ITAINNOVA
INSTITUTO TECNOLÓGICO DE ARAGÓN

OPENFOAM CONTRIBUTIONS TO INDUSTRIAL MANUFACTURING

María García-Camprubí

May 29th 2018

OpenFOAM 2nd Iberian Meeting | 28 & 29 May 2018 | Santiago de Compostela - Spain

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Outline

ITAINNOVA at a glance:

- 01. OpenFOAM group

Contributions to Industrial Manufacturing:

- 02. Rubber Injection Molding
- 03. Microfluidic Chip Control
- 04. Ongoing/Future projects

01

ITAINNOVA at a glance: OpenFOAM Group

ITAINNOVA – Instituto Tecnológico de Aragón

Research and Technology Centre

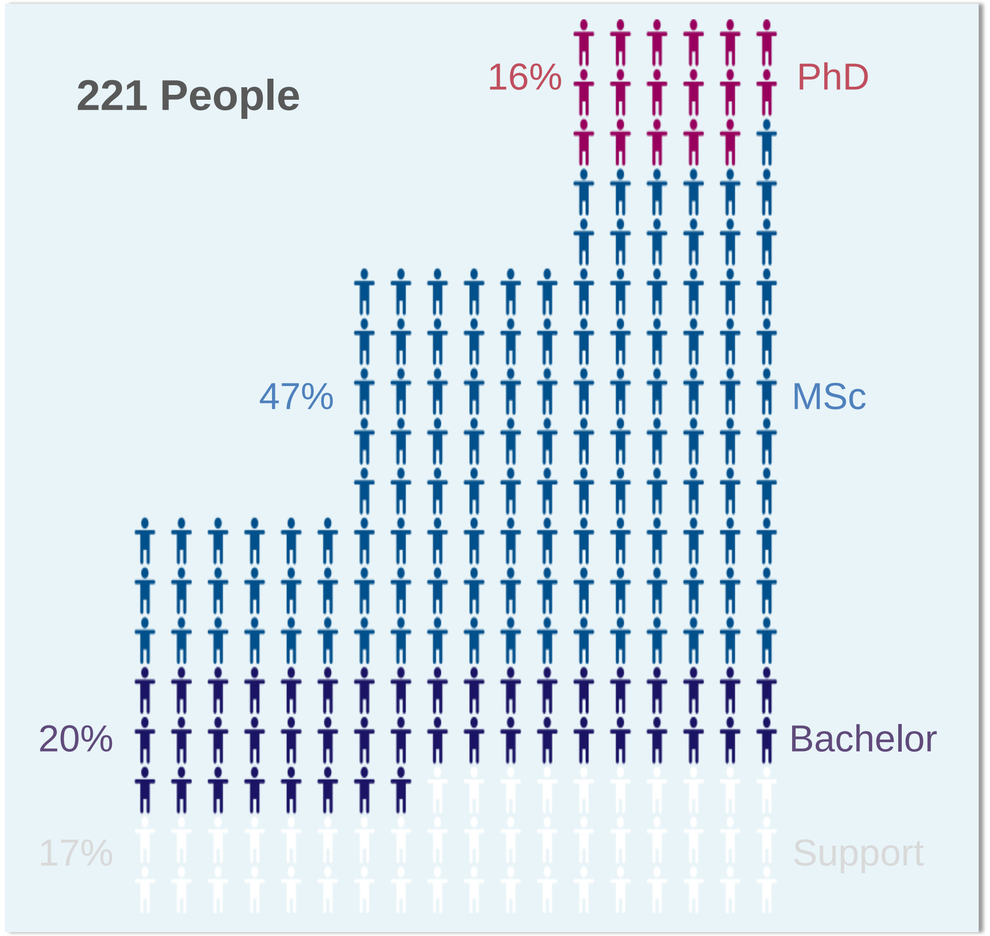
Ownership: Aragón Regional Government

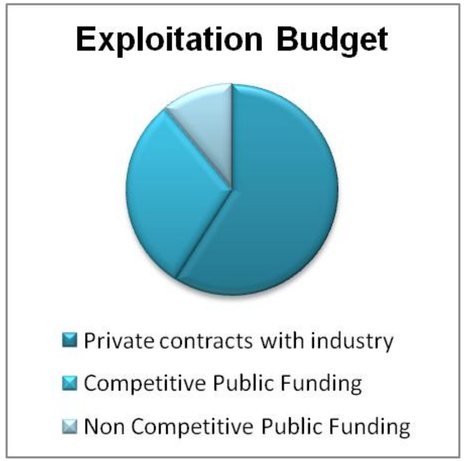
Entity: Public company - Non profit

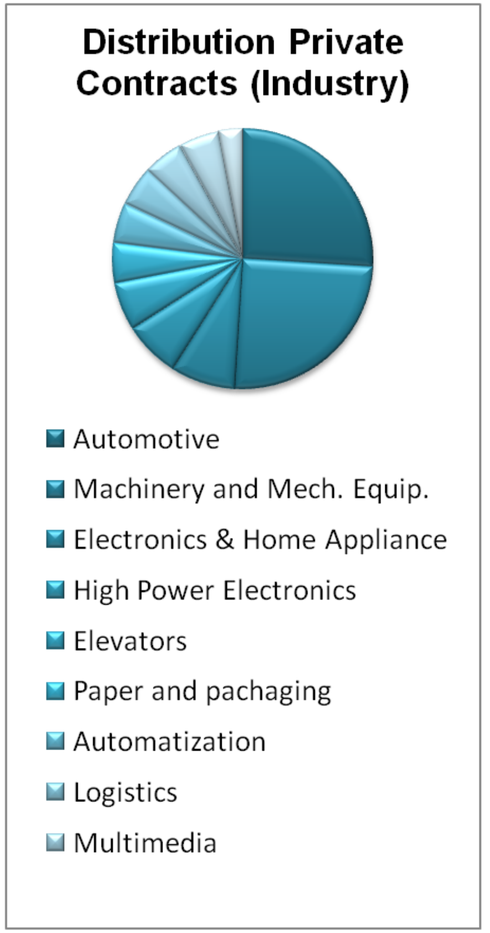
Locations: >25.000m^2 in Zaragoza and Huesca

