Fire safety engineering modelling problems of underground facilities

Rome, 3 march 2011
Rescue in Underground Facilities

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In my speech

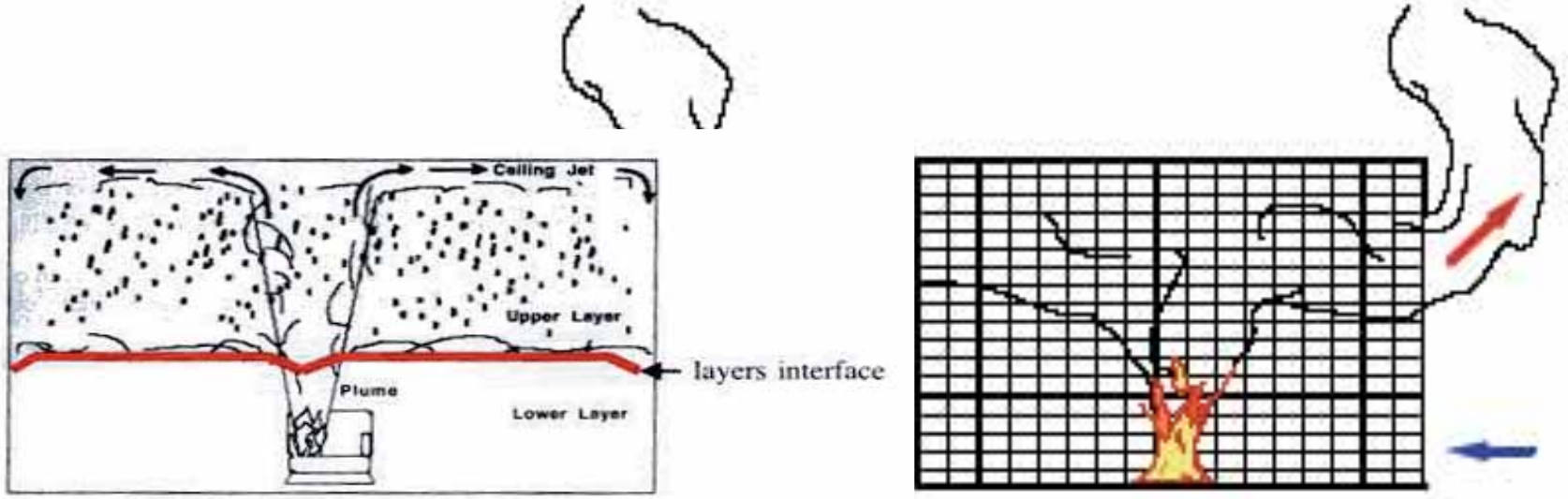
- Problems and (possible) aid..... CFD
- Internal and external CFD parameters
- *Colorful* Fluido Dinamics ?????
- Some examples..

- *Some references:*
- *Kai Kang - Daniel McNamee - Passanger rail vehicle fire models - Fire&Safety magazine - fall 2010*
- *Dr. Anja Hofmann - BAM - Five - fire in Vehicles proceedings - 09-2010- Gotheburg*
- *Dalmarnock fire tests proceedings- University of Edinburgh 2006-2007*
- *Leander Noordijk, Tony Lemaire - Modelling of fire spread in car parks - Fire&Safety magazine - fall 2010 fall 2010*
- *David Tonegran, Marcus Ryber - Increased quality and reduced uncertainty when using FDS.*

fire safety vehicle modelling - different perspectives

- *Safe evacuation of on board passengers*
- *Impact of the fire on environment (tunnel, parking lot, station..) during passenger evacuation*
- *Structural impact of the fire on environment (tunnel, parking lot, station..)*

