Modeling of Hidden Fire Smoke Signature in Aircraft

A CASE STUDY OF OVERHEAD AREA

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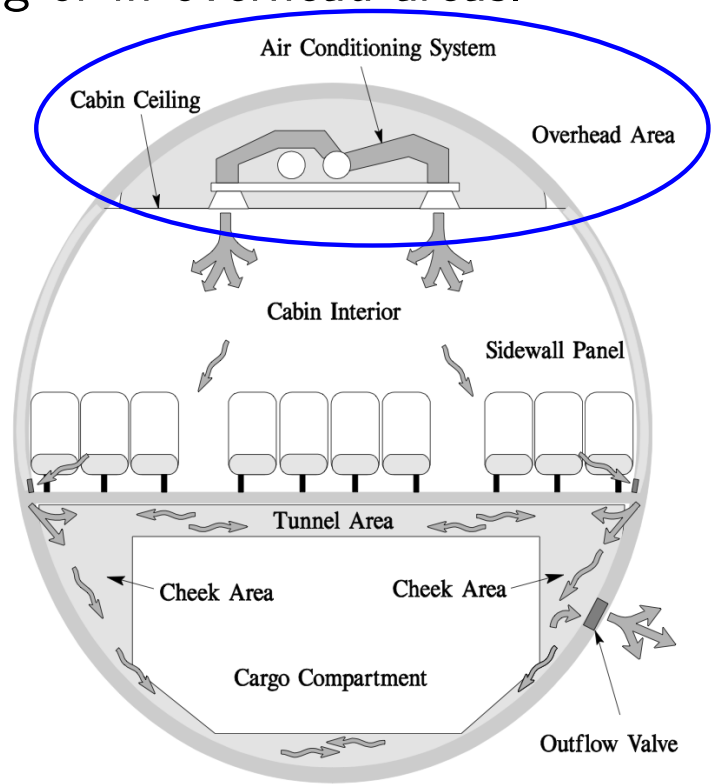
Outline

Outline

Introduction

Hidden fires

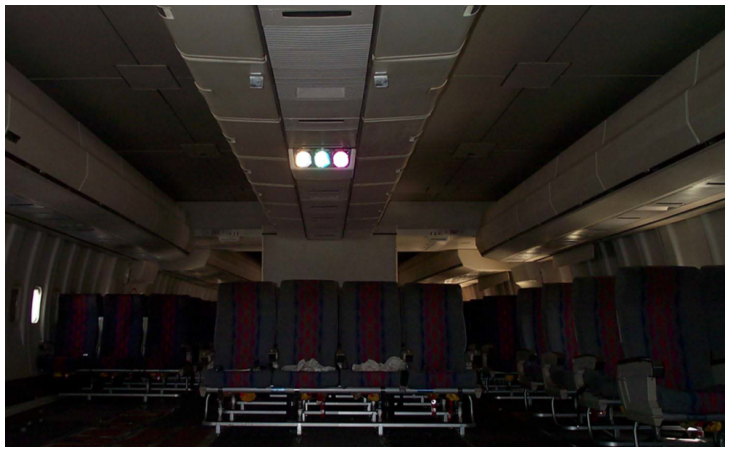
- FAA Advisory Circular (AC) 120-80, In-Flight Fires, 2004.
- **Definition of hidden in-flight fires:**
  Fires that are hidden are not readily accessible, may be difficult to locate and are more challenging to extinguish.
  - examples: fires behind sidewall paneling or in overhead areas.
- **Potential causes:** Wiring failures, electrical component failures, lightning strikes, hot temperature bleed air leaks, faulty circuit protection.
- **Indications:** Abnormal operation or disassociated component failures, circuit breakers, hot spots, odor, visual sighting - smoke.
- **Locations of interest:** Overhead area, cheek area, sidewall panel.



Outline

Introduction

Overhead area of **B747 SP** Test article



Courtesy of T. Marker

Outline

Introduction

Fire source

- The FAA Tech Center Aircraft Fire Safety group has adopted the polyurethane foam block as the standard fire-threat for in-flight fires*,†,‡.
  - $4 \times 4 \times 9$ inch^3 in size,
  - 49 kW/m^2, 781 ^{o}C,
  - Total burn time $\geq$ 10 minutes, active burn time $\approx$ 1 minute.

