STATEMENT OF CAPABILITIES

AVIATION FACILITIES

2014
EXECUTIVE SUMMARY .......................................................................................................................... 3
ENGINEERING and CONSULTING SERVICES ......................................................................................... 4
COMMERCIAL AVIATION EXPERIENCE .................................................................................................. 5
  Specialized Solutions for Airport Facilities .......................................................................................... 5
  Commercial Airport Experience ............................................................................................................ 6
  Additional Commercial Aviation Facility Design Experience .............................................................. 11
  Commercial Airside Facilities And Hangar Experience ......................................................................... 14
AIRCRAFT HANGARS EXPERIENCE ....................................................................................................... 16
  Specialized Solutions for Airside Operation Safety ............................................................................. 16
  Research and Development Experience .............................................................................................. 17
  Design Criteria ......................................................................................................................................... 20
  AFFF AND High Ex Systems .................................................................................................................. 20
  Low Level AFFF Experience .................................................................................................................. 21
  High Expansion Foam Experience .......................................................................................................... 22
  Water-Based System Experience ............................................................................................................ 23
  Additional Aircraft Hangar Experience .................................................................................................. 24
AIRCRAFT RESCUE AND FIREFIGHTING (ARFF) .................................................................................. 25
MIDDLE EAST NON-AVIATION EXPERIENCE ......................................................................................... 28
OUR GLOBAL REACH AND CONTACT INFORMATION ............................................................................. 29
EXECUTIVE SUMMARY

Celebrating more than 34 years in business, Hughes Associates is a global leader offering engineering and consulting services for fire protection and life safety, code compliance, hazard analysis and risk management, research and testing and physical security. Hughes’ experts are committed to providing the most cost-effective, sustainable, and appropriate solutions that meet our clients’ needs.

Founded in 1980, Hughes is headquartered in Baltimore, Maryland with over 35 offices worldwide. On-site laboratory and testing facilities in Baltimore complement our traditional consulting, engineering and forensic services. Hughes offers customers a unique combination of research capabilities and global application expertise.

Our staff consists of a renowned group of more than 270 engineers, scientists, and computer programmers, as well as investigators and other specialists, who are among the best in the field of fire protection engineering and code consulting services. Our engineers serve on numerous National Fire Protection Association (NFPA) committees including the Aircraft Hangar Committee, Life Safety Code, Fire Alarm and Signaling Code.

Superior Fire Protection Engineering

The Hughes team is exceptional in meeting the life safety, fire protection, code consulting and security needs and objectives for the sectors we serve. Hughes delivers timely and ground-breaking solutions that support the code-compliant expansion and fire protection systems reliability at government, military, and commercial facilities across the globe. Our fire protection engineers and life safety code consultants work collaboratively to ensure technical and cost-effective solutions.
ENGINEERING and CONSULTING SERVICES

Fire Safety System Design and Computer Modeling
Fire detection, alarm and mass notification systems design; water-based and foam fire suppression system design; fire pump system design; fire water supply analysis/fire flow testing; smoke control system design, plans and specifications development; shop drawing review; systems inspection; cost estimation; construction administration services; acceptance testing; fire scenario development; egress analysis; and fire/smoke movement analysis.

Code Compliance Consulting
Applicable code determination; code compliance analysis; construction type determination; code documentation; Accessibility/ADA compliance; code equivalency development; code variance preparation; code strategy analysis; code conflict resolution; performance based analysis; and negotiation with Authorities Having Jurisdiction.

Plans Review Services
Life safety/fire design criteria determination; egress analysis; fuel loading determination and inspections; special use permitting; review and analysis; third party installation plan reviews; fire separation requirements; and fire protection master planning.

Facility Assessments
Site survey; life safety analysis; risk assessment & quantification; fire hazards identification (including chemical, biological, radiological and natural hazards); fire hazard scenario development; fuel load analysis; and loss prevention consulting.

Life Safety Program Consulting
Occupant awareness training program development; fire safety procedures and manual development; evacuation planning and emergency preparedness planning; risk assessment; and loss prevention.

Fire Incident Support
Incident investigation; equipment failure analysis; systems analysis for code compliance; system false activation analysis; and litigation support.

Security Consulting
Security planning; security assessment; Crime Prevention Through Environmental Design (CPTED) review; security program management; security system engineering and design; and security training.

Environmental Services Consulting
Regulatory forecasting and analysis; policy and standards development; sustainable design; plan and audit services; and remediation.
COMMERCIAL AVIATION EXPERIENCE

SPECIALIZED SOLUTIONS FOR AIRPORT FACILITIES

Hughes’ consultants and engineers are recognized authorities in fire and life safety engineering for the aviation industry. Our experts apply in-depth knowledge in a wide range of disciplines to addressing the fire and life safety challenges that are unique to airports and aircraft such as preserving the integrity of complex architectural designs, ensuring life safety and fire protection within the stringent constraints of airport security, designing highly effective emergency communications systems (ECS), and providing comprehensive services for effective airside operations safety.

Fire Protection Engineering Services
Hughes’ aviation experts routinely work with architects and construction managers to preserve distinctive architectural design features while ensuring code compliance and fire and life safety. Hughes provides expert code consulting and systems designs and demonstrates the effectiveness of alternative design plans to regulatory authorities.

Emergency Security / Communication Systems Design
Airport operators face a wide range of technical challenges to emergency response and evacuation planning, including stringent security requirements. We have extensive experience in designing systems that protect airport property and communicate with patrons and employees during emergencies. Our designs integrate fire alarm and Emergency Communication Systems (ECS) using the latest notification technologies to elicit effective, controlled response in emergency situations.

Evacuation Design / People Movement Modeling Services
Hughes’ people movement modeling takes into account a wide range of factors and behaviors, including code or security limitations and patron reluctance to participate. These comprehensive models enable Hughes to design systems and processes that deliver optimal life and property protection in the event of fire, smoke hazard, and other emergency scenarios.

Airside Operations Safety
Hughes has extensive experience in helping airports provide airside operations safety – from aircraft evacuation and jet fuel fire suppression plans to aeronautical foam firefighting training. Our engineers work with airport and airline personnel to implement systems and procedures designed to mitigate risk and deliver maximum life safety protection.

