Preliminary Results of FAA Fuel Tank Inerting Flight Testing on the NASA 747 SCA

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FAA-NASA 747 Inerting Flight Test

Outline

• Goals and Objectives
• OBIGGs
• Instrumentation / DAS
  – Fuel Tanks
  – System
  – Additional Parameters
  – OBOAS / FAS
• Preliminary Data
• Status
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Testing Goals and Objectives

- Study the simplified inerting concept and validate/expand upon existing system performance models
- Develop/validate system sizing data
- Validate previous in flight inert gas distribution modeling done by FAA
- Measure the progression of flammability in the CWT and a single wing tank for a typical commercial transport airplane
OBIGGS - System Architecture

- Uses Air Separation Modules based on HFM technology
  - Exacts 350 degree F air from aircraft bleed system
  - Cools, filters, and conditions air
  - Air is separated in 3 ASMs and NEA is plumbed to output valves to control flow
  - OEA is dumped overboard with H/X cooling air
  - System flow control is presently configured with low flow orifice and high flow control valve

- System controlled by control box in cabin that is connected to system with cable

- System installed in empty pack bay area of 747 SCA
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FAA OBIGGs Assembly Drawing

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Simplified OBIGG System Installation

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Simplified OBIGG System Installation

AAR-440 Fire Safety R&D
Instrumentation and Data Acquisition

• Various thermocouples and pressure transducers used
  – Evaluate system performance
  – Measure tank flammability parameters
  – Measure ancillary parameters

• OBIGGS system flow meter and 2-channel oxygen analyzer for NEA and OEA analysis

• Onboard Oxygen Analysis System (OBOAS) measurements
  – 8-channel system analyzes 8 locations in tank

• Flammability Analysis System (FAS) will measure progression of CWT and #2 wing tank flammability in flight
  – 1 location in forward section of center tank
Note: Ullage Oxygen Sample Ports Located Adjacent to Thermocouples 1-8
#2 Wing Tank Thermocouples

## Ullage Gas Sample Location

<table>
<thead>
<tr>
<th>T'couple #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wing Tank Forward Spar Surface Temp</td>
</tr>
<tr>
<td>2</td>
<td>Wing Tank Inboard Fuel Temp</td>
</tr>
<tr>
<td>3</td>
<td>Wing Tank Rear Spar Surface Temp</td>
</tr>
<tr>
<td>4</td>
<td>Wing Tank Ullage Temp</td>
</tr>
<tr>
<td>5</td>
<td>Wing Tank Mid Fuel/Ullage Temp</td>
</tr>
<tr>
<td>6</td>
<td>Wing Tank Outboard Wall Surface Temp</td>
</tr>
<tr>
<td>7</td>
<td>Wing Tank Bottom Surface Temp</td>
</tr>
<tr>
<td>8</td>
<td>Wing Tank Top Surface Temp</td>
</tr>
</tbody>
</table>
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System Instrumentation Diagram

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Thermocouple Probe and Pressure Transducer
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Flow Meter

CONNECTOR, RECEPTACLE
PN D38999/25YB98PN
MATES WITH PLUG
PER MIL-C-38999, SERIES III

CONNECTOR, RECEPTACLE
PN D38999/20WB35PB
MATES WITH PLUG
PER MIL-C-38999, SERIES III

SENSOR ASSY,
PRESSURE

5.62 MAX

PLUG, 1/4 NPT

2X WELDED FLANGE,
SST, PER AS1650
AND MIL-C-22263

LINE ASSY, 1.00 O.D.

SENSOR ASSY,
FLOW/TEMPERATURE

VORTAB FLOW CONDITIONER

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OBOAS Mounted in FAA AMCO Racks

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DAS Rack with OBIGGS Analyzer
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Photo of FAS Sample System and Analyzer
Cabin Instrumentation/Rack Diagram

- Instrumentation Wiring
- Power Cable
- Purge Air Line
- System Wiring
- Sample Tubing
- Wing Tank Thermocouples
- Penetration STA 985
- Compressed Air Bank (Cargo Bay)

Aircraft Cabin

STA 990 to STA 1250

FAS Analyzer

FAS Sample System

DAS OBIGGS

OBOAS

OBOAS

To Avionics Bay

Penetration STA 1275 (CWT Thermocouples)

Penetration STA 1235 (Pack Bay Stuff)

Penetration STA 1244 (CWT Sample Lines)

Window Plug

Air

Air

Air

Air

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Cabin Instrumentation/Rack Diagram

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Test Plan

• Operated system in two flow mode for first test and in variable flow for remainder of testing

• Did a series of 7 flight tests ranging from 2 to 5 hours totaling approximately 30 hours of flight time
  – Validated the two-flow mode methodology and studied maximizing system flow during top of descent
  – Studied effect of CWT fuel on inerting and demonstrated the ability of a system to reduce the flammability exposure of an aircraft
  – Examined existing fleet flammability with baseline flammability testing
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Preliminary Data Measured

- System performance similar to airbus (per ASM) but with notable differences
  - Needed full heat exchanger capability on the ground to keep Asm inlet below 185 degrees F in low flow mode
  - Bleed air flow considerable less on a per ASM basis due to low cruise bleed pressures
- Inert gas distribution similar to previous models
  - Air entered the tank in a less distributed manner leading to a greater inequity of inert gas distribution after landing
- Fuel tank temperature magnitudes similar to previous ground tests
  - Did not cool off in flight as much as predicted
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System Performance Data

Test 2 Data - System Variation 1

- NEA [O2]
- NEA Flow
- ASM Pressure
- Altitude

Oxygen Concentration (% vol)

Alt (kft) \ Pressure (psi) \ Flow (scfm)

Time (mins)

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System Flow Data

Test 2 Data - System Variation 1

Flow (scfm) vs Time (mins)

Altitude (kFt) vs

Bleed Flow
NEA Flow
OEA Flow
Altitude

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CWT Inerting Data

Test 2 Data - System Variation 1

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CWT Heating Data - Ground

Test 2 Data - Ground Heating

Temperature (deg F)

Altitude (kFt)

Time (mins)

Average Ullage
Average Floor
Average Wall
Average Fuel
Average Pack Bay
Average Ceiling
Altitude

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CWT Heating Data - Flight

Test 2 Data - System Variation 1

Average Ullage
Average Floor
Average Wall
Average Fuel
Average Pack Bay
Average Ceiling
Altitude

Time (mins)
Altitude (kFt)
Temperature (deg F)

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Status

• Completed testing of the FAA Simplified Inerting System and commercial transport fuel tank flammability study
  – Preliminary data reduction completed
  – Data analysis to continue

• Preliminary results illustrate validity of the FAA concept
  – Plan to use data to expand existing system performance models
  – Fuel tank heating trends very much as expected

• More work needed to study fuel tank flammability