

# **A QUANTIFICATION STUDY OF THE AVAILABLE SAFE ESCAPE TIME (ASET) FROM A BOEING 737- 800 AIRCRAFT DURING AN IN-FLIGHT CABIN FIRE**

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# Speaker Profile

- **Joe Hart** BSc (Hons) MSc MIET MIFireE MSFPE AMEI
- Founder and CEO of the Delta Innovation Group
- Director and Head of Fire Engineering at Delta Fire Engineering
- Director and Head of R&D at Delta Research & Development
- Course Director and Chief Instructor at Delta Fire Training
- Vice President of the Institution of Fire Engineers Southern Branch
- BSc (Hons) Fire Engineering
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# Overview, Aims and Goals of Study

- This project aims to quantify the Available Safe Escape Time (ASET) from a Boeing 737-800 aircraft during an in-flight passenger cabin fire.
- This project is based on information provided by the Civil Aviation Authority (CAA) standard evacuation threshold of 90 seconds.
- The work applies the ASET/RSET methodology from the PD 7974-6 to an aircraft passenger cabin and comprehensively explores the fire safety provided within a commercial aircraft cabin.
- To achieve this a geometrically accurate model of a Boeing 737-800 aircraft is created within the CFD modelling software **PyroSim**.
- Various fire scenarios are considered within the 737-800, with these being based upon the review of case studies.
- The results which are created are compared with the CAA and FAA standard of 90 seconds that airlines must achieve to attain an operating licence.

# AEROFLOT flight 1492



## Brief Background

- 5th May 2019
- Moscow, Russia
- 41 fatalities
- 10 injuries
- Shortly after take-off the flight was involved in a lightning strike
- Emergency landing was necessary
- Aircraft weight exceeded maximum landing weight
- Subsequent attempted landing caused fuel spillage and ultimately the fire
- Full evacuation was prompted
- Evacuation slowed by passengers attempting to retrieve their luggage



# Uni Air Flight 873



## Brief Background

- 24<sup>th</sup> August 1999
- Hualien, Taiwan
- 1 fatality
- 27 injuries
- Turbulent landing led to disruption in over-head locker
- Contents of over-head locker included: flammable liquids and motorcycle battery
- Disruption led to rupture of bottle and subsequent flammable vapour was ignited by electrical arc from battery



# Jet2 Glasgow Evacuation



## Brief Background

- 19<sup>th</sup> October 2012
- Glasgow, Scotland
- 0 fatalities
- 17 injuries
- Jet2 flight aborted take-off
- Reports of 'misting' and 'strange-smell' in the cabin
- Decision made to evacuate aircraft despite ultimately no fire occurring
- Evacuation timed at 3 minutes and 38 seconds
- Evacuation time exceeds CAA and FAA guidance

# SwissAir Flight 111



## Brief Background

- 2<sup>nd</sup> September 1988
- Nova Scotia, Canada
- 229 fatalities
- 0 injuries
- In-flight fire causes crash and loss of life of everyone on-board
- Faulty wiring on the plane caused the fire
- Suggestion from the flight data suggests that the fire led to conditions on the aircraft become untenable
- Untenable conditions led to the aircraft crashing into the ocean



# Boeing 737-800

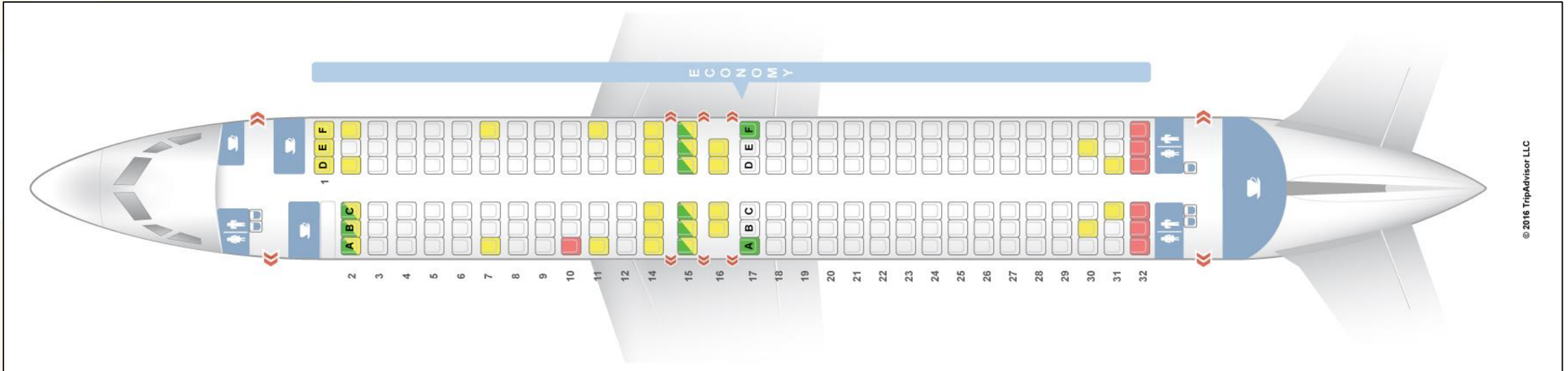


## Aircraft Overview

- Narrow bodied mid-range aircraft
- Most budget-friendly airlines who operate out of the UK and US feature numerous of these aircraft in their fleet
- Mass produced worldwide and considered one of the cheaper aircrafts to produce
- Until recently was the highest selling commercial aircraft of all time

