INTERNATIONAL AIRCRAFT SYSTEMS FIRE PROTECTION WORKING GROUP MEETING

Tolouse, 18th – 19th May, 2016

Multidisciplinary thermo-structural model FAR / CS 25 appendix F Part III
Multi-disciplinary Model for Smoke Movement Simulation

FINMECCANICA

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Background

INVESTIGATION AND CERTIFICATION RULES DEFINITION

Improving fire safety through improved **technologies** and **materials,** in terms of thermal-structural behaviour, fire penetration resistance and smoke detection time.

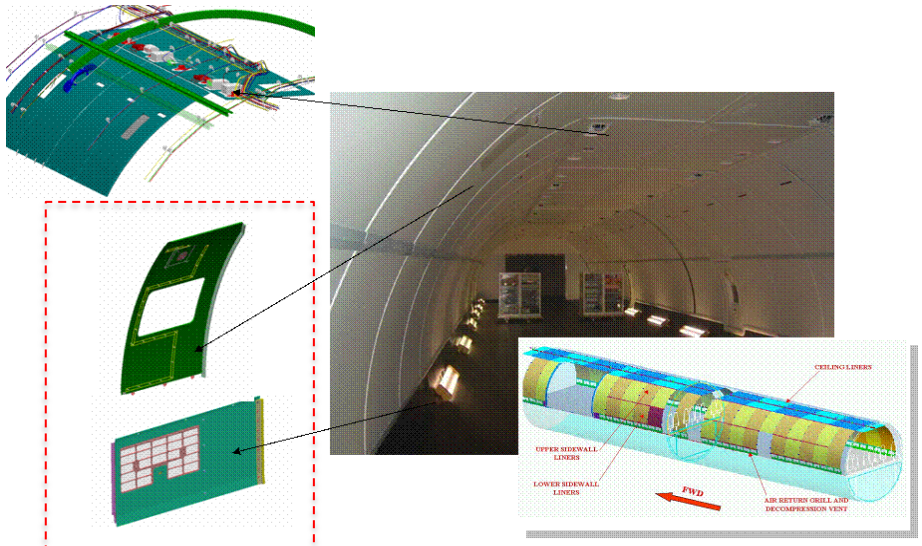
BENEFIT

Give more time for A/C evacuation

Protection of on board systems

Background

Cargo compartment



Lining

FAR/CS 25.855 (c) civil requirements:

In order to assure, in case of fire on board, the protection of essential systems to a “continued safe flight and landing”, the lining panels (ceiling and sidewall) installed in a Cargo Compartment classified as Class C and E meet the flame penetration test defined by **Appendix F Part III**.

Flame penetration test

The FAR/CS 25 Appendix F Part III defines:

• the typology of cargo panels to be tested, and in details they must be representatives of the installation on a/c, and where applicable they must include all “features” installed like joints, lights, smoke detector, air outlet etc.;

• the number of specimens (three) required for each installation;

Acceptance criteria:

- no flame penetration within 5 minutes after application of flame source;
- the peak of temperature, measured at 10 cm from the backside surface of the specimen, must not exceed 204° C when tested in horizontal position.

Currently, the only way to predict the failures of **certification tests** is the engineering test made with the similar equipment. This approach is **time consuming** and **expensive**.

Flame penetration test

Multidisciplinary model building and validation workflow

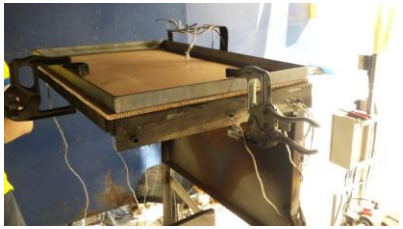
Multi-disciplinary flame penetration model validated

Test campaign - Manufacturing

Testing different material and configuration:

Monolitic panels and sandwich panels without junction







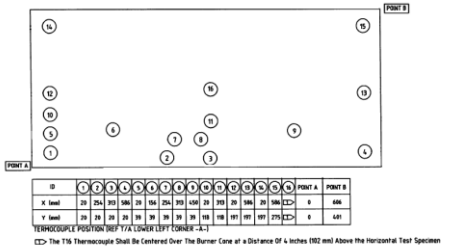
Monolitic panels and sandwich panels with junction