Fire source‡

Courtesy of R. Ochs

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*Development of repeatable hidden fire source, S. Le Neve, Toulouse Aeronautical Test Centre (CEAT), 2009.

†Development of an improved fire test method and criteria for aircraft electrical wiring, J.W. Reinhardt, FAA Tech Report, 2010.

‡Composite structure flame propagation test method development, R.I. Ochs, FAA Tech Center, 2012.

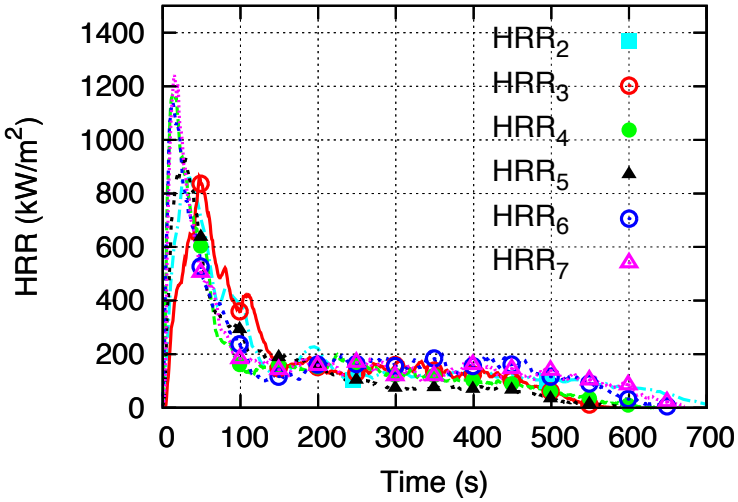
Outline

Methodology

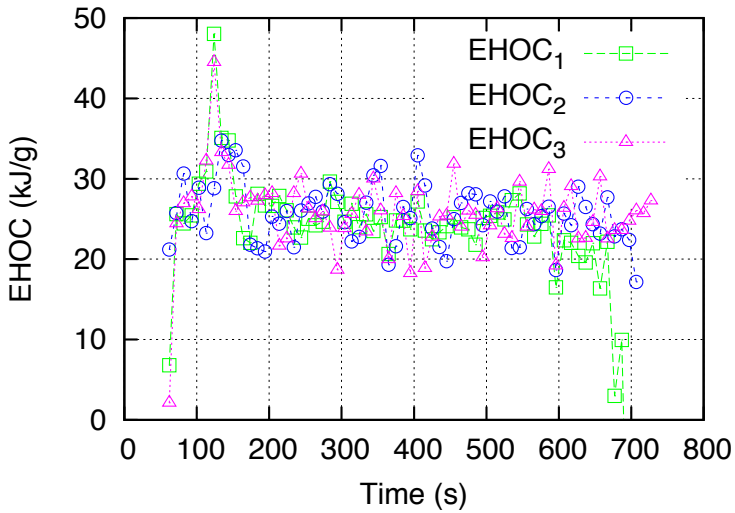
Fire source - Characterization

- The rates of **heat release** and **mass loss** are measured in bench-scale tests,
- The **heat of combustion** is calculated from the experimental data (cone calorimeter),
- The stoichiometry and the radiative fraction for the fire source are still unknowns. The selected values for these parameters will affect the simulation results.
  - Radiative fraction is assumed to be 0.335,
  - Stoichiometry is decided based on the known heat of combustion value.

Heat release rate (HRR)



Effective heat of combustion (EHOC)

