

Executive Summary

Endotracheal intubation (ETI) proficiency is difficult to maintain in emergency settings due to limited opportunities and unpredictable conditions, particularly for firefighters in the Arlington Fire Department (AFD). To address this gap, we propose a compact, integrated intubation support system designed to enhance accuracy and provide real-time guidance during ETI procedures.

The system consists of two accessories: (1) a laryngoscope attachment equipped with a 9-axis inertial measurement unit (IMU) to monitor blade direction, depth, and orientation, paired with visual and haptic feedback, and (2) a miniature capnography device that measures CO₂ levels to confirm correct endotracheal tube placement.

Designed to meet AFD operational constraints, the system is lightweight, sterilizable, and seamlessly integrates into existing workflows. This approach aims to improve intubation success rates, reduce errors such as esophageal placement, and enhance provider confidence in high-pressure emergency scenarios.

Motivation

- EMS and Fire personnel perform endotracheal intubations (ETIs) in challenging prehospital settings.
- Field intubations pose increased risk to the patient, involving limited visibility, patient instability, and high stress.
- Errors may result from improper laryngoscope use and incorrect endotracheal tube (ETT) placement.
- Failed airway trauma, or accidental esophageal insertion, which delays oxygen delivery and can be life-threatening.

Objectives :

- 1) An attachment to the laryngoscope handle that uses a 9-axis IMU to measure blade positioning and provide real-time feedback.
- 2) A miniature capnography device for the ETT that uses a CO₂ sensor to confirm tracheal placement and provide visual feedback.

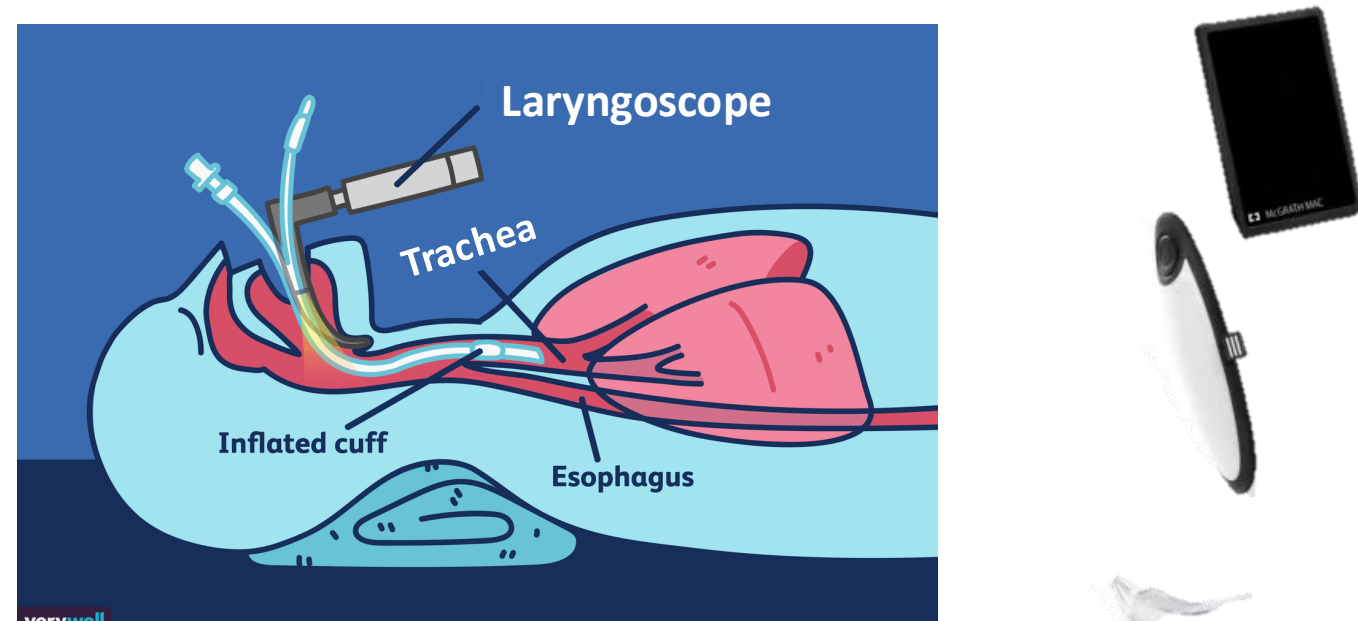


Fig 1: Illustration of endotracheal intubation anatomy and Medtronic's video laryngoscope device that AFD uses.

