Introduction to ScooerLab

ScooterLab
Workshop 2025
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At a Glance

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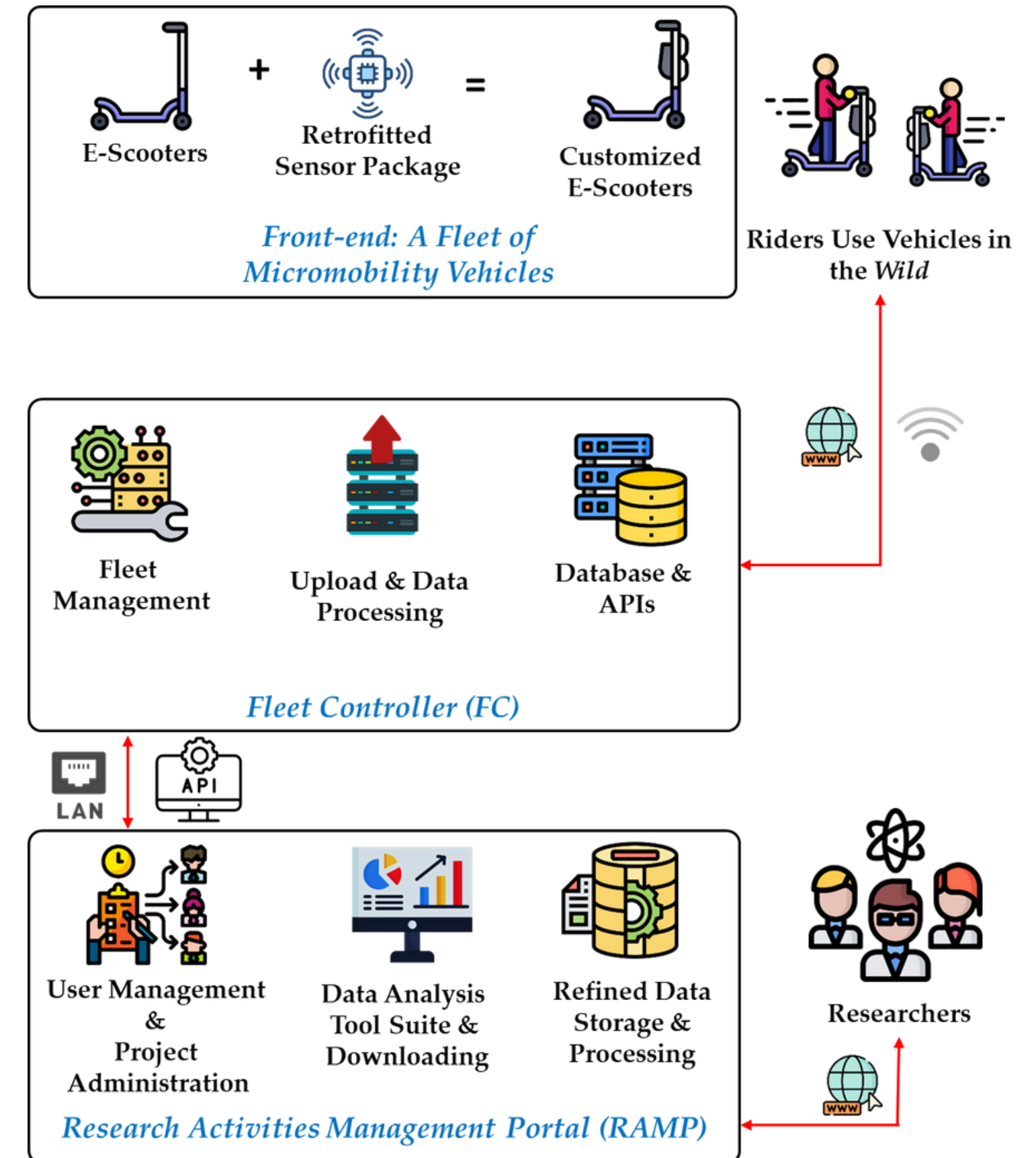
Overview

A community research testbed providing a programmable and participatory micromobility-supported sensing platform

