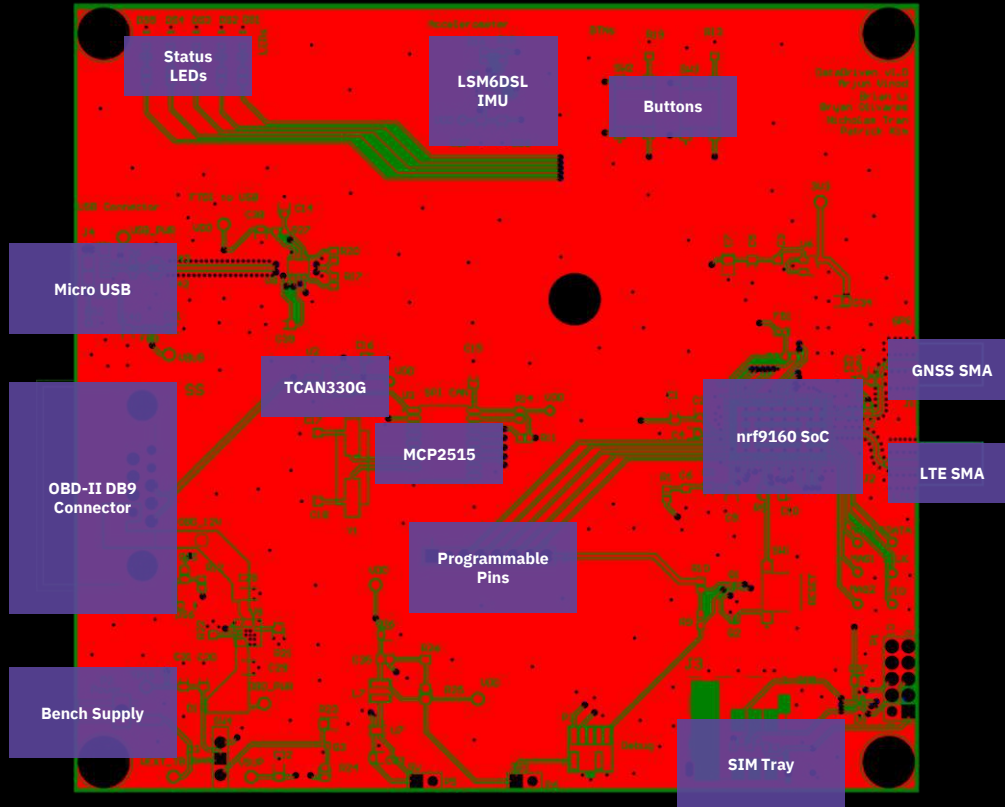
Layout



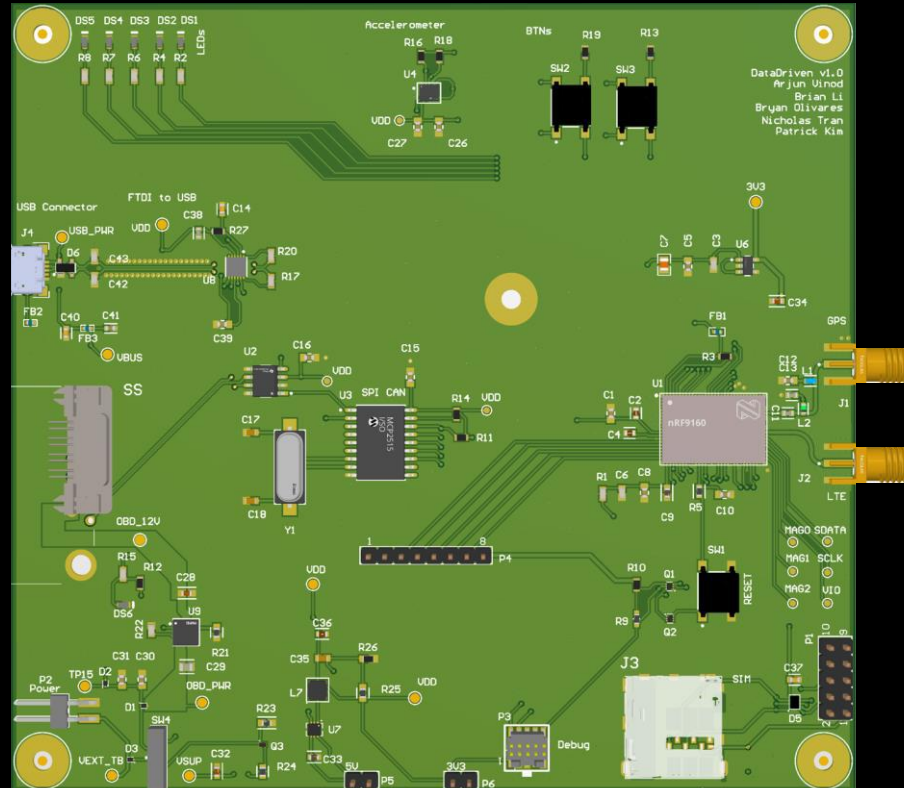
4-layer PCB

- Top Layer
- GND
- PWR
- Bottom Layer

131 components



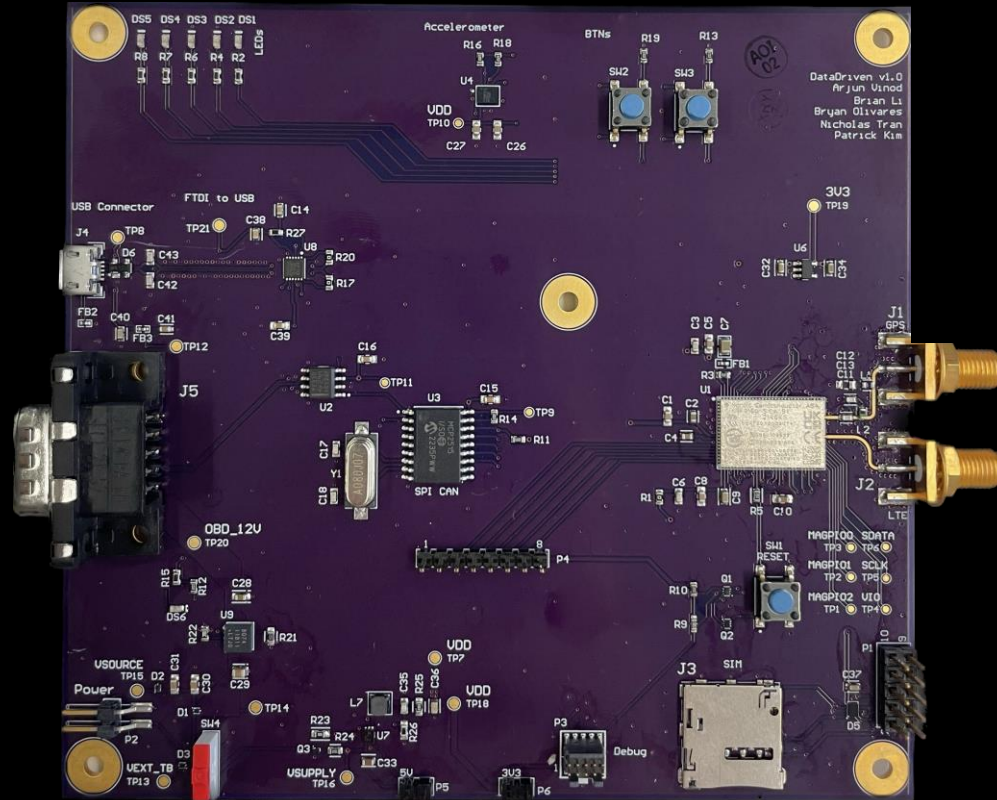