SERVICES FOR THE AVIATION INDUSTRY

- FACILITY EVACUATION PLANS
- EMERGENCY RESPONSE PLANS
- INTEGRATION OF FIRE ALARM AND EMERGENCY COMMUNICATION SYSTEMS (ECS)
- FIRE SUPRESSION / SPRINKLER SYSTEMS DESIGN
- SMOKE CONTROL SYSTEM DESIGN AND COMPUTATIONAL FLUID DYNAMICS (CFD)
- CODE COMPLIANCE REVIEWS
- PEOPLE MOVEMENT AND SIMULATION MODELING
- AIRSIDE OPERATIONS SAFETY
COMMERCIAL AIRPORT EXPERIENCE

Logan International Airport, Boston MA

Fire Alarm Upgrade Consulting Services  
Campus-Wide

Surveys of 60 buildings on the Logan Airport campus were conducted to determine the existing condition of the fire alarm systems through inspection and testing, and to make recommendations for upgrades. In addition, Hughes surveyed every space within Terminals B/C and E at Logan Airport verifying the location of existing fire alarm system equipment installed in these spaces. Hughes documented device type, equipment height, notification appliance candela rating, device address, and any other relevant information about the equipment. Digital pictures were provided, where necessary, to explain equipment configuration. Recommendations to correct deficiencies were included in a findings report.

Smoke Movement Analysis  
Gateway Airport Expansion Project

Hughes conducted a performance-based analysis of smoke movement and fire hazard impact analysis for public areas as part of the Logan-International Gateway Airport expansion project. Areas included gate areas, greeting and departure areas, and areas used for immigration, customs, retail and ticketing. Each area was analyzed, using computer modeling, in terms of smoke generation, smoke migration, fire safety system interaction, and the impact on emergency egress (life safety).

Code Analysis  
West Garage

Hughes performed a building code review on the fire protection requirements for the 5,000-space West Parking Garage to assure compliance with all applicable codes. The garage is an open-air parking structure, nine stories in height and with two sections, each approximately 105,000-square feet. The two sections are separated by an open space and connected by vehicle bridges. The lowest parking level is enclosed. The garage has open stairways, an elevator tower, and moving walkways at the sixth level and at the garage sublevel. At the center of the parking garage is an open courtyard with a canopy covering. Hughes met with the local Fire Marshal and with building code officials to discuss exceptions or appeals to the building code. Fire modeling was used to support Hughes’ position.
Hughes is currently engaged in a multi-year, multi-million dollar project providing program management and design services for a replacement fire alarm and emergency communication system at Denver International Airport. The first phase of this work was an evaluation of the existing fire alarm system that documented all major systems, hardware and software. An options report was developed for replacement of the existing system as well as a detailed phasing plan. Hughes provided “people movement” modeling services to help predict the impact various emergency scenarios might have on the population; Hughes also assisted the client in updating operating procedures and emergency protocols and has recently completed a comprehensive study on the needs of the disabled community during emergencies.

Phase 2 of the project involved an extensive site wide survey of the entire facility in order to develop a detailed design for the new system. This work includes design updates to the existing smoke control, deluge and other special extinguishing systems as well as an extensive risk analysis of the paging system. The risk analysis addresses issues of intelligibility, survivability, and redundancy. In addition a sophisticated visual notification system is being developed that will provide detailed textual messages to the hearing impaired and emergency instructions to the disabled community, which includes the capture during emergencies of FIDS/BIDS/GIDS, televisions, and dynamic signage and advertising screens.

The project includes a sophisticated control center for emergency management of events throughout the airport complex. Hughes is developing emergency response procedures that balance life safety needs with security concerns of a major transportation facility. The new design incorporates a dedicated fiber optic backbone connecting the five major structures that comprise the facility, a redundant backup wireless network, and 5 command and control centers.
Denver International Airport continued...

Fire Protection Engineering and Code Consulting Services
South Terminal Redevelopment Program

Hughes is currently providing fire-safety, life-safety and code compliance consulting services to support the South Terminal Redevelopment Program (STRP). Elements include a new train station servicing the RTD FasTracks commuter rail connection to and from downtown Denver, a new 500-key Westin hotel and conference center, and an outdoor public plaza linking the hotel, conference center and train station to the existing Jeppesen Terminal.

The combination of high-rise residential, high-occupancy assembly and storage occupancies merged with hazards ranging from rail cars to quantities of piled plastic materials (baggage and retail) to vehicular traffic creates an environment that is outside the scope of typical codes and standards. The physical arrangement and location of the structure complicates issues beyond those considered in typical building and fire codes by introducing unique needs for security, emergency response, movement of occupants and integration with existing infrastructure for the airport campus. Adding complexity to STRP are additional, project-specific issues, such as coordination with several major stakeholders, and integration with various design team leadership.

Hughes’ Scope of Services for STRP Includes:

- Code Consulting and Compliance Analysis, including Accessibility
- Fire Suppression System Design
- Fire Alarm System Design
- Emergency Communications System Design
- Fire Modeling
- Smoke Management System Design
- Egress System Design and People Movement Studies
- Design Criteria for Emergency Response, including a formal “Emergency Response Plan”
- Construction Administration
- Commissioning and Systems Testing
- Overseeing DIA Specification Updates
- Third Party Code Compliance Review for the Hotel
Commercial Airport Experience

Orlando International Airport, Orlando, FL

Owner's Representative, Fire Protection Engineering Services
Greater Orlando Aviation Authority Buildings

Hughes served as the Owner's Representative, managing the survey, evaluation, recommendations, code analysis, engineering design, system specification, and cost estimating services for the fire alarm system upgrades in buildings owned by the Greater Orlando Aviation Authority. The project included two phases. The first was “The Fire Alarm Program Evaluation”. This project benchmarked the existing fire alarm system protection for the Landside Terminal Building and Parking Garages, and the Airside Terminal Buildings Nos. 1, 3 and 4 against the adopted codes and standards, with specific recommendations to allow the Aviation Authority to make appropriate short and long range implementation plans.

The second phase included professional services for Fire Alarm Upgrades, Landside and Airside 4, North Terminal Complex, including: preparation of design/build criteria package, design/build proposal preparation and negotiation, and contract coordination and administration during construction. The project included the removal and replacement of existing conventional fire alarm system components with point-addressable devices and ADA-compliant appliances, and other related system alterations and/or additions. The fire alarm system interfaced with the smoke control and HVAC control systems, and provided immediate notification to a constantly manned on-site security post, from which on-site emergency services were contacted and emergency procedures could be initiated. Two-way telephone communications service was established at the Landside Building for use by Fire Department personnel. The airport Public Address System was expanded to become the primary means for emergency voice/alarm communications needed for partial or selective evacuation, or directed relocation instructions to building occupants in the event of a fire.