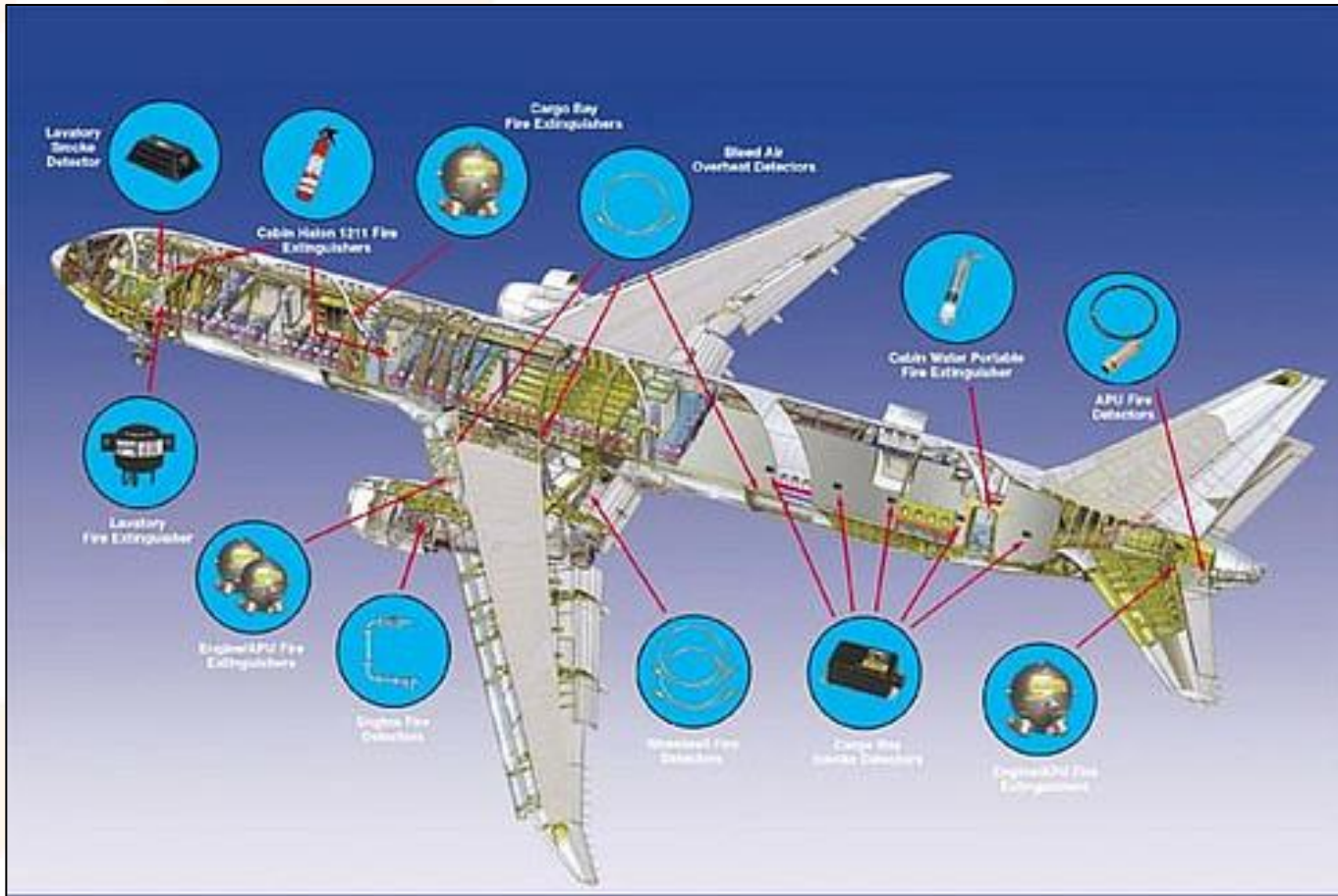


# Boeing 737-800 Seating Configuration



- Maximum seating capacity of 189
- If flight is at capacity minimum of 196 on-board (including flight crew)
- Configured in a 3-3 seating arrangement
  - 32 rows
- Typically, 8 emergency exits

# On-Board Fire Protection Systems



- An array of smoke detectors and alarms are present throughout the aircraft
- Suppression systems are seen in vital areas (APU & Engines)
- Cargo compartment sees detection and suppression systems in case of luggage fires
- Passenger cabin relies wholly on extinguisher usage

## **§25.803 Emergency evacuation.**

(a) Each crew and passenger area must have emergency means to allow rapid evacuation in crash landings, with the landing gear extended as well as with the landing gear retracted, considering the possibility of the airplane being on fire.

(b) [Reserved]

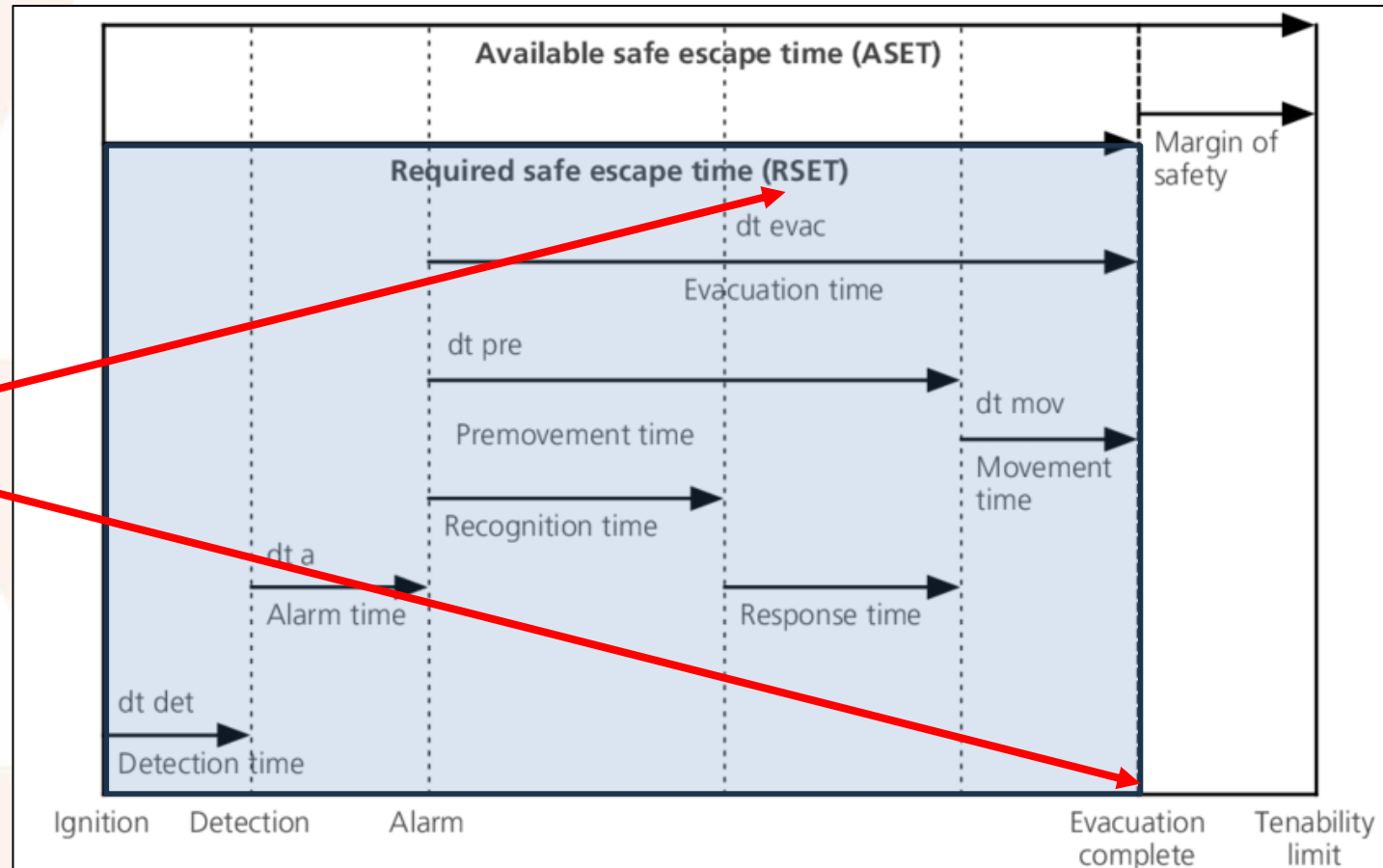
(c) For airplanes having a seating capacity of more than 44 passengers, it must be shown that the maximum seating capacity, including the number of crewmembers required by the operating rules for which certification is requested, can be evacuated from the airplane to the ground under simulated emergency conditions **within 90 seconds**. Compliance with this requirement must be shown by actual demonstration using the test criteria outlined in appendix J of this part unless the Administrator finds that a combination of analysis and testing will provide data equivalent to that which would be obtained by actual demonstration.

