International Aircraft Materials Fire Test Working Group

Developing an In-flight Fire Condition for Evaluating Performance of Composite Skin

Presented to: IAMFT Working Group, Brazil

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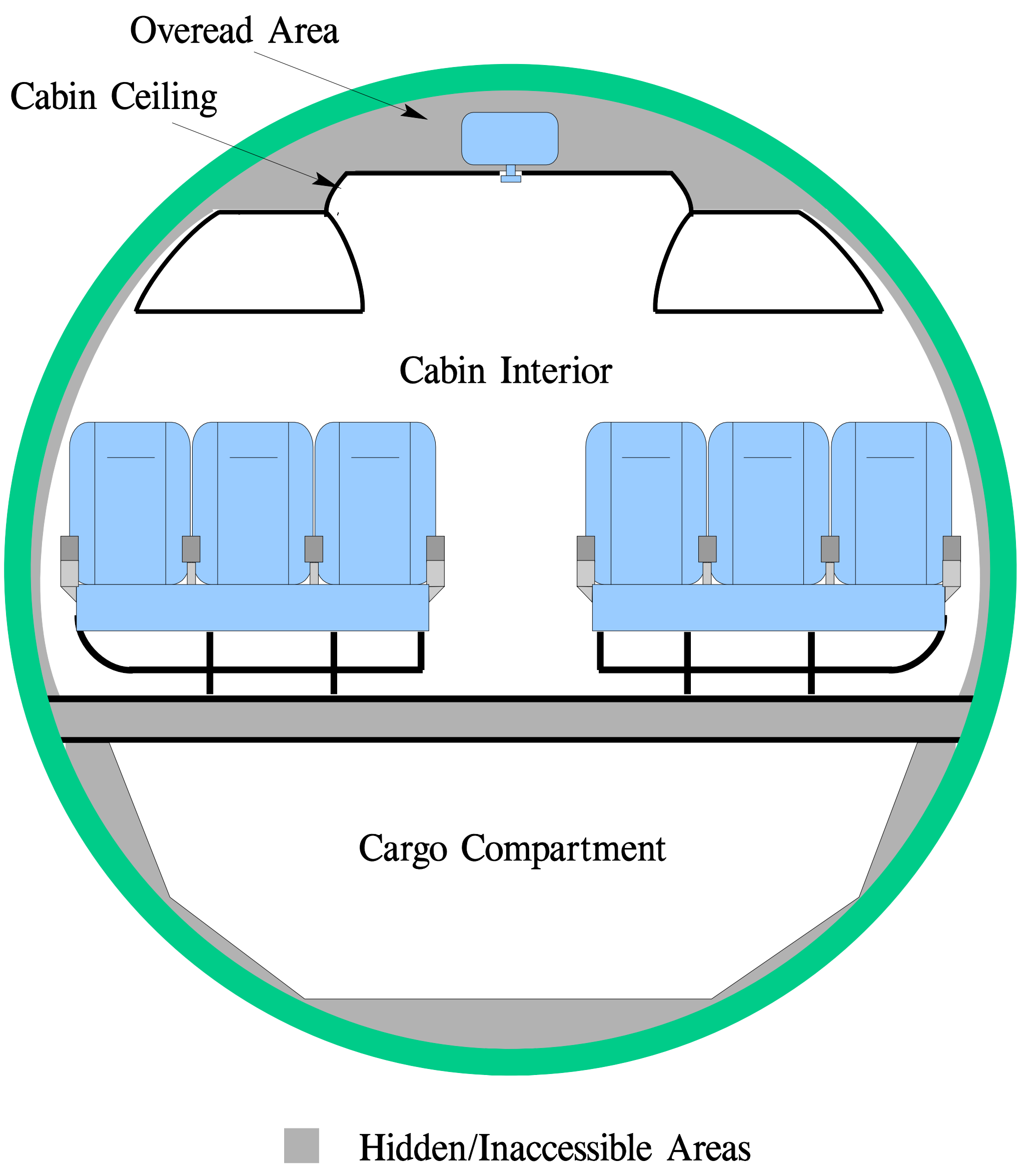
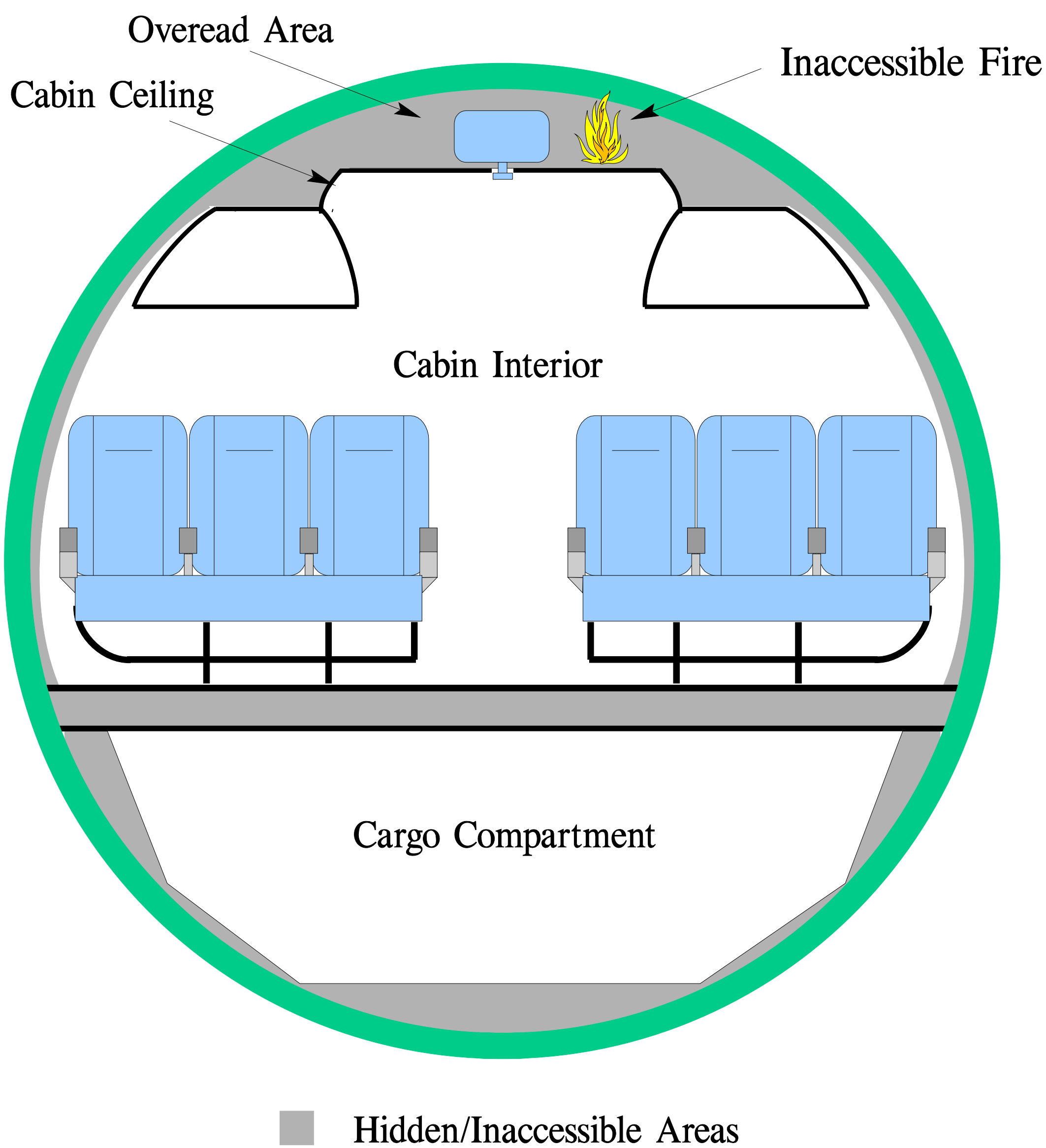

