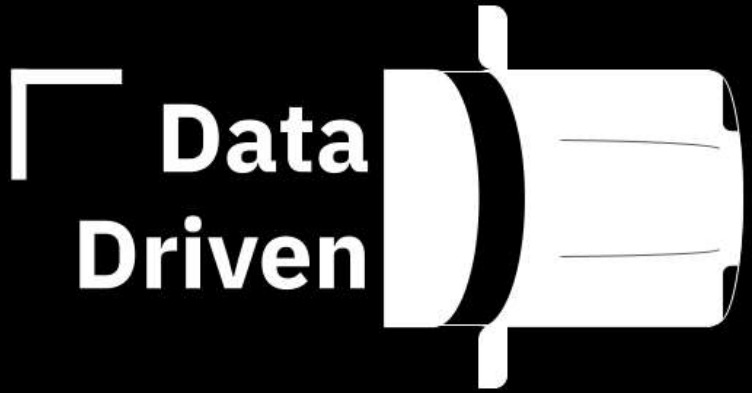

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Development Team

Data Driven

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

Data Driven

Lost in Translation

Data Driven

Lost in Translation

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

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

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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.

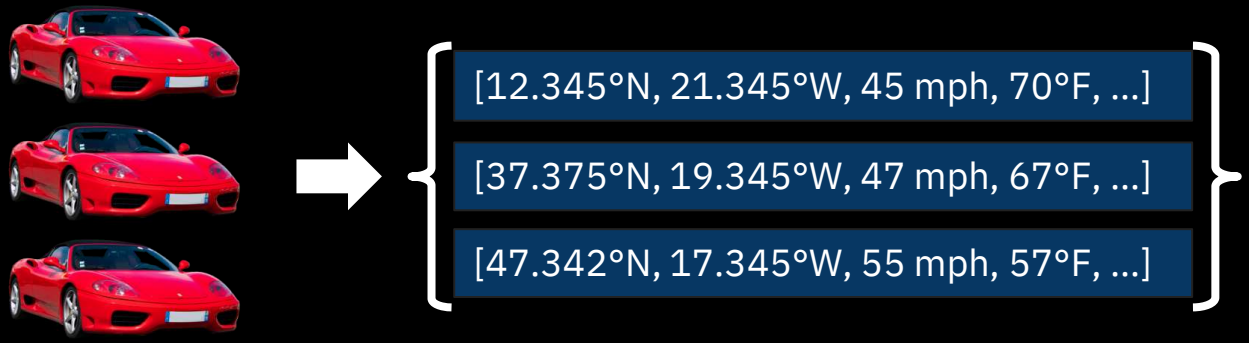
Proposed Solution

End-to-End Vehicle Data Tracking

Data Driven

End-to-End Vehicle Data Tracking

Collect live vehicle data.



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, ...]

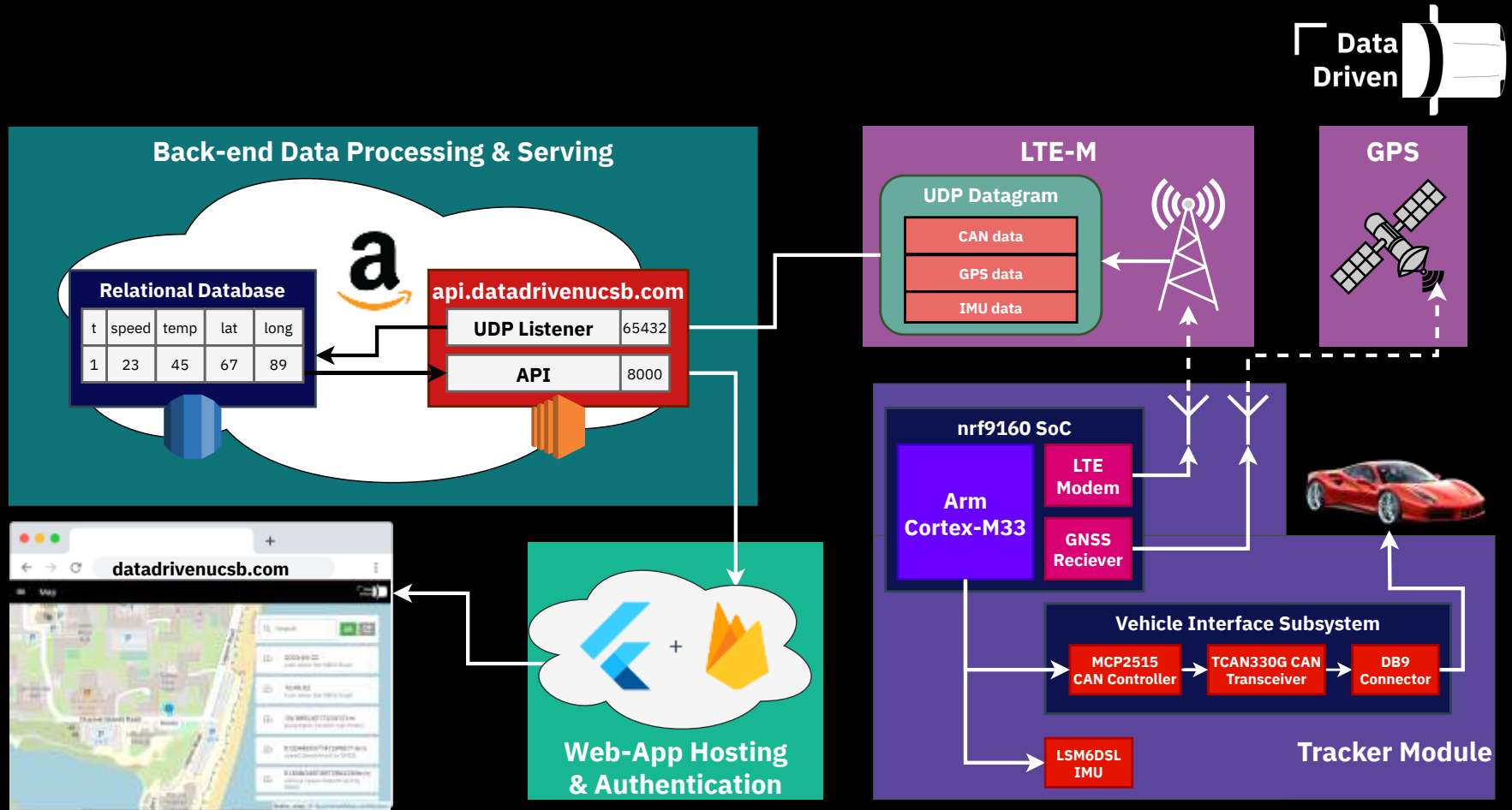
[37.375°N, 19.345°W, 47 mph, 67°F, ...]

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

Tracker Module Installation

Data Driven

Web App Overview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API
8000
LTE-M
UDP Datagram
CAN data
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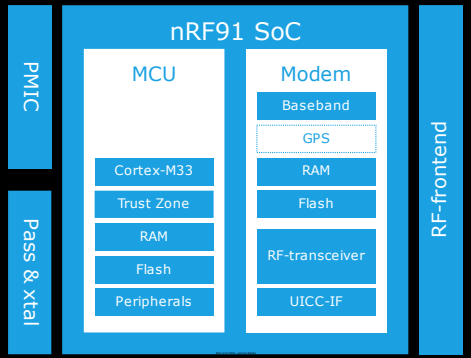
Web-App Hosting & Authentication

Location Data

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



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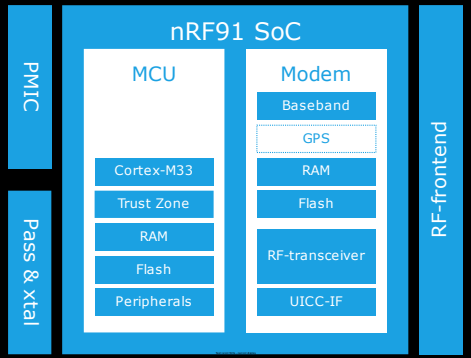

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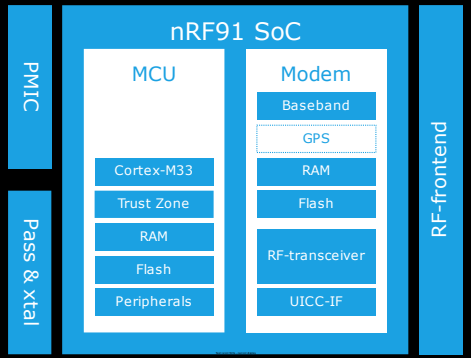

