Strategies for Improved Fire Detection Response Times In Aircraft Cargo Compartments

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Masters Thesis Defense Presentation

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Presentation Agenda

- Introduction and Background
- Experimental Set-up and Protocol
- Experimental Data
- Experimental Results and Analysis
- FDS Analysis
- Conclusions and Future Work

Prior Research

- Scalability of Smoke Density and the Viability of New Detection Methods in Aircrafts Research (Chin)
  - ASD outperformed the wired detector in response time
  - Blue & IR wavelength and gas sensor technology responded well in comparison to light obscuration
  - Recommended gas detection over photoelectric detection

Prior Research Proposed Work

- Similar testing to confirm conclusions
- Wireless detectors proposed
- ULD inside cargo compartment testing
- Standardization of detection testing

Project Goal

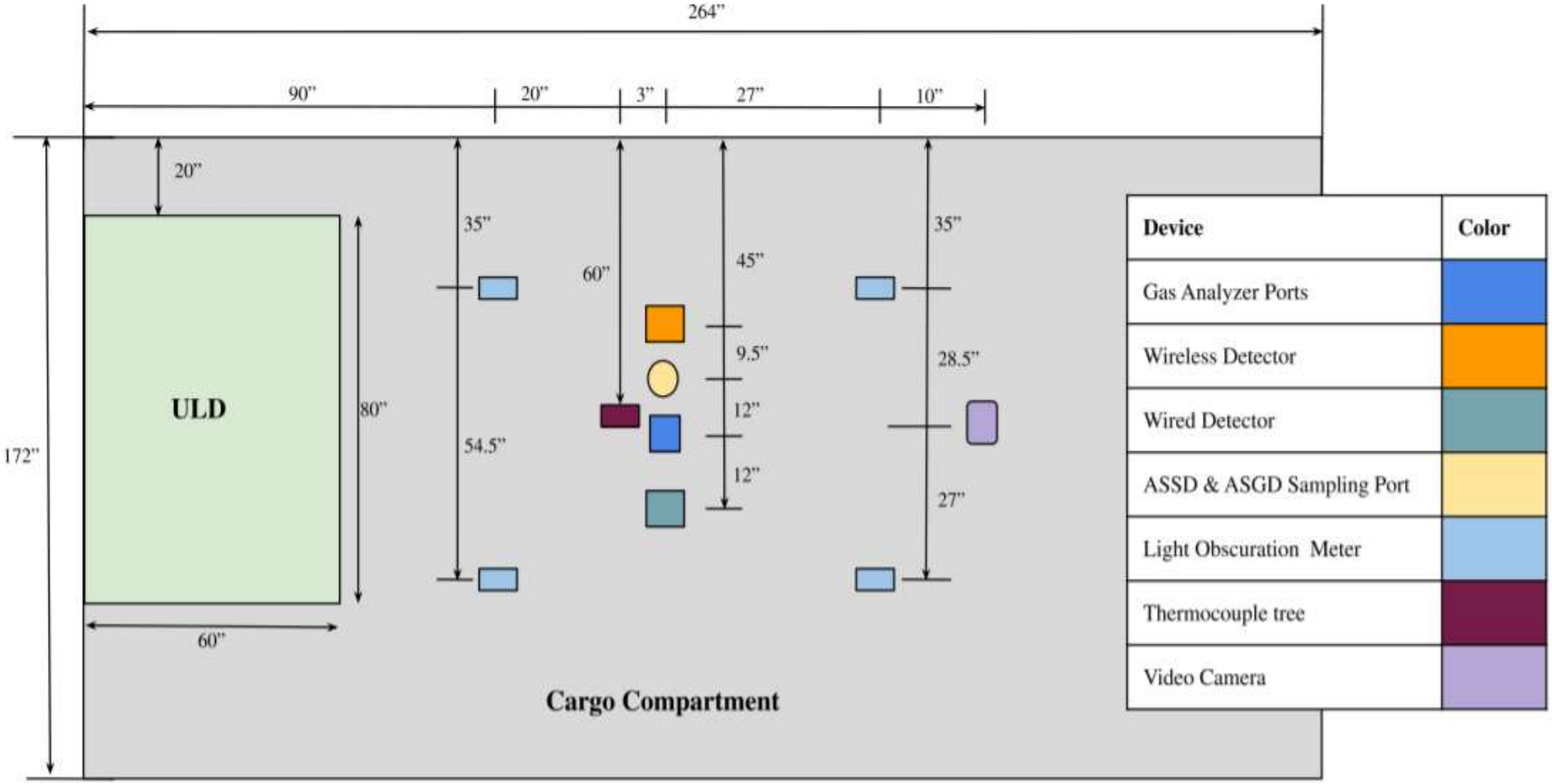
- Determine a detector technology and location in an aircraft cargo compartment which can produce the shortest response time to a wide variety of fire sources
  - Conducted through experimental and computational assessment

Experimental Program

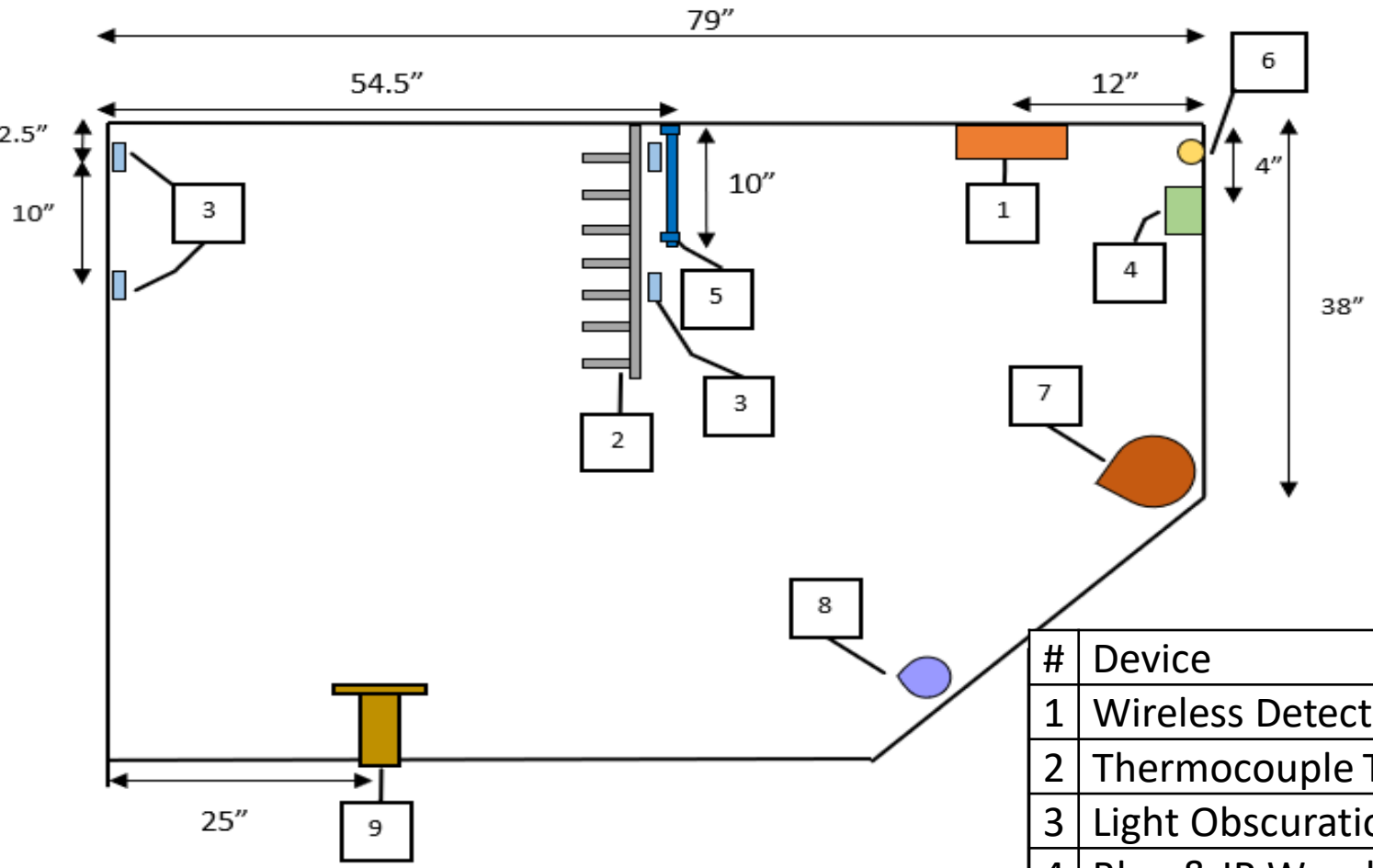
- Experiments conducted in Summer 2019 at the FAA Technical Center (FAATC)
- Testing performed using an LD3 ULD and cargo compartment of a DC-10

Experimental Set-up

Test Set Up: Cargo Compartment



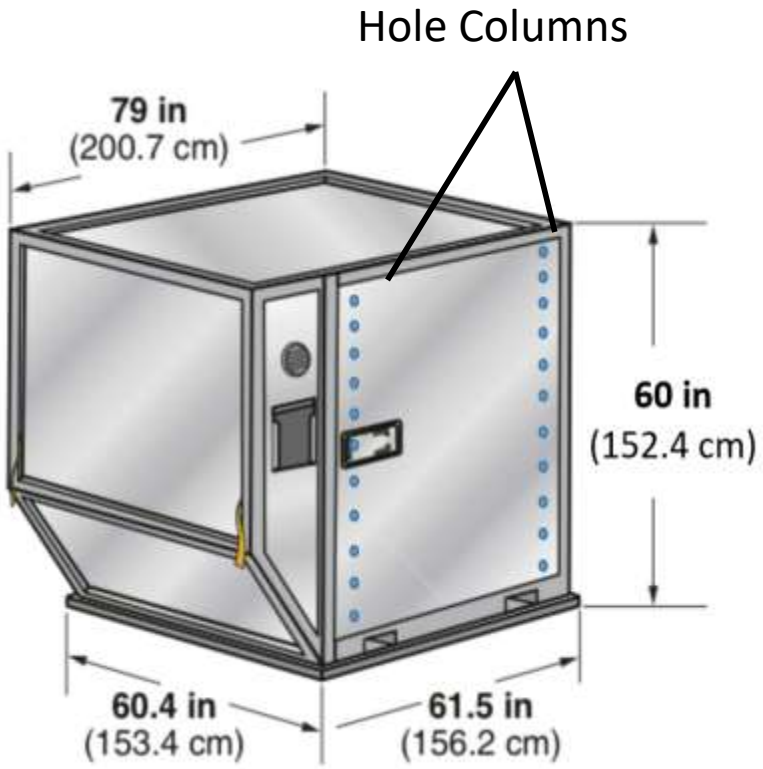
Test Set Up: Inside of ULD



#	Device
1	Wireless Detector
2	Thermocouple Tree
3	Light Obscuration Meters
4	Blue & IR Wavelength Detector
5	Gas Analyzer Ports
6	ASSG & ASGD Port
7	Infrared Camera
8	Video Camera
9	Fuel Placement

