ASCenSIon
Advancing Space Access Capabilities - Reusability and Multiple Satellite Injection

This project has received funding from the European Union's Horizon 2020 research and innovation program under the MARIE SKŁODOWSKA-CURIE grant agreement no. 860956

PhD student – Early Stage Researcher (ESR7) Aero-Thermo-Dynamics (ATD) modelling for Reusable Launch Vehicles (RLVs)

About ASCenSIon

The purpose of the ASCenSIon project is to develop a program that focuses on several specific areas of cutting-edge space access research, particularly on launcher systems that are (partially) reusable and capable of injecting multiple payloads into multiple orbits. More than providing design concepts, the network aims to identify and advance critical technologies to prove a feasibility of these concepts. Fields of research and training include propulsion technologies and their reusability; Guidance, Navigation and Control (GNC); aero-thermodynamics of re-entry and safe disposal. A variety of technologies will be advanced, including hybrid rocket engines, electric pump feeding and advanced nozzle configurations. Both computational and experimental (cold-flow and hot fire) techniques will ensure an efficient process and reliable results. The reuse of propulsion systems demands an assessment of their durability. It will be conducted by numerical simulations, system analysis with EcosiPro/ESPSS and experimental test runs. The development and integration of wireless sensor networks will allow health monitoring of these critical subsystems. Moreover, novel GNC strategies and processes have to be developed for the whole mission trajectory. This includes solutions for optimized flexibility w.r.t. the orbital insertion conditions as well as dedicated descend trajectories and GNC missionization for re-entry. The models will cover various recovery concepts and the support of multiple landing sites. This requires an extensive examination of the aero-thermo-dynamics during re-entry as well as of the interactions between stage recovery and propulsion system layout. Ecological and economical sustainability will be addressed as new payload concepts including large constellations increase the demand for safe disposal and space debris mitigation to ensure an open access to space in the future. Furthermore, the utilization of so-called green propellants will be investigated.

The ASCenSIon consortium includes Technische Universität Dresden, German Aerospace Center, SITAEL, Sapienza Università di Roma, ONERA, Université libre de Bruxelles, Hochschule Bremen, Università Di Pisa, Technische Universität Braunschweig, Politecnico di Milano, DEIMOS Space, ArianeGroup, ESA, AVIO, OHB, D-Orbit, SpaceForest and Telematic Solutions.

About the host organization

Office national d'études et de recherches aérospatiale (ONERA) is the French national aerospace research center. It is a public research establishment, with 8 major facilities in France and about 2,000 employees, incl. 1,500 scientists, engineers & technicians. ONERA conducts application-oriented research, which is designed to support the competitiveness and creativity of the aerospace and defense industries. ONERA covers all the disciplines and techniques needed to drive progress in aerospace: aerodynamics, flight dynamics, propulsion, structural strength, materials, optics and laser, acoustics, radar and electromagnetism, electronics, systems, robotics, information processing. The Multi-Physics for Energetics Department (DMPE) conducts research to identify and understand the physical phenomena in energetics and to proceed with their description. It is in charge of the implementation of physical models for combustion, internal and external flows in the multidisciplinary numerical codes developed at ONERA and of their validation based on experiments in representative

conditions. This implementation is also conducted to model the coupling phenomena (e.g. heat transfer and structure, aeroacoustics and its interaction with materials & multiphase flows). (https://www.onera.fr/en)

Task description

Your PhD project:

The design of launcher systems that are (partially) reusable and capable of injecting multiple payloads into multiple orbits requires precise knowledge about aerodynamic force and moment coefficients on the RLV. Determination of wall heat load is also necessary to avoid the launcher degradation during the atmospheric reentry phase. The mission definition is thus a multi-domain and multi-physics problem with a strong coupling between physical phenomena occurring in the flow, flight mechanics and system design. Such ability to predict aerodynamic forces, moments and wall heat fluxes for various shapes and to represent properly high energy physical phenomena encountered during re-entry is of particular importance for RLV design, as well as for safe disposal of upper stages.

