Multi-Stage Passive Dry Bay Fire Extinguishing SBIR Phase I Results

THE SIXTH TRIENNIAL INTERNATIONAL AIRCRAFT FIRE AND CABIN SAFETY RESEARCH CONFERENCE

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Abstract

This briefing summarizes the major portions of a Phase I Air Force led Small Business Innovative Research (SBIR) program to develop a multi-stage, passive fire extinguishing system for aircraft.

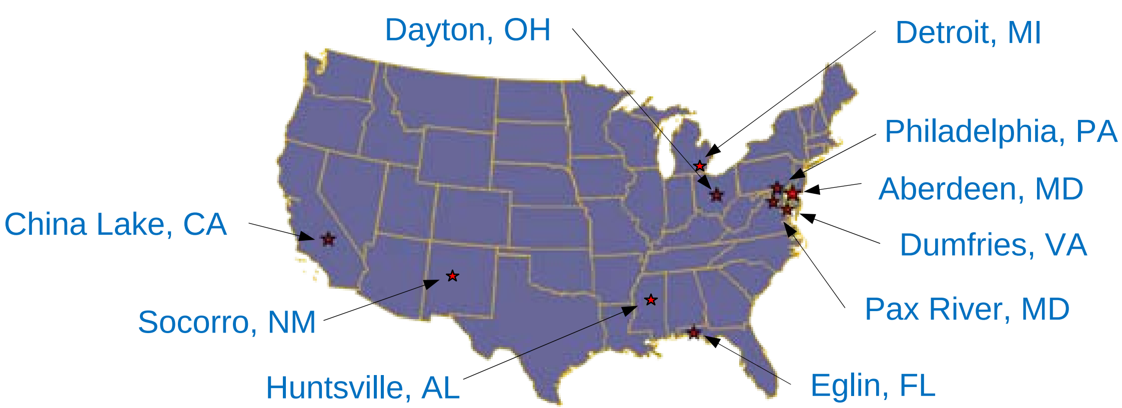
A prototype system was conceptualized , designed, prototyped, and successfully tested under the Phase I program.

Team

SURVICE / Firetrace Team

- SURVICE:
  - Vulnerability, susceptibility, lethality, survivability
  - Aircraft subsystem design and optimization
  - System integration
  - M&S, T&E
  - Fire prediction, evaluation, extinguishment
- Firetrace:
  - Manufacturer of non-electric Suppression Systems
  - ISO 9001 / AS9100 certified (100% Audit)
  - 50k ft2 engineering and manufacturing facilities
  - In-house fire test facility

SURVICE Engineering



Firetrace – Scottsdale, AZ

Problem, Objective, Requirements

Problem:

- Fire is typically the largest contributor to military aircraft vulnerability
- Fire vulnerability reduction measures are typically overruled because of associated weight, cost, and maintenance penalties
- Active suppression systems can be very complex and difficult to integrate

Primary Objective:

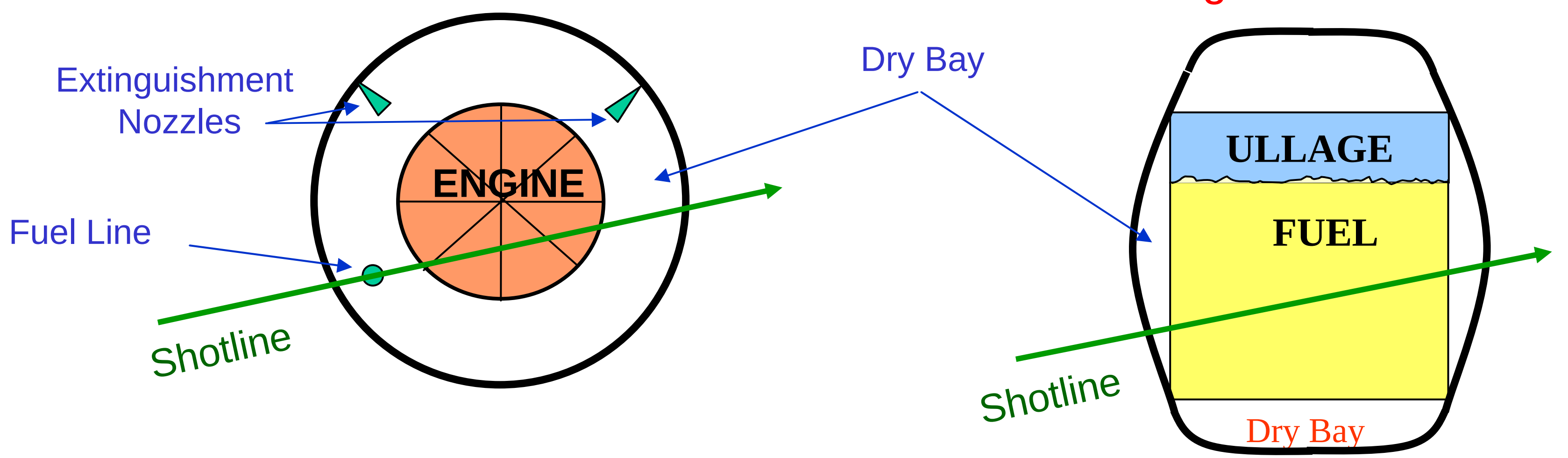
- Develop an effective, light-weight, low-cost, low-maintenance passive method to quickly extinguish aircraft dry bay (void space area) fires in manned and remotely piloted platforms

