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Sensitivity Analysis of Room Fire CFD-Simulations

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Fire Engineering.

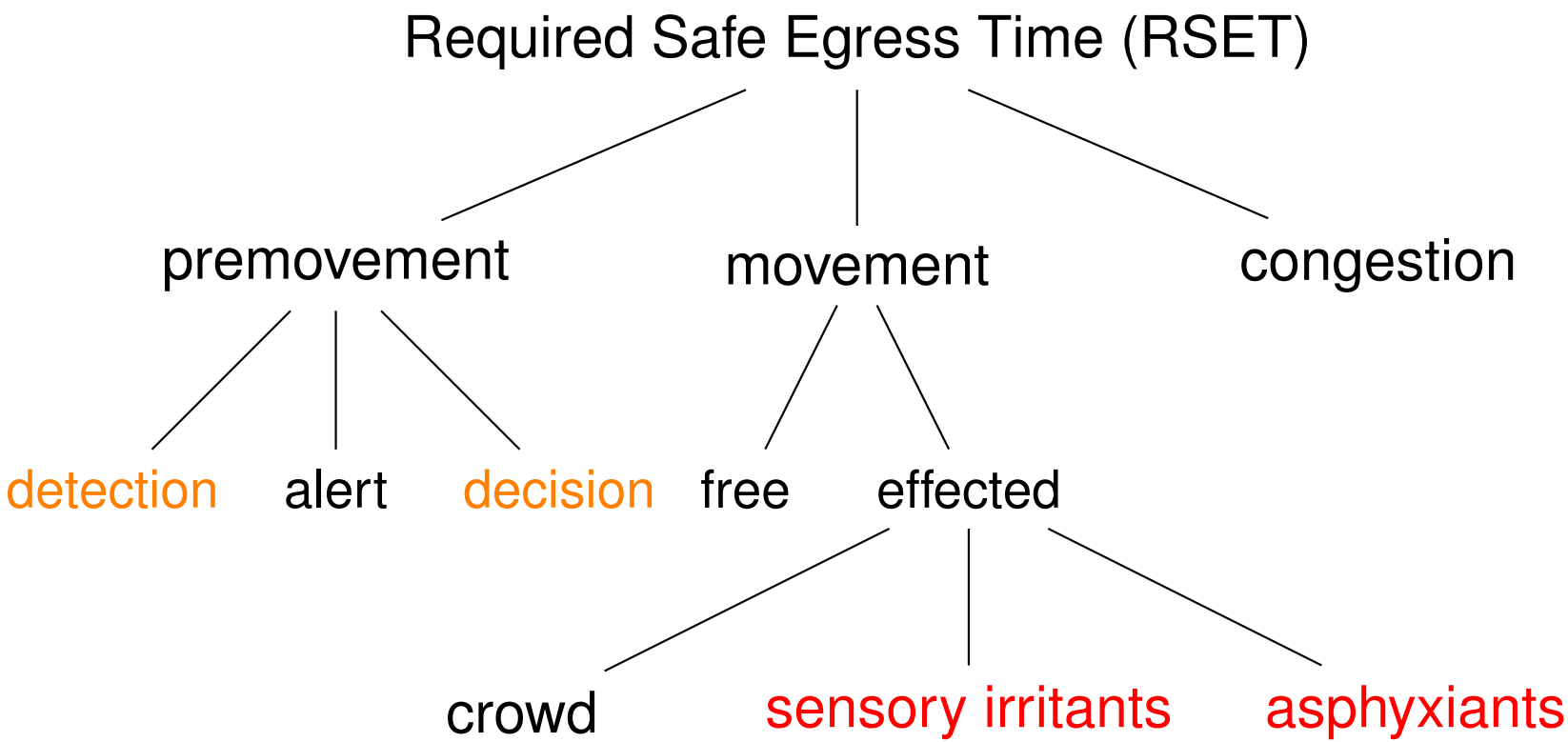
Need for Simulation.

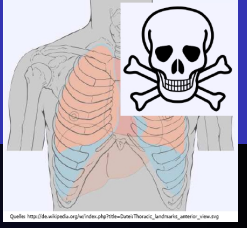
- PRE: Assessment of safe evacuation time (ASET, RSET).
- PRE: Assessment of structural safety.
- POST: Fire investigation.

Software.

