



# PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

**PNRR 117 Research Field: IN-FLIGHT ICING SIMULATIONS TOOLS FOR VIRTUAL  
CERTIFICATION OF UAM VEHICLES**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1400.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## **Context of the research activity**

**Motivation and objectives of the research  
in this field**

In EASA's 2019 annual report, in-flight icing was identified as a priority 1 issue for large aeroplanes with the aggregated European Risk Classification Scheme (ERCS) score being amongst the highest safety issues. In-flight icing can occur when an air vehicle flies through clouds of supercooled droplets, namely, drops of liquid water with a temperature below the freezing point. This is an unstable state for water, and when such drops impinge onto aircraft surfaces, they generally freeze, leading to ice accretion. Aircraft icing can reduce visibility, damage due to ice shedding, blockage of probes and static vents, reduced flight performance, adverse aerodynamic effects, engine power loss, etc. Climate change is already increasing the number and intensity of thunderstorms and pushing them upward into cruising altitudes. Urban Air Mobility vehicles, operating at low altitudes and in liquid ice and snow conditions, are expected to be strongly affected by icing and snow conditions. Certification costs are very high due to the complexity and innovative nature of UAM vehicles and the large variability of the operating conditions.

The present research aims at exploring the possibility of validating simulation tools as means of compliance for the certification of UAM vehicles in icing conditions.

To this purpose, Uncertainty Quantification techniques will be applied to assess the credibility of simulation tools as well as that of experimental results from icing wind tunnel testing, to be carried out at TU Braunschweig, over simple



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|  | <p>geometries. During the secondment at Lilium, the devised tools will be applied to UAM configurations.</p>   |
| <p><b>Methods and techniques that will be developed and used to carry out the research</b></p> | <p>The present research leverage on the theoretical, numerical, and experimental background developed during previous H2020 projects (UTOPIAE, NITROS, ICE-GENESIS) and the current MSCA Double-Doctoral network TRACES, coordinated by Politecnico di Milano. The PhD candidate will be involved in all activities within the TRACES network, including participation in the Design and Certification exercises to be assessed by EASA and FAA.</p> <p>The candidate will spend a period at the Technical University of Braunschweig (8 months), with the possibility of enrollment in a double-PhD program. The industrial secondment is at Lilium (6 months), both with grant increases.</p> <p>The timeline of the work is as follows:</p> <ul style="list-style-type: none"> <li>•First year: quantification of the model uncertainty in numerical simulation of ice accretion; uncertainty propagation using the in-house code PoliMIce. Icing simulation of eVTOL aircraft or lift/thrust system. Assessment of verification tools for ice accretion simulations.</li> <li>•Second year: assessment of experimental uncertainty at TU Braunschweig (droplet velocity and temperature slip at nozzles) and comparison with numerical simulations.</li> <li>•Third year: development of a verification and validation procedure for the comparison of experimental and numerical results. The internship at Lilium focuses on the simulation of icing on eVTOL geometries and the application of the uncertainty quantification procedure.</li> </ul> |
| <p><b>Educational objectives</b></p>   | <p>The PhD candidate will receive inter-disciplinary, international and intersectoral training within the MSCA DN-JD TRACES network. Formal training in fundamental aspects of icing, numerical methods, experimental techniques and a range of possible applications will be</p>  |



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|   | <p>delivered during network-wide training schools. Training will include a contribution of certification authorities EASA and FAA during Training Schools and the final Design and Certification exercise, to train the candidates on certification aspects that are often overlooked in engineering training. The TRACES training programme involves ‘training on-the-job’ via project-oriented research, complemented by training programmes in science and transferable skills. Direct access to previous EU-funded and international research will also put TRACES in a position to harvest the results of these major research efforts and pass that unique wealth of knowledge over to the next generation of icing researchers. Results from ICE-GENESIS, SENSE4ICE and MUSIC-haic are currently being collected in databases which will be available to the candidate.</p> |
| <p><b>Job opportunities</b></p>                 | <p>The project ambition is to train a PhD researcher in the inter-disciplinary, inter-national and inter-sectoral skills that will enable a successful career in:</p> <ul style="list-style-type: none"> <li>•the academic sector, where doctoral fellows could continue their fundamental research on in-flight icing, numerical and experimental fluids dynamics, and uncertainty quantification.</li> <li>•the industrial sector, as a researcher/technic in one of the TRACES partner companies or at Lilium, or as an entrepreneur,</li> <li>•certification authorities, contributing technical knowledge with policymakers about the available technical options for virtual certification.</li> </ul>   |
| <p><b>Composition of the research group</b></p> | <p>1 Full Professors<br/>0 Associated Professors<br/>3 Assistant Professors<br/>11 PhD Students</p>  |
| <p><b>Name of the research directors</b></p>    | <p>Prof. Alberto Guardone</p>  |

| <b>Contacts</b>  |  |
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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                      | 14      |

| National Operational Program for Research and Innovation   |                 |
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| Company where the candidate will attend the stage (name and brief description)                       | Lilium          |
| By number of months at the company   | 6               |
| Institution or company where the candidate will spend the period abroad (name and brief description) | TU Braunschweig |
| By number of months abroad   | 8               |

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