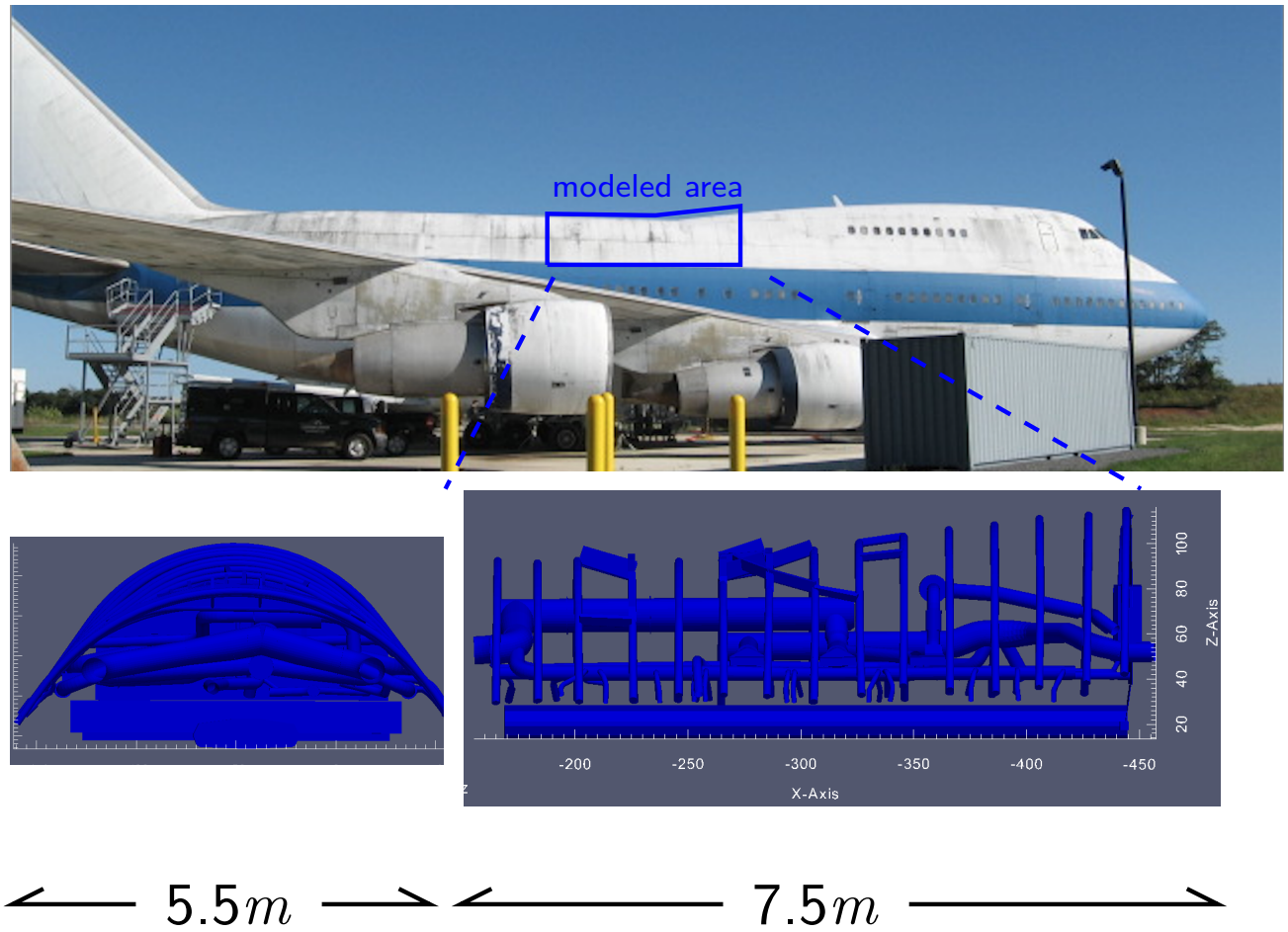


Outline

Methodology

Overhead area of B747 SP Test article

Bench-scale tests $\mapsto$ full-scale tests

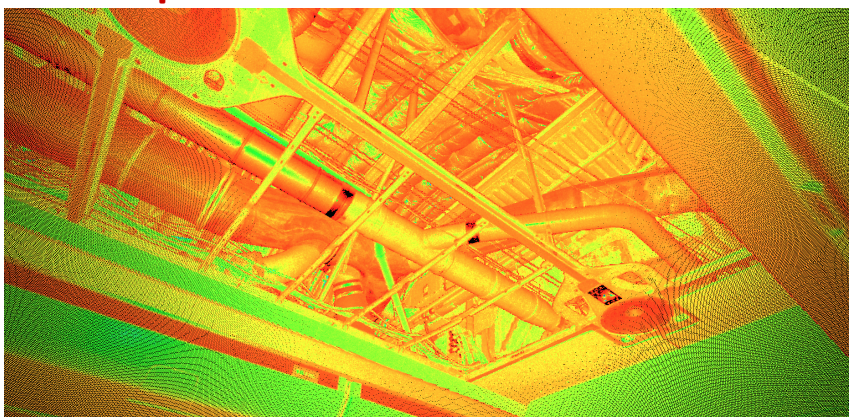


Methodology

CAD model for the B747 overhead area

LIDAR (Light Detection and Ranging) technology is used in the determination of the internal dimensions of the overhead area of 747SP test article.

