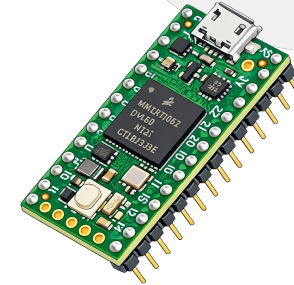
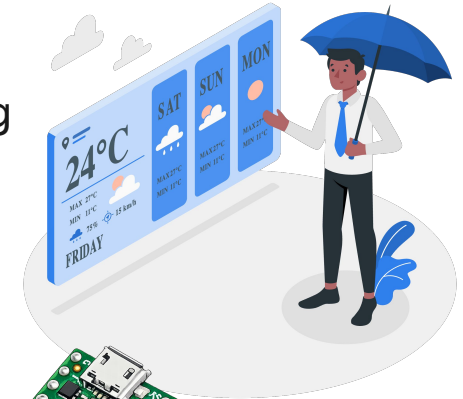




Open Arduino-Based Environmental Sensor Package for COSMOS Nodes:

Design, Integration, and Real-Time Environmental Monitoring

Presenter: Ben Katz





Project Team



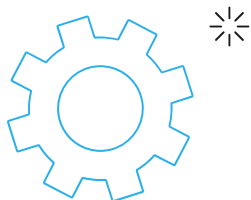
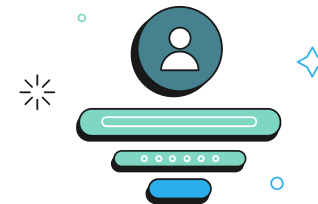
Ben Katz
Undergraduate Researcher
Electrical Engineering,
Rutgers SOE

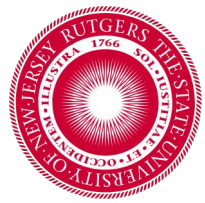
Hardware • Firmware • Data



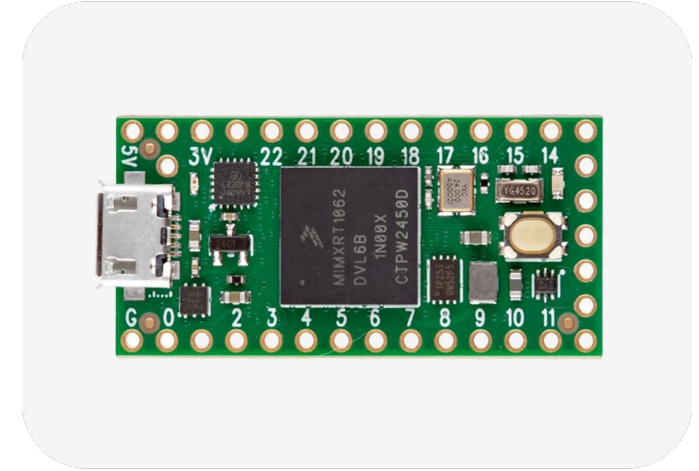
Jakub Kolodziejski
Advisor
Senior Lab Engineer,
WINLAB Advisor

Mentorship • Integration





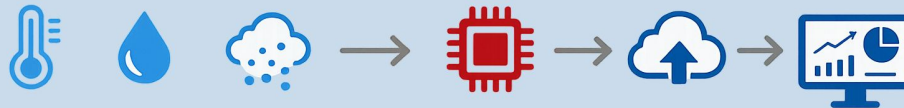
COSMOS Nodes & Microcontrollers



Programmable Research Infrastructure



Sensor Control & Data Collection



Microcontrollers enable environmental monitoring for COSMOS Nodes



Why Monitor the Environment?

Add Environmental Context

Measure temperature, humidity, air quality, sound, and motion around each node.

Reveal Local Patterns

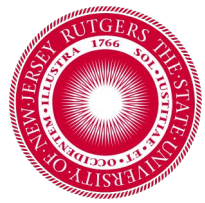
Correlate environmental conditions with wireless and camera-based activity.

