INVESTIGATION ON A CAR PARK FIRE

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CONVEGNO IF CRASC'15

III Convegno di **I**ngegneria **F**orense
VI Convegno su **CR**olli, **A**ffidabilità **S**trutturale, **C**onsolidamento
Sapienza Università di Roma, 14-16 maggio 2015

INTRODUCTION

The fire destroyed 39 cars and 17 motorcicles, parked on the ground floor of a residential multistore building 120 meters long and 27 meters high as well as the pipelines for gas, water, electricity and wastewater running all

along the building façade at the first floor level

OUTLINE

Fire Scenario

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Post Fire Investigation Operations

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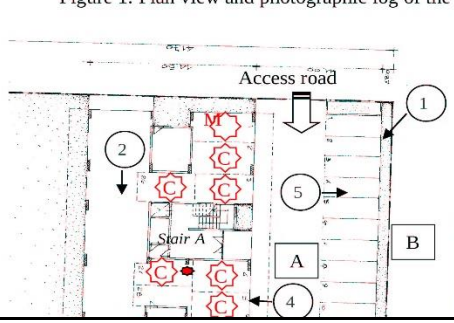
Numerical Simulation

Fire Scenario

Figure 1. Plan view and photographic log of the fire scene.



(1) Building front view

Time (hr:min)	Event
2:10-2:15 am	1st witness (position A in Figure 1): while walking to come back home, sees the fire starting from one car parked adjacent to stair A (1st item ignited in Figure 1).
2:22-2:25 am	2nd witness (position B in Figure 1, from an elevated floor of the front building): listens some bursts and sees the breaking-out the flames from the right side of stair A (access road).
2:25	Policemen: arriving on site refer the fire is involving the entire car park along the building.
2:35	1st engine on scene: fully developed fire involving the car park at ground level of the multistore building.

1. **Techniques of investigation**

2. **Small and real scale tests**

1. Techniques of investigation

- **Survey of the scene (photos, drawings, PID)**
- **Examination of video recording**
- **Interviews of witnesses**

2. Small and real scale tests

a. **Reaction to fire of polystyrene panels in horizontal configuration at ceiling**
b. **Fire dynamics of multiple cars in enclosure parkings**

Data analysis from small scale tests

Reaction to fire of polystyrene panels (M&F type 1)