Requirements

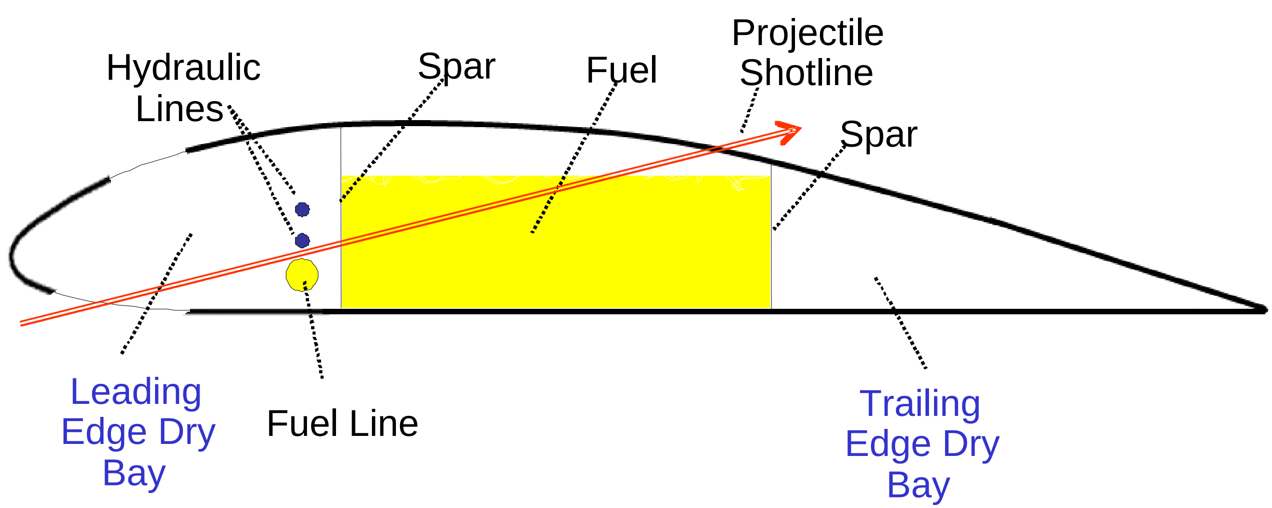
- 100% passive system independent of existing aircraft systems
- No electrical power source or powered sensors
- Effective for threat (military) and safety (commercial) applications
- Extinguish multiple fire events
- Quickly extinguish fires
- Lightweight and cost effective (*of course…)*

What is a Dry Bay?