(d)-(e) [Reserved]

# ASET/REST

'RSET' is 90 seconds...

What are conditions like at 90 seconds?

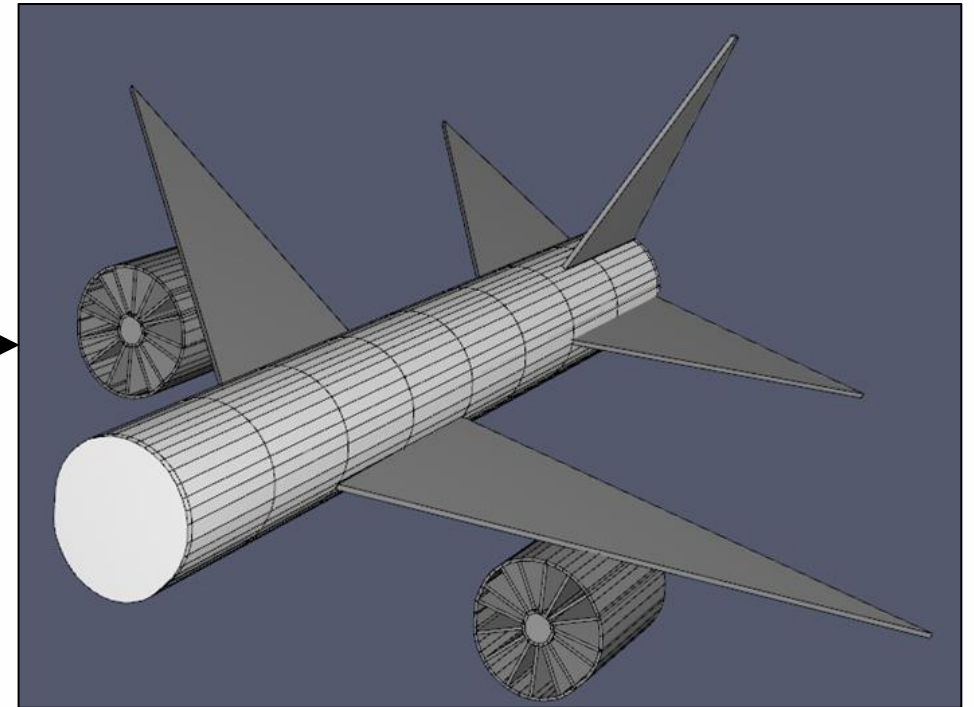


**ASET:** Available Safe Egress Time

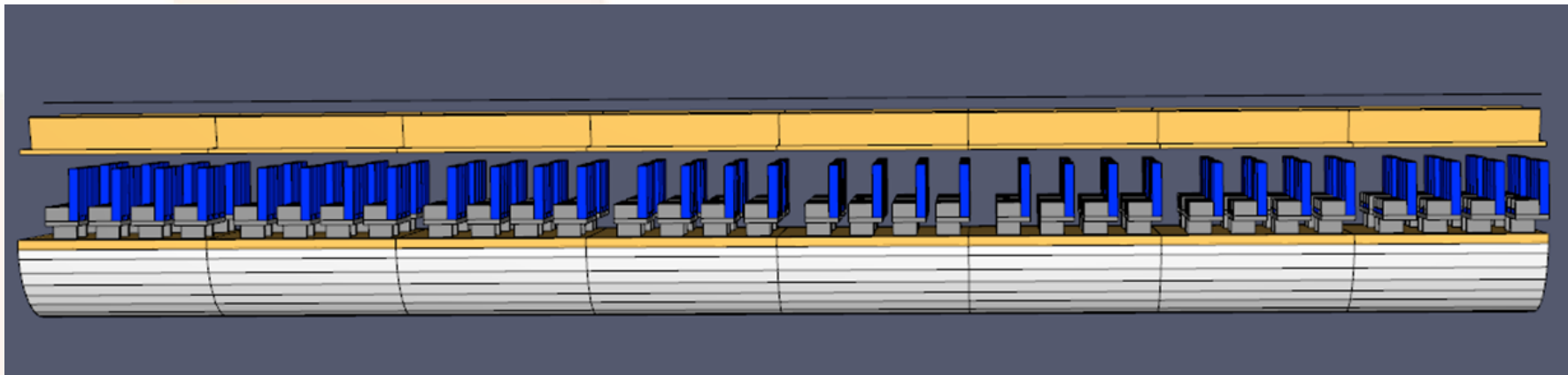
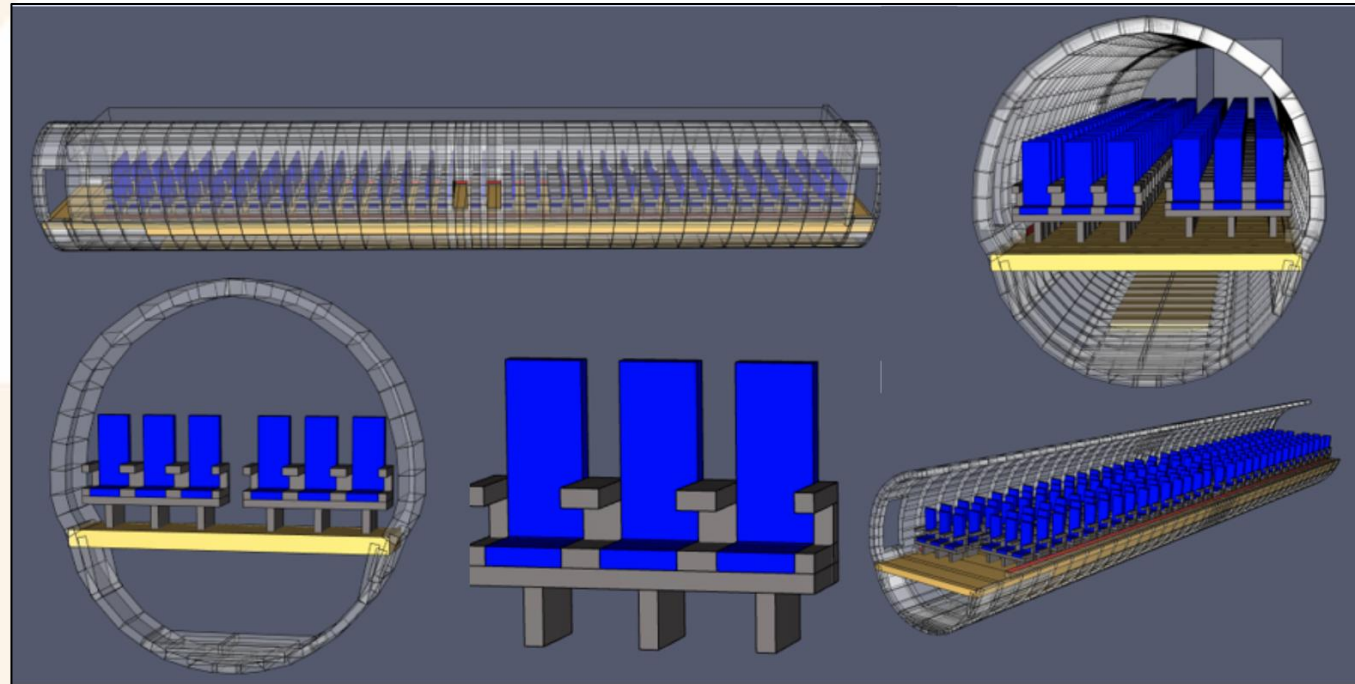
**RSET:** Required Safe Egress Time