Ref. Cocet research project

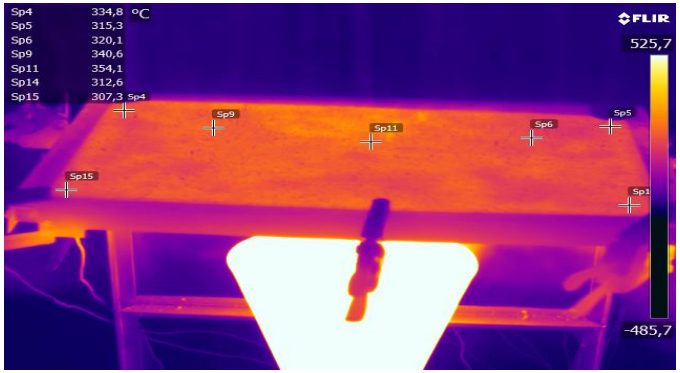
Test campaign validation tools

Thermocamera

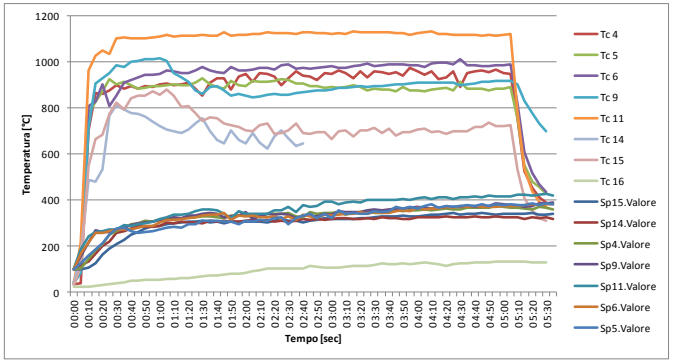
Thermocouples grids



Results necessary for the validation of numerical model



Thermocamera results

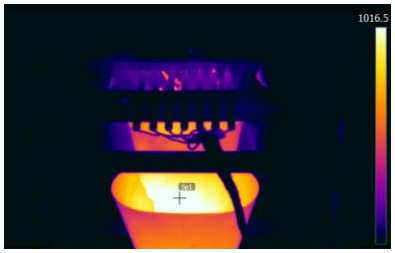


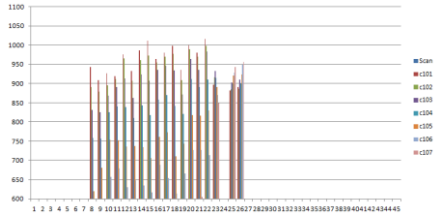
Temperature measured by the thermocouples and the thermocamera

Ref. Cocet research project

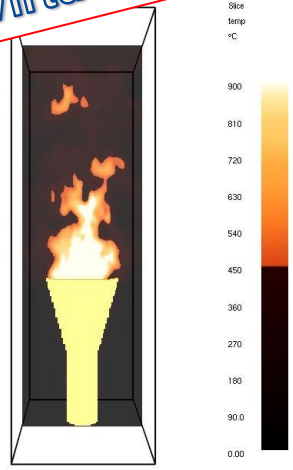
Calibration phase

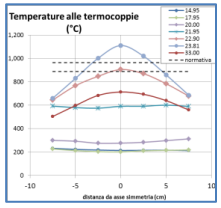
Real test



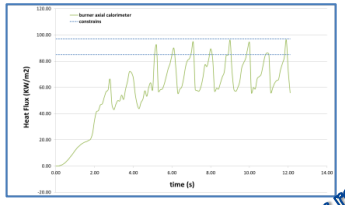


Virtual test





Thermocouples



Calorimetro

For reference only

Requirements

Thermocouples temperature: 927 ± 38° C

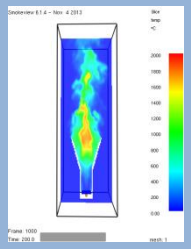
Calorimeter heat flux: 9.1± 0·6 Watts/cm^2

Velocity at end of draft tube: 7.9-9.1 m/s

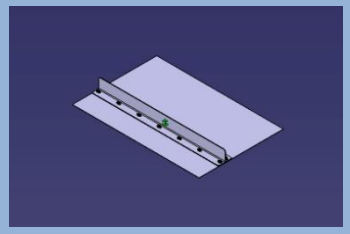
Ref. Cocet research project
M. Panelli, L. Cutrone, G. Mirra “CFD Simulation Of Flame Penetration Test – Calibration Phase” XXIII AIDAA Congress, Torino (TO), Italy, 17-19 November 2015.

