Effect of Fuel Load on Fire Dynamics in a Very Large and Open-Plan Compartment: x-TWO experiments

Dr. Mohammad Heidari

m.heidari@cerib.com

CERIB ARUP

IMPERIAL HAZELAB

Imperial College London

E. Rackauskaite, E. Christensen, M. Bonner, S. Morat, H. Mitchell, P. Kotsovinos, P. Turkowski, W. Wegrzynski, P.Tofilo, G. Rein

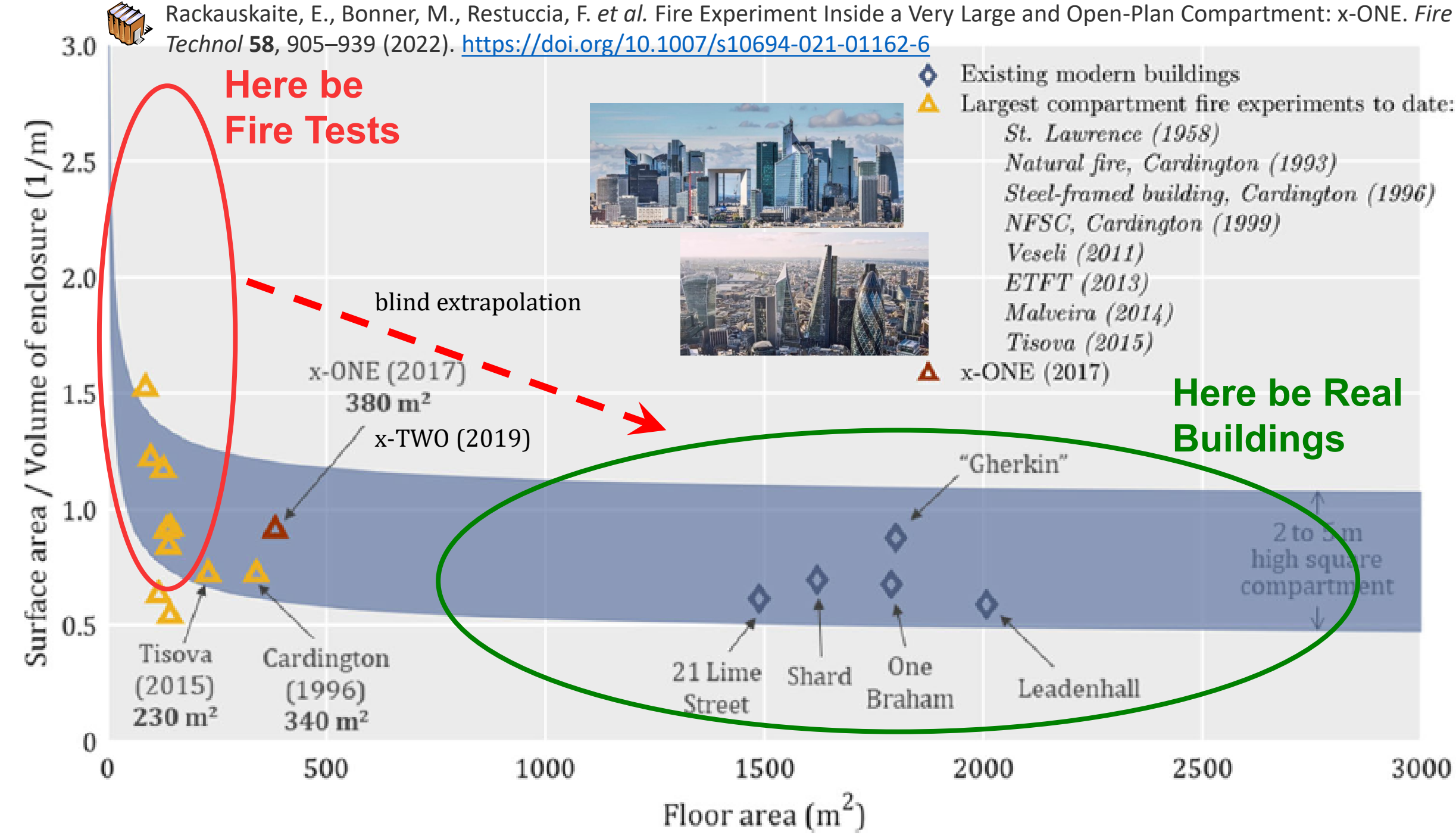

NIST

Modern infrastructure: Large open plan spaces


2A + P/A


Alfonso Correas

Rackauskaite, E., Bonner, M., Restuccia, F. *et al.* Fire Experiment Inside a Very Large and Open-Plan Compartment: x-ONE. *Fire Technol* **58**, 905–939 (2022). https://doi.org/10.1007/s10694-021-01162-6



x-ONE and x-TWO Experiments – Aims

- To capture experimentally a natural fire in a large enclosure (~380 m^2)
  - Solid wood fuel
  - Local ignition
  - Natural fire propagation