3D Rendering



13.203 cm

12.370 cm

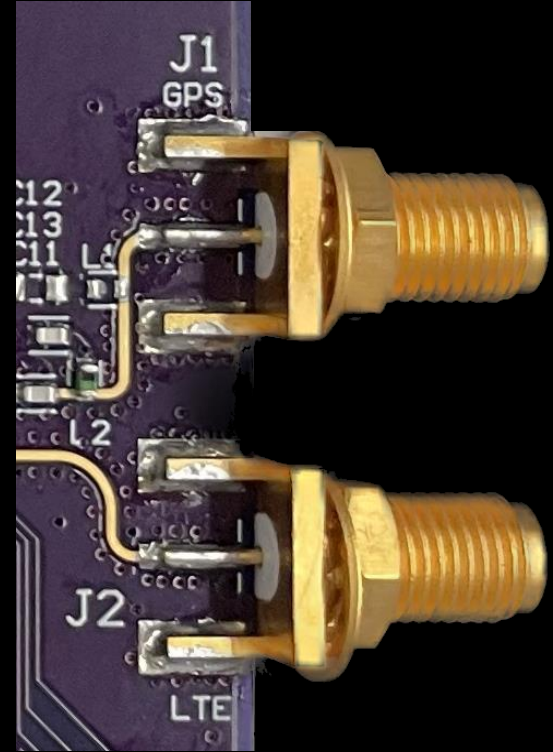
Final Product



Few modifications made between PCB being sent out and rendering 3D model were left out