Testing: Unit Loading Device (ULD)

- Account for wide variety of ULD shapes and sizes, 3 different leakage models
- CO_2 leakage rate test conducted for each model
  - SLRM = “small” leakage, no alterations, all holes sealed
  - MLRM = “medium” leakage, only edge column of holes sealed
  - LLRM = “large” leakage, both columns of holes open



Test Set Up: Implementation

Cargo Compartment

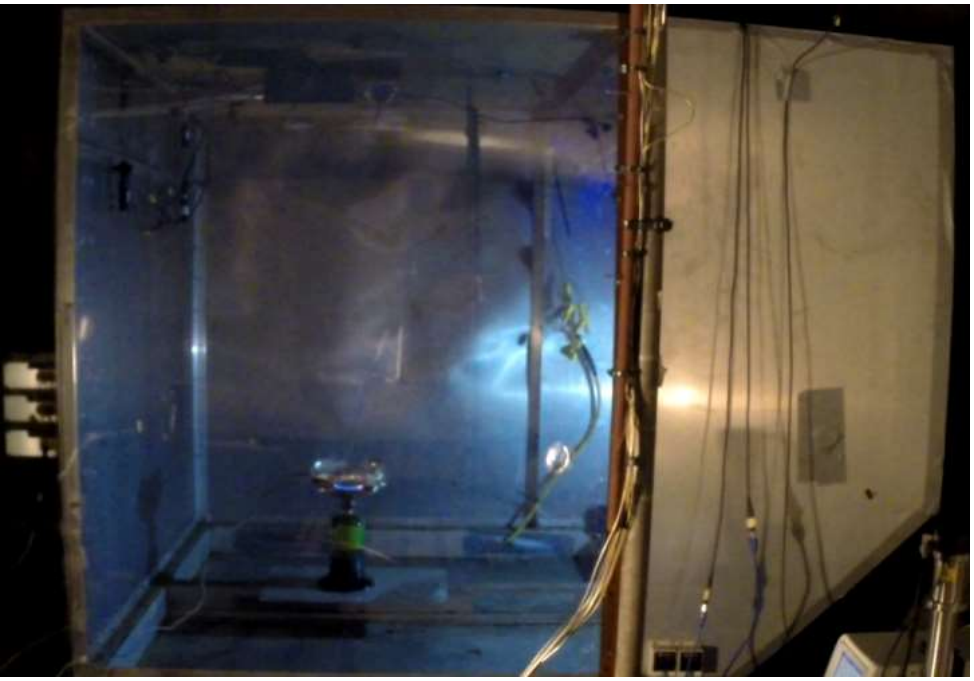
Inside ULD

Fuels

#	Fuel Source	Motive/Reasoning
1	Heptane	UL 268
2	PU Foam (flaming)	UL 268
3	PU Foam (smoldering)	UL 268
4	Suitcase (whole suitcase)	Expected on-board item
5	Shredded Paper	UL 268
6	Wood	UL 268
7	Baled Cotton	Expected on-board item
8	Lithium Ion Battery	Expected on-board item
9	Boeing Smoke Generator	Boeing protocol

Experimental Data

Smoldering PU Foam: MLRM ULD Test



60 seconds

120 seconds

Smoldering PU Foam: MLRM ULD Test

180 seconds

240 seconds

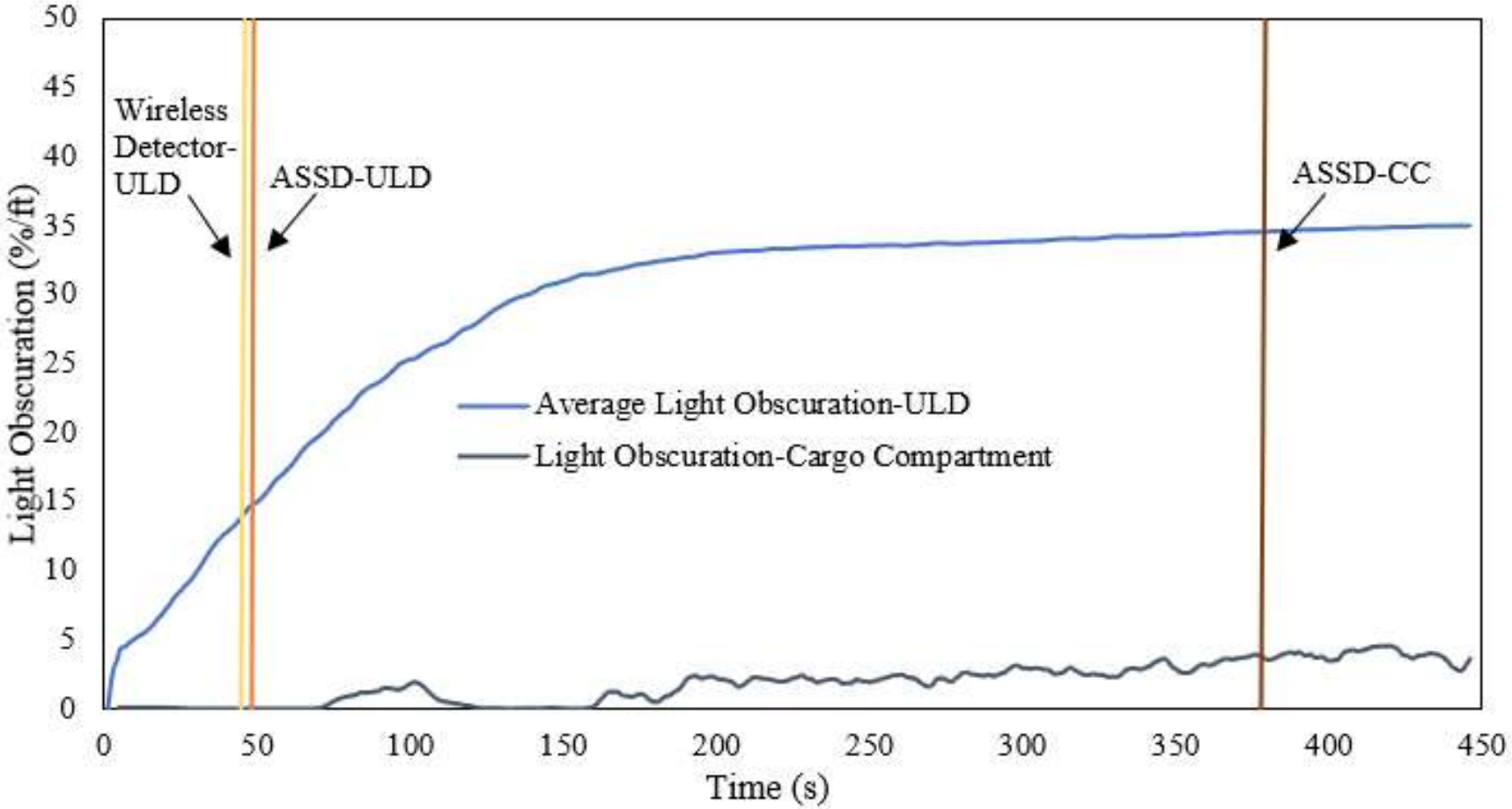
Smoldering PU Foam: MLRM ULD Test

300 seconds

360 seconds

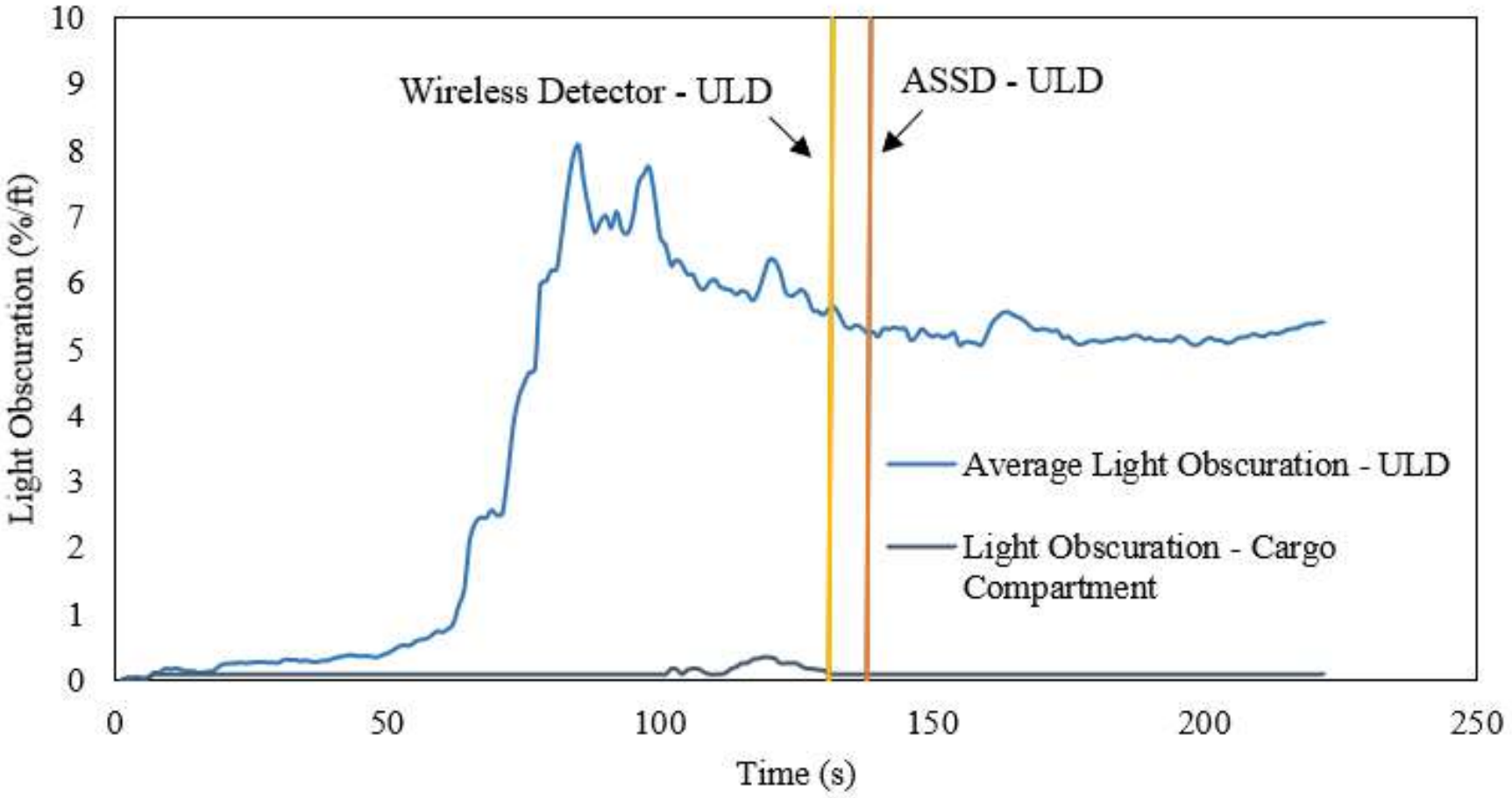
Light Obscuration & Detector Activation Times