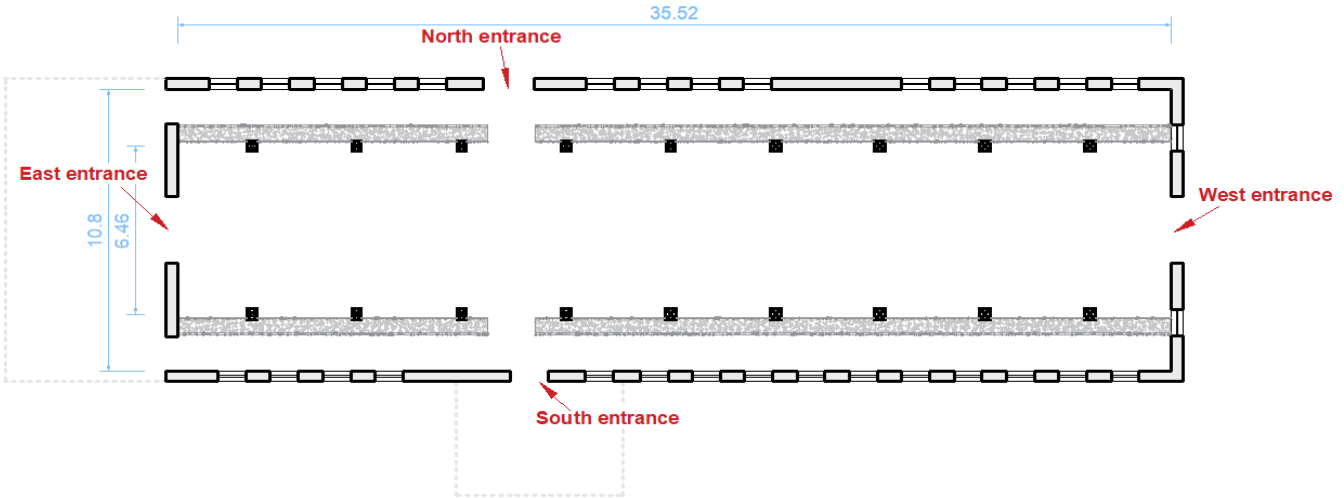
- Measure basic fire characteristics:
  - Fire dynamics (visual observations)
  - Spread rates
  - Temperatures
  - Leading and trailing edge
  - To understand the impact of fuel load on the temperature, fire duration, spread rate, and flame height in large compartments (x-TWO)

Heidari M. Travelling Fires Methodology and Probabilistic Design of Structures. Imperial College London; 2021. https://doi.org/10.25560/99999

The Building – ‘OBORA’

Located in a rural area within Warsaw West County in Poland.

- Concrete farm building
- Open plan section floor print ~380 m^2
- 10.8 m x 35.5 m x 3.10 m
- 6 door openings (5 open during x-TWO)
- 31 windows (30 open during x-TWO)



Fuel Load Design

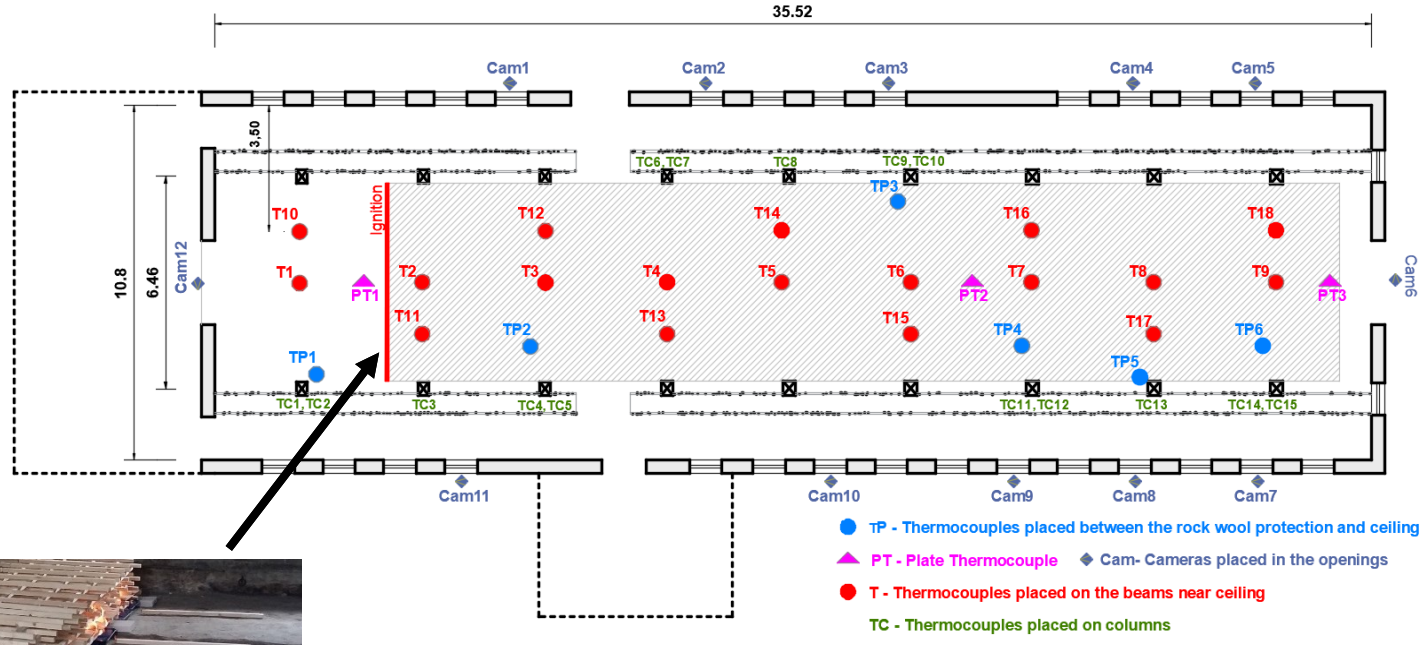
- **Based on:**
  - Previous large-scale experiments (Tisova, x-ONE)
  - Research on burning rates and fire spread across different wood crib arrangements

Harmathy (1972)
Heskestad (1973)
Thomas (1967)

- Continuous wood crib ~ 175 m^2, 3 cm x 3 cm x 100 cm
- Moisture: 9.3%-9.6%
- Fire load density : x-ONE (370 MJ/m^2) x-TWO.1 (355 MJ/m^2), x-TWO.2 (250 MJ/m^2)

