Improvements in Aircraft Fire Detection

May 8, 2017

Jim Milke, Irene Lemberos, Nick Schraffenberger
Dept of Fire Protection Engineering
University of Maryland

Motivation

- Need for timely fire detection in cargo compartments on board aircrafts
- High proportion of nuisance alarms from smoke detection systems
- Nuisance alarms lead to
  - operational delays
  - unscheduled landings
  - unnecessary safety recourse
  - potential to ignore alarms if nuisance alarms become frequent

Overview

- **Cargo Compartments**
  - **Smoke Detection Deficiencies**
    - Unit Load Devices
  - **Nuisance Sources**
  - **Outstanding Recommendations**
  - **Proposed Solutions**

- **Hidden Spaces**
  - **Accidents/Incidents**
  - **Outstanding Recommendations**
  - **Proposed Solutions**

Detection Technologies

Technology	Sensitivity-flaming fires	Sensitivity-smoldering fires	Nuisance alarm susceptibility	Maintenance
Ionization	H	M	H	H
Photoelectric	M	H	M	M
Air-sampling	H	M-H	M	H
Projected beam	M	H	M	H
Video	H	H	M	H
Spot heat	H	L	L	L
Linear heat	H	L	L	L
Radiation	H	L	L	H
Gas	M-H	M-H	H	H

H=High, M=Moderate, L=Low

Detection Technology Challenges

Technology	Principal Challenge
Ionization	Nuisance alarm susceptibility
Photoelectric	Modest response to flaming fires with limited visible smoke
Air-sampling	Maintenance of filters
Projected beam	Maintenance of photo-receiver, provision of clear pathway for light beam
Video	Provision of clearance space for viewing
Spot heat	Slow response to smoldering fires
Linear heat	Slow response to smoldering fires
Radiation	Maintenance of optics
Gas	Stability of sensors

Discrimination Strategies

- **None: Single sensor, single threshold**
- **Health-monitoring of sensor**
- **Alarm confirmation**
- **Multi-sensor**
  - **“or” logic**
  - **algorithm**

Cargo Compartments

- **Five cargo compartment classifications (A, B, C, E, F) from 25.857 of Code of Federal Regulations**
- **Environmental Conditions**
  - **Dark, unlit spaces**
  - **Temperature between about 32°F-77°F**
  - **Variations in humidity and CO_2, CH_4 and CO concentrations depending on type of cargo, e.g. livestock or fresh produce**