Advance research at the intersection of Computer and Information Science and Engineering and interdisciplinary domains such as urban planning, mobility analytics, privacy and security, environmental sensing, and smart city infrastructure.
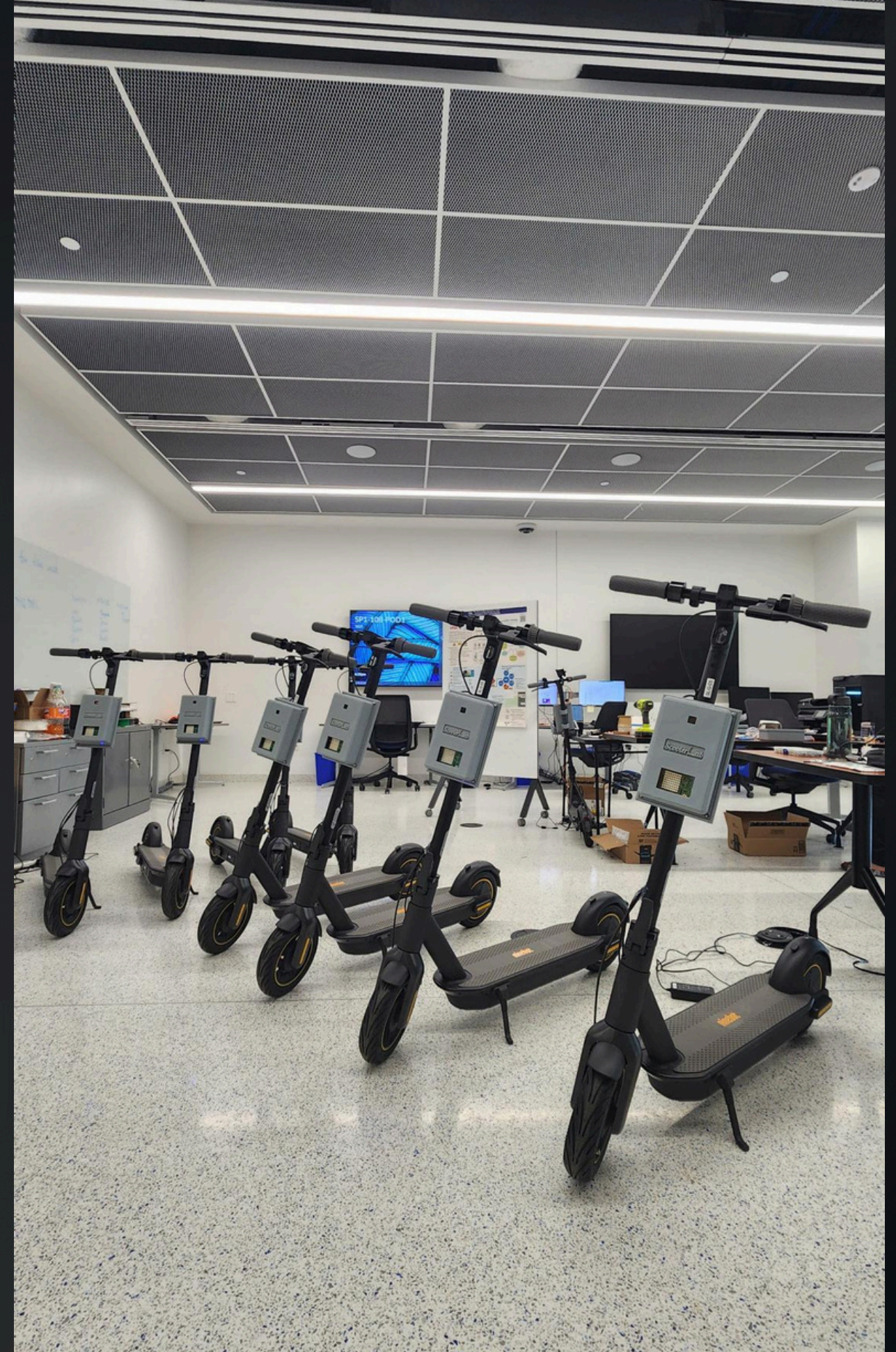
Architecture

1. Front-end: E-scooters & sensing
2. Fleet Controller
3. Research Activities Management Portal (RAMP)

E-Scooters + Retrofitted Sensor Package = Customized E-Scooters

Front-end: A Fleet of Micromobility Vehicles

Riders Use Vehicles in the *Wild*

Fleet Management · Upload & Data Processing · Database & APIs

Fleet Controller (FC)