Engine Bay Section / Fuselage Cross Section

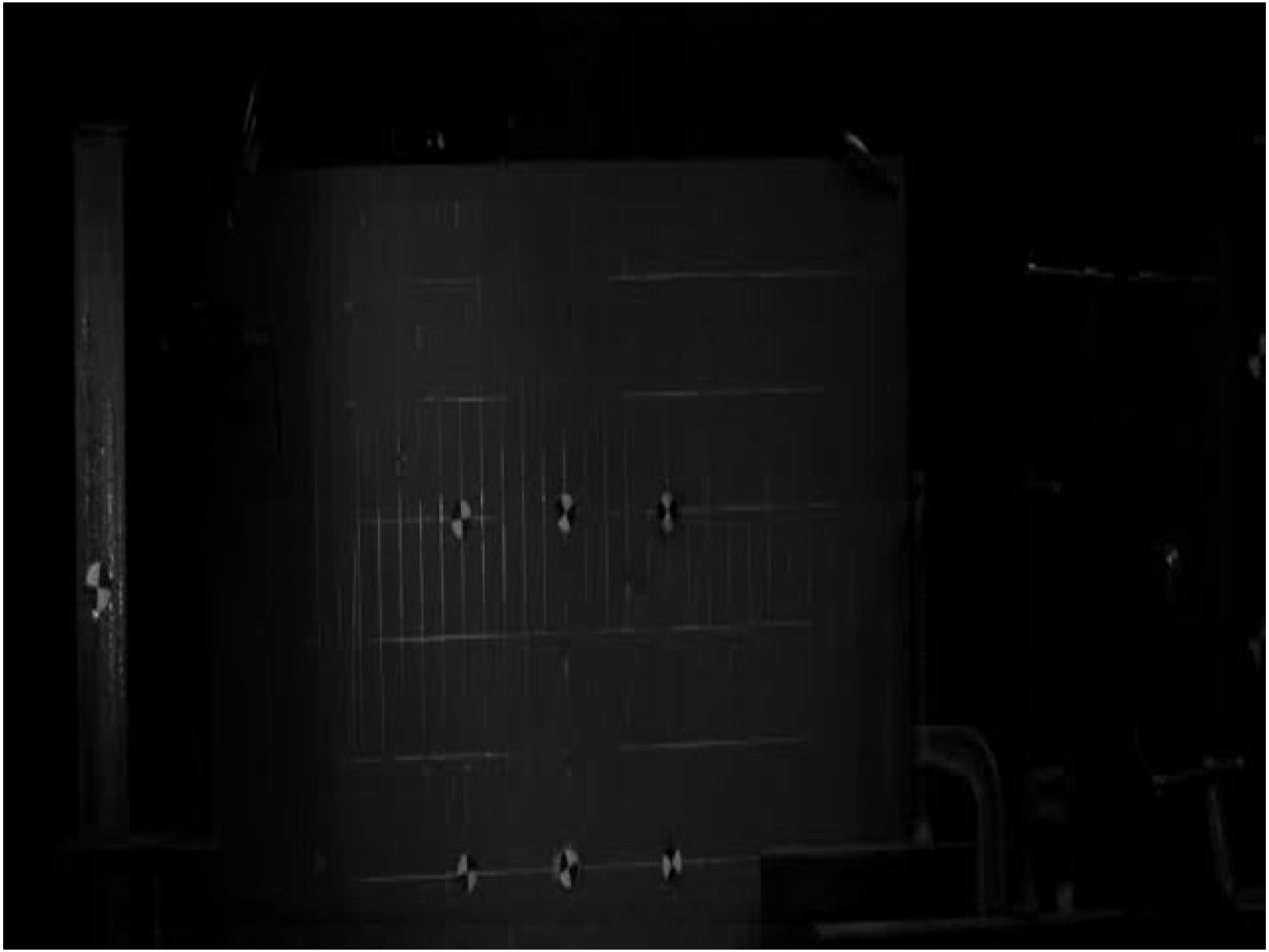


Wing Fuel Tank



Ignition Source

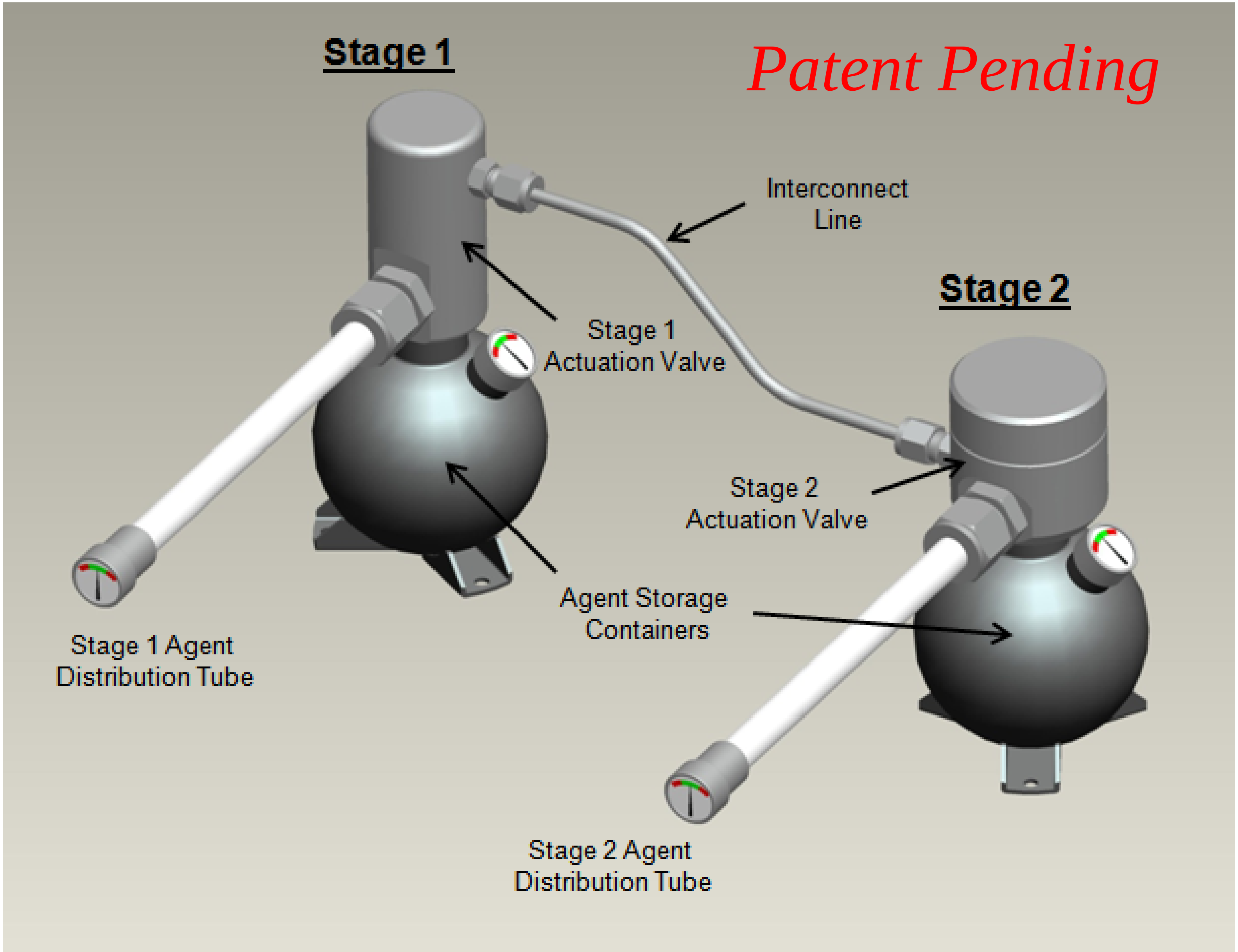
Ballistic Threat - Video



Dry Bay Fire

Typical Dry Bay Fire - Video

Phase I Solution

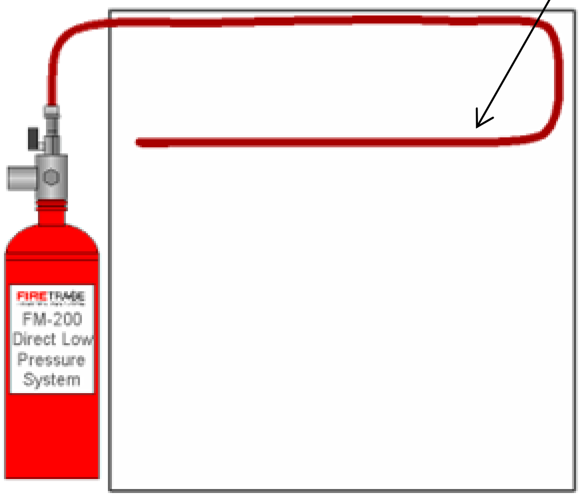


System Examples

Direct vs. Indirect

Direct System

Detection and agent dispersion



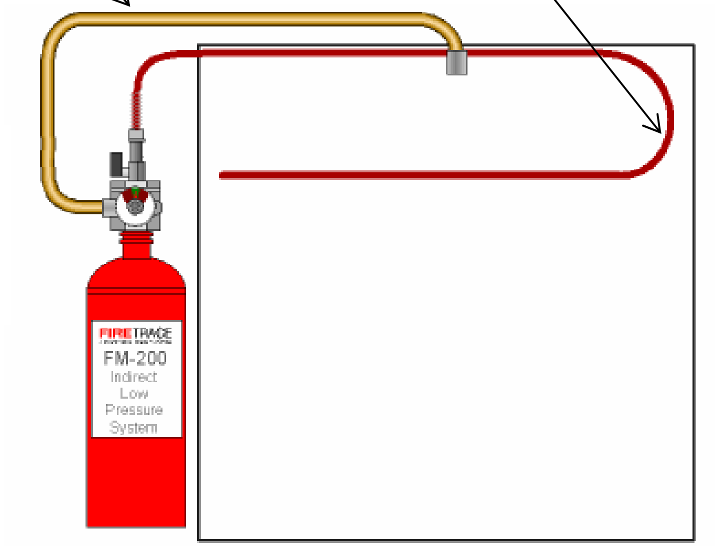
Stage 1 only shown

Stage 2 Omitted For Clarity

Indirect System

Agent dispersion line and nozzle

Detection Tube



Tubing is used for activation and delivery

"Point of Fire" Suppression

Protection for smaller volumes

Tubing is used for activation only

Distribution through separate nozzle(s)

Protection for larger areas

Installation

Prototype System Testing

Overview

- Goal was to verify actuation of new valve design and proper sequencing
- Performed "breadboard" testing at Firetrace Labs