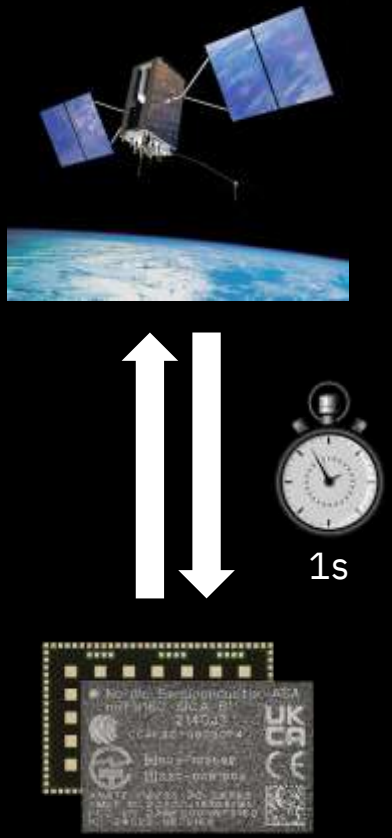

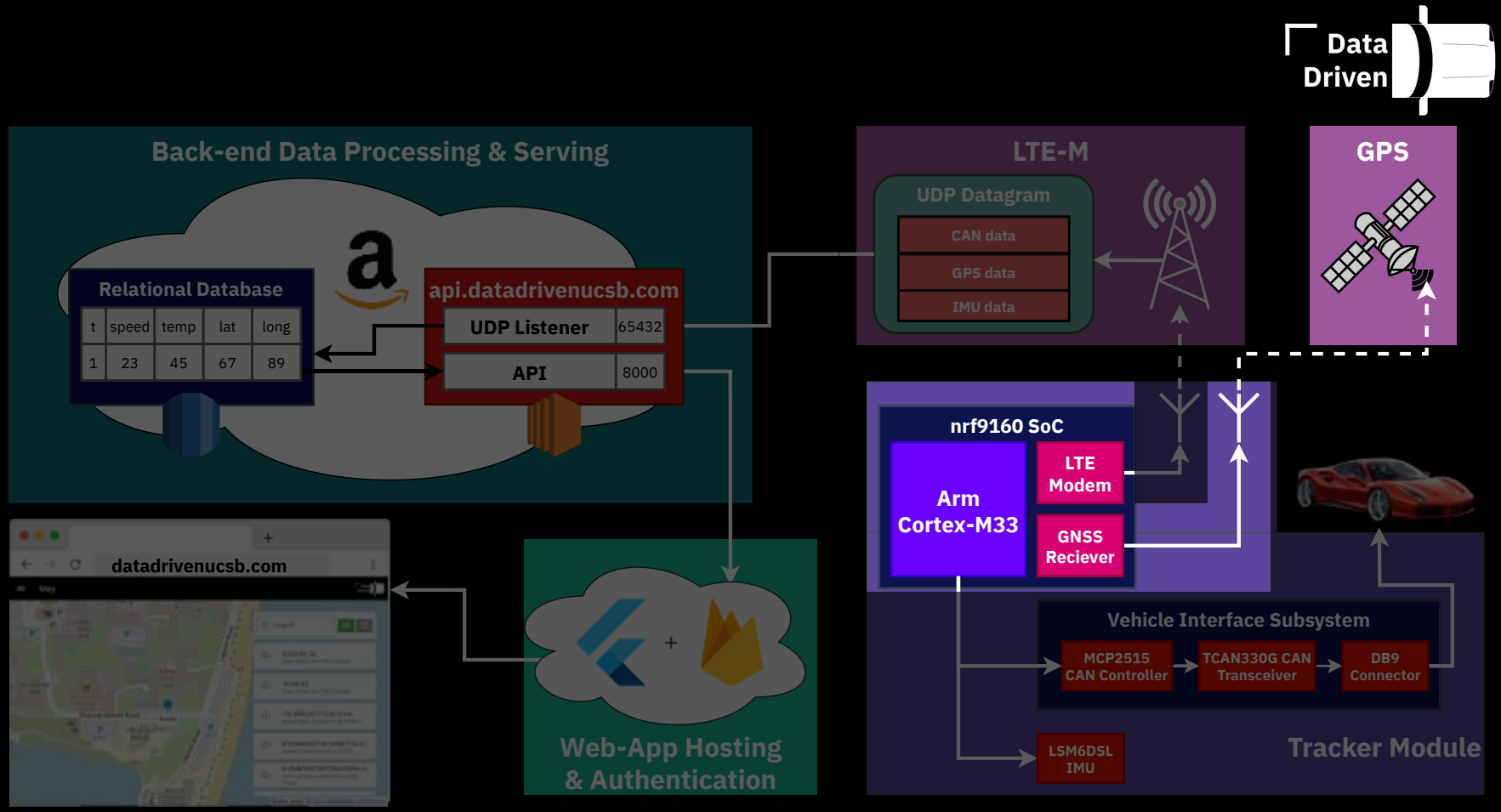
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CAN data
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GPS
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Vehicle Diagnostic Data

Diagnostic data is extracted from the car via the OBD-II diagnostic port (usually under the dash).

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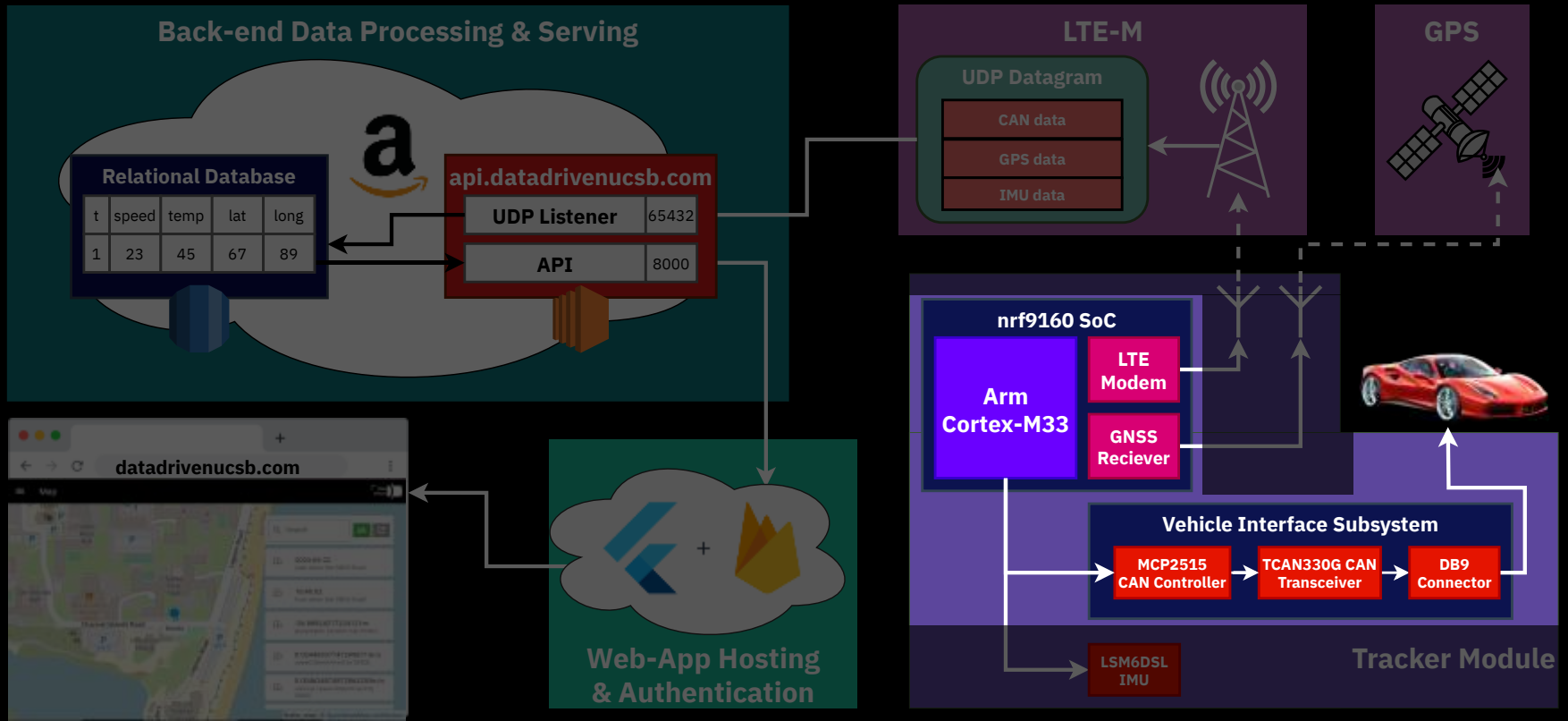
Data includes:

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

Data Driven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UDP Datagram
CAN data
GPS data
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Uploading Data to the Cloud

Uploading Data

Data Driven

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

Uploading Data

Data Driven

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

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

Uploading Data

Data Driven

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

Data Driven

UDP Datagram

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

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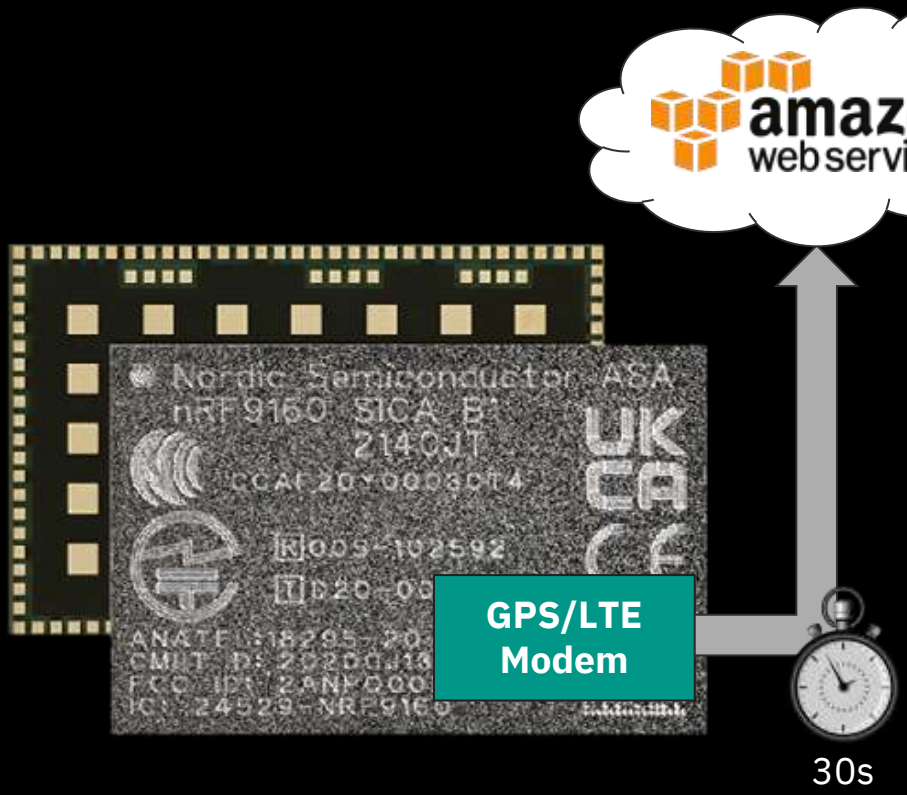
Data Driven



