Aviation Security Views on Aircraft Fire Safety – a Research and Development Perspective

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Topics

• U.S. Department of Homeland Security (DHS)/Science & Technology (S&T) Directorate
  • Explosives Division
  • Transportation Security Laboratory (TSL)
  • Aviation Security Approach

• Aircraft Protection Technologies
  • Commercial transport vulnerability to MANPADS
    • Counter-MANPADS Programs
  • Transport aircraft survivability
    • Requirements & Objectives
    • Vulnerability R&D
    • Mitigation R&D
    • Fuel Tank/Systems Survivability Issues

• Summary
Science and Technology Directorate

DHS U/S S&T (Jay Cohen)

- Director of Research
- Director of Innovation
- Director Office of Natl Labs
- Director T&E and Standards
- Director Intl Programs
- Director of Transition

Explosives
- Sec Dir Research
- Sec Dir Transition

Chem/Bio
- Sec Dir Research
- Sec Dir Transition

Command, Control, Interoperability
- Sec Dir Research
- Sec Dir Transition

Borders/Maritime
- Sec Dir Research
- Sec Dir Transition

Human Factors
- Sec Dir Research
- Sec Dir Transition

Infrastructure/Geophysical
- Sec Dir Research
- Sec Dir Transition

Innovation

Research

Applications
Explosives Division

• Mission: To develop, demonstrate and deliver to customers mature technology to prevent, render safe or mitigate the effects of explosives or other energetic materials used by terrorists against people or physical property.

• Threats –
  • Suicide bombers
  • Conventional and home made explosives (HME)
  • Vehicle borne improvised explosives devices (IED)
  • Guided and ballistic missiles
  • Others

• Targets –
  • VIPs, congregations of people and first responders
  • Conveyances - air, land, and sea vehicles
  • Property – structures, bridges, tunnels, and others
Transportation Security Laboratory

- “Migration” from FAA (Aviation Security Lab) to Transportation Security Administration (2002) to S&T Directorate (2005) – “are we there yet?”
- Located Outside of Atlantic City, New Jersey
- Responsible for Research, Development, Engineering, Test & Evaluation Activities, and Technology Deployments
- Staff is Composed of Scientists, Mathematicians, Engineers, and Technical Specialists
- Major Product Areas include Checked Baggage, Checkpoint, Cargo, Conveyance and Infrastructure
- Enabling Technologies include Bulk Sensors, Trace Sensors, Communications & RFID, Access Control, Modeling & Simulation, Human Factors, Explosives Effects & Survivability
Aviation Security Technology History

- 1970’s – Hijacking
  - Metal Detectors
- Early 1980’s – Explosives
  - Thermal Neutron Activation (TNA)
- 1988 – Pan Am 103
  - U.S. Aviation Security Improvement Act (Public Law 101-604) Mandated Current Laboratory
  - Explosives Detection Systems (EDS) & Trace EDE
- 1996 – TWA 800
  - Created Security Equipment Integrated Product Team (SEIPT)
- 2001 – 9/11
  - U.S. Aviation and Transportation Security Act (Public Law 107-71)
  - Today’s Efforts & Focus
Aviation Security System-of-Systems
Aircraft Protection Program Requirements

• Requirements Drawn from U.S. Legislation, Presidential Commissions, and Advisory Committees including:
  • 1990 Presidential Commission on Aviation Security and Terrorism
  • Aviation Security Improvement Act of 1990
  • 1996 Aviation Security Advisory Committee Domestic Security Baseline Final Report
  • 1997 White House Commission on Aviation Safety & Security
  • Aviation and Transportation Security Act of 2001 (PL 107-71)

Aircraft Protection Program

CONOPS and Technologies to Protect Against Terrorist Threats Directed at Civil Aircraft

- Understand Threats and Vulnerabilities
- Develop Deployable Technologies to...
  - Protect Aircraft
  - Reduce Vulnerability & Susceptibility $\Rightarrow$ Increase Survivability
  - Mitigate Effects on Passengers and Crew

$E_{\text{Total}} - E_{\text{Loss}} = E_{\text{Residual}}$
DHS MANPADS* Threat Summary

- MANPADS are readily available worldwide and capable of destroying aircraft

- Civilian aircraft are easy targets: slow and predictable, with large signatures

