



ECEN 404 Final Presentation

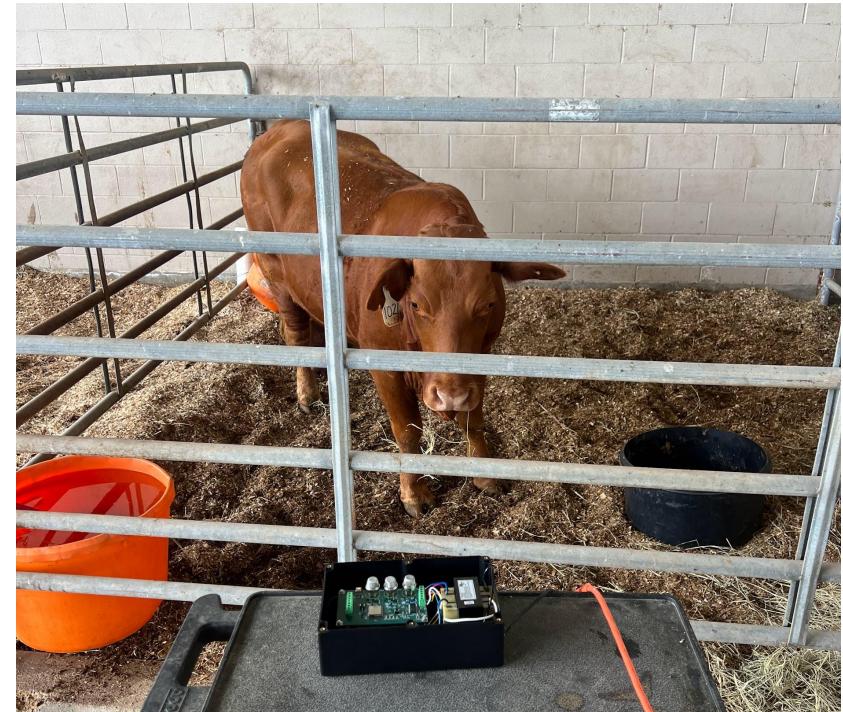
Team 28: Livestock Gas Monitor

**Matthew Owen, Joaquin Salas, Blake Schwartzkopf,
Tanmay Sarkar**

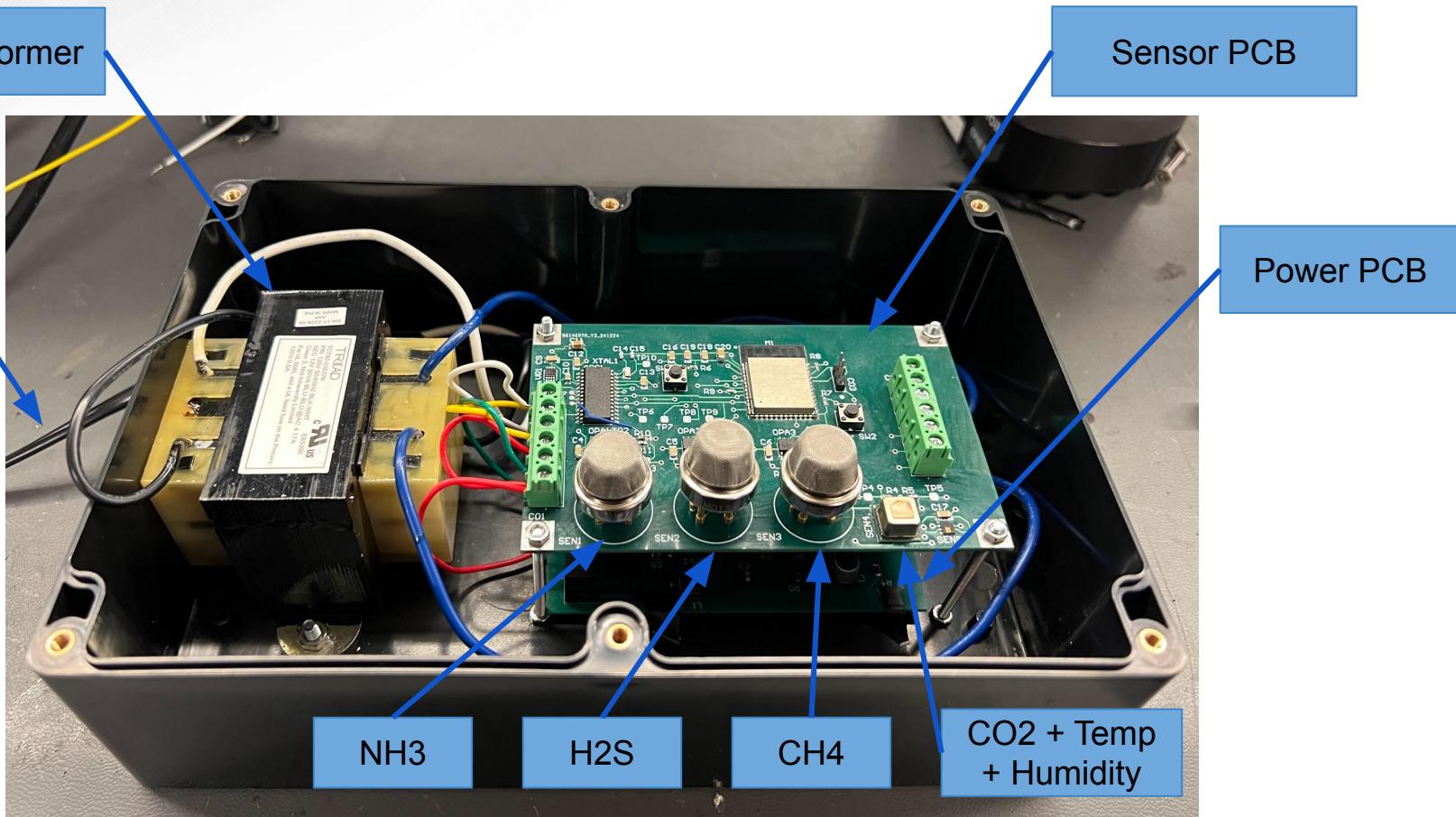
Sponsor: Global Hawk Solutions LLC (Justin Houck)
TA: Vishwam Raval

Problem Overview

- Monitoring environmental conditions in animal farms.
- To design and implement a durable, real-time gas monitoring system that can track harmful gases in animal farms.



Integrated Project Diagram



User Interface

Gas Monitoring System

Temperature (°C)

Average: , Min: , Max:

Humidity (%)

Average: , Min: , Max:

CO₂ (ppm)

Average: , Min: , Max:

ID	Temperature (°C)	Humidity (%)	CO ₂ (ppm)	CH ₄ (ppm)	NH ₃ (ppm)	H ₂ S (ppm)	Timestamp
3278	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:38:03
3277	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:58
3276	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:53
3275	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:48
3274	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:43
3273	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:38
3272	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:33

Engineering Design Accomplishments

Blake

- Designed 2 iterations of the sensor pcb that takes measurements of CH4, H2S, NH3, CO2, Temperature, and humidity in the air.
 - PCB consisted of 3 analog sensors, 2 digital I2C sensors, unity gain op amps, ADC, and microcontroller.
- Created equations to convert the voltage level detected to the gas concentration in parts per million.

Challenges	Solutions
Voltage divider for ain1 not working.	Ain1 input on ADC broken, rerouted to ain4.
Analog sensors heating up the board and causing skewed temperature measurements.	External sensor in the housing unit routed to the microcontroller.
Inaccuracy in voltage to ppm calculations.	Looked over datasheet again and fixed the equations.