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Processing and Persisting Data

Data Driven

UDP Listener (Port 6543)

Amazon EC2

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

Data Driven

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/s^2, 0 m/s^2]**

UDP Datagram

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Amazon RDS

UDP Datagram

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

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

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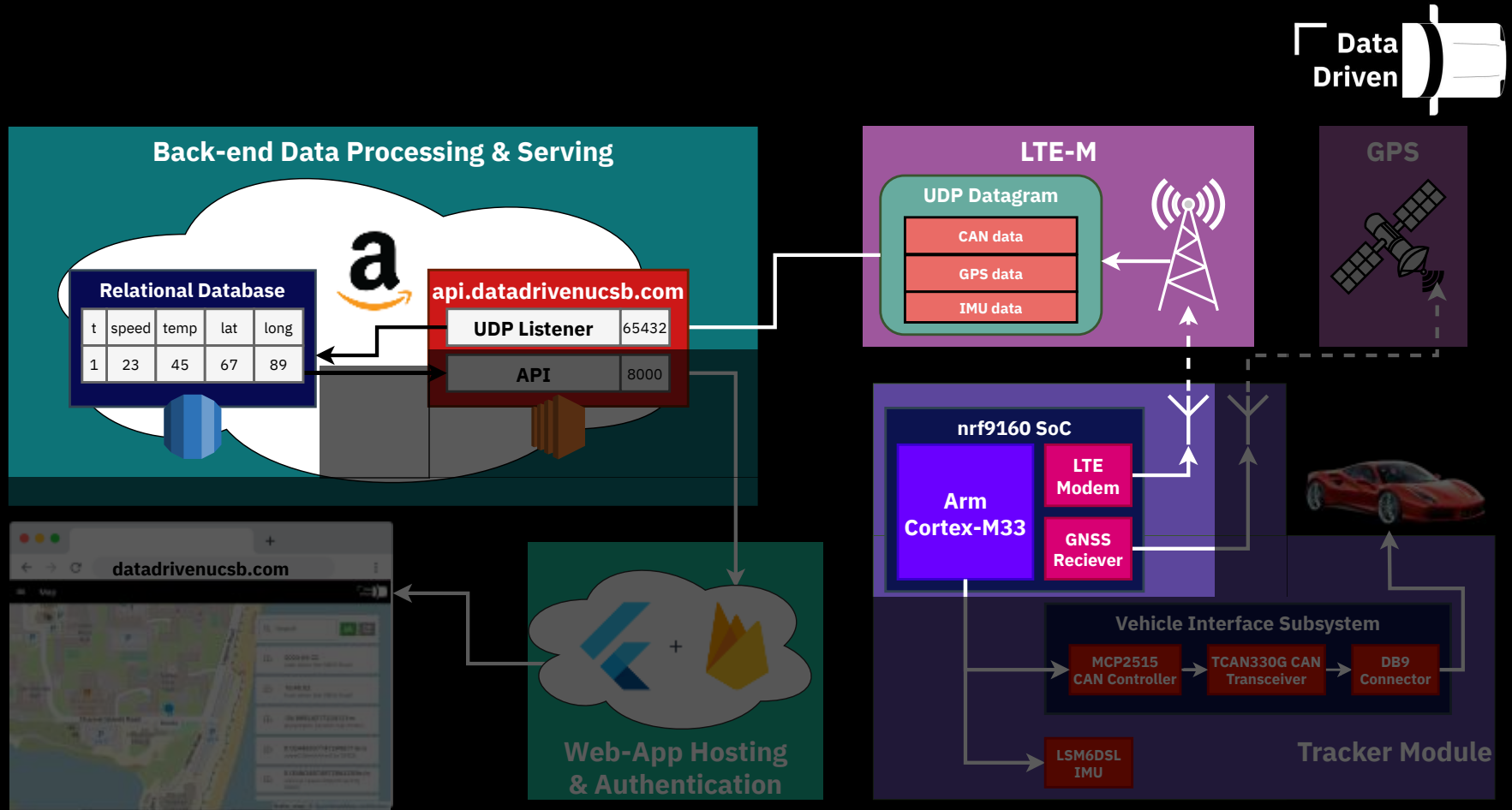
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API
8000
LTE-M
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GPS data
IMU data
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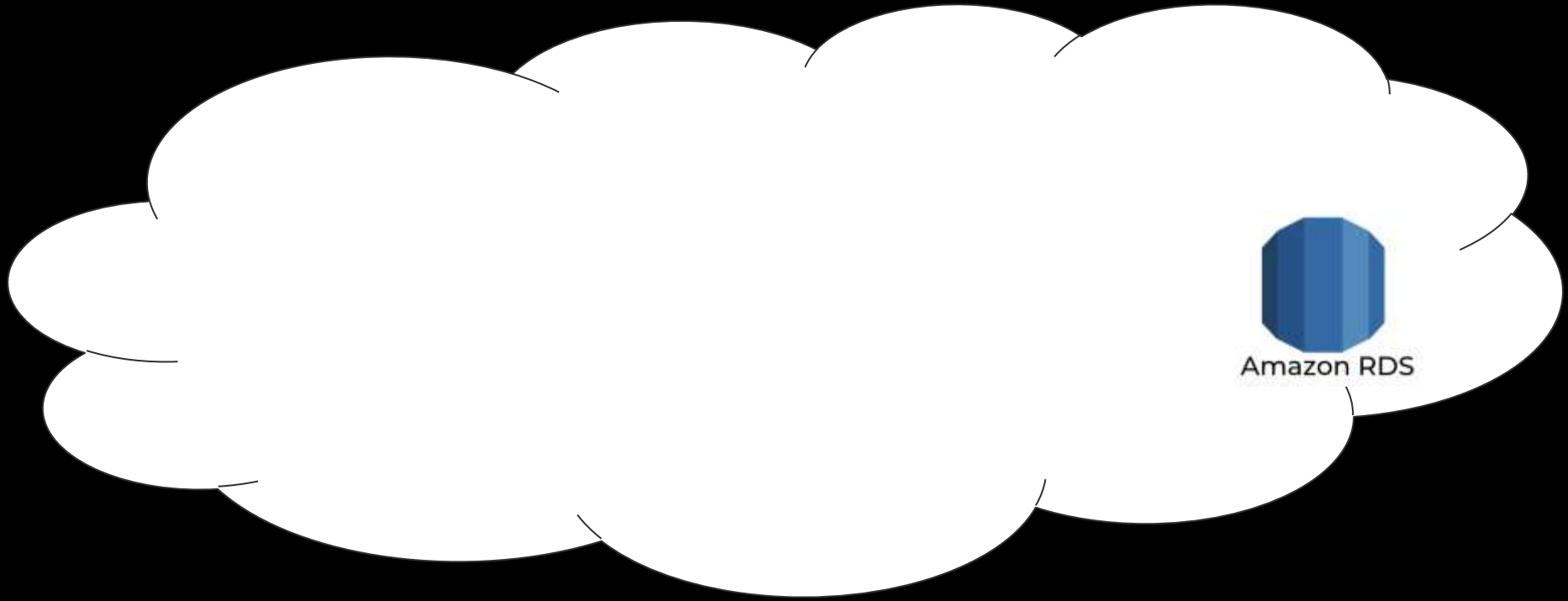
Serving Data to the User

Serving Data via API



Serving Data via API

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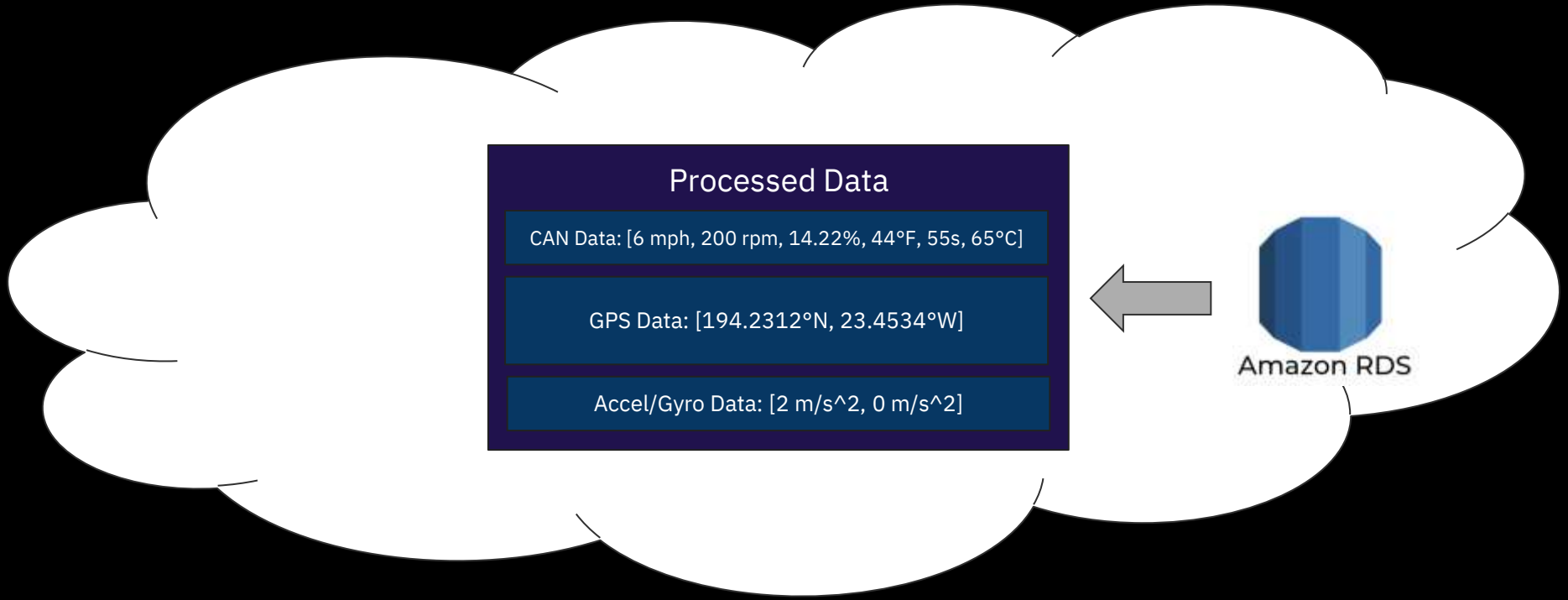