LIDAR point cloud data

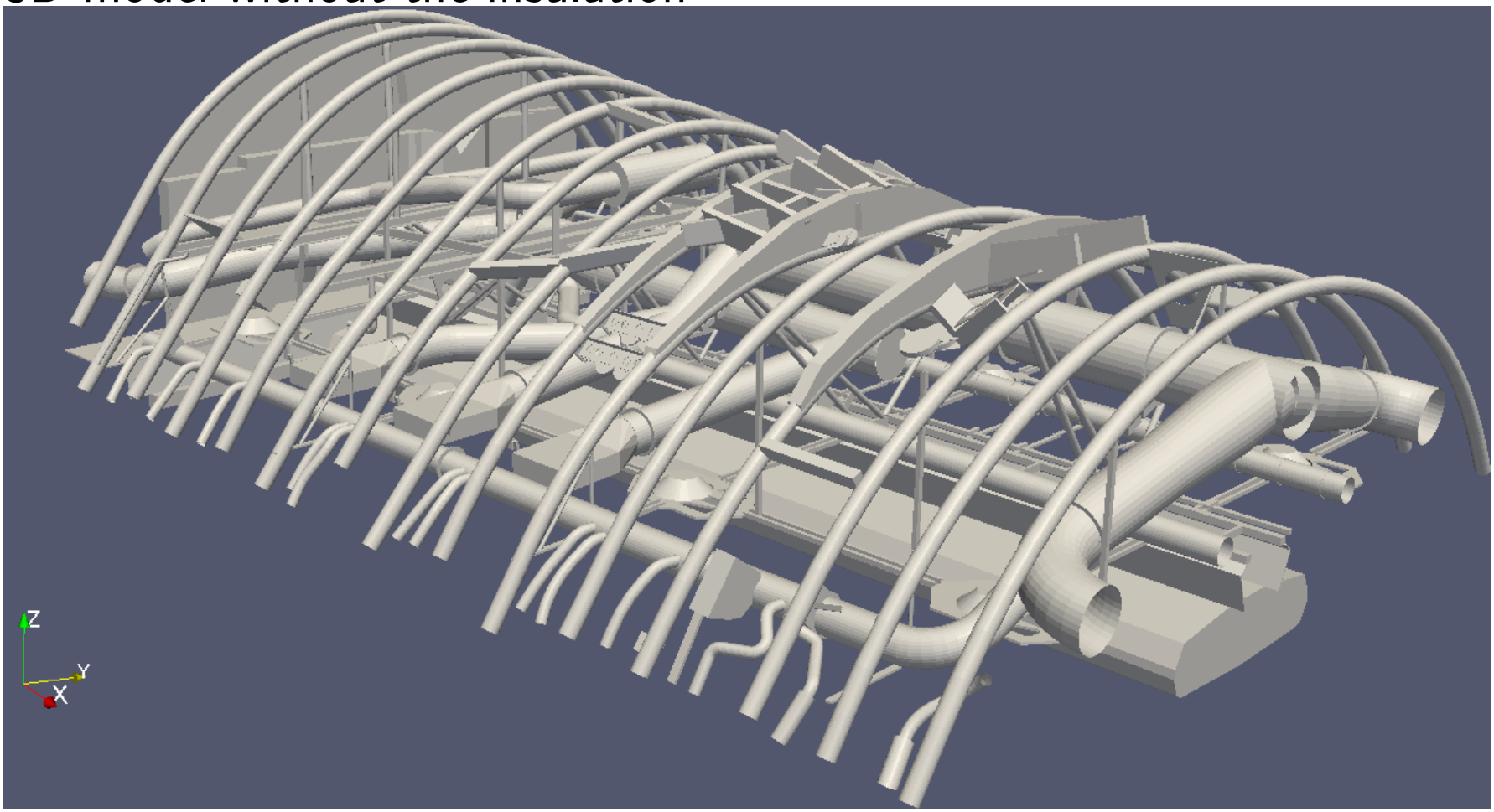


Scanned real geometry

Methodology

CAD model for the B747 overhead area