Foto n° 23 – prima prova 28/11/08 preparazione provetta

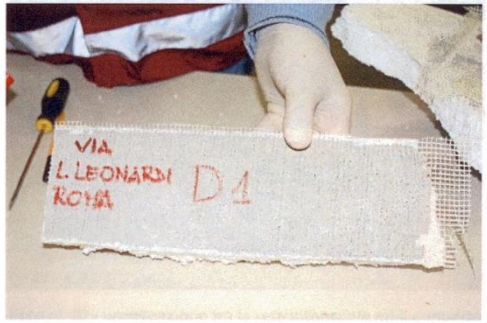


Foto n° 24 – fasi della preparazione della provetta

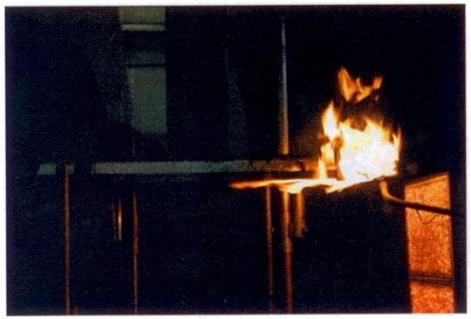


Foto n° 29 - propagazione della fiamma

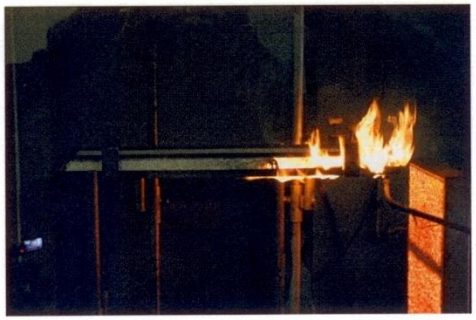


Foto n° 30 - propagazione tra la rete intonacata ed il supporto

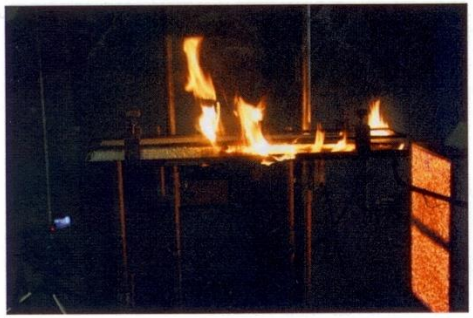


Foto n° 31 – assenza completa di gocciolamento

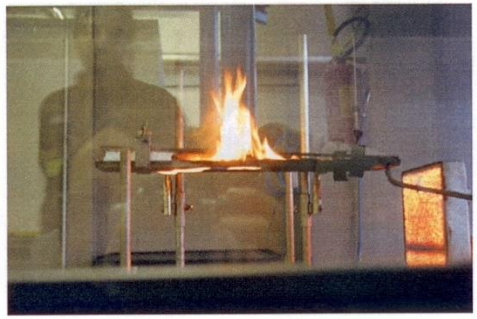


Foto n° 32 – propagazione avanzata senza gocciolamento

Data analysis from small scale tests

Reaction to fire of polystyrene panels (M&F type 2)