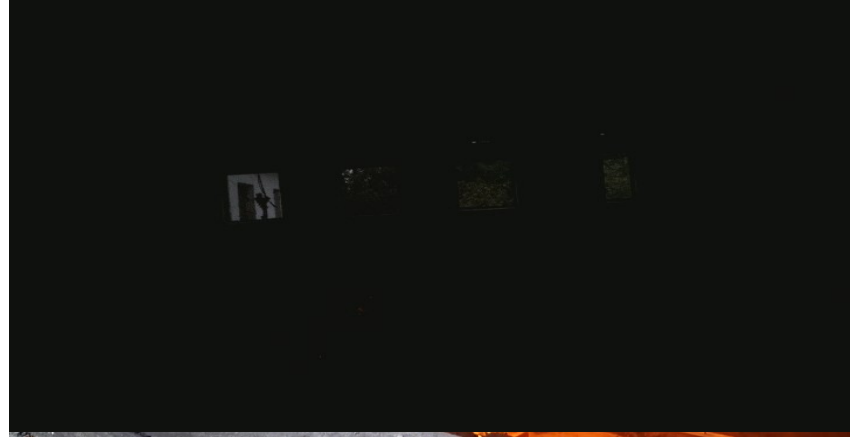
Instrumentation

- 13 Raspberry-pi cameras
- Visual cameras, go-pro, drone footage
- IR cameras
- Weather station
- **39 thermocouples**