Overead Area
Cabin Ceiling
Cabin Interior
Cargo Compartment
Hidden/Inaccessible Areas


Overead Area
Cabin Ceiling
Inaccessible Fire
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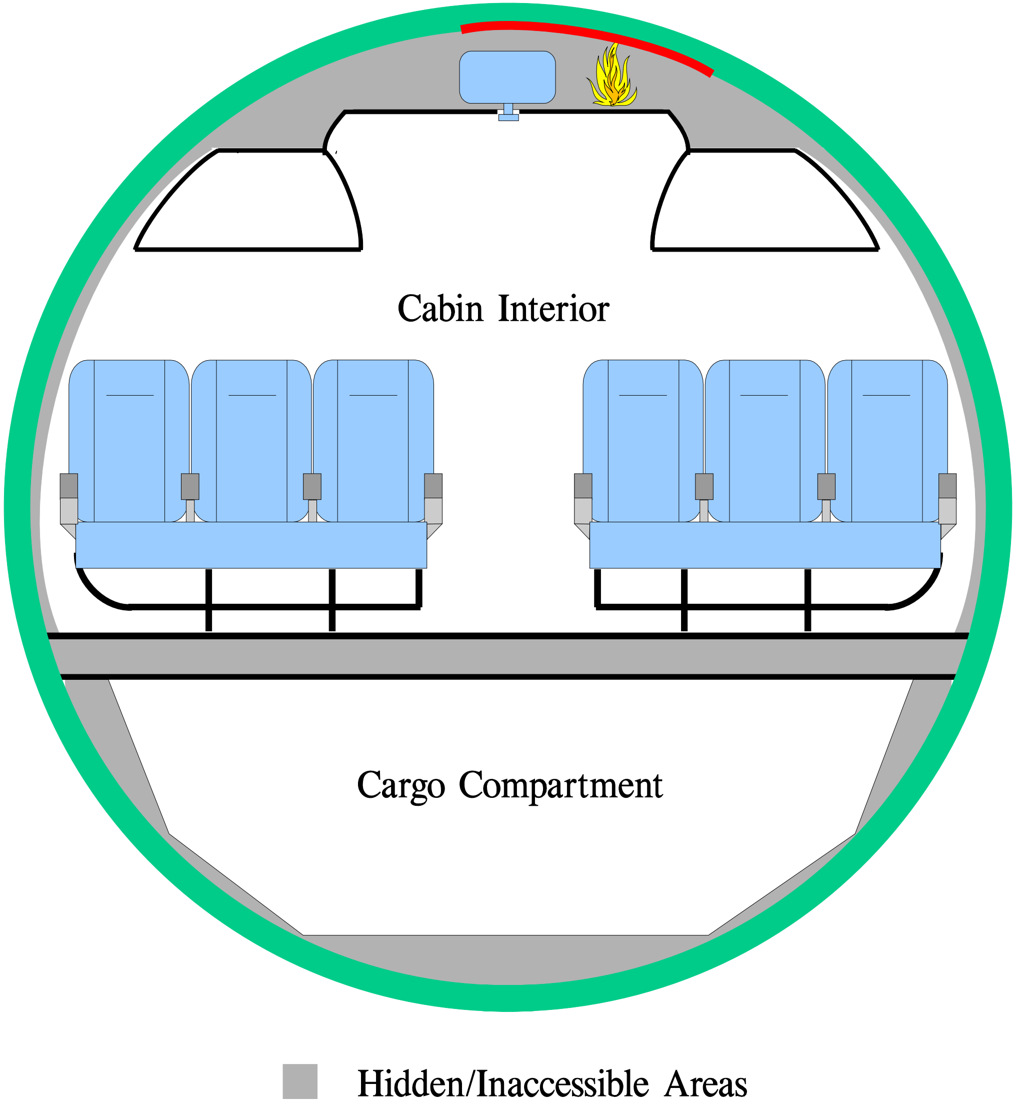
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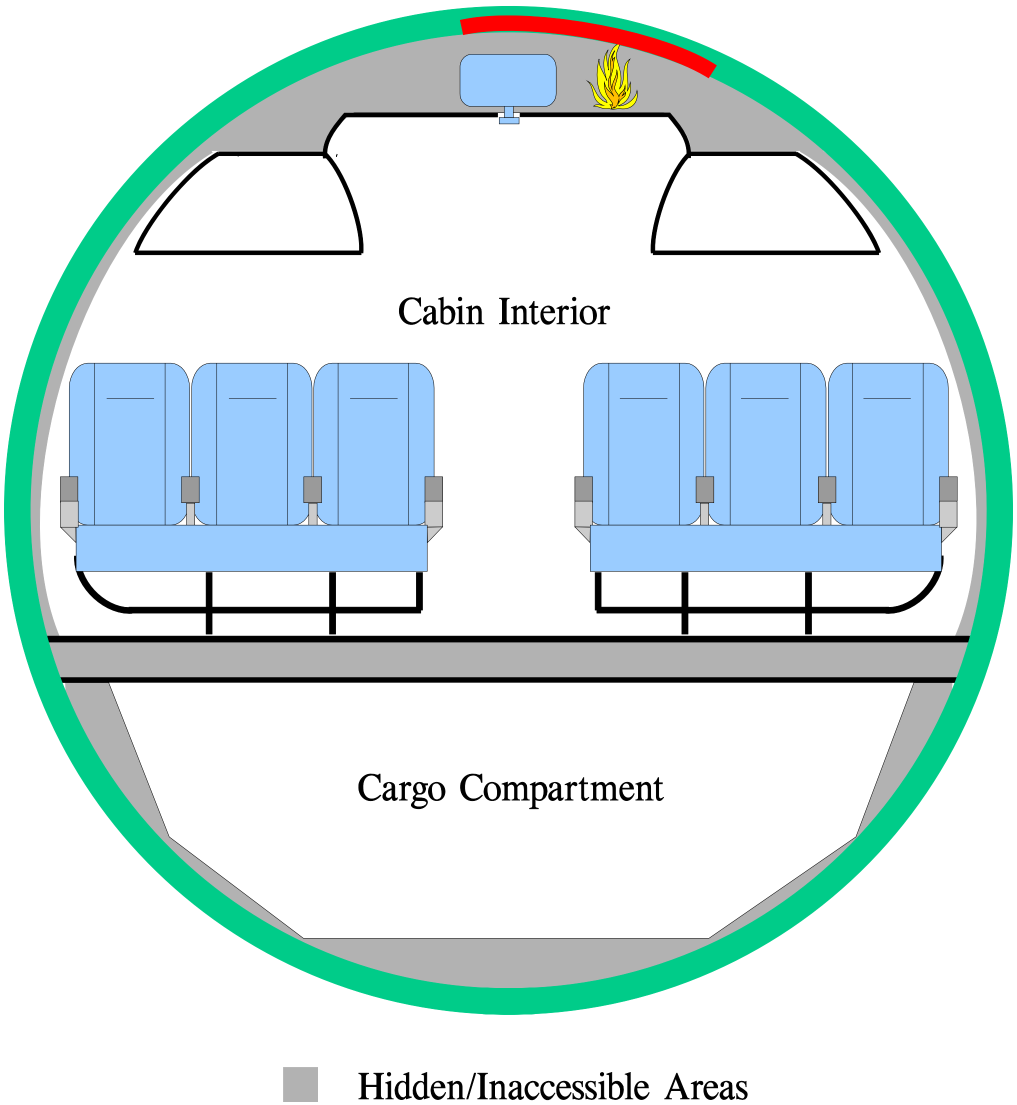
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