# Computational Fluid Dynamics (CFD)



# CFD Modelling Process



# Modelling Scenarios

Model	Location	Ventilation	Heat Release Rate
1	Under Seat (Row 1)	Emergency Exit Doors	250 kw
2	Overhead Lockers (Row 1)	Emergency Exit Doors	400 kw
3	Under Seats (Row 15)	Emergency Exit Doors	250 kw
4	Overhead Lockers (Row 15)	Emergency Exit Doors	400 kw
5	Under Seat (Row 1)	Air Conditioning	250 kw
6	Overhead Lockers (Row 1)	Air Conditioning	400 kw
7	Under Seats (Row 15)	Air Conditioning	250 kw
8	Overhead Lockers (Row 15)	Air Conditioning	400 kw

# METHODOLOGY (MODELLING SCHEDULE)

**Case 1**



Fire Location: **ROW 1 SEAT**  
Ventilation: **AIR-CONDITIONING ONLY**

**Case 2**



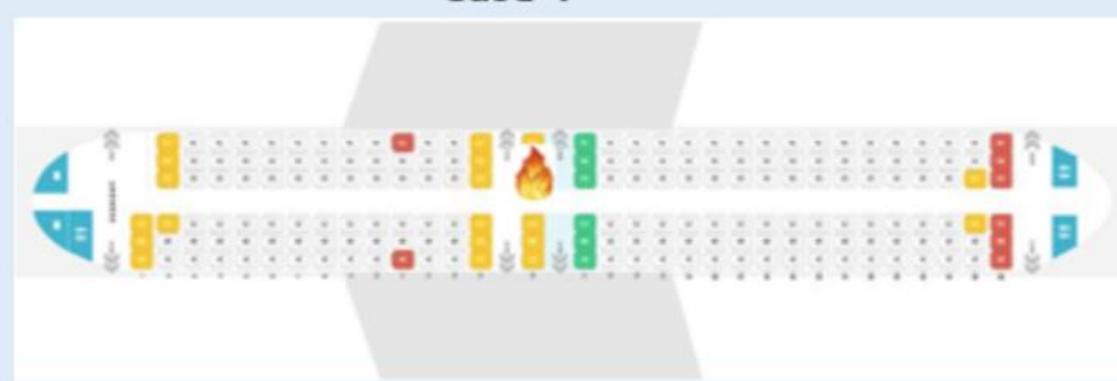
Fire Location: **ROW 15 SEAT**  
Ventilation: **AIR-CONDITIONING ONLY**

