SISSA
Scuola Internazionale Superiore di Studi Avanzati

European Research Council

# Advanced Reduced Order Methods with Applications in Computational Fluid Dynamics

## AROMA-CFD: ERC COG 2015 - GA 681447 - Panel PE1, Mathematics
## FARE-X-AROMA-CFD - MIUR FARE; H2020 EID ROMSOC; H2020 RISE ARIA

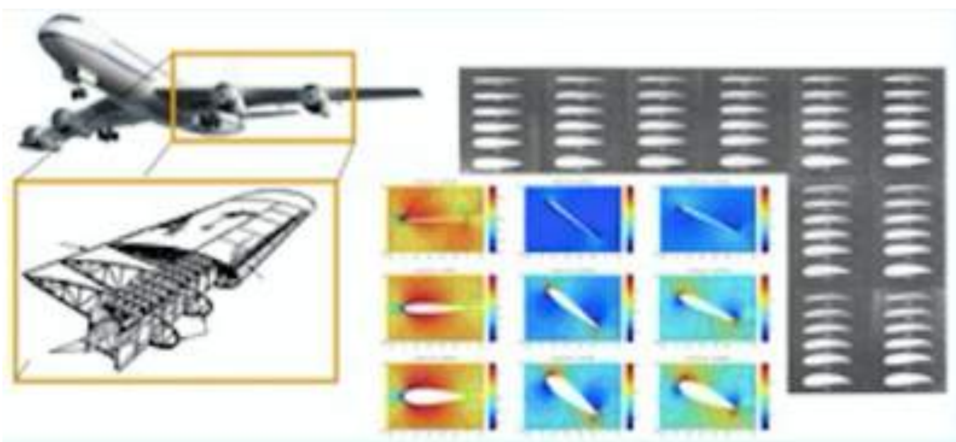

## Prof. Gianluigi Rozza, PI, Mathematics Area, mathLab

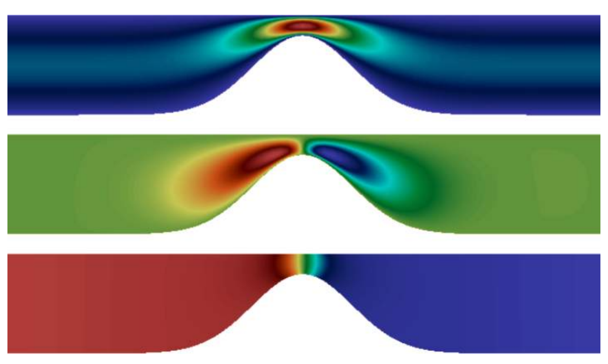

### Aim of AROMA-CFD, FARE and ROMSOC

- To create a team of scientists at SISSA for the development of Advanced Reduced Order Modelling intrusive and non-intrusive techniques with a focus in Computational Fluid Dynamics (CFD) for incompressible and compressible flows, also with turbulence.
- To face and overcome many current limitations of the state of the art and improve the capabilities of reduced order methodologies for more demanding applications in industrial, medical and applied sciences contexts.
- AROMA-CFD, FARE and ROMSOC deal with strong methodological developments in numerical analysis, with special emphasis on mathematical modelling and extensive exploitation of computational science and engineering as well as data science, machine learning and high performance computing.

### Tasks in reduced order modelling developments

- Study of bifurcations and instabilities in mechanics.
- Increase Reynolds number while guaranteeing the flow stability.
- Move towards parametric turbulent flows.
- Consider complex geometrical parametrizations of shapes as computational domains, interfaces, as well as extended networks.
- Special focus on nonlinear inverse problems, focusing on optimal flow control, shape optimization, as well as uncertainty quantification.