Fire Safety Consulting
South Terminal Complex (STC)

Services were provided for the proposed design of the South Terminal Complex (STC). Applicable code requirements were identified and a Fire Safety Analysis was prepared which addressed: occupancy type, building construction, fire resistance ratings, building separations, elevator and conveyance systems criteria, egress provisions, interior finish, fire department access, and identification of areas with fire suppression and fire alarm systems.
King Abdulaziz International Airport (KAIA), Jeddah, Saudi Arabia

**Fire Protection Engineering Services**

Services were provided by Hughes Associates Europe for the expansion and renovation of the King Abdulaziz International Airport (KAIA) North and South Passenger Terminals. Work included the development of a comprehensive fire protection plan for a terminal building and connected structures, and design of smoke control systems for the large atrium-type spaces in the airport, the Automatic People Mover (APM) subway system, and the adjacent railway station. Systems were designed using simulations from models constructed using the Fire Dynamics Simulator (FDS) computational fluid dynamics model.

Fire safety design and code consulting services were provided for the:

- Passenger Terminal Complex
- Carparks
- Airport Hotels
- Utilities Buildings
- APM/BHS Tunnels
- Railway Station & Ground Access Components
- Utilities Tunnel

All work was based on the prescriptive option of the NFPA codes, with specific reference to NFPA 415 and NFPA 5000. The renovation of the South and North terminals is part of the airport’s $250 million expansion and modernization effort.

**Security System Consultation and Design**

Hughes prepared a Security Concept of Design report for the expansion of the KAIA which will create a new state-of-the-art airport facility to receive both foreign and Saudi aircraft of varying sizes, including 555-seat A380 planes. This airport and support facilities expansion project represents a total surface area of approximately 900,000 m². The new airport terminal, of almost 550,000 m², will include 74 jet bridges, 42 pier-served aircraft stands (including 2 dedicated to the A380) and 10 remote stands, and is designed to receive 30 million passengers annually. The project comprises the design of a fully integrated and automated airport security and safety system utilizing advanced technologies to optimize safety and security of the KAIA terminal complex.
ADDITI
ONAL COMMERCIAL AIRPORT FACILTY EXPERIENCE

**Domestic Airport Facilities**

**U.S. DOT, Volpe National Transportation Center,**
**Cambridge, MA**
Fire Protection Engineering Services, Nationwide
ATCTs/ARTCCs (2013)

**Metropolitan Washington Airport Authority,**
**Washington, DC**

**Asheville Regional Airport, Asheville, NC**
Fire Protection Engineering Services (2005)

**Myrtle Beach Airport, SC**
Fire Safety Consulting, Airport Fuel Farm (ARFF) (2009)

**Melbourne International Airport, Melbourne, FL**

**Palm Beach International Airport, West Palm Beach, FL**

**Miami International Airport, Miami, FL**

**Winter Haven Airport, Winter Haven, FL**
Fire Safety Consulting Services, Terminal Building (2005)

**Tampa International Airport, Tampa, FL**

**Panama City Airport, Panama City, FL**
Fire Protection Engineering Services, Terminal/Public Safety Building (2007)

**Sikorsky Aircraft, West Palm Beach, FL**

**Million Air, Biloxi, MS**
New Hangar Building (2009)

**EJM Maintenance Hangar, Covington County, AL**
C-130/B-737 Modification Hangar (2005)

**Bell Aerospace Services, Ozark, AL**
Additional Commercial Aviation Facility Experience

Memphis International Airport, Memphis, TN

Somerset College Aviation Maintenance Facility, Somerset, KY
Aircraft Paint Hangar & Maintenance Hangar (2007)

Dallas/Fort Worth International Airport, Ryder Facility, Dallas, TX
Web-Based Training Modules for Operations (2010)

Texas State Technical College, Waco, TX

Wayne County Airport Authority, Detroit, MI
Security Design Services (2009)

Will Rogers World Airport, Oklahoma City, OK

Rocky Mountain Metropolitan Airport, Jefferson County, CO

Centennial Shop Hangar, Centennial, CO
Helicopter Modification Shop & Hangar (2008)

Lockheed Martin Corporation, Palmdale, CA
Plant 10 Hangar, Conversion of Deluge Sprinkler System to Closed-Head Wet-Pipe Sprinkler (2011)

Los Angeles International Airport, Los Angeles, CA
Commissioning Services; Third Party Inspection

Oakland International Airport, Oakland, CA
Safety Consulting for Phased Decommissioning of Terminal (2007)

Palm Springs International Airport, Palm Springs, CA

San Jose International Airport, San Jose, CA
Additional Commercial Aviation Facility Experience

San Francisco International Airport
San Francisco, CA

Sacramento International Airport, Sacramento, CA
*Fire Safety Consulting Services, Master Planning Support (2009)*

Truckee Tahoe Airport District, Truckee, CA
*Fuel Storage Review (2003)*

Riverside County Airport, Riverside, CA
*County Airport Fueling Standards Development (2005)*

**International Airport Facilities**

New Doha International Airport, Qatar
*Fire Safety Code Consulting (2009)*

Abu Dhabi International Airport, UAE
*Fire Protection Engineering Services, New Air Traffic Control Tower*

Capodichino Airport, Naples, Italy
*Fire Safety Consulting and Review Services (2009)*

PohnPei Airport, PohnPei, Micronesia
*Fire Alarm Review, Airport Crash Rescue Facility (2009)*

Costa Rica Airport, Costa Rica
*Fire Safety Consulting Services, Terminal Building (2007)*

Athens International Airport, Athens, Greece
*Fire Suppression Systems Analysis, Aircraft Maintenance Hangar (2007)*

Carrasco International Airport, Uruguay

Singapore International Airlines, Singapore
*Hangars 4 & 5, Systems Design (2002)*

Johannesburg International Airport, Johannesburg, South Africa
*Fire Protection Design Analysis, Terminal Renovation (1998)*
COMMERCIAL AIRSIDE FACILITIES AND HANGAR DESIGN EXPERIENCE

Hughes has provided fire protection engineering services for numerous airside facilities and airport hangars. Fire protection designs for aircraft hangars include both water and electrical hi-ex foam generators and utilize bladder tank foam proportioning systems.