Engineering Design Accomplishments

Blake

NH3 (ppm)	H2S (ppm)	CH4 (ppm)
27.5278	0.1324	0.336903
37.7256	0.135651	0.330812
602.433	0.113883	0.255422
37.541	0.172677	0.462406
37.6081	0.169129	0.382718
27.3617	0.104913	0.492009
28.5659	0.113744	0.398275



Temp with sensors (F)	Temp without sensors (F)
88.71	75.77
89.11	75.73
86.37	75.74
86.63	75.69
86.85	75.68
87.06	75.71
87.28	75.72

Engineering Design Accomplishments

Blake

Input Value	Output Value	Corrected Value	Error (%)
0.25	0.272611	0.24996	0.00016
0.3	0.3214	0.299959	0.00014
0.35	0.370206	0.349975	0.00007
0.4	0.419002	0.399982	0.00005
0.45	0.467812	0.450002	0.00000
0.5	0.516805	0.500005	0.00001
0.55	0.565394	0.550004	0.00001
0.6	0.614412	0.599039	0.00160
0.65	0.6629	0.649928	0.00011
0.7	0.710648	0.699913	0.00012
0.75	0.760481	0.749993	0.00001
0.85	0.858065	0.849934	0.00008
0.95	0.955856	0.949924	0.00008
1	1.00447	1.00046	0.00046
1.25	1.24846	1.250016	0.00001
1.5	1.429238	1.499936	0.00004
1.75	1.736281	1.749929	0.00004
2	1.980254	1.999953	0.00002

Sent voltages to the ADC and then to microcontroller.

Corrected error and calibrated the ADC.

Engineering Design Accomplishments

Matthew

- Designed multiple iterations of power PCB to provide 5,3.3,-8 V under max current of 1A to sensor subsystem
 - PCB consisted of buck boost converters, AC-DC rectifiers, inverters, and filtering circuits
- Fabricated a custom housing unit that securely mounted PCBs and the transformer. Wired all components in a way that protected both the parts and the connections

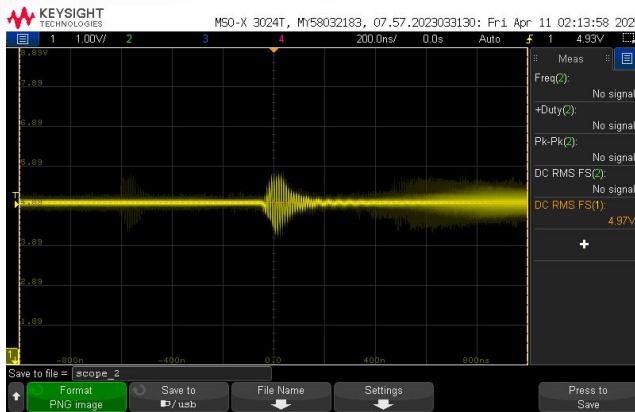
Challenges	Solutions
Power subsystem not handling load from sensors subsystem	Redesign pcb by removing overloaded capacitors and make changes to resistor values
Negative voltage not working	Identify and order new parts that were better suited to handle the amount of load necessary for project and revising the pcb to correct the input voltages of the inverter
Unreliable power for long periods over long periods of time	Rewired transformer and corrected all sloppy soldering points

Engineering Design Accomplishments

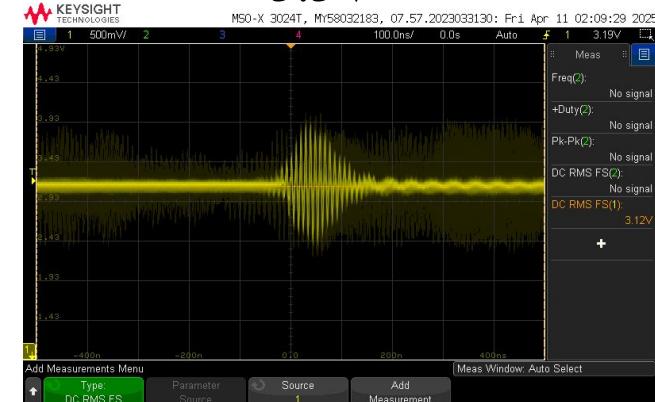
Matthew

- Voltages under full load conditions have been tested and validated

5V



3.3V



-8.5V



Engineering Design Accomplishments - Joaquin

- Programmed ESP32-S3 in ESP-IDF (C):
 - Several GPIO, Built in Wi-Fi/Bluetooth, low-level control, managing tasks
- Integrated sensors:
 - I2C: HDC1000 (Temp/Humidity), SCD41 (CO₂ + Temp/Humidity)
 - Analog: MQ-4, MQ-136, MQ-137 via AD7718 Analog-Digital Converter
- Developed Wi-Fi/MQTT transmission to AWS IoT for real time data visualization

