Project Introduction

The gas sensor in the PLSS of the ISS EMU will meet its projected life in 2020, and NASA is planning to replace it. At present, only high TRL devices based on infrared absorption are candidate replacements, because of their proven long-term stability, despite their size and power consumption and failures in the presence of liquid water. No current compact sensor has the tolerance for liquid water that is specifically required for a Portable Life Support Systems (PLSS), and NASA is investigating alternative technologies for the Advanced EMU under development. Intelligent Optical Systems (IOS) will develop a luminescence-based optical sensor probe to monitor carbon dioxide, oxygen, and humidity, and selected trace contaminants. Our monitor will incorporate robust CO2, O2, and H2O partial pressure sensors interrogated with a compact, low-power optoelectronic unit. The sensors not only will tolerate liquid water but will actually operate while wet, and can be remotely connected to electronic circuitry by an optical fiber cable immune to electromagnetic interference. For space systems, these miniature sensor elements with remote optoelectronics give unmatched design flexibility for measurements in highly constrained volume systems such as the space suit. In prior projects IOS has demonstrated a CO2 sensor capable of operating while wet that also met PLSS environmental and analytical requirements. In Phase I, a new generation of CO2 sensors was developed to advance this sensor technology and fully meet all NASA requirements, including sensor life. In Phase II IOS will develop a novel sensor system with unique capabilities for inspired gas monitoring, a unique tool for NASA space suit development. The proposed effort could lead to an alternative to infrared absorption-based devices for space missions. IOS has established collaboration with relevant primes for NASA and the aeronautics and defense industry for technology commercialization.

Anticipated Benefits

The proposed technology will apply directly to accomplishing the objectives of the NASA Advanced Exploration Systems (AES) program, facilitating the rapid and effective development of novel EVA systems, and the demonstration of key capabilities for future human missions beyond Earth orbit. Exhaustive testing of prototype systems reduces risk and improves the affordability of exploration missions. The proposed technology will significantly enhance current capabilities for demonstrating, in ground-based testbeds and in flight experiments on the International Space Station (ISS), the prototype EVA systems developed in the AES program. IOS sensor technology is probably the most advanced alternative to infrared-based gas sensors, and the proposed effort could lead to an alternative approach for gas monitoring in the PLSS for space missions, to infrared absorption-based devices, with the advantages not only of operation under wet conditions, but also of reduced power consumption and size.
IOS has already applied the proposed technology to monitoring pilots' inspired gases in military aircraft. The proposed technology has potential in other applications in military aeronautics, where the characteristics of the fiber optic sensor have significant advantages. Specifically, we are evaluating oxygen monitoring in on-board oxygen generation systems (OBOGS) and gas monitoring in on-board inert gas generation systems (OIGGS). Finally, the largest potential market for a combined carbon dioxide/relative humidity/oxygen (pCO2-H2O-O2) sensor is the indoor air quality control market. Advanced management of indoor air quality (IAQ) is essential to meet the DOE goal of reducing energy use by 20% in a decade while reducing IAQ-related health problems. Implementing novel building envelopes to reduce energy use can compromise indoor air quality. Technologies for the next generation of air control and monitoring must emphasize cost-competitiveness in widespread use. IOS has already started a development effort to produce low-cost, low-power, phase-resolved luminescence detectors for this attractive market.

**Primary U.S. Work Locations and Key Partners**

![Map of U.S. Work Locations]

**Project Management**

**Program Director:** Jennifer L. Gustetic

**Program Manager:** Carlos Torrez

**Principal Investigator:** Jesus Delgado Alonso

**Technology Maturity (TRL)**

- Start: 4
- Current: 4
- Estimated End: 5

**Technology Areas**

**Primary:**

- Human Health, Life Support, and Habitation Systems (TA 6)
  - Extravehicular Activity Systems (TA 6.2)
  - Portable Life Support System (TA 6.2.2)
### Organizations Performing Work

<table>
<thead>
<tr>
<th>Role</th>
<th>Type</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
<td>Johnson Space Center (JSC)</td>
<td>Lead Organization</td>
<td>NASA Center</td>
</tr>
<tr>
<td>Intelligent Optical Systems, Inc.</td>
<td>Supporting Organization</td>
<td>Industry</td>
</tr>
<tr>
<td>University of North Texas</td>
<td>Supporting Organization</td>
<td>Academic</td>
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</tbody>
</table>

### Primary U.S. Work Locations

- California
- Texas

### Images

- Dual-wavelength gas sensors for improved gas monitoring
- Electronic unit can be placed "outside" of the space suit; optical elements are integrated "inside" the space suit.

### Briefing Chart Image

Advanced Gas Sensing Technology for Space Suits, Phase II