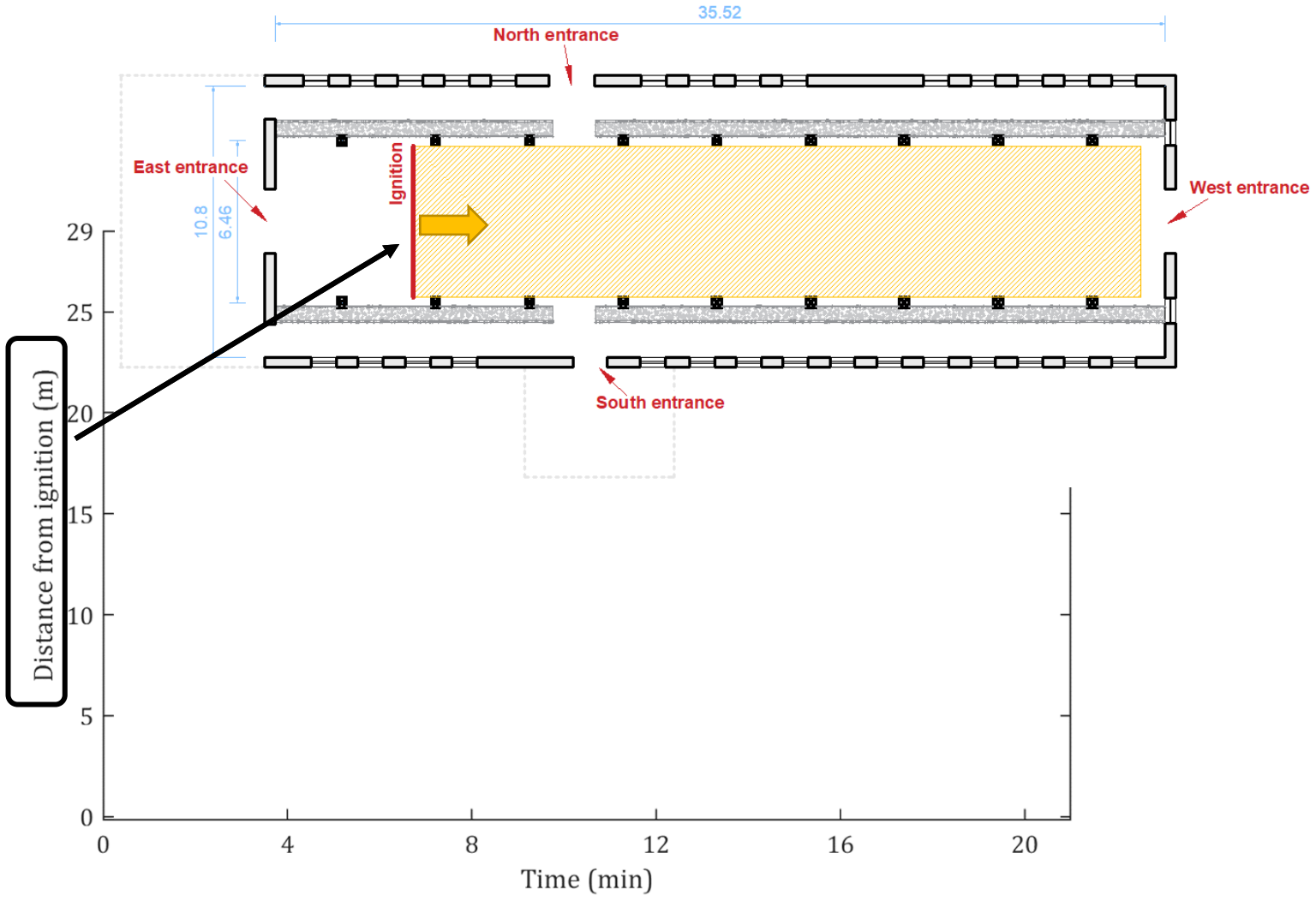


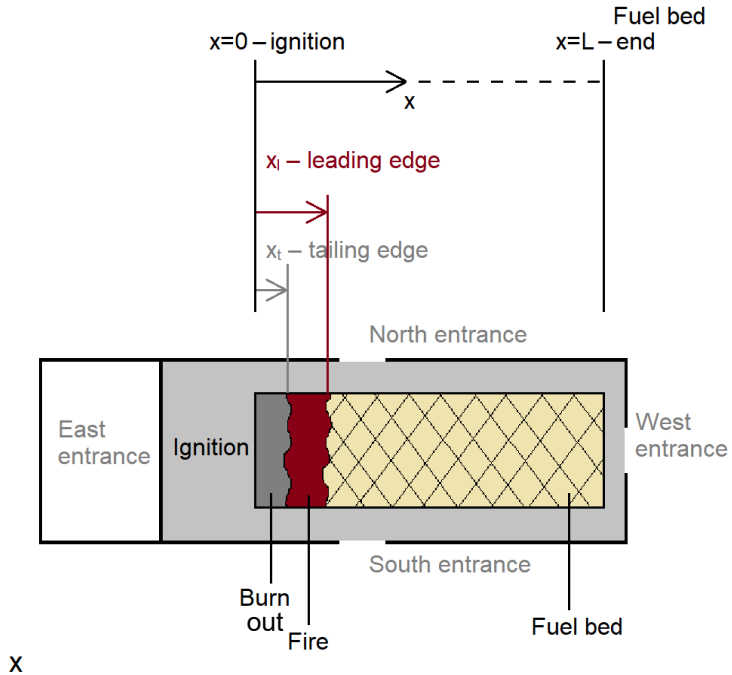
Ignition

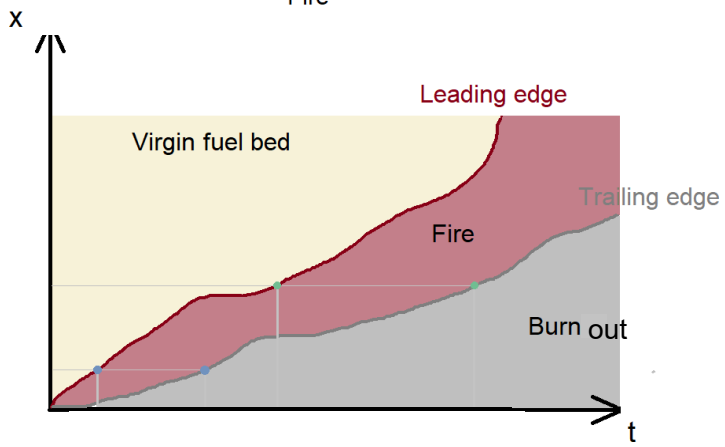
X-TWO Experiment



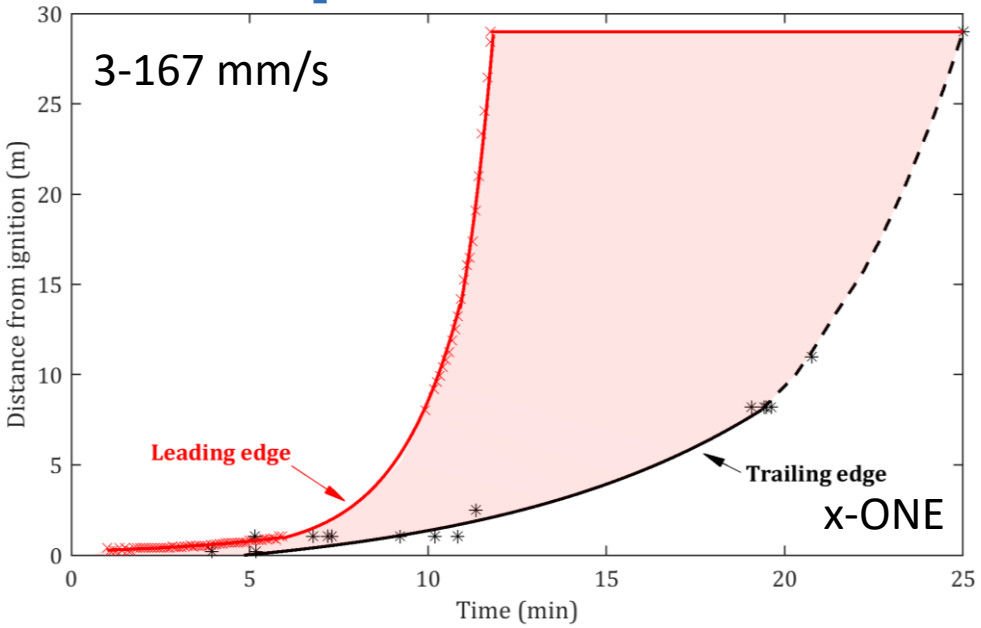
Fire spread

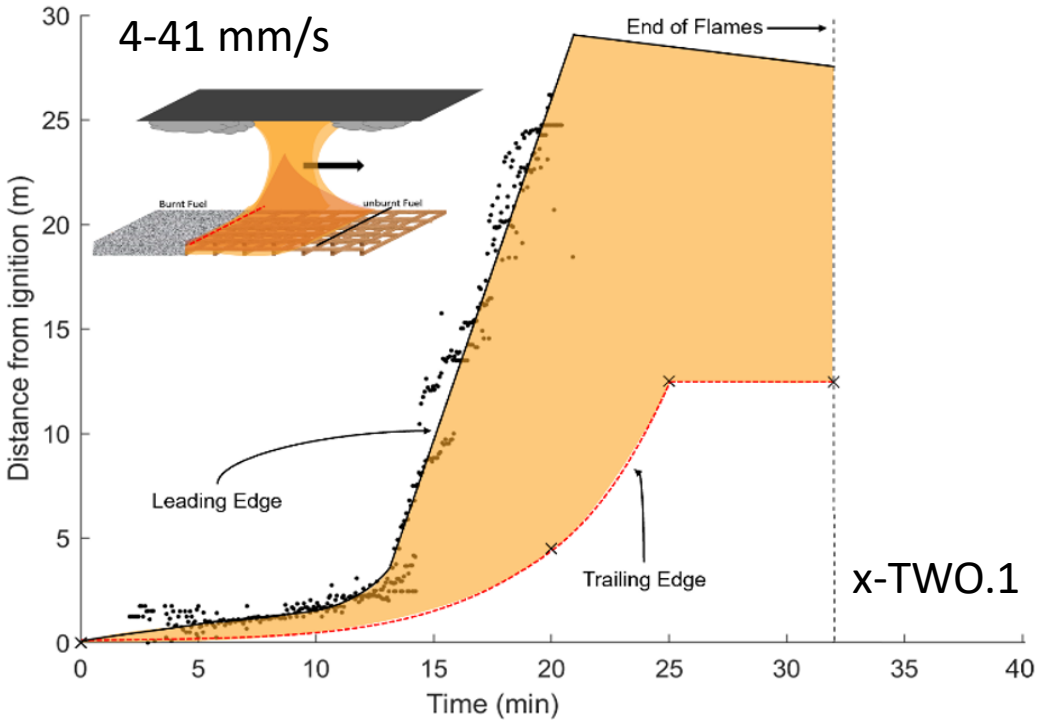

35.52
North entrance
East entrance
Ignition
West entrance