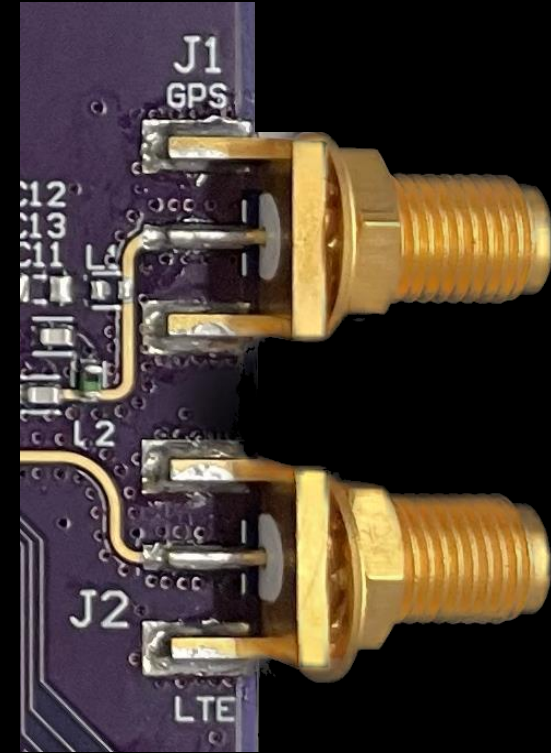
Design Challenges

- RF circuitry is **very sensitive**



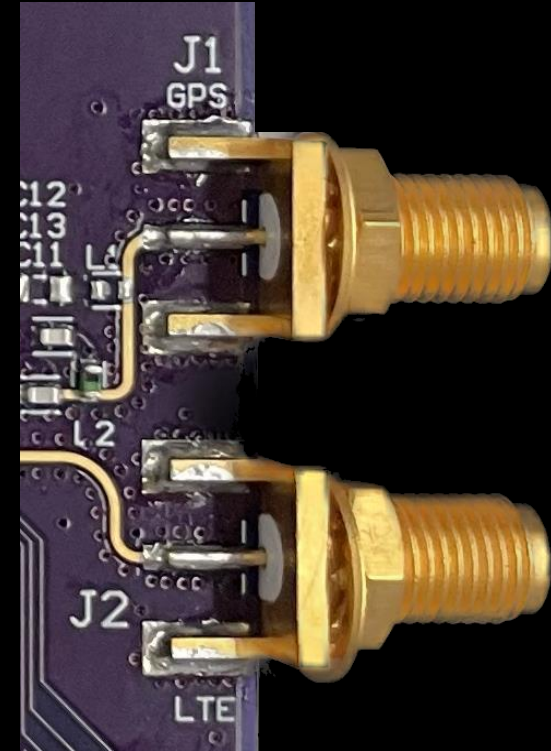
Design Challenges

- RF circuitry is **very sensitive**
- Learning & applying **best practices** on the fly



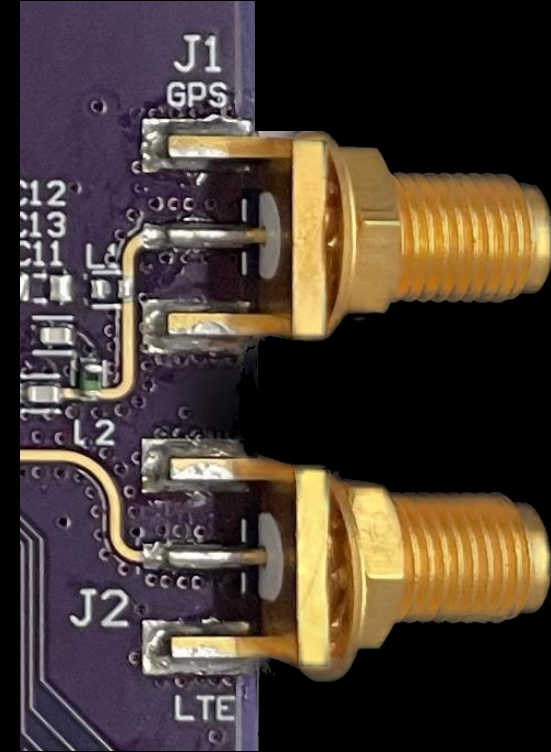
Design Challenges

- RF circuitry is **very sensitive**
- Learning & applying **best practices** on the fly
- Keeping track of **dynamic** requirements
 - Reworked GNSS & LTE RF circuitry from **onboard** antenna to **external** antennas