ITAINNOVA – Instituto Tecnológico de Aragón

Some Figures







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R&D Areas

Lab ITAINNOVA LABORATORIES & QUALITY

Trai ITAINNOVA TRAINING & INSPIRATION

Mat ITAINNOVA MATERIALS & COMPONENTS

Syst ITAINNOVA INDUSTRIAL SYSTEMS

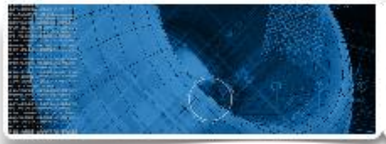
Log ITAINNOVA ICT 4 LOGISTICS

ICT ITAINNOVA SOFTWARE ENGINEERING

MulT ITAINNOVA MULTIMEDIA TECHNOLOGIES

69 people

DESIGN AND DEVELOPMENT OF NEW MATERIALS



ADVANCED MODELING AND CHARACTER

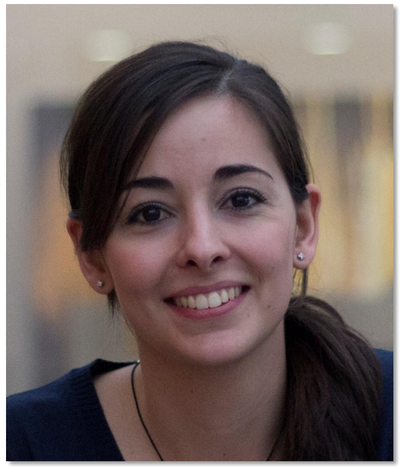
STRUCTURAL INTEGRITY AND RELIABILITY

MULTIPHYSISCS AND MULTISCALE SIMULATION

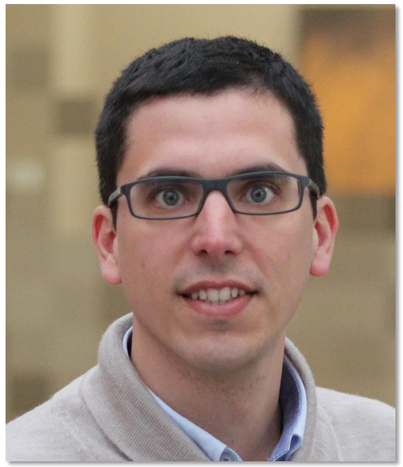
OpenFOAM Group

OpenFOAM group

@ Instituto Tecnológico de Aragón



PhD Fluid Mechanics
MSc Chemical Engineering



PhD Fluid Mechanics
MSc Chemical Engineering

PhD student
MSc Chemical Engineering

PhD student
MSc Mechanical Engineering

...Why OpenFOAM?

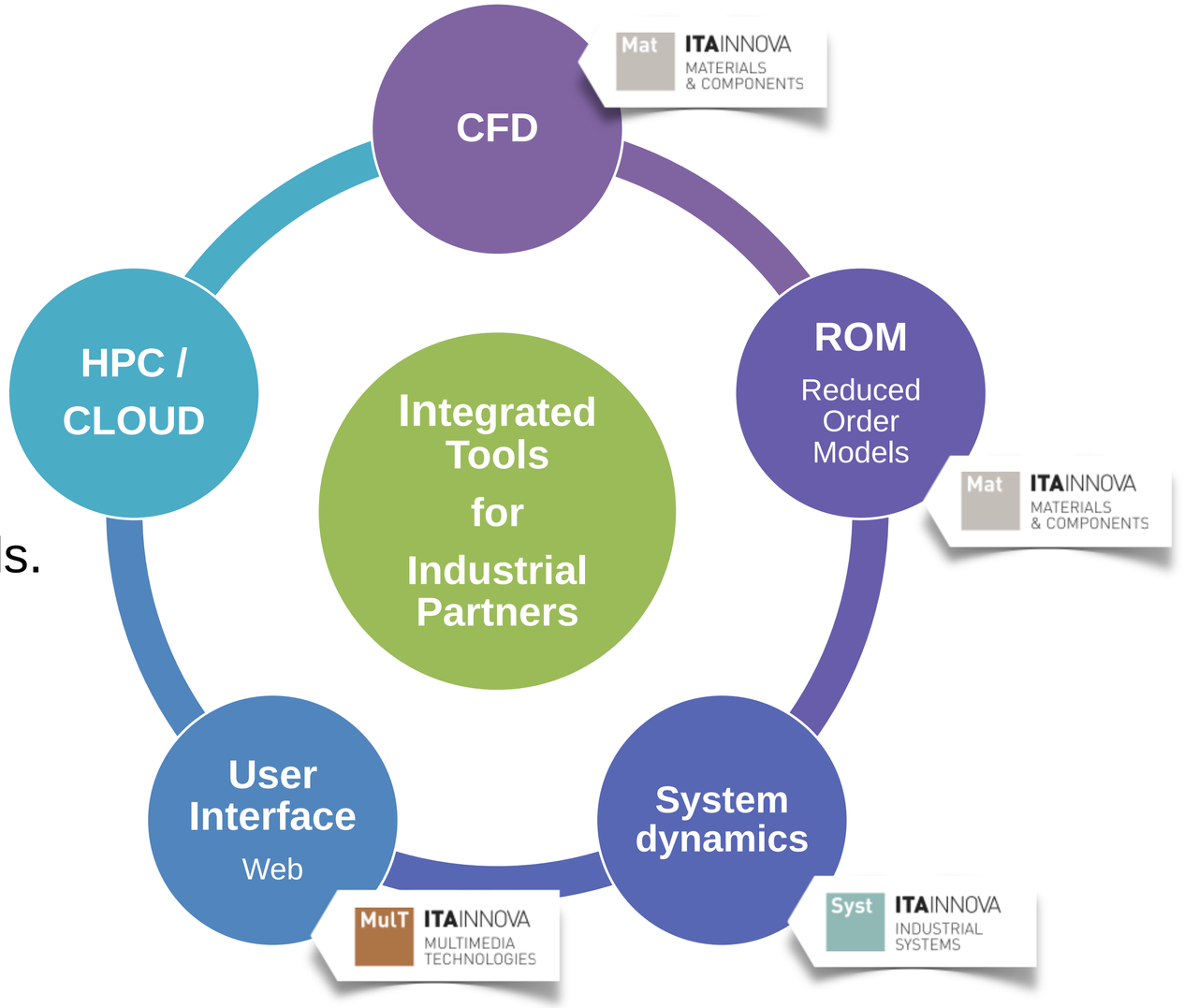
Open-source gives us flexibility to move CFD closer to industry

