

**Short Term Scientific Mission, COST Action MI-NET:
Novel optimisation strategies in industrial CFD**

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Summary. Recent advances in uncertainty quantification and model reduction allows to combine multi-level, multi-resolution, and multi-fidelity simulation to produce accurate surrogate models (i.e., emulators). This means that the parameter space can be sampled in an extremely fast way, enabling to explore advanced optimisation and experimental design strategies. In the field of Computational Fluid Dynamics, the strong emphasis on physical modelling has, so far, hindered the development of black-box optimisation approaches. In this project, we aim to explore new collaborative routes to combine state-of-the-art open-source CFD modelling with novel uncertainty quantification techniques such as multi-index monte Carlo and model reduction techniques.

Programme. The scientific visit has taken place in Torino, from April 12 to April 20 2017. The following activities has been carried out as planned with meetings held at the Mathematics Department of Politecnico di Torino, hosted by prof. Luigi Preziosi

Day 1 Dr. Icardi has been introduced about the activities of Optiflow in France and in Torino. An informal presentation of his recent research results in Multi-level Monte Carlo for uncertainty quantification in multiphase CFD led to a meaningful discussion about applicability for industrial test cases. A review of the use of optimisation in complex industrial CFD problems has been carried out, observing how the recent (and not so recent) theoretical results on optimisation and uncertainty quantification have, so far, struggled to be applicable and computationally feasible for real industrial problems. Possible ways forward have been identified that will be included in future joint research proposal applications and in a white paper.

Day 2 Dr. Fransos presented recent Optiflow activities and, in particular, a large on-going project

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related to the CFD analysis of sand barriers for railways in desert areas. The scientific and business strategy to go all the way from the scientific idea, the mathematical model, the patent applications, and the commercialisation has been discussed. Despite the specificity of the application, this general discussion about knowledge transfer and international commercialisation has been particularly interesting to improve the current strategies put in place by Dr. Icardi and his collaborators in Warwick for other fields (namely mathematical models for lithium-ion batteries)

Day 3 A joint meeting was carried at Politecnico di Torino with prof. Preziosi, prof. Canuto and local collaborators to discuss possible joint projects in these directions. During the meeting it turned out Dr. Fransos will soon move to the UK for an important CFD-related R&D position at a leading F1 car manufacturer. At the same time, Dr. Icardi also acknowledge his departure from Warwick to join the School of Mathematical Sciences at the University of Nottingham We explored possible ways forward, in relation to an European ITN project currently under review, to overcome and profit from his new role. Specificities of problem involving numerical strategies and optimisation in CFD simulation for F1 have been analysed.

Day 4 A final meeting to plan the next steps to bring forward the collaboration. Given the imminent changes of employers, the decision to postpone any further meeting and activity to Fall 2017 has been taken. This however gives new promising perspectives about possible scientific collaboration between a F1 company and Dr. Icardi's future institution (Nottingham University).

Outcomes. The scientific mission was intended to gain reciprocal knowledge of the activities with the aim of developing joint research projects within the UE funding schemes. This objective has been achieved. However, due to the future relocation of both investigators (Dr. Fransos and Dr. Icardi) it has been agreed that also UK funding schemes would be an option to explore. Furthermore the visit also allowed a fruitful interaction with the local university (Politecnico di Torino), involving academic staff, researchers and a small group of local master/PhD students in Engineering Mathematics. This will likely result in student exchanges between Politecnico di Torino, Warwick and, possibly Dr. Fransos new company. A white paper about optimisation strategies for CFD is currently under preparation and could become the first joint scientific paper between Dr. Icardi and Dr. Fransos.