- Aircraft are most susceptible near airfields and when traveling below 15,000 – 20,000 feet

- Danger zone of MANPADS attack is large
  - Largely outside airport boundaries (greater than 60 nm)
  - Attack corridor may be up to 8 nm wide

*Man-Portable Air Defense Systems
National Strategy: A Multi-Layered Approach

• U.S. Department of State – Non-Proliferation
  • Global weapons stockpile
  • Global export controls
  • MANPADS destruction program

• DHS/TSA – Tactical Operations
  • Airport vulnerability assessments and mitigation plans
  • Guidelines for identifying and reporting threats
  • Elevated alert guidelines

• DHS/S&T – Technical Countermeasures
  • Assess commercial transport vulnerability
  • Adapt military DIRCM systems for commercial transports
  • Assess MANPADS emerging countermeasure technology
  • Demonstrate innovative concepts - CHLOE
Commercial Transport Vulnerability Analysis
- MANPADS Hit-Point Analysis

example data product

- Simulated missiles (6,000) fired at B-747 IR model
  - Using USAF Guided Weapons Evaluation Facility (GWEF)
  - Multiple generation MANPADS, ranges, azimuths, and atmospheric conditions
- Determine statistically where missiles hit the aircraft
- Manufacturer estimated likely damage
- B-737 and B-757 IR models available
Counter-MANPADS DIRCM Program

• Phase I - Jan - July 2004 - 6 months
  • Feasibility and preliminary design - three contracts
    • BAE Systems Team - distributed DIRCM
    • Northrop Grumman Corp Team - DIRCM pod
    • United Team - decoy flares

• Phase II - Aug 2004 - Mar 2006 - 18 months
  • Adapted DoD technology for commercial transport protection
    • Evaluated performance through simulations and flight tests
  • Obtained FAA Supplemental Type Certification (STC)
    • B-767 with BAE system
    • B-747, MD-11 and MD-10 with NGC system
  • Developed operations, maintenance and supply procedures
  • Performed initial manufacturing/installation rate assessment
  • Completed preliminary ownership and life-cycle cost analysis

• Phase III - Mar 2006 - Mar 2009 - 3 years
  • Conducting in-service evaluations with cargo airlines
  • Plan to start passenger in-service evaluations late 2007 or early 2008
  • Improving system performance and reliability
  • Live fire tests at White Sands Missile Range Fall 2007
  • Goal to certify performance of both systems
DIRCM Counter-MANPADS Summary

• Program on schedule – to be completed early 2009
• Systems can protect commercial transports
  • Live fire test demonstrations Fall 2007
• Four different FAA-certified prototype installations
• Phase III designed to reduce risk and cost of ownership
• DHS results also improving DoD systems’ reliability and performance
• No decision to deploy
Aircraft Vulnerability/Hardening

• Commercial air transport vulnerability to interior detonated explosives
  • Type, amount, location, surroundings, etc.
  • Assess other Threats (e.g., MANPADs)

• Explosives Detection Systems (EDS) screening
  • Checked, carry-on bags & cargo
  • Costs increase as threat mass decreases

• Aircraft hardening/mitigation
  • Overhead bins, passenger cabin liners, cargo containers, cargo compartment liners, etc.
  • Costs increase as threat mass increases

• Is there a best combination of screening and hardening?
Aircraft Vulnerability – Research Overview

• Over 140 explosive vulnerability tests conducted on commercial aircraft structures since 1990
  • 98 Tests on Narrow-Body Aircraft (B707, B727, B737, DC9, MD80)
    • 45 in passenger cabin (9 Pressurized)
    • 53 in cargo hold (1 Pressurized)
  • 42 Tests on Wide-Body Aircraft (A300, B747, DC10, L1011)
    • 32 in passenger cabin (4 pressurized)
    • 10 in cargo hold (5 pressurized)

• Over 200 Supporting Data Tests
  • Includes determining suppressive properties of passenger luggage and air cargo contents on explosive effects
Aircraft Hardening – Mitigation Overview