Zone to Field Models

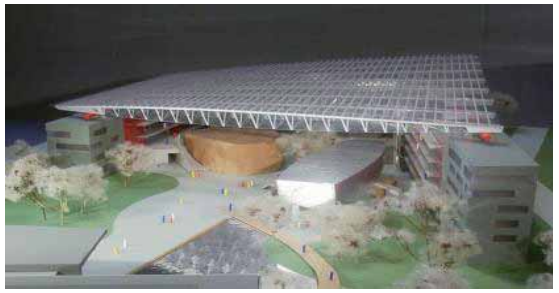


NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

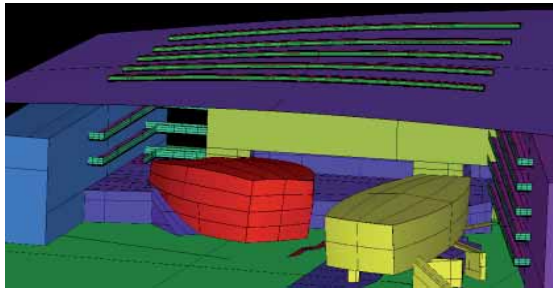
CFD Modeling

CFD = Computational Fluid Dynamics

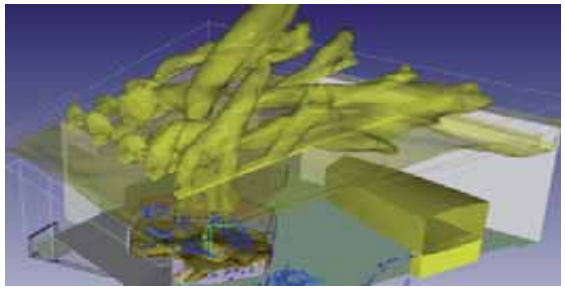
- Geometry model with details
- Generation of calculation mesh (e.g. 500’000 – 5‘000’000 cells)
- Transport equations are solved
- Initial and boundary conditions specified
- Interpretation of results
- Make recommendations for end-user



Geometry



Grid generation, boundary conditions



Result

Internal parameters of CFD models

- Numerical Methods
  - convergence
  - stability - sensitive analisys
  - mesh - cells dimensions
  - .....
- Validation (ex. FDS)
  - created for industrial buildings
  - well ventilated fires
- Designating a Fire (ex FDS)
  - only one gaseous fuel - mixture fraction model

External parameters of CFD models

- Geometrical
  - dimension
  - ventilation
  - boundary conditions
- Thermophisics
  - conductivity
  - density
  - specific heat
  - .....
- Designating a Fire (ex FDS)
  - HRR, combustible definition, mass loss,.....

Burning process and fire

- Volumetric fires
  - prescribing a date HRR realesed by a burner
  - experimental curves

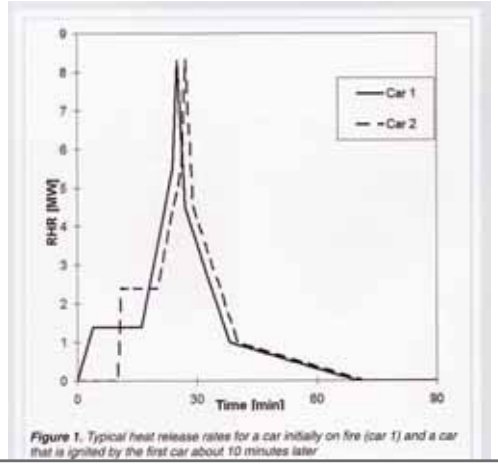
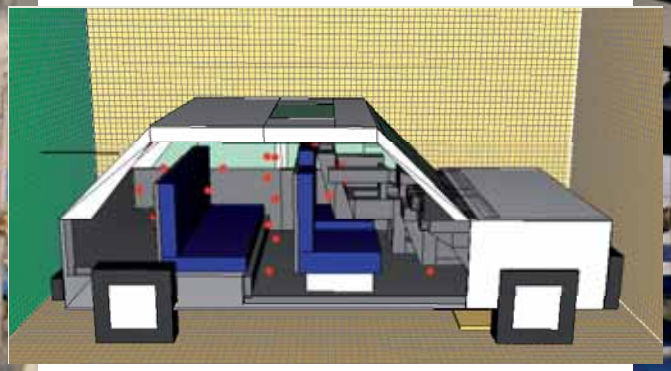


Figure 1. Typical heat release rates for a car initially on fire (car 1) and a car that is ignited by the first car about 10 minutes later