User Management & Project Administration · Data Analysis Tool Suite & Downloading · Refined Data Storage & Processing

*Research Activities Management Portal (RAMP)*

Researchers

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Vehicle & Sensing

Design and engineer a custom sensor package to collect mobility, environmental, and contextual data.

Source E-Scooters

**Procure commercially available e-scooters suitable for retrofitting.**
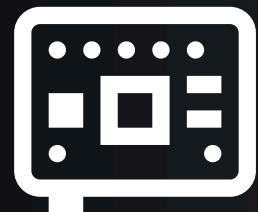
Develop a Sensor Suite

Design and engineer a custom sensor package to collect mobility, environmental, and contextual data.
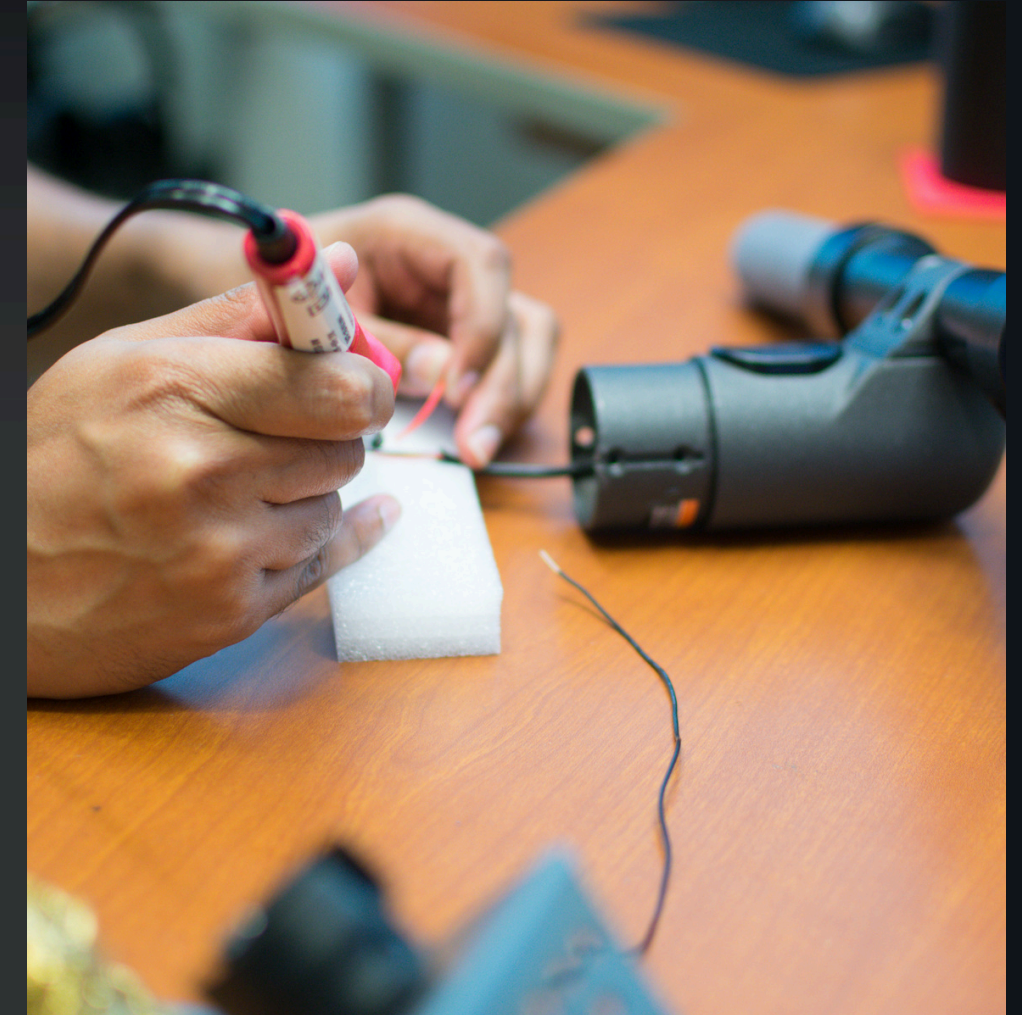
Retrofit & Integrate