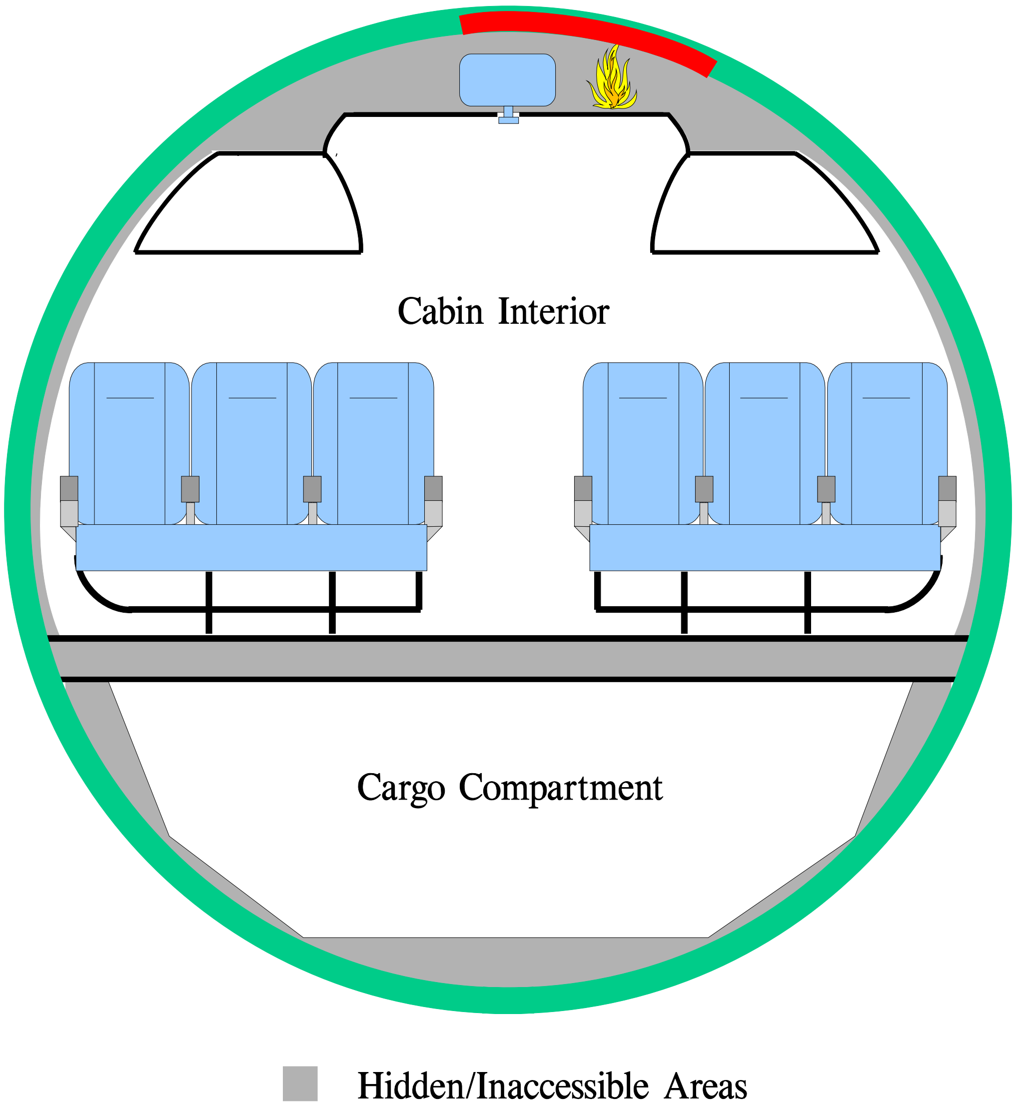
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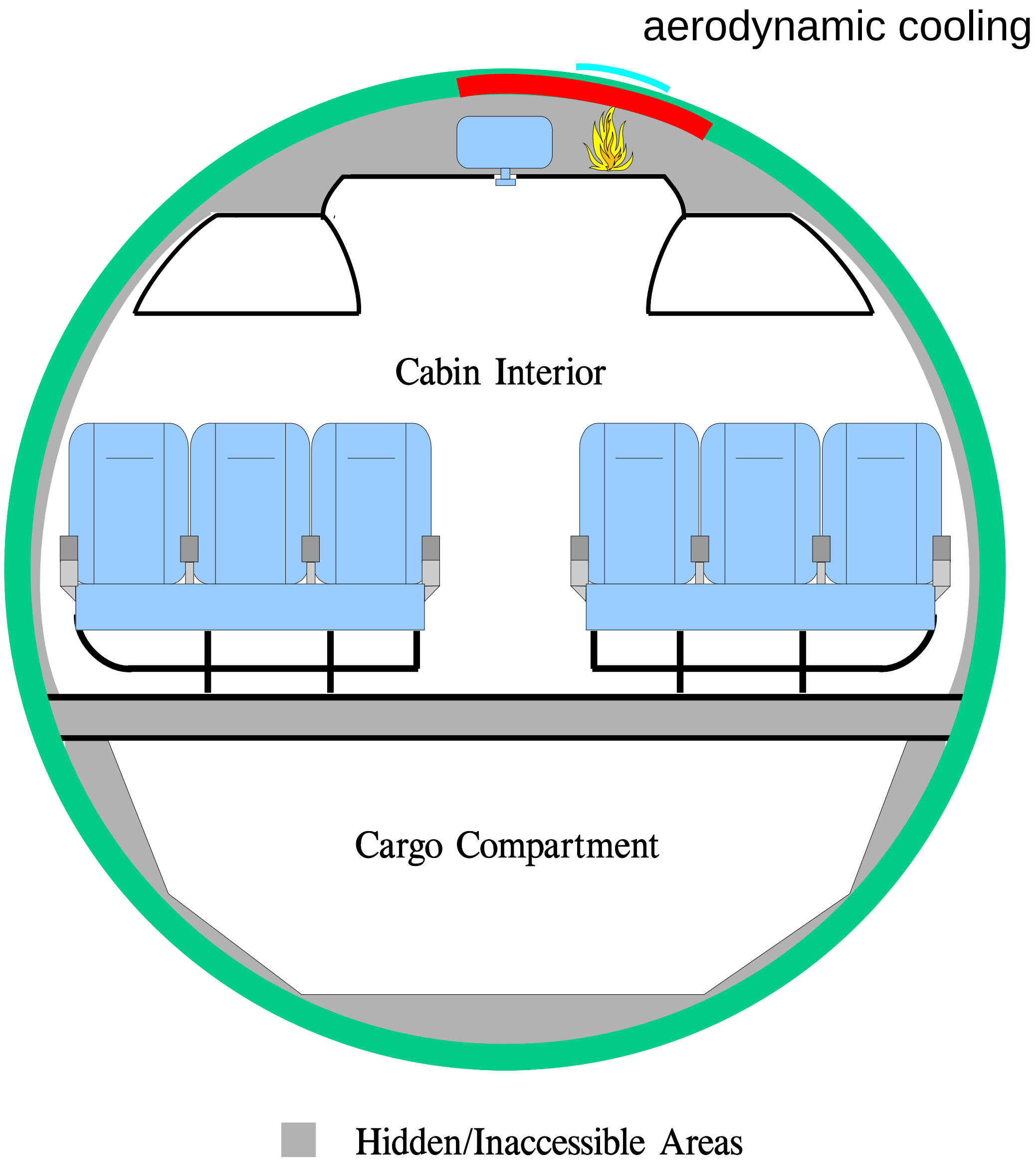
aerodynamic cooling
Cabin Interior