Smoldering PU Foam

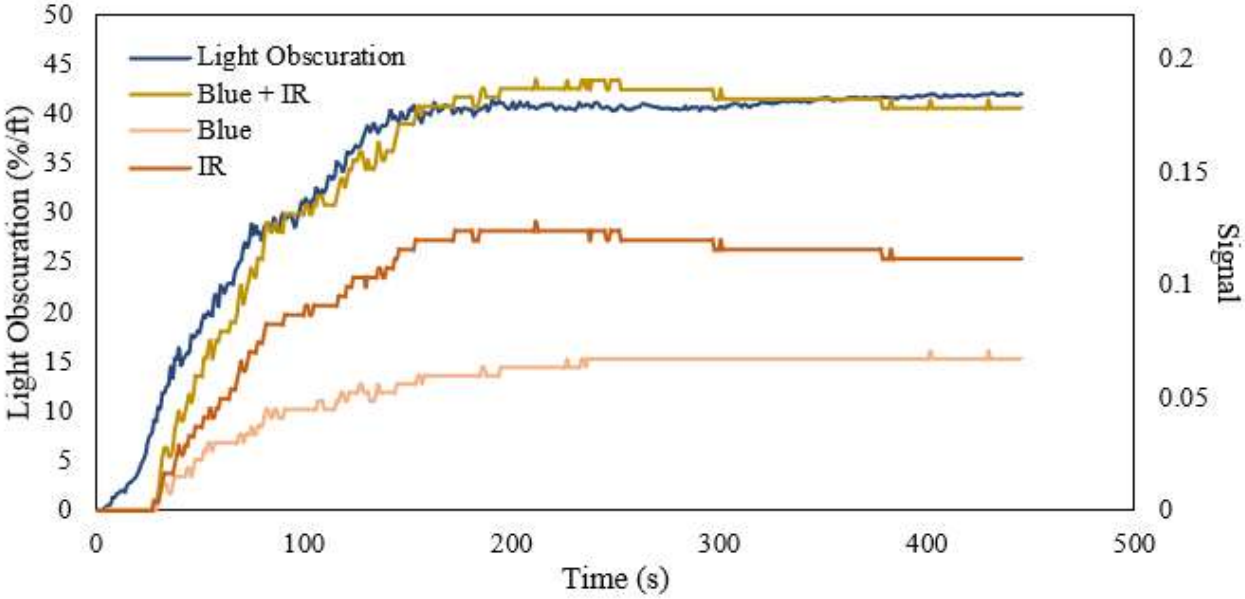


Light Obscuration & Detector Activation Times

Flaming PU Foam

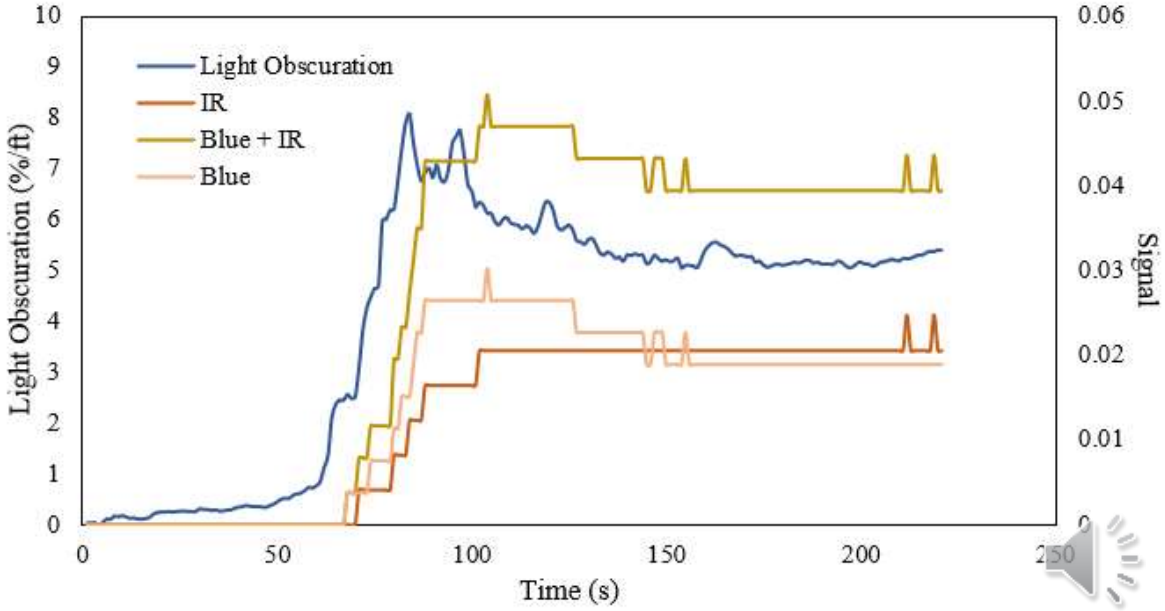


Light Obscuration & Blue, IR, and Blue + IR Signal

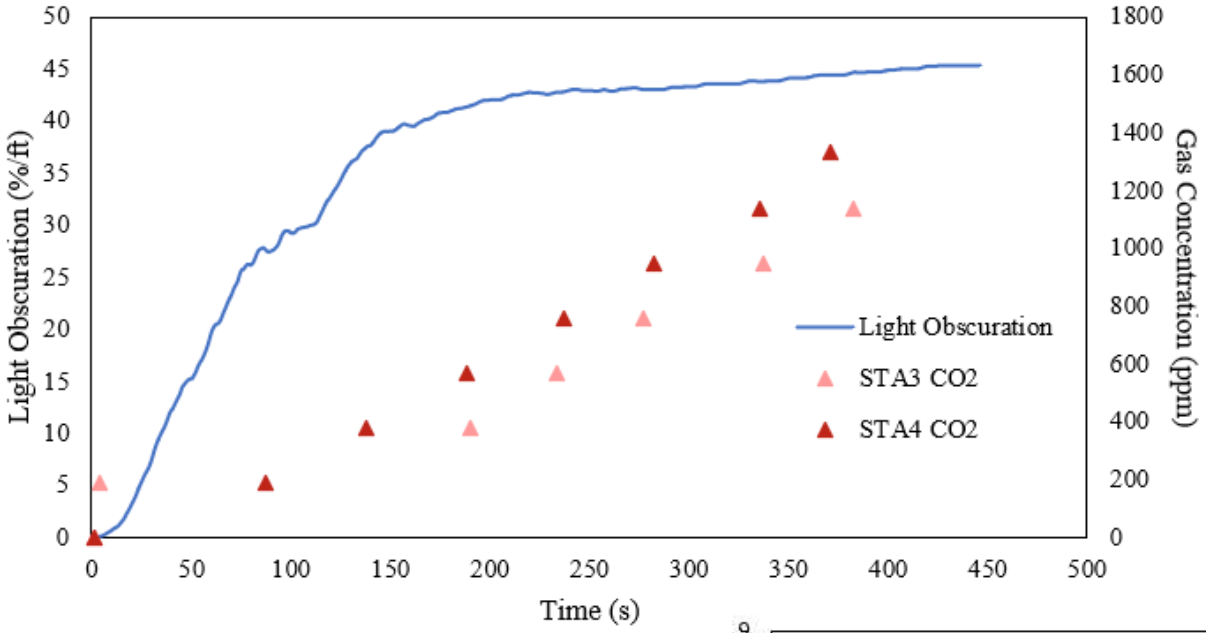


Smoldering PU Foam

Flaming PU Foam