Attach the sensor suite to e-scooters to create programmable research vehicles.

Sensor Suite

Wireless Base-station Computer (WBSC)

42V E-Scooter Battery

Step-down Transformer
42V → 5V

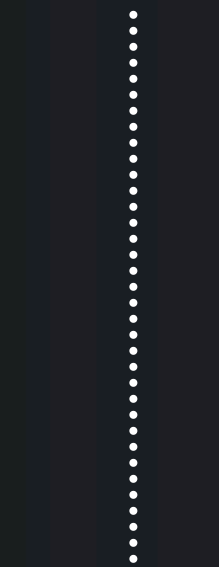Single Board Computer
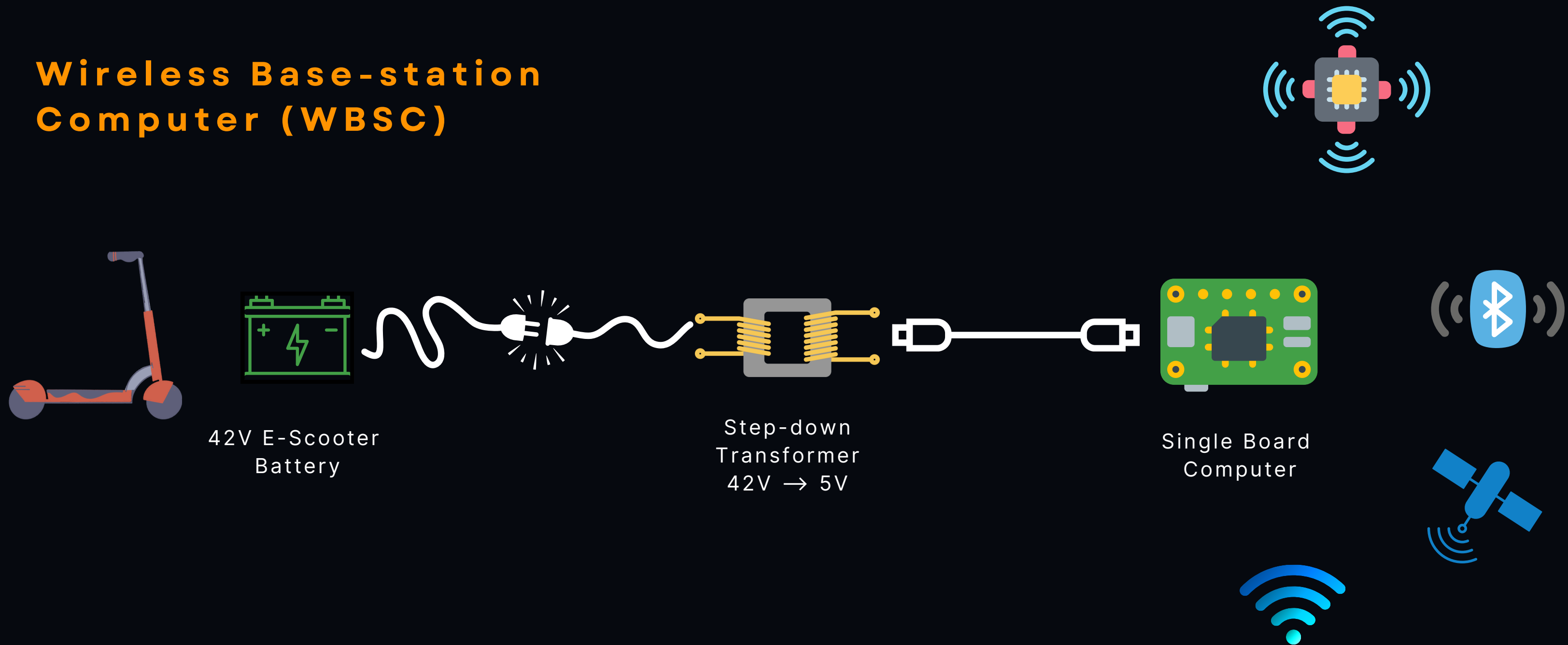
Timeline