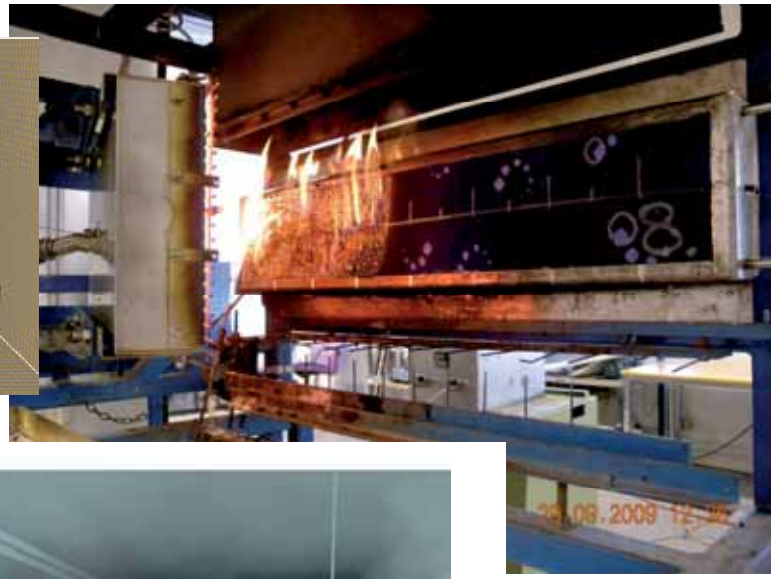
Burning process and fire

- FDS Pyrolysis model - specify thermophysical properties of solid fuel materials and let them pyrolyze if ignited. The HRR curve is not defined a-priori by the user.

ISO 3795 (ECE Reg No 118 annex 6), horizontal burning rate

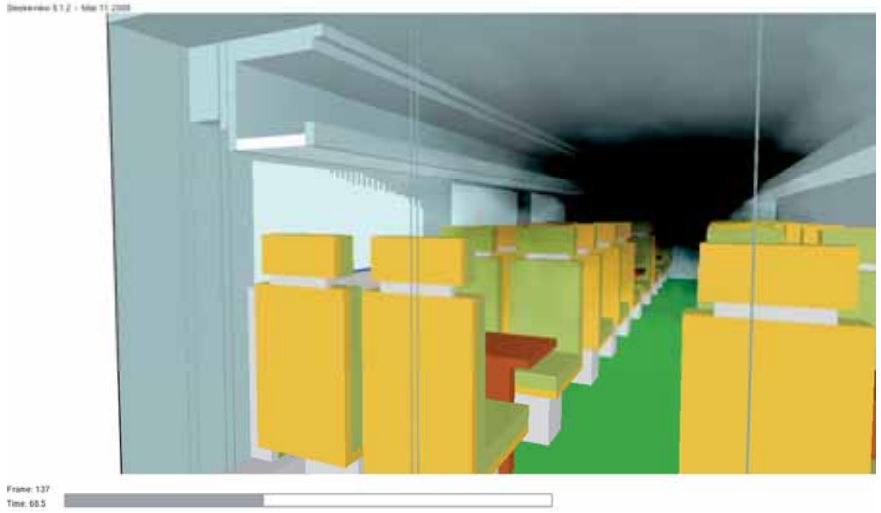


ISO 5658-2 (IMO Res A.643(16), CEN/TS 45545-2), Spread of



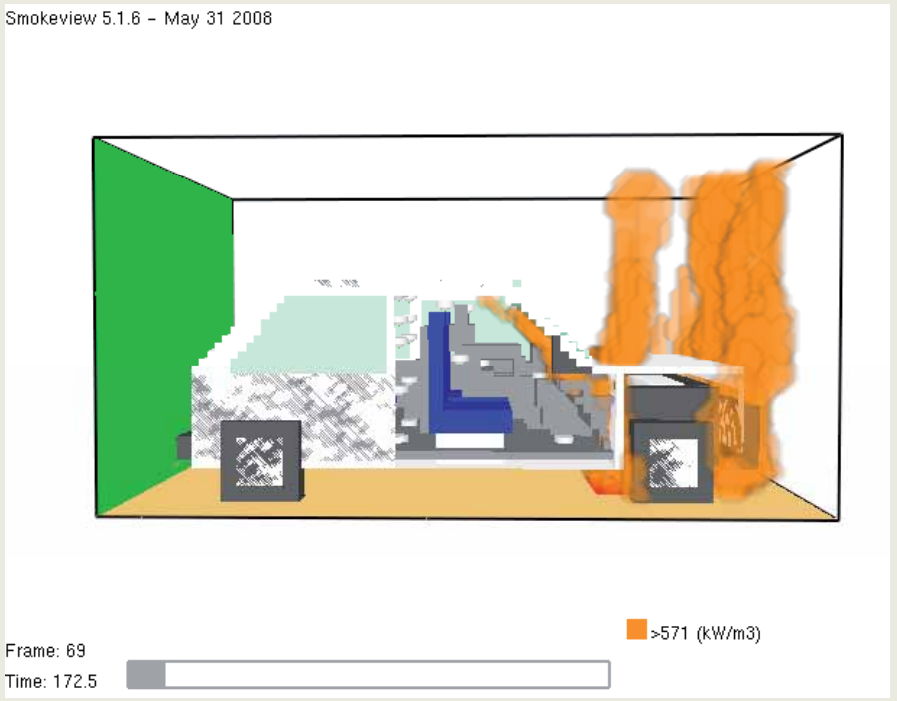
ling to ISO 5658-2.