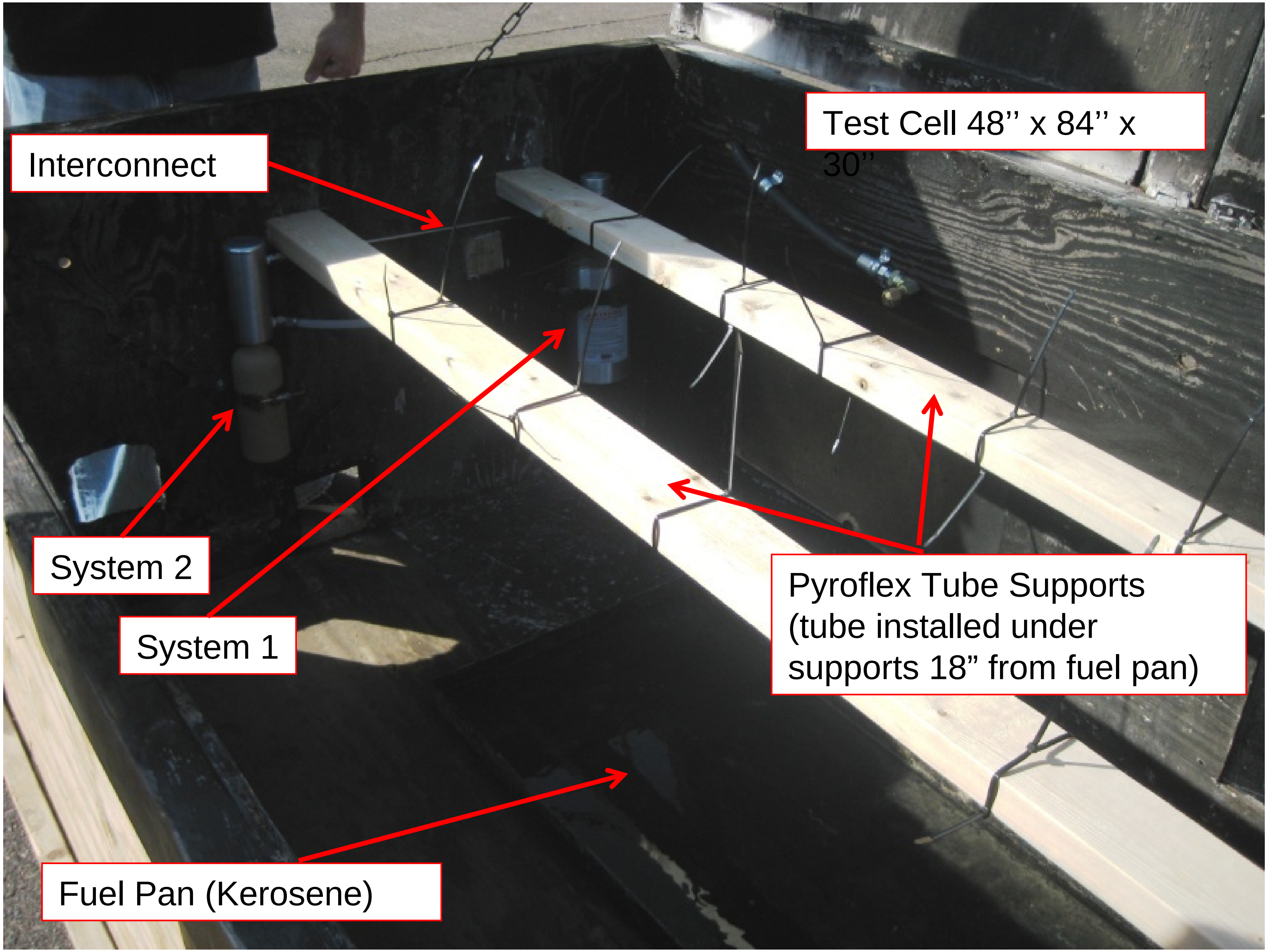
Configuration

- Test box 48"w x 30"h x 84" long (larger A/C dry bay)
- Pyroflex Tubing
- Kerosene
- First shot: 3 lbs FE-25 @ 600 PSI
- Second shot: 0.8 lbs Monnex (tube initially unpressurized)