Enable Scalable Monitoring

Low-cost, open-source sensors make deployment across multiple locations practical.



Locations of COSMOS Nodes at Columbia University (In Red)



Project Goals & Proposed Solution



Integrate

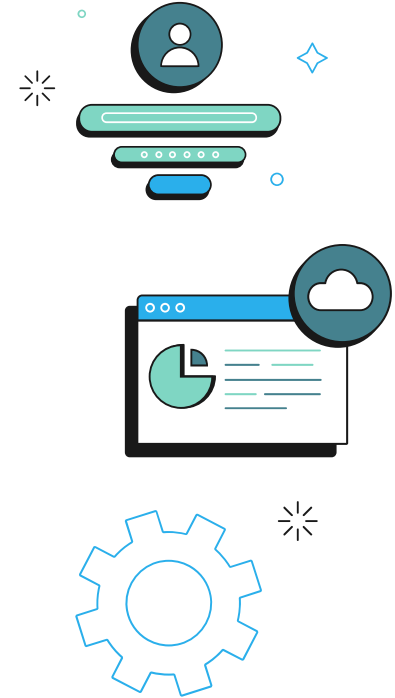
Connect multiple environmental sensors to one microcontroller.

Validate

Build and test a reliable working prototype.

Package

Design a compact enclosure for future deployment.





Sensor Selection



Climate



AmbiMate MS4

Temperature, humidity, light, TVOC, eCO₂, motion, and supply voltage

BMP085

Atmospheric pressure and estimated altitude

Particles



SPS30

Dust and airborne particles, including PM1.0, PM2.5, PM4.0, PM10, particle count, and typical particle size

Gases



MQ-7

Carbon monoxide and vehicle exhaust

MQ-4

Methane and possible gas leaks

MQ-2

Smoke and combustible gases

MQ-3

Alcohol vapor

MiCS-2714

Nitrogen dioxide and traffic-related pollution

Sound



AmbiMate MS4 + BOB-09868

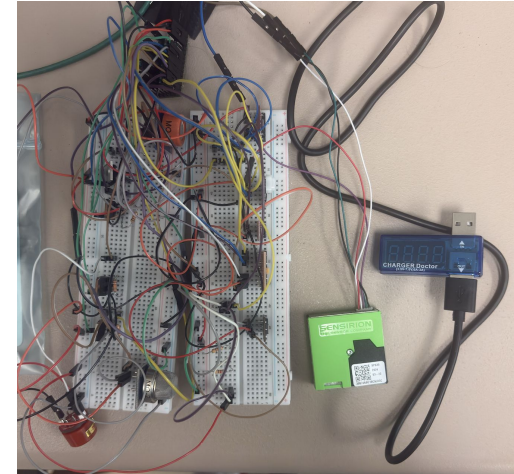
Ambient noise activity



Result 1:

Multi-Sensor Hardware Integration

- Connected 10 environmental sensors to a Teensy 4.0
- Integrated communication interfaces
- Added transistor heater-control circuits for the MQ-series sensors
- Used voltage dividers to protect the Teensy's 3.3 V analog inputs
- Verified simultaneous sensor operation through real-time data acquisition