Challenges	Solutions
Interfacing and calibrating AD7718 ADC	Referencing spec sheet to find setup processes, read/write/reset register. Improved voltage measurement with a linear calibration equation.
Wi-Fi connectivity and flexibility (no hard-coded credentials)	Integrated Wi-Fi provisioning. Added error-handling and reconnection logic to always stay online.
Replica/Repeated Data Transmissions	Implemented a mutex (semaphore) to protect shared sensor data during updates, preventing repeated or stale values from being transmitted.

Engineering Design Accomplishments - Joaquin

Requirement	Target Spec	Result
Read Analog Sensor Data	±1% error max across 0-2.5V	Minimum Error: 0.000001% Maximum Error: 0.00160% Average Error: 0.00017%
Read Digital Sensor Data	Digital sensor initializes and reports valid CO ₂ , temperature, and humidity values	Successful sensor initialization and realistic environmental readings under test conditions
Transmit Sensor Data	Send all sensor values every 5s to AWS MQTT broker without data loss	0 data loss, corrupted data, repeated data
Wi-Fi Range and Stability	Maintain stable transmission over extended time periods (30 min, 1 hr, 2 hrs, 3 hrs)	Successful under ideal Wi-Fi. Under busy Wi-Fi network/weak signal: Wi-Fi reconnects every 5-20 data transmissions.

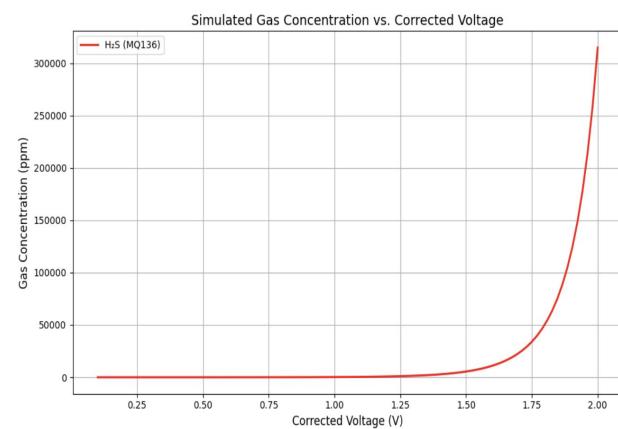
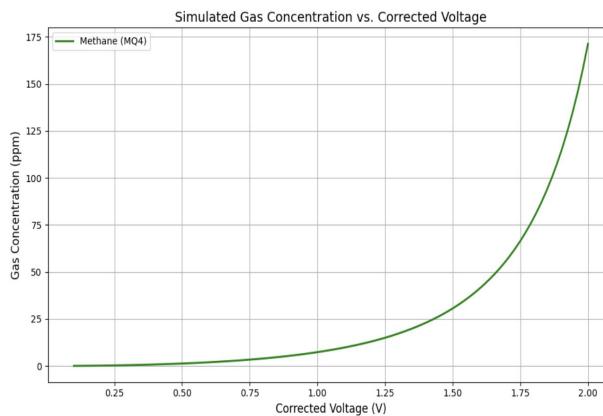
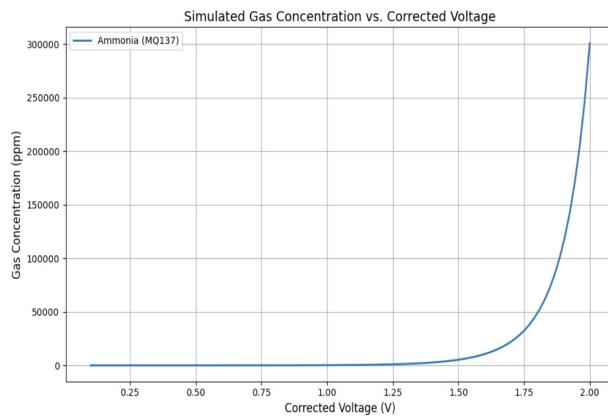
	Temp (°F)	Humidity (%)	CO ₂ (ppm)
min	76.85	51.55	390.0
max	87.06	60.45	764.0
mean	84.88	56.81	475.85