During the atmospheric entry, the launcher system will encounter hypersonic to subsonic flows in continuum regime. In hypersonic regime, the flow in the shock layer could experience various physical regimes and specifically thermo-chemical nonequilibrium regime. Moreover, flight geometries with detailed design (steps, roughness, gaps, etc.) let appear complex physical phenomena having strong influence on aerothermodynamic coefficients. Numerical simulations (Navier-Stokes equations) of these flow regimes can be occasionally performed for some characteristic flight points (maximum pressure, maximum heating, maximum Reynolds number for instance). However, Mission preparation cannot afford to simulate pre-flight complete trajectories involving different vehicle designs due to important CPU cost and time. Therefore, models with low response time become mandatory to cover a larger envelope of values for aerothermodynamic databases definition and mission performance consolidation.

However, current engineering approaches used for pre-design activities are not yet able to predict the effects of complex physical phenomena due to complex geometrical design. **The objective of the PhD thesis** is thus to develop a new approach based on the fast resolution of 3D Euler equations to obtain wall pressure distribution, aerodynamic coefficients as well as shock position around the RLV. This approach will be associated to new models for the wall heat flux prediction since main patterns of the flow are expressed by pressure topology (wall geometrical change, shock/shock interaction, shock boundary layer interaction, etc.). For this purpose, different machine learning techniques such as Gaussian processes or artificial neural networks will be investigated and adapted to such fluid mechanics target. As far as possible, the tool developed could be coupled to an existing engineering multi-physics code (flight mechanics, GNC, Earth atmosphere conditions) developed at ONERA to perform complete atmospheric entry trajectories of different RLV design. This new approach will speed up the design of future reusable launcher concepts and their optimal trajectory.

Communications:

Two publications in peer-reviewed international journals and one international conference are expected. An annual progress report should be issued for the first two years. These reports will match with the deliverables of the ASCenSIon project.

Secondments:

Two secondments are foreseen to:

1) Ariane Group (Les Mureaux), for a duration of 3 months during the first year of the PhD, to work on general guidelines and constraints
2) DLR (Bremen), for a duration of 3 months during the second year of the PhD, for multi-disciplinary studies

The PhD position is open at the ONERA Toulouse Center.

The diploma will be delivered by the engineering school ISAE of the Toulouse University.

Profile and requirements

Essential skills:

- MSc or equivalent in the field of fluid dynamics, energetics or applied mathematics
- Applicants must have a solid knowledge of applied mathematics, computational fluid dynamics, numerical modelling, code development (Fortran, C/C++, Python, etc...)
- Ability to work highly efficient and self-reliantly in a diverse inter-disciplinary and multicultural environment
- Ability to work in a team, as well as independently
- Ability to solve complex problems with adherence of strict deadlines
- Excellent communication skills (both written and verbal) in English to derive the full benefit from the network training
- Proactive attitude
- As secondments and events are foreseen, applicants must be ready to travel
- Applicants must be eligible to enroll on a PhD program at ISAE (school issuing the doctoral diploma), a significant research experience during the master's studies is required
- ONERA is a 'zone with restricted access' (ZRR). Access to ONERA is conditioned to authorization of the French Ministry of Defense

Desired skills:

- Project management
- Knowledge of the host institution language is a plus

Applicants can be of any nationality of the EU or ESA member states.

Candidates may apply prior to obtaining their master's degree but cannot begin before having received it.

In addition:
H2020 MSCA Mobility Rule: researchers must not have resided or carried out their main activity (work, studies, etc.) in the country of the host organization (France) for more than 12 months in the 3 years immediately before the recruitment date. Compulsory national service, short stays such as holidays, and time spent as part of a procedure for obtaining refugee status are not taken into account.
Eligible researchers must not have spent more than 12 months in the 3 years immediately prior to the date of selection in the same appointing international organization.

