



## INVESTIGATING THE CAUSES OF FIRE

2<sup>ND</sup> INTERNATIONAL WORKSHOP

# TESTING NUMERICAL AND EXPERIMENTAL SIMULATION METHODS IN THE FIRE INVESTIGATION ON A SUPER STORE ARSON

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**Abstract:** this work describes the investigation activities related to a fire that developed in a do-it-yourself Italian super store, in November 2008, damaging the whole area and the structures of the fire compartment where it originated.

**Introduction:** the subsequent investigation conducted by the Nucleo Investigativo Antincendi, the specialist unit for fire investigation of the Italian Fire Department, was aimed at understanding the causes of the event. According to the collected evidence, the fire originated from a plastic cabinet put on display on metallic shelves and the evolution of the accident was very rapid. Also, traces of an accelerant substance have been found in proximity of the cabinet.

**Methods:** in order to understand the dynamics of this fire, a numerical simulation of the cabinet combustion, based on Fire Dynamics Simulator by NIST, was carried out. The results of the numerical simulation, namely heat release rate and temperature evolution, were used to define a test plan for a full-scale experimental simulation, and was subsequently executed.

The full-scale experimental simulation aimed to reproduce the same configuration and kind of ignition of the real blaze. After that, a comparison between numerical and experimental results was carried out in order to improve the numerical model accuracy.

**Results:** This work has contributed significantly to the investigation activities by providing a description of the probable fire origin and early propagation phases; furthermore, improved knowledge of thermoplastic material combustion has been gained by the numerical-experimental

**Input data:** some of the input properties needed for the numerical model were determined by tests performed by the Reaction to Fire Laboratories of Central Directorate for Prevention and Technical Safety of the Italian Fire Department. Specifically, the heat of combustion was measured by a calorimetric bomb, and the thermoplastic nature, or thermosetting of the material, was deduced by fire reaction tests performed according to Italian test methods. Finally, the exact polymer used was found by a spectrometry test (FT-IR). Moreover, other tests conducted by a laboratory chosen by the Court identified the accelerant substance likely used to initiate the fire. A pool fire model was then adopted to determine the heat release rate of the initiating substance combustion.