ISO 6941 (ECE Reg No 118 annex 8), vertical burning rate



Test of Product No.11, polypropylene needle felt, according to ISO 6941.

SP Sveriges Tekniska Forskningsinstitut



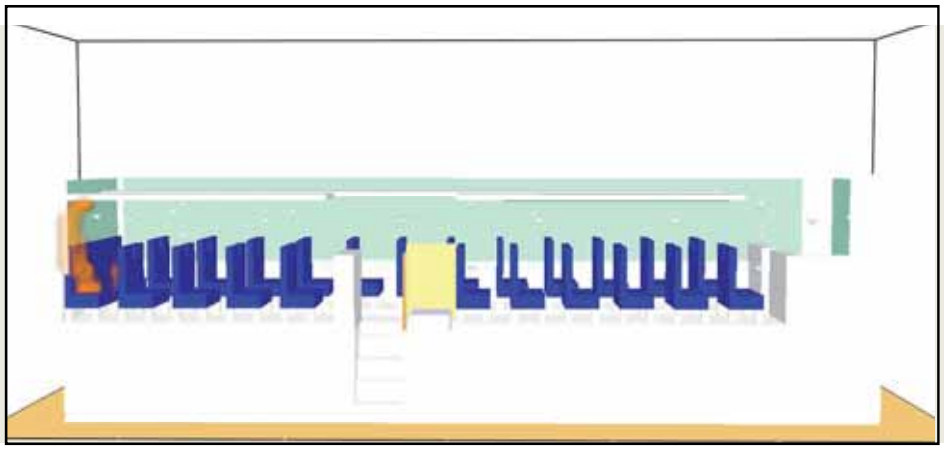
Flames in the interior after 170 s / 172 s