Hardware Integration





Result 2: Real-Time Multi-Sensor Data Acquisition



- Collected live measurements from the integrated sensor package
- Recorded temperature, humidity, pressure, light, sound, motion, and gas-sensor outputs
- Displayed MQ-series heater status and measurement cycles
- Verified that multiple sensors could operate within the same program
- Produced structured serial output for downstream data processing

```
Output Serial Monitor - X
Message (Enter to send message to 'Tosney 4.0' on 'usb-110000')

14:38:54.339 -> ----- AmbiMate -----
14:38:54.339 -> Raw Audio: 58
14:38:54.339 -> Temperature (C): 22.58
14:38:54.339 -> Humidity (N): 47.48
14:38:54.339 -> Light: 172
14:38:54.339 -> TVOC: 7
14:38:54.339 -> eCO2: 451
14:38:54.339 -> Voltage: 3.35
14:38:54.339 -> Nearby Motion: FALSE
14:38:54.339 -> ----- Pressure Sensor -----
14:38:54.339 -> Pressure (Pa): 100384
14:38:54.372 -> Pressure (hPa): 1003.88
14:38:54.484 -> Temperature (C): 21.98
14:38:54.484 -> Altitude (m): 78.22
14:38:54.477 -> ----- B08-89868 Microphone -----
14:38:54.471 -> Mic Min: 255
14:38:54.471 -> Mic Max: 622
14:38:54.471 -> Sound Level Raw Peak-to-Peak: 367
14:38:54.471 -> ----- MQ-7 Carbon Monoxide Sensor -----
14:38:54.471 -> MQ-7 Raw: 173
14:38:54.471 -> MQ-7 Voltage: 0.556 V
14:38:54.471 -> ----- MQ-4 Methane Sensor -----
14:38:54.471 -> MQ-4 Raw: 224
14:38:54.471 -> MQ-4 Voltage: 0.723 V
14:38:54.471 -> ----- MQ-2 Combustible Gas Sensor -----
14:38:54.471 -> MQ-2 Warning Up - No Reading
14:38:54.471 -> ----- MQ-3 Alcohol Sensor -----
14:38:54.471 -> MQ-3 Warning Up - No Reading
14:38:54.471 -> ----- MQ-3 Warning Up - No Reading
14:38:54.471 -> ----- NO2 Sensor -----
14:38:54.471 -> NO2 Raw: 872
14:38:54.471 -> NO2 Voltage: 2.168 V
14:38:54.471 ->
```

Arduino IDE Output (C++)

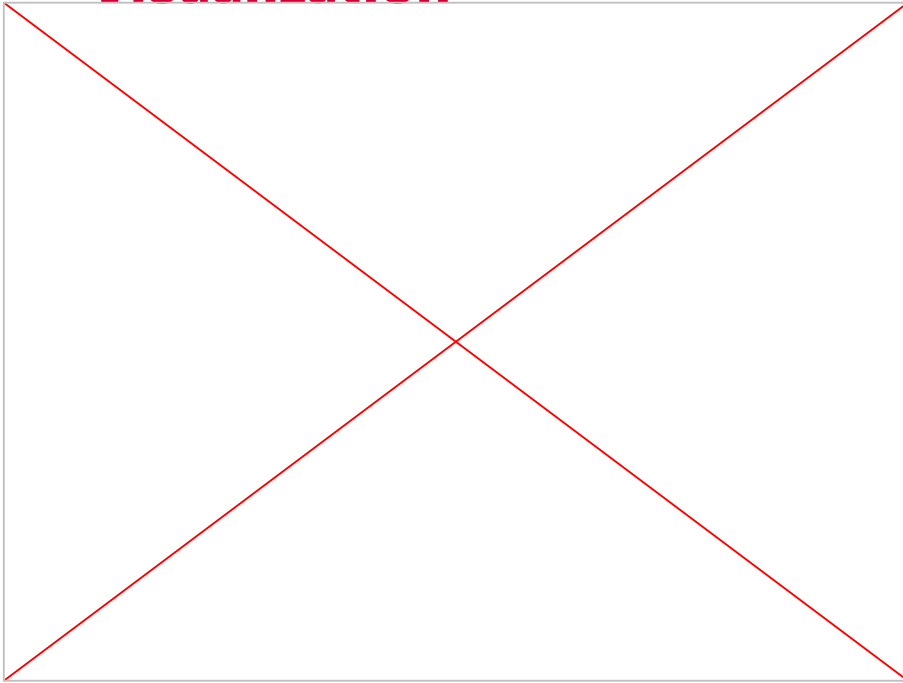
```
sensor-stack -- Python serial_to_influx.py -- 80x24
----- AmbiMate -----
Wrote 17 fields to InfluxDB.
Raw Audio: 58
Temperature (C): 22.98
Humidity (N): 45.28
Light: 177
TVOC: 2
eCO2: 416
Voltage: 3.35
Nearby Motion: FALSE
----- Pressure Sensor -----
Pressure (Pa): 100288
Pressure (hPa): 1002.88
Temperature (C): 22.38
Altitude (m): 93.58
----- B08-89868 Microphone -----
Mic Min: 255
Mic Max: 622
Sound Level Raw Peak-to-Peak: 371
----- MQ-7 Carbon Monoxide Sensor -----
MQ-7 Raw: 178
MQ-7 Voltage: 0.574 V
----- MQ-4 Methane Sensor -----
MQ-4 Warning Up - No Reading
```