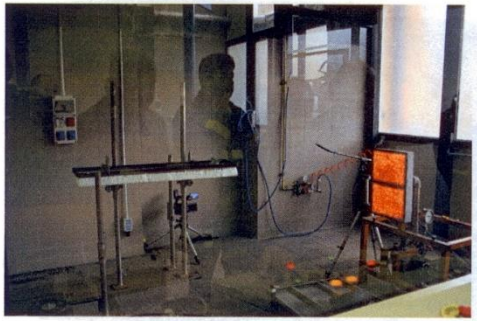


Foto n° 35 – seconda prova 03/12/08

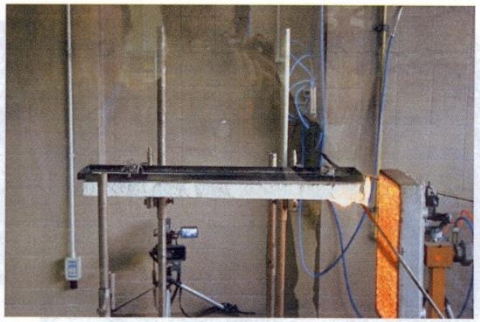


Foto n° 36 - materiale innescato con la fiamma pilota

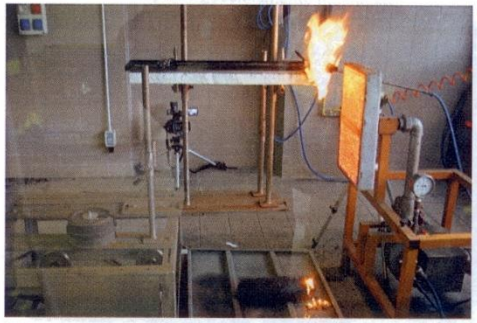


Foto n° 37 – accensione ed inizio gocciolamento

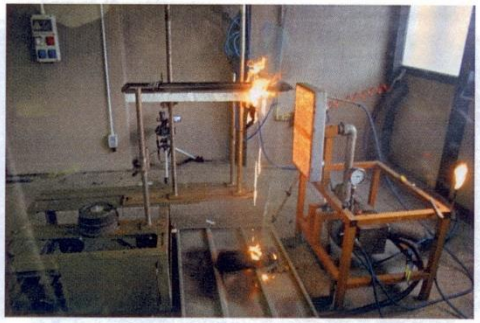


Foto n° 38 - propagazione della fiamma e gocciolamento

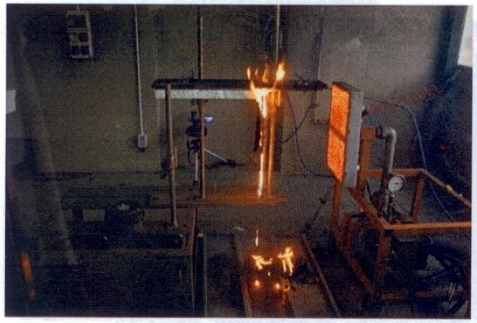


Foto n° 39 – distacco della rete incombustibile

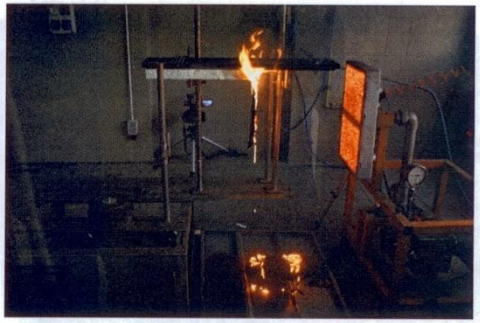
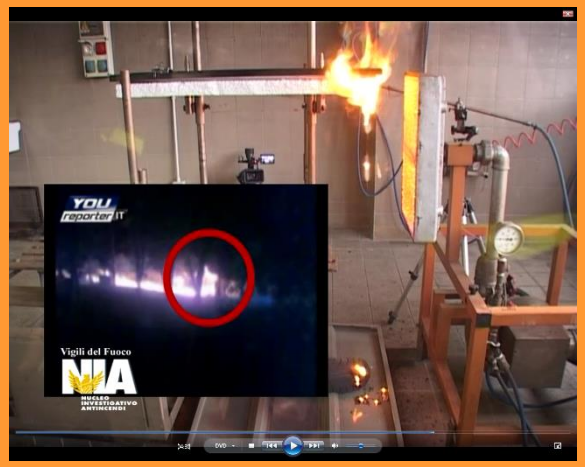


Foto n° 40 – propagazione dell'incendio al copertone

Data analysis from small scale tests



Polystyrene panels characterization (M&F!)

Density	28 kg/m^3
Heat of combustion	40 MJ/kg
Ignition criteria for combustion	Reference temperature 259°C

NUMERICAL SIMULATION

The CFD program FDS5 and its companion Smokeview from NIST [1-4] have been employed to investigate the car park fire with a holistic approach that can bring added value to fire engineering practice [5-7].

A first aim was to understand and simulate the behavior of cars catched on fire in an enclosure where a characteristic direction of propagation could be activated.

A second aim was to try to replicate the wave of traveling fire that can be expected in such situations.

NUMERICAL SIMULATION

The space chosen for the numerical simulation is the part of the car park bounded by two stair blocks, with several cars parked, where the ignition of the first car was most probably set, as witnessed and recorded by some video images.

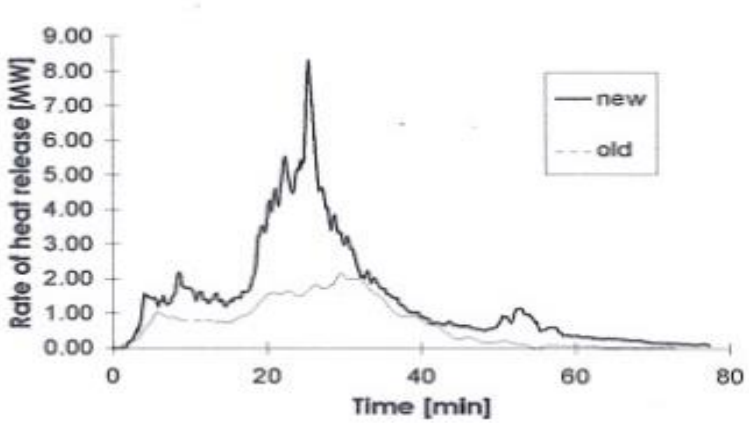
NUMERICAL SIMULATION

The critical parameters for this kind of scenario are: mesh cells size, firepower from the cars, ignition criterion for the cars.

Two more parameters show a strong effect in the fire dynamics simulations: the ventilation of the enclosure and the combustible ceiling panels.

Modeling based on car fire tests

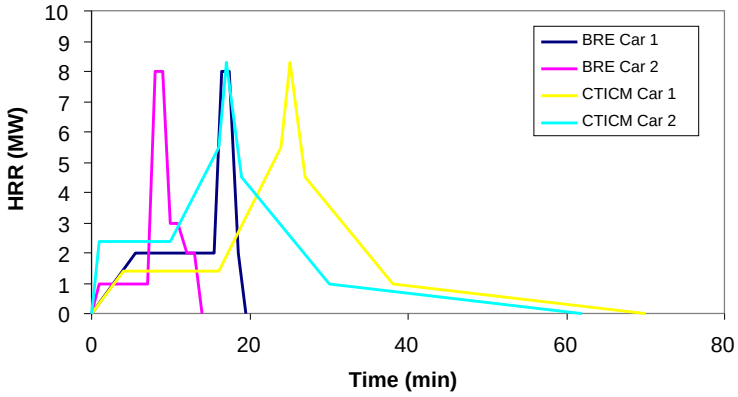
1 car burning cat. 3 (Morgan,Schleich et al, 1998)



category	car mass (kg)	mass loss (kg)	released energy (MJ)
1	850	200	6000
2	1000	250	7500
3	1250	320	9500
4	1400	400	12000
5	1400	400	12000

