Center for Computational Simulation

SSeMID
Stability and Sensitivity Methods for Industrial Design

European Commission

The project **SSEMID: Stability and Sensitivity Methods for Industrial Design** finished in December 2019. SSEMID received nearly 4 million euros from the European Union’s Horizon 2020 research and innovation programmes. This European Training Network is embedded within the Marie Skłodowska-Curie actions. The activities carried out in SSEMID aim at improving the current aerodynamic performances of existing aircrafts, by developing new innovative methods and tools for modern airplane’s designs and providing doctoral training to 16 international young researchers.

SSEMID counted with the participation of a large international consortium, including five Universities: Universidad Politécnica de Madrid (Spain), Imperial College London (UK), University of Cambridge (UK), KTH (Sweden), Katholieke Universiteit Leuven (Belgium). Three National Research agencies dedicated to aeronautic research: Office National d'Etudes et de Recherches Aerospatiales (France), Deutsches Zentrum für Luft – und Raumfahrt e.V. (Germany) and Von Karman Institute (Belgium) and two leading companies of the aeronautical sector: Airbus (UK) and NUMECA (Belgium). SSEMID also includes the collaboration of two American Universities: Purdue and San Diego University.

During these 4 years, the project has generated results which have contributed to significantly advance the development of numerical tools, the formulation of direct and adjoint methods for flow stability and the analysis of flow sensitivity under external perturbation. The application of these methods to the development of new and more efficient industrial designs has been the cornerstone and the motivation of this project.

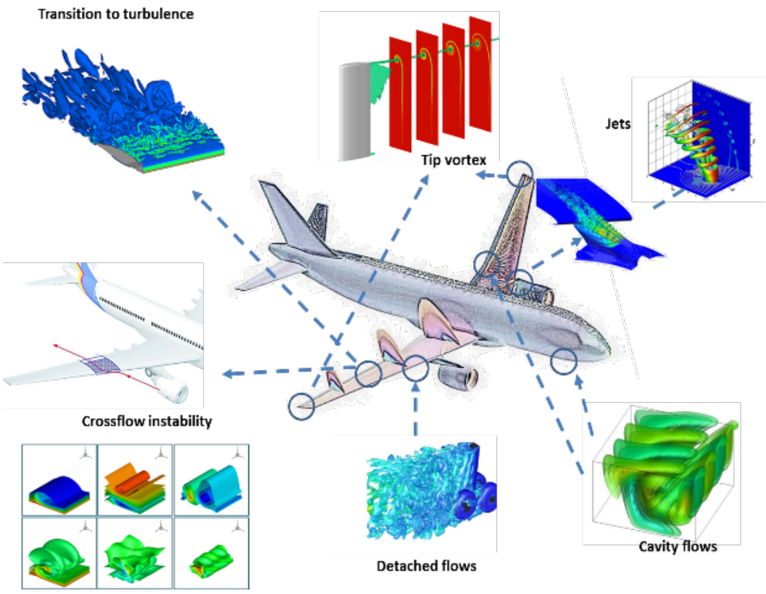

Figure 1: Areas of application of stability analysis and flow control

In more detail, SSEMID´s research focused on the stability analysis as a key element in the understanding of the current limitations of aircraft designs, and on new numerical methodologies and models applied so the aircraft manufacturing industry obtain innovative solutions. SSeMID has matured and industrialized new methods to obtain sensitivity maps of critical aerodynamic features with high impact on aircraft performance and environment, such as noise or fuel consumption. The direct applications of this methodology are flow control and advance optimization. Flow control is an emerging technology that describes a variety of techniques by which aerodynamic performance can be enhanced to levels beyond those achieved by changes to external shape alone. The application of stability and sensitivity analysis can provide very valuable information to the design engineers about “how and where” achieving an optimal design.