**Case 3**



Fire Location: **ROW 1 LOCKER**  
Ventilation: **AIR-CONDITIONING ONLY**

**Case 4**

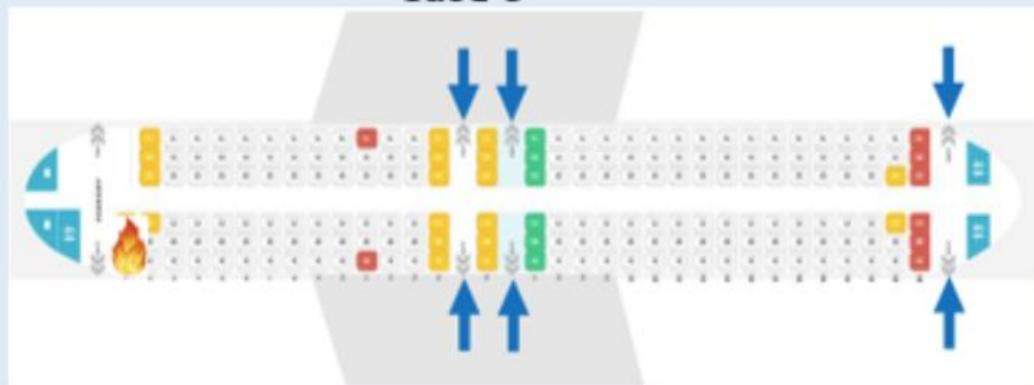


Fire Location: **ROW 15 LOCKER**  
Ventilation: **AIR-CONDITIONING ONLY**



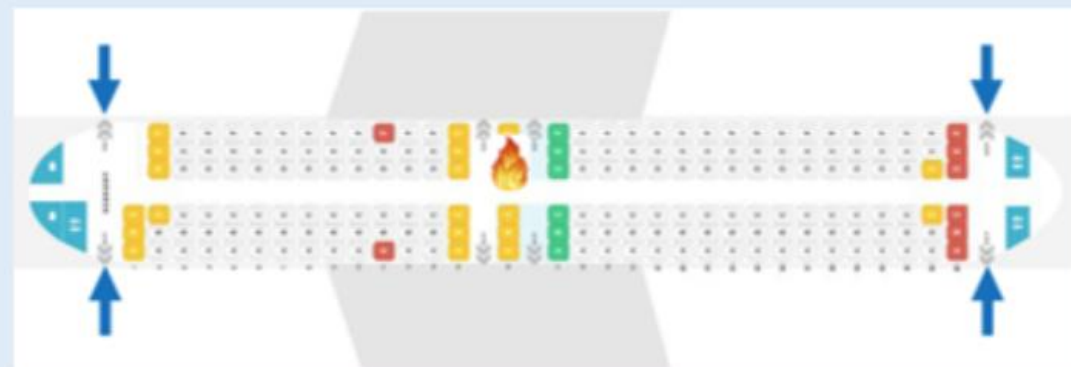
# METHODOLOGY (MODELLING SCHEDULE)

**Case 5**



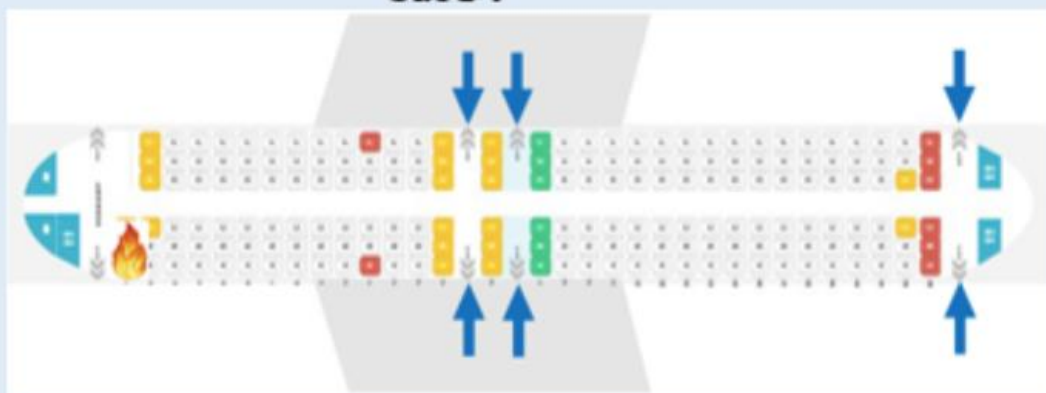
Fire Location: **ROW 1 SEAT**  
Ventilation: **DOORS OPEN**

**Case 6**



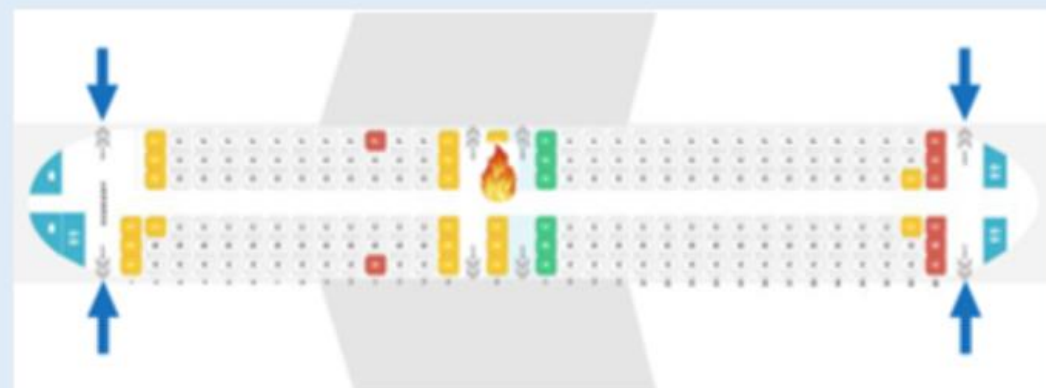
Fire Location: **ROW 15 SEAT**  
Ventilation: **DOORS OPEN**

**Case 7**



Fire Location: **ROW 1 LOCKER**  
Ventilation: **DOORS OPEN**

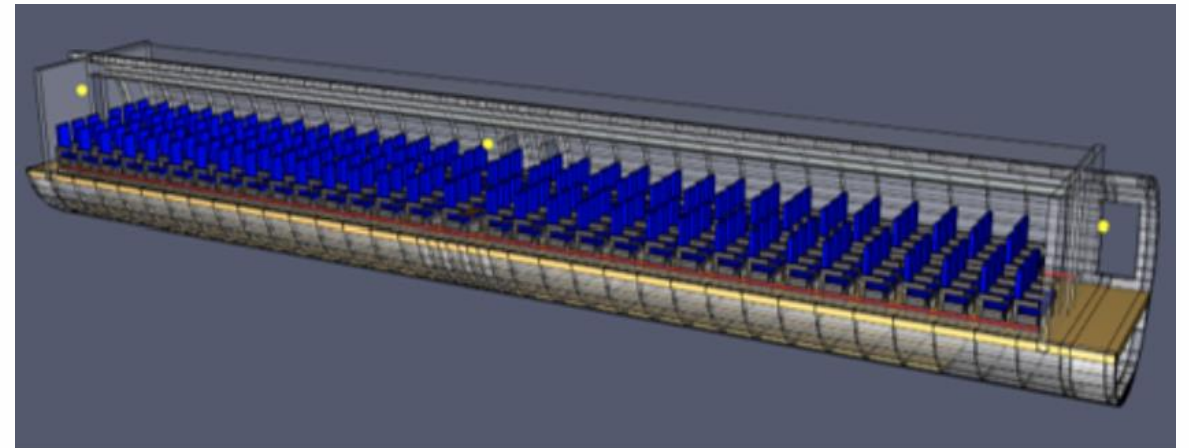
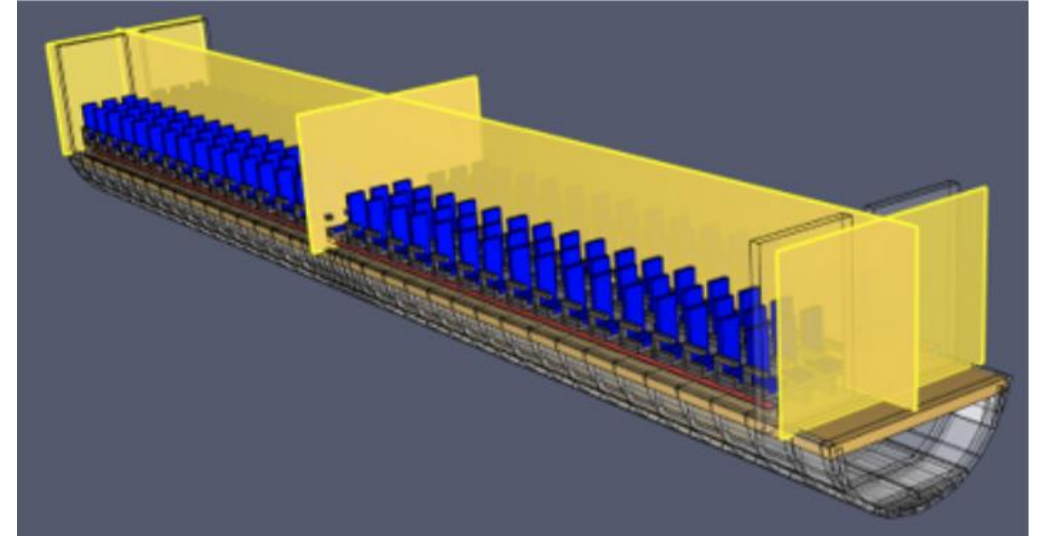
**Case 8**