Design Requirements

Laryngoscope IMU Attachment

	Engineering Requirement	Target Value	Test Method
Functional	Blade Tilt Detection	±5°	Compare with protractor
	Insertion Depth Detection	±1 cm	Compare with a meterstick
	Battery Powered & Wireless	≥ 2 hrs	Run device continuously over 2 hours for 3 consecutive cycles
Physical	Size	Easily portable	Ruler, laryngoscope and ETT model
	Easily attachable to existing device	<5s	Timing people
	Lightweight	<200g	Scale
	Cost	\$1000	Budget Tracking

ETT CO₂ Attachment

	Engineering Requirement	Target Value	Test Method
Functional	CO ₂ Concentration	±0.5%	Incubator
Physical	Size of connector	Standard Size	Ruler

Fabricated System

Laryngoscope IMU attachment

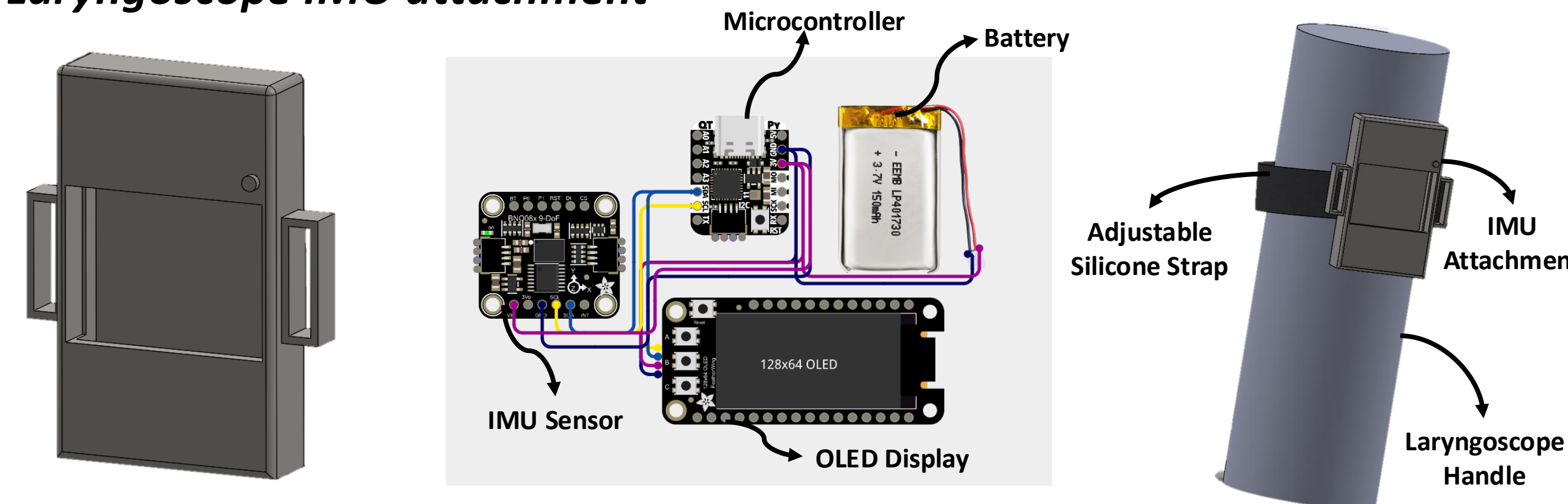


Fig 2: SolidWorks model with Circuit Schematic

ET Tube CO₂ Attachment

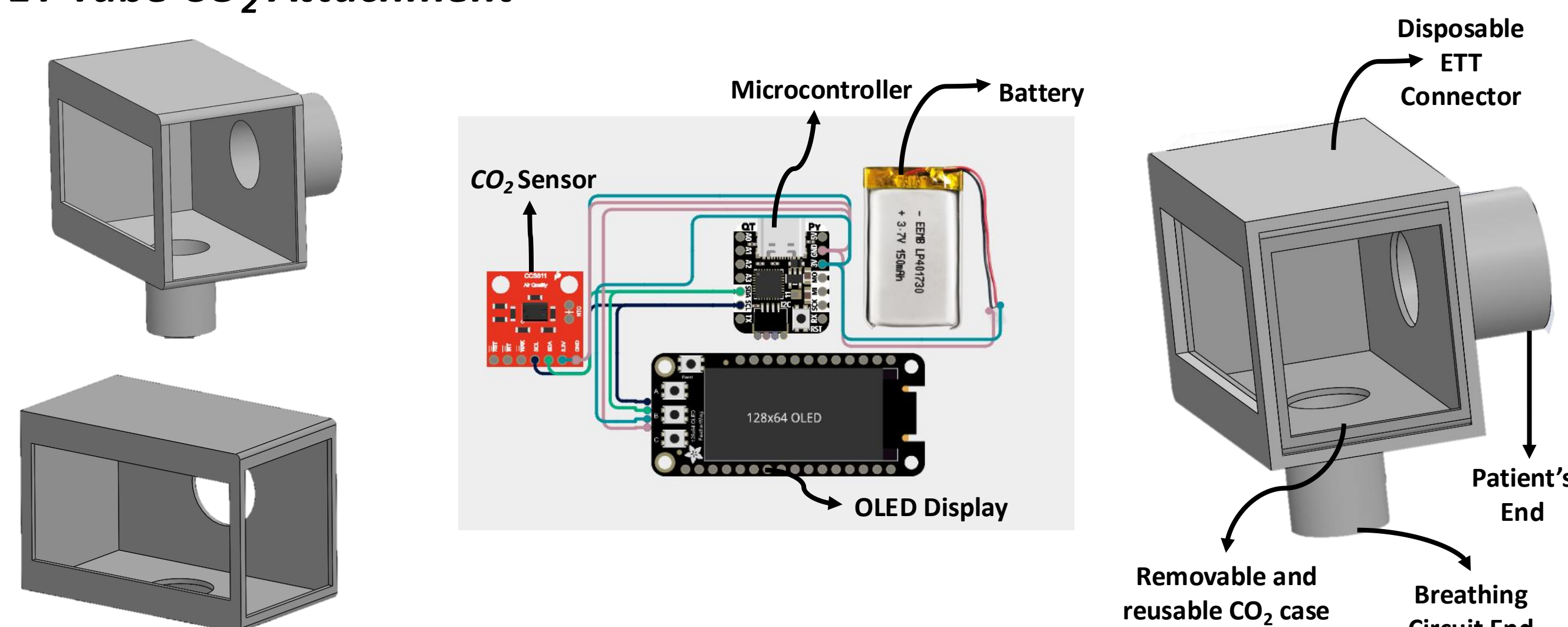


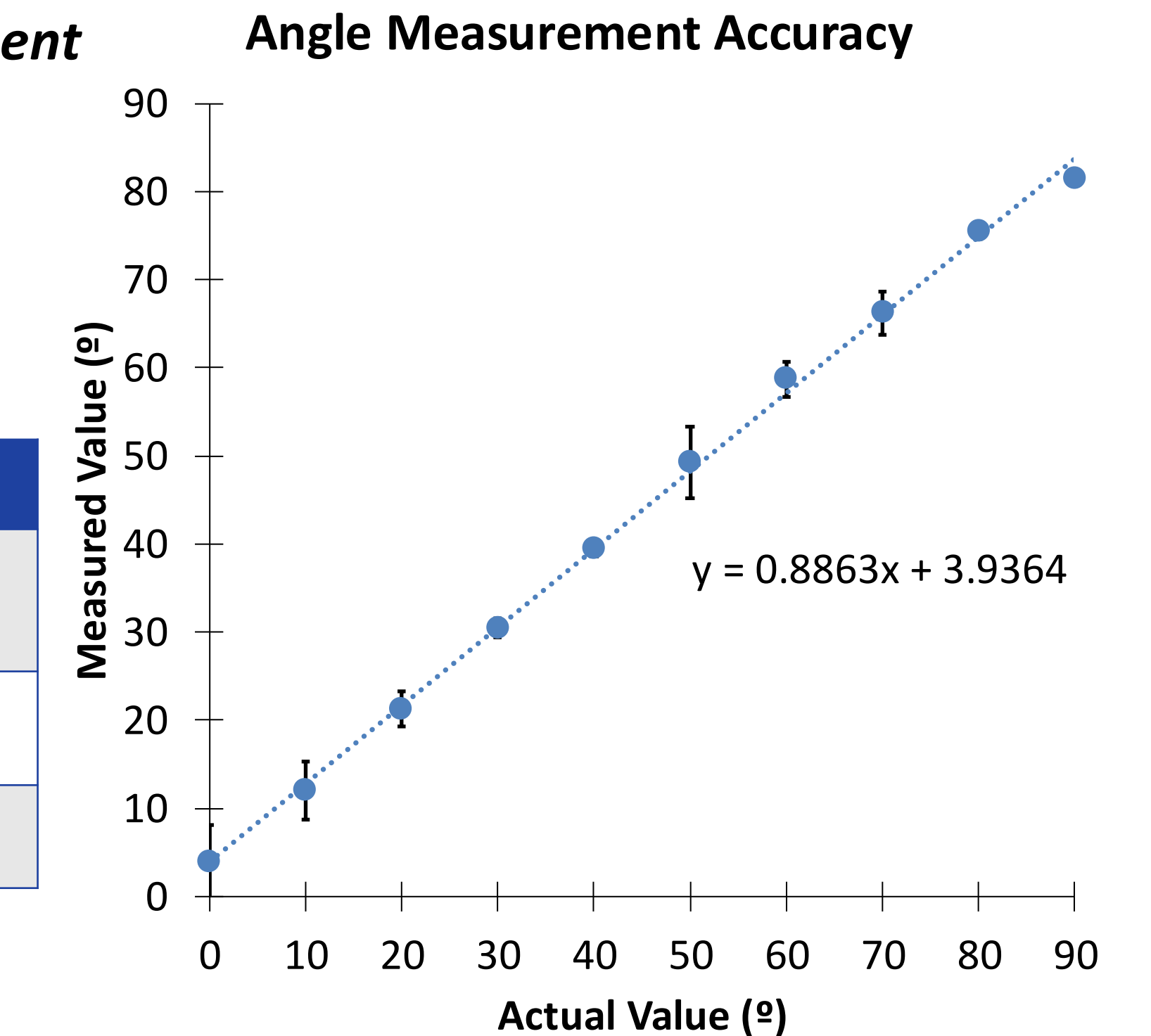
Fig 3: SolidWorks model with Circuit Schematic