H2020 MSCA eligibility criteria: Early Stage Researchers (ESRs) must, at the date of recruitment by the host organization, be in the first four years (full-time equivalent research experience) of their research careers and have not been awarded a doctoral degree. Full- Time Equivalent Research Experience is measured from the date when the researcher obtained the degree entitling him/her to embark on a doctorate (either in the country in which the degree was obtained or in the country in which the researcher is recruited, even if a doctorate was never started or envisaged).

Applicants who do not fulfill these requirements CANNOT be considered for the research position.

Benefits

- You will be working within our international group of > 30 researchers with experience in a broad range of sciences
- You will get in contact with the other members of this international consortium and will benefit from the joint training platform to develop skills necessary for developing a thorough understanding of space transportation systems
- You will be employed by the host organization for 36 months
- A competitive salary plus allowances. Moreover, funding is available for technical and personal skills training and participation in international research events
- You will benefit from the well-structured training program offered by the host organization

and the consortium

- You will participate in international conferences and secondments to other organizations within the ASCenSIon network and in outreach activities targeted at a wide audience

Please find additional information in the Information package for Marie Curie fellows.

Selection procedure

For the selection procedure, the ASCenSIon consortium will appoint a Committee, consisting of at least three members: one main supervisor, two co-supervisors and the project coordinator from University of Dresden.The preliminary selection is made by review of the application documents specified below. The final selection will be made after interviews with the final candidates. The applicants will be informed about rejection or admission to an interview by end of May at the latest. The interviews will take place either in person at the host institution or via video-conference. The timeframe for the interviews is May - June.

Application

Interested candidates are invited to submit **one single PDF** containing the following documents in this exact order:

- Application form (see end of this document)
- Cover letter
- CV
- Educational and professional certificates (university degree(s) with marks, internships, workshops, languages, etc.)
- A letter of recommendation
- To provide at least one scientific document (internship report, conference proceeding, journal article, …) written in English by the candidate is a plus

Moreover, you must submit:

- Short video (max. 30 s.). The video must include: personal introduction, background, motivation to apply to the research position… show us why you are the ideal candidate!

All the application documents must be submitted via email to **ascension@tu-dresden.de**

The email subject must be "**Application for ESR7 position**".

The email size incl. attachments **must not exceed 30 MB** in total.

You will receive an automatic reply if we have received your email. Please avoid any questions on the status of the selection process. We will inform you as soon as there is an update.

Candidates whose application is not compliant with the requirements above will not be considered.

Application deadline: 19 April 2020 at 11:59 PM CET
Expected start date: 1 October 2020

Applications and enclosures received after the deadline will not be considered.

More information and other vacant positions can be found at:

- Website: https://www.ascension-itn.eu/
- Facebook: https://www.facebook.com/ascensionitn/
- LinkedIn: https://www.linkedin.com/company/ascensionitn/

Additional information

We in the ASCenSIon consortium value diversity and we commit to equal treatment of all applicants irrespective of gender, sexuality, health status as well as social, cultural or religious

background.

For additional information about the research project and this individual position, please contact:

ascension@tu-dresden.de

ASCenSIon ITN Application Form

Name and surname: **Applying for ESR No. 7**

Age:

Nationality:

Country of residency in the last 3 years (if more than one, state also for how long you resided in each country):	
Country where you carried out your main activity (study, work, etc.) **in the last 3 years** (if more than one, state also the duration of your activities):	
University and course degree:	
Master's degree final mark:	
Final thesis title:	
Thesis supervisor(s):	
Starting and ending year of your university studies (Bachelor and Master):	
Professional experiences carried out in the last 4 years, if any (internships, scholarships, free collaboration, research, work experience and/or internship abroad, participation in Erasmus + or Summer School programmes, etc.)**:**	
Professional experiences relevant to the research position you are applying for (specify up to three experiences in chronological order, starting from the most recent):	
Language skills (language and level):	
Relevant computer skills (software, programming, etc. and specify user level: basic, average, experienced):	
Please specify any relevant professional teamwork experience (and your role within the team)**:**	
State three aspects that would make you the ideal candidate for this position:	