Development Timeline

Initial efforts focused on shaping the project vision, identifying research needs, and establishing a path toward functional prototypes.
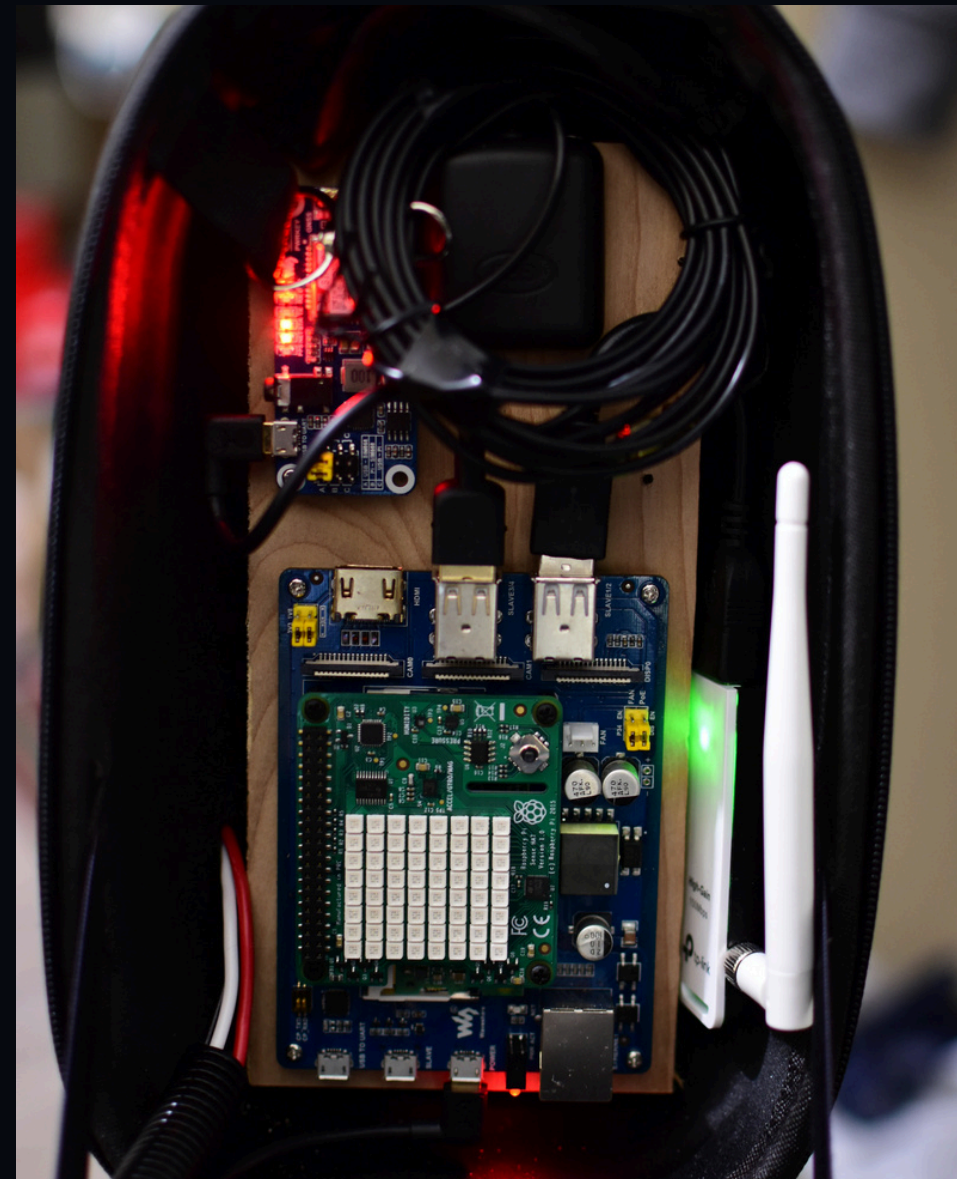
Planning Grant

2020

1st Prototype

2021
Codename: SLP1

First prototype

Segway Ninebot ES2
Raspberry Pi Compute Module 3+
Raspberry Pi Sense HAT v1
Sensors: Temperature, Pressure, Humidity, Accelerometer, Gyroscope, Orientation, Magnetometer
GPS, Bluetooth, WiFi

# Designing ScooterLab: Community Planning Workshops

- 2020 (Local Focus):
  - Identified community needs and outlined foundational goals for a micromobility research platform.

- 2021 (National Focus):
  - Engaged cross-disciplinary researchers to align on data collection needs, testbed design, and deployment strategies.
  - Attendees from 30 different institutes.

Timeline

Development Timeline

With the full grant awarded, efforts shifted toward scaling system architecture, refining prototype hardware, and preparing for testbed deployment.
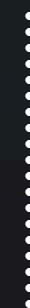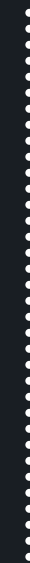
Full Grant

2023
NSF Community Infrastructure for Research in Computer and Information Science and Engineering (CIRC)

2nd Prototype

2023
Codename: SLP2

Goals for the SLP2

Improving hardware durability, expanding sensing capabilities, and enabling real-time data collection for research-grade deployments.

Weatherproof
WBSC (Sensor Box)

Robustness

Trip Data from
E-Scooter Firmware

Data Uploading

Roadblock

Supply Chain Issues...

In 2023, global shortages made Raspberry Pis nearly impossible to source in volume.