Multidisciplinary thermo-structural model

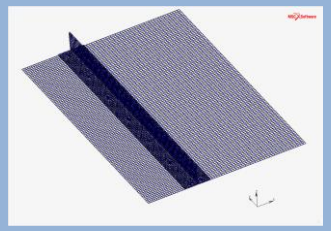
Flame CFD model



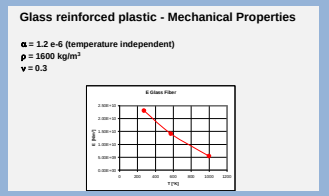
Geometrical model



FEM model

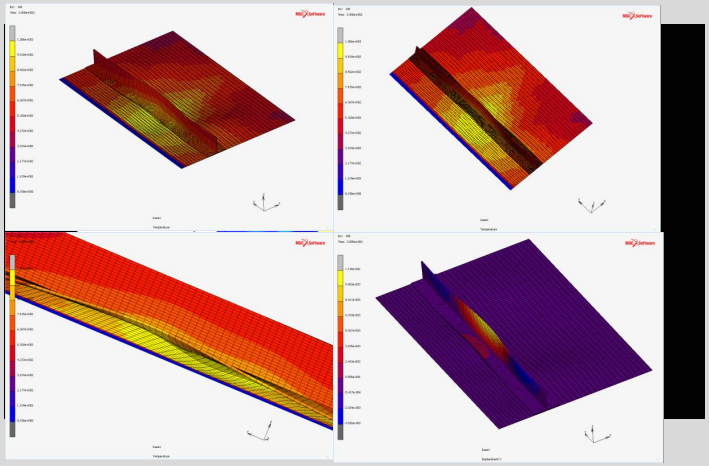


Thermo-mechanical material properties

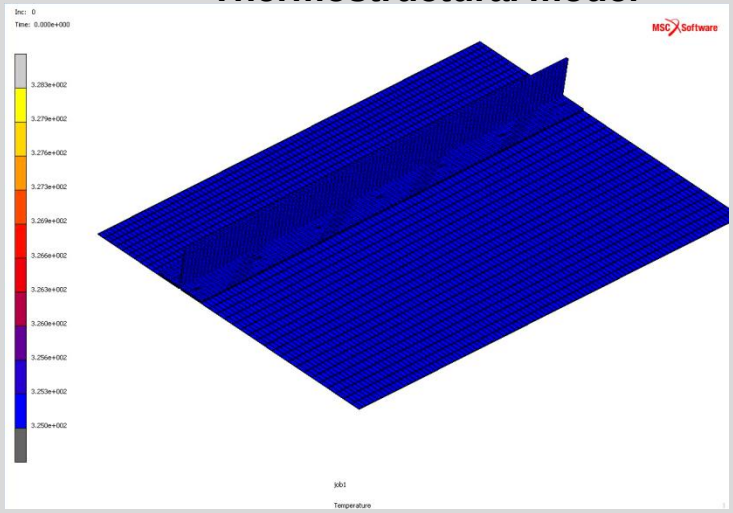


Multidisciplinary integration model

CFD model



Thermostructural model



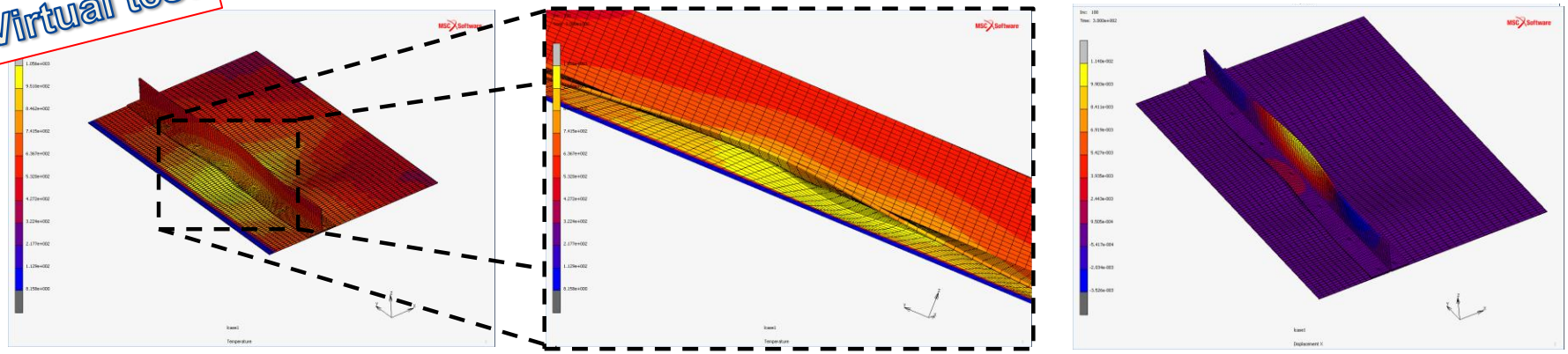
Multidisciplinary thermo-structural model

Ref. Cocet research project

Validation phase

Comparison between temperature pattern on the bottom side of the panel (thermocouples results vs simulation) to verify and tune flame simulation model.
Comparison between temperature pattern on the top side of the panel (thermocamera results vs simulation) to verify the thermo-mechanical behaviour of the specimen and tune the simulation model.

Virtual test



Real test

Ref. Cocet research project

Conclusion 1

Applicability:

- Simulate the thermal-mechanical behaviour of a specimen in fire condition.
- Simulate the flame penetration test .

Benefit:

- Reduce the time and costs of specimen suppling.
- Reduce test time, the experimental activity is minimized to the confermation of the results for the design approval.
- Reduce number of development tests and certification tests **(cost reduction)**
- Reduce risk associated to the development phase: the refinement is anticipated in the concept phase. **(cost reduction)**
- A wide spectrum of configurations and cases (optimized design)