3D model without the insulation

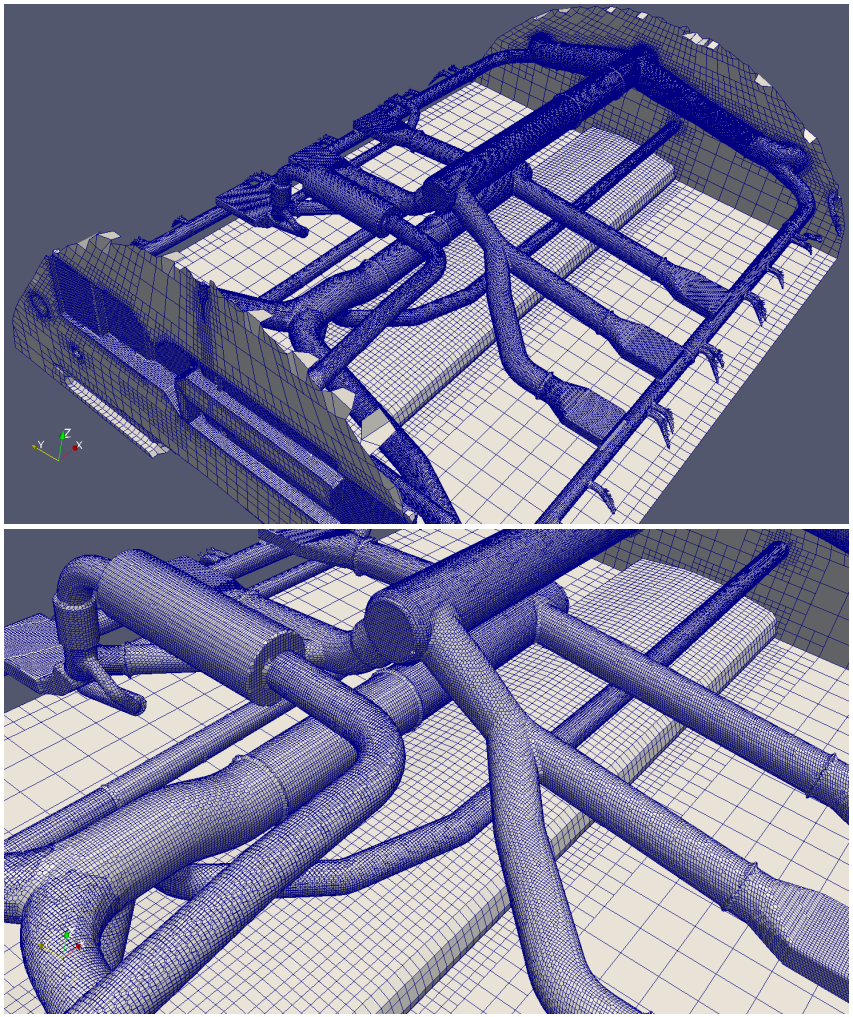


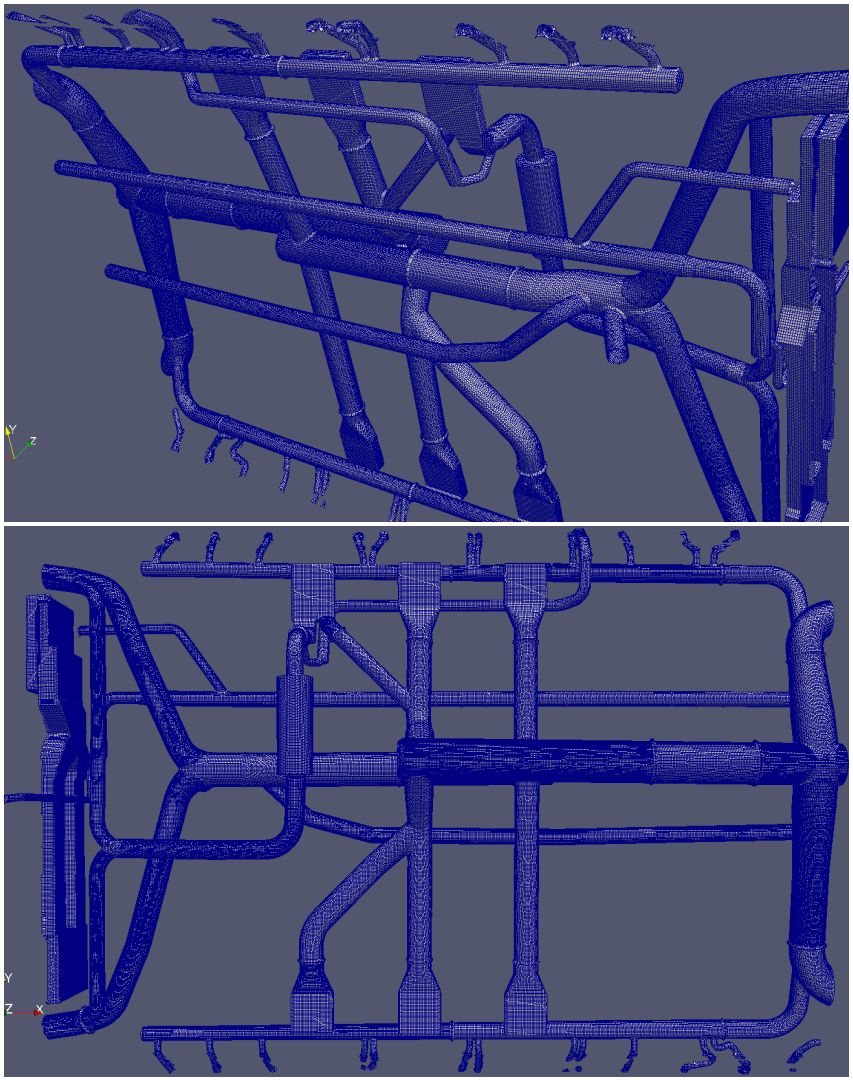
Outline

Methodology

Mesh for the B747 overhead area

Small features, such as droppers on each end, require finer resolutions with an increase in the total number of grid points.