From 11:00 AM to 2:00 PM on April 3rd:

Temp (°F): Min = 81°F, Max = 88°F, Average = 85.25°F

Humidity (%): Min = 61%, Max = 79%, Average = 68%

Engineering Design Accomplishments - Joaquin



```
I (2940) gasmonitor: TLS connection successful
I (3610) coreMQTT: MQTT connection established with the broker.
I (3610) gasmonitor: MQTT connection successful
I (4110) gasmonitor: mqtt_process_task started
I (4620) AD7718: AD7718 initialized!
I (5110) main_task: Returned from app_main()
I (9630) SCD41: Sensor initialized!
I (9820) AD7718: AIN1 Voltage: 0.484118 V
I (10020) AD7718: AIN2 Voltage: 0.485083 V
I (10220) AD7718: AIN3 Voltage: 0.319886 V
I (15420) AD7718: AIN1 Voltage: 0.483310 V
I (15620) AD7718: AIN2 Voltage: 0.484435 V
I (15820) AD7718: AIN3 Voltage: 0.319314 V
I (19640) gasmonitor: Publishing: {"temperature":91.98, "humidity":43.32, "co2":558.00, "NH3":4.513113, "H2S":0.556384, "CH4":1.663040}
I (21020) AD7718: AIN1 Voltage: 0.482838 V
I (21220) AD7718: AIN2 Voltage: 0.483742 V
I (21420) AD7718: AIN3 Voltage: 0.319410 V
I (25660) gasmonitor: Publishing: {"temperature":91.50, "humidity":43.94, "co2":564.00, "NH3":4.480154, "H2S":0.557184, "CH4":1.659512}
I (26620) AD7718: AIN1 Voltage: 0.509980 V
I (26820) AD7718: AIN2 Voltage: 0.572995 V
I (27020) AD7718: AIN3 Voltage: 0.532796 V
I (30670) gasmonitor: Publishing: {"temperature":91.08, "humidity":44.54, "co2":619.00, "NH3":10.875322, "H2S":7.065025, "CH4":1.870822}
I (32220) AD7718: AIN1 Voltage: 0.540971 V
I (32420) AD7718: AIN2 Voltage: 0.568763 V
I (32620) AD7718: AIN3 Voltage: 0.413384 V
```

Above: Equations used for calibrating gas sensors

Example Equation: Ammonia (NH₃) — MQ137 (AIN4)

$$\text{PPM} = 1264.231 \times (Rs / 10064)^{(-4.1325)}$$

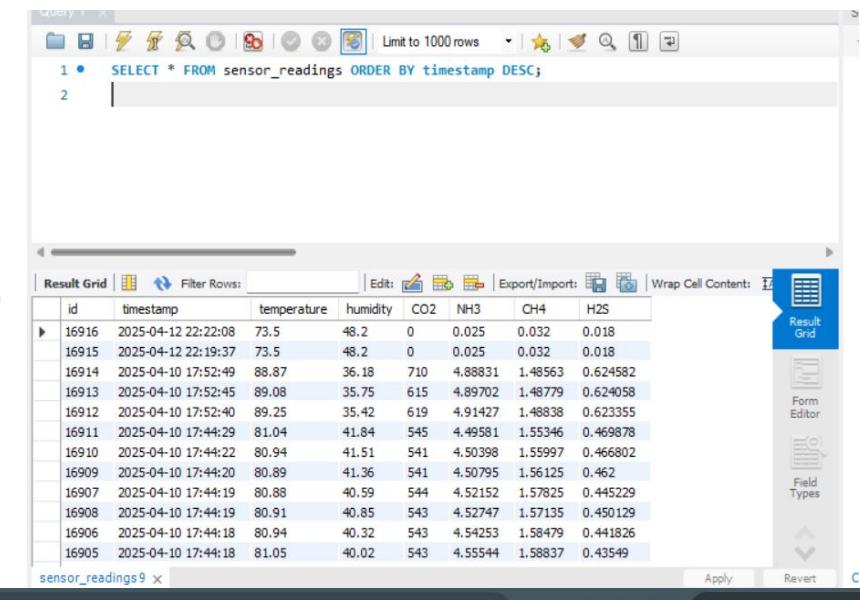
$$Rs = (5 - 2 \times Vout) \times 10000 \div (2 \times Vout)$$