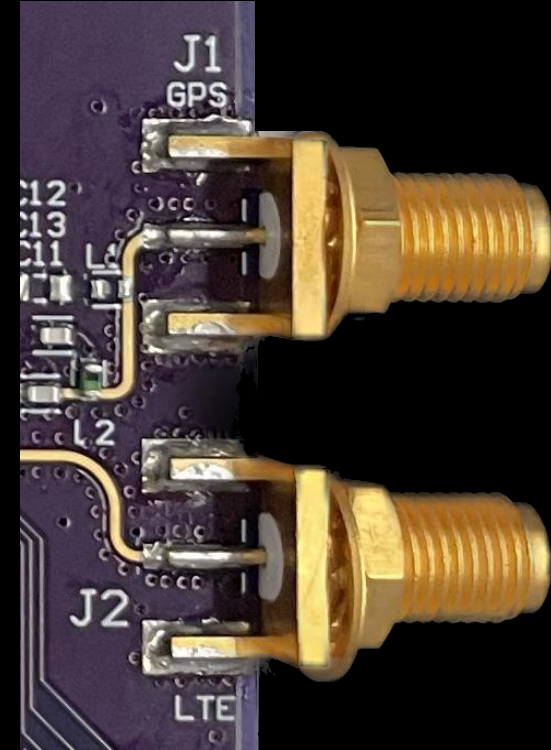
Design Challenges

- RF circuitry is **very sensitive**
- Learning & applying **best practices** on the fly
- Keeping track of **dynamic** requirements
 - Reworked GNSS & LTE RF circuitry from **onboard** antenna to **external** antennas
 - Accelerometer went **out of stock**



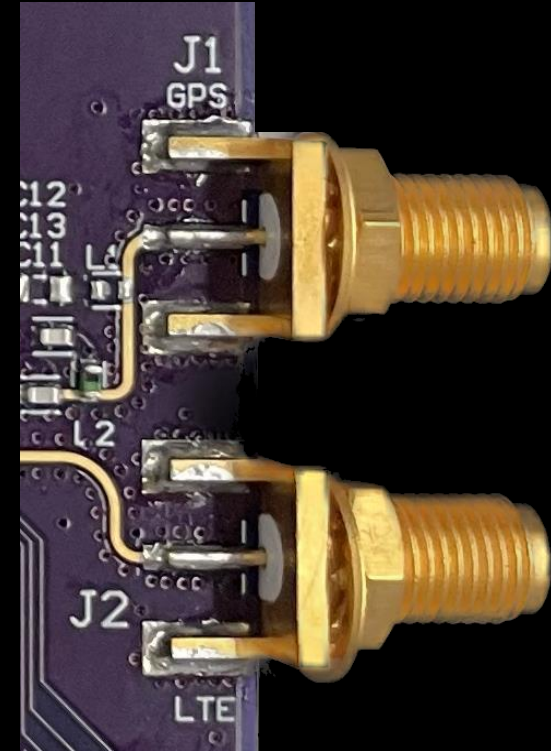
Design Challenges

- RF circuitry is **very sensitive**
- Learning & applying **best practices** on the fly
- Keeping track of **dynamic** requirements
 - Reworked GNSS & LTE RF circuitry from **onboard** antenna to **external** antennas
 - Accelerometer went **out of stock**
 - MicroSIM on nRF reference board was **cost-prohibitive**, so we pivoted to Nano SIM



Design Challenges

- RF circuitry is **very sensitive**
- Learning & applying **best practices** on the fly
- Keeping track of **dynamic** requirements
 - Reworked GNSS & LTE RF circuitry from **onboard** antenna to **external** antennas
 - Accelerometer went **out of stock**
 - MicroSIM on nRF reference board was **cost-prohibitive**, so we pivoted to Nano SIM
- **Coordinating** efforts within the team (not easily parallelizable)