OpenFOAM group

Instituto Tecnológico de Aragón

How...?

Adding value to CFD simulations,
by means of multidisciplinar integrated tools.



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How...?

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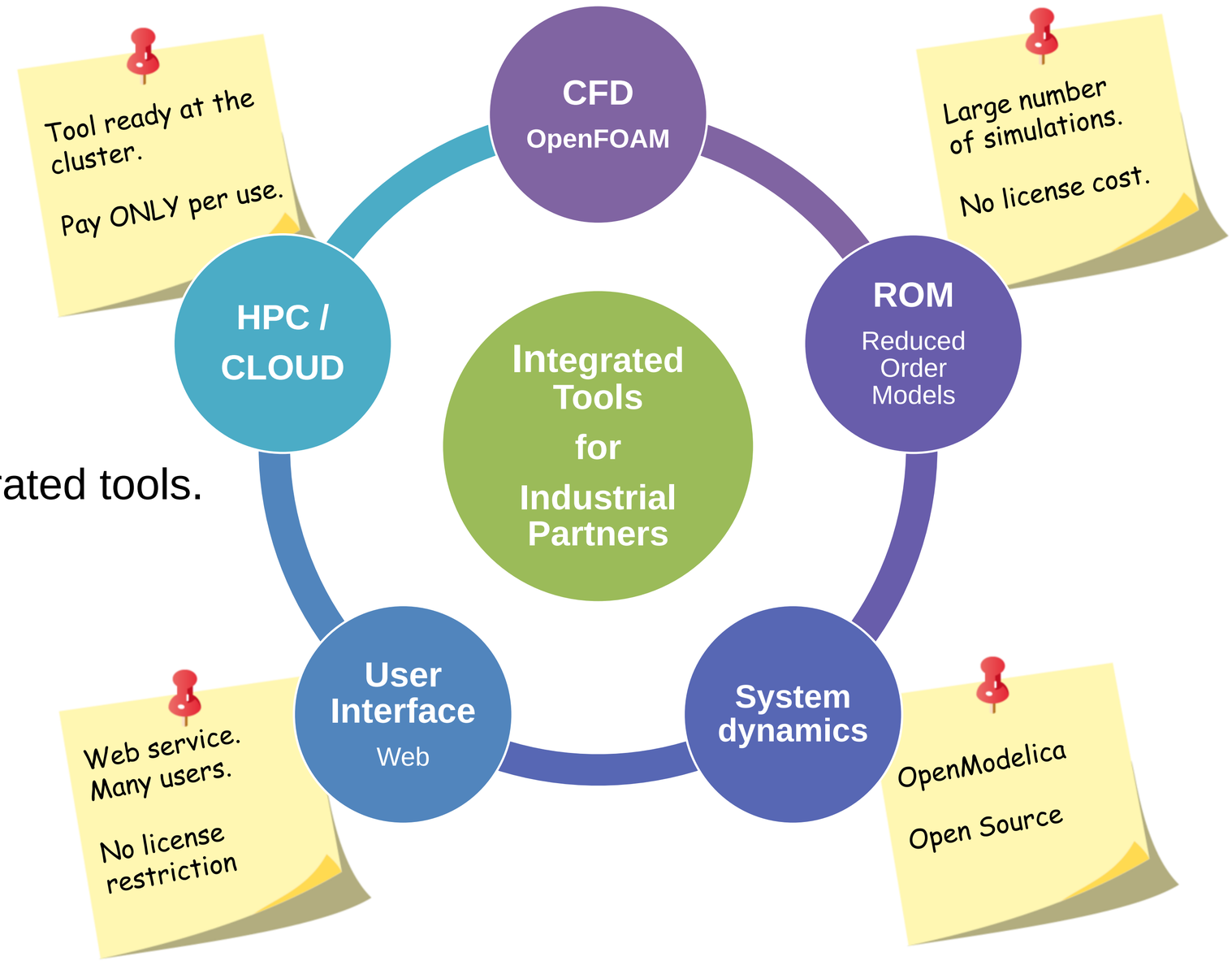