Cargo Compartment
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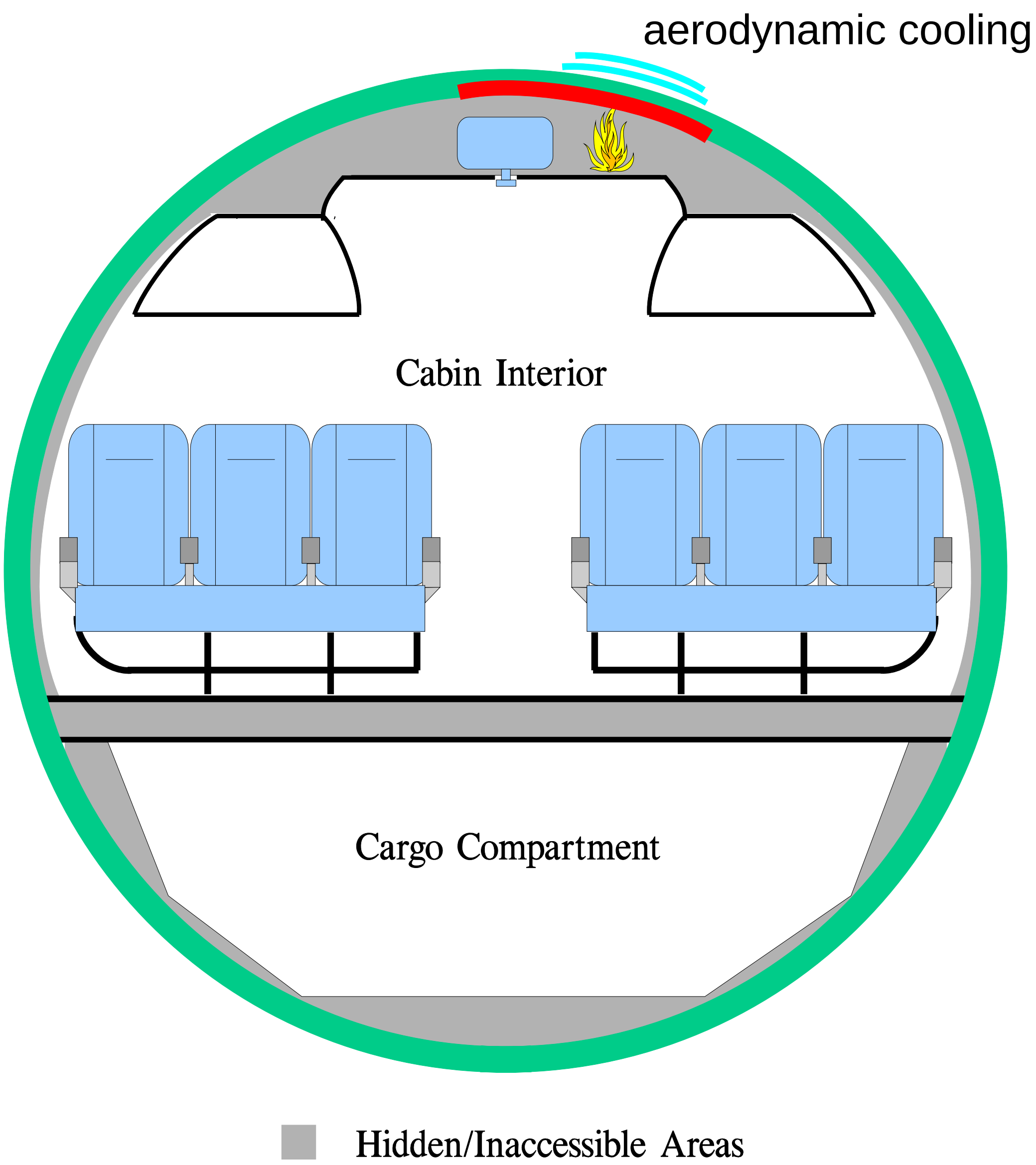
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Background