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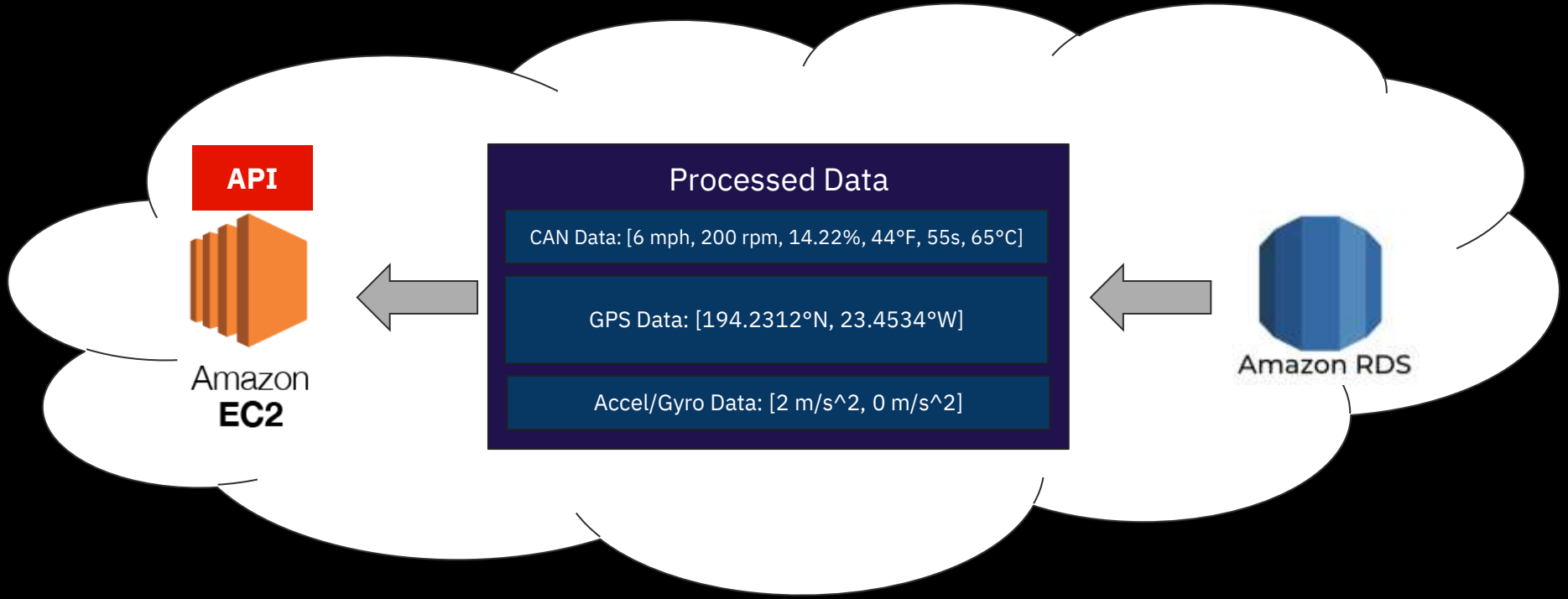

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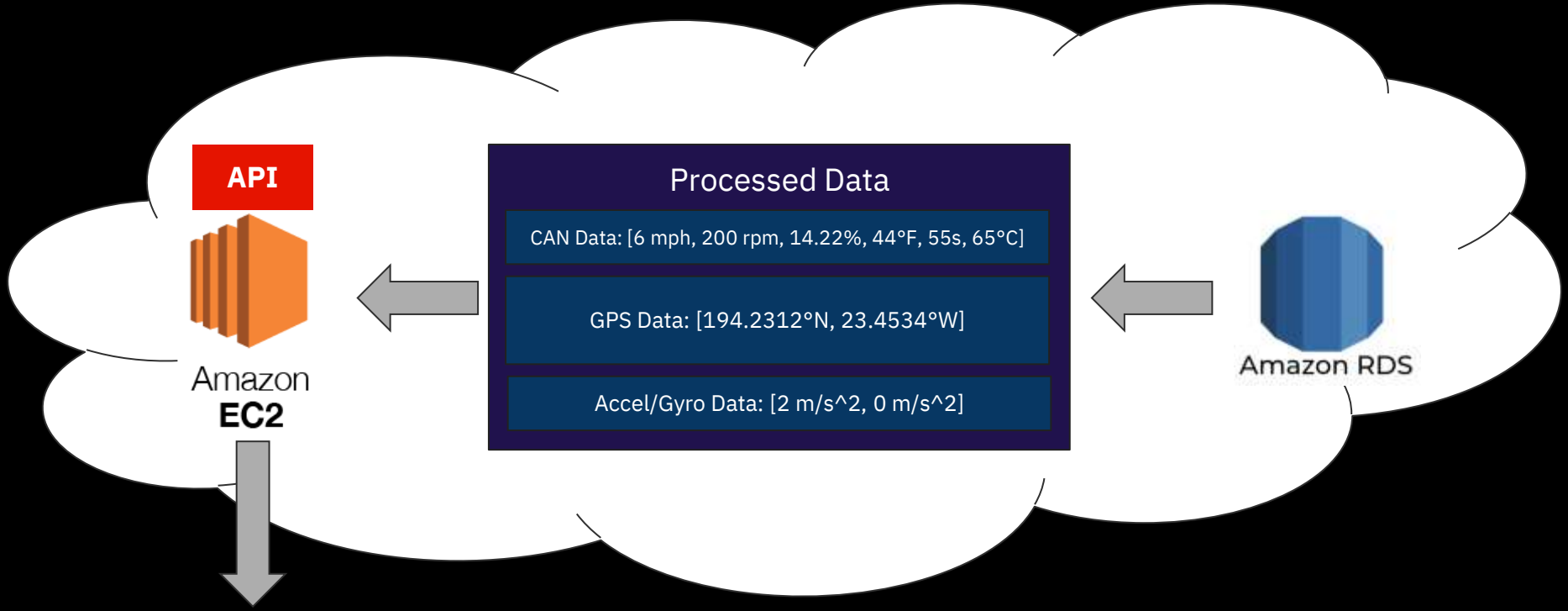

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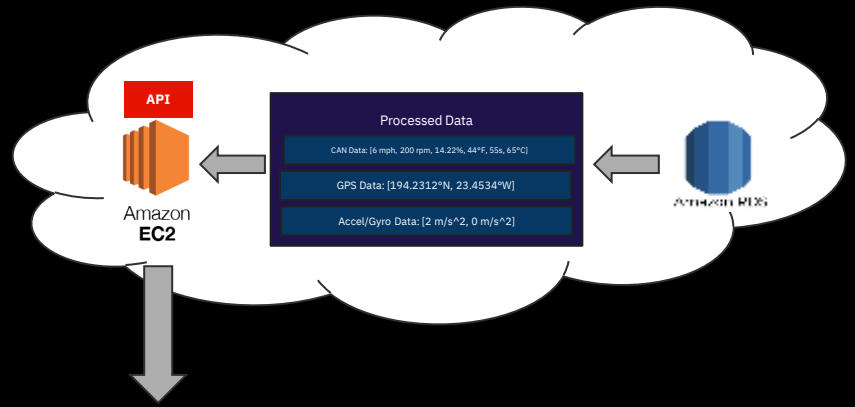
Serving Data to the Front-End



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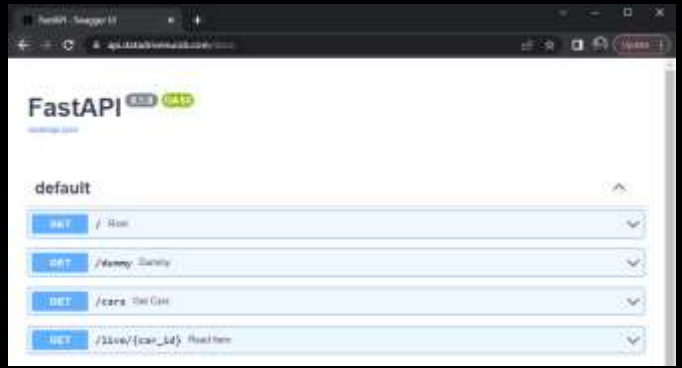
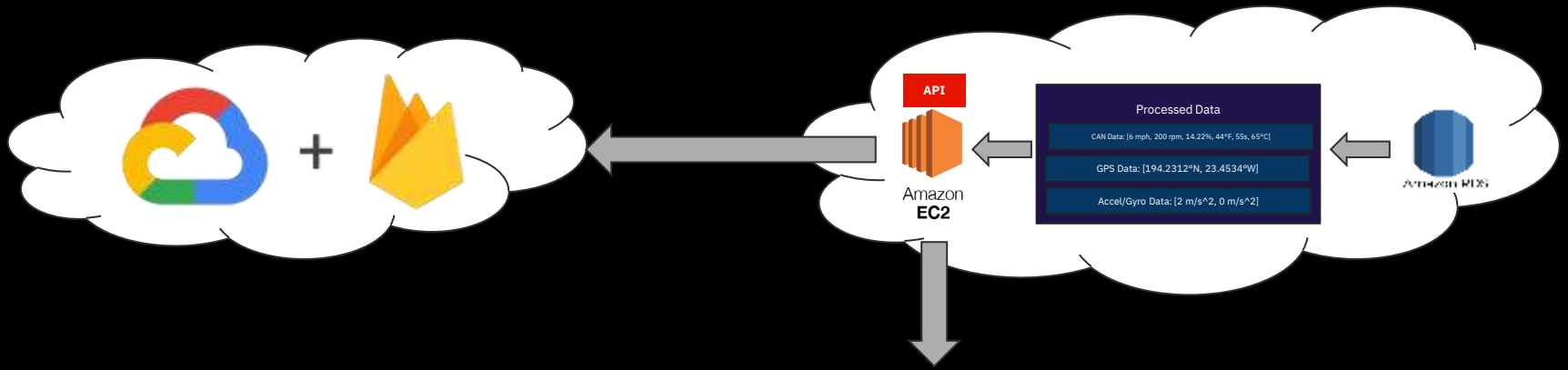