U.S. DOT, Volpe National Transportation Systems Center, Cambridge, MA
Fire Life Safety Program Support
Hughes provides fire protection and life safety support services on a task-order basis to the U.S. Department of Transportation’s Volpe National Transportation Systems Center for its Fire Life Safety (FLS) Program that includes FAA owned and operated facilities located nationwide. These facilities include Air Traffic Control Towers (ATCTs) and Air Route Traffic Control Centers (ARTCCs).

Contract services since 2002 have included:

- Codes and standards compliance evaluations
- Fire protection systems design/engineering support
- Fire modeling/design flow analysis
- Test and evaluation
- Risk assessment/hazard analysis
- Policy and code evaluations/equivalency determinations
- Training development and implementation
- Field construction engineering support
- Emergency preparedness planning
- Master Specification development

Metropolitan Washington Airport Authority, Washington, DC
Fire Safety System Design Services
The design was provided for the sprinkler system and the fire alarm system as part of Hangar 5 renovations at Reagan National Airport in Washington, DC.

Bell Aerospace Services, Ozark, AL
Fire Protection Engineering Services
Fire safety design and code consulting services were provided for the design and construction of a 30,000 square foot aircraft (helicopter) hangar.

Abu Dhabi International Airport, New Air Traffic Control Tower, UAE
Fire Protection Engineering Services
Hughes Associates Europe srl provided code compliance services in order to assess the fire and life safety provisions applicable to the new Air Traffic Control Complex (ATCC) of Abu Dhabi International Airport, including the Air Traffic Control Tower 110 meters high and the annexed office building. The design was checked according to the prescriptions of applicable NFPA codes for Fire Safety and Life Safety.
New Doha International Airport, Qatar Airways Maintenance Hangar, Doha, Qatar

**Fire Protection Engineering Services**

Services were provided for the design and construction of one of the world’s largest aircraft maintenance, repair and overhaul facilities (186,000 square meters) hangar for Qatar Airways. The hangar can accommodate 12 aircraft, and also has administrative, workshop, and worship spaces.

Guam Airport Traffic Control Tower (ATCT) Fire/Life Safety (FLS) Upgrade, Tiyan, Guam

**Fire Protection/Life Safety Consulting Services**

Hughes was the engineer of record for the design of the Guam ATCT upgrade and is responsible for the conduct of a site design survey concurrent with the scoping survey, development of the 29 CFR 1960.20-compliant FLS Upgrade Design, and development of the Government Cost Estimate. Hughes is also responsible for construction period services, including site construction visits, electronic & telephone support, shop drawing reviews, and RFI & Change Order Support.

Athens International Airport, Maintenance Hangar, Athens, Greece

**Fire Suppression Systems Design**

Hughes developed conceptual designs of fire suppression system options for an aircraft maintenance hangar.

Hellenic Aerospace Industry, S. A. Tanagra, Maintenance Hangar, Athens, Greece

**Fire Protection Engineering Services**

Hughes Associates Europe srl provided the conceptual design and the fire protection engineering consulting services to support Hellenic Aerospace Industry S.A. to investigate the suitability of the existing maintenance hangar facilities (jumbo size) and the maintenance workshops to comply with the requirements of NFPA 409 reference standard.

Milan Malpensa International Airport, Maintenance Hangar, Milan, Italy

**Fire Protection Engineering Services**

Hughes Associates Europe srl provided hangar safety conceptual design, code consulting services, fire protection design and engineering, technical evaluation of bids submitted by vendors, construction supervision, and the acceptance commissioning of the detection and fire protection systems. Work included resolution of water supply issues and design conflicts; modification of the design requirements for the fire pump; review of sprinkler contractor’s shop drawings, hydraulic calculations, and manufacturer’s submittals for compliance with the project specifications and applicable code requirements; and performance of installation inspections and preparation of punch list items during construction and acceptance testing.
AIRCRAFT HANGAR EXPERIENCE

SPECIALIZED SOLUTIONS FOR AIRSIDE OPERATION SAFETY

In addition to providing traditional fire protection and life safety services, Hughes has extensive experience in providing fire protection engineering services for unique military infrastructure, including aircraft hangars, aviation engine test facilities (hush houses), aircraft production facilities, airports and related support facilities. Services include fire protection design, life safety analysis, code consulting, fire detection and alarm design, smoke modeling, and fire hazard analysis. In particular, Hughes conducts research and testing on aircraft hangar suppression and detection system designs.

Hughes is the leader in applying advanced concepts to military facilities in order to save costs, reduce maintenance, and mitigate environmental impact of fire suppression system agents. Because of our fire science and developmental work in military fire protection R&D, Hughes has a clear understanding of DOD criteria (i.e., the rationale, intent, and interpretation of MIL HDBK 1008C on Fire Protection and associated U.S. Air Force Engineering Technical Instructions). Hughes helped produce these requirements for the U.S. military. Hughes has worked closely with fire protection engineers in the U.S. Air Force, U.S. Navy, and U.S. Army in applying scientific solutions to military problems.

Fire Protection – Aircraft Hangars

Hughes consultants and engineers are recognized authorities in fire and life safety engineering for the aviation industry and are aware of current trends in hangar fire protection design and environmental issues. Our experts apply in-depth knowledge to address the challenges that are unique to aircraft hangars that include:

- Fire suppression and detection system design and criteria
- Operation and maintenance
- Environmental criteria and AFFF containment designs
- Special hazard design experience

National and International Recognition in Aviation Fire Protection

Hughes has established a reputation for expertise, ethics, and competency in fire protection engineering and research. We have achieved this through years of active participation with regional, national and international building and fire code committees and regulatory bodies. We continue to contribute to the development of such codes through our representation both on and before many of these committees.

- Committee participation includes the following codes:
  - NFPA Aviation Section (Past Chair)
  - NFPA 409 Aircraft Hangars
  - NFPA 403 Aircraft Rescue and Firefighting
  - NFPA 11 Foam Standard
  - NFPA 16 Foam Water Sprinklers
  - SFPE Handbook: AFFF Design
  - NFPA Handbook: Foam
RESEARCH AND DEVELOPMENT EXPERIENCE

Hughes has been instrumental in conducting initial studies and research for the design and operation of military aircraft hangars. This work has included:

**Policy & Design Criteria Development, U.S. Navy:** A study to develop a rational policy and design criteria to address containment and disposal of aqueous film-forming (AFFF) discharge from facilities having AFFF suppression systems.