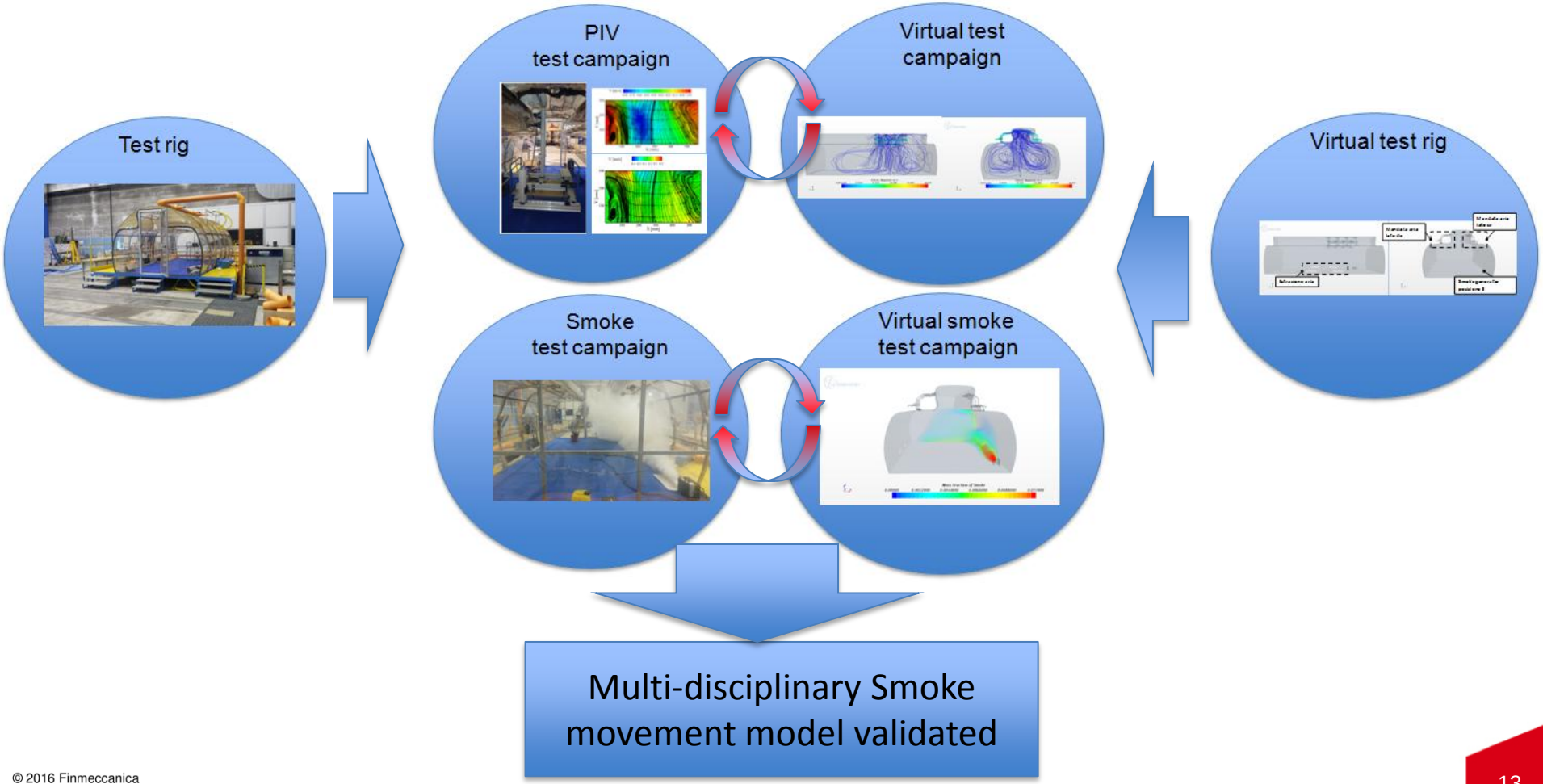
Smoke detection system test

In accordance with **FAR/CS 25.858 (a)** civil requirement, when the certification with cargo compartment fire detection provisions is requested, in case of fire and smoke on the board, the smoke detection system must provide a visual indication to the flight crew within one minute after the start of a fire.