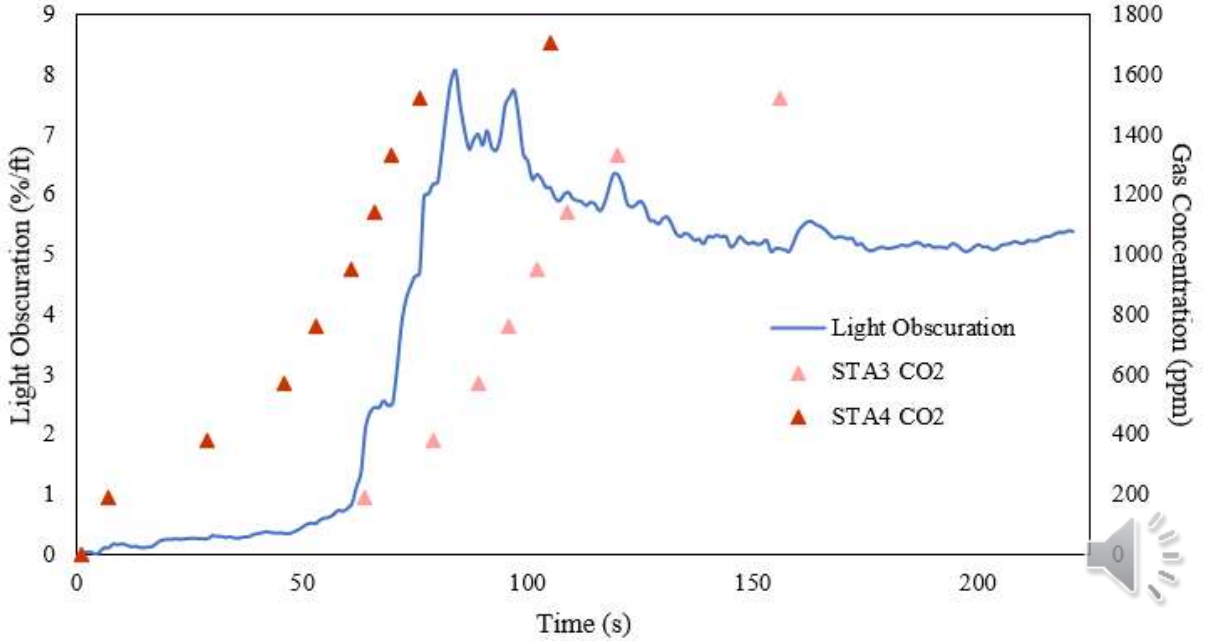


Light Obscuration & Gas Concentrations

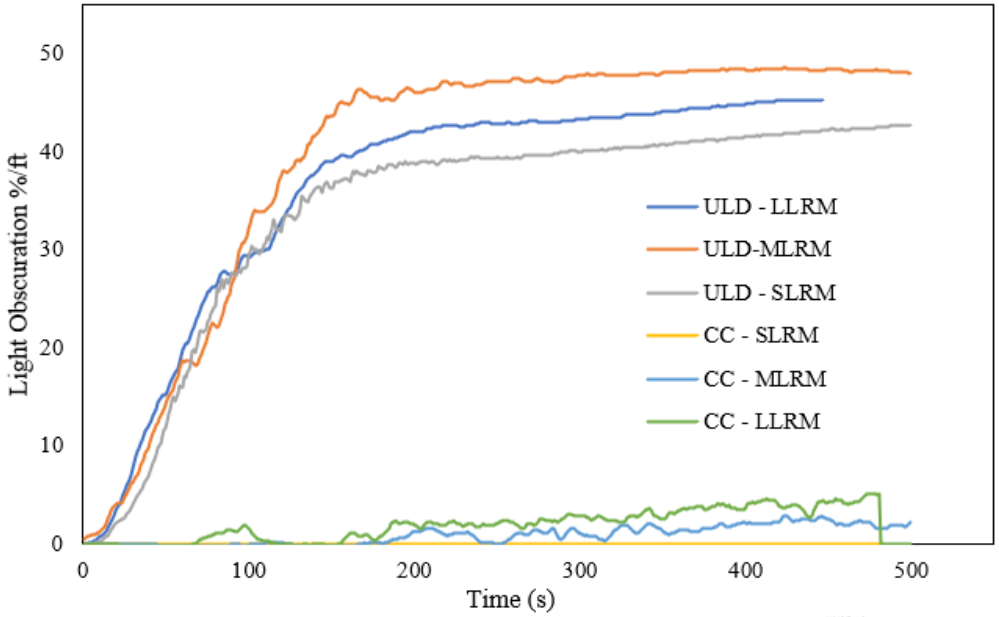


Smoldering PU Foam

Flaming PU Foam

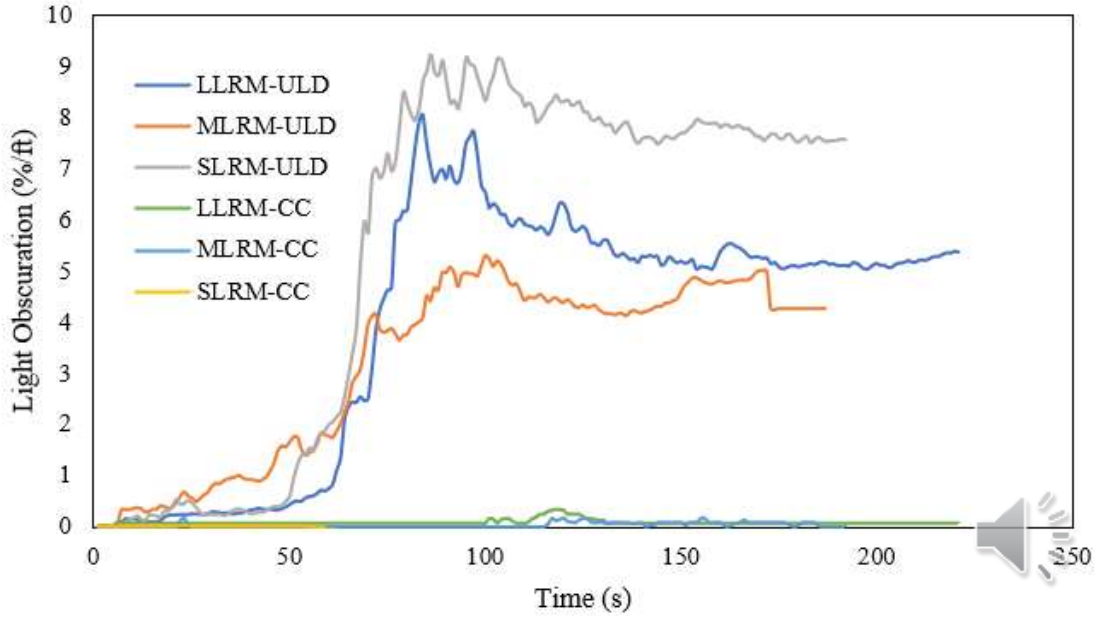


Leakage Rate Comparisons



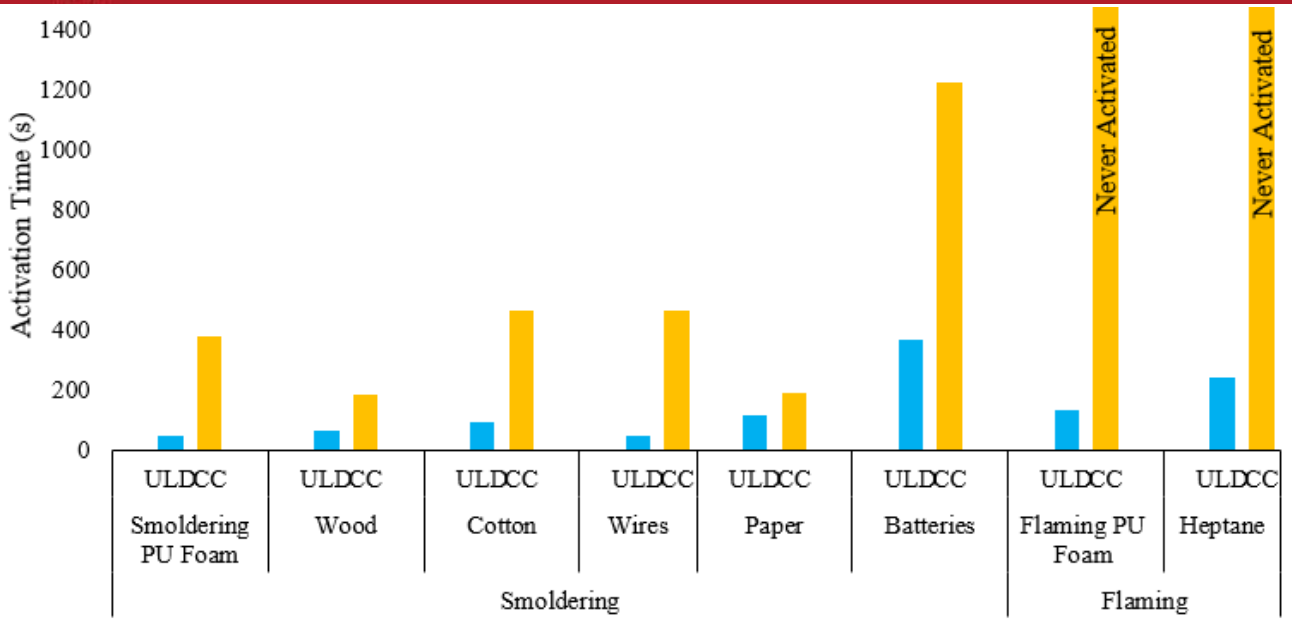
Smoldering PU Foam