**Design Criteria Development, U.S. Navy:** An evaluation of the capabilities of an aircraft hangar fire suppression system consisting of a low level AFFF extinguishing system and an overhead water sprinkler system were evaluated.

**Hangar Research & Testing, U.S. Air Force:** A determination of the technical validity of two proposed alternative systems (water-based system and compressed air foam system) for improvement of overhead suppression systems in hangars to avoid false discharges and environmental concerns. Hughes provided a test plan, test facility description, and test supervision. Results were reported to the U.S. Air Force.

**USAF Hangar Clean Up Guidance:** Develop guidance for new and enhanced response and clean-up criteria for protecting personnel and assets in the aircraft hangar mission area from exposure to fire fighting chemicals and processes.

**Hush House Fire Hazard Evaluation, U.S. Air Force:** A fire hazard analysis of USAF aviation hush houses to determine appropriate protection to replace Halon 1301 total flooding fire suppression systems. The hazard analysis included operational requirements, identification of plausible fire scenarios, fire modeling, and logistics aspects of replacements, and environmental impact of alternatives.

**AFFF Protection of Naval Aviation Assets, U.S. Navy:** A threat assessment to determine the level of protection required of AFFF systems to limit damage to Naval aircraft in the event of a fire. Scenarios considered were aircraft carrier flight decks and naval station airfields. An analysis was performed to determine if the level of protection afforded by the AFFF systems (both fixed and mobile) was embodied in the criteria of small scale AFFF qualification testing (i.e. AFFF MIL SPEC criteria).

**B-2 Bomber Hangar Design, Naval Research Lab, Washington, DC:** An evaluation of hangar design criteria for the USAF, including low-level application of AFFF and damageability criteria for aircraft.

**Optical Detector Response Testing/Performance Specification Development, Naval Research Lab, Washington, DC:** Small and large scale tests to determine appropriate fire signals which should be detected by optical detectors. Large scale tests were conducted to identify detection performance for a range of detector types. Associated tests were conducted to determine which types of detectors were most immune to false alarm signals. Based on test data and hazard analyses, Hughes developed an optical detector performance specification.
Hughes engineers were responsible for the preparation of the Tri-Service UFC 4-610-01, *Fire Protection for Aircraft Hangars*. They were also part of the P141U Aircraft Maintenance Hangar Functional Analysis Concept Development Team, designing the fire suppression and alarm systems for a state-of-the-art aircraft maintenance hangar at NAS Oceana.

**Specialized Research and Development Experience**

- Use of Plastic Pipe for Hangar AFFF Systems (USAF)
- AFFF Environmental Policy and Criteria Development for Facilities (DoD)
- Hangar Water Sprinkler Suppression Tests (USAF)
- Hangar Portable Monitor Tests (USAF)
- High Expansion Foam Drainage Tests (USAF)
- Uniform Aircraft Hangar Facilities Criteria Handbook (USAF, Navy, Army, USMC)
- Unified Fire Protection Performance Technical Specifications (Navy)
- Low-level AFFF Performance and Burnback Resistance (NAVFAC)
- Low-level AFFF Nozzle Design (NAVFAC)
- Optical Detector Tests (NAVFAC and Canadian MOD)

**Joseph L. Scheffey, PE** is Vice President of Research and Development at Hughes. He is past-Chairman of the NFPA Aviation Section, where he chaired the 2010 *NFPA Symposium of Aviation Fire Protection* at the NFPA Annual Meeting in Las Vegas. He is a principal member of the NFPA Foam-Water Sprinkler Committee, Flammable Liquids Committee, and Aircraft Hangar Committee. He has chaired the NFPA 412 Task Group on Foam Test Methods and is a principal member of the NFPA committee on Aircraft Rescue and Firefighting.

Mr. Scheffey has directed the design of an innovative low level AFFF system for military aircraft hangars. His experience includes being tasked by the FAA to independently review test criteria for firefighting foams used at airports. As a result of this review and analysis, standard test and approval methods were validated for use by the FAA.

Mr. Scheffey has considerable large-scale fire test experience in projects involving foams, flammable liquids, and suppression systems. He is a member of SFPE and NFPA, and has authored engineering design criteria on foam fire protection systems for both the NFPA and SFPE handbooks.

*National Fire Protection Association, Aviation Section, Distinguished Member Award, 2010*
Research and Development Experience

NAS Patuxent River, MD (2009)

P263 BAMS Hangar Complex
Code consulting and design services for the development of an RFP for the design and design/build construction of a Research, Development Testing and Evaluation (RDT&E) hangar complex and associated support, administrative, and maintenance facilities. The complex will support the Broad Area Maritime Surveillance (BAMS) Unmanned Air Systems (UAS) program and the NAWC Aircraft Division.

NAS Oceana, Virginia Beach, VA (2001)

Policy & Design Criteria Development
A study was conducted to develop a rational policy and design criteria to address containment and disposal of AFFF discharge from facilities having AFFF suppression systems. A technical analysis of the pollution aspects of AFFF was performed to assess the environmental impact of liquid effluent discharges on soil and water, including toxicity to organisms. The study also addressed waste water treatment and airborne pollutants, and took into consideration local jurisdictional requirements. An environmental impact analysis was made to develop options for containment and disposal. The results of the survey and analysis were submitted as draft design criteria for inclusion in MIL-HDBK-1008C.

Aircraft Hangar Design Study, Naval Research Laboratory, and the U.S. Navy (2001)

Design Criteria Development
The capabilities of an aircraft hangar fire suppression system consisting of a low level AFFF extinguishing system and an overhead water sprinkler system were evaluated. Full-scale testing was conducted to evaluate the overhead water sprinklers on AFFF foam blankets. Hughes proposed changes to the design criteria for hangar protection to incorporate AFFF application from only the low level system combined with overhead closed head quick response water sprinklers.

Aircraft Rescue and Firefighting Criteria, Federal Aviation Administration (2008)

Policy Review
Review current NFPA, FAA and ICAO requirements for providing aircraft rescue and firefighting services at airports as it applies to new large body aircraft such as the A380 and B787. Fire loss history, tactical requirements and foam effectiveness were considered. Heat transfer modeling of a fire to aircraft was performed.