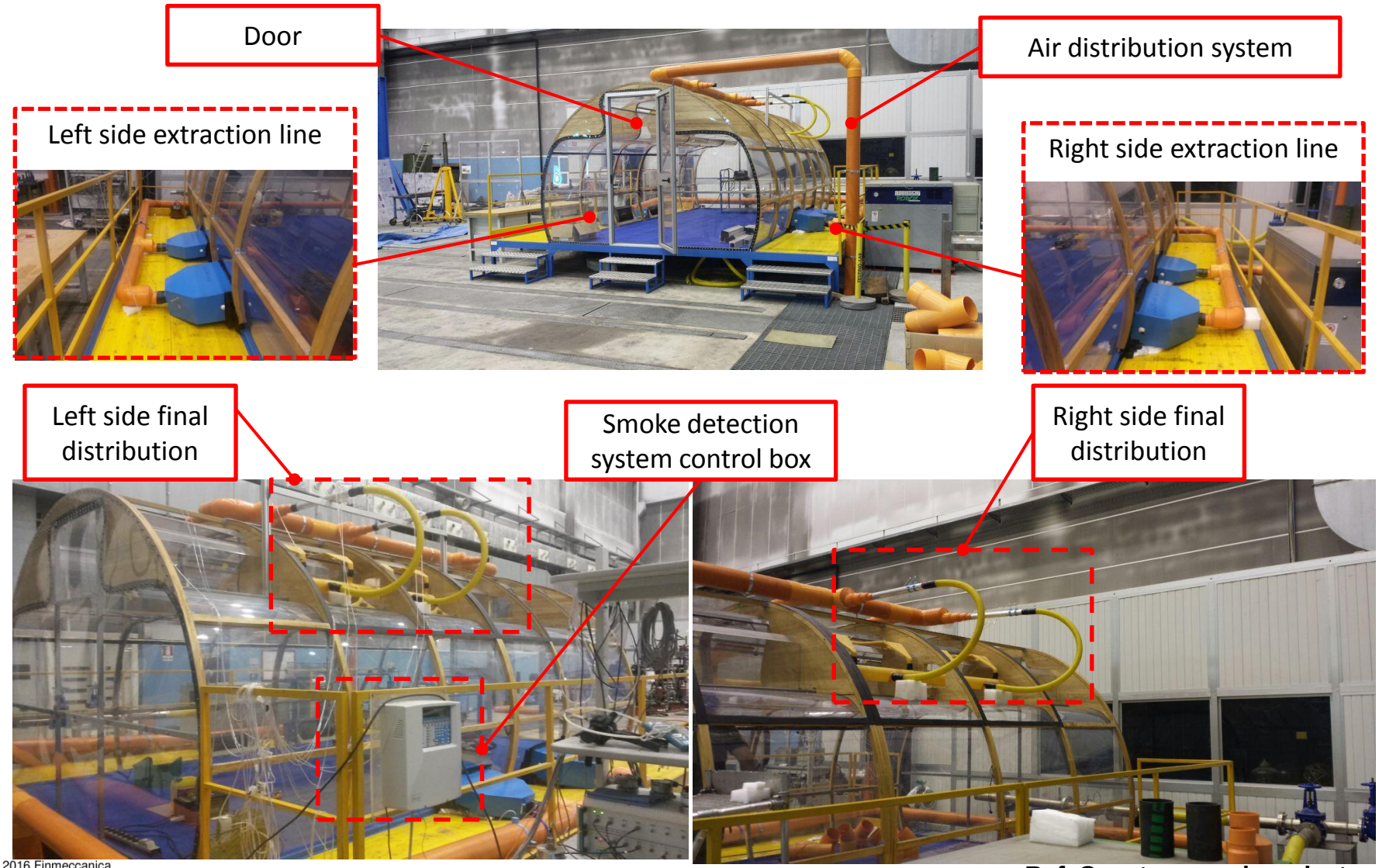
Currently, engineering tests made with the similar equipment are the only means for system development and certification; this approach is **time consuming** and **expensive**.

Smoke detection system test

Multidisciplinary model building and validation workflow

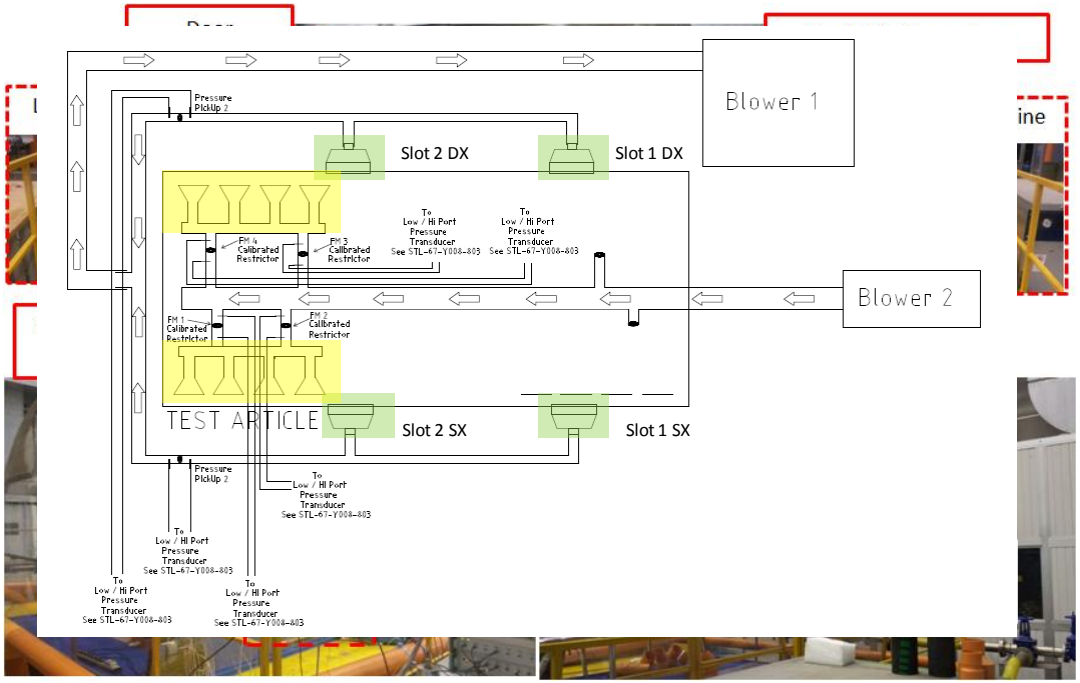


Test rig



Ref. Cocet research project

Test rig



Tools:

Pressure sensors,
Temperature sensors
PIV
Camera
Smoke generator
Control box
Smoke detectors

Test results.