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02

Contributions to Industrial Manufacturing (1): Rubber Injection Molding

Optimal rubber injection moulds through cloud-based simulation

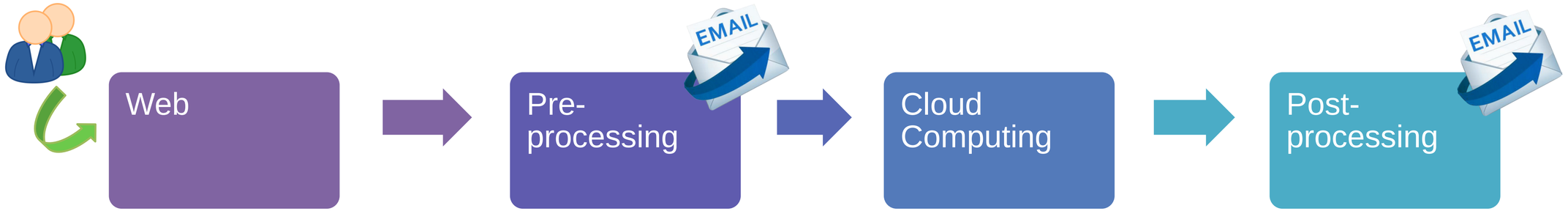
Cloudflow

- Funding: CloudFlow (Exp.17. 3th Wave) - 7th Framework Programme of the European Commission
- Goal: Lean Cloud App aiming at zero-defect manufacturing (i.e. scotch, flash, weld lines, air-trapped) while minimising injection time.
- Involved entities:

End-User	• SME
R&D	• ITAINNOVA
Cloud	• Institute for Biocomputation and Physics of Complex Systems

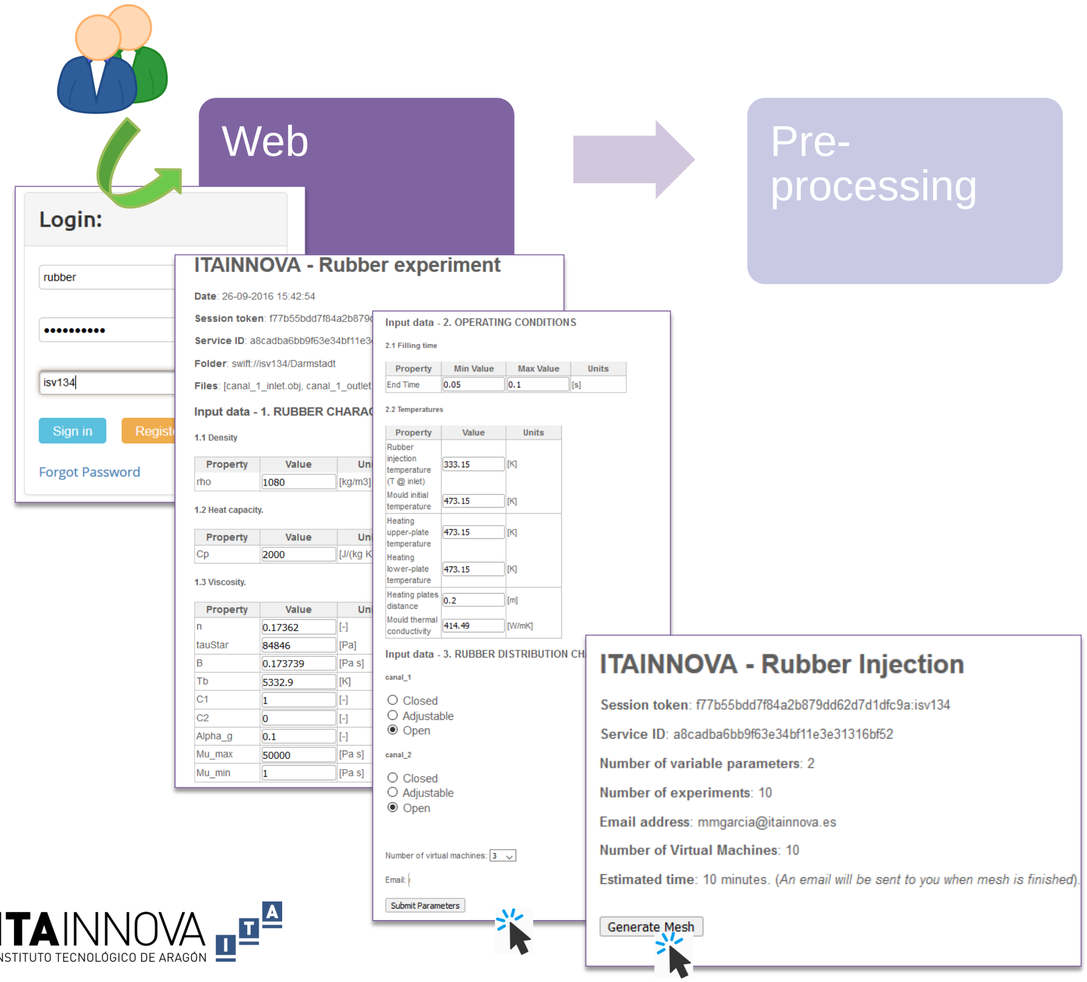
Optimal rubber injection moulds through cloud-based simulation