Serving Data to the Front-End

Data Driven



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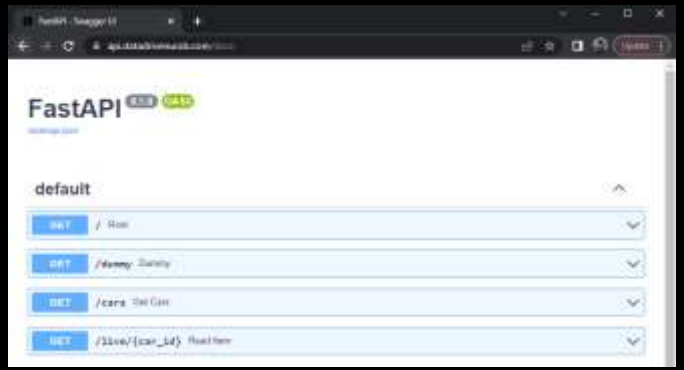
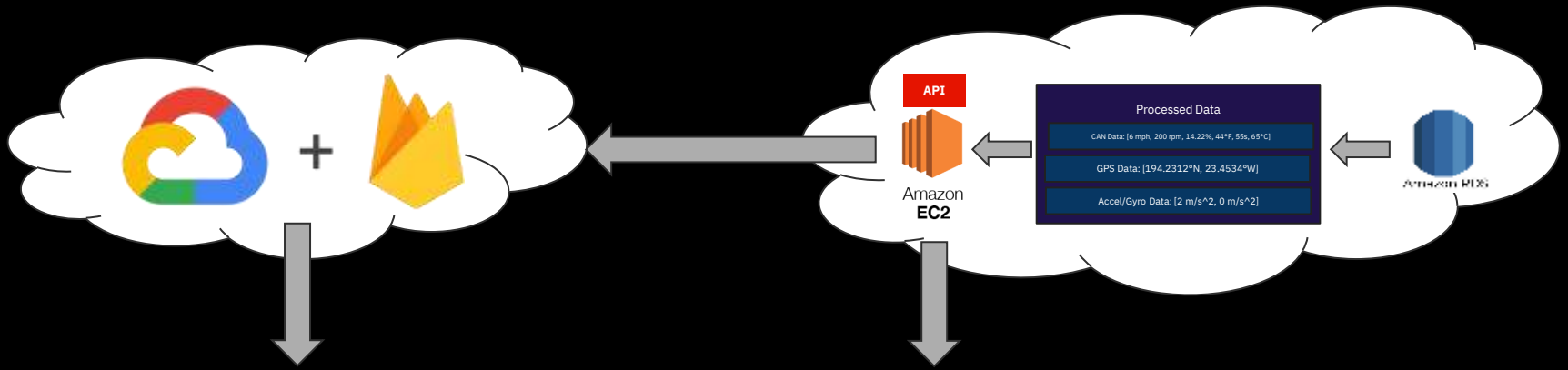
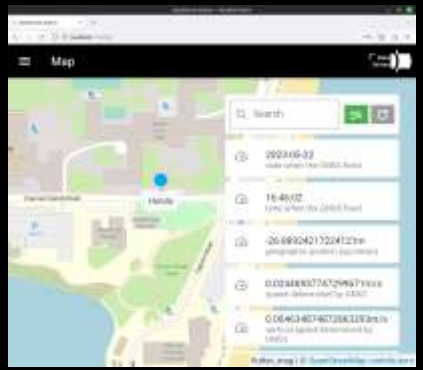
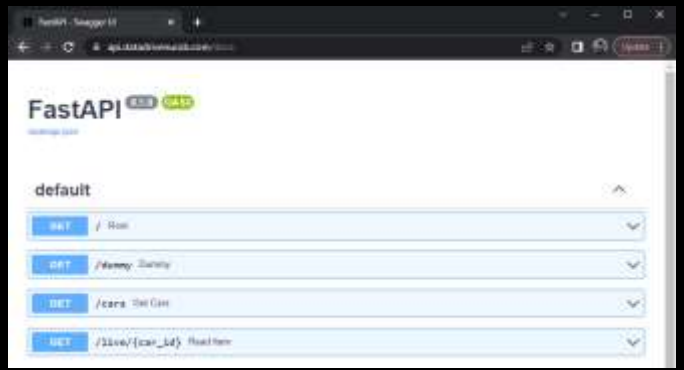