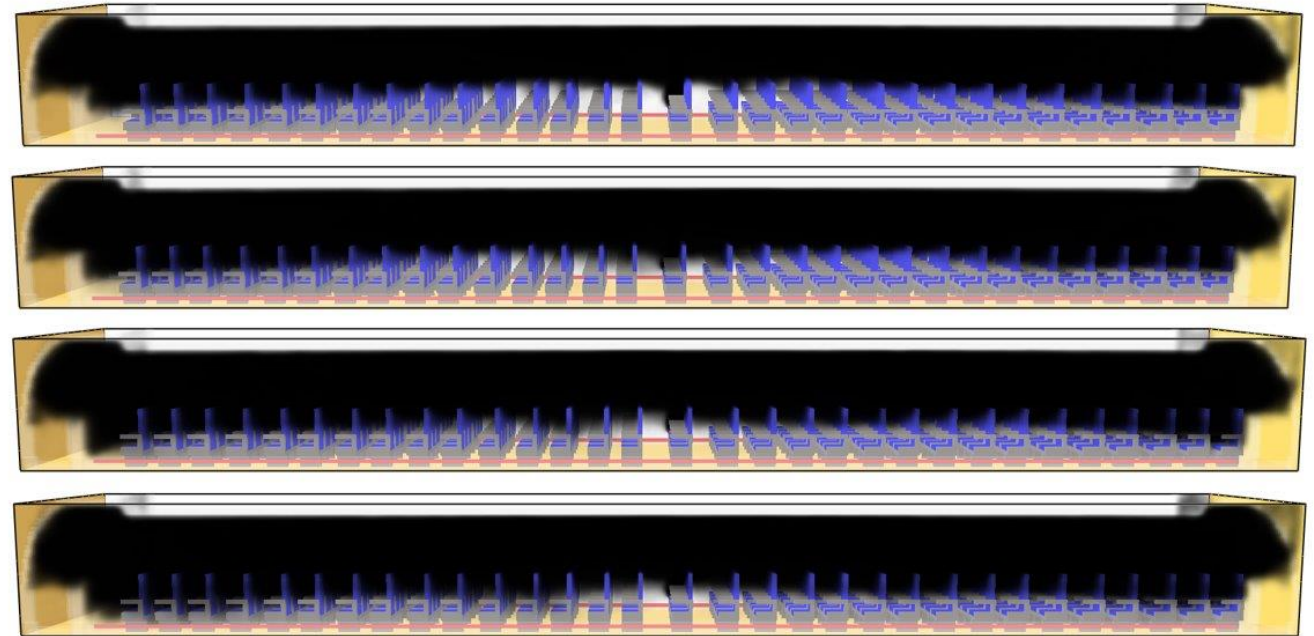
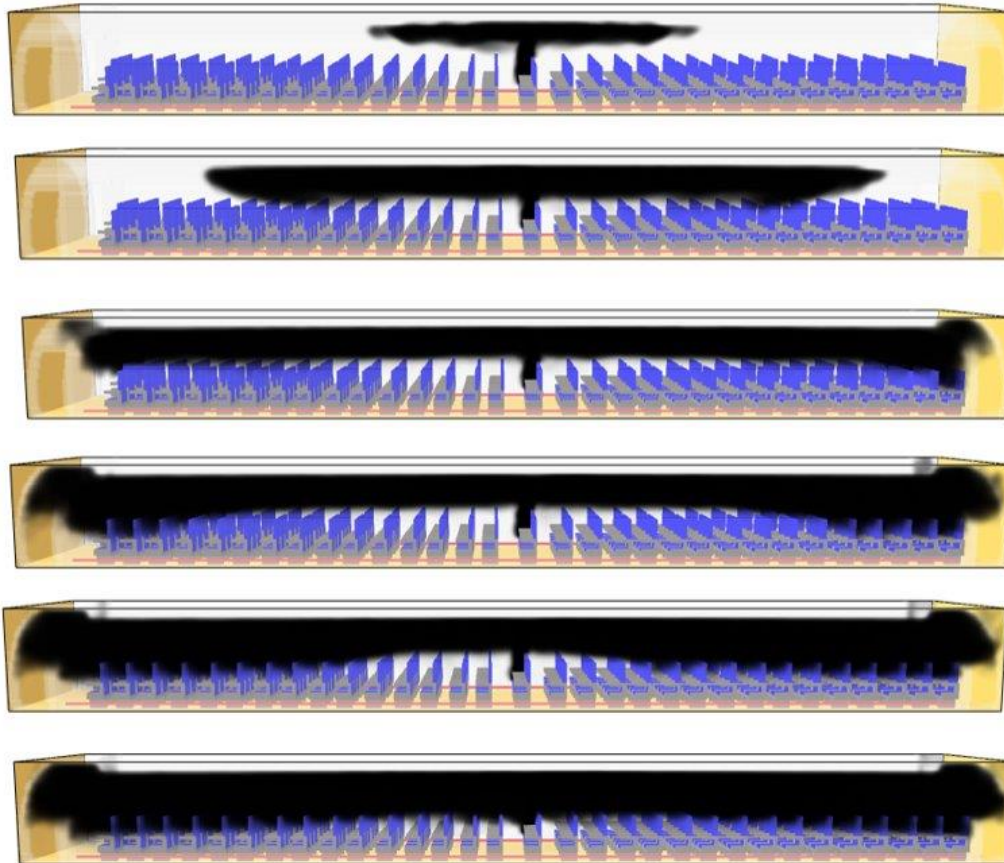
Fire Location: **ROW 15 LOCKER**  
Ventilation: **DOORS OPEN**

