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

SSEMID counted with participation of international consortium with participation of 5 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 industries in aeronautic sector: Airbus (UK) and NUMECA (Belgium), with the additional participation of two American Universities: Purdue and San Diego University.

During the 4 years of its duration, the project generated results which 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, and in the application of these methods to the development of new industrial and more efficient aeronautical designs.

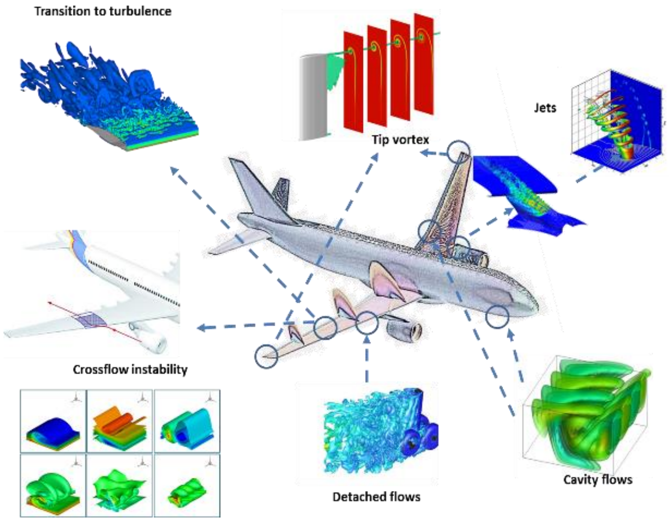

Figure 1: Areas of application of stability analysis and flow control

SSEMID´s research was focused on stability analysis as a key element in understanding the current limitations of aircraft designs, and on new numerical methodologies and models applied to obtain innovative solutions by the aircraft manufacturing industry. SSeMID has matured and industrialized new methods by obtaining the sensitivity maps of critical aerodynamic features that strongly affect the design variables, and its impact on aircraft performance, such as noise or fuel consumption. The direct application of this methodology will be to 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 provides the aircraft engineers with very valuable information to achieve an optimal aircraft design. SSEMID´s results combined model developments, experimental validation and application of new methodologies to industrial practice.

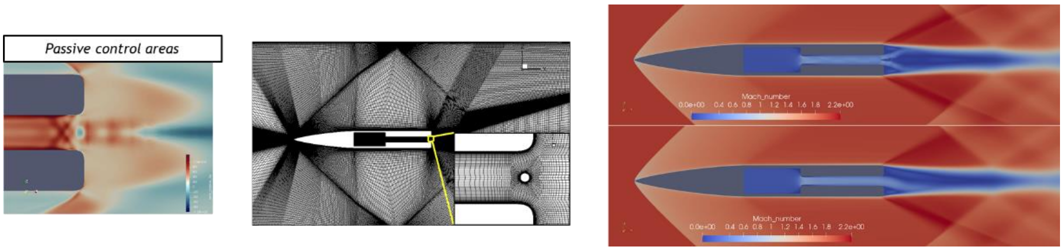

Figure 2: Passive control of flow detachment at the trailing edge of a turbine blade. Results obtained in SSEMID

Finalization of the project's tasks has contributed to maturing of the new generation of numerical methods for simulation in engineering, with the contribution new algorithms for high-order Discontinuous Galerkin schemes and its industrialization for feature detection; shedding light on the complicated problems faced by industry at the limits of the flight envelope or when unsteady configurations are dominant. The research results are expected to have 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, which are mainly based on wind tunnel testing, into more automated process, relying on real time fast simulations. Use of accurate CFD tools will lead to savings of millions of Euros in operational cost, and drastically reduce the time needed for of design process. As a results, an airplane with a much more mature design, adding to its safety and stability will be delivered to the market in shorter time. More efficient aircrafts contribute to reducing CO_2 and NO_x 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, will be reduced with the more optimal design of the aircraft. In general, accurate predictions for the aircraft's configurations, as those obtained in SSEMID, will allow optimization of the aeronautical technology, with cheaper and safer aircrafts with less negative environmental impact, ultimately benefiting the European society.

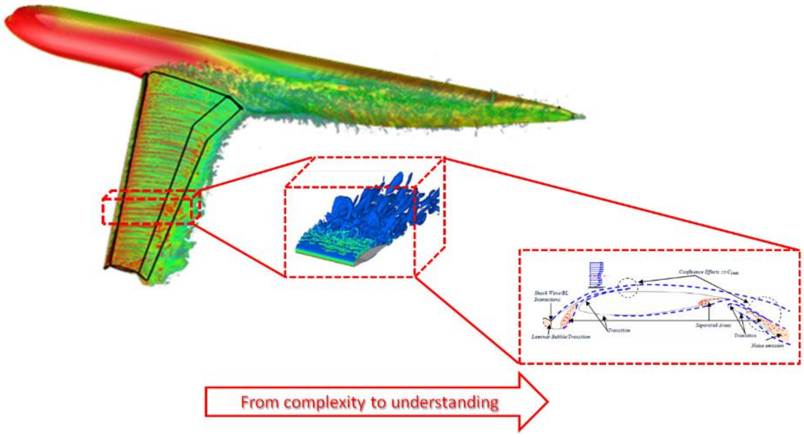

Figure 3: Complex flow configurations understood thanks to new numerical methods.

The young researchers employed by the project obtained their doctoral degrees within international and intersectoral environment. They took active part in the innovation process by developing new methodologies and incorporating immature technologies into the industrial design processes. Students were introduced to a global view of the aircraft design process: from understanding the mathematical basis of numerical methods for simulation in engineering to their industrial application. Participation in SSEMID allowed them to gain in depth understanding of problems associated with tunnel testing and industrial design and experience how the results of their research are directly influencing advances in the aeronautical industry.

European Commission

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