Aircraft Fire Sensing based on Optical Detection of Key Species

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Our Approach

- **Reduce False-Positive Smoke Alarms (~200:1)**
  - Detect CO & CO\textsubscript{2} with Optical Absorption
  - Add Other Species (acetylene & HCN) if Warranted
  - Built-In Algorithm to Validate Smoke Alarm to Fire

- **Validate Measurement & Algorithm**
  - Tested at U. of Maryland Fire Lab w/ Different Fuels
  - Algorithm Testing Planned at U. Maryland
  - (Hope to) Piggyback at FAA Fire Testing Lab
Prototype Test Data (Cont’d)

CO/CO\(_2\) Ratio vs Smoke Detector

- **CO/CO\(_2\)**
- **Smoke Detector**

```
0 120 240 360 480 600
```

```
4 5 6 7 8
```

```
Time (Second)
```

```
CO/CO\(_2\) Ratio (x1000)
```

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Concerns

• Optical Detection
  - Mirror Degradation (Filter)
  - Long Term Reliability (Telecom Components)
  - Measurement Location (Near Smoke Detector)
  - Orthogonal to Smoke Sensor (Algorithm Validation)

• Economics
  - Price (x4 Smoke Sensor)
  - Form Factor (x3 Smoke Sensor)

• Acceptance
  - Users (Pilots, Airlines)
  - Manufacturers (Boeing, Airbus)
Detection of Four Gases

- 3 lasers into single optical fiber
- Each laser modulated at different frequency
- Light detected on single photodiode
- DSP processor used to demodulate each laser separately
- HCN and acetylene could be detected in same spectral scan
Frequency Multiplexed Detection Data

- CO₂ detect at 18.2 kHz
- CO detect at 20.0 kHz

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>CO₂ Concentration (ppm)</th>
<th>CO Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>367 ppm</td>
<td>192 ppm</td>
</tr>
<tr>
<td>2000</td>
<td>239 ppm</td>
<td>368 ppm</td>
</tr>
<tr>
<td>3000</td>
<td>893 ppm</td>
<td>368 ppm</td>
</tr>
</tbody>
</table>
Gases Accessible for TDL Measurement

296 K, 1 atm
$\alpha_{\text{min}} = 10^{-5}$
Future Improvements

• Optical Measurement
  ◆ Longer Wavelength Lasers (available now)
    • Compact Optical Cell (No mirrors)
    • Integrate Smoke Detector/Gas Sensor
  ◆ Fiber Optic Distribution
    • Multiple Measurement Locations
    • Multiple Species Detection

• Economics
  ◆ TDL Price will Continue to Drop
  ◆ Longer Wavelengths Reduce Form Factor