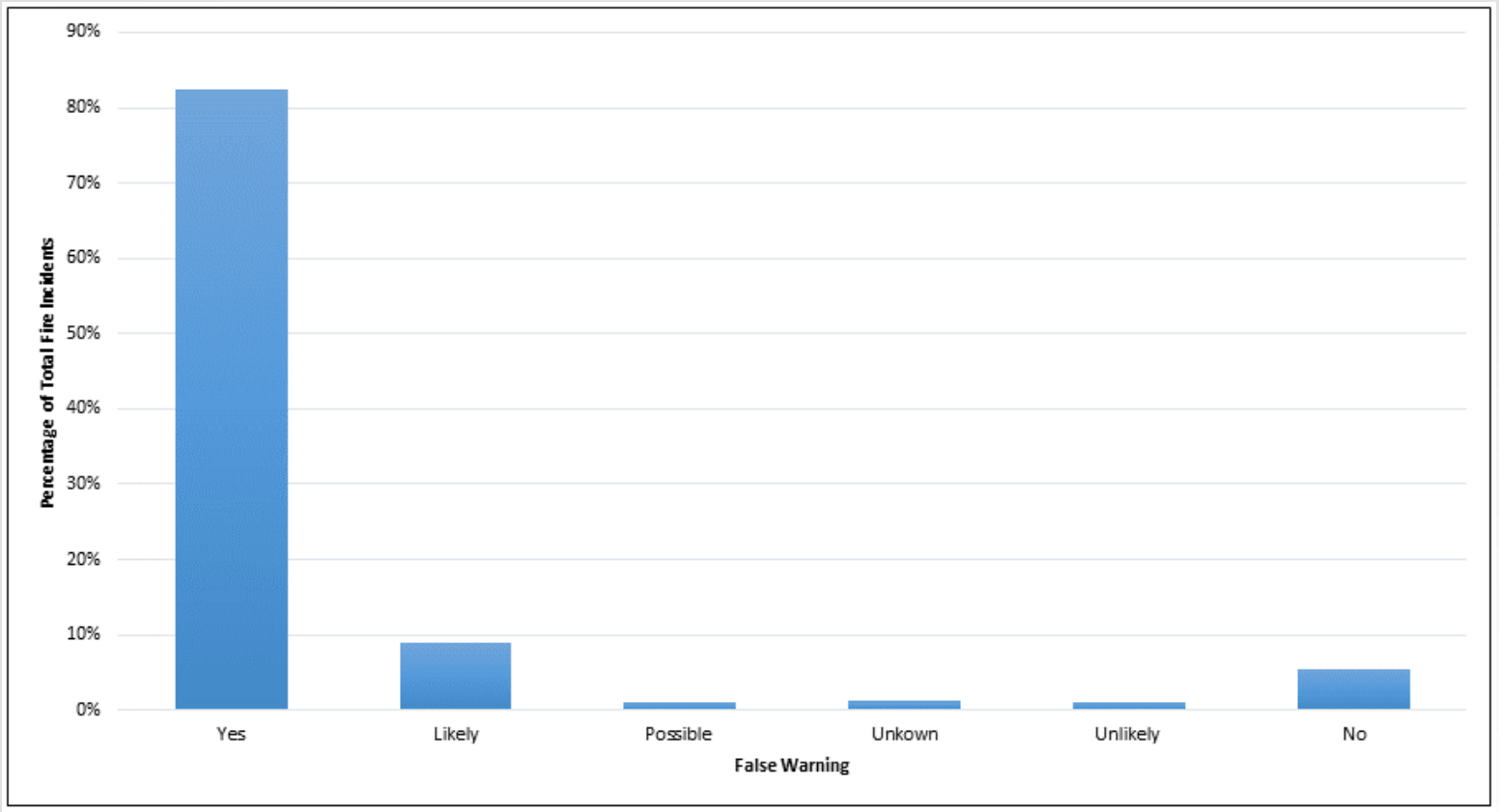
Class E Cargo Compartment

Nuisance Alarms-Cargo Compartments

- **Analyzed frequency of nuisance alarms in cargo compartments**
  - **FAA database of reported fire related events for all civil flights between 2002-2014**
- **Event categories**
  - **nuisance alarm**
  - **likely a nuisance alarm**
  - **possibly a nuisance alarm**
  - **unlikely a nuisance alarm**
  - **Unknown**
  - **real fire condition**

Smoke Detection Deficiencies

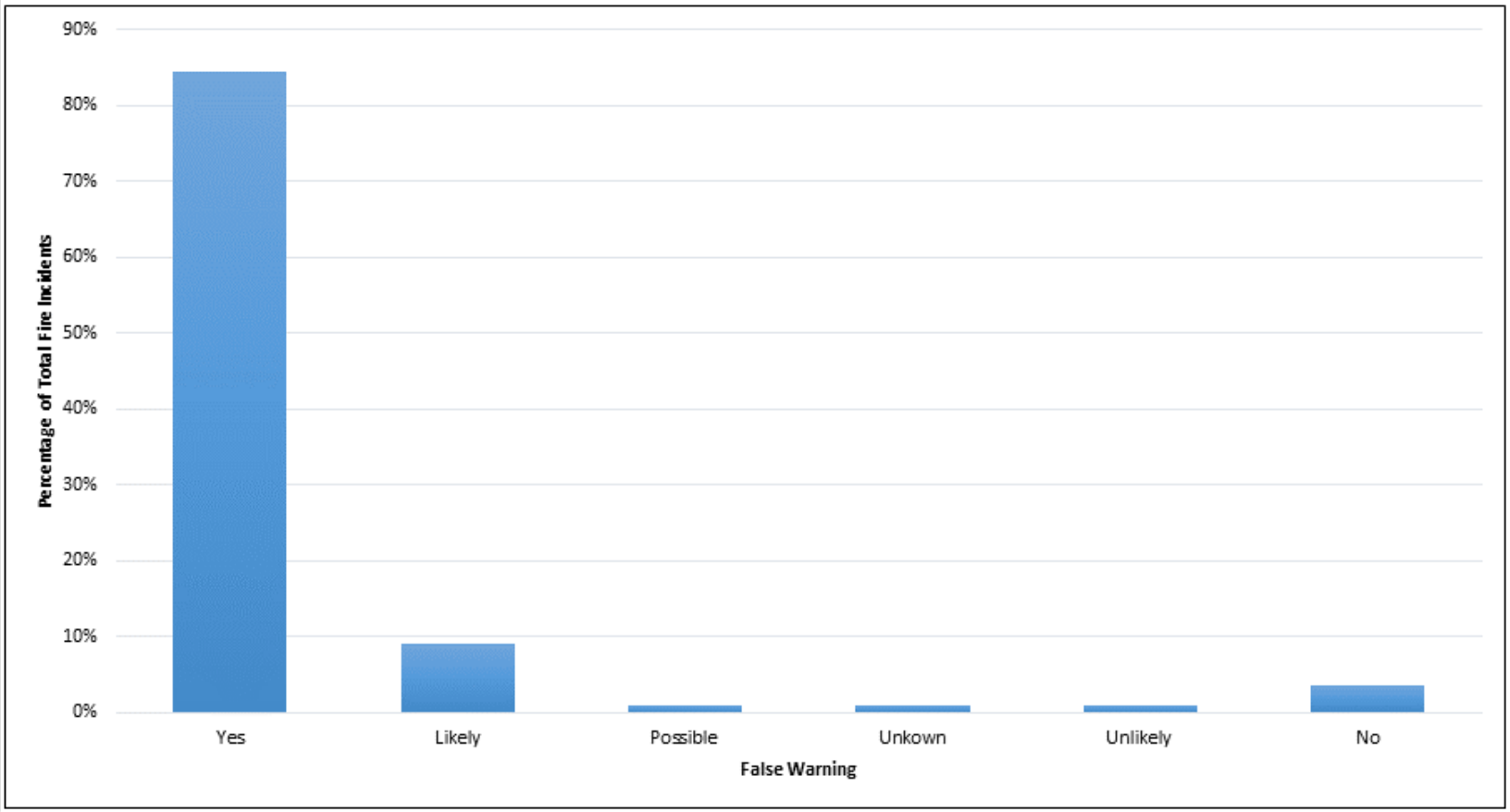
- **91.5% of reported incidents in all cargo compartments are from nuisance alarms or likely nuisance alarms**