Experimental Results

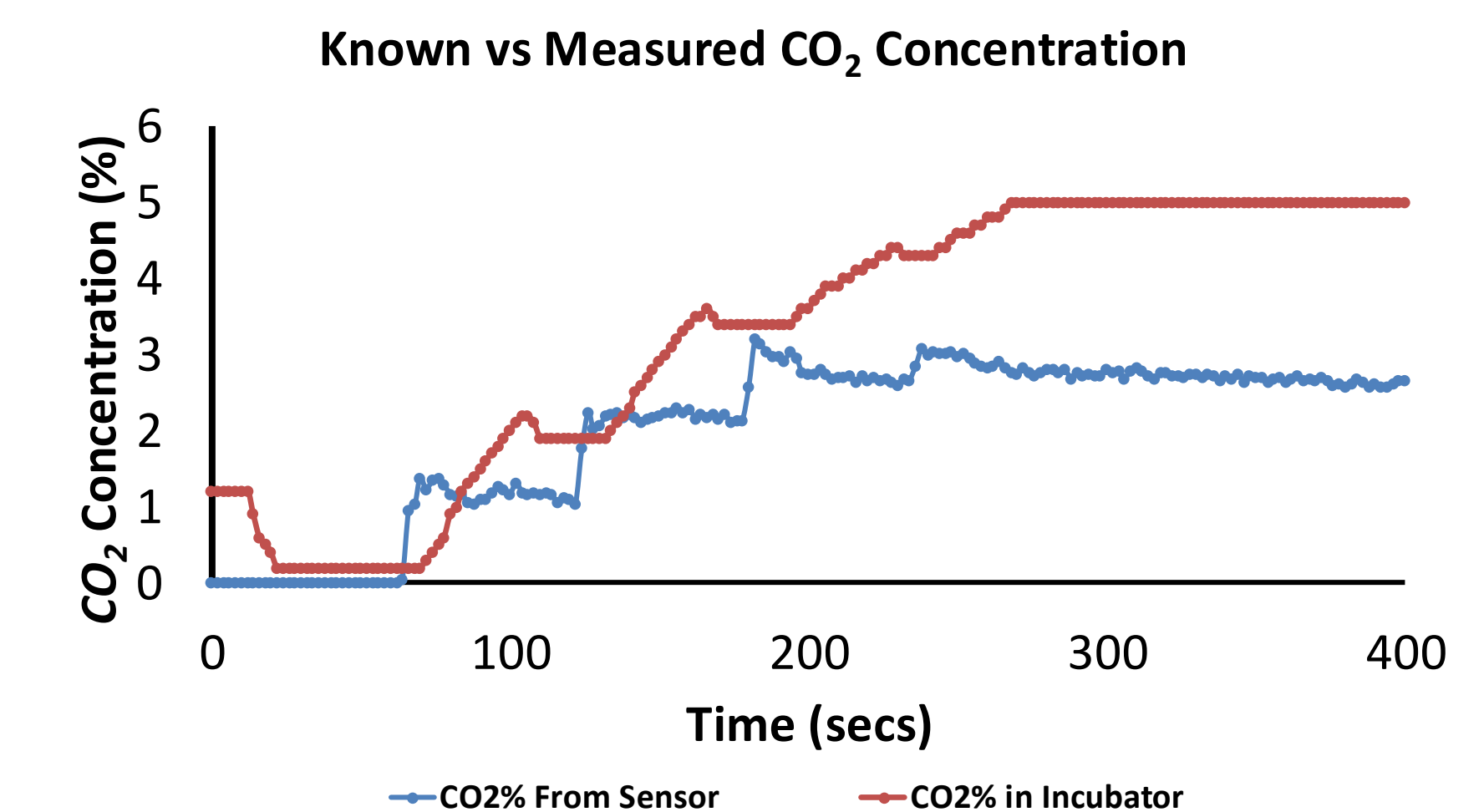
Laryngoscope IMU Attachment

Table 1: Ideal values for each measurement of interest.

Measurement	Ideal Value
Depth	2.54 cm
Steadiness	0 rads/s
Angle	35°



ETT CO₂ Attachment



Discussion

- Our design effectively met the client's goals by providing a compact, portable system that improves intubation accuracy through real-time orientation feedback and CO₂ confirmation, while meeting key constraints such as ease of use, low weight, and compatibility with existing equipment. Testing showed promising accuracy and functionality, though future work will focus on wireless integration, durability, and real-world validation; we would like to thank our clinical and faculty mentor for their guidance and support.

Future Work

- Convert microcontroller to be wireless and lithium ion-battery powered with charger add-on once sensor testing is complete.
- Test with AFD's laryngoscope and ETTs with airway manikin at the UTA Smart Hospital.
- Recruit firefighters/EMS personnel to measure baseline laryngoscope orientation values with IMU sensor to compare with target values from literature.

References

1. Horton WA, Fahy L, Charters P. Defining a standard intubating position using "Angle Finder." British Journal of Anaesthesia. 1989;62(1):6-12.
2. Sum-Ping, S. T., Mehta, M. P., & Anderton, J. M. (1989). A comparative study of methods of detection of esophageal intubation. Anesthesia and analgesia, 69(5), 627-632.