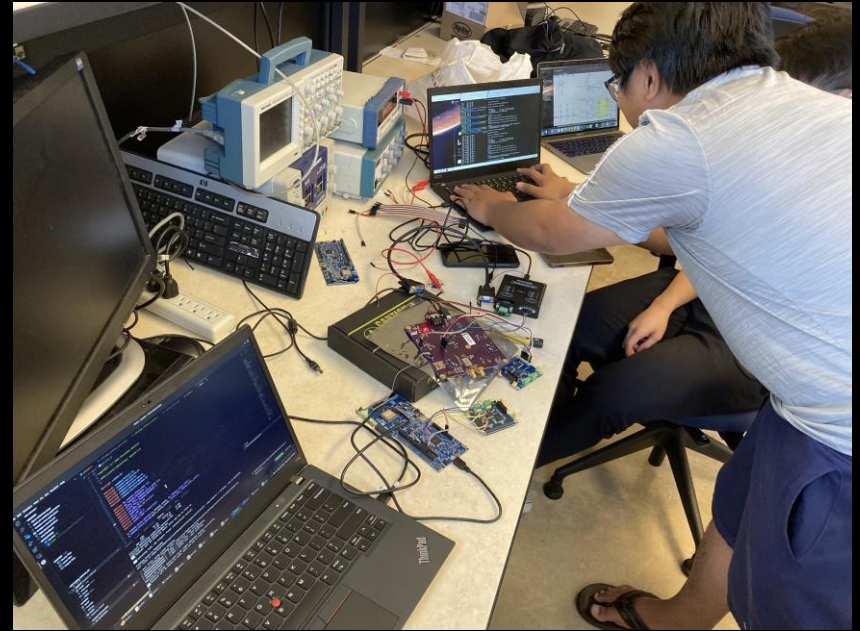




Live Tracking Demo

Retrospective

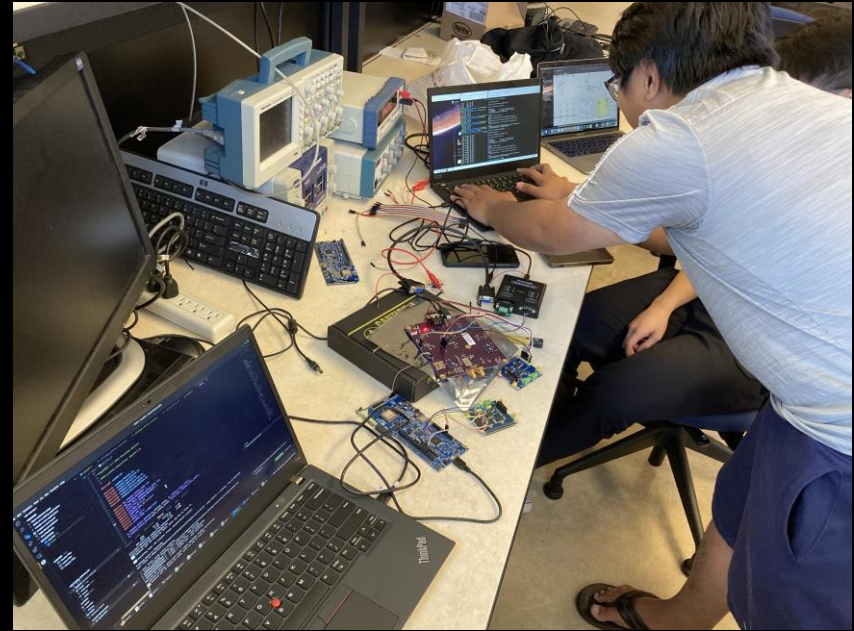
- Modular design made it easy to develop each part of the system independently