To the left: Gas Monitoring system fully functional

Engineering Design Accomplishments

Tanmay Sarkar

- Created a realistic auto-generating database which went into a locally hosted web application.
 - This was used for testing/validation
 - Gradually increasing rate/volume of data to test the efficiency of the website/database.
- Integrated real time data from AWS which was fed from an ESP32 Microcontroller



The screenshot shows a MySQL Workbench interface. At the top, there's a toolbar with various icons. Below it is a query editor window containing the following SQL code:

```
1 • SELECT * FROM sensor_readings ORDER BY timestamp DESC;
2 |
```

Below the query editor is a results grid titled "Result Grid". The grid has columns for id, timestamp, temperature, humidity, CO2, NH3, CH4, and H2S. It displays 16 rows of data, each corresponding to a sensor reading from April 10, 2025, at various times between 17:52:45 and 22:22:08. The data includes values for temperature (e.g., 73.5, 88.87), humidity (e.g., 48.2, 36.18), and concentrations of CO2, NH3, CH4, and H2S.

id	timestamp	temperature	humidity	CO2	NH3	CH4	H2S
16916	2025-04-12 22:22:08	73.5	48.2	0	0.025	0.032	0.018
16915	2025-04-12 22:19:37	73.5	48.2	0	0.025	0.032	0.018
16914	2025-04-10 17:52:49	88.87	36.18	710	4.88831	1.48563	0.624582
16913	2025-04-10 17:52:45	89.08	35.75	615	4.89702	1.48779	0.624058
16912	2025-04-10 17:52:40	89.25	35.42	619	4.91427	1.48838	0.623355
16911	2025-04-10 17:44:28	81.04	41.84	545	4.49581	1.55346	0.469878
16910	2025-04-10 17:44:22	80.94	41.51	541	4.50398	1.55997	0.466802
16909	2025-04-10 17:44:20	80.89	41.36	541	4.50795	1.56125	0.462
16907	2025-04-10 17:44:19	80.88	40.59	544	4.52152	1.57825	0.445229
16908	2025-04-10 17:44:19	80.91	40.85	543	4.52747	1.57135	0.450129
16906	2025-04-10 17:44:18	80.94	40.32	543	4.54253	1.58479	0.441826
16905	2025-04-10 17:44:18	81.05	40.02	543	4.55544	1.58837	0.43549



https://us-east-2.console.aws.amazon.com/elasticbeanstalk/home?region=us-east-2#/environment/dashboard?environmentId=e-beqswrntq3

aws Search [Alt+S] United States (Ohio) tanmay_capstone @ 4384-6517-1645

Elastic Beanstalk Environments gas-monitor-env

gas-monitor-env Info Actions Upload and deploy Change version

Environment overview

Health Ok

Domain gas-monitor-env.eba-i7f7pc9e.us-east-2.elasticbeanstalk.com

Environment ID e-beqswrntq3

Application name gas-monitor

Platform

Platform Python 3.11 running on 64bit Amazon Linux 2023/4.5.0

Running version app-250412_181546234082

Platform state Supported

Events Health Logs Monitoring Alarms Managed updates Tags

Events (100) Info Filter events by text, property or value

Time	Type	Details
April 13, 2025 03:45:15 (UTC-5)	INFO	Environment health has transitioned from Severe to Ok.
April 13, 2025 03:44:15 (UTC-5)	WARN	Environment health has transitioned from Ok to Severe. 91.3 % of the requests are erroring with HTTP 4xx.
April 12, 2025 20:40:53 (UTC-5)	INFO	Environment health has transitioned from Severe to Ok.