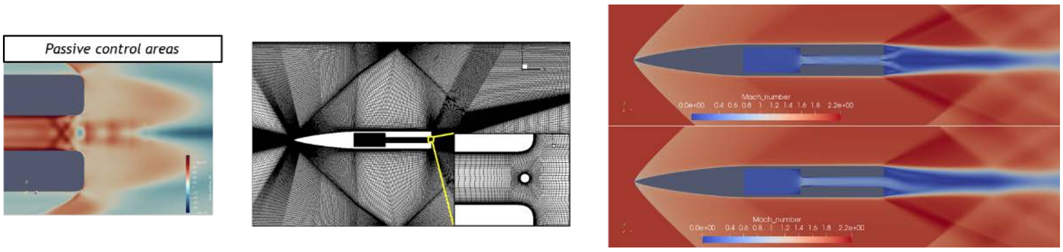

Figure 2: Passive control of flow detachment at the trailing edge of a turbine blade. Results obtained in SSEMID

Finalization of the project’s tasks has contributed to maturing a new generation of numerical methods for simulation in engineering, with the development of new algorithms for high-order Discontinuous Galerkin schemes and its industrialization; shedding light on the complicated problems faced by the industry at the limits of the flight envelope or when unsteady configurations are dominant. The research results are having a profound impact on the design of the modern aircraft. The development costs will be reduced as high performing aircraft design simulation tools will contribute to the transition of existing aircraft testing methods – mainly based on wind tunnel testing – into more automated process, relying on real time fast simulations. Accurate computational tools lead to millions of Euros in operational cost reduction per aircraft per year, saving years of design process. The product is delivered to the market in shorter a time and has a much more mature design improving its safety and stability. More efficient aircrafts contribute to reducing CO2 and NOx emissions to the atmosphere since these emissions are directly related to the aircraft fuel burn, drag and airplane weight. Noise, which is a consequence of flow instabilities and becomes especially evident in high lift configurations, is reduced with the more optimal design of the aircraft. In general, accurate predictions for the aircraft’s configurations, as those obtained in SSEMID, allow optimization of the aeronautical technology, with cheaper and safer aircrafts with less negative environmental impact, ultimately benefiting the European society.

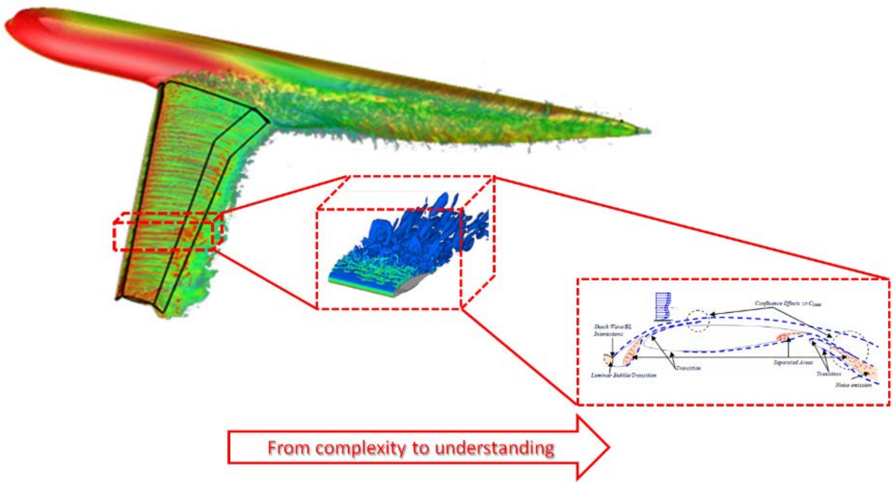

Figure 3: Complex flow configurations understood thanks to new numerical methods.

The 16 young researchers employed by the project have obtained their doctoral degrees within an international and intersectoral environment. They have taken an active part in the innovation process by developing new methodologies and incorporating immature technologies into the industrial design processes. In this way, they were introduced to a global view of the design process: from understanding the mathematical basis of numerical methods for simulation in engineering to their industrial application. They also have learned about the problems associated with tunnel testing and industrial design as well as experienced how the results of their research are directly influencing advances in the aeronautical industry.

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