CTICM 1995 - 1996

2 cars burning (CTICM,1995-96/BRE,2007-09)



Car materials response (BRE, 2010)

Material	Critical Irradiance (kW/m²)
Mohair soft top	8
PVC soft top	9
Mud flaps	10
Tyre	11
Bumper trim	11,5
Wheel arch	12
Roof box	12,5
Petrol tank (plastic)	16,5
Hubcaps	17,5
Bumper grill	17

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Modeling based on car fire tests

DESIGN FIRES	INDOOR CAR PARK WITHOUT SPRINKLER SYSTEM or with sprinkler system without floor slopes	INDOOR CAR PARK WITH SPRINKLER SYSTEM and with floor slopes
Design fires	5x5 m	2x5 m
Perimeter	20 m	14 m
Total calorific power (Qf)	6 MW (BS7346-7: 8 MW)	4 MW

PrEN/TS 12101-11 (2010)

NOTE 1 : In case of sprinkler system without floor slope, the hydrocarbon liquids in fire coming from a car could spread very rapidly at great distance on the water layer, under other cars parked , which would risk to accelerate the propagation of the fire from one car to another. In this case, several cars could simultaneously be in the most powerful stage of the fire development, and it is the fire furnace defined in Table 2 for indoor car parks without sprinkler system or with sprinkler system without floor slopes that should apply.

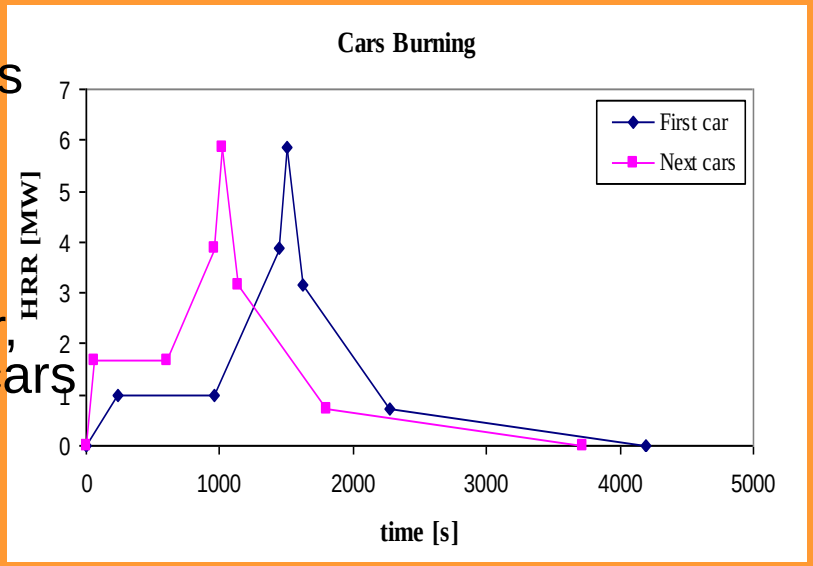
NOTE 2 : The total calorific power Qt of the fire includes all the heat emitted by it including that radiated towards the walls. It is independent of the car park design. The calorific power values in Table 2 are taken from the most recently known actual fire tests measured on cars representative of late 1990s models and take account of the fire propagation from one car to the next. Each value given above represents a mean value corresponding to the calorific power during the most intense phase of the development of the fire over three cars with no sprinkler system, one car with a sprinkler system (duration in the order of twenty minutes from the beginning of the fire) taking into account the risk of propagation of the fire from the first car to the adjacent cars before the intervention of the fire service.

NOTE 3 : For car parks and parking spaces intended for other types of vehicles, the data in Table 2 are not applicable and the calorific power should be assessed from case to case taking into account the vehicles, their loads and means of fire protection fitted.