Flaming PU Foam



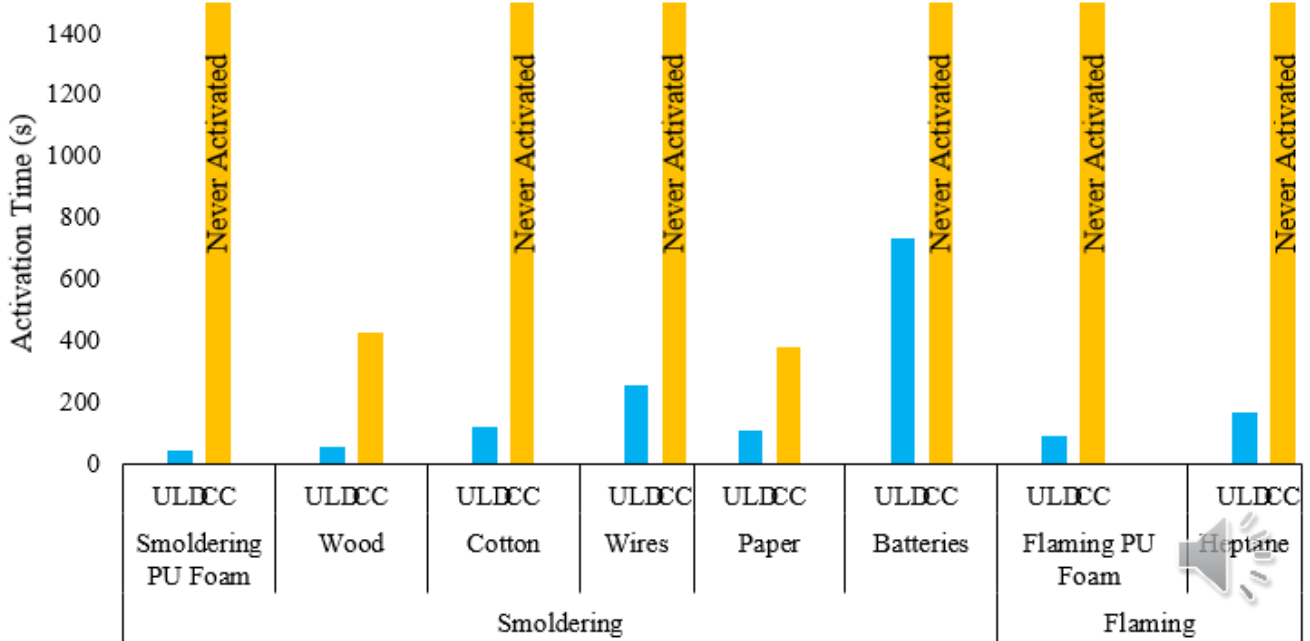
Analysis of Results

Results and Analysis: Activation Times

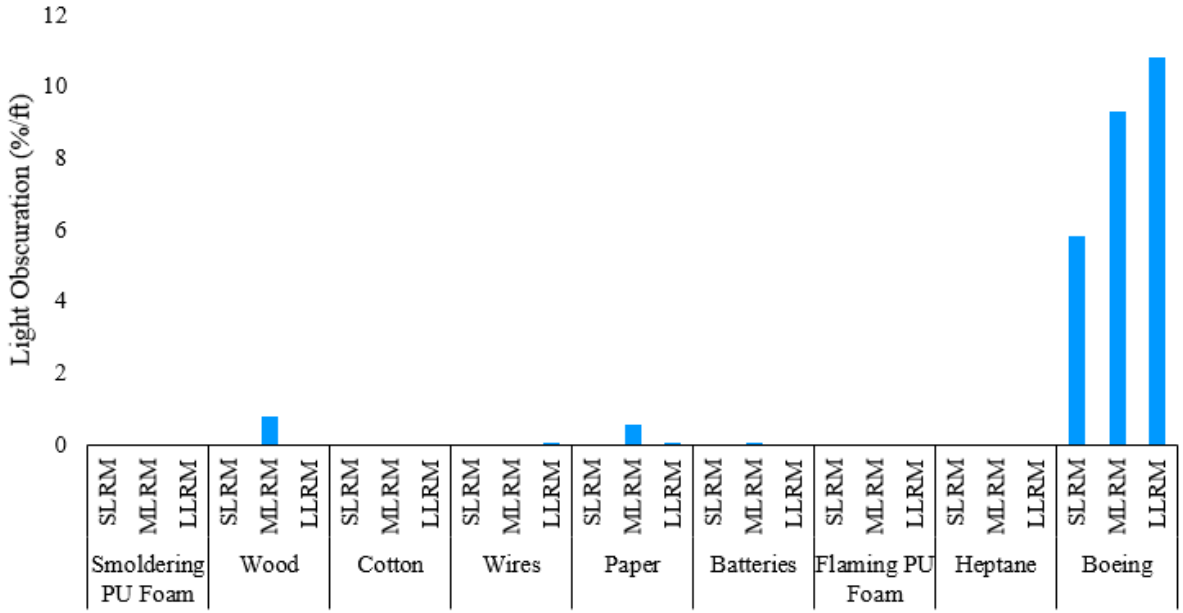


ASSD

Wireless Detector

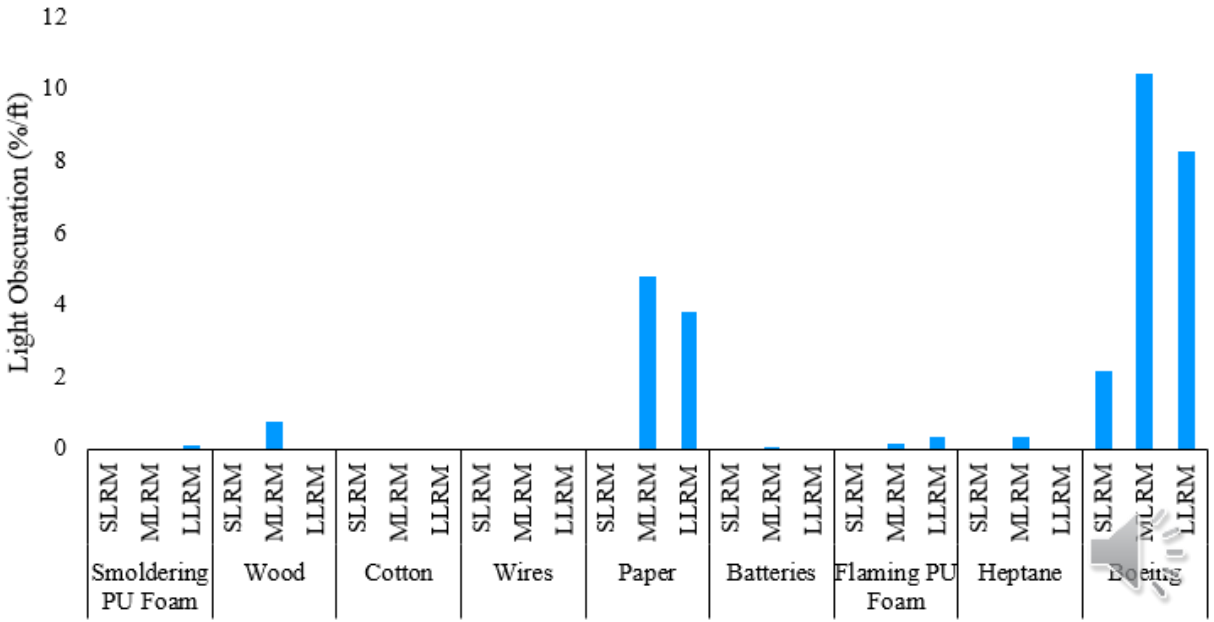


Leakage Rate Effects: Cargo Compartment

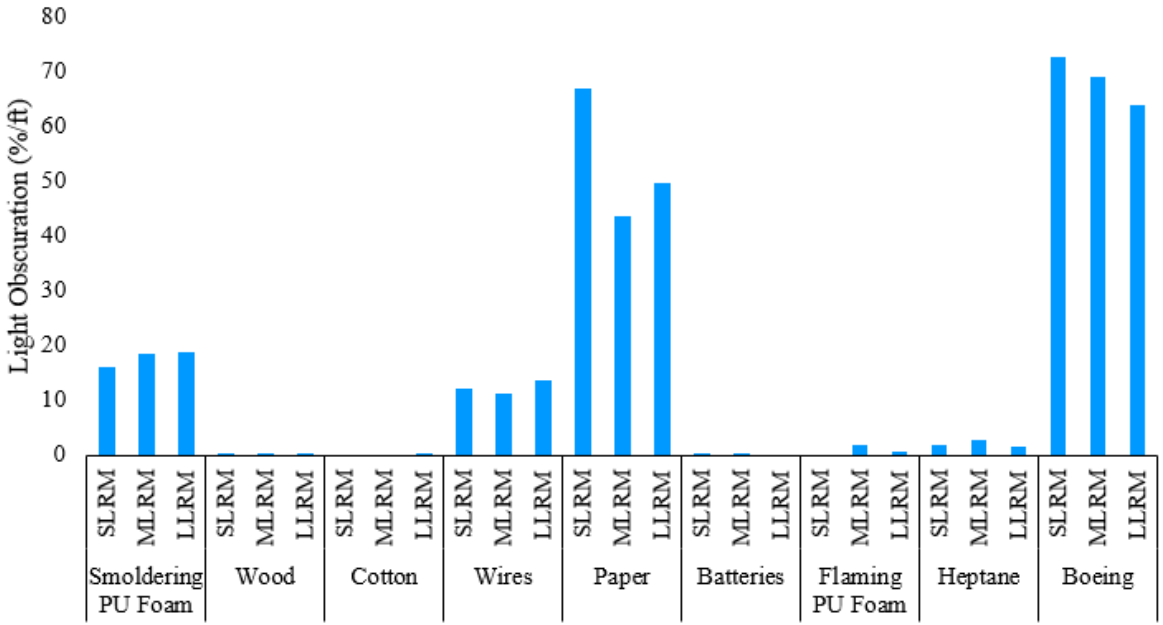