Raspberry Pi
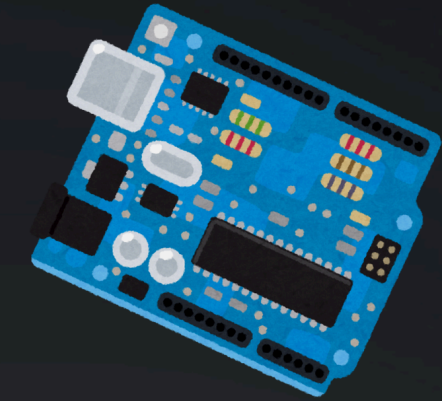
Custom Board?

? Solution?

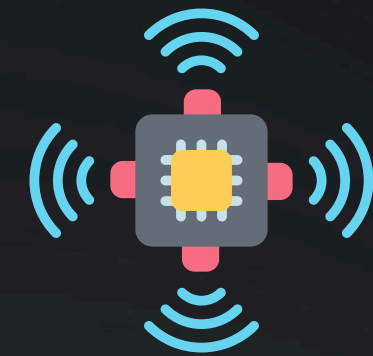Custom board vendors required minimum orders in the thousands

Pivot

Smartphone as WBSC

To maintain progress, we restructured the architecture to use off-the-shelf Android smartphones as the Wireless Base Station Computer (WBSC)

IN STOCK

Readily Available

Built-in GPS, IMU, WiFi, Bluetooth

?

Customizability?

USB interface for additional sensors?

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Second Prototype

Segway Ninebot G30LP
Samsung Galaxy A14
Sensors: Pressure, Humidity, Accelerometer, Gyroscope, Magnetometer
GPS, Bluetooth, WiFi

New Enclosure

The new and improved 3D printed enclosure to house the WBSC.

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3D Printed In-House

Material: PLA+
Print Time: ~20 hours

In-House Modeling

- **Modeled for modularity and weather protection**
- **Custom fit for scooter stem dimensions**
- **Easily replaceable and upgradable**
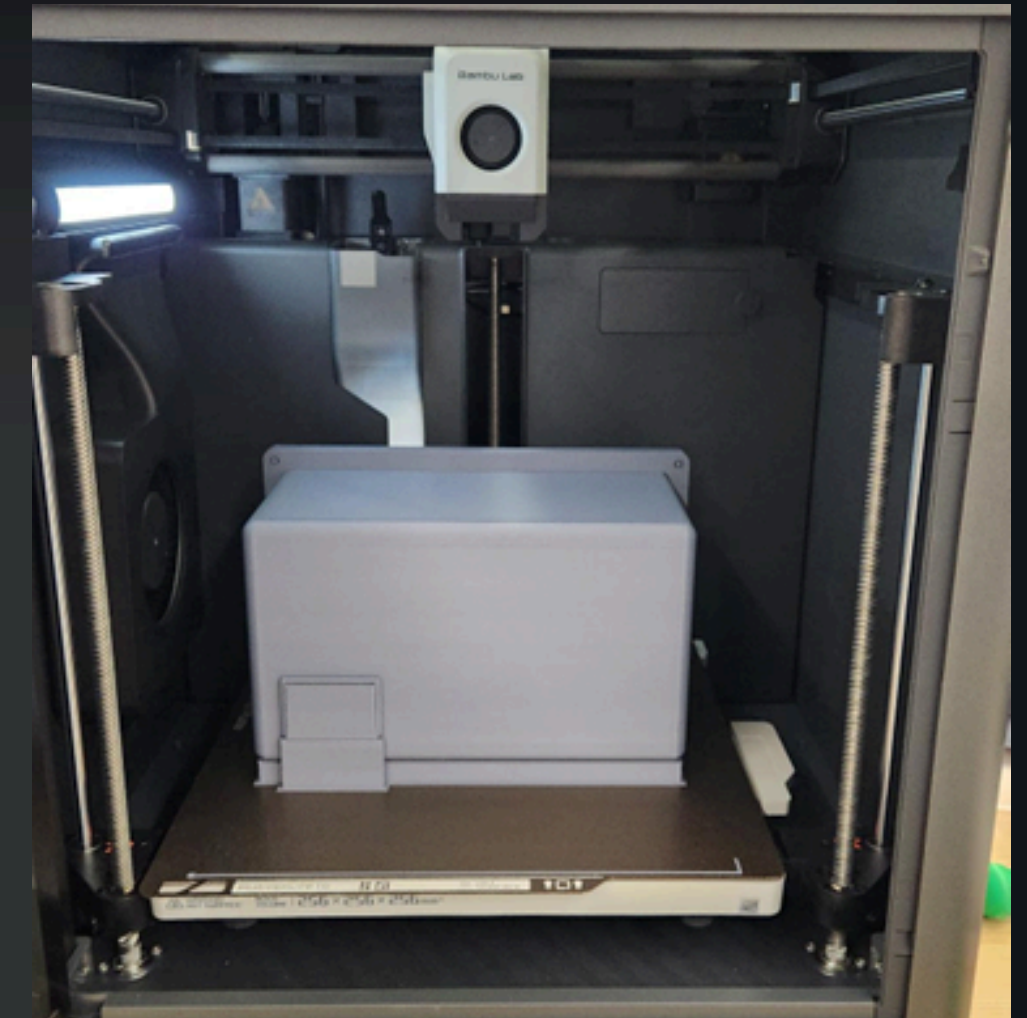
More Challenges

Bureaucratic challenges?

Purchasing smartphones required additional layers of approval under university IT and asset policies.
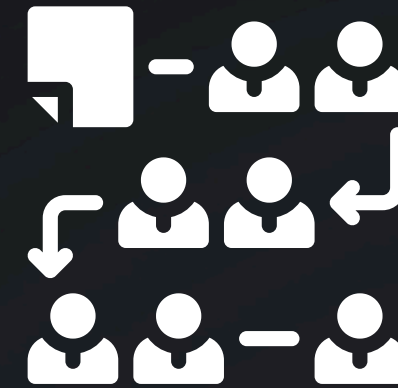
Smartphone purchase...