Modeling based on car fire tests

Type of cars characterisation in this study

Geometry	Simple rectangular box with top
Fire power	Trapezoidal form plateau followed by triangular peak
Total duration of firepower	4200 s 1st car, 3720 s next cars
Ramp to plateau	240 s 1st car, 60 s next cars
Plateau	0.99 MW 1st car, 1,69 MW next cars
Peak	5,85 MW
Energy	4,8 GJ
Efficiency of combustion	0,71



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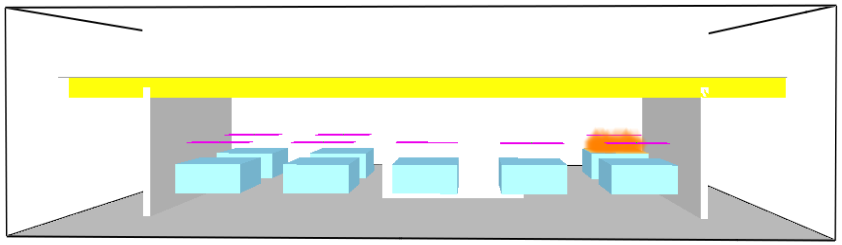
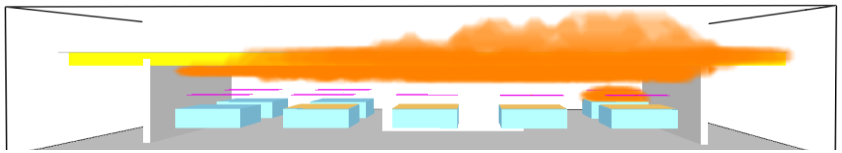
CFD run type 1

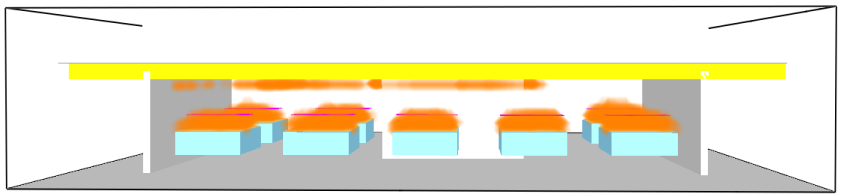
Mesh	20 cm cubic cells
Car Ignition criteria	Irradiance level on top of cars 15 kW/m^2