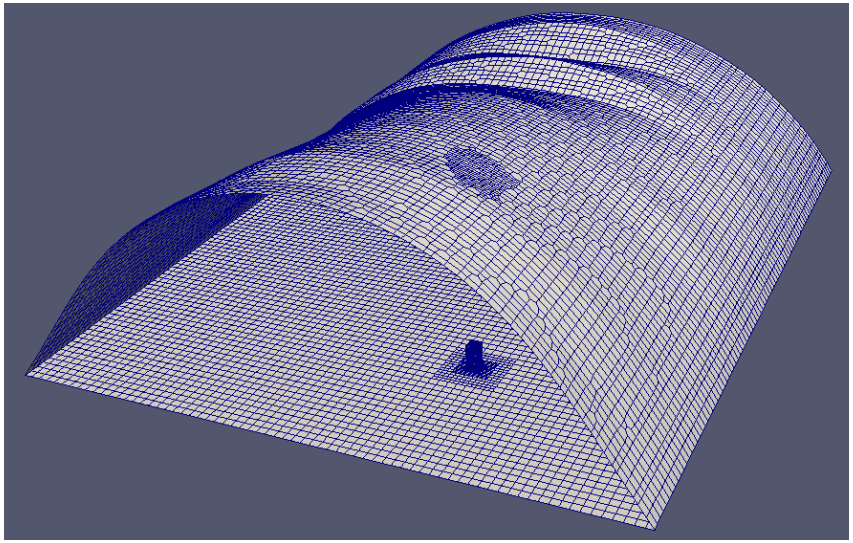


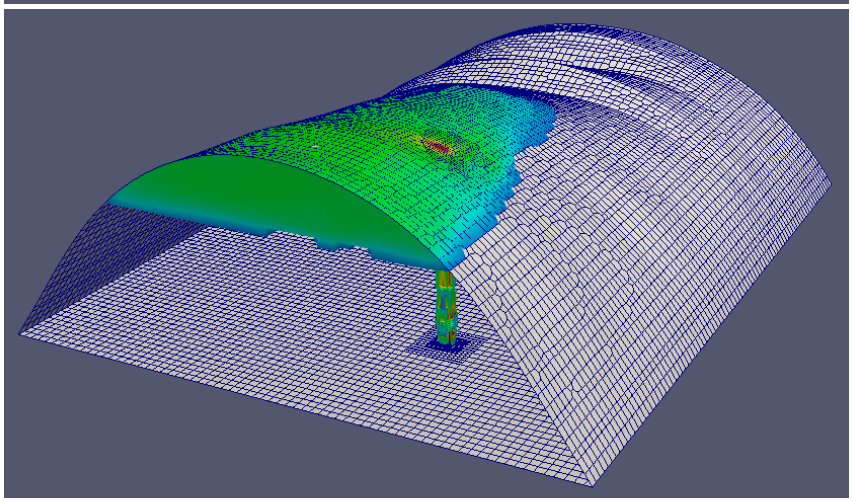
Outline

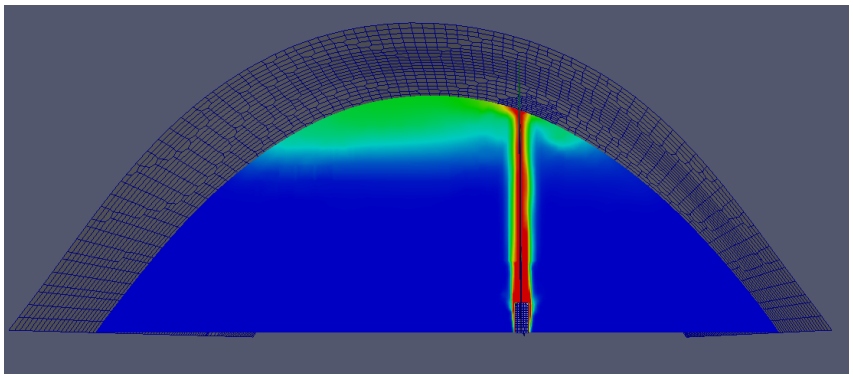
Methodology

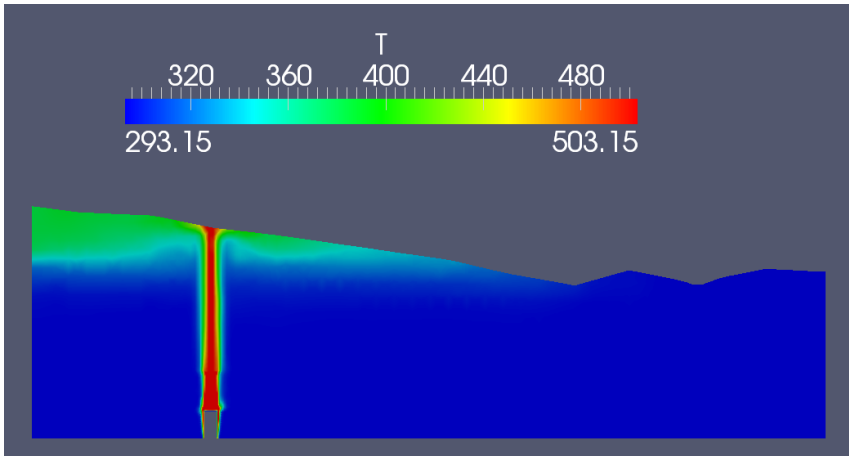
Preliminary solution for the empty overhead area

Simulations suggest accumulation of hot gases in the forward part of the overhead area due to empty-hull geometry.





