



# Enhancing Gas Measurement and Monitoring: A Laser-Based Portable Sensor Integrated with UAS



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Team: 54

## Introduction

Detecting methane has been a global demand in two main aspects: detecting leaks and possible natural gas fields and understanding methane's effect as a greenhouse gas.

### Final Specifications

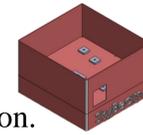


### Constraints



Current Methane Detectors	SkyBeam
281,288 SAR	< 25,000 SAR

The casing was designed using SolidWorks with multiple design iterations. 3D printing was utilized to build the casing. Materials such as PLA and Carbon Fiber were used to satisfy the weight condition.

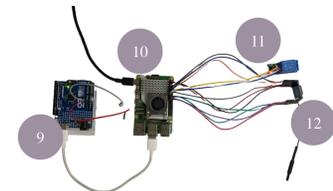


## Prototype

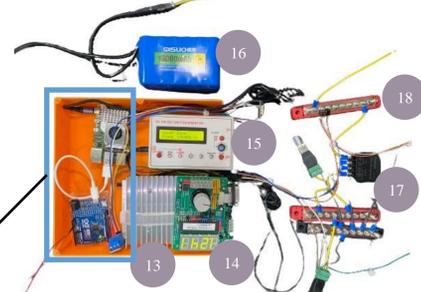


Laser Setup

Component	Component
1 Laser Diode	10 Raspberry Pi 5
2 Beam Splitter	11 Relay
3 Mirror	12 LoRa Module
4 Laser Detector	13 Laser Controller
5 Laser Detector	14 Parameter Display
6 Mirror	15 Function Generator
7 Reference Cell	16 Battery
8 Wires Intake	17 DC Converter
9 Arduino R4	18 Bus Bar



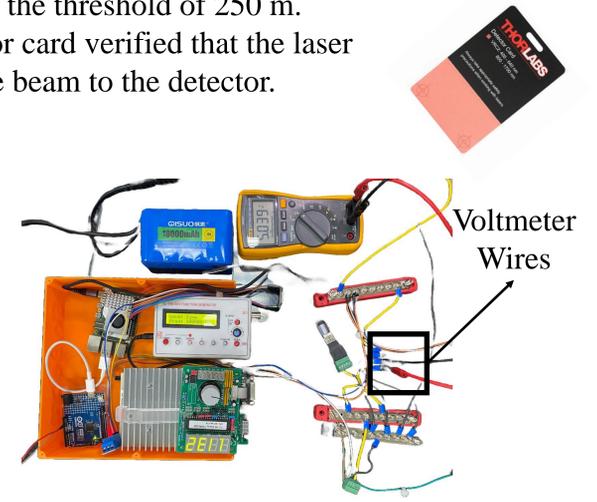
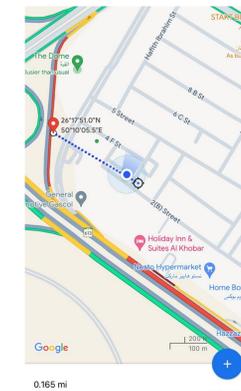
Data Acquisition System



Power Distribution System

## Validation

- The entire system's weight did not exceed 5.5 KG!
- Several validation tests were performed such as: Data signal coverage, laser diode signal and validating the circuitry of the power distribution system.
- The data signal coverage was tested, and the band width reached 266 m! This exceeds the threshold of 250 m.
- THORLABS detector card verified that the laser diode transmitted the beam to the detector.



## Design

### Spectroscopy System

Contains all the optics and laser equipment required to scan a sample of gas. This system is extremely delicate and requires precise tuning.

### Data Analysis System

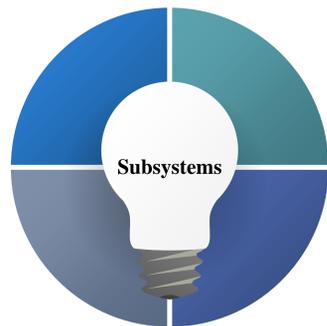
Responsible of recording all the data received from the laser detectors. It is also responsible of transmitting all the signals required to operate the laser setup.

### Power Distribution System

Developed to power all the other systems rather than the UAV.

### UAV Casing

Developed using 3D printing techniques in order to ensure secure and light carriage of the entire system.



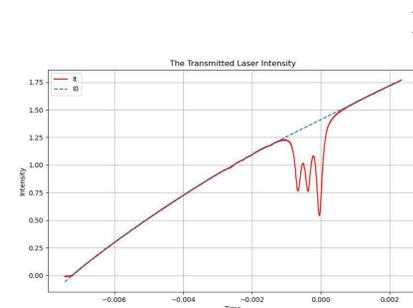
Designing the laser setup requires precise tuning to allow the laser to pass without disruption.

The Beer-Lambert Law was used in order to obtain the concentration of Methane. Python codes were utilized the relations below in order to find the molar fraction ( $\chi_i$ ).

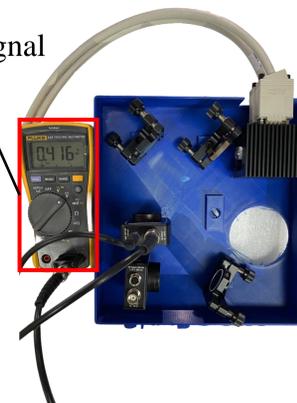
$$\frac{I_t}{I_o} = \exp(-k_v \cdot L)$$

$$A_i = \int \alpha_v dv = P \chi_i S_i(T) L$$

## Testing



Recorded Signal



- All the systems were tested rigorously.
- The Python code is designed to find the ratio of laser intensities  $\frac{I_t}{I_o}$ .
- To test the function generator, a separate oscilloscope was used with different waves such as: Sawtooth, square, triangular and sinusoidal.
- To ensure that the laser diode is emitting the laser beam as planned, the lab-based spectroscopy cell was tested. Successful results were yield using our data analysis system.

## Conclusion

SkyBeam, a multidisciplinary project, developed an innovative integrated portable laser spectroscopy sensor designed for Unmanned Aerial Systems (UAVs) for precise aerial methane monitoring. The spectroscopy payload reached 5.5 KG, giving it the advantage of portability. Key advantages include localized aerial gas mapping, real-time onboard data collection, mobility, adaptability to detect other gases (by laser tuning and minor setup changes), and cost-effectiveness. This cutting-edge enhanced solution supports safety, environmental protection and natural gas field management through validated precise optical sensing.

## Future Work

- Conduct a flying test with SkyBeam installed on the UAV
- Develop a comprehensive algorithm model that predicts the required parameters instead of normal Python coding
- Generalize SkyBeam to be easily tunable for other gases of interest
- Develop a business model that is sustainable to industrialize the project.