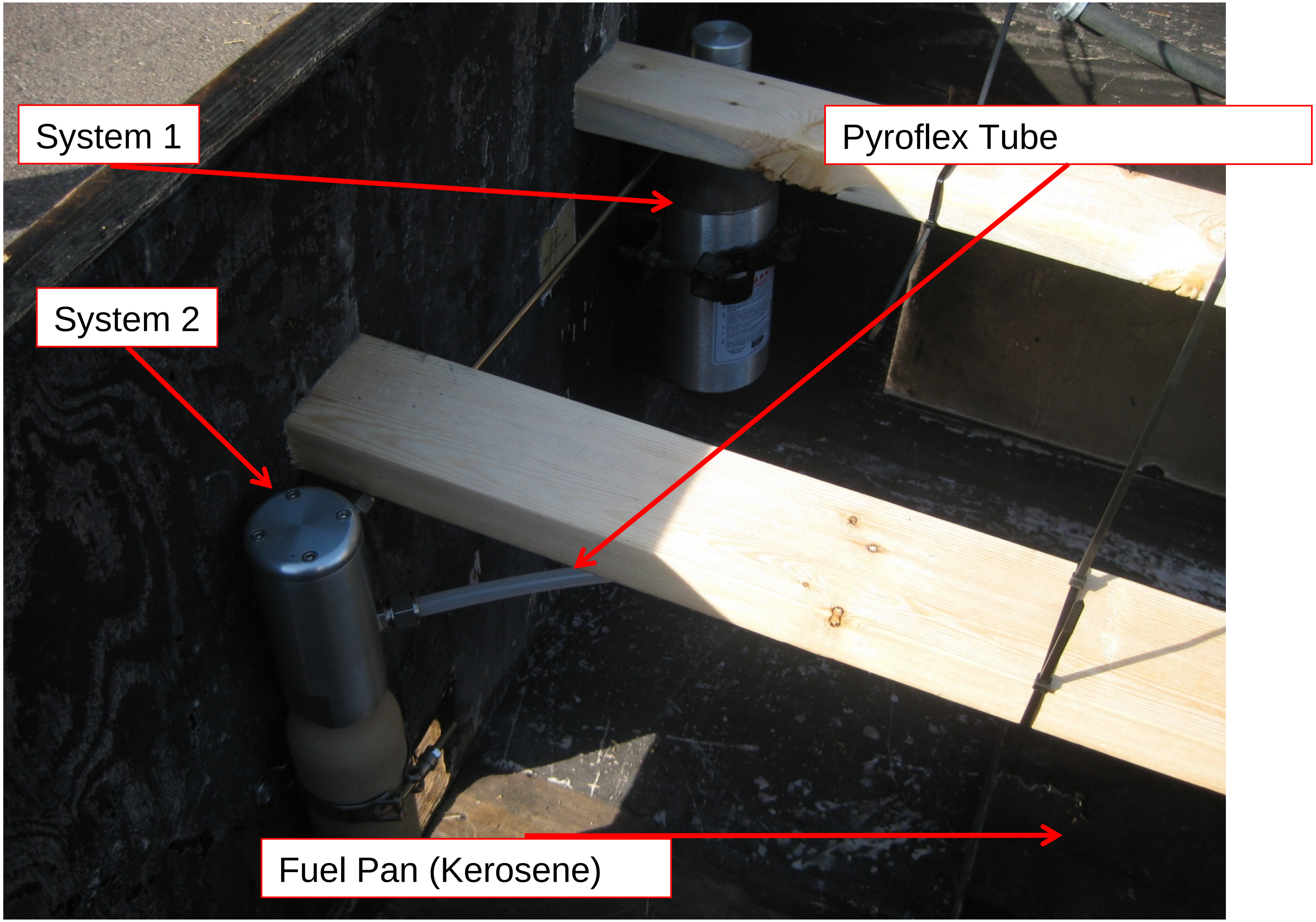
Results

- Tubing reacted and opened in key locations as desired
- Stage 1 discharge armed Stage 2 as designed
- Fire relit and Stage 2 extinguished fire as designed