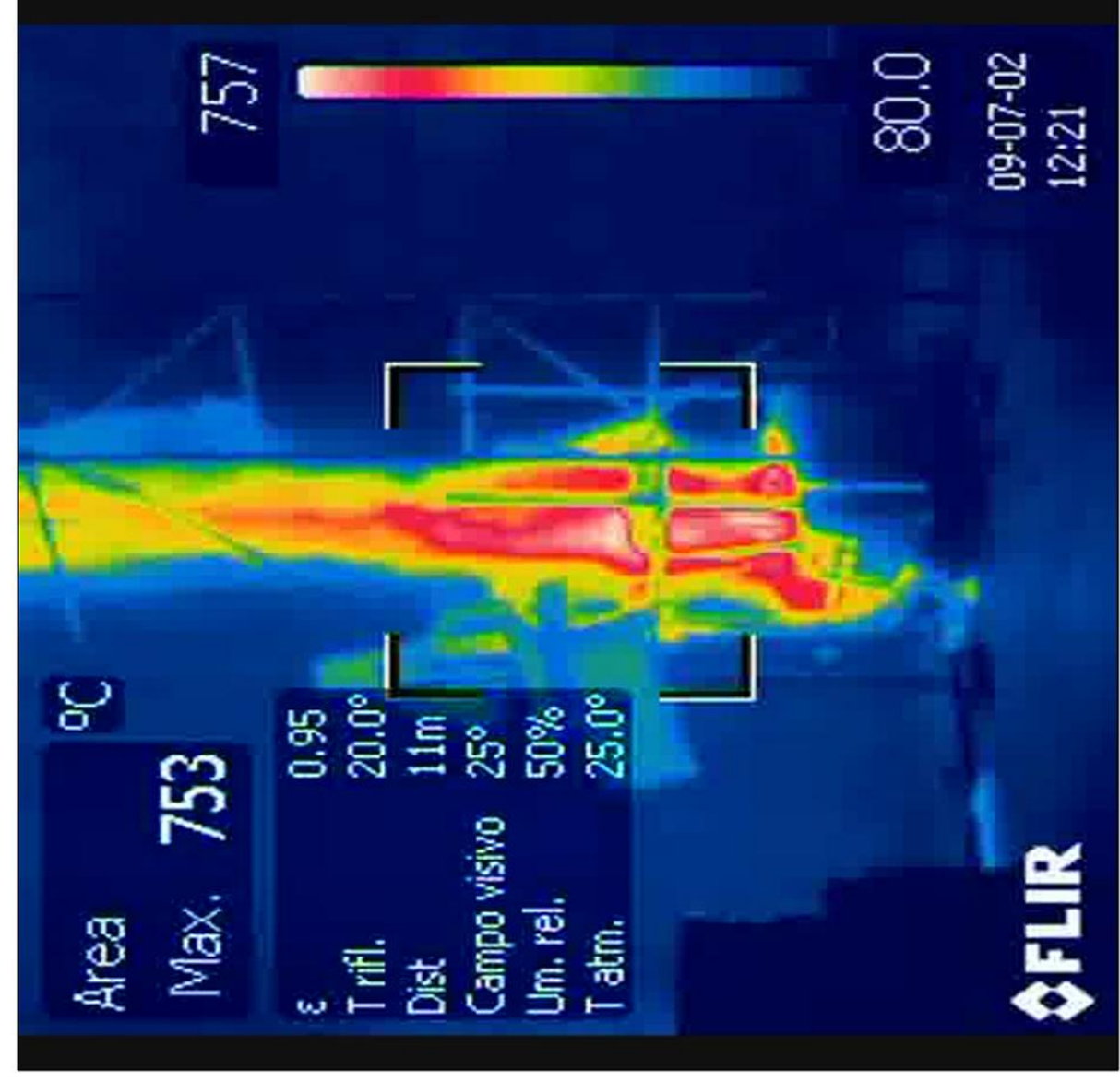
The super store destroyed by the fire



The fire investigation activity. Samples