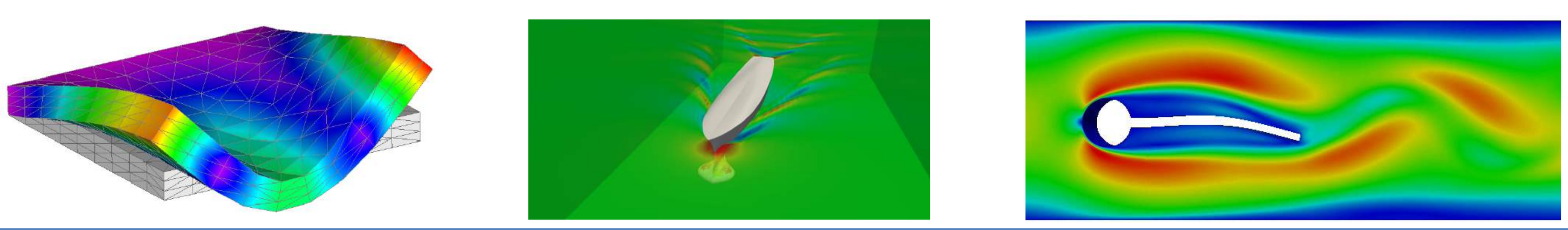




### Applications in multiphysics

Advanced developments in reduced order modelling for CFD will be delivered for applications in multiphysics and/or multiphase flows, such as:

- Fluid-structure interaction problems.
- More general coupled phenomena involving inviscid, viscous and thermal flows, solids and porous media.



### Collaborations

SISSA mathLab, MIT, University of Toronto, Houston, Sevilla, Konstanz, Stuttgart, Ghent, Bordeaux, Santiago, Ulm, Muenster, Pavia, Trento, Milano, Florida State University, RWTH Aachen, Sandia National Laboratories, Politecnico di Milano and Torino, Paris VI UPMC, EPFL, ETHZ, Imperial College, Duke University, Virginia Tech, INRIA, Max Planck Magdeburg, Ospedale L. Sacco, Ospedale San Camillo, Sunnybrook Hospital.

### Rozza Group Research staff

Research associates:

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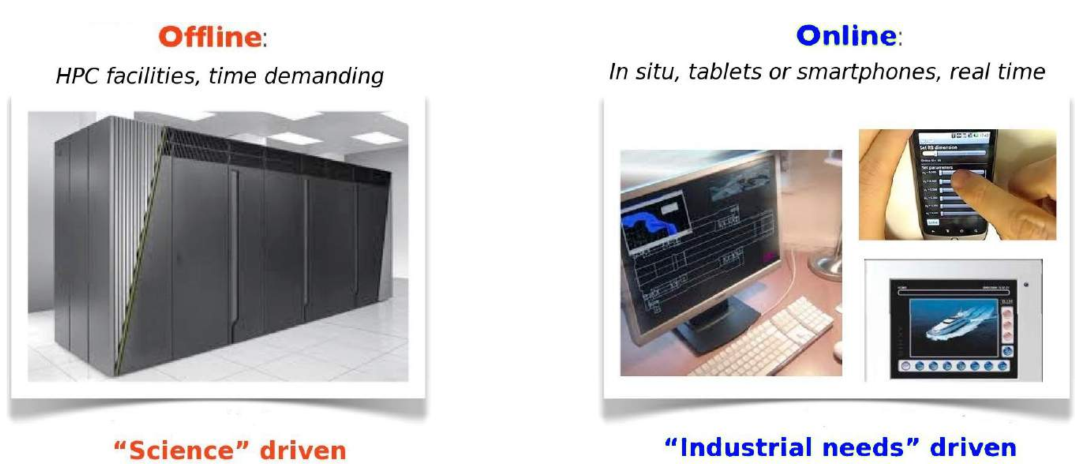
- Maria Strazzullo (2Y)
- Nirav Shah (2Y)
- Matteo Zancanaro (2Y)
- Marco Tezzele (1Y)
- Laura Meneghetti (1Y)
- Umberto Morelli (1Y).

### Industrial and medical applications

- Aeronautical, mechanical, naval, nautical, civil, off-shore, wind, sport, biomedical engineering with a focus on cardiovascular surgery applications.

- Towards real-time computing and visualization, through an offline–online computational paradigm that combines high performance computing (in dedicated supercomputing centers) and advanced reduced order modelling techniques (in common devices such as tablets and smartphone).




### Industrial Collaborations

- Monte Carlo Yachts
- Fincantieri
- Danieli
- Arcelor Mittal
- Cetena
- Electrolux Professional
- Bormioli Pharma
- Optimad
- Micad

### Software

A new open source software library for AROMA-CFD is created: ITHACA galaxy (FV, SEM, DG) In real Time Highly Advanced Computational Applications, enhancing current RBniCS educational and training capabilities based on FEM. Other tools are developed in Python: PyGeM, PyDMD, EzyRB, BladeX. More info: http://mathlab.sissa.it/cse-software

ITHACA | ITHACA - FV | ITHACA-SEM | ITHACA-DG | RBniCS
BladeX | PyDMD | PyGeM | EZyRB | multiphenics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