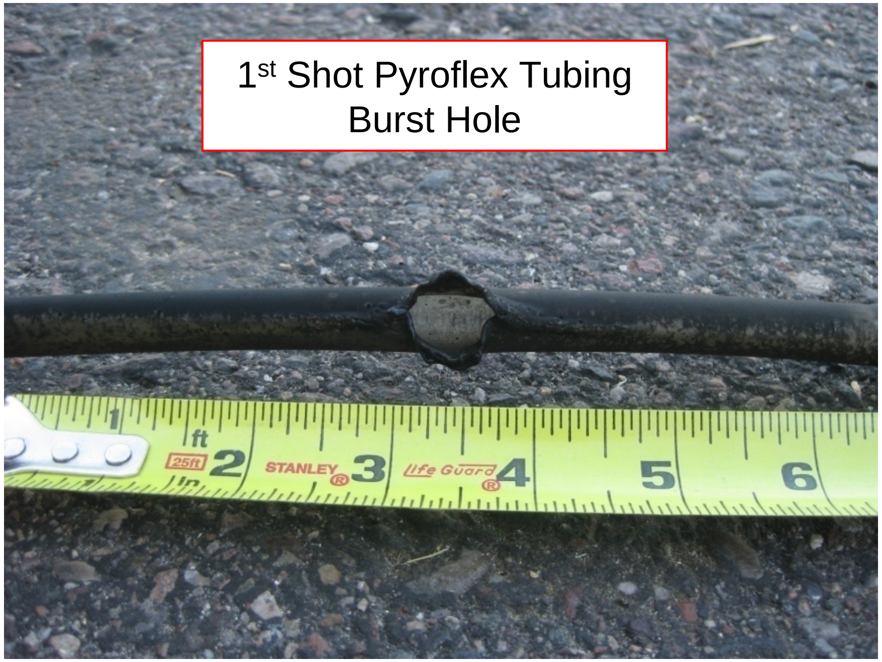
Prototype Demonstration

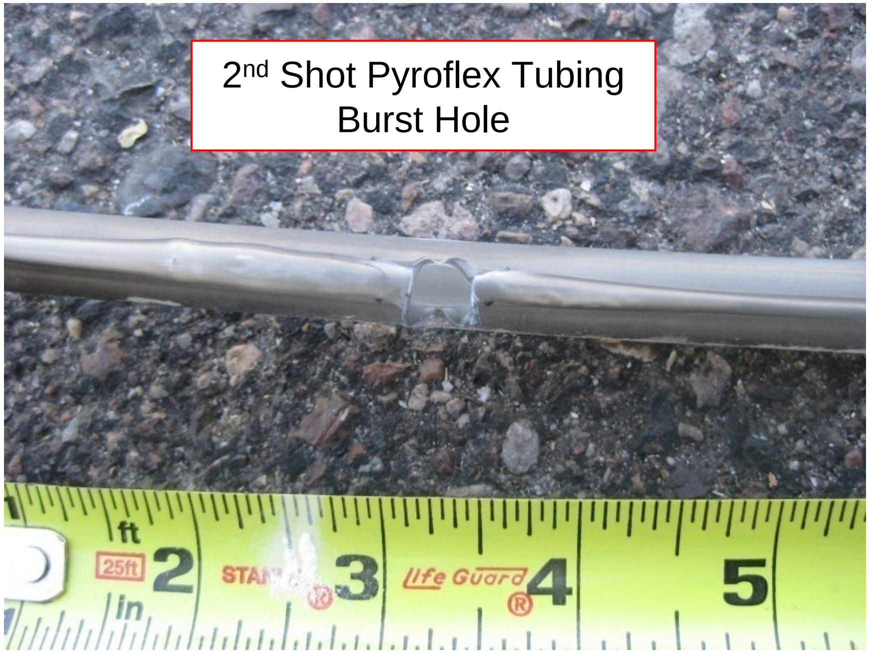


Prototype Demonstration



Prototype Demonstration





Prototype Demonstration

Valve Operation Test - Video

Sizing the System

Goal

- Establish a preliminary M&S method for sizing the system for specific applications and to study scalability

Approach

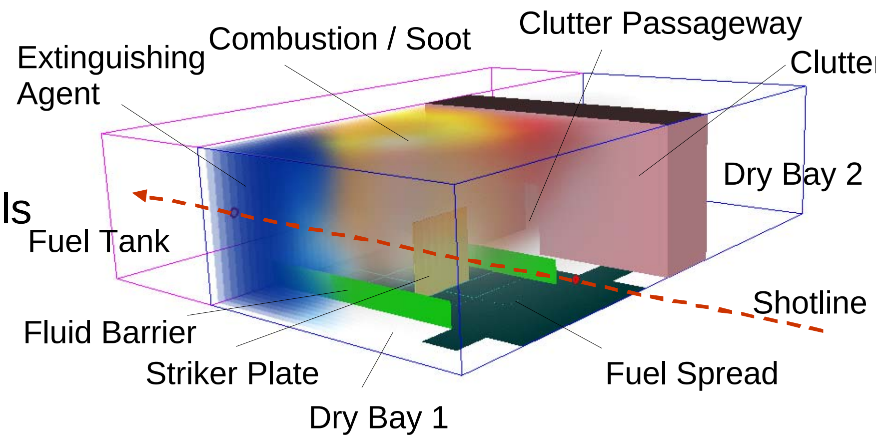
- Apply computer modeling and analysis to develop a methodology for determining the optimal amount of agent per unit dry bay volume, tubing requirements, container volumes, etc

Scope

- Investigate adaptability of the Joint Aircraft Survivability Program Fire Prediction Model (FPM)
- Calibrate FPM with Phase I testing where possible
- Scope Phase II effort to further enhance modeling approaches an develop a tool for sizing installations

JASP Fire Prediction Model (FPM)

FPM Simulates 3 Key Scenarios



Dry Bay Fire

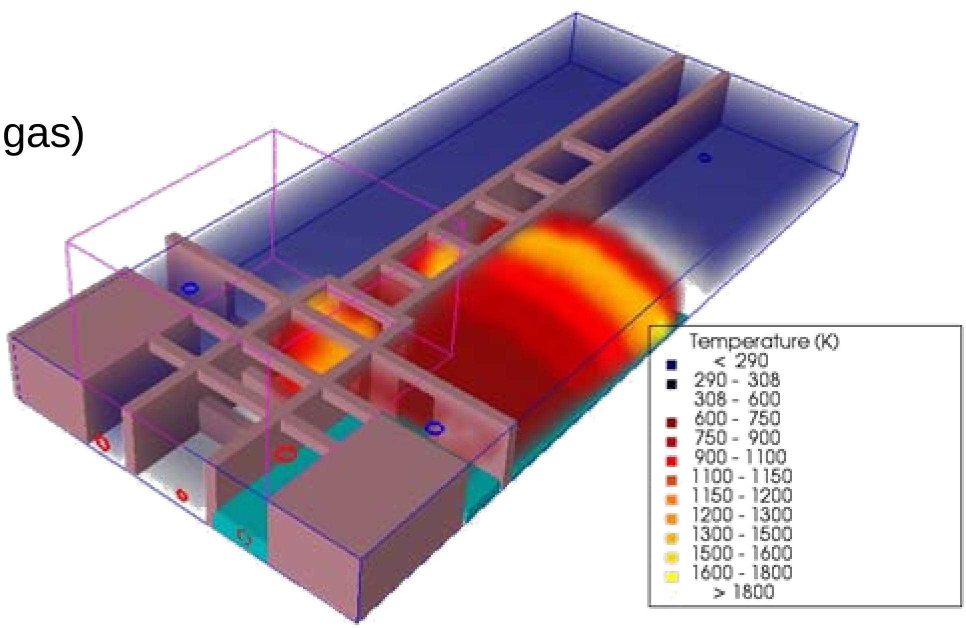
- Ballistic penetration into tanks/lines/vessels
- Threat, Spark, Hot surface ignitions
- Liquid spray ignition
- Fire Initiation, growth, and sustainment
- Heat flux
- Fire extinguishment

Spray Fire

- Dual phase simulation (trajectory and gas)