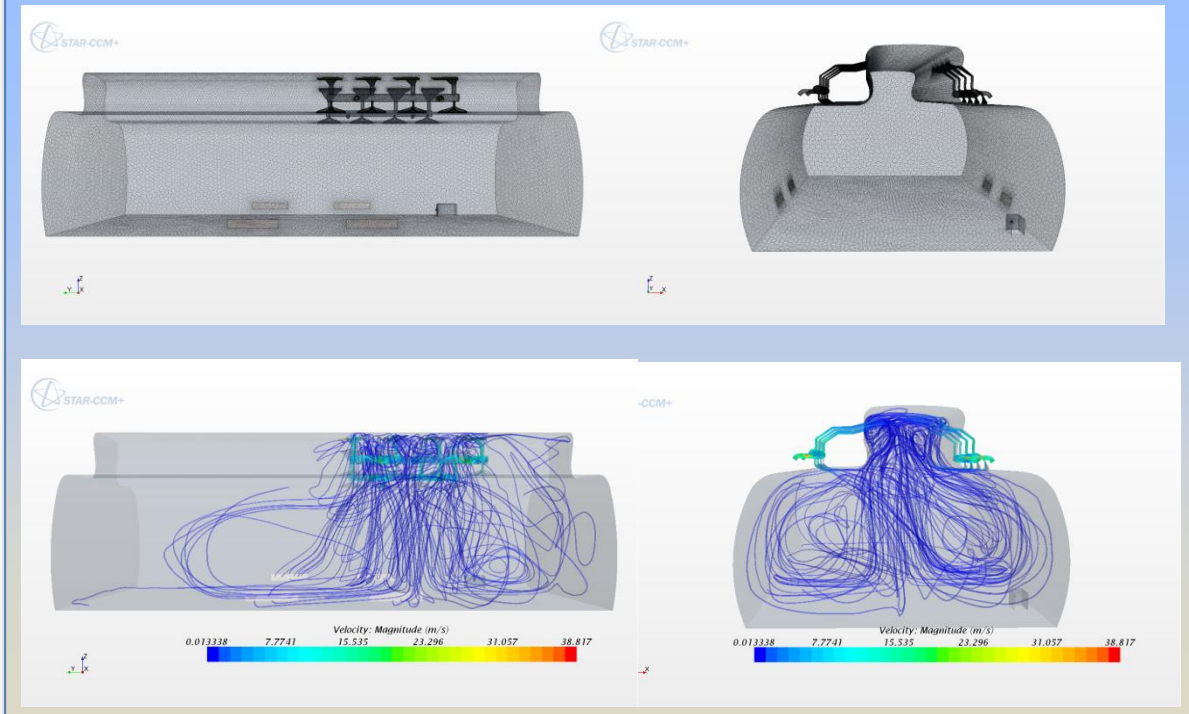
Air massflow and temperature in each branch of air distribution system
Smoke detectors activation time
Velocity pattern in characteristic slice defined in the test room
Smoke tracking

Ref. Cocet research project

Multidisciplinary model - Air

Assumption and boundary conditions
Air Massflow and temperature measured during the test campaign

Modello CFD



Smoke generator off

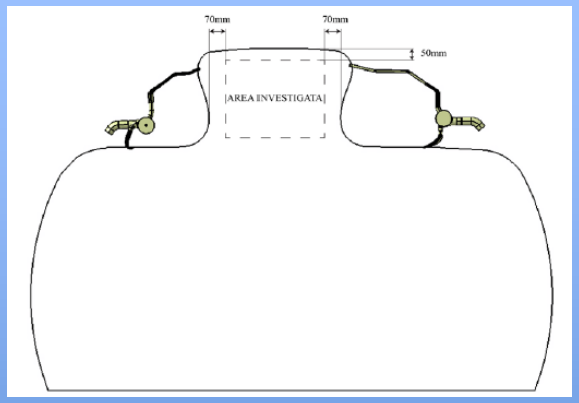
Results:

Air massflow and temperature pattern
Velocity pattern
Pressure pattern

Ref. Cocet research project

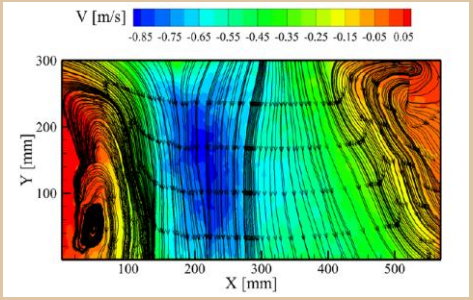
Multidisciplinary model validation - PIV

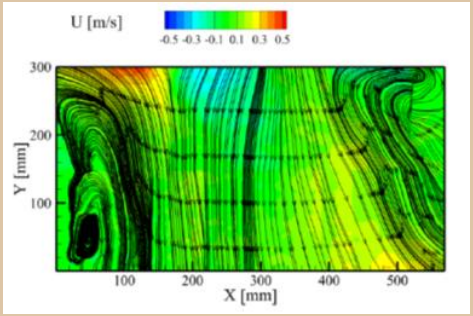
Measure of velocity pattern and velocity vector field through PIV tool.