- Fire Dynamics Simulator (FDS)
- Software developed by the National Institute of Standards and Technology (NIST, USA) and the Technical Research Center of Finland (VTT)
- Numerical methods of computational fluid dynamics (CFD) adapted to the requirements of fire engineering

Required Safe Egress Time (RSET)

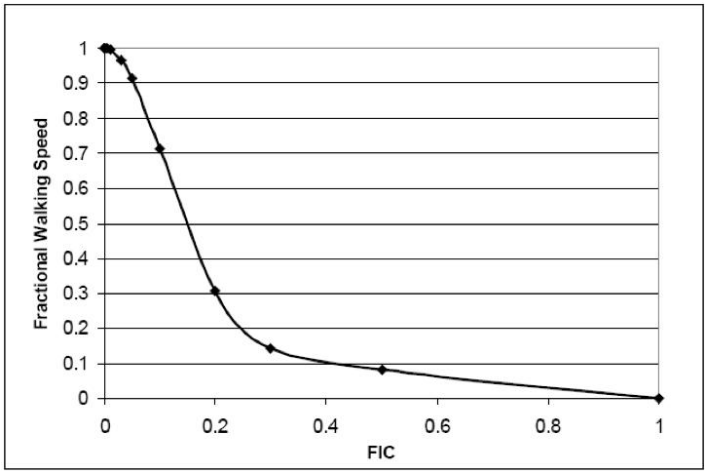




Available Safe Egress Time.

Irritants are impeding evacuation.

Asphyxiants lead to incapacitation.



Fractional Effective Dose (Purser):

$$\mathrm{FED}_{\mathrm{Purser}}(t) = max\left\{ \sum_{t=0}^{t^*} \left[(\mathrm{F}_{\mathrm{CO}}(t) + \mathrm{F}_{\mathrm{HCN}}(t) + \mathrm{FLD}_{\mathrm{irr}}(t)) \cdot \mathrm{V}_{\mathrm{Hyp}}(t) + \mathrm{F}_{\mathrm{O_2}}(t) \right], \sum_{t=0}^{t^*} \mathrm{F}_{\mathrm{CO_2}}(t) \right\} < 0.3$$


Available Safe Egress Time
Fire Scenario
Temperature rise
Production and transport of fire effluents
Oxygen depletion
Required Safe Egress Time
walking direction
sight
walking speed
changes during the process
parameter changes
opening doors
Exhaust openings
glass-breaking
highly variable
fuel
ventilation
ignition
room of fire origin
low scattering
geometry
wall material
floor material
ceiling material
openings

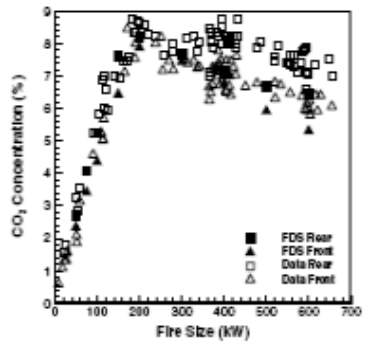
Validation Tests

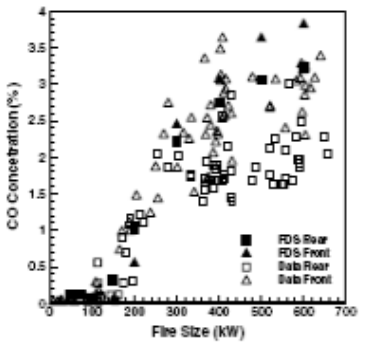
MULTIPLE PARAMETER MIXTURE FRACTION WITH TWO-STEP COMBUSTION CHEMISTRY FOR LARGE EDDY SIMULATION

Jason E. Floyd[1] & Kevin B. McGrattan[2]
[1]Hughes Associates, Inc. USA
[2]Building and Fire Research Laboratory, National Institute of Standards and Technology, USA

INTRODUCTION

A common approach for treating combustion in practical fire models is to use the mixture fraction, a conserved scalar to which all gas species can be related. Typically, infinitely fast chemistry is assumed, in which case the technique works well for fires scenarios in which there is an adequate supply of oxygen. A somewhat more complex approach is to create flamelet libraries that map temperature and mi… tions and … ures, the … odel use … us to des … basic frai …





In t … on of gas … le to acc … tead, we … f the difl … For exa … ed to dec … xture frac … hood experiment, and a compartment fire experiment. All three sets of experiments involve relatively clean burning fuels because the emphasis is on CO, not soot, production.