Too late to switch back now?

BACK IN STOCK

Raspberry Pi

SLP2 was already in testing phase...

Rapid Prototyping

Reinitiating Raspberry Pi development in parallel, while SLP2 testing proceeded uninterrupted
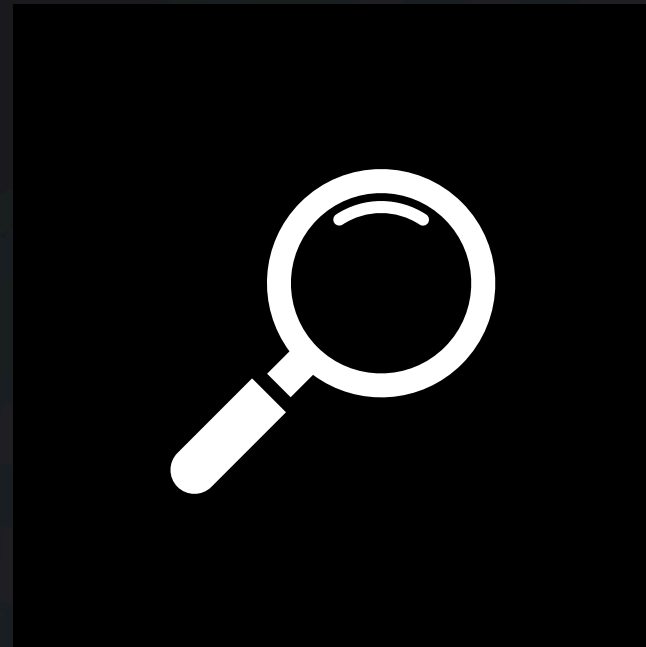
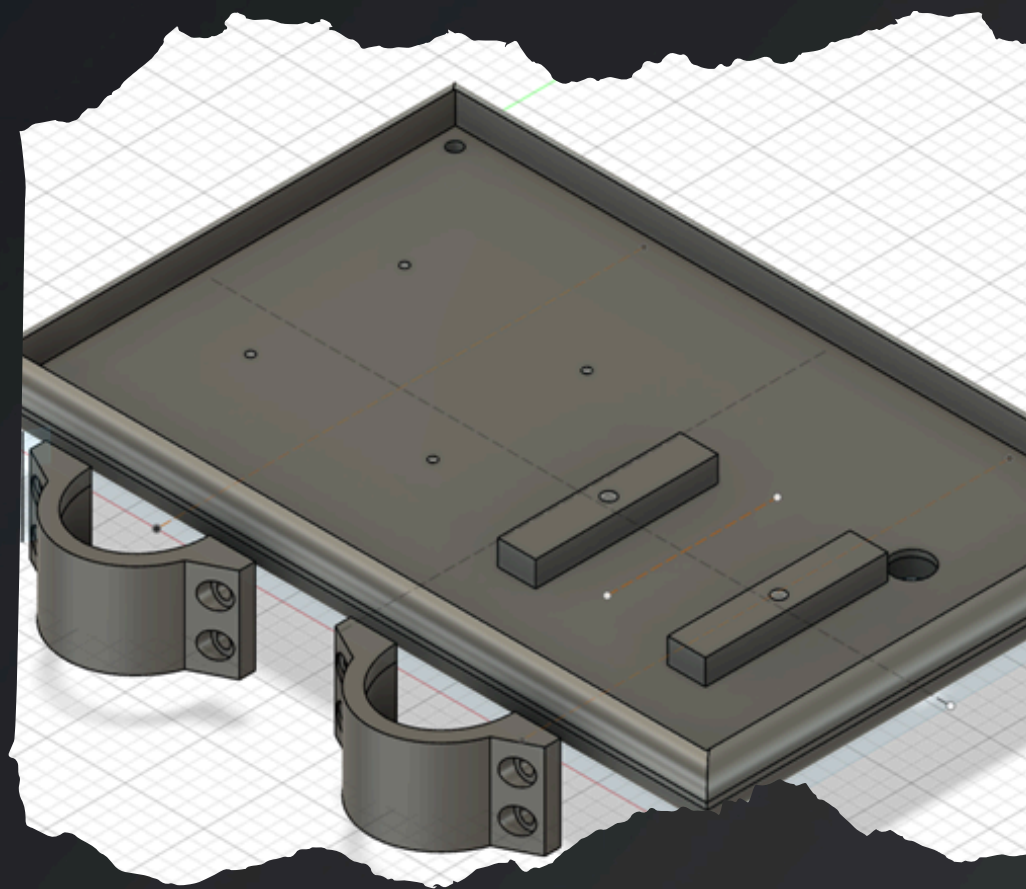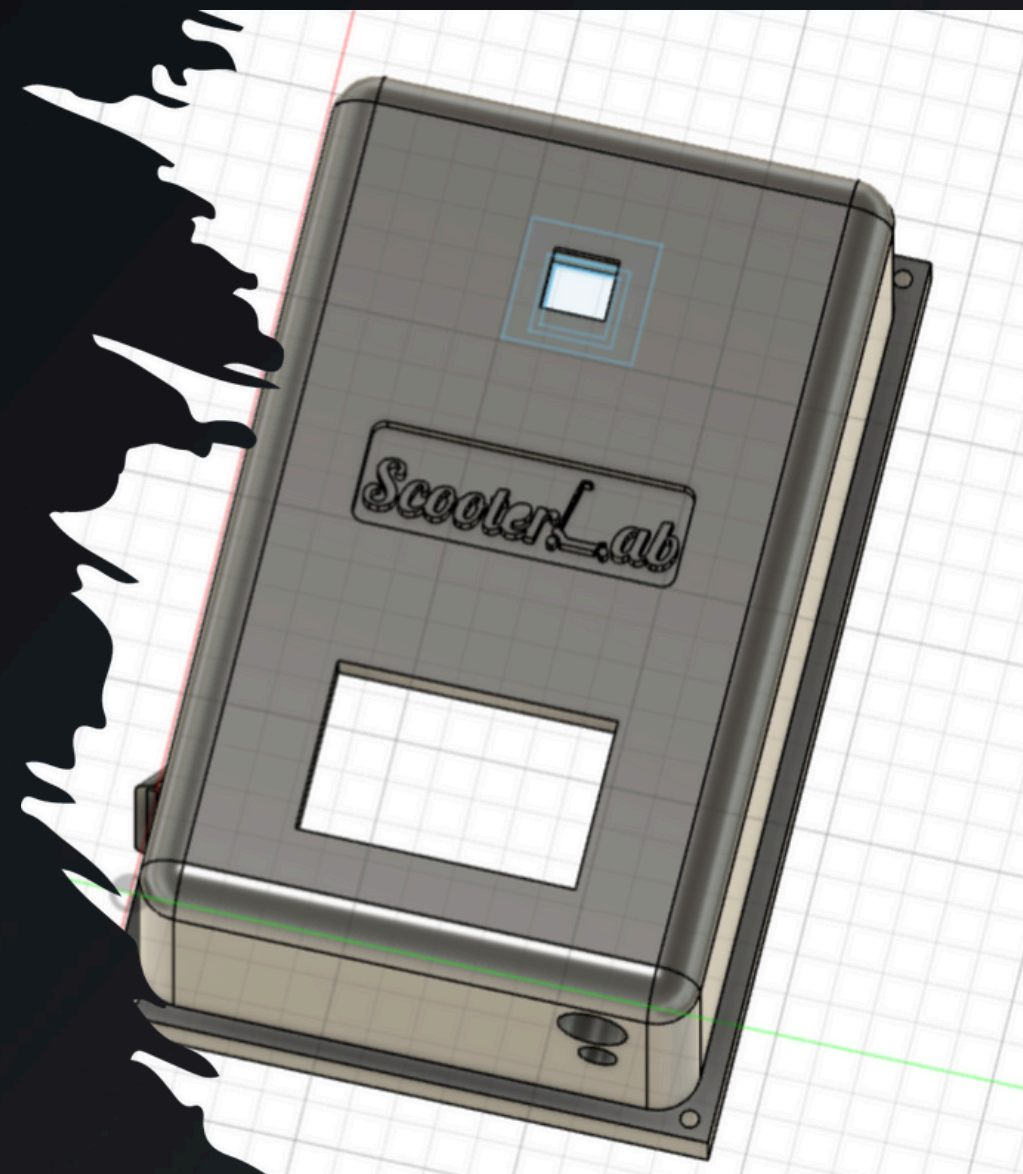*" With a larger team in place, front-end development accelerated. "*