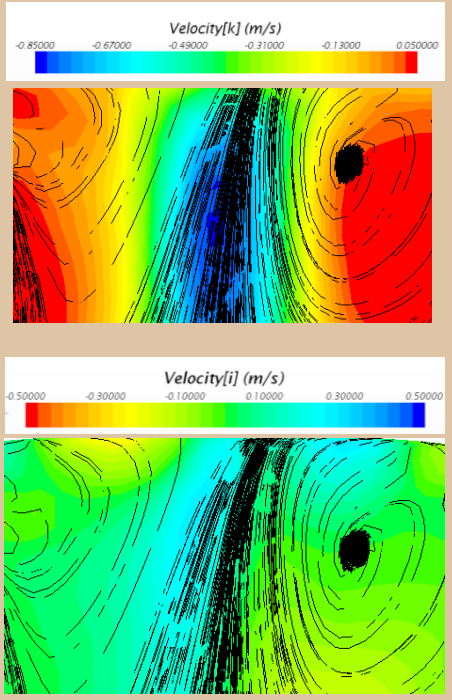
Validation of fluid dynamic model with smoke generator off

Test results





CFD



Ref. Cocet research project

Multidisciplinary model - Smoke

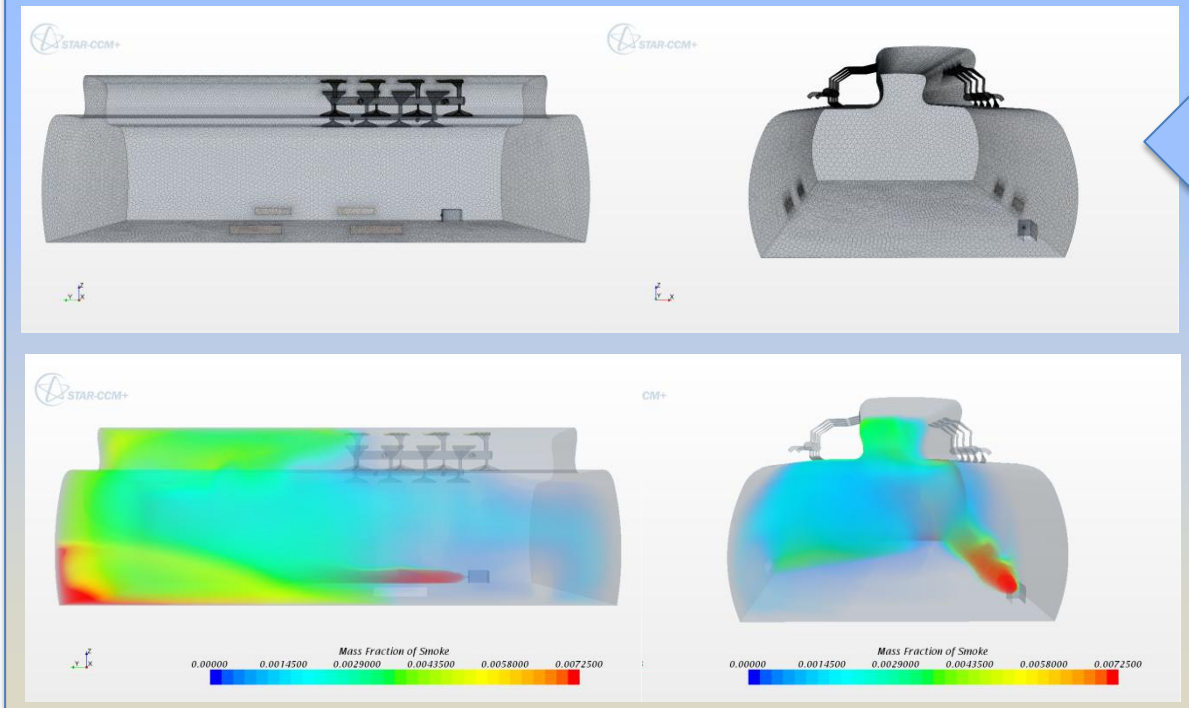
Assumption and boundary conditions

Air Massflow and temperature measured during the test campaign

Model bi-component: air and smoke. The smoke characteristics are defined on the basis of dedicated model defined in Italian research project (ref. Cocet research project)