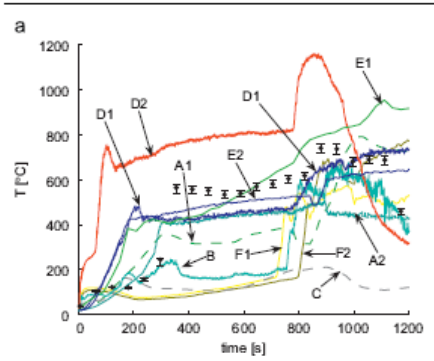
MATHATICAL FORMULATION

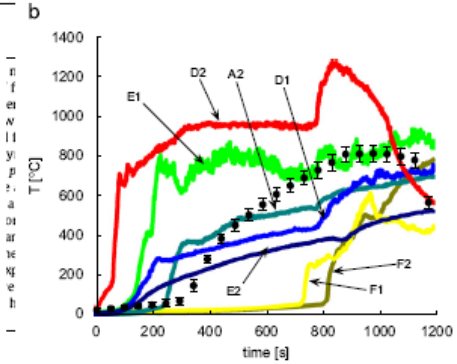
The combustion model in the Fire Dynamics Simulator (FDS), version 4,[1,2] uses only a single …

Fire Safety Journal 44 (2009) 590–602
Contents lists available at ScienceDirect
Fire Safety Journal
journal homepage: www.elsevier.com/locate/firesaf

Round-robin study of *a priori* modelling predictions of the Dalmarnock Fire Test One

Guillermo Rein [a,*], José L. Torero [a], Wolfram Jahn [a], Jamie Stern-Go
Sylvain Desanghere [d,1], Mariano Lázaro [e], Frederick Mowrer [f], Andr
Daniel Alvear [e], Jorge A. Capote [e], Allan Jowsey [a,b], Cecilia Abecassi
[a] BRE Centre for Fire Safety Engineering, University of Edinburgh, Scotland, UK
[b] Arup, London, UK
[c] Packer Engineering Inc., Chicago, USA
[d] CTICM, Paris, France
[e] GIDAI, Universidad de Cantabria, Santander, Spain
[f] Department of Fire Protection Engineering, University of Maryland, USA
[g] Arup, San Francisco, USA
[h] Efectis, Paris, France