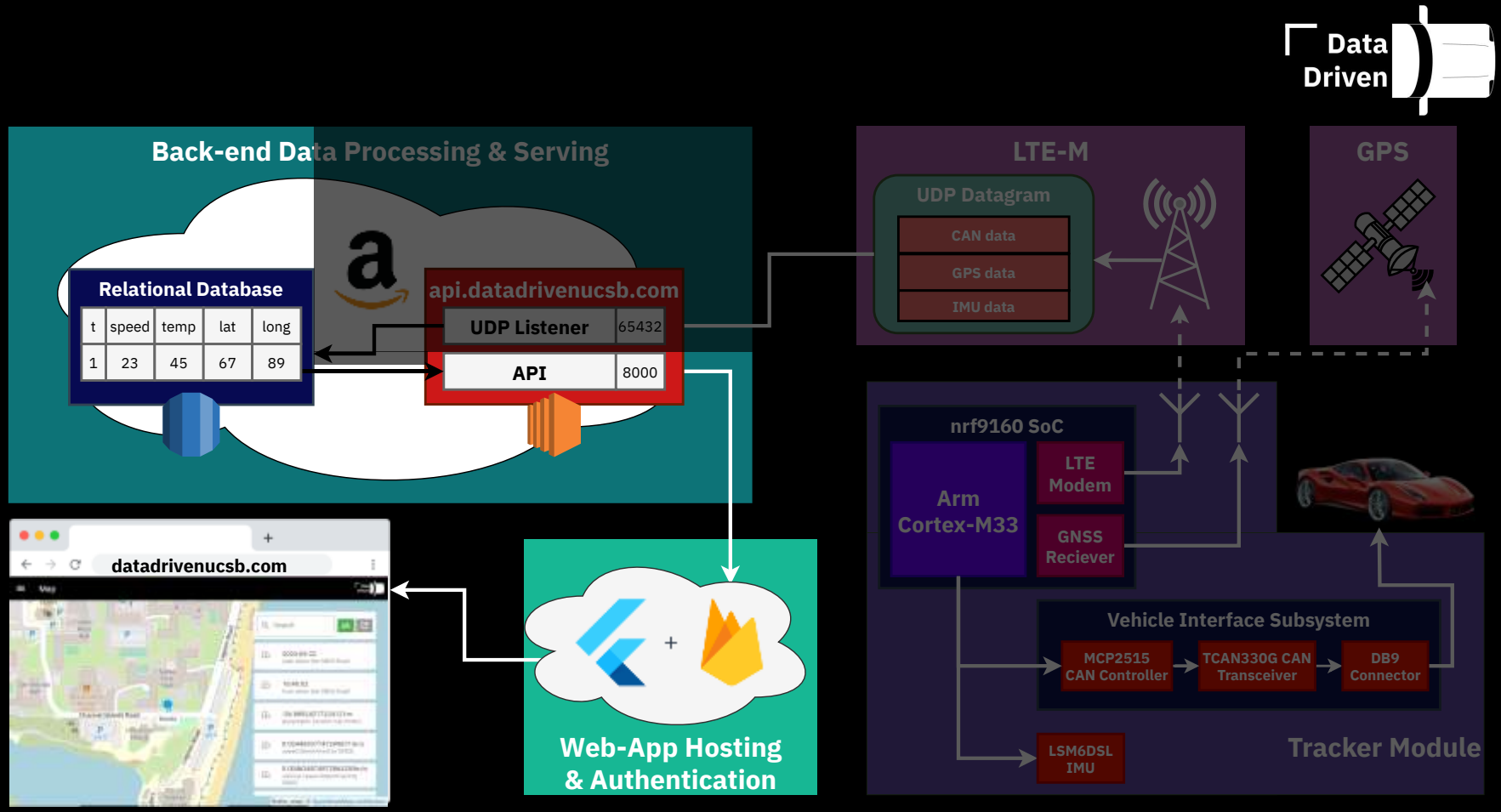
Serving Data to the Front-End

Data Driven





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Relational Database
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API
8000
LTE-M
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CAN data
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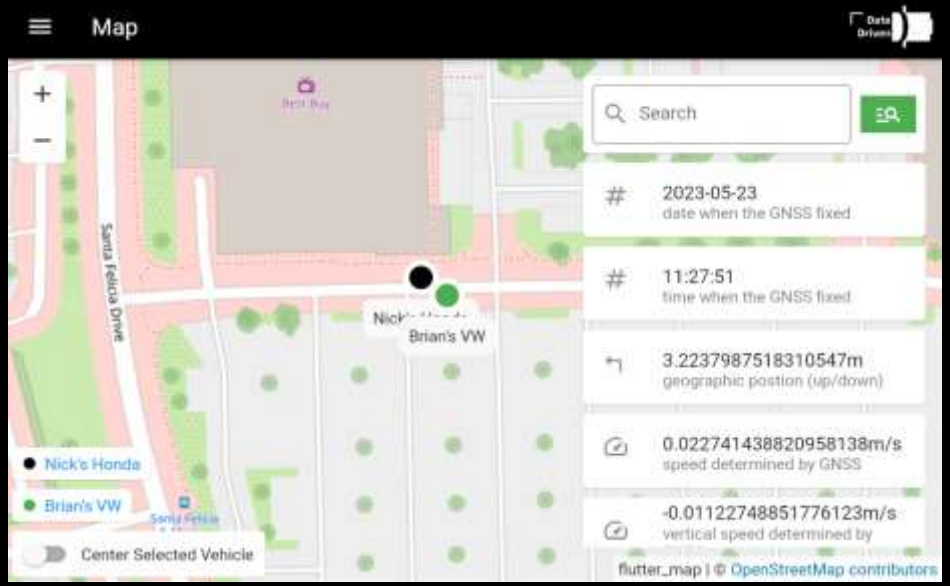
Web App

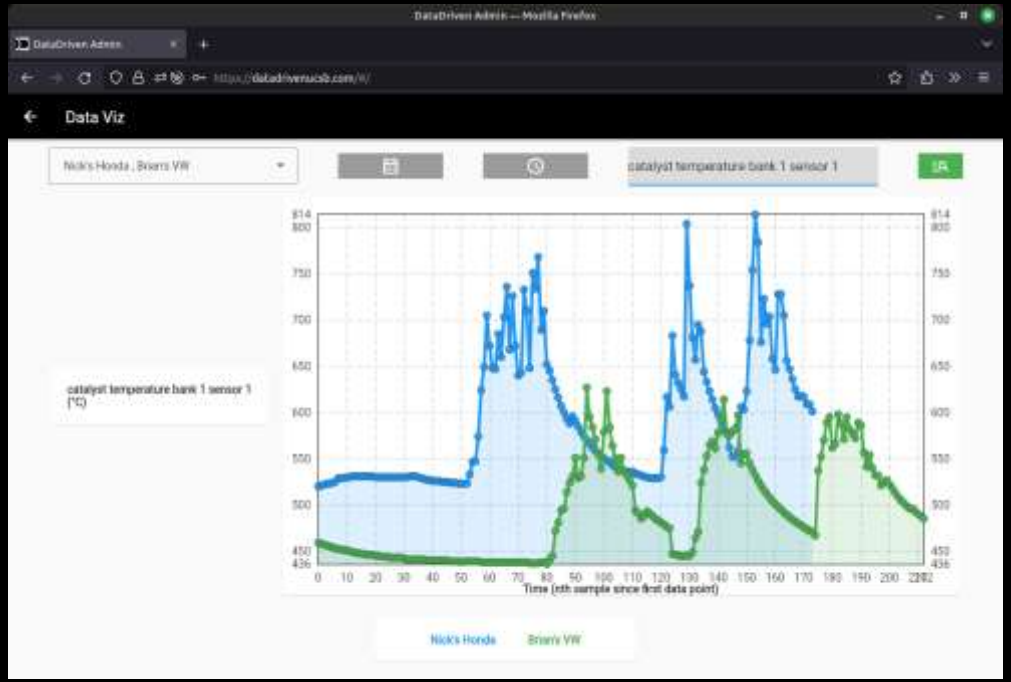
Web App: Live Tracking

- **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

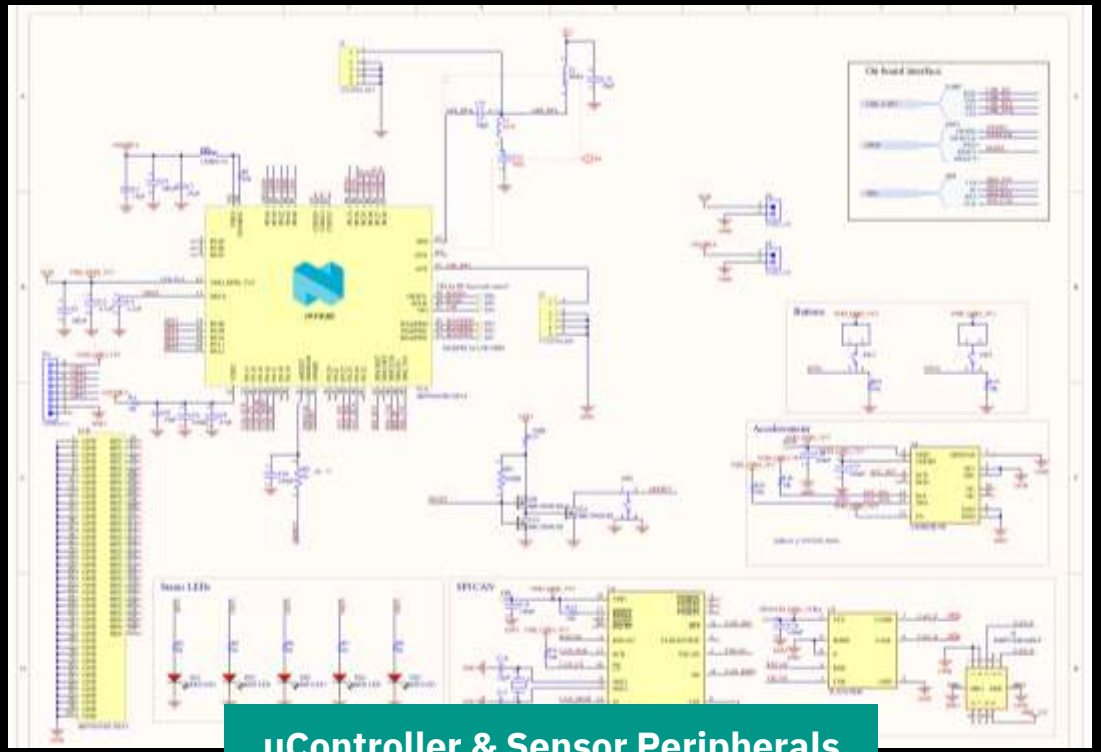
- **Plot** vehicle data parameters.
- Supports selecting **multiple vehicles** for **comparing** data parameters in a date range.



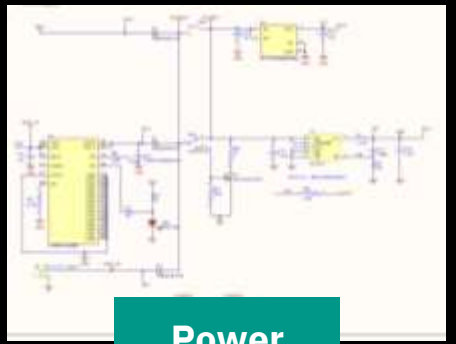
PCB Design

Schematics

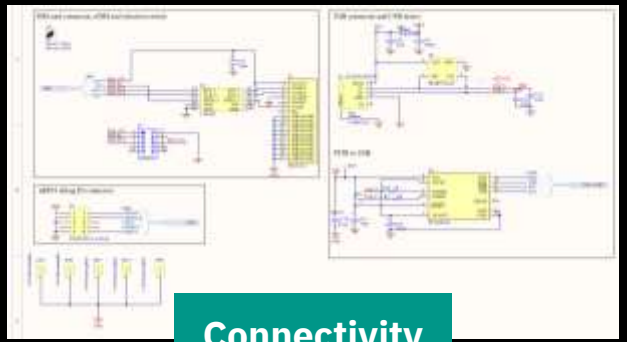
Data Driven



µController & Sensor Peripherals

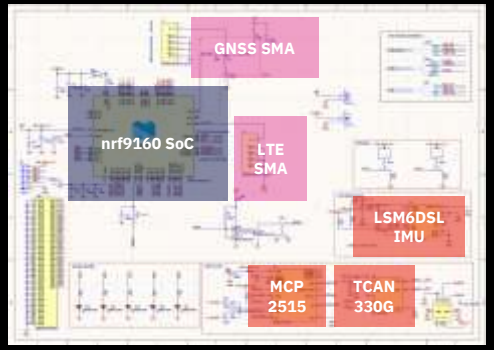


Power



Connectivity

Schematics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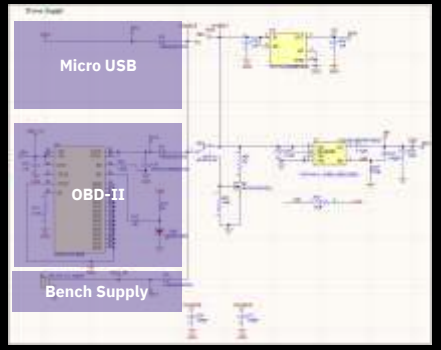
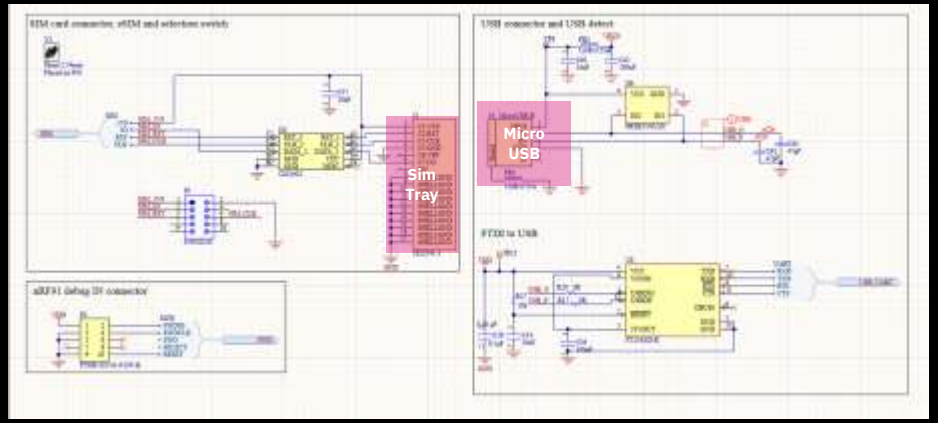
LSM6DSL IMU
MCP 2515
TCAN 330G