Python Script (.py)

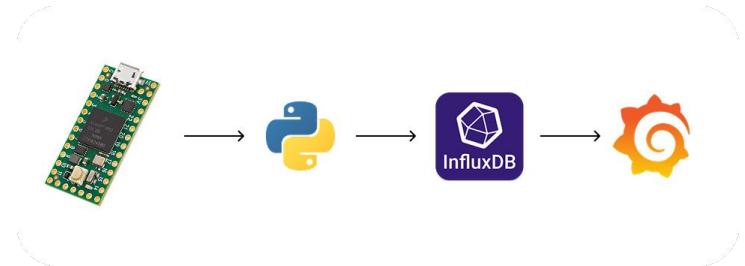


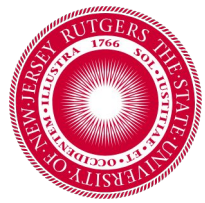


Result 3: Real-Time Data Pipeline and Visualization



- Parsed live sensor data with Python
- Stored measurements in InfluxDB
- Visualized live data in Grafana
- Verified continuous Teensy-to-dashboard transfer





Result 4: Compact Modular Enclosure Design



Sensor Station Inspiration

- Designed a compact, 3D-printable enclosure
- Added removable mounting and ventilation components
- Optimized airflow and sensor placement
- Reduced internal volume and simplified assembly
- Prepared the package for outdoor deployment



CAD Enclosure



Future Work and Recommendations

Custom Printed Circuit Board Development (PCB)

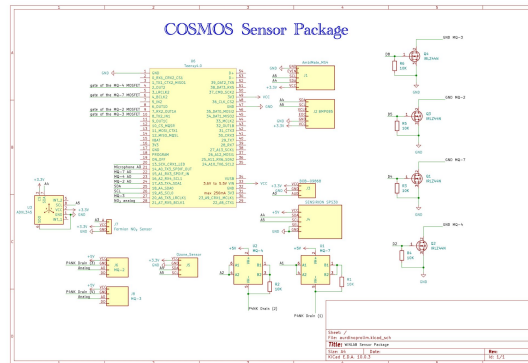
- Consolidate the modular architecture into a single integrated board
- Reduce wiring complexity and improve manufacturability

Sensor Validation and Calibration

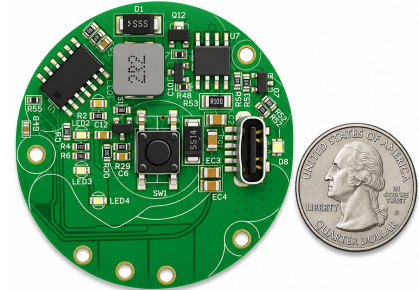
- Validate measurements against reference data
- Improve long-term stability and accuracy

Future COSMOS Deployment

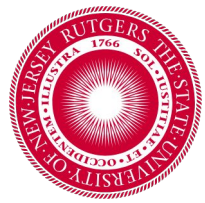
- Install and test the package at a Manhattan COSMOS node
- Evaluate real-world sensing performance



KiCad Schematic



Custom PCB Example



QUESTIONS?