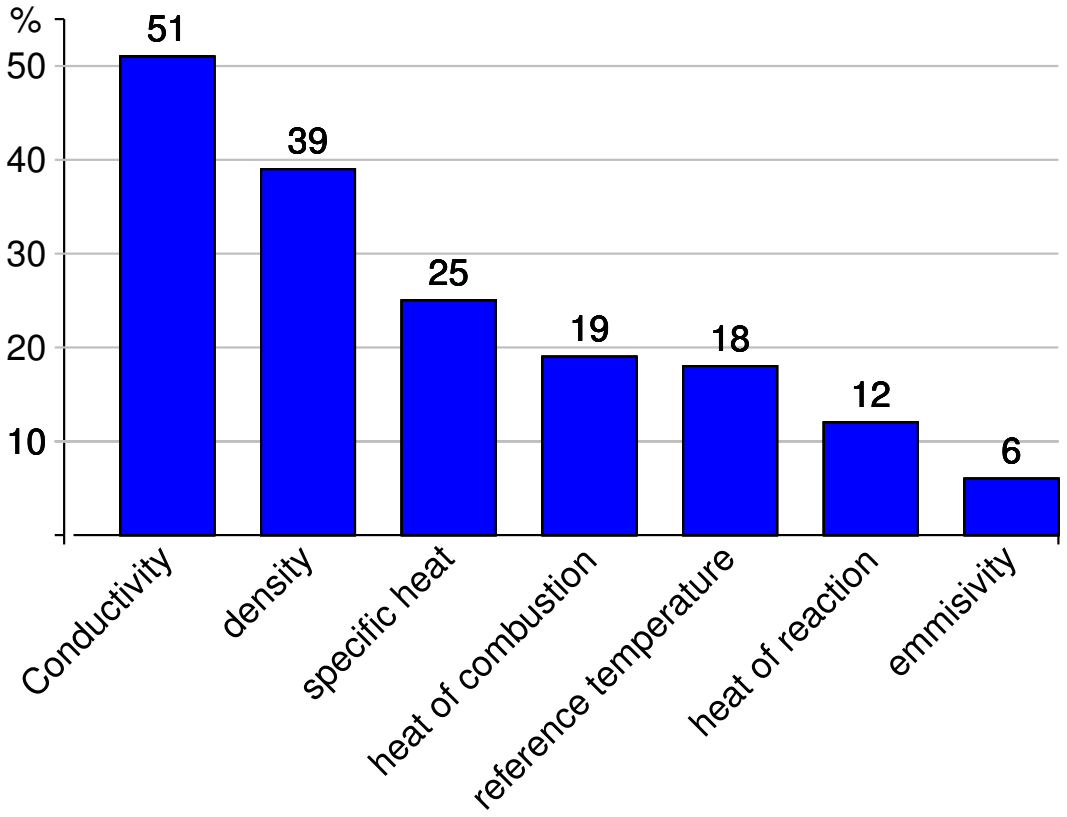


1. Introduction

behaviour, and design of fire safety. Modelling is being used to study fire dynamics in enclosures and to simulate flames, plumes,

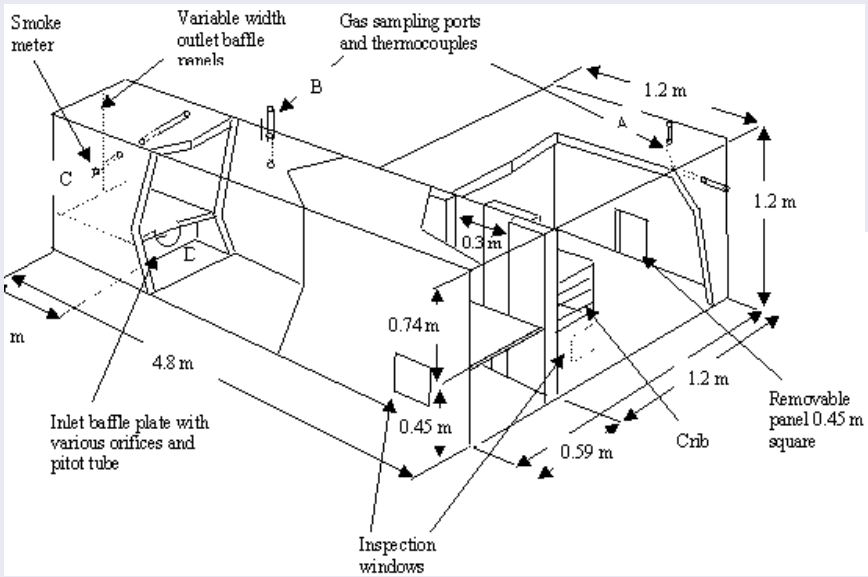
Scattering of Input Parameters

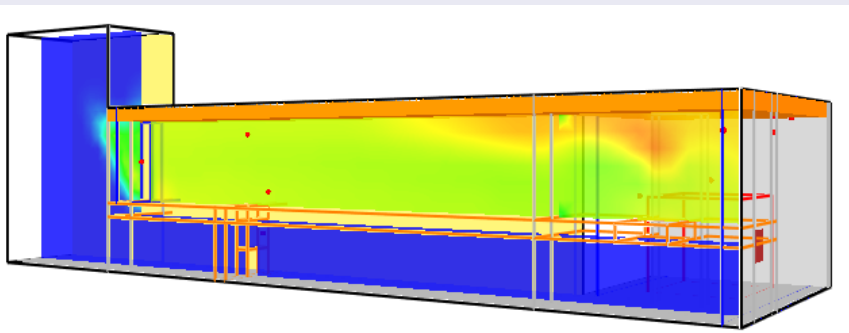
Scattering of material parameters for different types of wood (FDS pyrolysis model)



Model

UCLan Fire Toxicity Facility: ISO 9705 half scale room and corner test.