# Modelling Outputs

- Slice files and point source measurements are taken for:
- Temperature
- Visibility
- Velocity
- Toxicity
- Pressure
- Smokeview visualisation package is utilised for visual representation of results

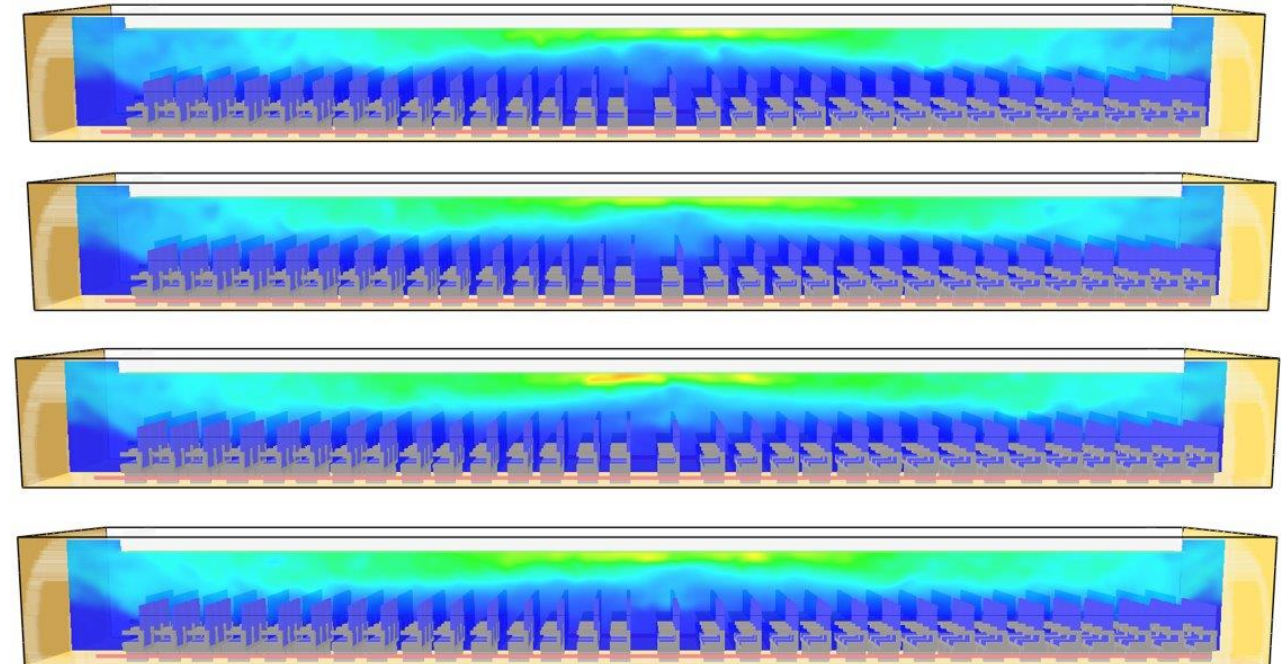
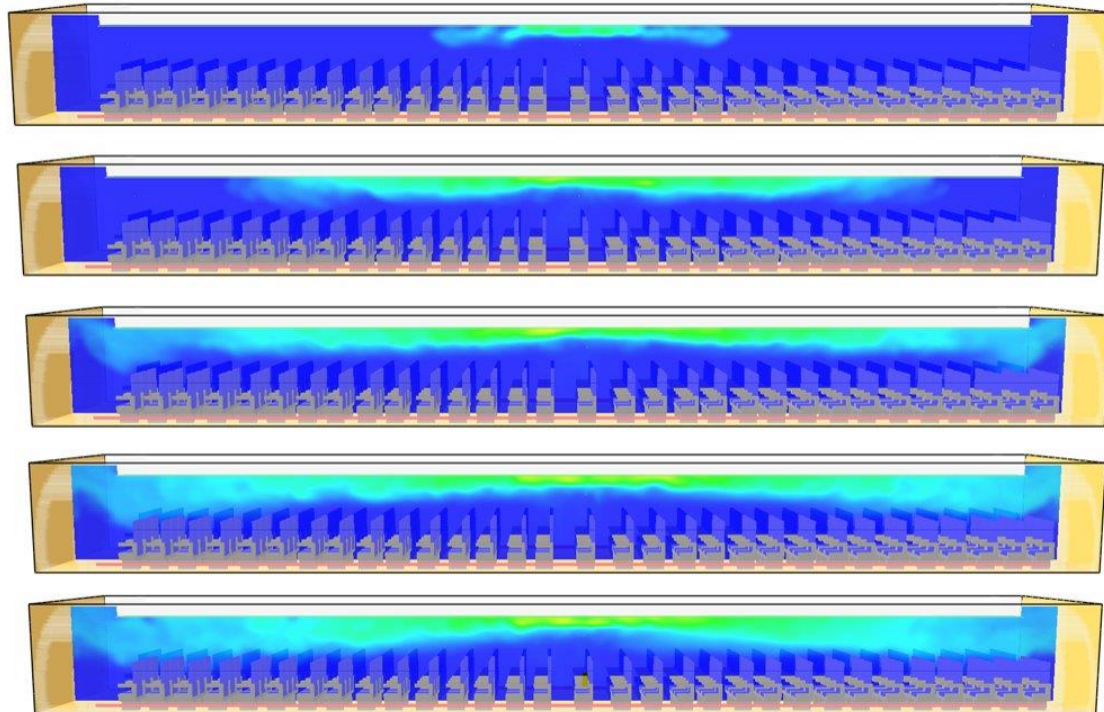