Micro USB
OBD-II
Bench Supply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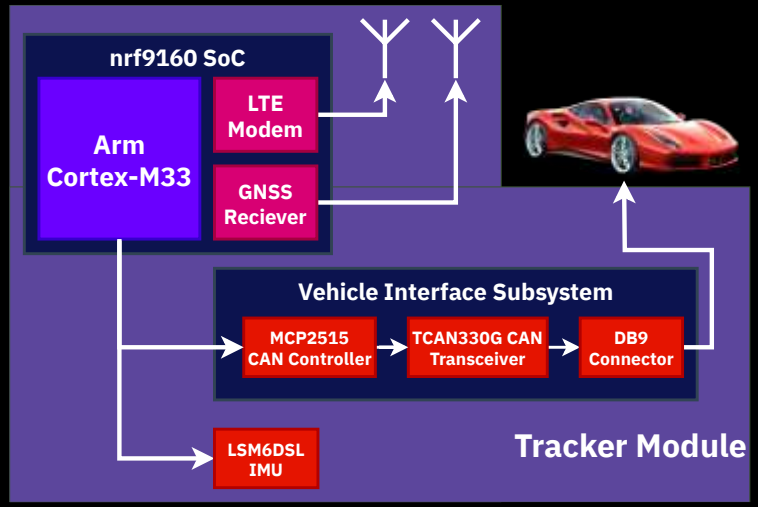
Micro USB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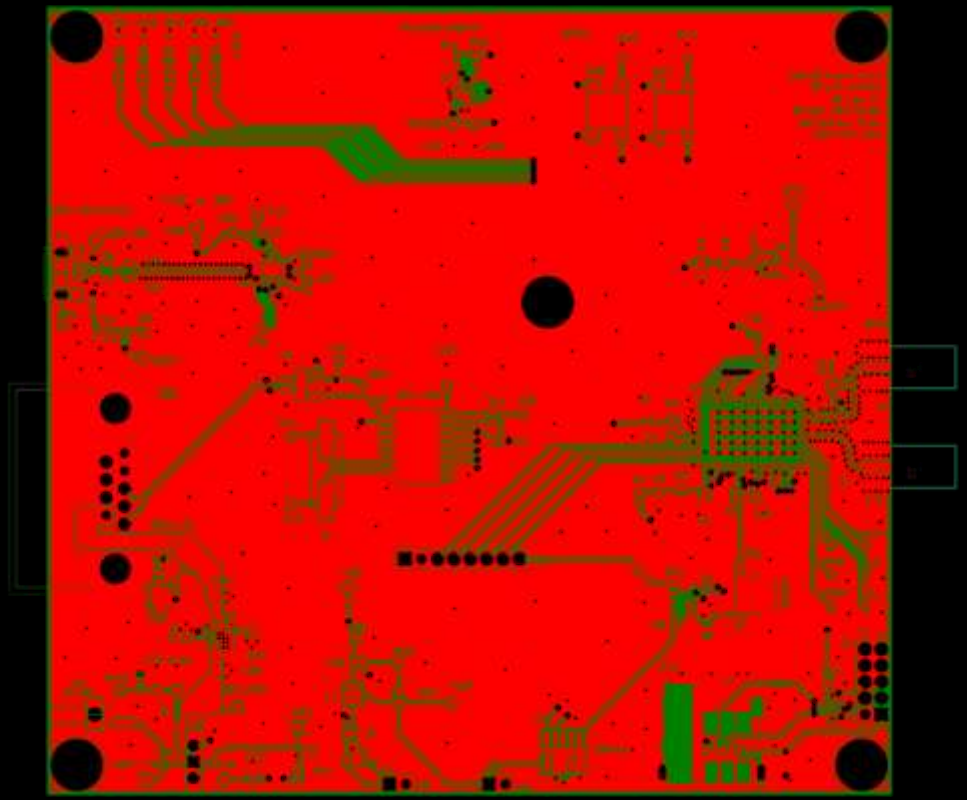


