MADELEINE

MEDIA RELEASE, JUNE 2020

MADELEINE STANDS FOR "MULTIDISCIPLINARY ADJOINT-BASED ENABLERS FOR LARGE-SCALE INDUSTRIAL DESIGN IN AERONAUTICS".

The project focuses on the development and validation of multidisciplinary design tools for optimisation.

Special attention is given to:

- multidisciplinary optimisation
- understanding of multi-physics phenomena
- simulation of manufacturing processes
- transition to High-Performance Computing

Our media releases include interviews with project partners to let you discover how they cooperate to achieve the project objectives. The "Get Together" section will show you when we disseminate the MADELEINE results. This is in case you feel like meeting with us! Meanwhile, we invite you to visit our website at www.madeleine-project.eu and follow us on Linkedin via #madeleineproject

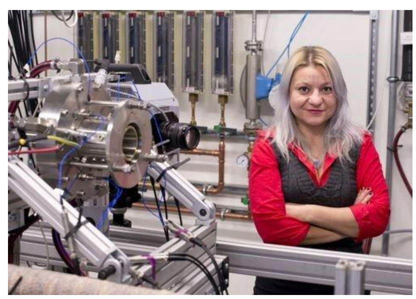
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769025.

Interview With The Team Of The University Of Sheffield, UK

NING QIN, PROFESSOR OF AERODYNAMICS

ALISTAIR JOHN, UNIVERSITY TEACHER IN AEROSPACE ENGINEERING

CLEOPATRA CUCIUMITA, RESEARCH ASSOCIATE



AND LUKA VINCEKOVIC, PHD STUDENT

Question 1 (Q1): The University of Sheffield is the leader of the work package entitled "Methods and tools" in MADELEINE. Can you briefly describe the objectives of this work package?

Answer 1 (A1): The focus of this work package is on developing the reliability and accuracy of key technology bricks that are needed for the adjoint-based MDO (multi-disciplinary optimisation) processes. In this work package, existing adjoint solvers based on High Fidelity (HiFi) direct simulations will be improved and extended in order to deal with complex multi-physics phenomena. MDO formulations will be tested and validated to define the most efficient way to couple disciplines for a

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given problem. Uncertainty Quantification (UQ) and Robust Optimisation (RO) design methods and tools will be extended to consider the gradient information provided by the multi-physics adjoint in the design process. Specific parameterisation techniques enabling the multi-disciplinary design space will be considered and robust and efficient mesh deformation techniques will be extended to become compatible with the adjoint approach.

Q2: In MADELEINE, the technology developments called enablers are driven by industrial needs represented by the project demonstrators. The consistency between the developments and industrial needs is guaranteed by the requirement that each enabler is tested on at least one demonstrator. How are the methods and tools exploited in the demonstration activities of the project?

A2: As can be seen in the exploitation diagram below (which nicely explains how methods and tools are exploited by the demonstrators), all of the enablers apart from one are tested on multiple demonstrators. For example, multi-physics adjoint solvers are tested for all of the demonstrators. Some examples of these multi-physics adjoint solvers are aero-structural adjoint (demonstrated on the wing and fan cases), aero-thermal adjoint (demonstrated on the turbine blade case) and aero-acoustic adjoint (demonstrated on the propeller and inlet/fan cases).