Engineering Design Accomplishments

Tanmay Sarkar

- Built a MySQL Database hosted by AWS (Relational Database Services)
 - Managed by MySQL Workbench.
- Flask web application with real time data updating and CSV export capabilities
- [Link](#)

Challenges	Solutions
Connection of AWS Lambda to MySQL Database	Debugging python script that was being uploaded to Lambda by breaking it down part by part.
Keeping website updated as more sensors were added on and the JSON text format was changing	Keeping track of the order of the sensors and updating each part of the software flow one at a time.
Website deployment	Debugging the folder structure of my project and reading the EB (elastic beanstalk) logs

Integrated System Results

Farm Visit #1 with Sponsor Justin Houck:

- Met sponsors expectations
- Collected an hours worth of data
- Data sent to sponsor for analysis
- Farm Visit #2 on Thursday, April 17th

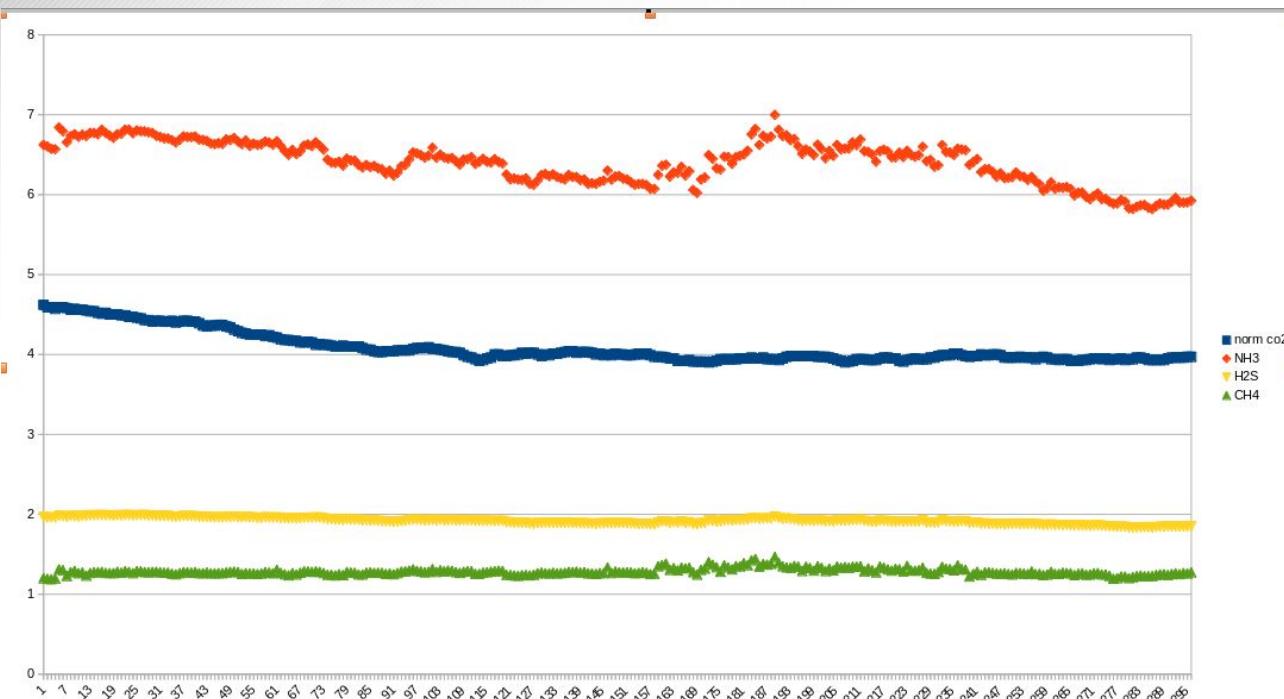


Integrated System Results

Test 1	Room State	11:46
Test 2	Cow Patty	11:55
Test 3	Damp Cattle Bedding	12:06



Integrated System Results



Red: NH₃
Blue: CO₂
Yellow: H₂S
Green: CH₄

Most significant detection in NH₃ and CO₂. H₂S and CH₄ detection less present.

Conclusions

- Moved from LoRaWAN to Wi-Fi due to ease of use, cost, and requirements
- Temperature reads higher due to system heat
- Current status:
Integration, Test, and Validation Complete
Second field test April 17th to collect more data with highly detailed experimental plan