- Aluminum’s high capacity for heat rejection prevents melt-though while in-flight due to the cooling effect of the airflow around the fuselage.
- Once on the ground, the cooling effect of the airflow no longer exists, resulting in skin melt-through.
- Melt-through may allow rapid escape of trapped heat and gases to occur.

Background

- Composite material may not be capable of dissipating heat from an in-flight fire, causing elevated temperatures in the crown area.
- Extreme localized heat can potentially cause structural damage to composite surface.
- Trapped heat in overhead area may pre-heat surrounding materials, allowing for ignition to occur more easily.

Objective

- To develop an in-flight fire condition for the purposes of evaluating the melt-through performance of both metallic and composite structures.
- Collect heat dissipation and burn-through data for aluminum material under in-flight conditions.
- Collect heat dissipation and burn-through data for composite material under in-flight conditions.

Facilities

- **The tests described here will utilize the FAA Technical Center's Airflow Induction Facility.**
  - Subsonic wind tunnel
    - 5.5 foot diameter by 16 foot long test section
    - Airflow speed range of 200-650 mph
- **A test article was fabricated to simulate the crown-area surface of an aircraft with a fire in the cabin/overhead area**

FAA Airflow Induction Facility

High Speed Test Section

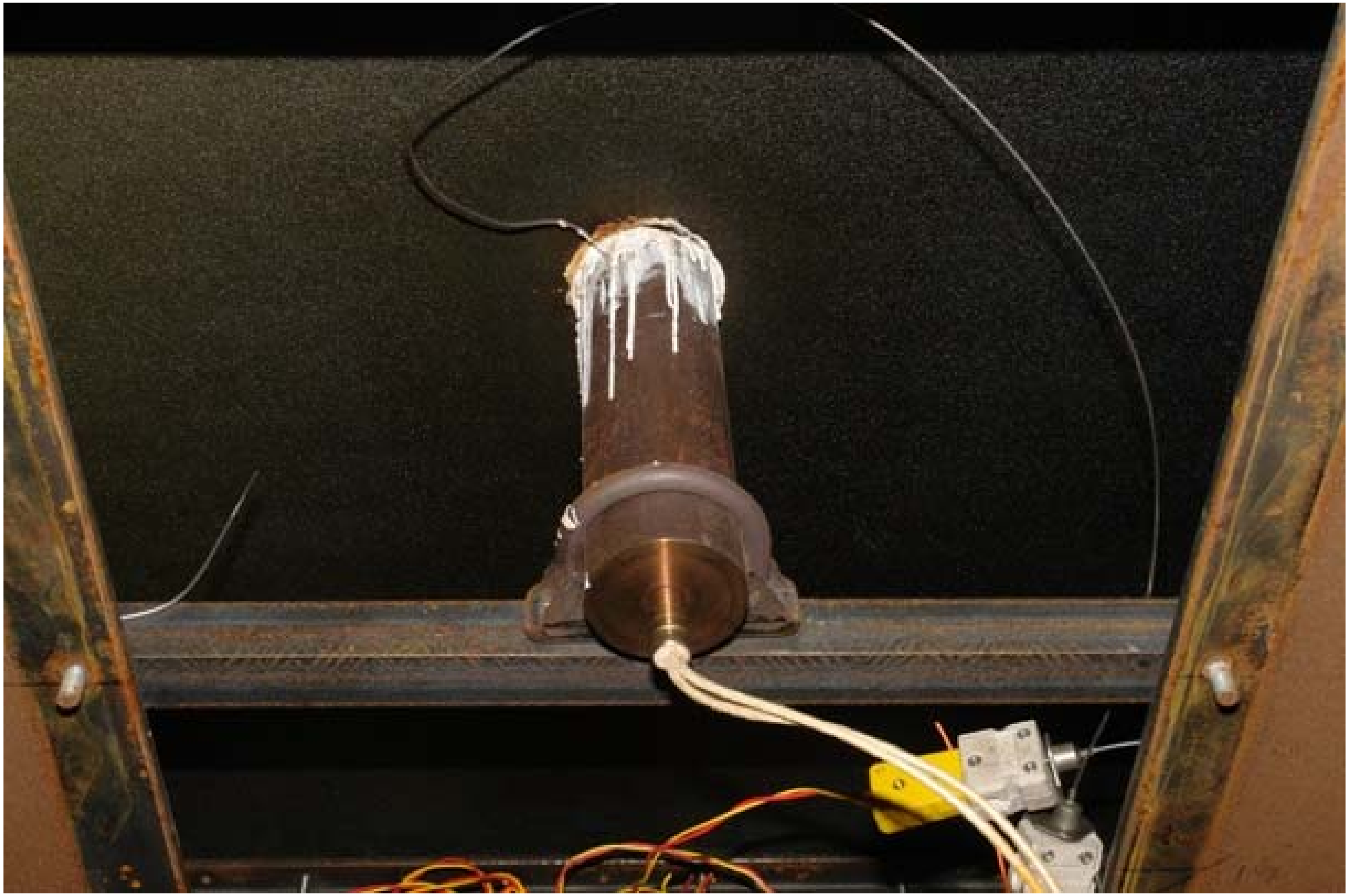
Test Design

- Construct long “ground plane” to smooth airflow over test section
- Replaceable test section located near rear of ground plane
- Construct aerodynamic faired “box” under test panel to hold heat / fire source
- Initial tests with electric heat source to determine heat transfer characteristics

Ground plane- use to smooth airflow over test panel, simulating top of aircraft fuselage

Faired Heat Source Test Chamber

Electric Heat Source Configuration



Test Design- Live Fire

- **Develop a fire source that can be operated with the wind tunnel in operation**
- **Size the fire intensity so that:**
  - Aluminum panel burns through under static (non-airflow) conditions
  - Aluminum panel does NOT burn through under in-flight (airflow) conditions