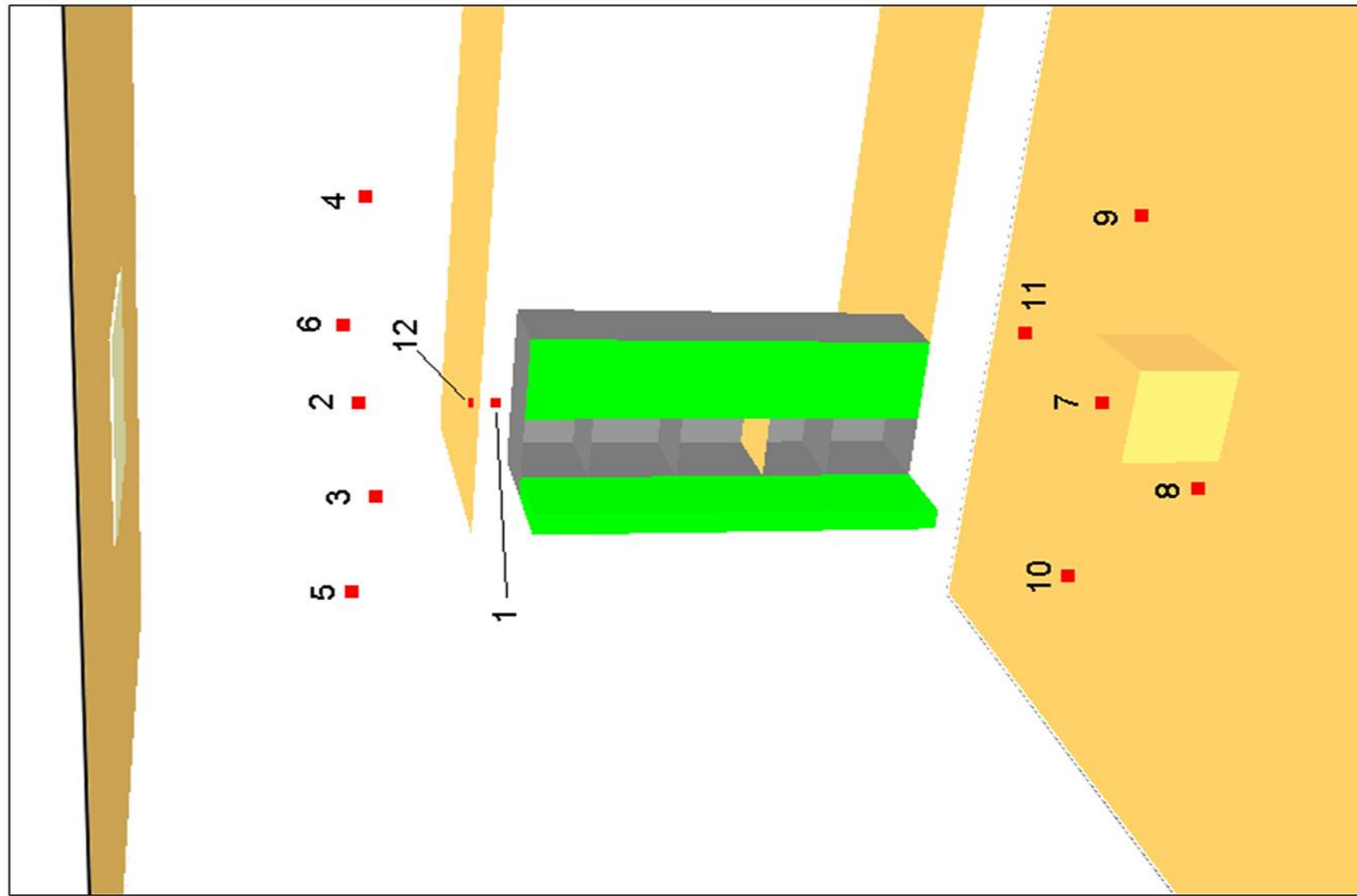
The full-scale experimental simulation. A thermo camera image