60 seconds

120 seconds

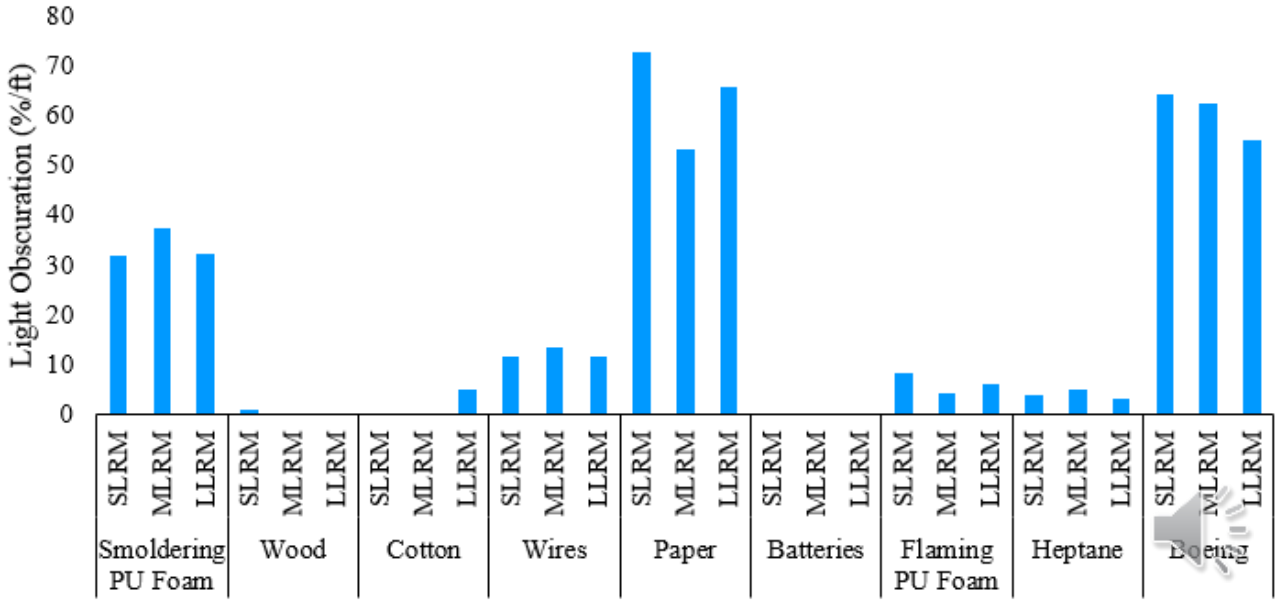


Leakage Rate Effects: ULD

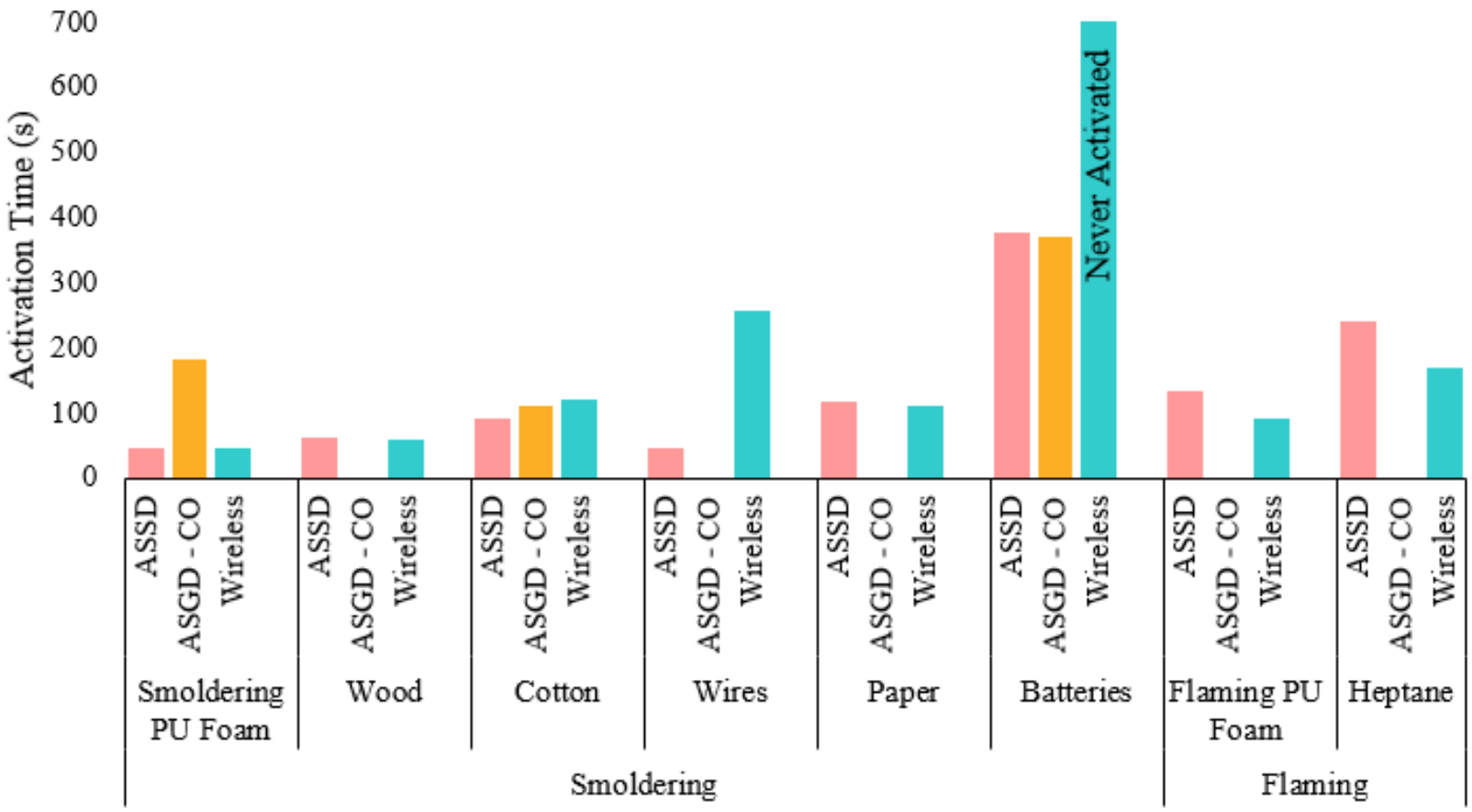


60 seconds

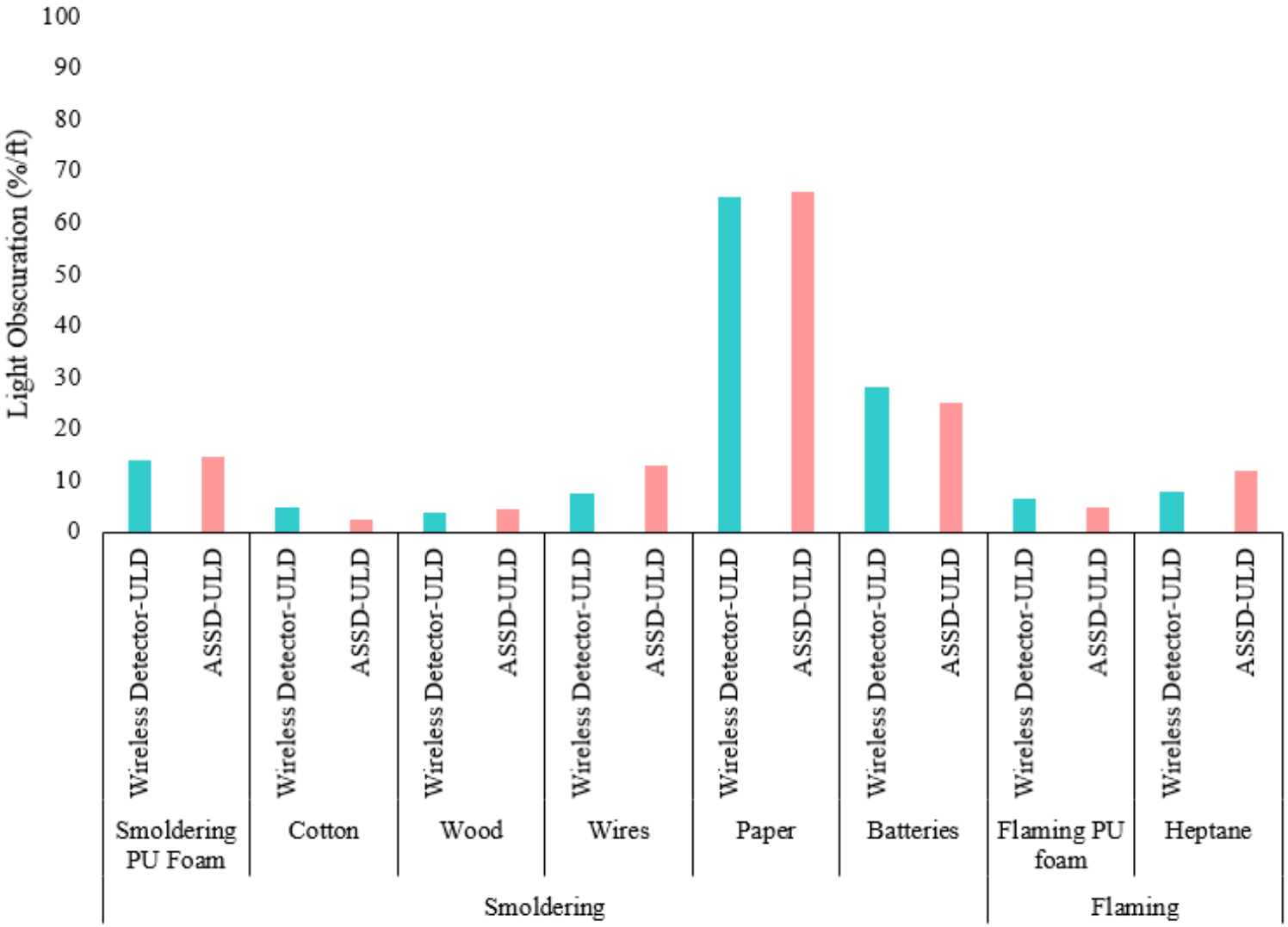
120 seconds



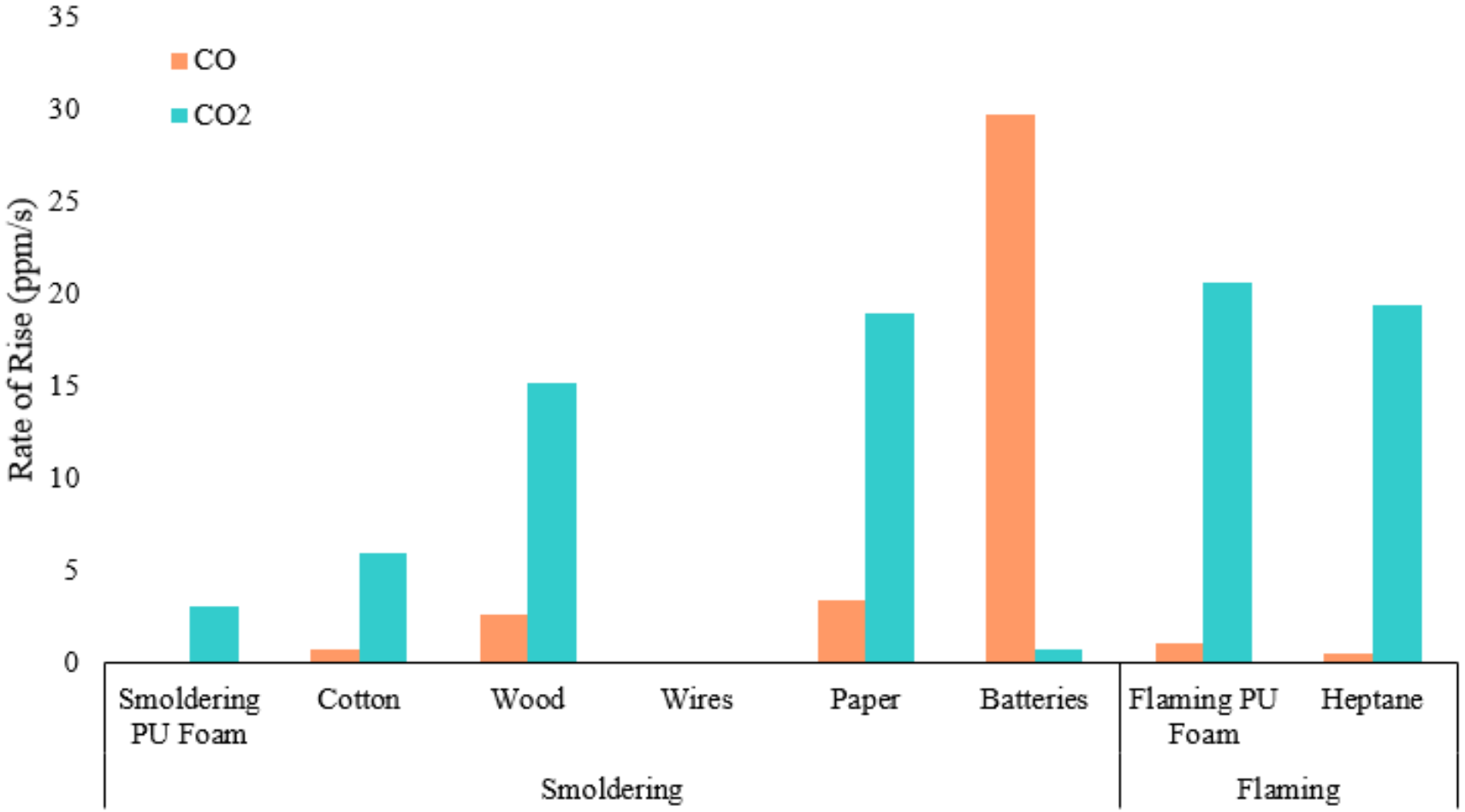
Analysis - Detector Technologies Inside ULD



