As commercial space travel expands, the need for specialized instrumentation to ensure the safety of crew and cargo becomes increasingly necessary. Both the Federal Aviation Administration (FAA) and pioneers in the space tourism industry have expressed an interest in a robust, low cost, and low power consumption sensor to measure atmospheric composition aboard spacecraft. To achieve this goal a time-resolved NDIR absorption sensor that measures transient levels of gaseous carbon dioxide (CO₂) and carbon monoxide (CO) was developed. The developed sensor has a wide range of applications applicable to the growing needs of industry, from monitoring CO and CO₂ levels for crew cabin safety to early detection of gas leaks, fires, or other atmospheric altering events. A proof of concept, lab-bench dependent sensor has been previously developed to begin to target the needs of this industry.

This thesis discusses the expansion and evolution from this previous lab-bench dependent design into a portable, autonomous, and remote sensor that is able to withstand the harsh environmental conditions required for its intended operation in near space. The sensor incorporates compact high-efficiency LEDs that transmit in the 3-5μm wavelength range. These LEDs are further centered at 4.2μm and 4.7μm by the use of narrow band-pass filters to measure the spectral absorbance features of CO₂ and CO respectively. Active and passive thermal management of all components is achieved via thermal electric coolers (TEC) and thermal sinks to enable sensor temperature control in applicable low convection environments. To accomplish the needs for a stand-alone sensor, remote and autonomous operation is achieved via the inclusion of a real-time embedded controller with configurable FPGA/IO modules that autonomously handle thermal management, LED operation, and signal data acquisition/storage. Initial instrument validation was completed by utilizing a thermal vacuum chamber with a testable temperature and pressure range from standard temperature and pressure (STP) down to -22°F and 8mbar. Variable measurements of CO/CO₂/N₂ gas mixtures were supplied via mass flow controllers to the sensor’s gas cell in order to determine various key metrics of sensor operation. The culmination of the sensor's operational validation was via its flight aboard a NASA funded Louisiana State University (LSU) high-altitude balloon. This flight reached an altitude of 123,546ft with ambient temperatures and static pressures ranging from 910mbar and 53°F at ground level to .68mbar and -54°F at float altitude. A total mission time of 18h:09m:30s was reached with a total float time of 15h:08m:54s. Successful sensor operation was achieved throughout the entire mission which demonstrates the applicability, adaptability, and relevance of the technologies discussed here for space applications.

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The public is welcome to attend.