Aircraft Composite Fire Performance, Federal Aviation Administration

Policy & Design Criteria Development
Identify firefighting agent requirements for composite airframe materials as they are more widely adopted in airframe design. Develop a reduced scale test to evaluate suppression agent requirements as a function of composite material flammability.

Glass Boarding Bridge Fire Performance, Fire Protection Research Foundation (2013)

Policy & Design Criteria Development
Glass boarding bridges, used in many parts of the world, are restricted in some countries/jurisdictions due to fire safety concerns. Information on the global experience on the use of boarding bridges was gathered, including fire resistance, fire test methods, use of alternate/additional escape routes from the plane, and psychology/sociology of occupants that might egress through a bridge with a large fire below. A performance-based approach was used in evaluating the fire safety to passengers and crew.
DESIGN CRITERIA

Hughes uses one or more of the following design criteria when designing fire protection systems for aircraft hangars:

- National Fire Protection Association (NFPA) 409: Standard on Aircraft Facilities
- Air National Guard (ANG) Engineering Technical Letter (ETL) 97-1 Design Policy Section 15: Fire Protection
- NFPA Standard on Heliports
- Other NFPA Codes and Standards such as NFPA 11 and 16
- Client-specific Design Requirements

Aqueous Film-Forming Foam (AFFF) and High Expansion (HI EX) Systems

Hughes has completed the fire protection designs for numerous aircraft hangars involving Aqueous Film-Forming (AFFF) or hi-ex foam systems. The hi-ex foam projects include water and electrically powered hi-ex generators and utilized bladder tank foam proportioning systems.

Foam systems for other hangar designs have included pumped foam proportioning systems, giving us experience in designing all types of foam proportioning systems and generators. Given the large water flow requirements of fire protection systems for aircraft hangars, many of the projects also included the design of booster fire pump sets and/or extensive water supply analysis. All projects included the design of foam releasing control systems and their integration with building fire detection and alarm systems.

Hughes performed foam system nozzle discharge test in a newly constructed 30,000-sf helicopter hangar at the Flight Operations Building at Bell Aerospace Ozark, AL airport.
LOW LEVEL AFFF SUPPRESSION SYSTEMS EXPERIENCE

Fire Protection, Life Safety & Code Consulting
Services were provided for the design/build project, P-526/P-651 aircraft maintenance hangar for V-22 aircraft. Work included: a fire protection analysis; life safety plan; code submittal certification; design of fire alarm, automatic sprinkler, fire pump, and low-level low expansion foam fire suppression systems; review of contractor shop drawings; and, final testing and commissioning of fire protection systems.

Wright-Patterson AFB, OH (2008)
Fire Protection Engineering Services
Hughes provided fire protection engineering and code consulting services for the construction of a 70,000-sf multi-purpose hangar servicing and maintaining C-5 aircraft. The project included the preparation of a fire protection and life safety code analysis, general fire protection, building, and life safety code consulting, and the design of fire detection and alarm systems, wet-pipe sprinkler systems, pre-action foam/water sprinkler systems in the hangar bay, a low level, high expansion foam system for the hangar bay, and design of a new fire protection water supply.

Singapore International Airlines, Singapore (2002)
Foam Fire Suppression System Design & Code Consulting
A fire safety code analysis was performed for Hangars 4 and 5 and an annex building. The design was provided for a fire pump system, an overhead sprinkler system, and a low-level foam fire suppression system in compliance with NFPA 409.

Chambers Field, Naval Station, Norfolk, VA (2001)
Fire Suppression System Design
Hughes provided fire protection engineering services for the fire alarm and detection system design for four aircraft maintenance hangars (P-522/P-524 and P-523/P-525) at Chambers Field, Naval Station, Norfolk, VA. All buildings work included new low-level AFFF and sprinkler systems as well as building fire alarm systems. All work was performed in accordance with MIL-HDBK-1008.

NAS Oceana, Virginia Beach, VA (2000)
Fire Suppression System Design; Design for a state-of-the-art AFFF fire suppression system design for a new F/A-18 aircraft maintenance hangar (Type I, cantilever framed; 7,000-square feet). The state-of-the-art system included under wing spray nozzles located in floor trenches. Work also included the design for a fire pump, AFFF low level suppression systems, and shop drawing review services. The existing water supply was evaluated for adequacy to support the new system. Support and guidance were also provided to the electrical engineer on designing the fire detection and alarm systems. Received DoD Award for Outstanding Achievement Through Value Engineering.

Forward Operating Locations, Aruba & Curacao (2000)
Fire Protection Design Analysis
Hughes provided fire protection engineering services for the design of USAF hangars and associated buildings for FOL operations. Fire protection systems consisted of low-level AFFF systems, sprinkler systems, and building and base-wide fire alarm systems.
HIGH EXPANSION FOAM SYSTEMS EXPERIENCE

**High Expansion Foam Fire Suppression System**
High expansion foam and wet pipe sprinkler systems were designed for an aircraft maintenance bay, and a fire alarm system for the building, as part of the renovation and plan to reoccupy the abandoned McCalla Hangar (1,850 m2) hangar at the US Naval Base, Guantanamo Bay, Cuba.

Aviano Air Base, Aviano, Italy  (2003)
**Fire Protection Engineering Services**
Fire suppression system design was provided for a fuel cell maintenance hangar that met USAF criteria. The design included a high expansion foam system for the fuel cell maintenance bay. Work included specification development, review of shop drawings, and preparation of record drawings.

**High Expansion Foam Fire Suppression System**
A complete design engineering package was supplied for the construction of a new high expansion foam fire suppression system for Buildings D-1. Work included field investigation, design analysis, construction documents preparation (drawings and specifications), and coordination with other project design professionals to complete the bid package.

Langley AFB, VA  (2001)
**High-Expansion Foam Fire Suppression System**
Fire protection engineering services for the conversion of Building 371 into a static hangar which will be used as an assembly space for VIPs and ceremonial functions. Aircraft would be displayed behind a removable stage during various assembly functions, and will remain at least partially fueled. Hughes installed a high-expansion foam fire suppression system and a wet-pipe sprinkler system throughout the hangar area.

USAF Air Combat Command, Lajes Field, Azores, Portugal  (2001)
**Hangar Renovation**
A site survey was conducted and cost estimates provided for the renovation of Hangar T-820. Recommendations were made for a new fire protection system to include high expansion foam system and necessary upgrades to the water supply for the building.

