

# OpenFOAM® Request for Quotation

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| <b>TITLE</b>   | <b>GPU Acceleration Pilot:</b><br>Productisation of newly developed <a href="#">AmgX4foam</a> external module for GPU acceleration of linear algebra solver inside OpenFOAM-vYYMM<br>Linear algebra profiling in standard output<br><b>[Optional]</b> Physics modelling and Linear solver in CUDA |
| <b>FAO</b>   | Potential bidders (ratified by OpenFOAM Governance Steering Committee)  |
| <b>Requester/TC</b>  | Ivan Spisso on behalf of HPC TC's members:<br>Simone Brà, Filippo Spiga, Matthew Martineau, Stan Posey, Raman Bansal, Neil Ashton, Fabrizio Magugliani, Mark Olesen   |
| <b>Funding offered</b>   | Range 25-40kEUR<br>Funded through third-party bespoke donations to OpenFOAM Governance Funds  |
| <p><b>Requirements</b></p> <ul style="list-style-type: none"> <li>- Create a self-contained library to use amgx4foam/nvidia4foam with NVIDIA GPUs as a third-party plug-in to OpenFOAM-vYYMM <ul style="list-style-type: none"> <li>o Profile code for named application(s), assess and propose potential speed-up</li> <li>o Demonstrate potential speed-up through library plugins for the chosen application(s)</li> </ul> </li> <li>- Assess speed-up potential, implement via CUDA-code and demonstrate for a named application (e.g. underhood thermal) speed-up for a chosen Physics Model (e.g. Radiation)</li> <li>- Assess speed-up potential, implement via CUDA-code and demonstrate for a named application (e.g. underhood thermal) speed-up for a chosen Solver (e.g. view-factor)</li> </ul> <p><b>Partners (coordinated by Ivan Spisso, HPC-TC chair)</b></p> <ul style="list-style-type: none"> <li>- <b>Bidder (funded)</b></li> <li>- Nvidia (in-kind)</li> <li>- ESI/OpenCFD (funded)</li> <li>- Cineca (in-kind)</li> <li>- 3<sup>rd</sup> party contributors (three-to-five funders)</li> </ul>   |   |
| <p><b>Description:</b></p> <p>GPU porting of linear algebra inside OpenFOAM, using AmgX by NVIDIA, is based on three libraries:</p> <ol style="list-style-type: none"> <li>1. <a href="https://gitlab.hpc.cineca.it/openfoam/foam2csr">https://gitlab.hpc.cineca.it/openfoam/foam2csr</a>: responsible for converting the sparse matrix system from native LDU format of OpenFOAM into CSR suitable for external linear algebra solvers, low-overhead conversion from OpenFOAM LDU matrices to GPU-resident CSR matrices, and AmgX integration</li> <li>2. <a href="https://develop.openfoam.com/modules/external-solver">https://develop.openfoam.com/modules/external-solver</a>,</li> <li>3. <a href="https://github.com/NVIDIA/AMGX">https://github.com/NVIDIA/AMGX</a>, the open-source NVIDIA GPU-accelerated multi-grid accelerated solver</li> </ol> <p>Activity proposed:</p> <ol style="list-style-type: none"> <li>1. Adding profiling hooks for linear algebra solver part of the code (<b>Task owner:</b> ESI/OpenCFD)</li> <li>2. Software engineering: package the different pieces of codes in a self-contained package in a public repo (<b>Task owner:</b> Bidder, Nvidia, ESI/OpenCFD) <ol style="list-style-type: none"> <li>a. Fuse FOAM2CSR + AmgX in one library, and start version 1.0: (<b>Task Owner:</b> NVIDIA)</li> </ol> </li> </ol> |   |

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- b. Deployment of a plug-in [external-solver](#) to use this library as an external module, such as nvidia4foam/amgx4foam (similarly/based on petsc4foam, modify petscUtils.C in something along with as amgxUtils.C). (Task owner: ESI/OpenCFD)
- 3. Testing, benchmarking, and profiling of GPU performance on various CPU host architectures and tests on industrial test-cases by working closely with the ongoing developer: cluster CPU + GPUs (Task owner: Bidder)
  - a. Optimization of the library
- 4. **Optional** Porting a selected physics model to GPUs (Task owner: Bidder). *Has to maintain compatibility with standard version OpenFOAM-vYYMM*
- 5. **Optional** Porting of a selected solver to GPU (Task owner: Bidder). *Has to maintain compatibility with standard version OpenFOAM-vYYMM*

**References:**

1. <https://gitlab.hpc.cineca.it/openfoam/foam2csr>,
2. <https://develop.openfoam.com/modules/external-solver>
3. <https://github.com/NVIDIA/AMGX>

**Bidder Qualifications/Requirements:**

The Bidder should

- 1) Reference knowledge and experience in using OpenFOAM as a Development and Applications specialist
- 2) Demonstrate experience in CUDA coding
- 3) Illustrate appropriate background for solver deployment on heterogeneous CPU and GPU systems

**Response requested from the Bidder**

A full proposal referencing the Requirements stated herein, and detailing

- 1) Tasks and deliverables
- 2) Costs
- 3) Timescales (request completion before end Dec.2022)
- 4) Unit and Applications tests suitable for integration into the standard Regression Tests

Please send the Proposal to Ivan Spisso, HPC Technical Committee Chair <[spissoivan@gmail.com](mailto:spissoivan@gmail.com)> cc Karen Kettle, OpenFOAM Governance Administrator <[ext-Karen.Kettle@esi-group.com](mailto:ext-Karen.Kettle@esi-group.com)>

Deadline for proposal from bidder to be sent back by mid-day (CEST): **22<sup>nd</sup> July 2022**

**For Official use:**

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| Date Submitted to Technical Committee (via OpenFOAM Governance Administrator) | 5 <sup>th</sup> July 2022  |
| Tender Published Externally (by Technical Committee)                          | 6 <sup>th</sup> July 2022  |
| Proposal Deadline Date  | 22 <sup>nd</sup> July 2022 |
| Decision and Recommendation to Steering Committee                             | 29 <sup>th</sup> July 2022 |