Analysis - Detector Technologies Inside ULD

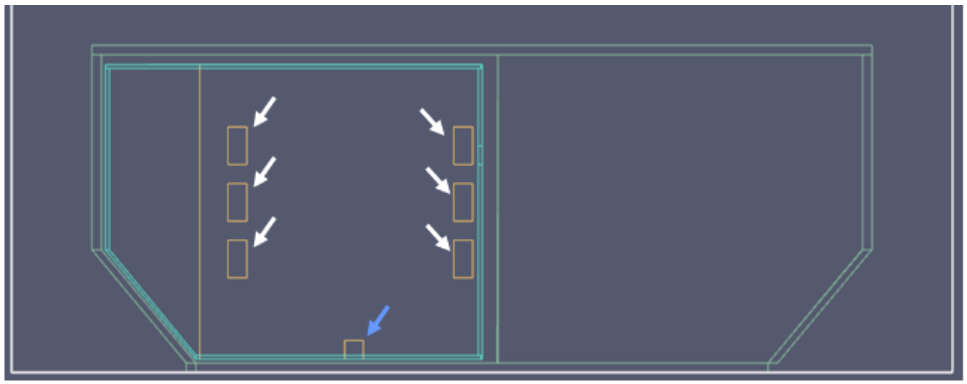


Average Gas Concentration Rate of Rise



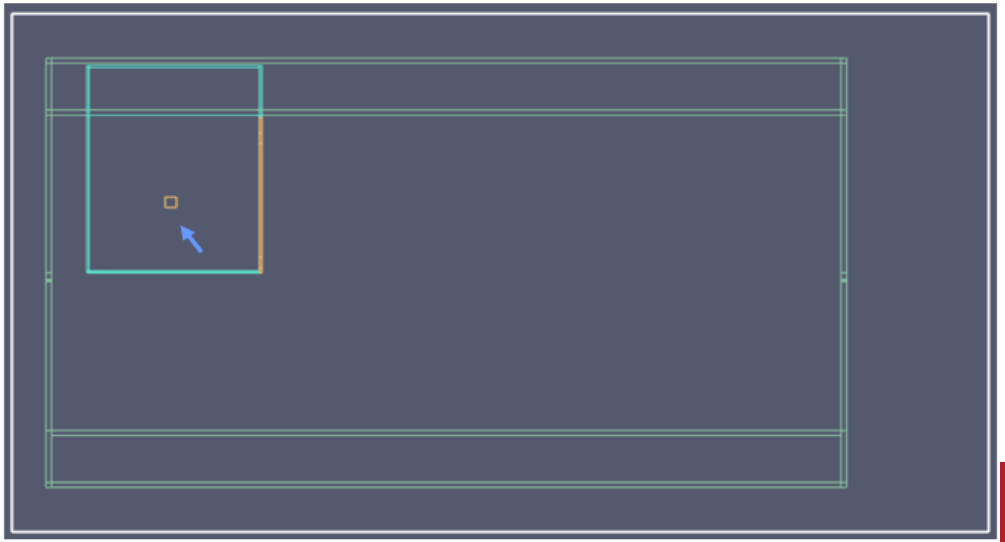
FDS Model

Computational Model



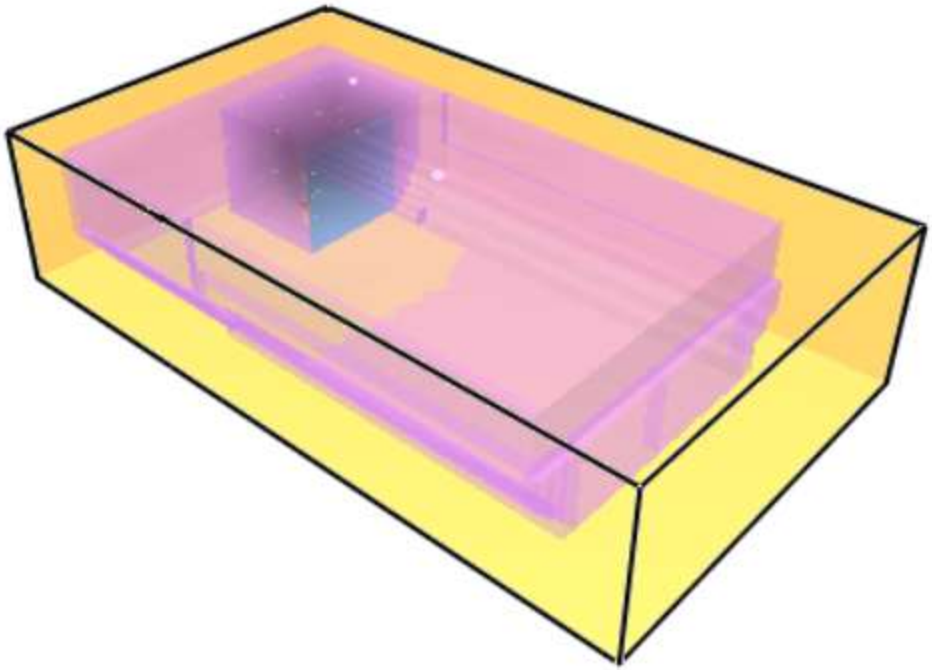
Elevation Side View

Elevation Front View



Plan View

Results in Smokeview

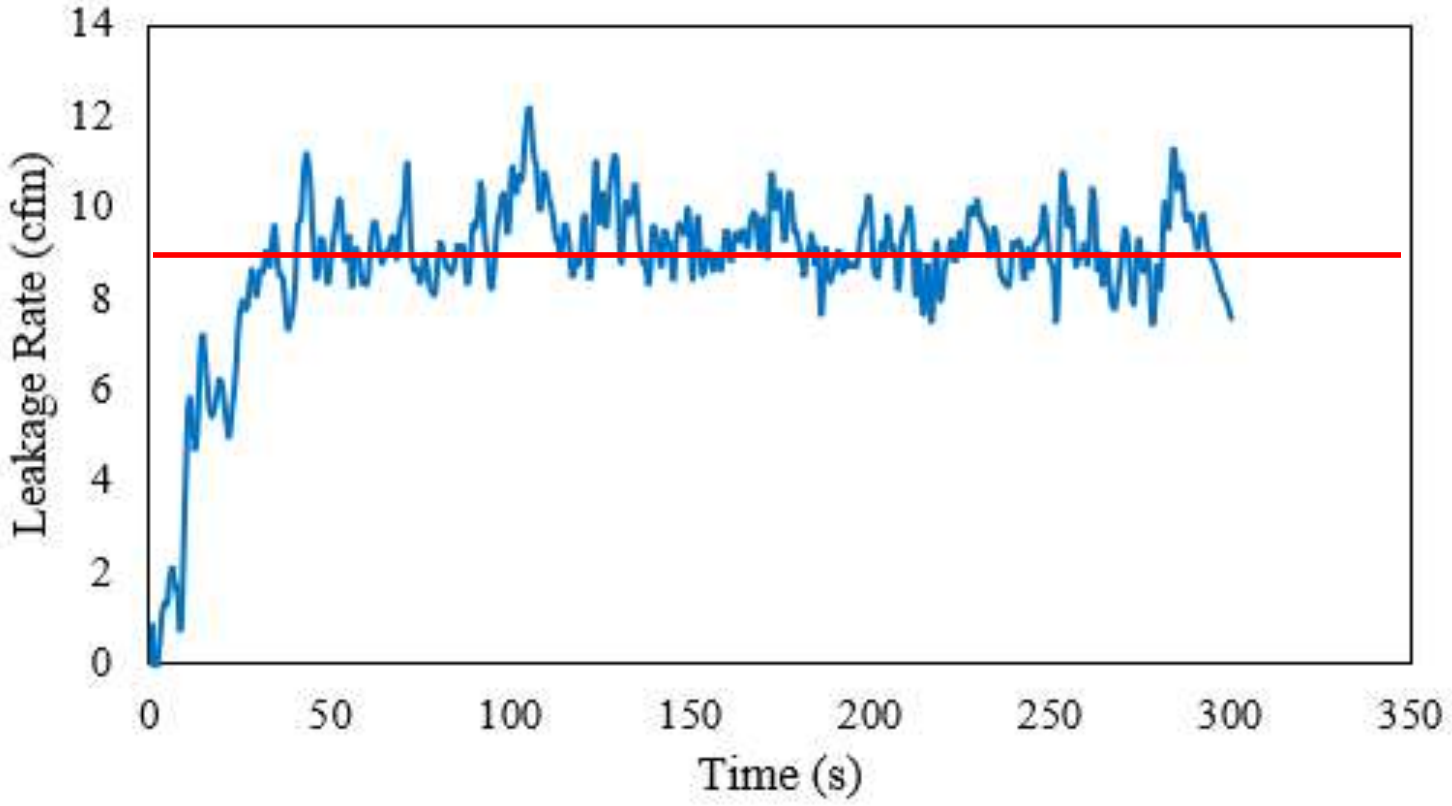


What was included?