Retrospective

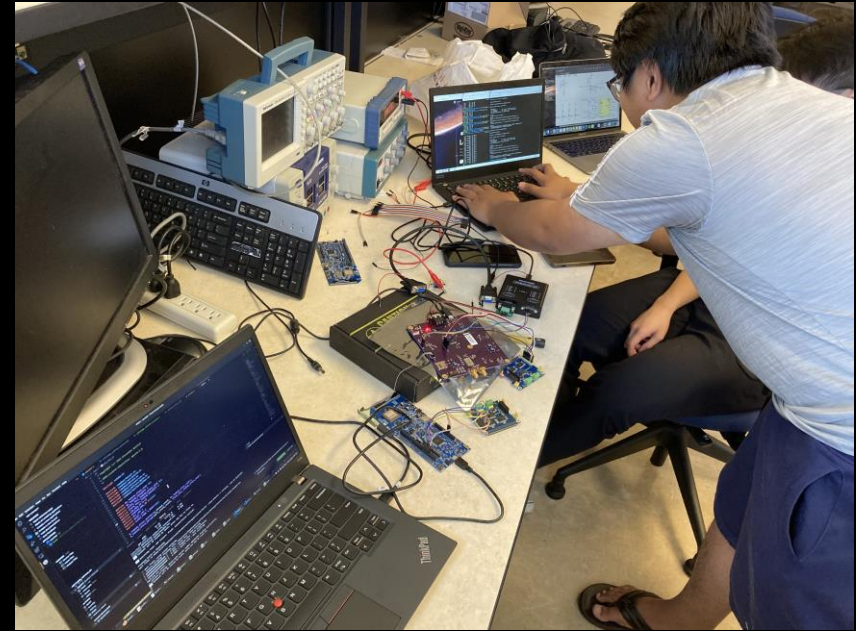


- Modular design made it easy to develop each part of the system independently
 - Web App
 - API
 - UDP Listener
 - Tracker



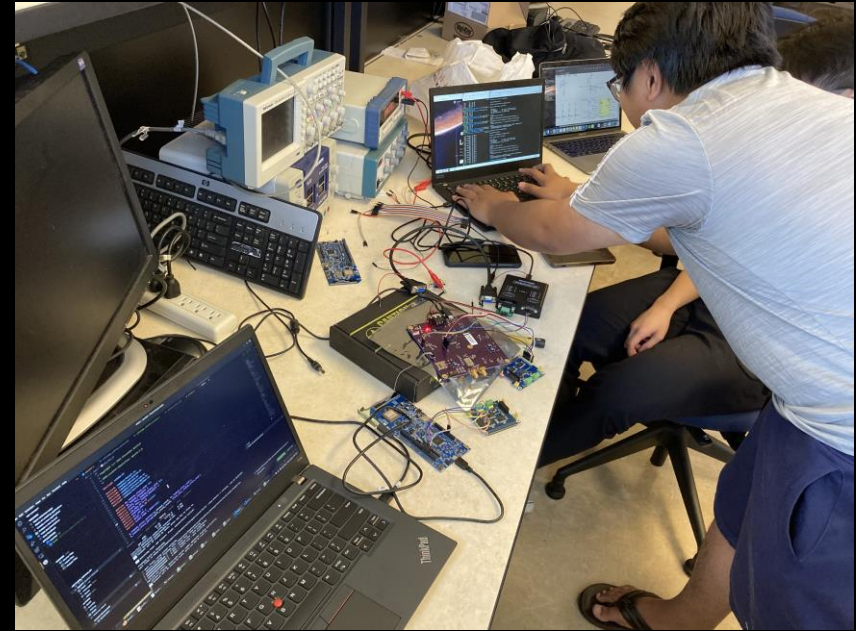
Retrospective

- Modular design made it easy to develop each part of the system independently
 - Web App
 - API
 - UDP Listener
 - Tracker
- Learned a lot in every level of the technology stack:
Web to Firmware to PCB design



Retrospective

- Modular design made it easy to develop each part of the system independently
 - Web App
 - API
 - UDP Listener
 - Tracker
- Learned a lot in every level of the technology stack:
Web to Firmware to PCB design
- Got working PCBs in the **first spin**
 - On-board RF added significant complexity to the design process



Retrospective (cont.)



- More **test points**



Retrospective (cont.)



- More **test points**
- **Better labels** for non-power TPs, like SPI, I2C, etc. signals



Retrospective (cont.)

- More **test points**
- **Better labels** for non-power TPs, like SPI, I2C, etc. signals
- One **incorrect resistor** used for OBD-II power supply, soldered an external resistor



Retrospective (cont.)

- More **test points**
- **Better labels** for non-power TPs, like SPI, I2C, etc. signals
- One **incorrect resistor** used for OBD-II power supply, soldered an external resistor
- One board didn't have functioning UART, cause is TBD



Retrospective (cont.)

- More **test points**
- **Better labels** for non-power TPs, like SPI, I2C, etc. signals
- One **incorrect resistor** used for OBD-II power supply, soldered an external resistor
- One board didn't have functioning UART, cause is TBD
- Would've used separate LTE and GPS modem so we could use **streaming protocols** like MQTT





Next Steps

Acknowledgements



Dr. Yogananda Isukapalli

Brian Canty

Austin Hwang

Alex Lai

Stefan Crigler

David McCarthy

Jimmy Kraemer

Martin Fay

Eric Nystrom

Venkat Krishnan

Duane Gardner

John Buckley