Dr. Anja Hofmann - BAM - Five - Gotheburg

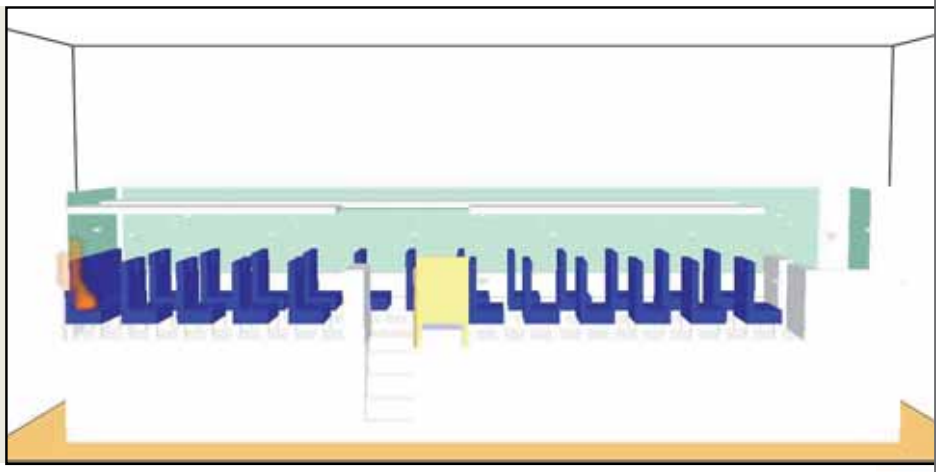
Bus upholstered seat

Railway upholstered seat

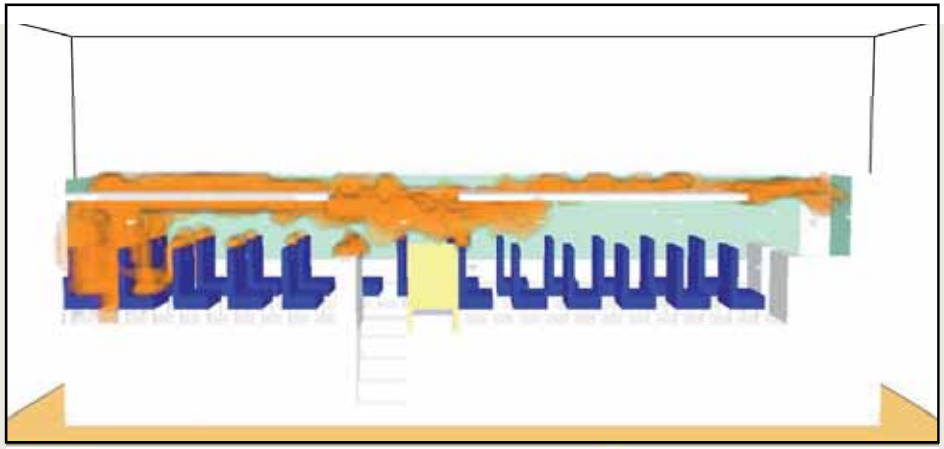
After 40 s



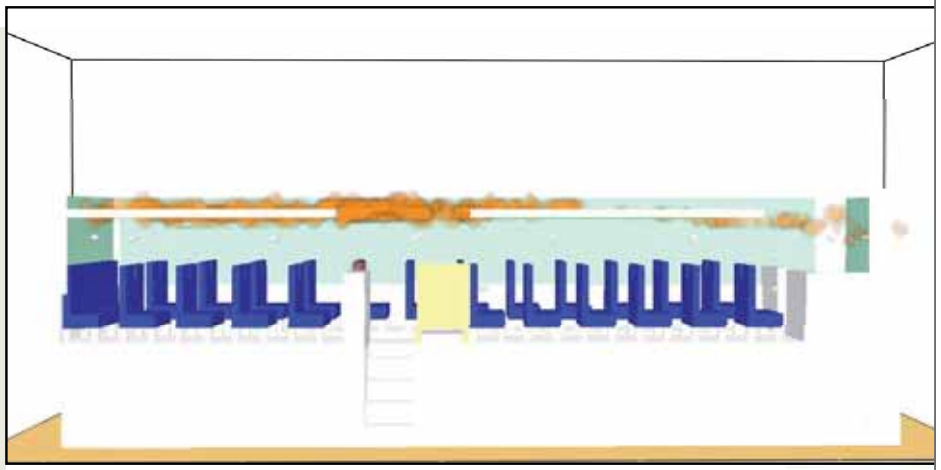
After 40 s



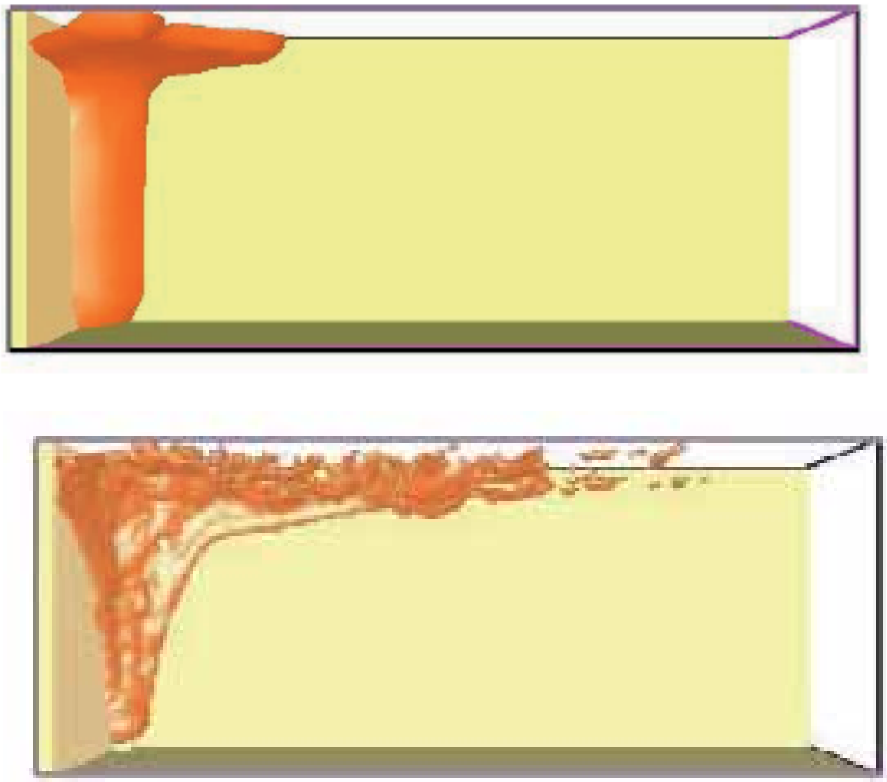
After 66 s



After 66 s



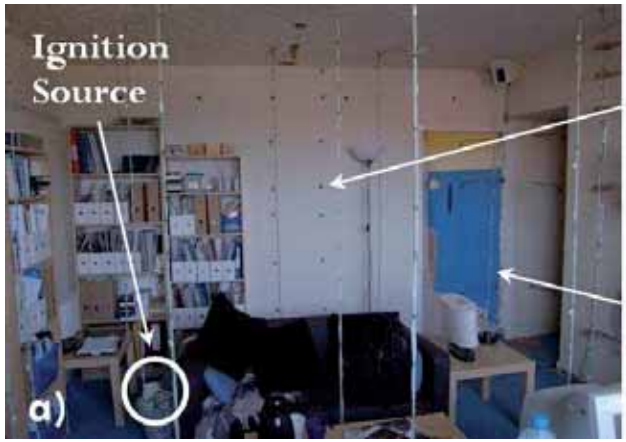
Dr. Anja Hofmann - BAM - Five - Gotheburg

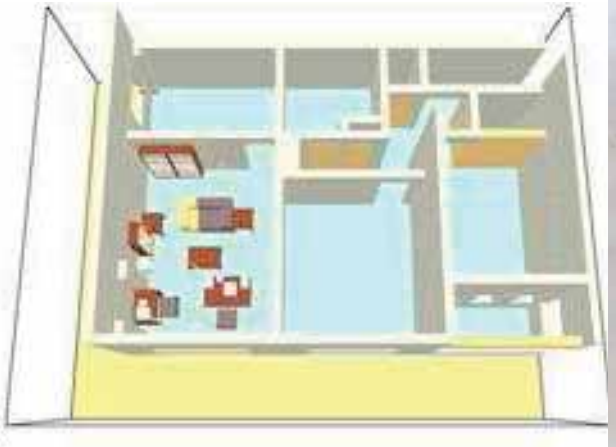


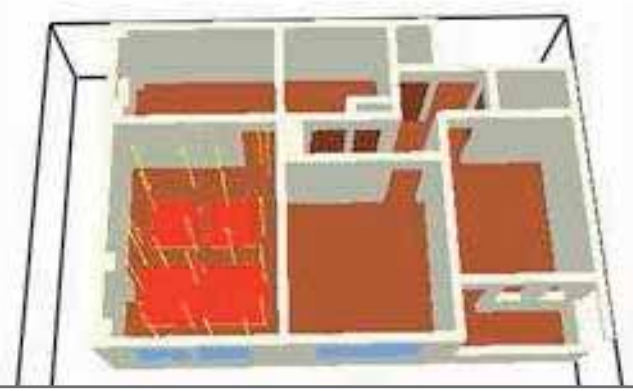
The upper image is a corner burn showing the flame spread over a layered paint surface. The cell size is 10 cm. In the lower image the fire is the same size, the surface properties are the same and the images are captured at the same time in the simulation. The only difference is that the cell size is 2.5 cm. As you can see, the scenario with the higher resolution displays greater fire spread.