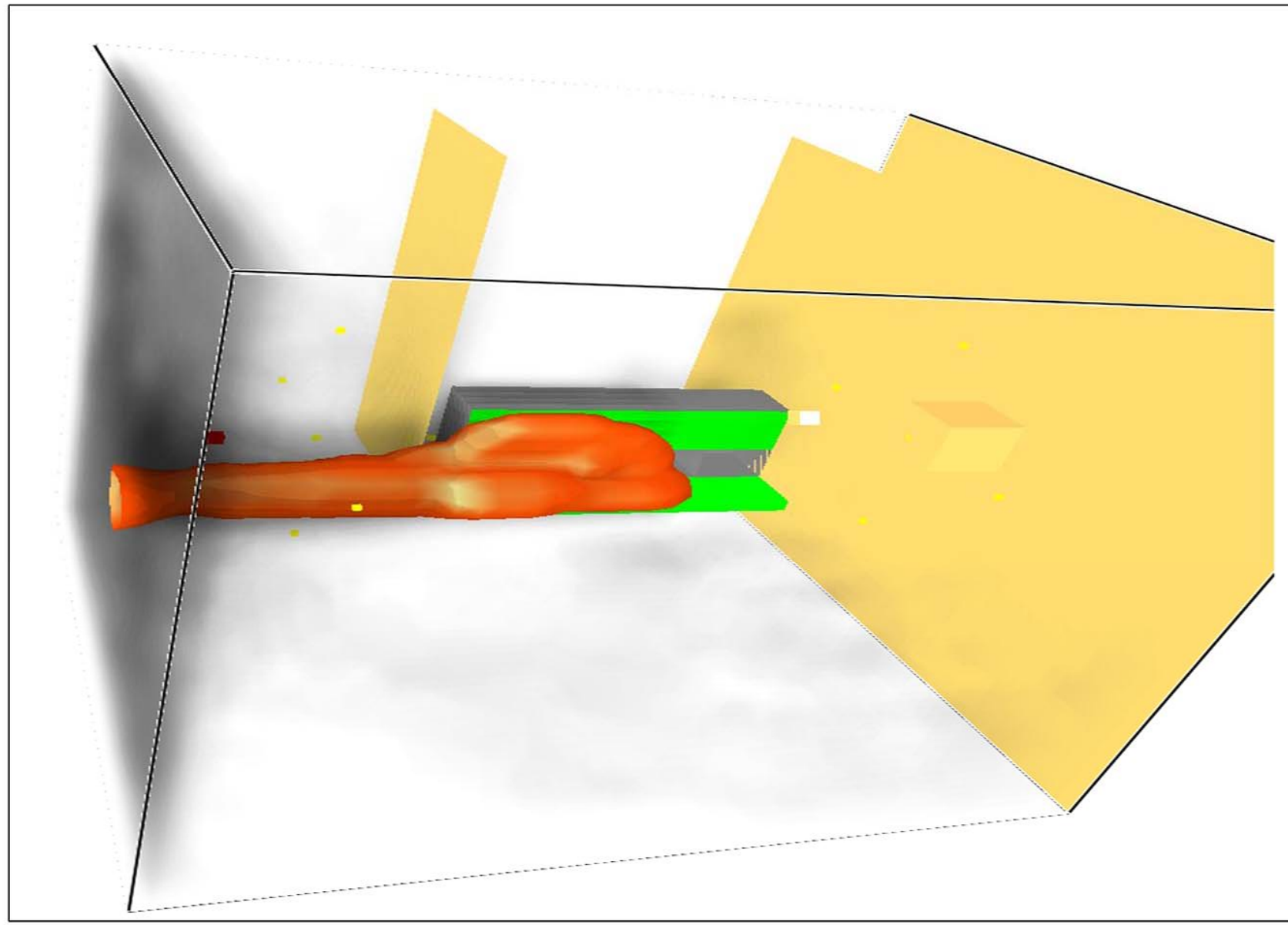
**Conclusion:** The simulation enabled us to verify the reason why the fire spread so quickly. The rapidity of the combustion process is correlated to the physical properties of the thermoplastic material which melting in a pool fire on the floor ignited within a short time all the adjacent combustible materials.

Even after the fire had been extinguished, the fire investigation's use of a full-scale experimental simulation enabled us to sample pieces of cardboard absorbed with the accelerant; the same kind of samples found after the real arson.

