SHAPE 13th Call - Application Form

At this application stage some SMEs may not be in a position to provide all of the information requested e.g. specific hardware details, quantity of machine time etc. The review process can accommodate this, but please provide as much relevant information as possible to assist in the assessments. You can submit the application form to shape-application[at]prace-ri.eu until **01 June 2021, 17:00 Brussels Time.**

Project Title	Space Capsule Aerothermodynamic Database
Company Name	Ingénierie et Systèmes Avancés
Company Address	16 chemin de l'Ousteau de Haut 33610 Cestas France
Company Website	http://www.isa-space.eu/
Number of Employees	1
Contact (full name)	Philippe Reynier
Contact (job title)	Director
Contact (e-mail)	Philippe.Reynier@isa-space.eu
Contact (phone)	**International code (e.g. +32): +33** **Phone number: 5 56 47 92 74**

Which of the following describes best the main revenue source of your company?

(x) Private sector

( ) Public funds

Has your company worked with PRACE before?

No

What does your company do?

Ingénierie et Systèmes Avancés (ISA), is a limited company created in 2006, that carries out research and development activities and provides technical support and expertise for the development of new technologies.

The company has a large suite of software that allows technical studies in the following domains:

- Computational Fluid Dynamics;

- Trajectory analysis;

- Thermal Engineering;

- Electromagnetism;

- Multiphysics;

- Radiation.

The company activities are oriented around the following axes:

- System studies for the atmospheric entry of spacecraft;

- Software development;

- Development of emerging technologies for energy sector and cryogenic applications;

- Technical support for the design and development of experimental pilots, and innovative non-intrusive measurement techniques;

- Review of industrial work and support to the definition of future R&D activities and technology roadmaps;

ISA has a core capability in computational fluid dynamics, this for a large range of flow regimes. They can be simulated using 2D/3D codes based on the finite volume approach and structured or unstructured meshes. For the time being, capabilities are available in relation to the following points:

- Rarefied flows;

- Incompressible flows;

- Compressible (supersonic) flows;

- Hypersonic flows accounting for thermal and chemical non-equilibrium, catalysis, and gas blowing in the boundary layer;

- Turbulent flows (two-equation models, LES);

- Multiphase flows (solid/liquid, gas/liquid, Lagrangian-Eulerian coupling, mixture model, two-fluid approach).

ISA is working on industry contracts, but also participating to national and European research programmes. Most of ISA's studies are performed for space applications; however the company is working to diversify its activity to other domains such as high-energy physics, and artificial intelligence related to medicine.

Project Abstract

Space Case consists in a space capsule of small size (around 40 kg, less of one meter in diameter) dedicated to perform experiments in low Earth orbit. The experiments to be performed are of several types:

- Tests of scientific payloads in microgravity;

- In-flight validation of space sub-systems and components;

- Re-entry experiments (thermal protection system, materials, Guidance Navigation and Control)

The project based on an initial idea from Ingénierie et Systèmes Avancés (ISA) has been proposed by HYFAR-ARA (the re-entry association in the region Nouvelle Aquitaine: https://www.hyfar-ara.org) to the Space Hub puts in place by the region and Bordeaux Métropole in 2021. It is developed through a partnership of Ariane Group Space, CEA (Commissariat à l'Energie Atomique), the Universities of Bordeaux and Limoges, and different SME's. In the frame of Space Case, in cooperation with Ariane Group Space and CEA, ISA focuses its efforts on the market survey and the aerodynamic and aerothermodynamics databases.

For what concerns the aerothermodynamics activity, numerical tools dedicated to hypersonic flows available at ISA, are going to be used. These software have the capability to simulate the high hypersonic flows characterized by non-equilibrium chemistry effects encountered during atmospheric re-entry. For this purpose, the company possesses a small network of Linux workstations. They are generally sufficient for the current needs of the company but the computational effort associated to the generation of aerodynamic and aerothermodynamics databases to be simulated in the frame of Space Case (several tens of 3D calculations) are beyond the available capabilities. Concerning the numerical software to be used, two have been retained for the project. The first one is a Navier-Stokes code dedicated to hypersonic flows, TINA, available at ISA as a source code (through an agreement with the British company Fluid Gravity Engineering). The second tool to be used, more advanced from a programming aspect, is the open source code SU2 originally developed by the University of Stanford that the company would like to use more particularly for 3D configurations on parallel computers.