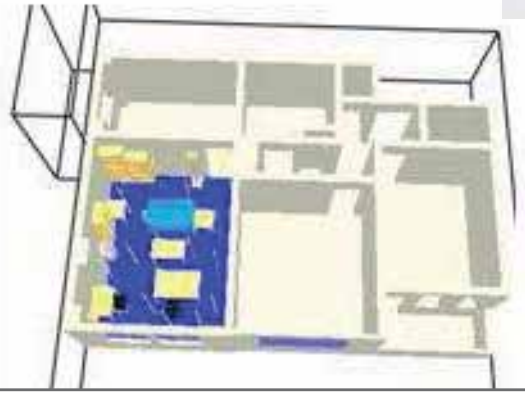

30 seconds
NIST
00:00:47

Dalmarnock fire tests - University of Edinburgh 2006-2007









Combustible
furniture modeled

Dalmarnock fire tests - A priori and a posteriori analysis

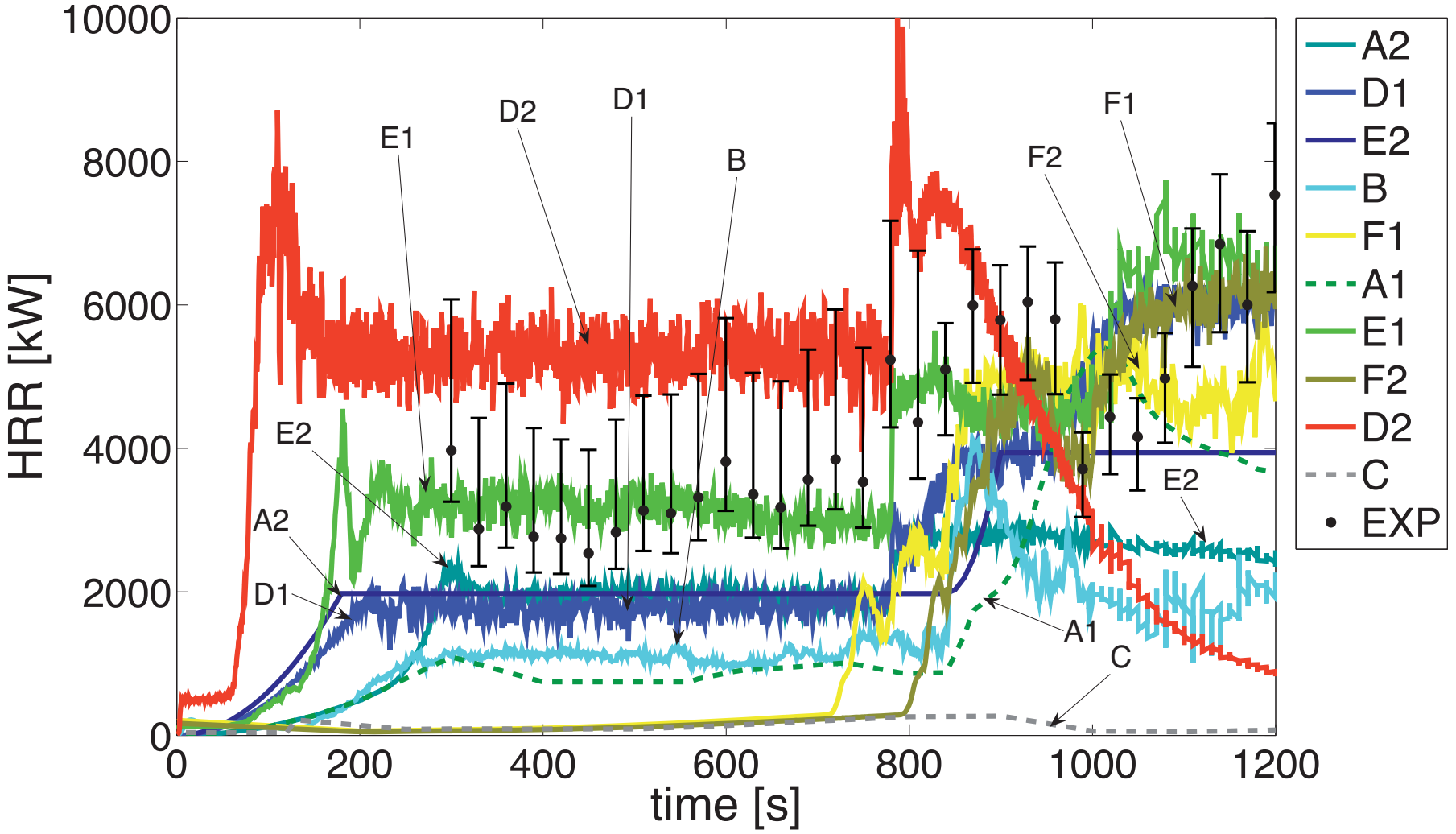


Figure 6: Evolution of the global heat release rate within the compartment. Legend for the different curves: continuous line for CFD simulations; dashed line for zone model simulations; and dotted for the experiment data with error bars.