NASA Langley Research Center, Hampton Roads, VA  (2001)
**High Expansion Foam Fire Suppression System**
An analysis was provided of design options for the renovation of fire suppression systems in an existing aircraft maintenance hangar bay. A solution utilizing high expansion foam was selected as the best alternative for this 9,000 m2 hangar. Hughes provided design of the new system incorporating the replacement of the existing fire pumps and underground water supply piping.

Little Rock AFB, AR  (2008)
**Design of High Expansion Foam System**
Design services were provided for this design/build project to construct a new C-130 aircraft hangar. The bay enclosed one C-130 aircraft and is used for periodic aircraft washing and maintenance. Work included design of a high expansion foam system and wet sprinkler design.
# WATER-BASED SYSTEMS EXPERIENCE

**Boeing 787 Dreamliner Assembly Plant, North Charleston, SC** (2011)

*Fire Protection Design Services*

Hughes provided fire protection design and safety services for the newly constructed Boeing 787 Dreamliner final assembly facility in North Charleston, South Carolina.

Hughes performed design of fire suppression and fire pump systems, life safety drawings, and smoke code consulting for the assembly and utility buildings.

Completed in 2011, the 1,037-foot long assembly plant has 692,000-square feet of covered space and 1.2 million-square feet of usable space. This project represents the largest single capital investment in South Carolina's history ($750 million).

Project components include a final assembly building, delivery center, administration building and support facilities.

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**MALPENSA 2000 Hangar, Milan Airport, Italy** (2000)

*Fire Protection Survey; System Design*

A fire protection survey and a detailed design of fire protection systems for the new hangars at MALPENSA 2000 – Milan Airport. The main hangar building contained three parts: the central hangar building containing ten hangars that range in height from 65-100 ft and cover 68,000 ft², and two lateral two-story buildings on opposite sides of the main hangar that each contain six smaller hangars as well as office and storage spaces. The following systems were designed in accordance with NFPA 409: separate deluge foam-water systems for each hangar, dry-pipe sprinkler systems for the external shelters, wet-pipe sprinkler systems to protect the offices and storage areas, water reservoir, diesel driven fire pumps, AFFF foam storage tanks, self-oscillating foam-water monitors, heat and flame detectors.

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**Camp Lejeune, NC** (2004)

*Fire Protection Engineering Services*

Fire protection engineering design for the renovation of Building AS4100, a helicopter hangar building. New devices and wiring were provided throughout the building to include a new addressable fire alarm system, IR detectors, radio transmitter, fire pump controllers, smoke detectors, pull stations, etc. The existing overhead deluge system was converted to a wet pipe system. Existing foam tanks and pumps were replaced with a bladder tank system. A fixed side wall foam system was provided.

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**NAS Jacksonville, FL** (2003)

Design of a fire suppression, foam suppression, and fire alarm systems for Hangar 1000. Demolition and alteration work was provided to an existing aircraft hangar bay (47,000-square feet), the first of five to be remodeled. Three existing fire pump units and associated components were replaced, and an existing wet-pipe fire sprinkler system was replaced. The sprinkler system was supplemented with four water-foam cannons that are activated by double-zone IR detectors. In addition, the existing underground water supply loop was abandoned upon completion by providing an interior water supply loop to all bays.
ADDITIONAL AIRCRAFT HANGAR EXPERIENCE

*Fire Protection Design Services*  
Generalized code review and fire hazard analysis (FHA) to assess the overall fire safety of the heliport, with emphasis on the impact of the V-22 Osprey. Analyzed hazards, identified mitigation strategies, and determined appropriate level of safety.

Melbourne International Airport, Melbourne, FL (2012)  
*Fire Protection Design Services*  
Fire sprinkler and fire alarm system design for 74,000-square foot hangar building with approximately 18,500-square foot of mezzanine.

Boeing Company, Long Beach, CA (2012)  
*Fire Alarm Design*  
Fire Protection Engineering Services for the replacement of the existing fire alarm in Building 58 at Boeing’s C-7 Plant.

Hanscom AFB, Bedford, MA (2010)  
*Fire Protection Engineering Services*  
Fire protection and life safety consulting services related to a Fire Protection and Life Safety Property Conditions survey, analysis and report for the 30,000-square foot Hangar IIA.

West Virginia Air National Guard, Martinsburg, VA (2010)  
*Fire Protection Engineering, Life Safety, and Code Consulting Services*  
Fire protection engineering, life safety, and code consulting services for the design and construction of a 80,000-sf C-5 Fuel Cell Maintenance Hangar for the WV Air National Guard.

Embrarer Aircraft Service Center, Multiple Locations in CT, AX, and FL (2007)  
*Fire Protection Design Services*  
Design of fire protection systems for three hangars for corporate aircraft.

Naval Air Facility, El Centro, CA (2000)  
*Fire Protection Design Services*  
A base-wide fire protection engineering report evaluating all facilities for code compliance. Facilities include aircraft hangars, residential quarters and assembly occupancies. An assessment of existing fire reporting systems was performed and recommendations were made for a base-wide fire alarm reporting system to interface with existing building systems. Hughes evaluated fire suppression, extinguishing, fire alarm and detection systems for adequacy and compliance with applicable codes. Recommendations were made to upgrade fire protection systems.

Naval Air Weapons Station, China Lake, CA (1999)  
A base-wide fire protection engineering study surveying fire inspection, maintenance and test records. Water flow and fire alarm tests were conducted.
AIRCRAFT RESCUE AND FIREFIGHTING (ARFF)

**Aqueous Film Forming Foam (AFFF) and ARFF Resources**

The Federal Aviation Administration (FAA) Airport Technology R&D branch is responsible for developing and implementing technologies which maximize the potential of aircraft passenger survivability in a post-crash environment. Aircraft size and construction is evolving to an extent where traditional crash rescue firefighting concepts may be outdated.

The size of passenger aircraft is increasing, with associated increases in fuselage size, wing span, passenger capacity, and jet fuel load. In order to improve the effectiveness of aircraft rescue and firefighting (ARFF) resources, the FAA is interested in a review of the current methodology for calculating the total amount of firefighting agent required to combat aircraft fires.

Hughes performed an independent, objective, thorough review of the existing agent formulas (particularly those involving AFFF) and associated vehicle requirements to determine their applicability to today’s technology.