Lean Cloud App: for Moulds Design aiming at Zero Defect Manufacturing



Optimal rubber injection moulds through cloud-based simulation

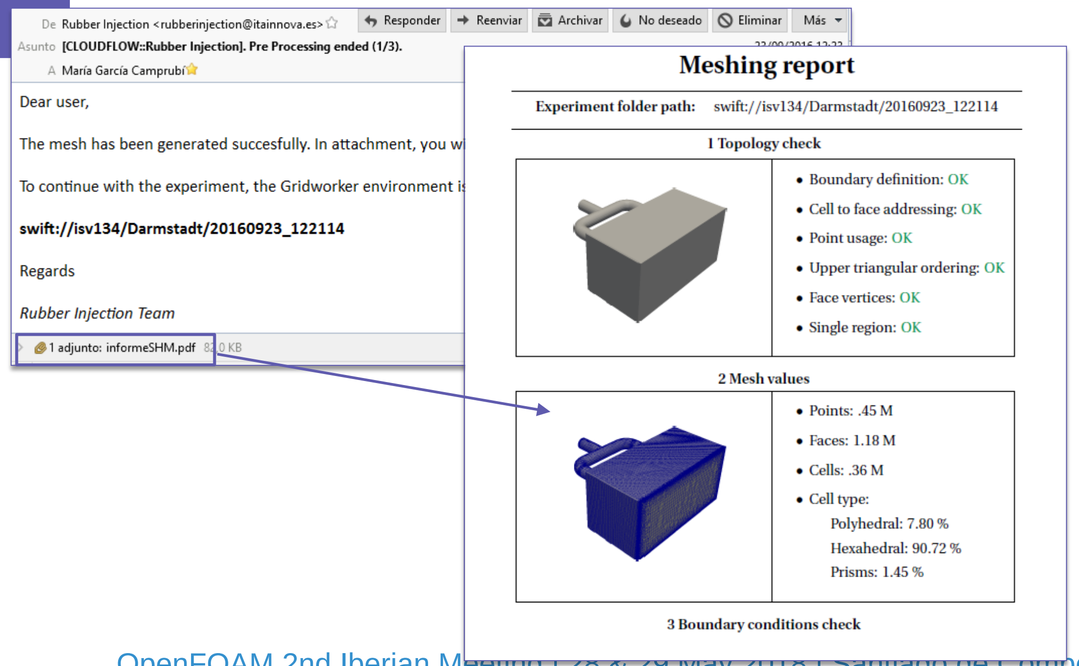
Lean Cloud App: Workflow



Optimal rubber injection moulds through cloud-based simulation

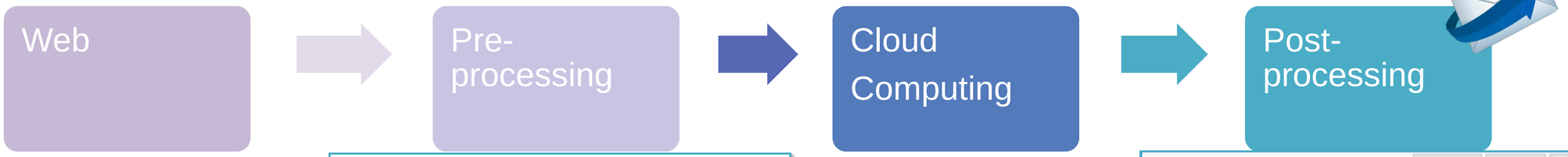
Lean Cloud App: Workflow

Web → Pre-processing: DoE & MESHING → Cloud Computing → Post-processing



Optimal rubber injection moulds through cloud-based simulation

Lean Cloud App: Workflow

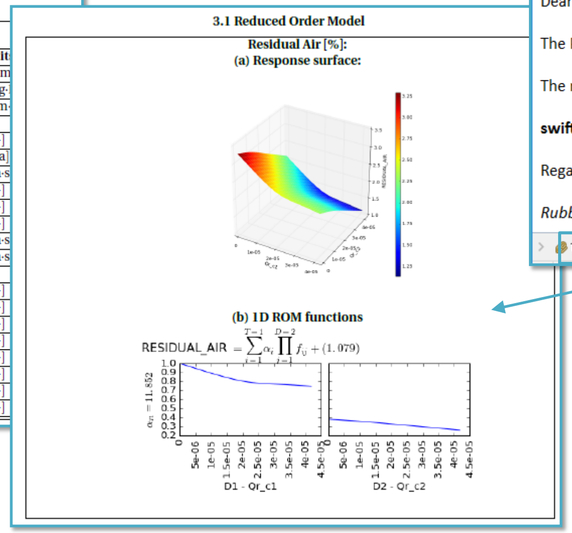


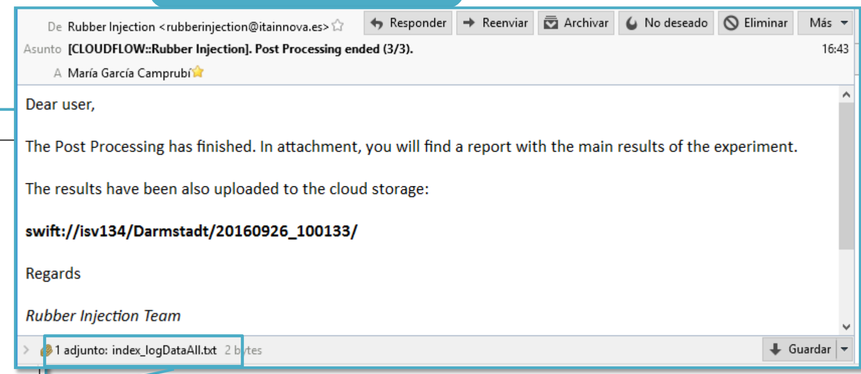
Results report

Experiment folder path: swift://isv134/Darmstadt/20160926_181217

1. Rubber characterization

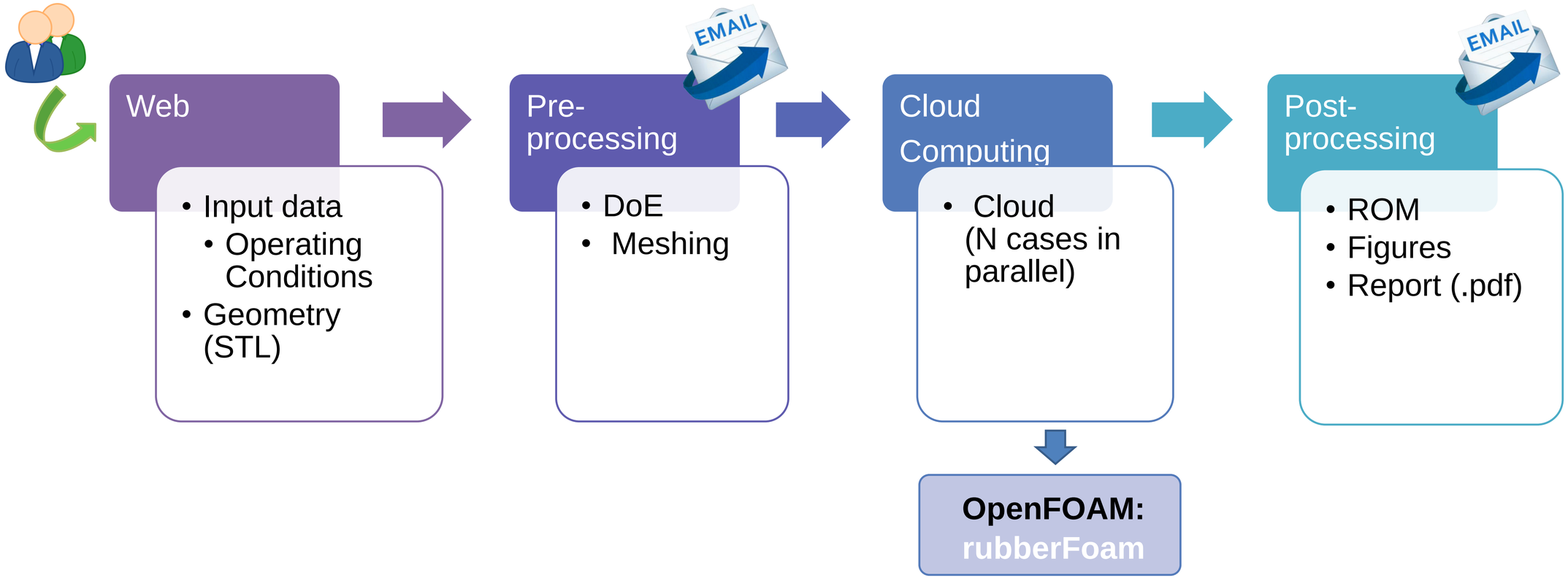
Physical properties	Value	Unit
Rubber density	1080	[kg/m
Heat capacity at constant pressure	2000	[J/(kg·
Rubber termal conductivity	0.3836	[W/(m·
Viscosity model parameters :		
n	0.17362	[-]
Tau*	84846	[Pa]
B	0.173739	[Pa·s
C1	1	[-]
C2	0	[-]
Alpha g		[-]
Max Viscosity	0.173739	[Pa·s