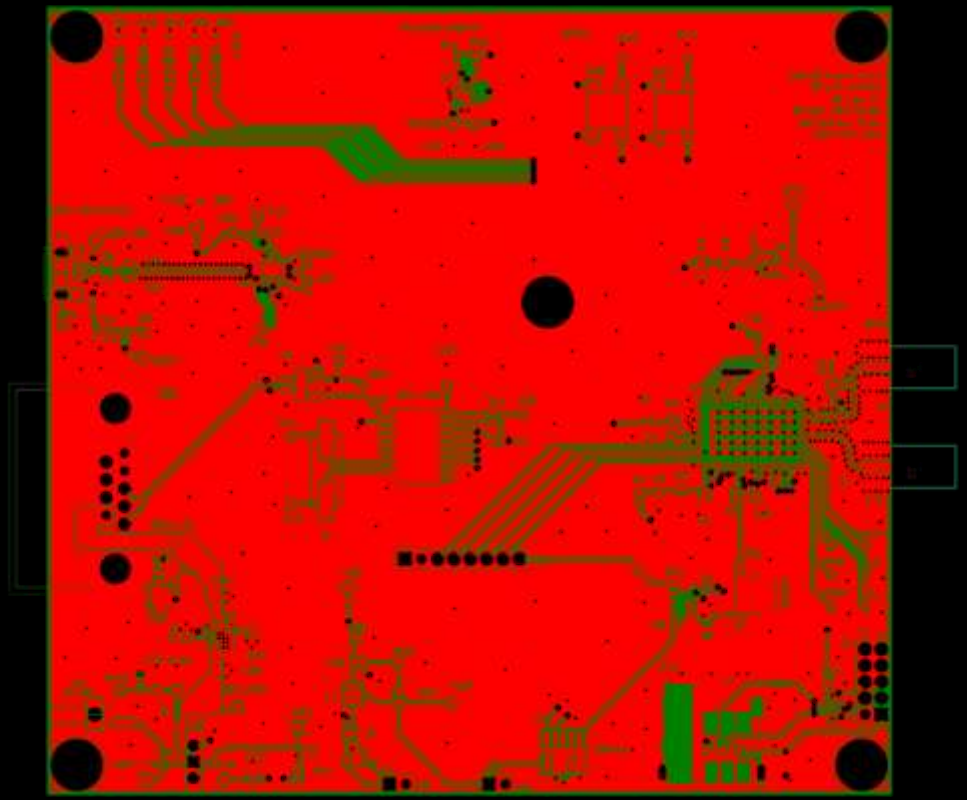
Data Driven

Layout

4-layer PCB

- Top Layer
- GND
- PWR
- Bottom Layer

131 components

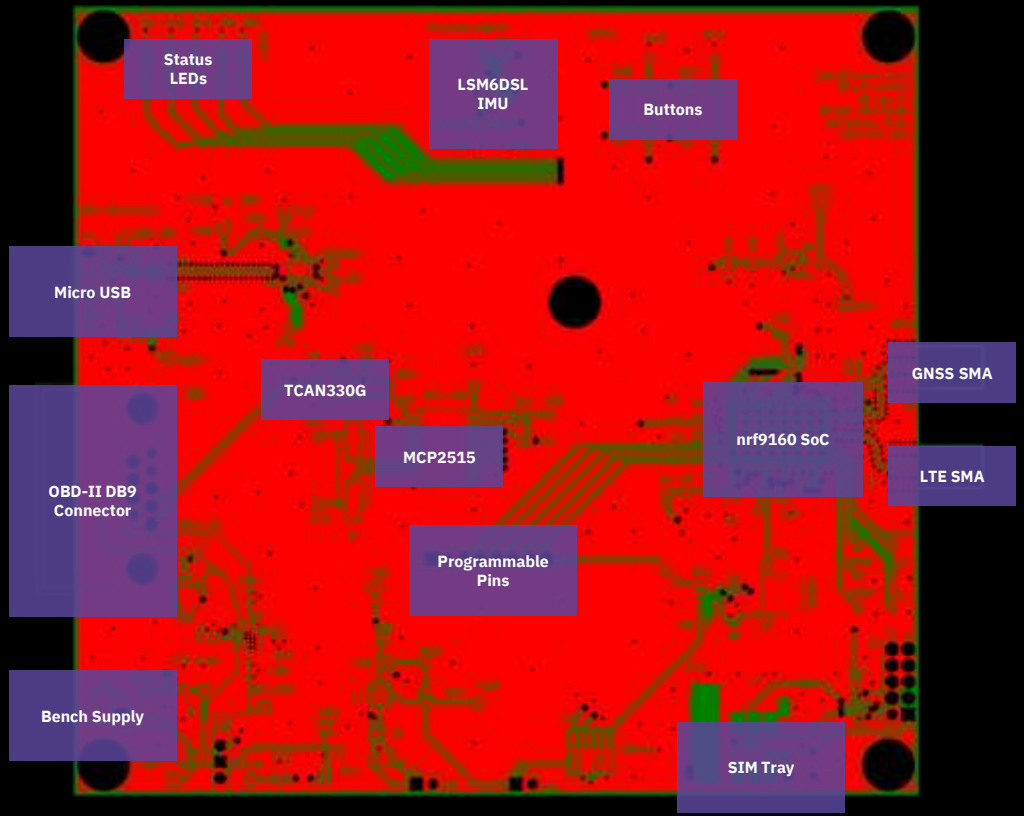


Layout

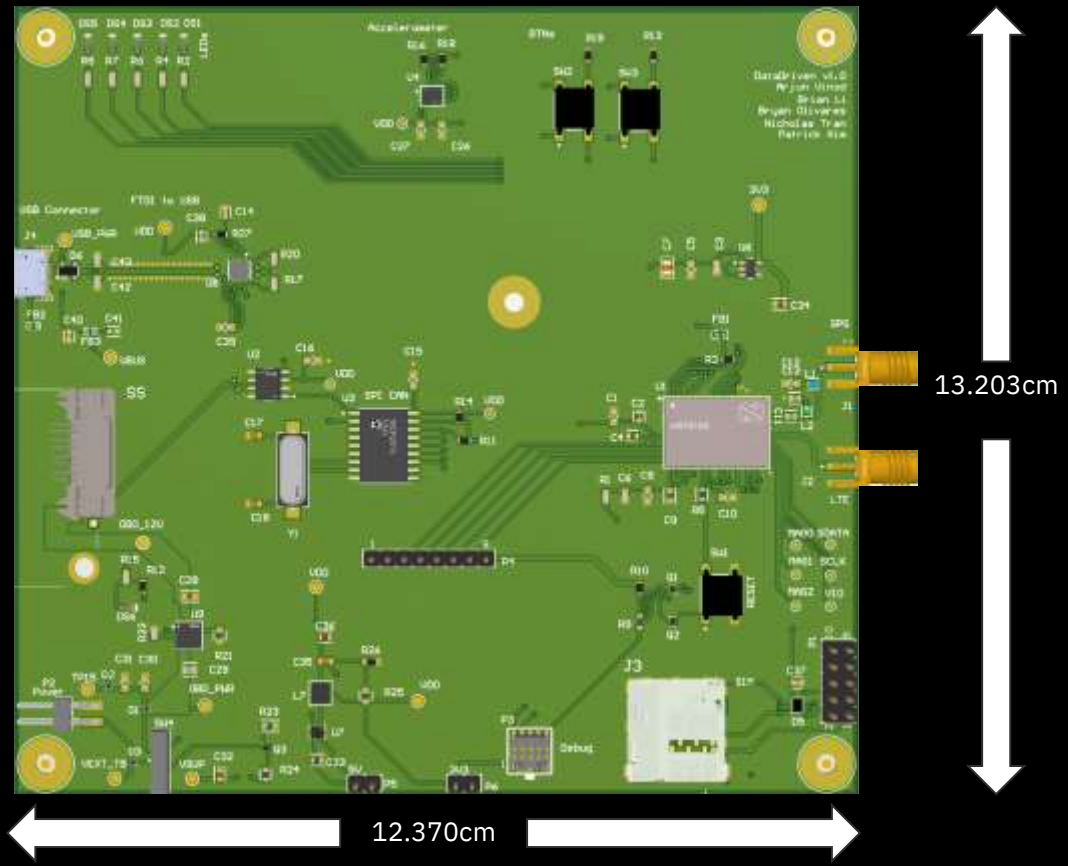
4-layer PCB

- Top Layer
- GND
- PWR
- Bottom Layer

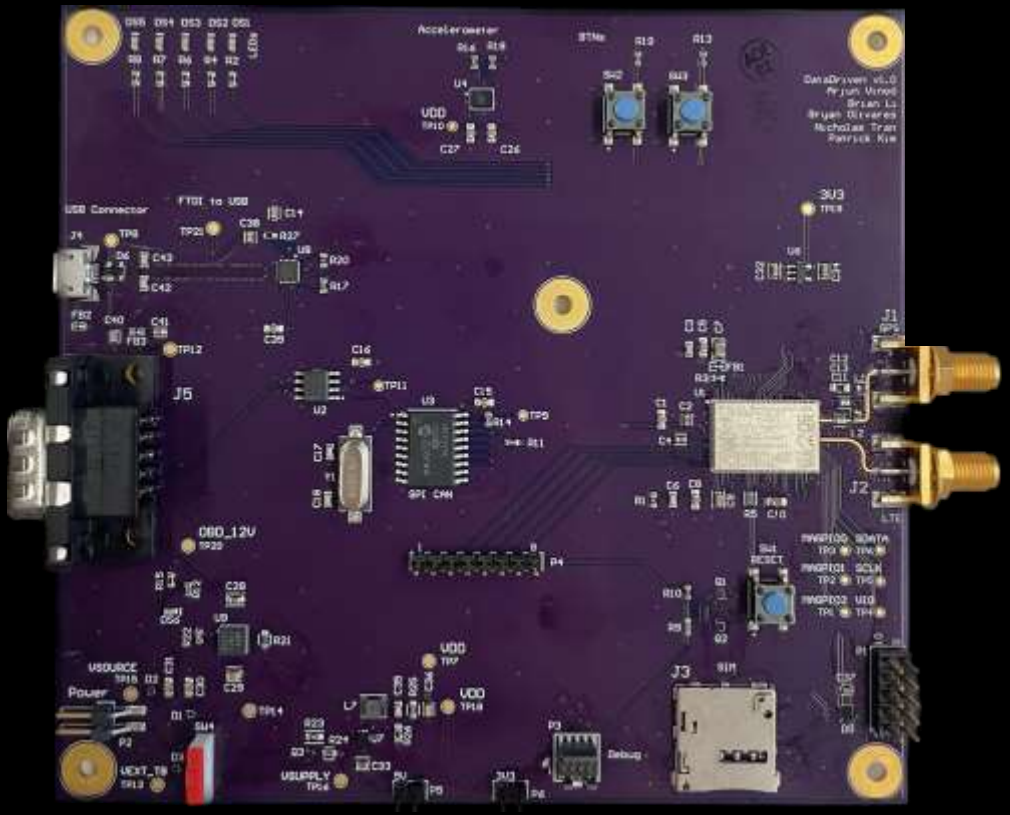
131 components



3D Rendering



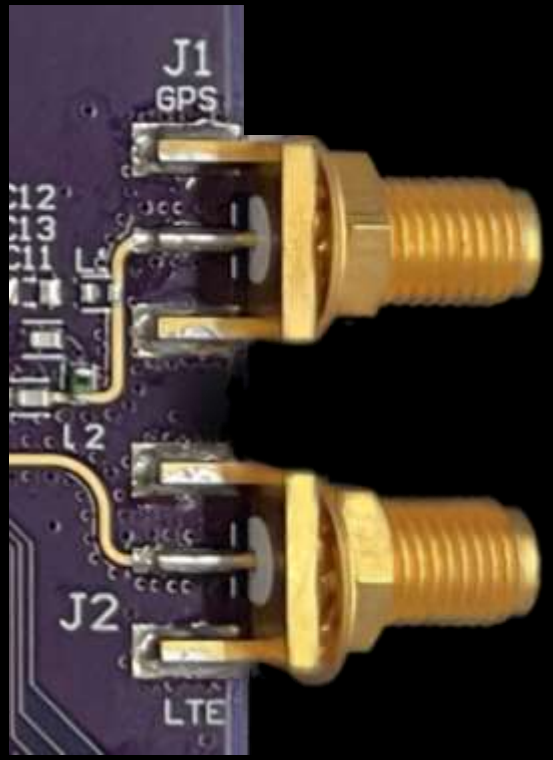
Final Product



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

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).

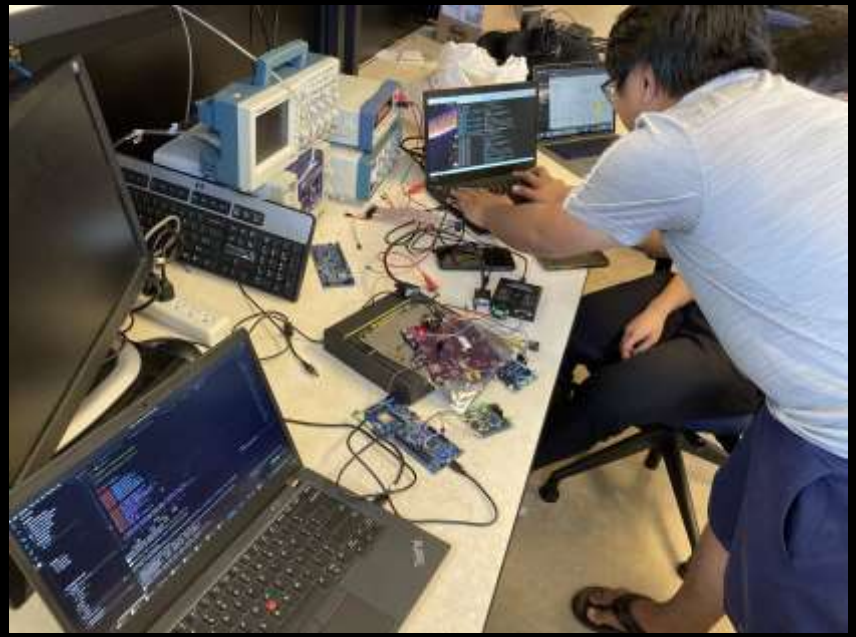


Live Tracking Demo

Retrospective

Data Driven

- 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.)

Data Driven

- More **test points.**
- **Better labels** for non-power TPs, like SPI, I2C, etc. signals.
- One **incorrect resistor** used for OBD-II power supply, so we needed to solder an external resistor for target resistance.
- 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.

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