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Empowered decision-making in simulation-based engineering: Advanced Model Reduction for real-time, inverse and optimization in industrial problems

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Computational mechanics tools are well integrated in the technological industrial practice. However, the global effort (pre-process, solve and post-process) is a major overhead for real industrial problems and simulation-based engineering is not extensively used in real-time decision-making. Fast-queries (i.e. real-time) are critical for control of manufacturing processes, non-destructive testing and fast decision-making at production phases. This is also the case for multiple-queries in optimization problems and parameter identification with uncertainty. Addressing multiple-queries in an efficient and reasonably accurate manner is crucial in applications of industrial interest, independently of the manufactured product, e.g. engines, cars, planes, helicopters, rockets or medical devices.

Currently, the main bottleneck lies in the computational effort due to the solution of each of the aforementioned queries with a desired accuracy. Thus, many computational models are not exploited to their full potential by the European industry and a competitive edge is being lost with respect to other well-established (e.g. USA, Japan) and new-emerging economies (e.g. China, Brazil, India). Developing frontier research and training a new generation of engineers to empower simulation-based engineering for fast and multiple-queries in industrial problems is the mission of AdMoRe. AdMoRe is a Marie Skłodowska-Curie Innovative Training Network-European Training Network funded by the European Union Horizon 2020 research and innovation program with grant number 675919. The consortium consists of three academic institutions (Universitat Politècnica de Catalunya, Swansea University and École Centrale de Nantes) and four industrial partners, all world

leaders in their respective fields: Volkswagen AG, Siemens Magner Technology, Airbus and ESI Group. The industrial problems tackled by the AdMoRe consortium include interactive design and optimization of vehicles and aircrafts with high-fidelity computational tools able to capture complex flow features; fast analysis instruments and high-fidelity benchmarking tools to validate acquisition by means of Magnetic Resonance Imaging scanners; real-time monitoring and controlling of the production of large thermoplastic composites in aerospace and automobile industries; incorporation of the latest scientific and technical developments into commercial codes.

AdMoRe is an industry-driven program which aims to maintain the worldwide leadership of the four European industrial partners involved. The problems studied within the consortium involve multi-disciplinary modeling (i.e. solids, fluids, structures, electromagnetics, heat, acoustics) and require managing inter-disciplinary connections (i.e. fluid-structure interaction, electro-magneto-mechanics, thermo-mechanics, aerodynamic noise) bridging the gaps among different formulations. Classical approaches fail in addressing these challenges for fast and multiple-queries within a high-fidelity and accurate perspective. Therefore, frontier research is being performed on two main streams. On the one hand, accelerating the numerical resolution of each of the queries to vanquish the aforementioned computational bottlenecks. Reduced order models - in particular, the proper generalized decomposition - is being used to account for the multidimensionality in fast and multiple-queries without suffering a dramatic increase of the computational complexity. On the other hand, a new "full-pack" of cutting-edge computational mechanics approaches is required to solve these industrial problems accurately and reliably. Moreover, todays' global economy requires shorter transfer periods between the uncovering of a new method and its incorporation into a daily industrial production environment. AdMoRe aims to drastically reduce this adoption period and facilitate the transfer of technology with a *knowledge to codes* concept bridging the gap between academic knowledge and technical competences of the industry.

This contribution aims to describe the industrial context in which the AdMoRe consortium is operating and disseminate in the community the current challenges faced by the eight Early Stage Researchers involved in the program. A short motivation of the benefits of the application of reduced order modeling techniques will be given for each of the industrial problems tackled by the AdMoRe project.