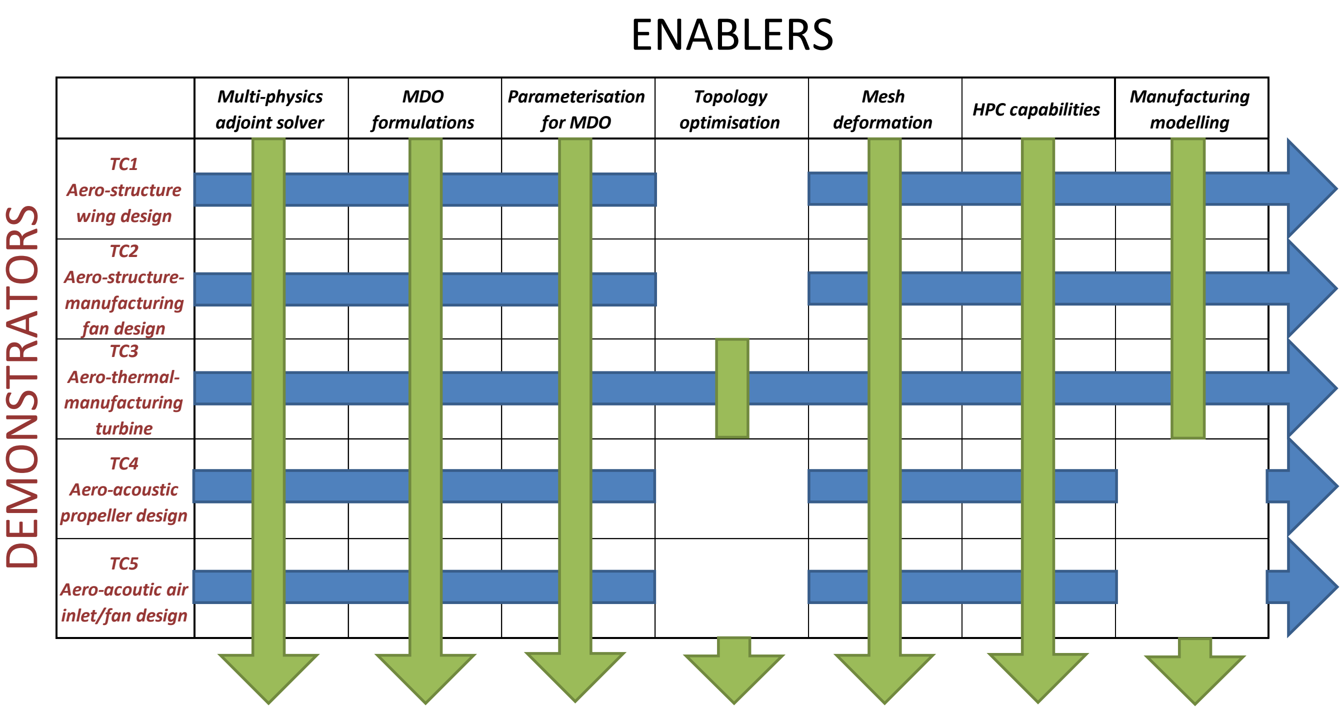

FIGURE 1: SYNERGIES BETWEEN ENABLERS AND DEMONSTRATORS CONSIDERED IN MADELEINE.

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Q3: What are the limitations of current methods and tools used for multidisciplinary optimisation? How do the MADELEINE enablers progress beyond the state of the art?

A3: Today, adjoint Computational Fluid Dynamics (CFD) solvers enable efficient aerodynamic design without restrictions on the number of design parameters but cannot be applied for MDO. MADELEINE will extend these solvers to multi-disciplinary applications such as aero-structure, aero-thermal or aero-acoustic design. MADELEINE will also develop parameterisation techniques to enable the easy use of a large number of geometrical constraints which is currently not possible. Topology optimisation, mesh deformation and MDO formulations will also be developed to make them easier to use, more effective and more efficient than the current state of the art. An additional development through MADELEINE is including manufacturing in the MDO process. This is usually ignored in conventional design optimisation, but is here addressed via two approaches: uncertainty quantification to model the tolerance of the manufacturing process or by modelling directly the manufacturing process and defining a trade-off between performance and manufacturing costs.

Q4: How are the improvements verified and quantified?

A4: To quantify and verify the improvement to the MDO process through MADELEINE, specific objectives and success criteria have been defined. The objectives are to increase the capability of MDO, to improve the efficiency of the MDO process and to enhance the usability of the process. The seven success criteria (which, if met, show the success of the project) are to verify the multi-physics adjoint sensitivities, to include the impact of manufacturing criterion in the MDO process, to remove the limits on design space exploration, to have robust and fast adjoint solvers, to reduce MDO development time in industry by a factor of 10, to have MDO parameterisations defined with and approved by industrial aircraft and engine designers and to compare coupled adjoint MDO to single objective optimisations and to define best practices and guidelines.

Q5: What are the expected benefits of using the MDO formulations in the industrial test cases investigated in MADLEINE? How can the industrial partners use the project results in short- and long-term?

A5: The main benefits of using the new MDO processes on the industrial cases will be improved product performance, reduced development lead time and improved cost-efficiency. These are achieved through reducing the number of iterations in the design process (right design first time), improving performance by considering all disciplines and assessing more accurately trade-offs between various configurations. Development lead-times will also be reduced along with the potential for shorter flight test campaigns as the physical behaviour of the tested aircraft/engine will match more closely the numerically predicted result.

Within 5 years following the end of MADELEINE, designers will apply the adjoint-based optimisation capability for the design of flexible wing (TRL 6) and in the 5 years following the end of MADELEINE, the adjoint-based optimisation capability will be progressively used from the beginning of the design process to develop new aircraft configurations, considering the critical multi-physics interactions and exploring new multi-disciplinary design spaces. The impact of this technology will be even greater with

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the introduction of innovative aircraft and engine concepts considering the lack of feedback on the disruptive architectures.