Rate of Nuisance Alarms in all Cargo Compartments

Rate of Nuisance Alarms in Inaccessible Cargo Compartments

- **93.5% of reported incidents in inaccessible cargo compartments are from nuisance alarms or likely nuisance alarms**



ULD Smoke Detection Challenges

- **Response time set at 1 minute from ignition**
  - **In regulations for buildings and industrial applications, detector response is associated with time for hazard development and time needed to respond**
- **Expect time delay to detect fire that originates within ULD (until breach of ULD)**
- **No detection requirements for fires originating within ULDs under FAR regulations**

Nuisance Sources

- **Difficult to identify nuisance sources due to**
  - **Inability to access Class C cargo compartments**
  - **Limited room to navigate main deck compartments in narrow body Class E compartments**
  - **Incident reports do not identify nuisance source**
- **Listed nuisances sources include**
  - **Faulty signal loops, burnout lamp bulbs, and broken connector pins**

Outstanding Recommendations

- **National Transportation Safety Board (NTSB) recommendations**
  - **Develop fire detection system performance requirements for early detection of fires originating within cargo containers and pallets (A-12-68)**
  - **Ensure cargo container construction materials meet same flammability requirements as all other cargo compartment materials (A-12-69)**
  - **Require the installation and use of active fire suppression systems in all aircraft cargo compartments or containers (A-12-70)**

Proposed Solutions

- **ULD**
  - **Prevent undeclared hazardous material from entering shipping system (SE 125)**
  - **Develop or improve containment systems (SE 126)**
  - **New standards for the construction of standardized cargo containers (SE 127)**
- **Detection (maintain responsiveness, reduce nuisance alarm susceptibility)**
  - **Multi-sensor detection, consider video back-up**
  - **Include detection capability within ULD**

Hidden Areas

- Spaces not normally exposed or seen from inside of aircraft
  - Space between the exterior shell and interior lining of an aircraft
  - Spaces range from 15 cm – 1.6 m wide
- Contents include insulation, wire bundles, electronics, batteries, ducts, and piping
- Currently no detection in hidden areas

Example Accidents/Incidents

- **Delta Airlines Flight 2030: Probable source was smoldering insulation blanket next to static port heater**
- **AirTran Flight 913: Probable cause was phase-to-phase arc in the heat exchanger cooling fan relay located behind the captain's seat**
- **American Airlines Flight 1683: Lightning struck the aircraft, fire developed in ceiling panel**

Outstanding Recommendations

- **National Transportation Safety Board (NTSB) recommendations**
  - **Develop and require implementation of training procedures**
  - **Provide access to areas behind panels**
  - **Consider halon for suppressing in-flight fires**

Proposed Solutions

- **Linear heat detection**
  - **Minimal maintenance after installation**
  - **Can route along existing wire bundles in hidden spaces**