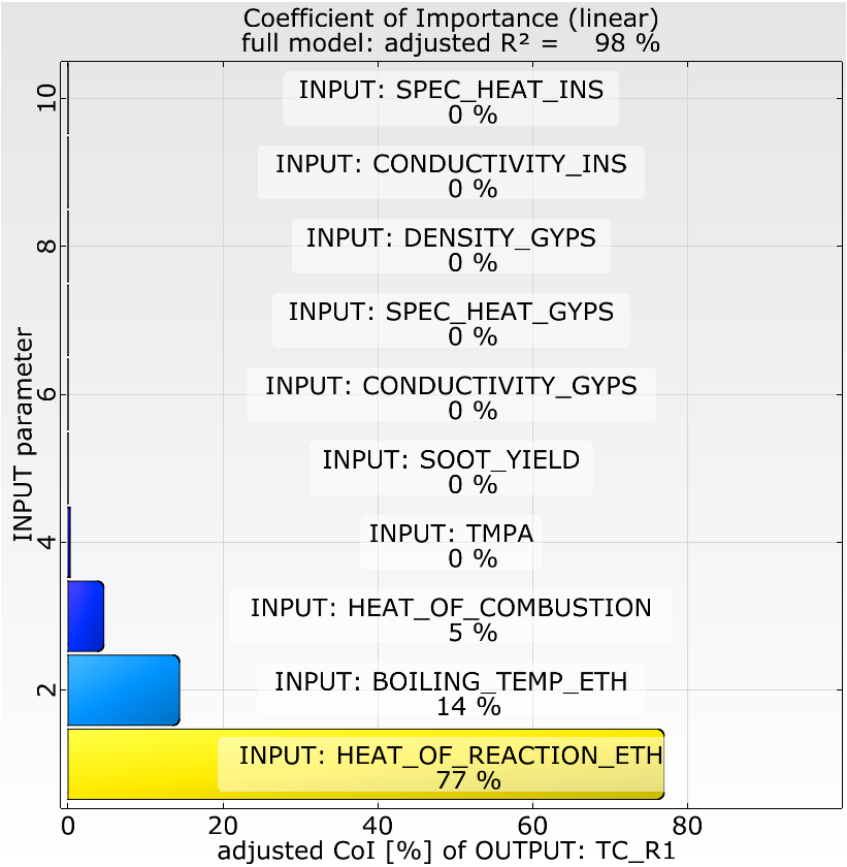




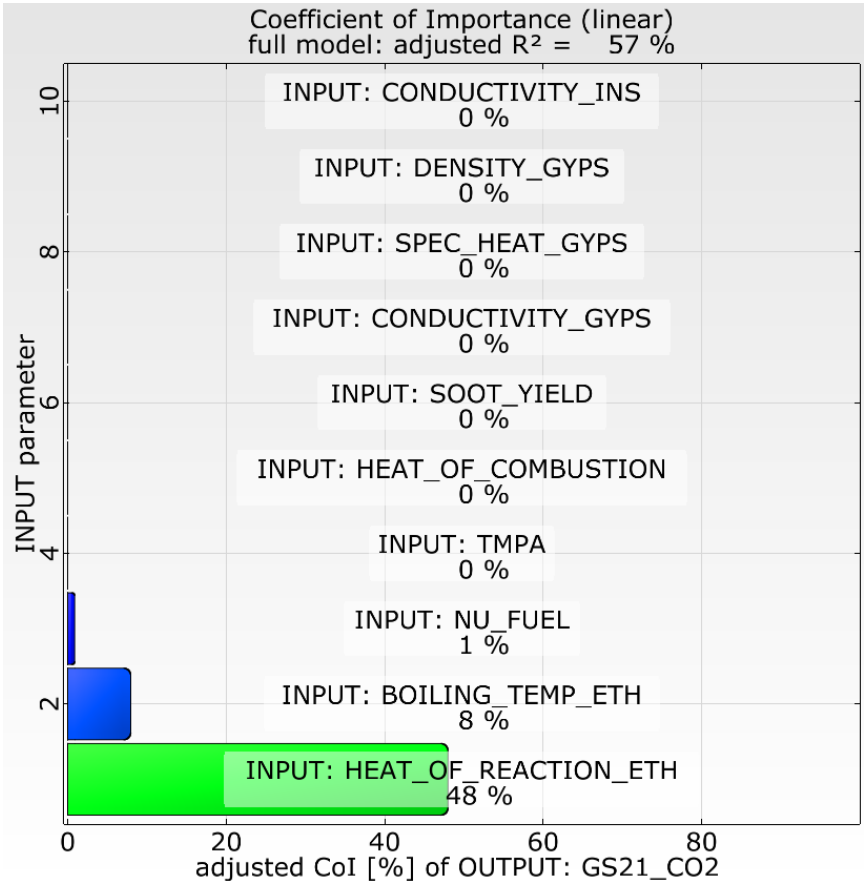
Sensitivity Analysis.