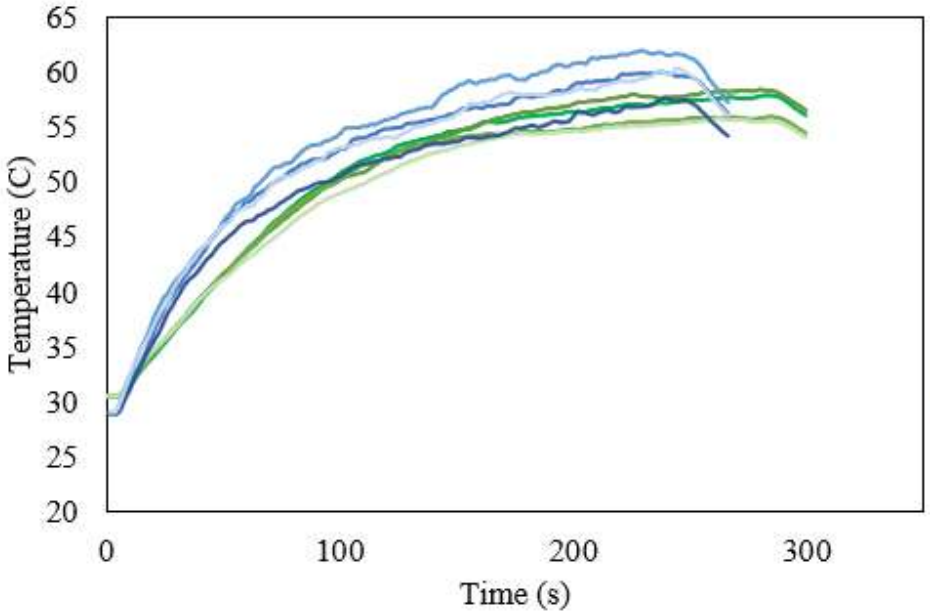
- Fuel Source: Heptane
- Thermocouples
- Optical Density
- Gas Analyzers
- Smoke Detectors
- ASSD systems

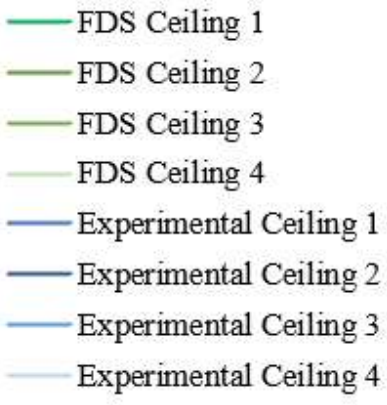
FDS vs. Experimental: Leakage Rate Comparisons

Goal: Simulate leakage rate of LLRM ULD (8.78 cfm, indicated by red line)



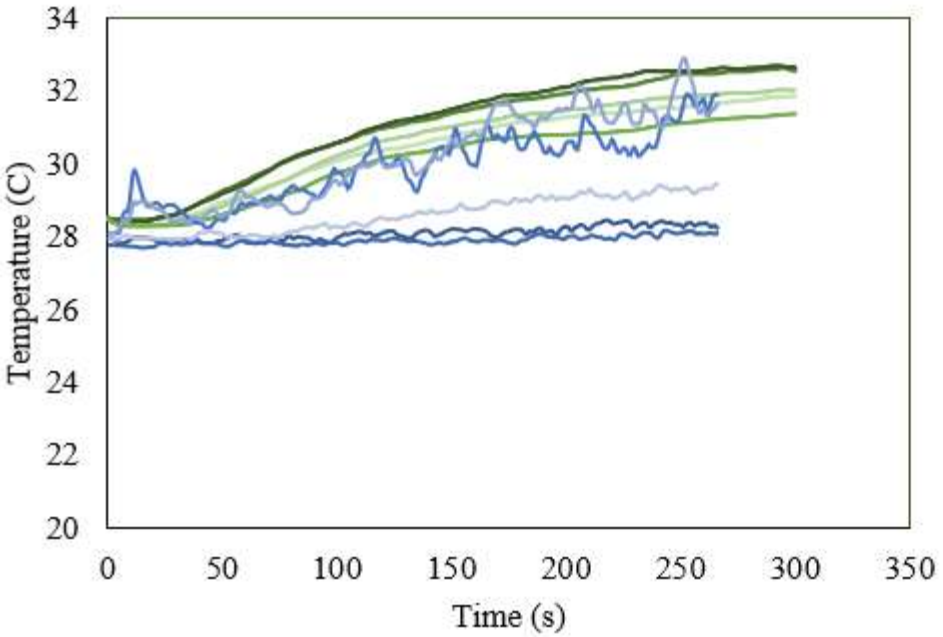
FDS vs. Experimental: Thermocouple Comparisons

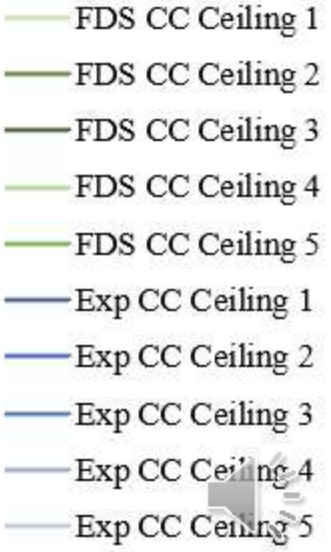




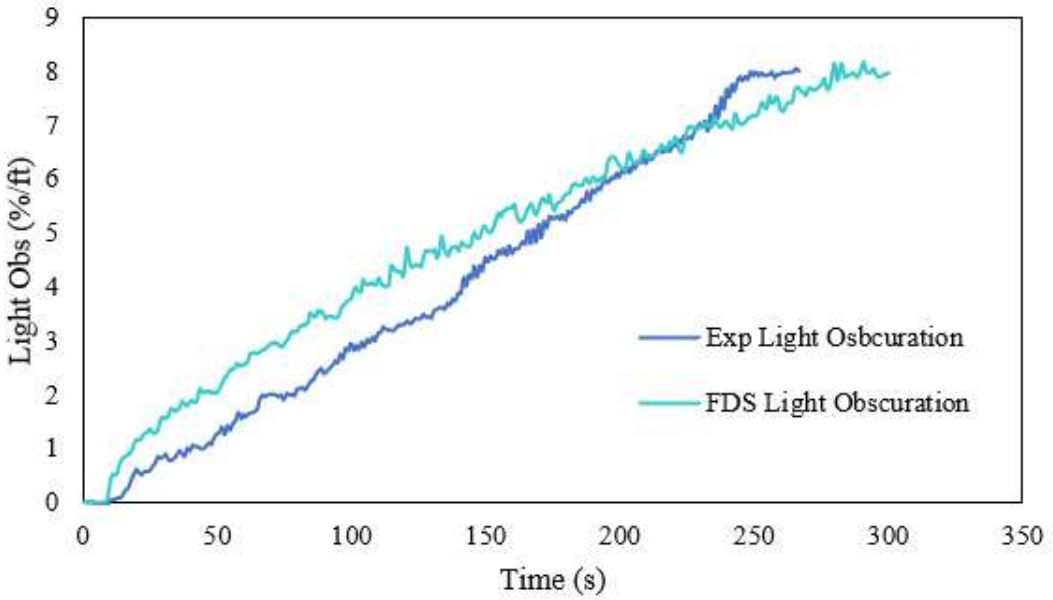
ULD

Cargo Compartment



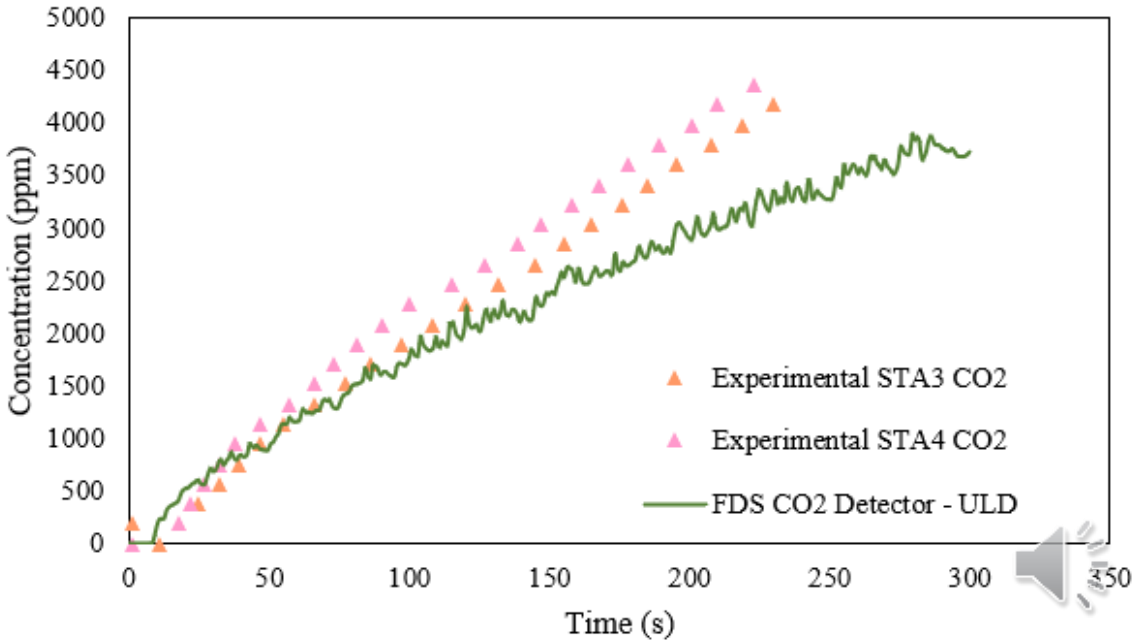


FDS vs. Experimental: Instrument Comparisons



Light Obscuration

CO_2 Concentration



Conclusions

- Detectors located inside ULD provides the quickest activation time
- Within the ULD, the wireless detector outperformed the other detectors for a majority of testing
  - Threshold constraints may play big role in quickest activation time
- FDS model provided relatively good agreement with experimental results

Future Work

- Reproducible nuisance source testing
- Wireless Detector replacement daily or by fuel type
- CO_2 ASGD
- FDS Model replicates all three leakage rate models
- Standardize fire detection systems

Acknowledgements

- Federal Aviation Administration
  - Robert I. Ochs, PhD
  - Engineering Team
  - Technicians
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- Nicole Hollywood
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- Space Age Electronics
- Xtralis (by Honeywell)
- Friends and Family

Thank You!

Questions?