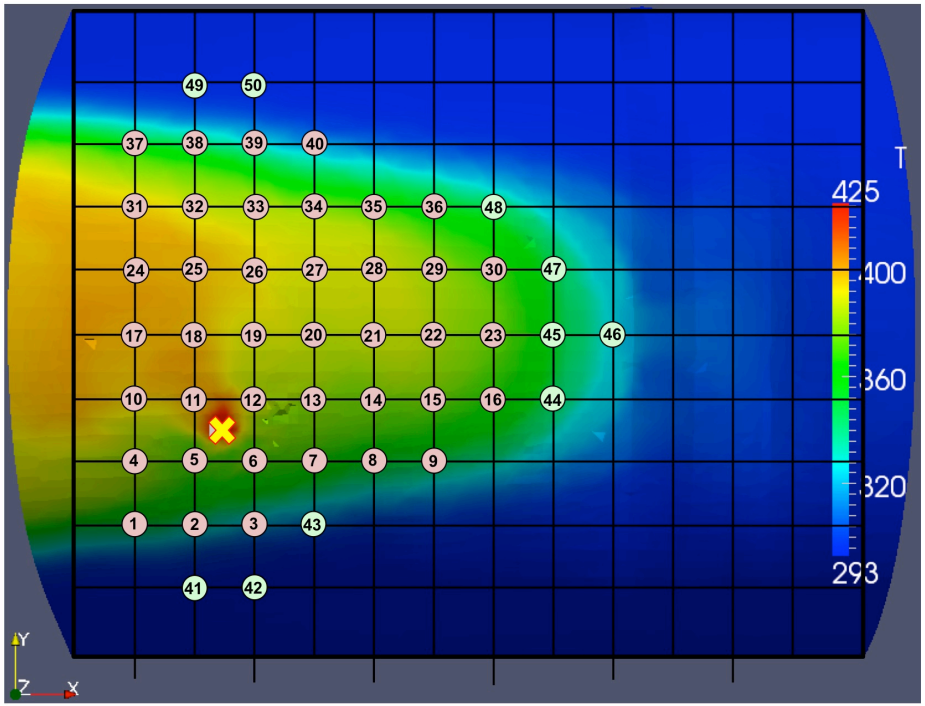


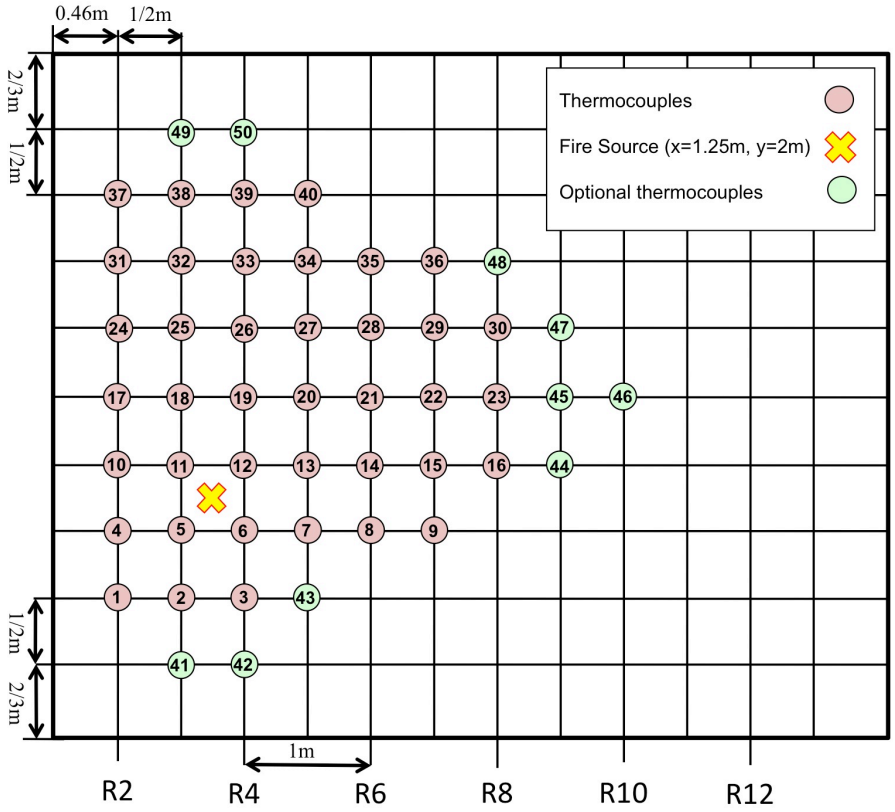


Methodology

Instrument locations for the test set-up

Thermocouple locations (≥ 50) are determined based on preliminary simulations of empty overhead area.





Summary and Future Work

- ✓ Selection of a CFD solver ..... **[Done]**
- ✓ Characterization of the fire source ..... **[Done]**
- ✓ CAD model for the B747 overhead area ..... **[Done]**
- ▶ Mesh generation for the modeled geometry ..... **[In progress]**
- ✓ Acquiring computational resources ..... **[Done]**
- ▶ Solution and analysis ..... **[In progress]**