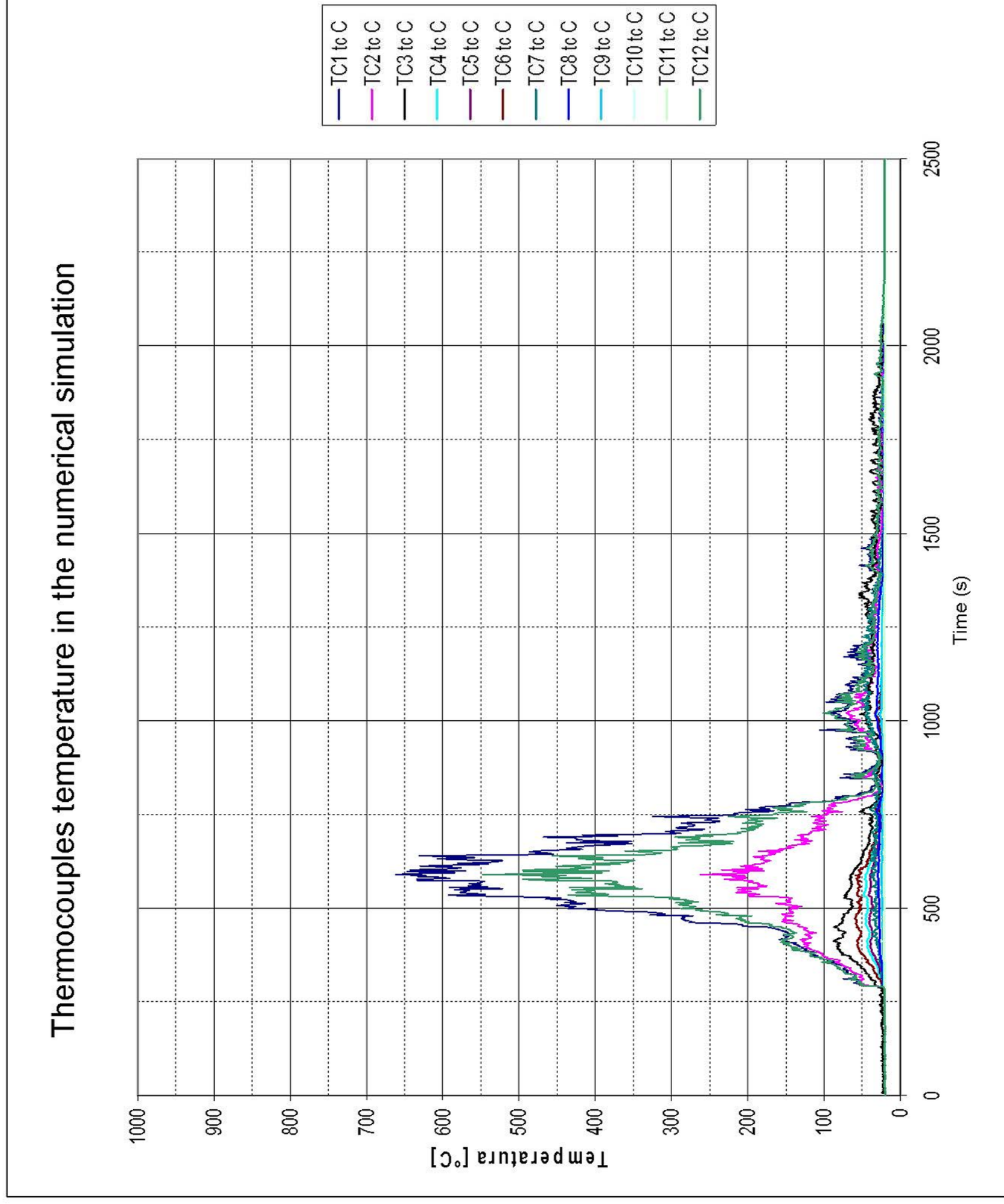
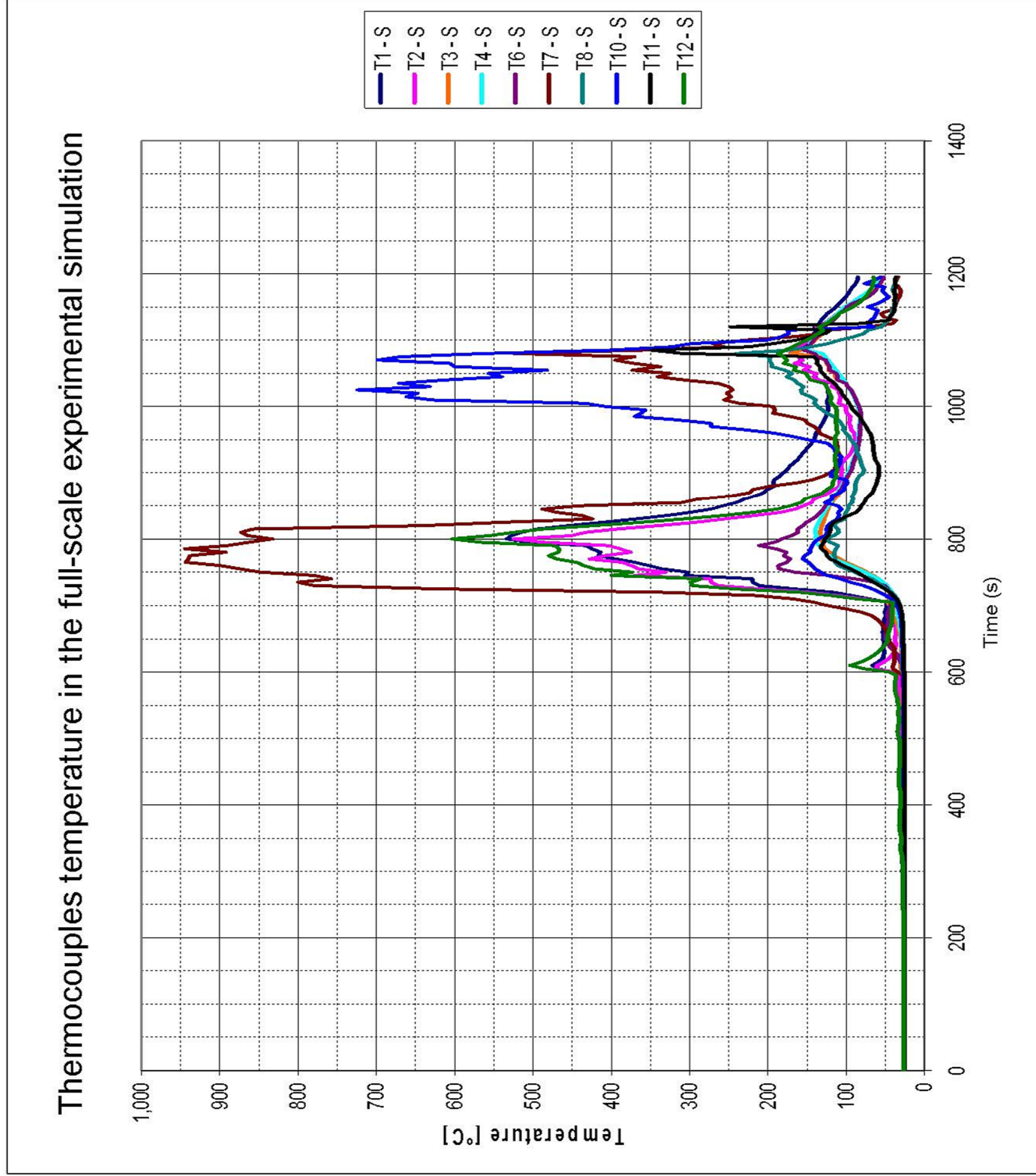
Comparing output data of numerical simulation with instrumental measured data in the full-scale simulation it's possible to point out the FDS software's limit in representing the thermoplastic behaviour of material in case of fire. This limitation caused the absence in the FDS simulation of the second fire involving the packed cabinet under the shelf that, however, did occur in the full-scale simulation. Therefore, the numerical model underestimated the power of the thermoplastic material blaze in setting fire to the adjacent combustible materials. The FDS software alone is not able to describe the pool fire caused by melting material. With respect to the fire dynamics of the cabinet on the shelf, however, the numerical simulation describes faithfully the trend of temperature registered in the full-scale simulation. The numerical model calculated a temperature of about 650°C compared to the measured temperature of about 600°C in the full-scale simulation.



Thermocouples position in the simulation with FDS (Version 4)



A phase of the numerical simulation with FDS (Version 4)



Comparison between thermocouples temperature in the full-scale experimental simulation and the numerical simulation

[1] K. McGrattan, G. Forney: "Fire Dynamics Simulator (Version 4) – User's Guide", NIST Special Publication 1019  
[2] D. Drysdale: "An Introduction to Fire Dynamics, Second Edition", JWS 1998  
[3] W. F. Smith: "Scienza e tecnologia dei materiali, Seconda Edizione", McGraw-Hill

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