South entrance
10.8
6.46
Distance from ignition (m)
Time (min)
0
4
8
12
16
20
0
5
10
15
20
25
29

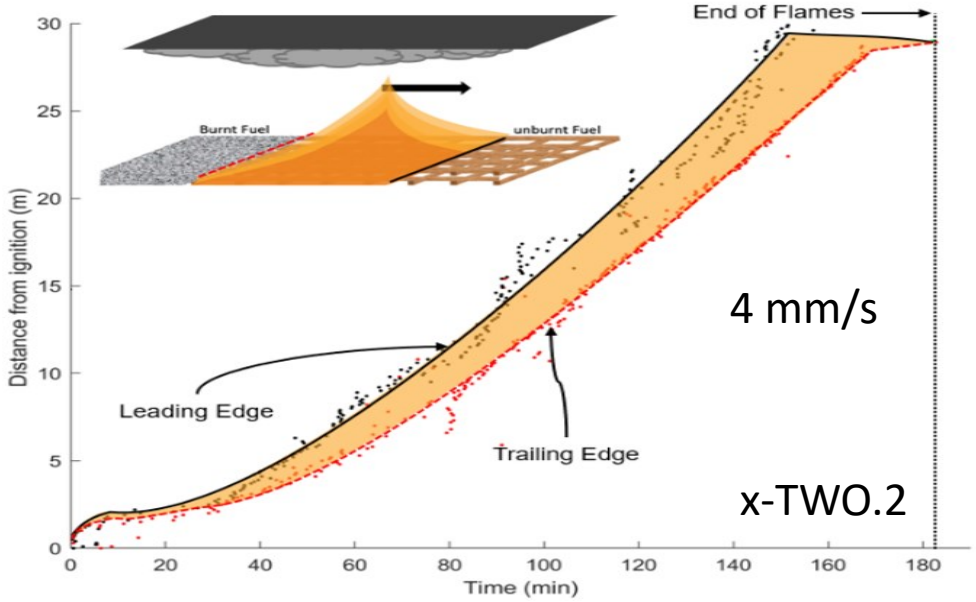

x=0 – ignition
Fuel bed
x=L – end
x
x_l – leading edge
x_t – tailing edge
North entrance
East entrance
Ignition
West entrance
South entrance
Burn out
Fire
Fuel bed