# Results - Visibility



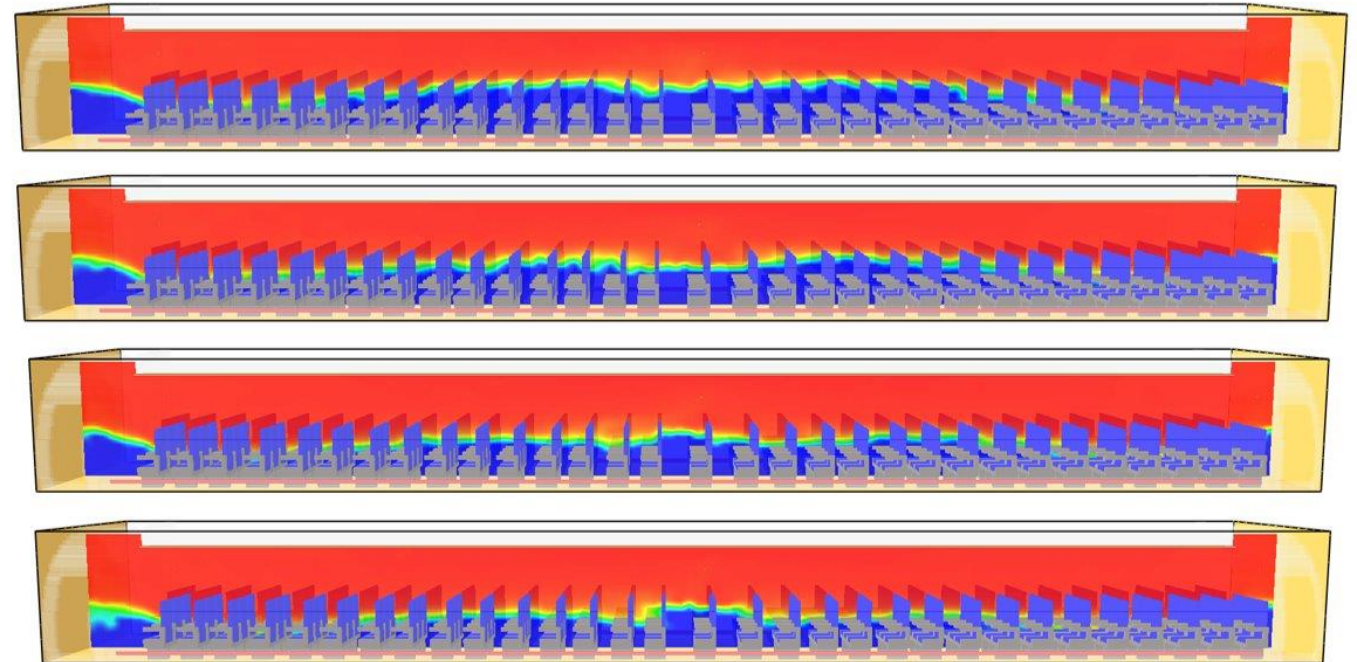
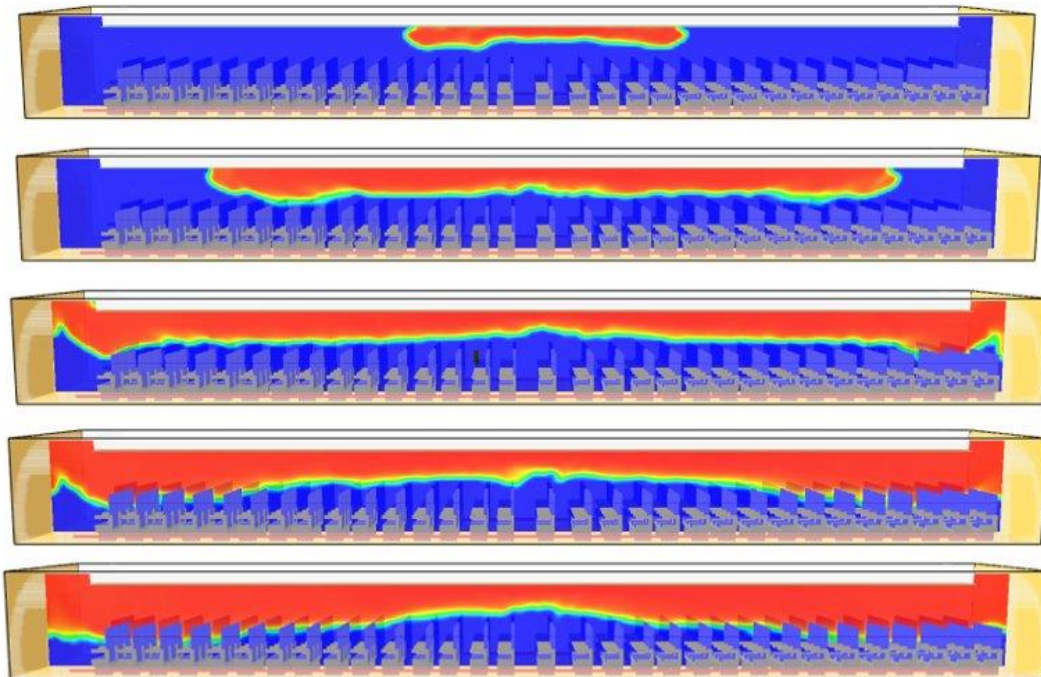


# Results - Toxicity





# Results - Temperature



# Quantitative Results

Model	Fire Location and Ventilation	ASET	Failure Criteria
Case 1	Under Seat (Row 1) Emergency Exit Doors	141 seconds	TEMPERATURE
Case 2	Overhead Lockers (Row 1) Emergency Exit Doors	88 seconds	TEMPERATURE
Case 3	Under Seats (Row 15) Emergency Exit Doors	158 seconds	TEMPERATURE
Case 4	Overhead Lockers (Row 15) Emergency Exit Doors	94 seconds	TEMPERATURE
Case 5	Under Seat (Row 1) Air Conditioning only	138 seconds	VISIBILITY
Case 6	Overhead Lockers (Row 1) Air Conditioning only	52 seconds	VISIBILITY
Case 7	Under Seats (Row 15) Air Conditioning only	142 seconds	VISIBILITY
Case 8	Overhead Lockers (Row 15) Air Conditioning only	78 seconds	VISIBILITY

# Conclusion and Further Research

There is correlation between failure mode and ventilation condition – where the emergency doors are opened, the *temperature* tenability is lost whereas for air-conditioning only cases it is *visibility/toxicity* that is lost.

In three of the eight cases tested the ASET is ***less than*** the 90 second threshold, demonstrating that conditions can become untenable prior to full evacuation

A more refined ASET/RSET model may be necessary to effectively design aircraft escape routes in fire





# Further Research

Future work will look at mitigation measures and refining the fire sizes for fires involving passenger luggage

Delta R&D are currently investigating the effect of emollient cream on fabrics and material dripping properties from overhead storage compartments

The live fire test data will be built into the CFD models and tested in the coming months