Industrial relevance and potential business impact

The PRACE SHAPE programme is a high opportunity for ISA, particularly in the context of the Space Case project. Firstly, the use of the HPC infrastructure will allow the prediction of aerodynamic and aerothermodynamics databases in a shorter time when comparing to the use of the in-house capabilities. The second benefit of the programme will be the external support from IT experts in order to increase the parallel efficiency of the tools. This particularly applies to the set-up of an ad-hoc script in order to perform the computations in an automatic way, this will improve the tool capabilities and the company state-of-the-art on this computational point. This is an important point, since this will be an asset for future similar projects requiring intensive computations. For these reasons the support of this programme will be an important asset for the company in order to increase the computational efficiency. The project will benefit from this support, but this will also enlarge the capabilities of ISA to applications requiring high computational power. An additional point is the potential need of additional scientists and/or engineers for future projects in line with the improved company service quality.

Proposed high-level Work Plan

The project will be split in several tasks as described hereafter.

- Testing and assessment of potential improvements of computational tools on HPC hardware. This is a crucial point to estimate the tool performance and the time required for generating an aerodynamic or aerothermodynamic database. Another point is the tool optimization on HPC computers that requires the support of IT engineers with the relevant expertise.

- Script development for generating an automatic process for computational cases series. This is another important point since this will automaze the generation of the numerical data along a re-entry trajectory. This point is particularly relevant for aerodynamic databases for forces and moments.

- Computation of aerodynamic and aerothermodynamic databases for a generic capsule of apriori Soyouz-like shape. A certain number of trajectory points will be computed for an orbital re-entry trajectory with an initial velocity in the range of 6 km/s.

- Same process as before but for a slender body.

The different tasks of the work plan are resumed in the following table with an estimate of the manpower required.

Start date:		Kick-off (foreseen in September/October 2021)		
Task	**Title**	**Description**	**SME effort (PM)**	**PRACE effort (PM)**
1	Initial Profiling	The software will be handed over to the PRACE partner and installed on the target system, along with example test cases and benchmarks. These will be verified and profiled to identify bottlenecks	0.5	1.5
2	Optimisation strategy	Based on profiling data from previous task, propose strategies for code optimisation. This will also include the development of an ad-hoc script for generating a aerodynamic (and aerothermodynamic) database for different trajectory points.	0.5	1
3	Soyouz-like shape	Generation of the aerodynamic and aerothermodynamics database for a blunt body re-entry capsule (final retained shape might slightly change).	4	1
.4	Slender capsule	Generation of the aerodynamic and aerothermodynamics database for a re-entry slender body.	3	1
6	Final report	Produce report on the outcomes of the work. Part of the activity will be presented in dedicated conferences and workshops.	0.5	0.25
		Total	8.5	4.75

Technical and business requirements

Compute Resource

Existing compute resource	Small network of Linux workstations
Preferred compute resource	HPC machine, as available at IDRIS (preferred center)
Parallelisation strategy	SU2 is parallelized using OpenMPI, TINA uses MPI.
Storage (Gbyte)	Since the calculations focuses on a static approach along a trajectory, the storage should be reasonable. From the elements available at ISA, it should be in the range of 100 GB.
Third party software	SU2 is available as open source code (see https://su2code.github.io). TINA is available through a contractual agreement between ISA and Fluid Gravity Engineering Ltd (see http://fluidgravity.co.uk/fgewebsite/). Copy of the contracual agreement can be made available when required, or can be requested directly at the Greffe du Tribunal de Commerce de Bordeaux (this is annexed to the company statutes).
Typical run	A 2D run for a re-entry calculation around a blunt bode geometry requires around 2 days on one workstation core. However, this depends on the flow conditions: strong non-equilibrium effects require a lot of care at the beginning of the calculation.
Core hours	This is a difficult point that will be clarified during task 1. However, from the available information Pflops machines are available at IDRIS. So when comparing to a worstation performance, the computing time shall be an issue.
Memory	Usually memory is not a critcal point for these codes, and is estimated to be in between 1 and 10 GB per node
Other	N/A

Non-technical resource

In the case where particular results may be commercially sensitive to the SMEs business, it is still expected that a white paper could be published with a higher-level discussion of the techniques and approach used, omitting the details of particular sensitivity.

Confidentiality	NDA requires for the project particularly for computational conditions (in terms of trajectory points), capsule geometry details, and results.
Other	Part of the results will be presented during workshops and dedicated conferences (PRACE support acknowledged as required). Common publications with supporting IDRIS scientists will be welcome, when possible.