- Investigation of sensitivity of results to scattering of input parameters
- Different studies with 100 to 200 samples investigated with optiSLang 3.2.0
- Advanced Latin Hypercube Sampling

Coefficient of Importance (COI)

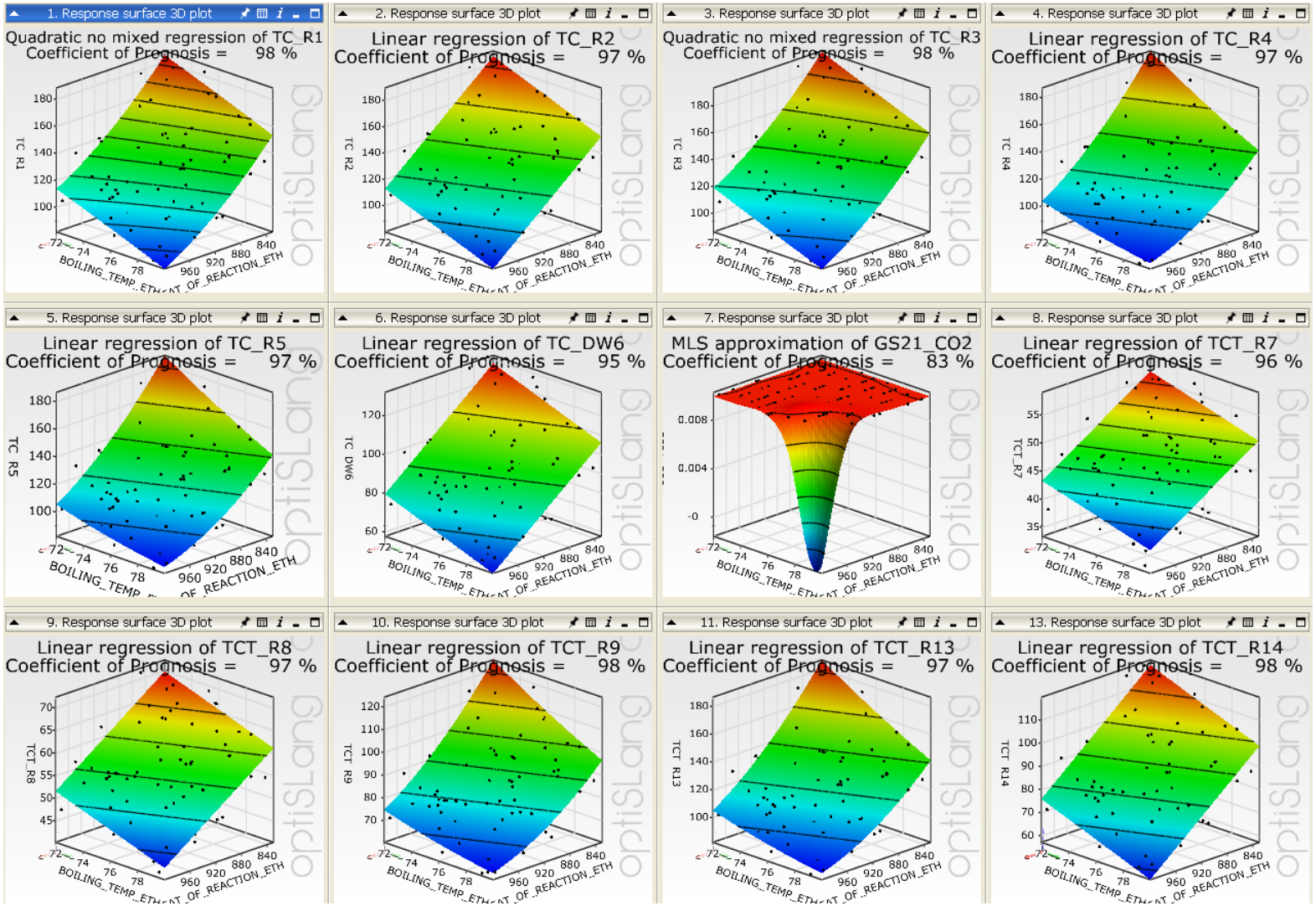


COI for the gas temperature below the ceiling in the room of fire origin



COI for the concentration of carbon dioxide close to the doorway

Metamodel of Optimal Prognosis (MOP)



Summary

- Stochastic methods are appropriate to evaluate and improve the reliability of fire simulations.
- Significant sensitivities were observed for very few input parameters of fuel only: *heat of combustion, heat of reaction, boiling temperature.*
- Most input and output parameters are nearly linearly correlated. For carbon dioxide a strongly non-linear relationship to the fuel properties was identified.
- Further studies with varying ventilation will be carried out to investigate the dependencies of toxic gas concentrations on input parameters. The results can be used to improve combustion modelling.

Ferit Boysen, President & CO Fluent Inc.:

It is now possible for more people to get bad results from CFD faster and cheaper than ever before.

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www.brandschutz-simulation.de

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