x
Leading edge
Virgin fuel bed
Trailing edge
Fire
Burn out
t

Fire spread



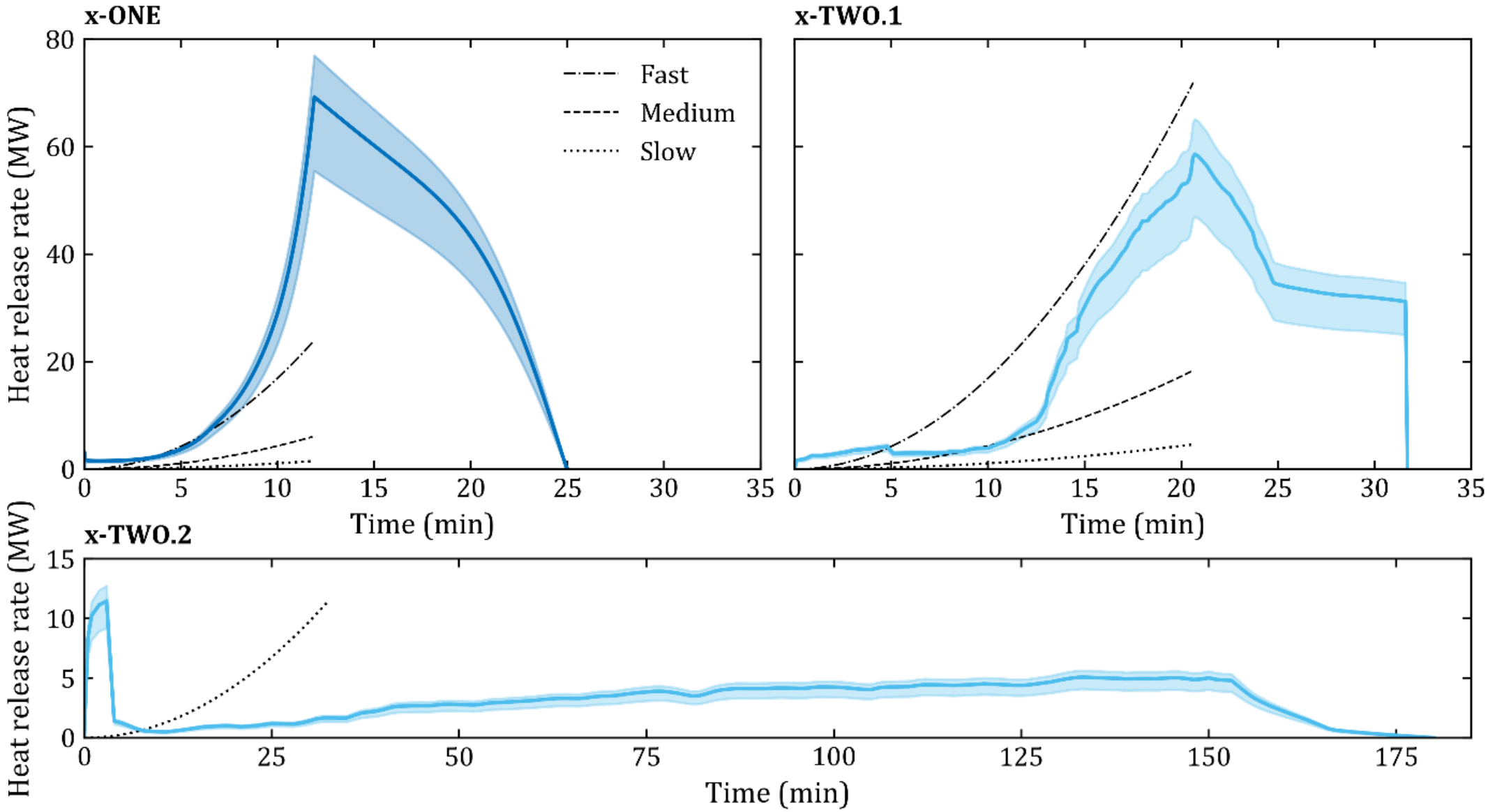




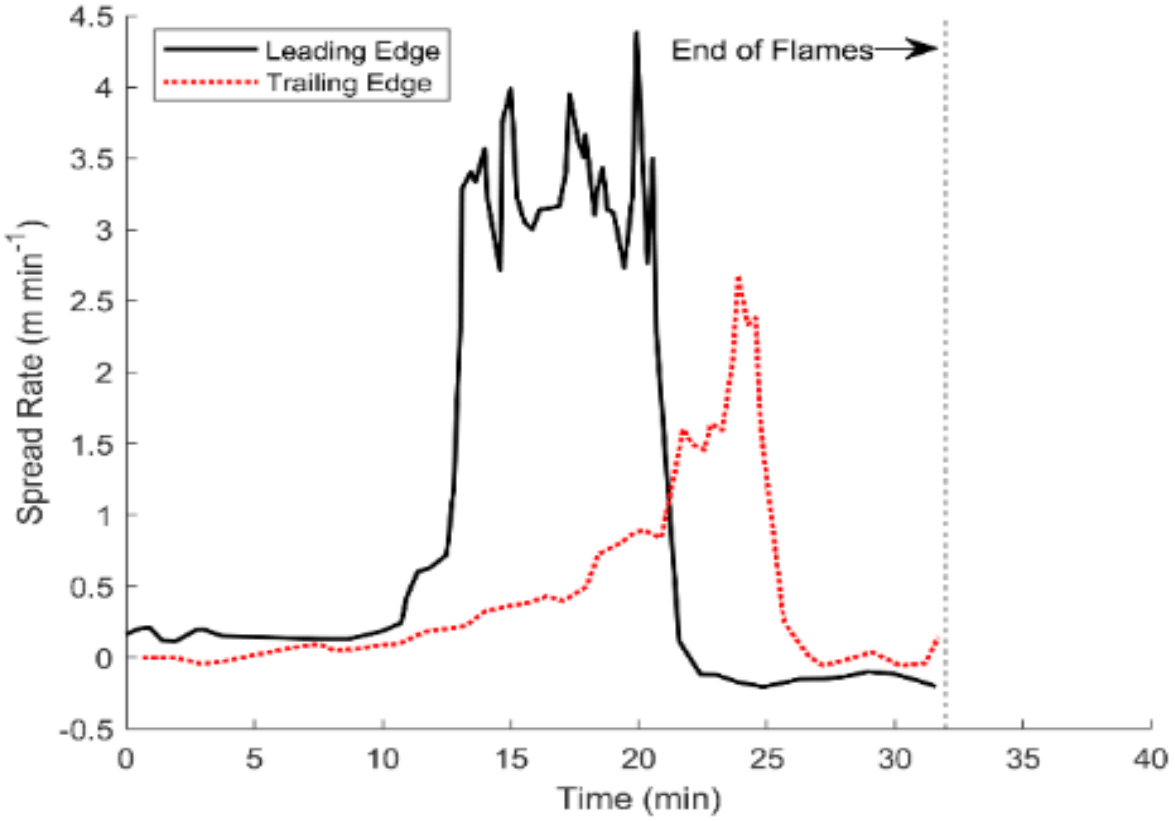
- The fire **did not burn uniformly** but continuously travelled along the compartment
- The fire did not transition to flashover but progressively **accelerated** from one end to the other

Heidari, M, Rackauskaite, E, Bonner, M, Christensen, Eirik, et al. Fire experiments inside a very large and open-plan compartment: x-TWO. 11th International Conference on Structures in Fire (SiF2020), https://doi.org/10.14264/b666dc1