Min Viscosity	0.002554497	[Pa·s
Cure kinetics parameters :		
m	0.7914	[-]
n cure kinetics	2.1873	[-]
A1	0	[-]
E1	3.09E+07	[-]
A2	3.09E+07	[-]
E2	0.1	[-]
B1	0.002554497	[-]
B2	3889.8	[-]





Optimal rubber injection moulds through cloud-based simulation

Lean Cloud App: Tools



Optimal rubber injection moulds through cloud-based simulation

OpenFOAM: rubberFoam

Solver for two compressible, non-isothermal and immiscible fluids using a VOF phase-fraction based interface capturing approach; where one of the fluids is a **non-Newtonian rubber.**

- Rubber rheological behaviour: **Reactive Viscosity Model**

$$\mu_{(\omega,T,\dot{\gamma})} = \frac{\mu_{0_{(T)}}}{1+\left(\frac{\mu_{0_{(T)}}\dot{\gamma}}{\tau^*}\right)^{1-n}}\left(\frac{\omega_g}{\omega_g-\omega}\right)^{(C_1+C_2\omega)}$$

- Degree of cure:

$$\frac{d\omega}{dt} = \Upsilon * (K_1 + K_2\omega^{m_c})(1-\omega)^{n_c}$$

Solver developed by ITAINNOVA

03

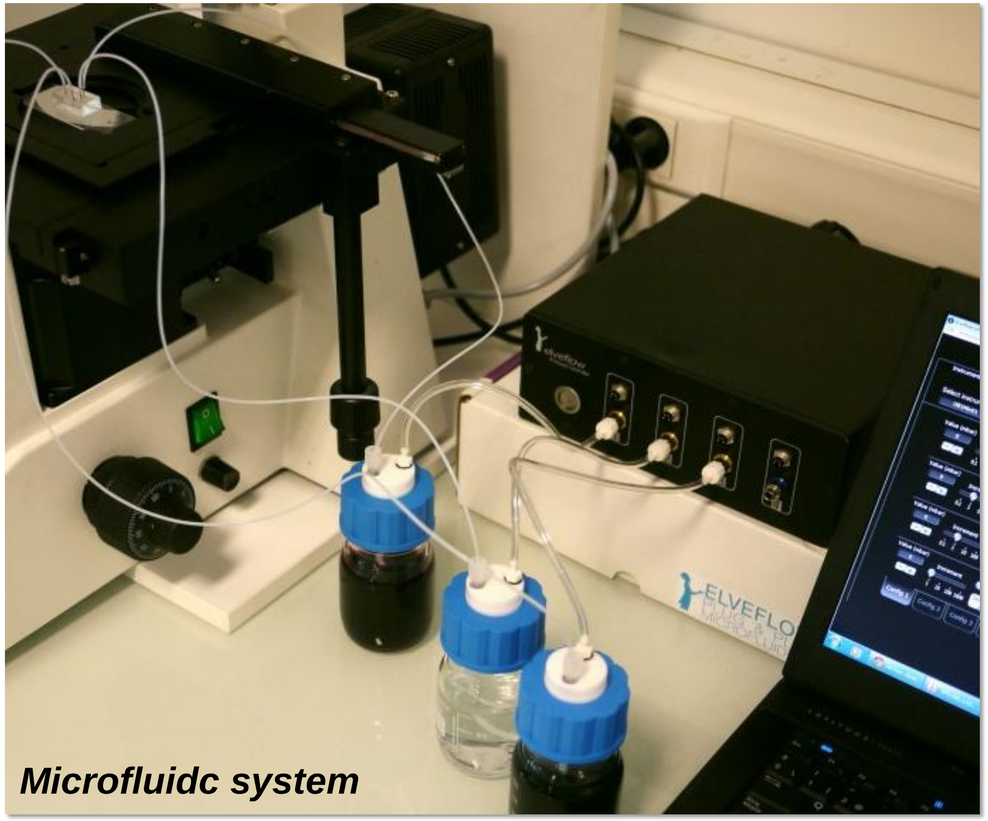
Contributions to Industrial Manufacturing (2): Microfluidic Chip Control