Temperature of smoke

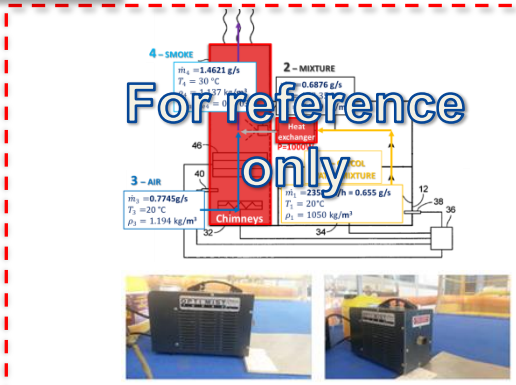
Modello CFD



Smoke distribution after 60 s

Defintion of new fluid element in the CFD tool: Smoke

Chemical characteristics and mass fraction of the smoke

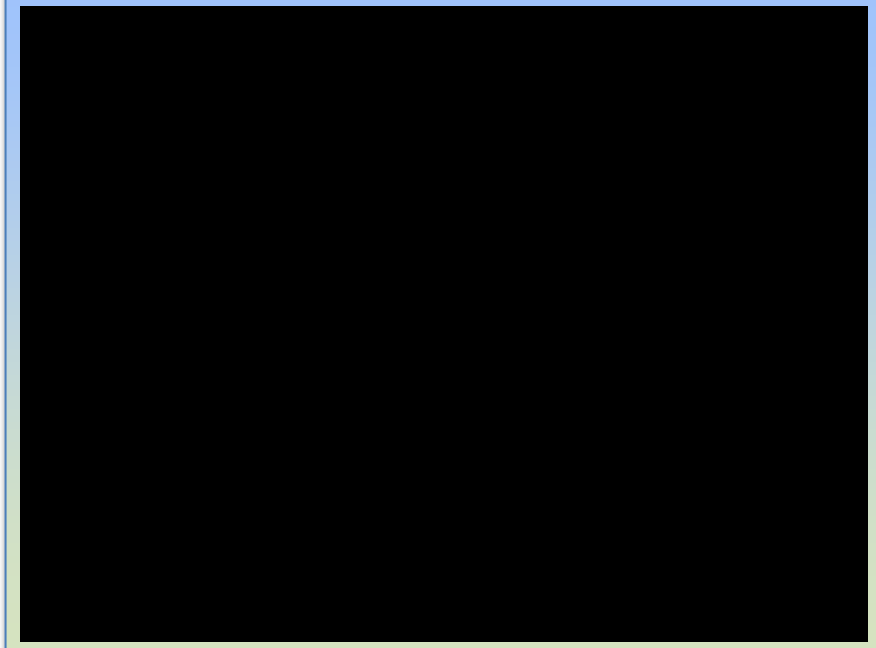


Smoke generator

Ref. Cocet research project

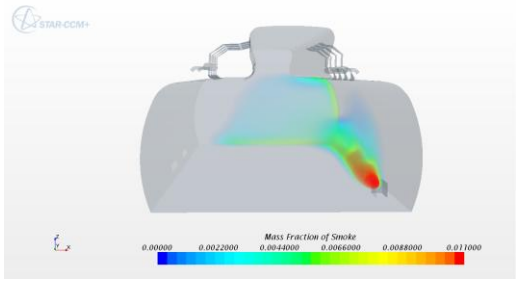
Multidisciplinary model validation – smoke movement

Multidisciplinary model results

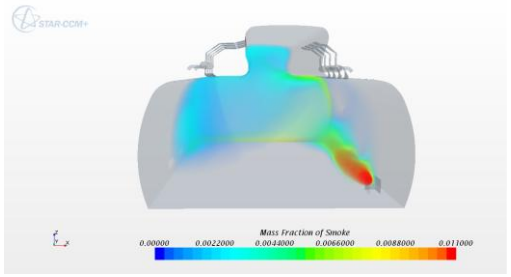


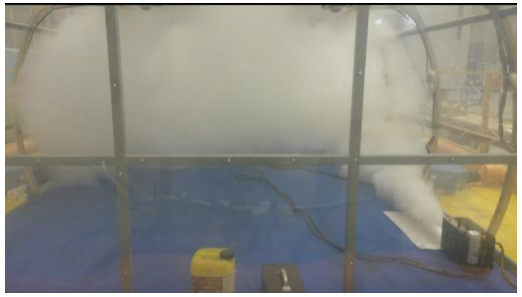
Real test

Multidisciplinary model validation – smoke movement

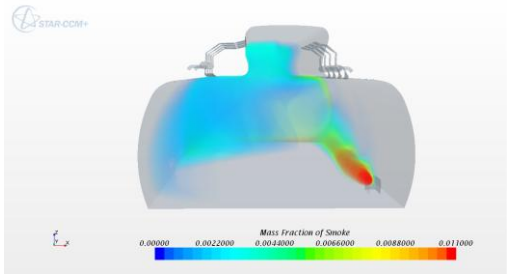


10 sec





30sec



50 sec

Ref. Cocet research project

Conclusion 2

Applicability:

- Simulate the thermal and fluid-dynamic environment in a conditioned cabin.
- Simulate and predict the flow of the smoke generated by a smoke generator located inside a conditioned cabin.
- Verify and predict the smoke detectors time activation and sequence activation.

Benefit:

- Passenger comfort evaluation.
- Optimization of Smoke detector position and number.
- Evaluation of emergency labels position.
- Reduce number of development tests and certification tests. **(cost reduction)**
- Reduce risk associated to the development phase: the refinement is anticipated in the concept phase. **(cost reduction)**
- A wide spectrum of configurations and cases (optimized design)

NEXT STEPS AND IMPROVEMENT

Flame penetration test model

- Improve model reliability through:
- validation activities with experimental results
- materials chemical and thermo mechanical characteristics data gathering

Smoke movement model:

- Dedicated test to measure the smoke mass flow
- Dedicated test to measure the smoke detector activation time
- Dedicated test to measure in detail the chemical characteristics of the smoke

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