• 104 tests conducted on various explosive mitigation concepts since 1990

• Investigating a number of explosive mitigation concepts including:
  • Passenger cabin blast resistant liners
  • Hardened overhead baggage storage bins
  • Cargo compartment liners
  • Hardened Unit Load Devices (HULD) for Wide-Body Aircraft
  • Validation of least risk bomb location (LRBL) procedures
  • Threat Containment Unit (TCU) for airport terminal deployment
Optimized Telair International HULD Design

- Reduced Aluminum Frame (6061-T6) Extrusion
- Kevlar 129 body panels (3-8 ply)
- Replaced SS Connecting Hardware w/Titanium
- Revised Door Handles and Frames
- Enhanced Operability
- Tare weight: 265 lbs.
- FAA Airworthiness Certification Pending (TSO-C90c)
- Cost: $15K (<100 units prod.)
On-Board Weapons Effects

- Identify Adverse Effects of Weapons Discharge on the Flight Deck or Passenger Cabin
  - Joint U.S. Transportation Security/Federal Aviation Administration Project Evaluating the Risk of Catastrophic Failure due to Accidental FFDO (Armed Pilot) Weapon Discharge
  - Performed “Quick Look” Report on Practicality of Electric Stunning Pistols on the Flight Deck (with much Input from FAA)

- Future Efforts in this Area likely to Require Similar Cooperation

- Clear Link between Aviation Safety & Security
Threats and Potential Consequences

- Threats include Internal (Explosive Devices, Firearms, EMI) and External or Stand-off (MANPADS, RPGs, Small Arms Fire, Directed Energy)

- Potential Structural Modifications to Increase Aircraft Survivability after an Event include:
  - Cargo Hold and Passenger Cabin Liners, Hardened Overhead Bins
  - Protection of Fuel Tank & Systems from the Possibility of Secondary Fire/Explosion from Internal Threat
  - Protection of Fuel Tank & Systems from External Attack
  - Survivability of Fire Suppression Systems Exposed to an Explosion (i.e., will the System still be effective?)
Threats and Potential Consequences (continued)

- Damage Mechanisms Primarily are Fuel Tank Fires, Fuel Tank Explosions, and Hydrodynamic Ram

- Fires and Explosions can Cascade from the Original Source; Fires can Propagate and Lead to Explosion, etc.
  - Potential Solutions include Fuel Tank Inerting and Suppressive Agents, both “Active” (such as Foams or Meshes) and “Reactive” (release triggered by a sensor alarm)

- Hydrodynamic Ram Typically caused by Projectiles Entering Fuel Tank; Stand-off Attack is Greatest cause for Concern (Wing Tanks), but also Potential Exists for an Internal Device to Fragment
  - Shockwave in Fuel, likely to Cause Structural Damage, Particularly in Wing Structures
  - Active Suppressive Agents the most Likely Solutions
Threats and Potential Consequences (continued)

• Fire Suppression Systems in the Cargo Hold must be Robust enough to Still be Effective

• Security Solutions must Consider the Capability of Fire Suppression to Contain Explosion-Induced Fires

• Example – Will the Fire Suppression System still Function after Detonation of a Bomb in a Hardened Container?
  • Fully Functioning System in a Retired DC-10-40 Aircraft Evaluated in December 2003 – Fire Suppression Performed Nominally

• Similar Activity Planned for FY08 for Evaluation of Cargo Hold Liners
Thoughts

• Solutions to Many Safety Problems, Particularly in the Fuel Systems Area, also have Benefit to Security Concerns
  • With Tight Resources, Leveraging of Efforts Provides Maximum Return to all Parties

• Commercial Aircraft Survivability Solutions must Strive to Satisfy Security Goals with Minimal Penalty for Weight and Cost
  • Compliance with Current Airworthiness Requirements is also Essential

• Security Enhancements must be Balanced against Safety Requirements and Customer Service (Operational Considerations)

• Holistic Approach to the Aircraft Survivability Discipline would Synergistically Consider both Safety & Security Threats

• What are the Win-Win areas to Pursue?
Summary

- Program is Generally Testing-Centered with Security-Critical Mission

- Survivability Work allows for Identification of Measures/Criteria for Prevention (Screening) and Mitigation (Vulnerability Reduction)

- Mitigation Products Serve to Provide Layered Protection to Secure against Breach/Avoidance of Screening Initiatives

- Program Initiatives Evolving to Address Sophistication of Terrorist Threat