Cloud-based multiphysics simulation for designing highly dynamic and highly accurate flow controls for microfluidic applications

FORTISSIMO

- Funding: H2020 – European Comission
- Goal: Digital Twin of a Microfluidic System
- Involved entities:

End-User	• SME — ELVEFLOW PLUG & PLAY MICROFLUIDICS
R&D	• ITAINNOVA — ITAINNOVA INSTITUTO TECNOLÓGICO DE ARAGÓN
HPC	• GOMPUTE — GOMPUTE A GRIDCORE COMPANY

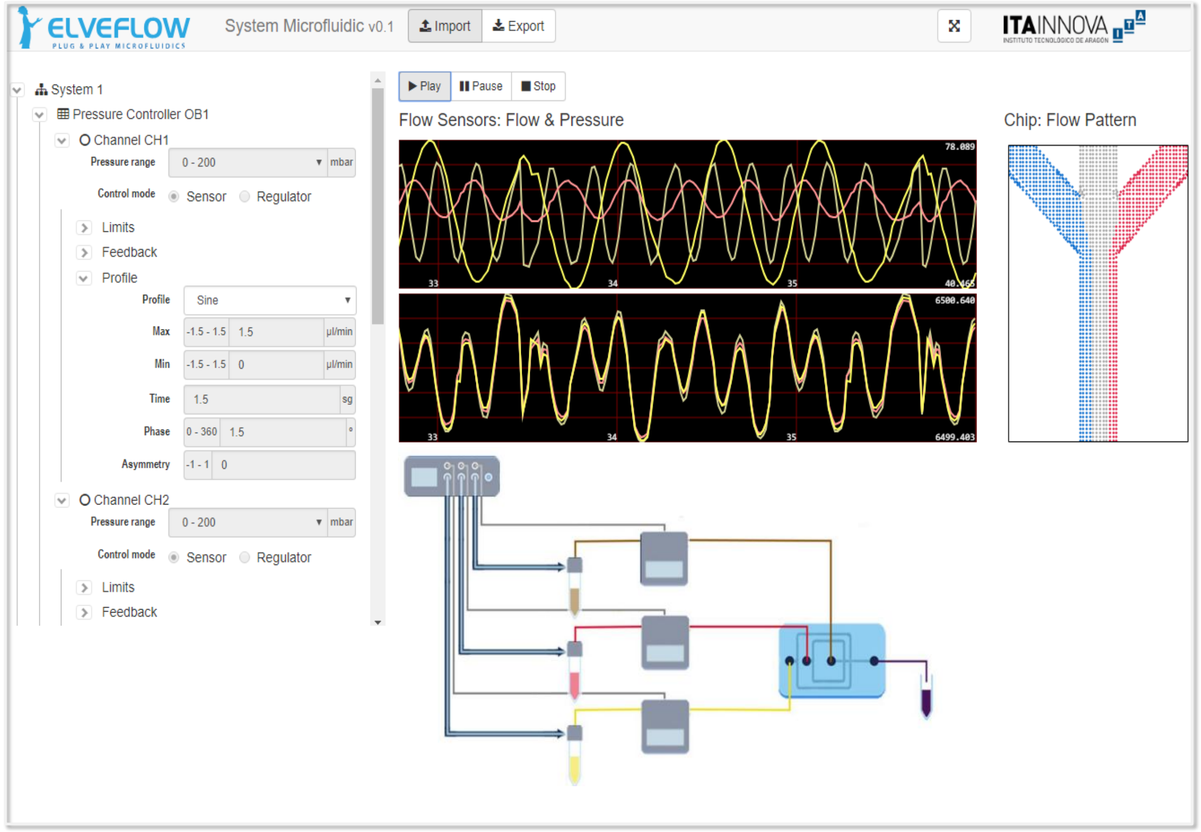


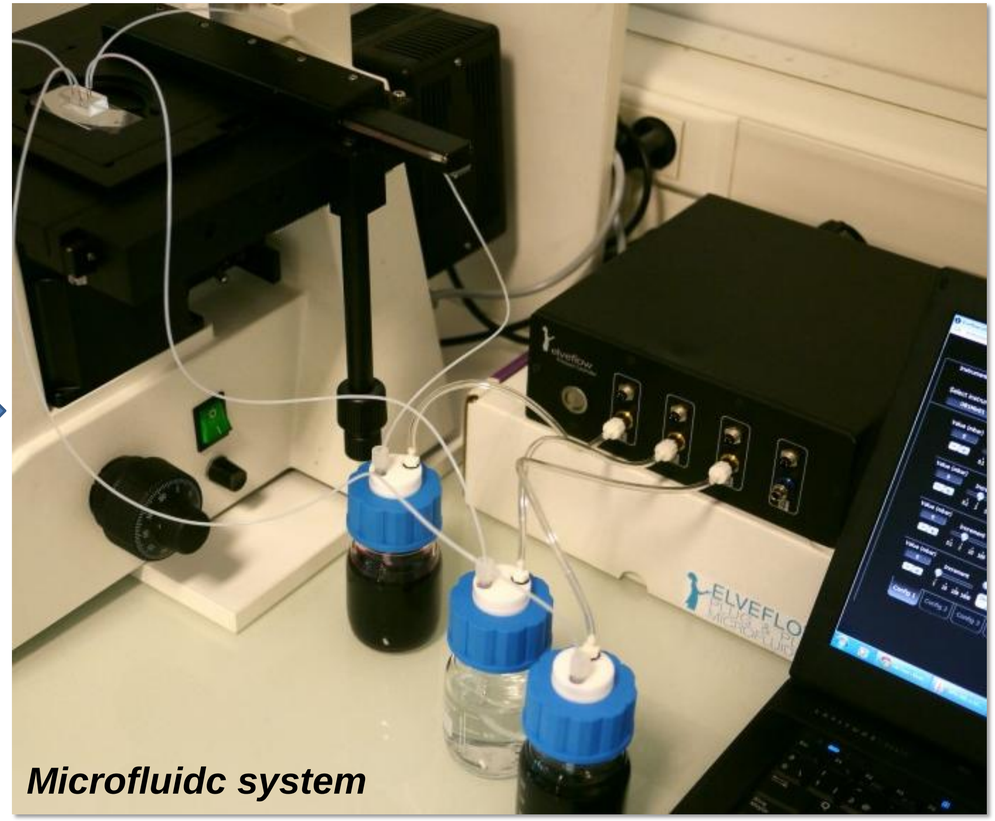
Microfluidc system

Microfluidic System: Digital Twin

FORTISSIMO

Digital twin



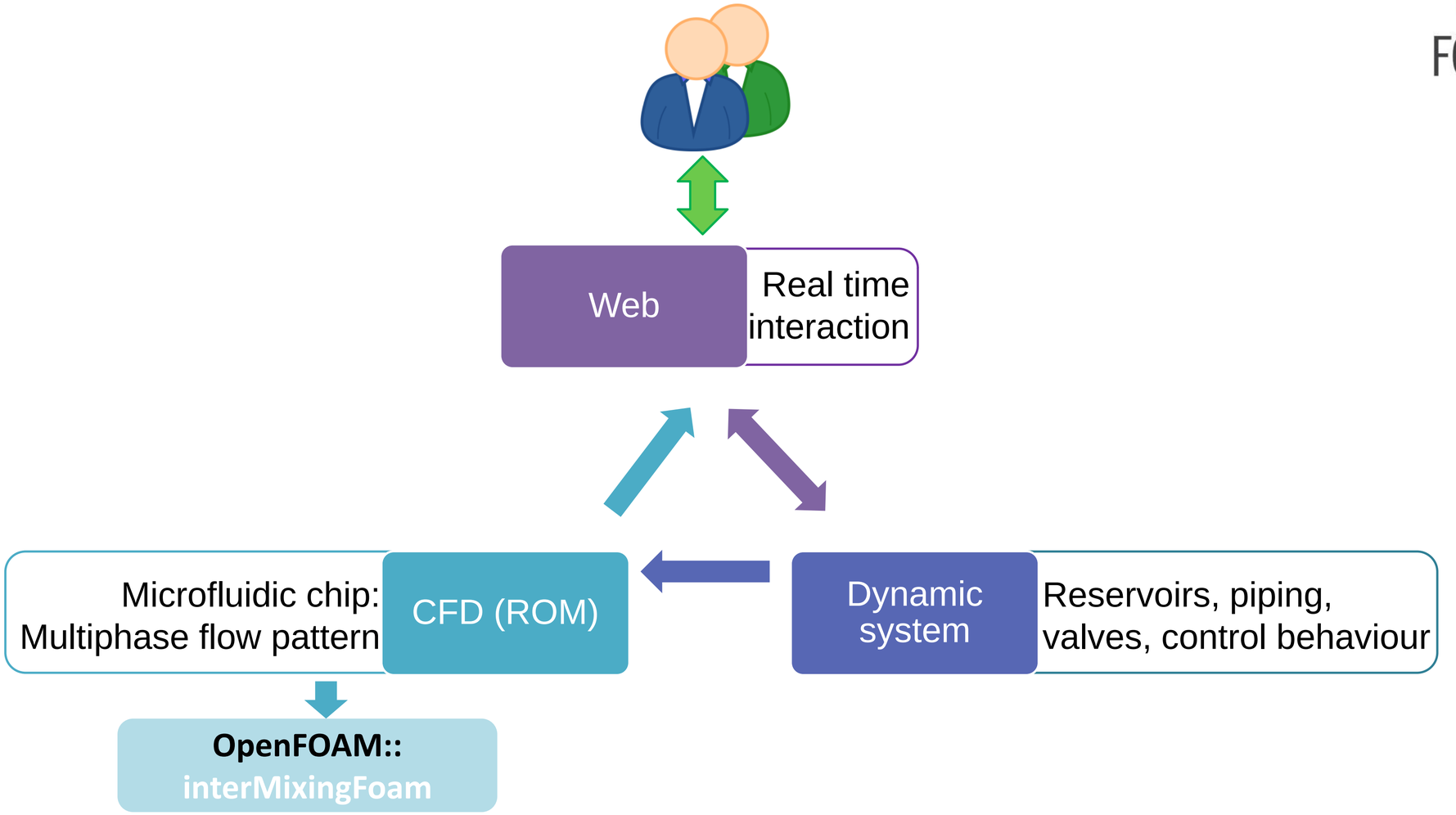


Microfluidc system

Microfluidic System: Digital Twin

FORTISSIMO

Digital twin: Core



04

Ongoing/Future Projects

Future projects

- Towards **CFD bots** for supporting engineering tasks:
  - Smart automatic building of simulation workflows.
  - Automatic mesh building.
  - Application of real-time simulation models.
  - CFD simulations ontologies

- Complex multiphysics solvers:
  - Heat-transfer
  - Multiphase
  - Electrochemistry

... Any idea / colaboration is welcome!

Thank you for your attention

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Steps into the future

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