POLITECNICO DI MILANO

# PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 38th cycle

## PNRR_352 Research Field: ROTOR BLADE DYNAMIC STALL: FROM HIGH ORDER AERODYNAMICS TO COMPREHENSIVE MODELS

| Monthly net income of PhDscholarship (max 36 months) |
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| **€ 1400.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | Funded by PNRR M4C2 (dalla ricerca all¿impresa)<br>Contributes to M1C2 (digitalizzazione, innovazione e competitività nel sistema produttivo)<br><br>Dynamic stall is a peculiar flow condition that is typically encountered in rotorcraft and wind turbines. It is caused by the combined effect of the rotational motion of the blade and the cyclic change of the angle of attack. In these conditions, flow separation or stall is very different from what is observed in steady configuration, e.g., fixed-wing aircraft. Due to the unsteadiness of both the rotor attitude and of the separated flow, the dynamic stall is a challenging problem that requires the combined use of simulations and experiments to be investigated. The eVTOL and fast rotorcraft concept push further rotor aerodynamics challenges particularly with an extensive region of the rotor in reverse flow or impacted by the dynamic stall.<br>The aim of the project is to measure and simulate with high-order aerodynamics CFD tools (validated with experimental test benches) the dynamic stall phenomena in order to derive the key parameter needed to implement the dynamic stall phenomena within mid and low-fidelity rotor simulation for flight mechanics, loads and stability analysis. A digital twin of the rotor in dynamic stall conditions will be produced to be used in flight mechanics applications. |

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| **Methods and techniques that will be developed and used to carry out the research** | The project will be carried out in collaboration with Leonardo Helicopter Division and the University of Bristol.<br>The approach consists of a combination of both simulations using the CFD toolkit SU2 and experiments to calibrate a dynamic stall model.<br>The timeline of the work is split as follows:<br>¿ First year, development of the numerical formulation. 2D rotor blade airfoils dynamic stall simulations with high-order CFD tools<br>¿ Second year, 3D rotor blade airfoils dynamic stall simulations with high order CFD tools<br>¿ Third year, 2D wind tunnel testing on specific airfoil geometries including flow visualization and surface pressure measurements. Implementation in a comprehensive rotorcraft tool of dynamic stall model to be used in the digital twin of the rotorcraft.<br>A period of 6 months is spent at the University of Bristol for the acquisition of measurement techniques for rotorcraft noise.<br>The creation, validation, and optimization of the rotor digital twin in dynamic stall conditions are done in collaboration with Leonardo Helicopter Division. |
| **Educational objectives** | This Ph.D. aims at developing skills in the understanding of rotorcraft aerodynamics, and the use of both numerical and experimental tools for rotorcraft.<br>Internship: a period of 6 months is spent at the University of Bristol for the acquisition of measurement techniques for rotorcraft noise. The creation, validation, and optimization of the rotor digital twin in dynamic stall conditions are done in collaboration with Leonardo Helicopter Division.<br>In addition to the hard skills required to develop the tools, many soft skills will be acquired such as presenting the research, creating industrial reports, and writing scientific papers. The exposure to the industrial and academic environments will allow the student to adopt a wide range of techniques and methodologies and implement them in his/her future work. |
| **Job opportunities** | Rotorcraft and wind turbine aerodynamics, CFD simulations, industrial product design and optimization, |

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| | creation of a product¿s digital twin |
| **Composition of the research group** | 1 Full Professors<br>0 Associated Professors<br>2 Assistant Professors<br>8 PhD Students |
| **Name of the research directors** | Prof. Alberto Guardone |

| **Contacts** |
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| **Additional support - Financial aid per PhD student per year (gross amount)** | |
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| **Housing - Foreign Students** | -- |
| **Housing - Out-of-town residents (more than 80Km out of Milano)** | -- |

| **Scholarship Increase for a period abroad** | |
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| **Amount monthly** | 700.0 € |
| **By number of months** | 6 |

| **National Operational Program for Research and Innovation** | |
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| **Company where the candidate will attend the stage (name and brief description)** | Leonardo Helicopters |
| **By number of months at the company** | 6 |
| **Institution or company where the candidate will spend the period abroad (name and brief description)** | University of Bristol, UK |
| **By number of months abroad** | 6 |

| **Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information** |
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| The PhD candidate will receive a desk and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses, to receive economic support to attend summer schools and participate in conferences. There will be the possibility of paid teaching assistantship. |