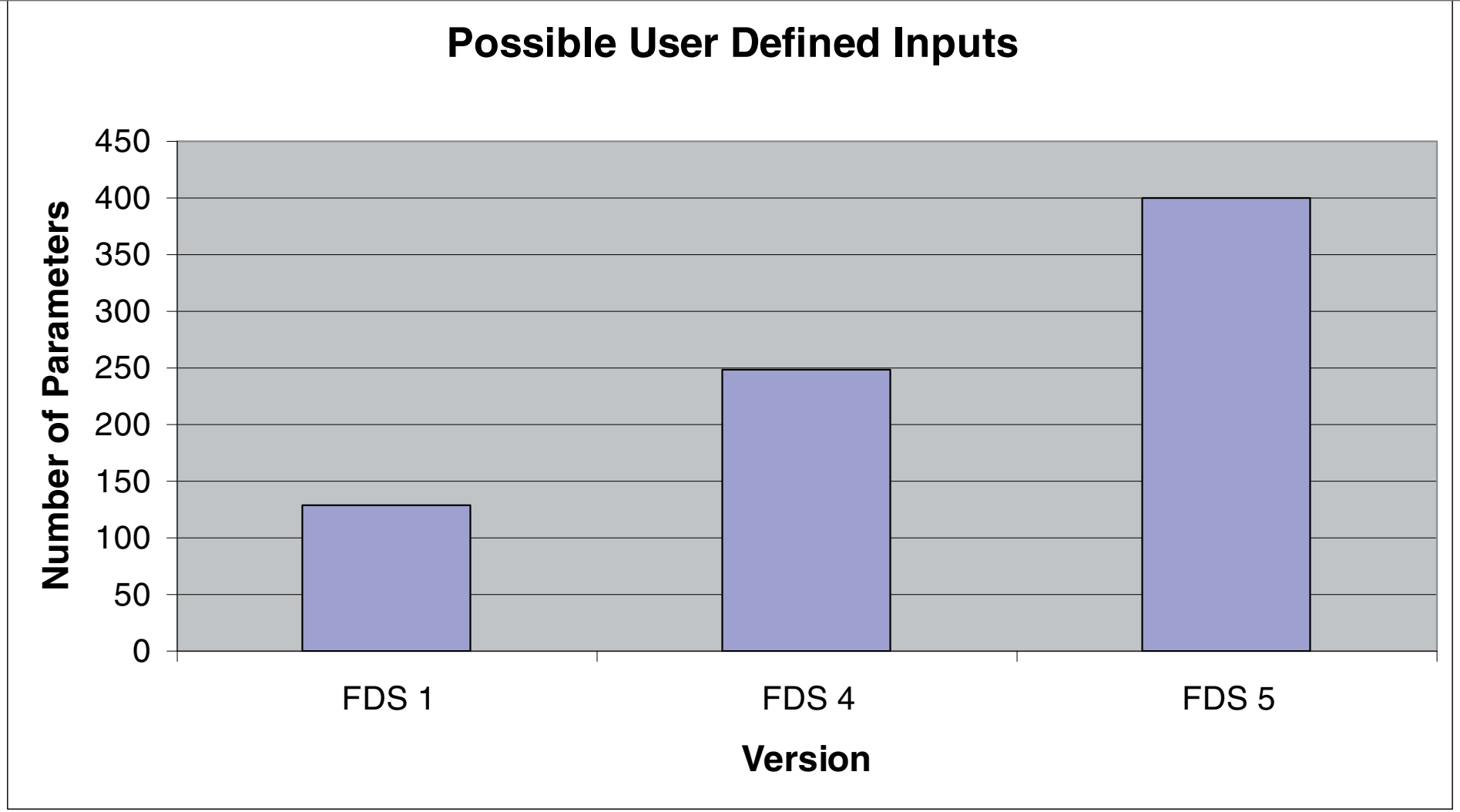


Fig 1 – Increase of possible user defined variables in recent versions of FDS

Each new version of FDS is increasingly more sophisticated .....more and more Knowledge is required from the user of the software...

- CFD can give an accurate and detailed solution for a fire modelled by a volumetric burner in a specific case, with specific parameters

- Also, we have many uncertain parameters, solutions should be evaluated by experts and validated by results from full scale tests

- Simulating the burning of combustible objects and the spreading of a fire adds further uncertaines...

Near Skipol Airport in this privat car park around 30 cars were on fire at the same time (october 2002)

Leander Noordijk, Tony Lemaire FS-world.com fall 2010

Current, empirical assumption: at most 3-4 vehicles are at fire at the same time (??)