The basic approach was to fully document the historical basis of the Theoretical Critical Area (TCA) and Practical Critical Area (PCA) formulations. Up-to-date airframe characteristics were established, and the current agent calculation methodology were compared to the hazards associated with the airframes. Finally, the methodology was varied using alternative or potential firefighting agents and vehicle technology not currently included in the baseline requirements.

**Joseph L. Scheffey, PE, VP** is a member of the NFPA Aircraft Rescue and Fire Fighting Technical Committee. He has chaired the NFPA 412 Task Group on Foam Test Methods. His experience includes being tasked by the FAA to independently review test criteria for fire-fighting foam. As a result of this review and analysis, standard test and approval methods are being adopted by the FAA.

**FAA Technical Center – Airport Safety Technology**

Hughes supports Systems Research and Applications Corp. in the study of agent quantities calculations for New Large Aircraft (NLA) to determine if advanced composite materials, evacuation slides, aircraft length, width, and height, passenger loads, and fuel loads necessitate increased agent quantities for fire protection and complete extinguishment.

This effort expands upon the previously submitted report “A Technical Review of Methodologies for Calculating Fire Fighting Agent Quantities Needed to Combat Aircraft Crash Fires”. Testing determines what exposures and hazards present difficulty in extinguishing an NLA fire emergency. Results will determine if current Index requirements are sufficient to combat a NLA fire. A new methodology will be established should the current calculation prove insufficient.
Aircraft Rescue and Firefighting (ARFF) Experience

Scope of work includes:

- Continue to develop an agent application test protocol for aircraft composite skin materials.
- Determine the fire hazard presented by advanced composites as used on a large scale in primary and secondary structures.
- Assess total fuel load and potential crash fuel release area as compared to TCA/PCA areas for necessary adjustments to the TCA/PCA. Make recommendations for adjusting the TCA/PCA if applicable.
- Conduct testing to determine the difference in fire fighting effectiveness for an open fuel pool fire versus a fuel pool fire under an aircraft with numerous evacuation slides deployed as found in NLA.
- Submit recommendations for adjusting the current agent quantity calculation or adoption of an entirely new method.

Naval Air Station, Oceana, Virginia Beach, VA

**Fire Suppression and Alarm System Design**

Hughes provided the design for a state-of-the-art AFFF fire suppression system for a new F/A-18 aircraft maintenance hangar (Type I, cantilever framed 40,000 ft²). The state-of-the-art system included the Viking Corporation under-wing spray nozzles located in floor trenches. This is the first installation of its kind in the world.

Services included design of the AFFF low level system, design of the water sprinklers, and design of the fire alarm/detection systems. Additional construction follow-up services were provided. Based on this effort, the design team was recognized with the Year 2000 DoD Value Engineering Award.

**AFFF Containment Criteria**

**Policy & Design Criteria Development**

Hughes conducted a study to develop a rational policy and design criteria to address containment and disposal of aqueous film-forming (AFFF) discharge from facilities having AFFF suppression systems. A technical analysis of the pollution aspects of AFFF was performed to assess the environmental impact of liquid effluent discharges on soil and water, including toxicity to organisms.

The study also addressed waste water treatment and airborne pollutants, and considered local jurisdictional requirements. An environmental impact analysis was made to develop options for containment and disposal, including a risk assessment. The results of the survey and analysis will be submitted as draft design criteria for inclusion as for military-wide policy.

**U.S. Air Force Suppression System Pipe Evaluation**

**Engineering Evaluation**

Hughes performed an engineering analysis to determine if plastic pipe could be used in aircraft hangar AFFF piping systems. The intent was to eliminate high maintenance costs of steel pipe resulting from corrosion. An analysis was performed, based on large scale test data, on the potential thermal threat to pipes. Test criteria was developed to evaluate candidate plastic pipe designs.
Aircraft Rescue and Firefighting (ARFF) Experience

Aircraft Hangar Design Study

*Design Study and Large Scale Testing*

Hughes evaluated the capabilities of an aircraft hangar fire suppression system consisting of a low level AFFF extinguishing system and an overhead water sprinkler system for the Naval Facilities Engineering Command. Full-scale tests were conducted to evaluate the effects of overhead water sprinklers on AFFF foam blankets. Changes to design criteria were proposed for hangar protection to incorporate AFFF application from only the low level system, combined with overhead closed head quick response water sprinklers. Changes have now been incorporated in NFPA 409.

AFFF Nozzle Design, Naval Research Lab, Washington, DC

*Fire Protection Hardware Design*

Hughes tested and finalized the design of a new low level AFFF nozzle which will be installed flush with the trench drains in new and retrofit aircraft hangar projects.

Optical Detector Response Testing/Performance Specification Development, Naval Research Lab, Washington, DC

*Research, Testing & Hardware Specification Development*

Hughes conducted small and large scale tests to determine appropriate fire signals which should be detected by optical detectors. Large scale tests were conducted to identify detection performance for a range of detector types. Associated tests were conducted to determine which types of detectors were most immune to false alarm signals. Based on test data and hazard analyses, Hughes developed an optical detector performance specification.

**NFPA 415 – STANDARD ON AIRPORT TERMINAL BUILDINGS, FUELING RAMP DRAINAGE, AND LOADING WALKWAYS**

*Glass Loading Walkway Study*

There are several manufacturers that build aircraft glass loading walkways, which are currently permitted in countries that have not adopted National Fire Protection Association (NFPA) standards. The Technical Committee for NFPA 415 desired more information about the global experience of using glass loading walkways, including fire resistance of the loading walkways, fire test methods, use of alternate/additional escape routes from the plane, passenger behavior during actual emergency incidents, and psychology/sociology of occupants that might egress through a glass loading walkway with a large fire outside/below.

The Fire Protection Research Foundation and Hughes are undertaking a project to provide information on the use of glass boarding bridges that may be used as the technical basis for inclusion of glass bridges in the standard. The scope of this project provides information directly related to the construction of both traditional and glass loading walkways, a review of fire history, a discussion of the loading walkway as a means of egress, and the psychological impacts occupants may experience while using the loading walkway as a means of egress during a fire event.
United States Office Locations:

- Arizona: Phoenix
- California: San Francisco, Los Angeles, San Diego
- Colorado: Colorado Springs, Denver
- Florida: Orlando
- Georgia: Atlanta
- Illinois: Chicago
- Indiana: Fort Wayne
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- Massachusetts: Boston
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