Ullage Explosions

- Describes initial conditions
- Flight profile effects
- Vapor ignition and wave propagation



System Sizing M&S

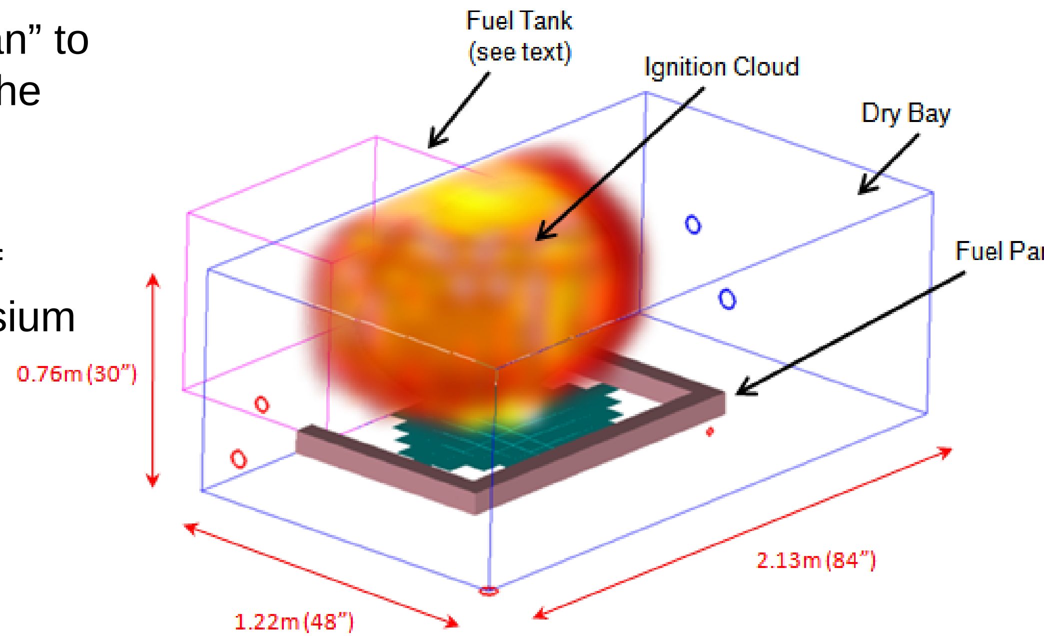
"Injector" centered over the fuel "pan" to replicate the tube burst point over the primary heat source

Simulations conducted with 3 lbs of HFC-125 and with 2.4 lbs of Potassium Carbonate

More than 100 simulations varying weight and discharge time

Some success was realized but trending indicates more work would needs to be done to develop the FPM as a sizing tool

This M&S challenge will be continued in Phase II



Baseline Test Parameters

- Firetrace test cell
- Large test box 48"w x 30"h x 84" long
- Pyroflex Tubing
- Kerosene
- First shot: 3 lbs FE-25 @ 600 PSI
- Second shot: 0.8 lbs Monnex

Cost, Weight, Maintenance

Cost

- Simple and robust design not requiring sensors, batteries, or wiring
- Agent dispersed directly at fire location thereby increasing effectiveness
- Can be easily retrofitted with basic clamps, ties, and brackets
- Individual systems could range from $5K to $15K depending on installation

Weight

- Based on the prototype design, weight is anticipated to be slightly lower
  - Effectiveness is increased as agent is delivered at the hottest part of the fire
  - Less agent may be needed and thus smaller containers
  - Non-metallic tubing is lighter than traditional metallic agent lines
  - An active system requires a network of fire/smoke sensors, wiring, and power

Maintenance

- Anticipated low maintenance inline with standard aircraft schedules
- No sensors, detectors, batteries or electrical power are required
- No continuously moving parts; units completely sealed
- Distribution tubing is flexible and can be easily moved for accessibility

Phase II Development Plans

Optimization

- New types of agent storage containers
- Tubing and materials
- Valve miniaturization

Further development of M&S

- M&S development to aid in sizing and installation

Detailed testing

- Conduct detailed testing with airflow, multiple materials, multiple agents, etc.

Summary

A working prototype was successfully prototyped and demonstrated

Requirements and Objectives for Phase I were met

The system is applicable for both military (combat) and commercial (safety) installations

A high level of support and interest from industry and DoD organizations show the need, feasibility, and potential for co-funding a detailed design under Phase II

Key Personnel

Jim Tucker, SURVICE Engineering (Principle Investigator)

- M.S., Fire Protection Engineering
- SURVICE Subject Matter Specialist for Fire and Explosion
- SURVICE Fireworks Technical Lead
- Fire Prediction Model Methodology Lead

Brian Cashion, Firetrace Aerospace (Lead Product Development)

- B.S., Mechanical Engineering
- Technical product design, development, and manufacturing

Ron Dexter, SURVICE Engineering (Program Manager)

- B.S., Aerospace Engineering
- SURVICE Fireworks Manager

Chad DeVere, Firetrace Aerospace (Business Capture)

- Business Development Manager
- Masters Business Adminsitration