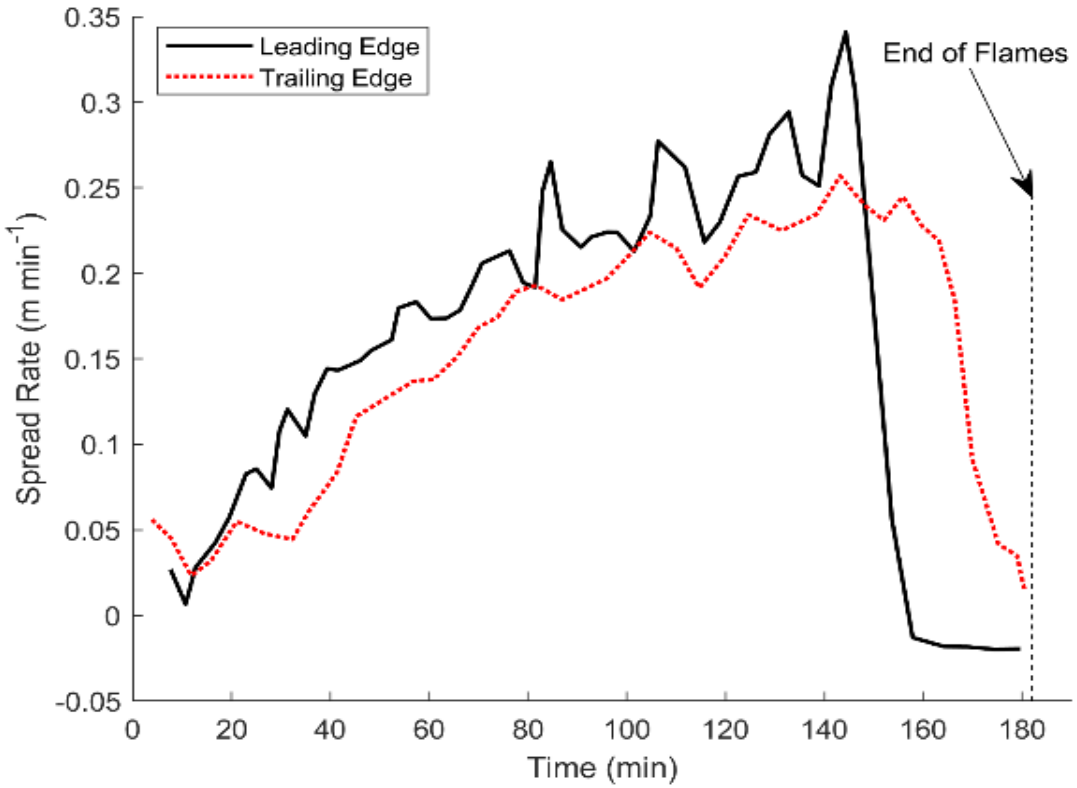
Heat Release Rate



Fire spread



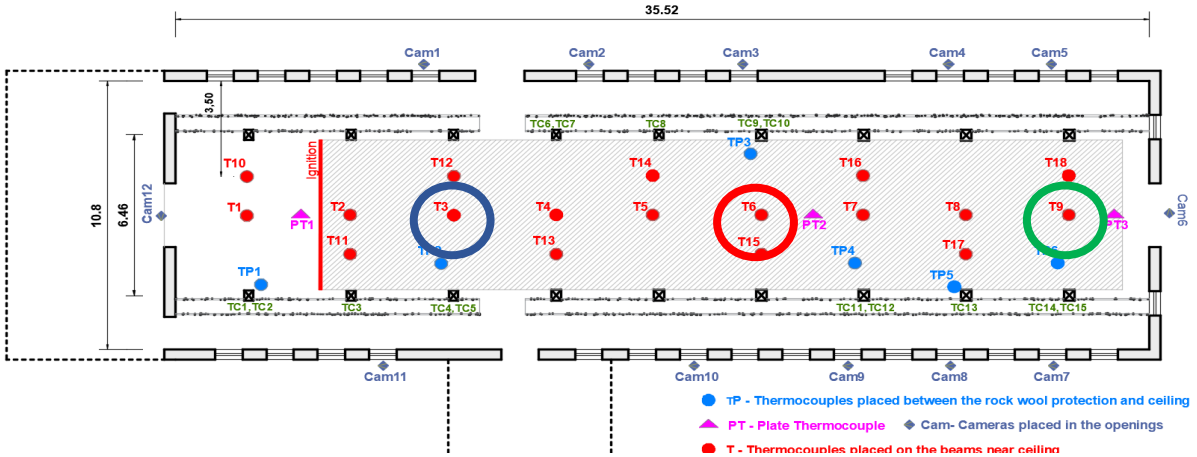
x-TWO.1

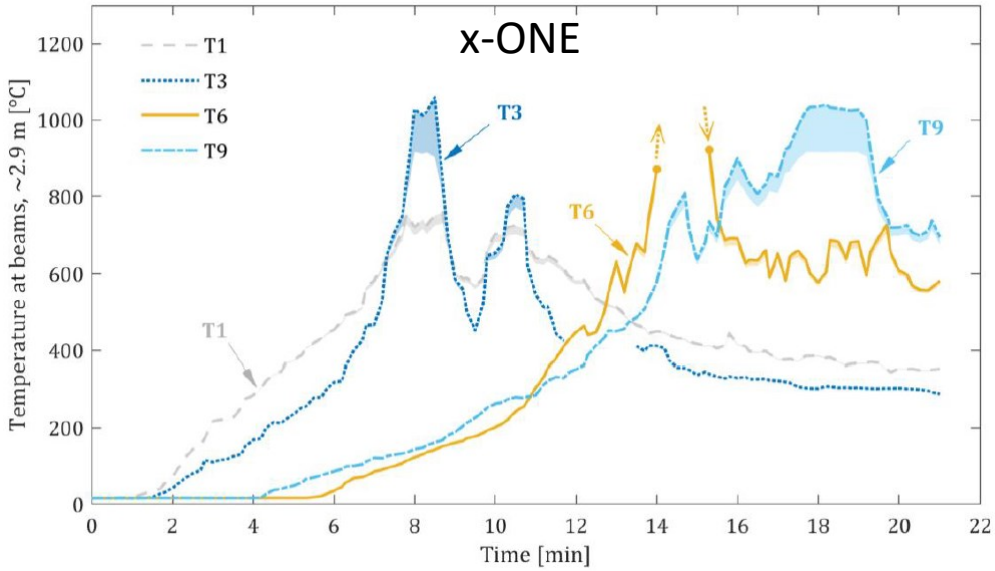


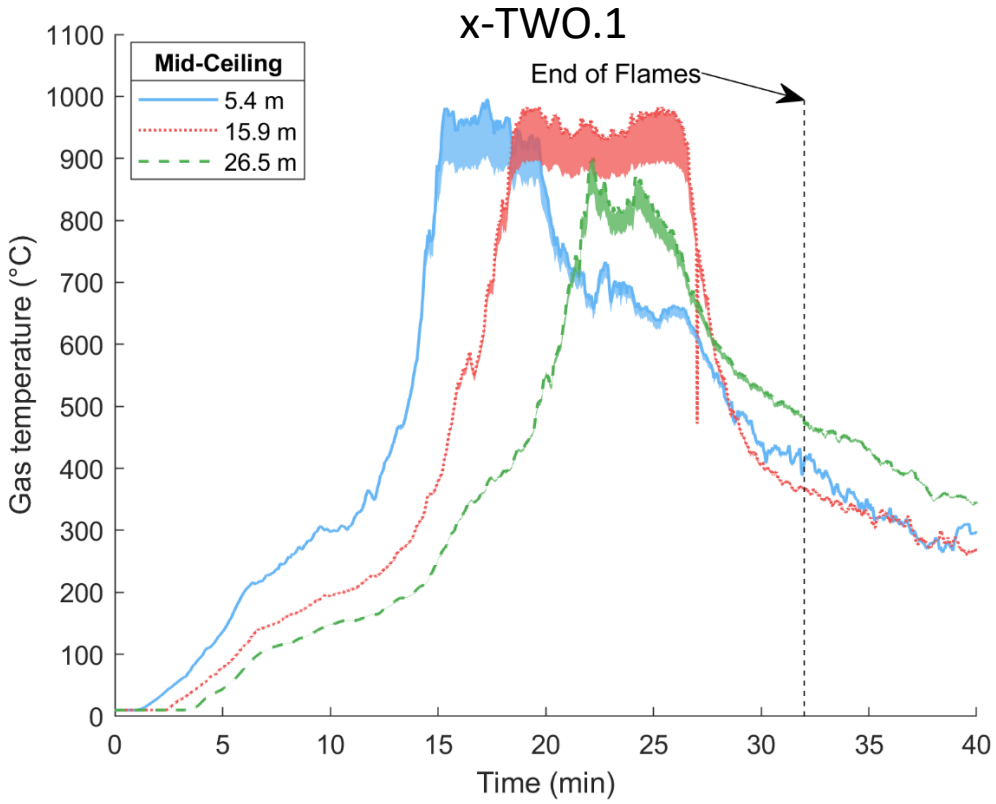
x-TWO.2

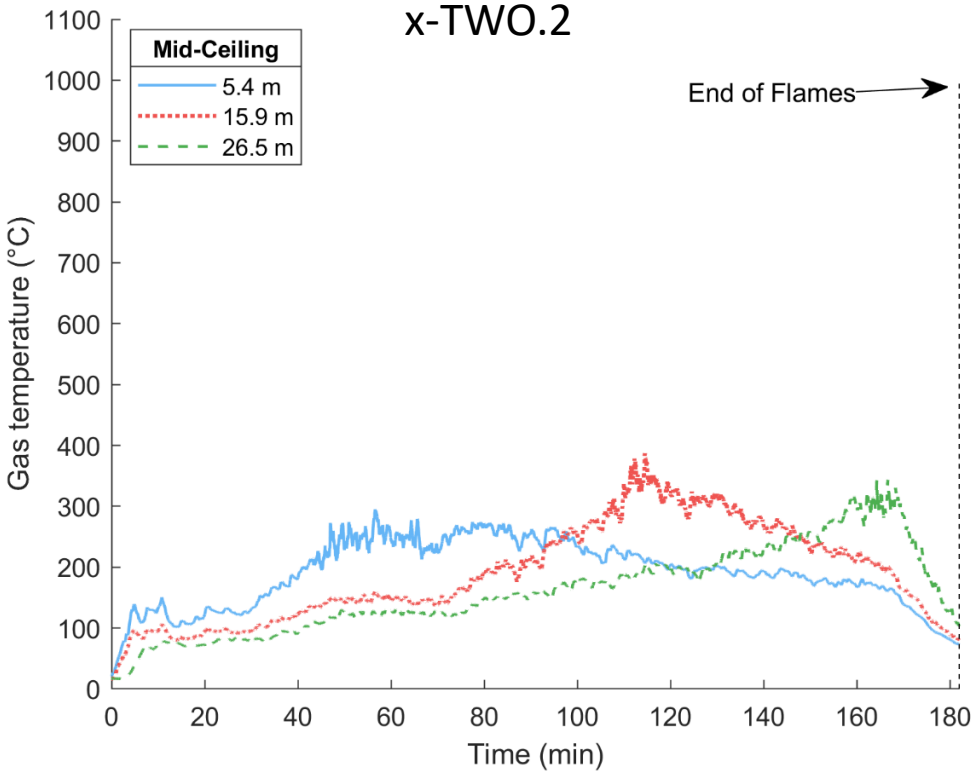
- A function of the fuel load density when the ventilation condition is unchanged

Thermocouple measurements









Conclusions

- x-ONE and TWO – the experiments captured naturally travelling fires with distinct leading and trailing edges in a large enclosure (~380 m^2)
- Fire did not burn uniformly but continuously travelled along the compartment
- Fire did not transition to flashover but progressively accelerated from one end to the other end
- The temperature field measured was not uniform but highly non-uniform, varying in space and time
- The spread rate of the fire is not always constant as is assumed in travelling fire methodology but was in fact gradually increasing.
- The accelerating nature of fire is likely related to the fuel load and its arrangement.
- Further experiments are required to understand the impact of other parameters (i.e., the compartment area, available ventilation, etc)

Thank you!