(I) Ignition of 1st car



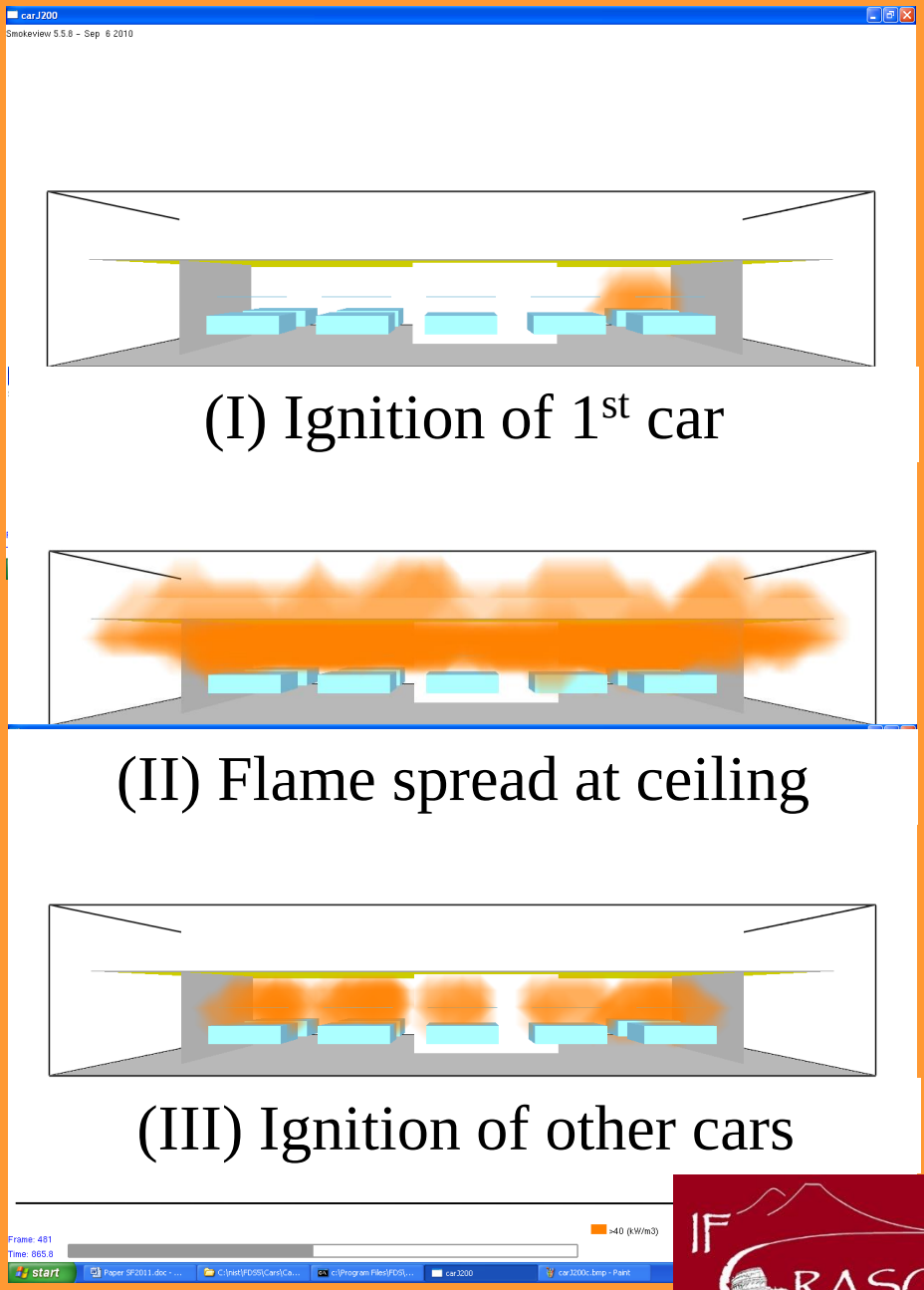
(II) Flame spread at ceiling



(III) Ignition of other cars

CFD run type 2

Mesh	50 cm cubic cells
Car Ignition criteria	Ignition temperature 200°C



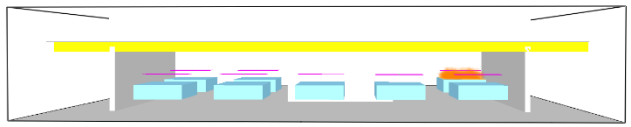
3. Wave of traveling fire

a. *Evaluation of space configuration (long box)*
b. *Accelerating factors (polystyrene at ceiling)*
c. *Ignition criteria for cars (kW or °C)*
d. *Critical parameters (sensitivity)*

Conclusion

- Fire investigation was requested in order to ascertain if the fire was due to fault or arson and, in case of arson, if the fire started from one or more cars (this change the charge) and the simulation has demonstrated to be credible, when properly applied, as a tool to help fill in critical details of a fire incident.
- The test results come from proper reaction to fire tests made on some polystyrene panels coming from the pilotis floor, not destroyed by the fire. The fire dynamics submodels come from the description of the event observed.
- The essential fire properties needed as input in the fire computer model were generated from the small scale (reaction to fire tests) and real scale measurements (for fire dynamics in car parks) in order to add credence to the results of the simulation performed for the fire reconstruction. Supplemented with first person interviews and examination of the scene after the fact, it may help and support the experts involved in the fire reconstruction.

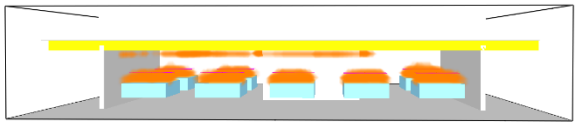
Conclusion



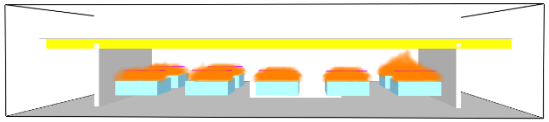
(I) Ignition of 1st car

(II) Flame spread at ceiling

(III) Ignition of other cars



(IV) Burn out at ceiling



(V) Fire wave in cars

Conclusion

Average apparent velocity of fire front wave along ceiling	
~ 8-12 cm/s	Video images of the event
~ 12 cm/s	Small scale test of PS panels
~ 9-10 cm/s	FDS5 PS ref temp 259°C & cars ignition 15 kW/m^2
~ 10-11 cm/s	FDS5 PS ref temp 259°C & cars ignition 200°C

Cristina D'Angelo

…THANK YOU FOR YOUR KIND ATTENTION !