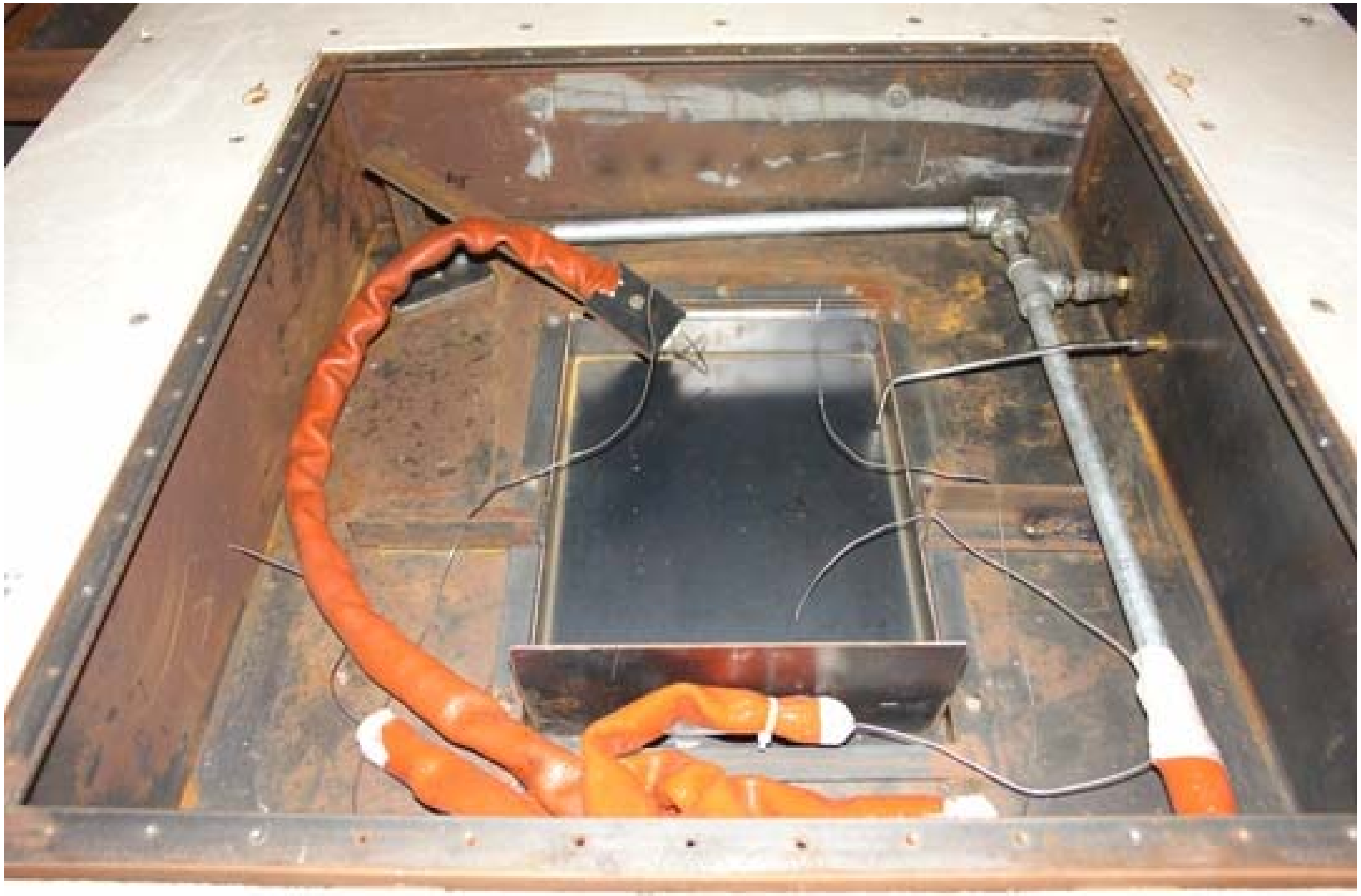
Fire Source Selection

- **Several fire sources were evaluated for this test scenario**
  - Jet fuel pool fire
    - Naturally aspirated
    - Boosted with compressed air
  - Propane burner
  - Oxy/Acetylene torch
    - Standard nozzle tip
    - Rosebud tip (s)

Fire Source Selection

- Both the jet fuel pool fire and the propane torch suffered from oxygen starvation within the confines of the test fixture
- The addition of a compressed air source to the fixture improved the performance
- Ultimately, the fires from these sources were not repeatable within a reasonable tolerance

Jet Fuel Pool Fire Configuration



Fire Source Selection

- **To eliminate the oxygen starvation within the test fixture, an oxygen/acetylene torch was selected as the fire source**
  – The standard nozzle was too narrow, producing a very hot flame that penetrated the aluminum test panel in under two minutes
  – The nozzle was replaced with a series of “rosebud” nozzles in an attempt to spread the flame over a wider area. This was partially successful.
  – The solution was to place a steel plate in the fire path, forcing the flame to spread around it.

Oxygen-Acetylene Fire Source

Live Fire Calibration

- **With the goal of aluminum burn through static and no burn through under airflow conditions, the following settings were varied:**
  - Acetylene pressure
  - Oxygen pressure
  - Mixture settings and resultant flame appearance
  - Distance between torch tip and test panel
  - Size of steel diffuser plate
  - Holes in steel diffuser plate
  - Location of steel diffuser plate

Live Fire Calibration

- **After much trial and error a set of conditions were established such that:**
  - Static tests with aluminum panels yielded repeatable burn through times of 9-10 minutes
  - Tests in a 200 mph air stream produced no penetrations

Instrumentation

- Interior panel temperature measured with two thermocouples, fixed to underside of test panel
- Panel topside temperature measured with FLIR infrared camera
- Flame temperature and heat flux
- Flame Visual characteristics monitored by video

Status

- **Test fixture capable of both electric and live fire heat sources.**
- **Calibration of FLIR infrared camera in progress.**
- **Test panels for both aluminum and composite materials are being fabricated.**