Purchasing

- **Verified RPi and external sensor availability to prepare for fallback**

Prototyping

- **Built the third prototype (SLP3) using Raspberry Pi 4**
- **Reused/upgraded SLP1 software stack**
- **Implemented BLE-based e-scooter firmware data extraction**

New Box Design

Third Prototype
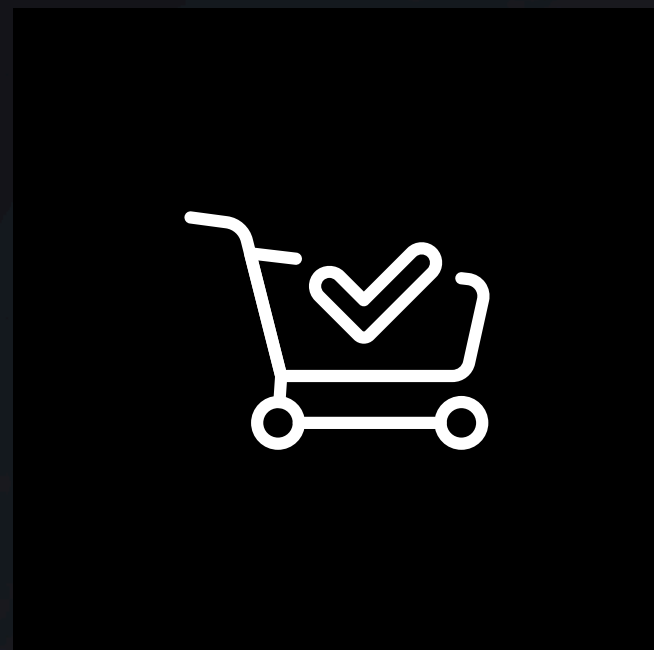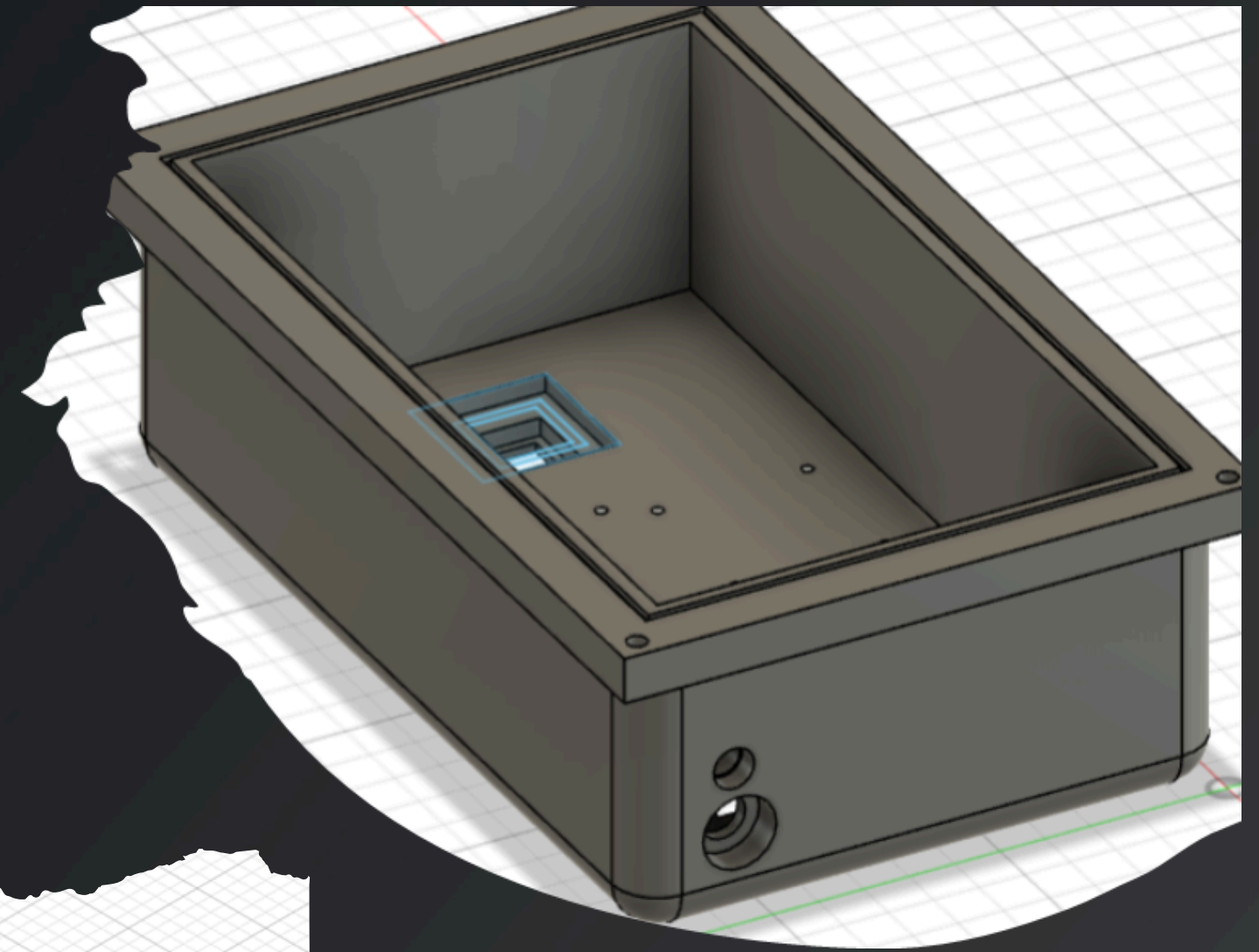
Segway Ninebot G30P MAX
Raspberry Pi 4, SenseHAT v2
Sensors: Light, Temperature, Pressure, Humidity, Accelerometer, Gyroscope, Orientation, Magnetometer
GPS, Bluetooth, WiFi
Software Upgrades: BLE connection to E-Scooter firmware. Data upload/download to backend server(FC).

Third Prototype

Segway Ninebot G30P MAX
18.6mph max speed
40mile range

Fleet Controller

Central hub for fleet operations, data ingestion, and RAMP integration

- Dual Intel Xeon 12-core CPUs
- 512 GB RAM, 720 TB storage
- 10 Gbps LAN for FC–RAMP communication

Fleet Management

- Deploys config files to scooters
- Supports dynamic parameter updates (e.g., sampling rates, sensor toggles)

Upload & Data Pre-Processing

- Preprocesses trip data
- Deidentification
- External datasets (e.g., traffic, weather) integration

Database & API

- Stores preprocessed data in MySQL
- Provides real-time access to RAMP via Flask-based API

Institutional Review Board (IRB)

- An IRB was approved for the base-experiment.

- Future experiments may either require modifications or new IRBs based on the experiment criteria.

Operations

A procedure of participant recruitment and e-scooter loaning.

Current model:
- Up to 2-week loan period
- Renew or return every 2 weeks

Open for exploring other models

PARTICIPANT ONBOARDING

1 Check-out appointment

CONSENT, TERMS & CONDITIONS

2 IRB approved consent form

SAFETY VIDEO

3 Mandatory safety video

TRAVEL SURVEY

4 Demographic & Travel behavior survey

Recruitment

Fleet Management Portal

Deployment Launch

- September, 2024

- ScooterLab loaned its first e-scooter to our inaugural student participant from UTSA.

TOTAL TRIPS

903

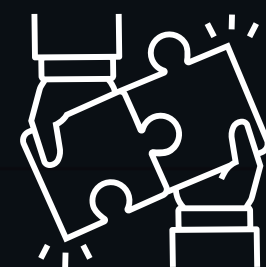TOTAL MILES

1771
MILES

AVG DISTANCE

2 MILES

Stats So Far

What's next?

Scaling up

Scaling up the fleet to 80-100 e-scooters

Collaborative Experiments

Executing research proposals submitted by the community on the ScooterLab

COMING UP NEXT: RAMP