In the 2 to 5 years following MADELEINE, the objective is to achieve TRL 7 for the different adjoint-based MDO technology for aero-engines. Designers will be able to apply this adjoint-based MDO capability to improve the design of existing engines, to design new engine demonstrators or to integrate innovative technologies (e.g. new materials) and have more efficient interactions with other disciplinary experts. In the 5 to 10 years following the end of the project, the objective is to meet TRL 8/9 i.e. productionise by being mature enough to be applied to a range of turbomachinery components. The adjoint-based MDO capability will be used from the beginning of the design process to develop new engine concepts, considering the critical multi-physics interactions and exploring new multi-disciplinary design spaces.

Q6: Statistics show that a gender gap persists in aeronautics which is still a male dominated sector. As a female researcher participating in MADELEINE, can you tell us how gender aspects are considered in European research & innovation collaborative projects? What would be your recommendations to make science and technology more women-friendly and to increase women's visibility in this field?

A6: In the last decade, European Union has set clear targets for increasing women participation in both decision level mechanisms as well as in research and innovation actions. This has visible effects in collaborative projects, both at proposal and at implementation level, where teams are being built mindful of achieving gender balance. However, research and innovation are a highly competitive field, where success is strongly dependant on personal skills and vision. Therefore, I see the existing gender gap in aeronautics as more of a social and cultural problem, that needs to be mitigated in earlier stages to maximise the impact. Personally, I believe one way to both make science and technology more women-friendly and to increase women's visibility in this field is by engaging more successful women from this field in promoting activities for a very young target audience, either through media, social networks, or physical visits. The goal would be to teach by the power of example that stereotypes can be broken and help young women build the confidence that reaching high goals in science and technology it is only a matter of personal choice and ambition, and not a gender related issue.

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GET TOGETHER

Get Together selects the events at which MADELEINE will be represented. Nevertheless, we regret to inform that due to the Covid-19 pandemic, many conferences planned in 2020 have been either postponed or cancelled.

AIAA AVIATION 2020, 15-19 JUNE 2020, VIRTUAL

The plenaries, Forum 360s and technical sessions of AIAA Aviation Forum 2020 were part a virtual event. The University of Cagliari and Rolls Royce had submitted a paper to the conference entitled "Least Squares Approximation-based Polynomial Chaos Expansion for Uncertainty Quantification and Robust Optimization in Aeronautics". The presentation was scheduled for the 17th of June 2020 from 3:00 PM to 4:00 PM Eastern Time, USA, during the session MDO-16 Non-deterministic Design Methods and Applications.
Source: AIAA Aviation Forum 2020

WCCM-ECCOMAS CONGRESS 2020, CANCELLED ON 19-24 JULY 2020, PARIS, FRANCE

The MADELEINE partners had organised the mini-symposium "Adjoint Methods For Multi-Physics, Including Applications" in the framework of the 14th WCCM-ECCOMAS Congress 2020. Unfortunately, the Congress is cancelled in July 2020. Alternative options are being explored by the organisers along with the IACM and ECCOMAS.
Source: WCCM-ECCOMAS Congress 2020

TURBO EXPO 2020, 21-25 SEPTEMBER 2020, VIRTUAL

The Covid-19 pandemic prevents the face to face event from taking place in June. Thus, the Turbomachinery Technical Conference 2020 will be held as a virtual event on 21-25 September 2020. The University of Sheffield and Rolls Royce had submitted two papers to the Turbo Expo Conference 2020. The participants can expect more detailed information in the coming weeks.
Source: Turbo Expo 2020

AERODAYS 2020, 24-26 NOVEMBER 2020, BERLIN, GERMANY

The new date for the Aerodays 2020 event has been recently announced. We will keep you informed about the planned participation from MADELEINE.
Source: Aerodays 2020

We hope to meet you soon!

CONTACT US

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MADELEINE in a nutshell:

GRANT AGREEMENT NUMBER: 769025	**15** PARTNERS	6 **EUROPEAN** COUNTRIES	CALL: **H2020-MG-2016-2017**
50 RESEARCHERS AND ENGINEERS	**RESEARCH & INNOVATION** ACTION	TOTAL MANPOWER: 631 PERSON-MONTHS	TOTAL BUDGET: **5 815 181 EUROS**
36 MONTHS	**TOPIC:** MG-1.3-2017	PROJECT COORDINATOR: **MICHAËL MEHEUT** (ONERA)	PROJECT OFFICER: **MIGUEL-ANGEL MARTI-VIDAL** (INEA)

MADELEINE consortium:

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