

# Mission, Overview and Challenges

*exaFOAM*

**Exploitation of Exascale Systems for Open-Source  
Computational Fluid Dynamics by Mainstream Industry**

**Funding Body:** EuroHPC-03-2019

**Call:** H2020-JTI-EuroHPC-2019-1

**Project Number:** 9564167

**Project Duration:** 1<sup>st</sup> April 2021 to 31<sup>st</sup> March 2024

**Presenter:** Marta M. Garcia-Gasulla



**EuroHPC**  
Joint Undertaking

- Computational Fluid Dynamics is ubiquitous

**~1,000,000,000**

Euros of CFD Annual Value

**~1,000,000**

Lines of code in OpenFOAM

**~100,000**

CFD Users

**~10,000**

CFD Organizations

**~100**

Contributors

**1**

Project – exaFOAM

- The algorithmic technology-base is known, well established and universally applied, but is not fully fit to take best advantage of recent major developments in HPC
- Performance on HPC is notably worse than idealised algorithms (inherent bandwidth needs, three-dimensional and time-date handling with non-sparse matrix dependencies, spatial domain decomposition requirements, I/O challenges, etc.)

Improve performance of industrial software and codes !!!



Join efforts to overcome the current limitations of CFD technology, with focus on massively parallel HPC architectures

## Approach

- Development and validation of a range of algorithmic improvements (preprocessing, simulation, I/O, post-processing);
- A large set of **HPC Grand Challenges** and **Industrial Applications** will be used to assess the effectiveness of the developments (covering a wide range of applications)
- All developments will be implemented in the open-source CFD software OpenFOAM®
- All developed codes and validation cases will be released as open-source to the community in coordination with the OpenFOAM® Governance structure



upstreamCFD



- Assess the current main bottlenecks in mainstream CFD
- Identify and realise algorithm improvements to enhance HPC scalability
- Identify and realise engineering design/analysis process improvements for industrial software codes, including pre-processing, post-processing and I/O
- Provide a complete tool-set for performance and scalability measures across all HPC platform-flavours
- Demonstrate improvements in performance and scalability
- Identify, provide and disseminate best practices for coding, software execution process, performance and scalability measures
- Achieving European leadership in different industrial areas of application of the target code (aerospace, power generation, automotive, disaster prevention, and more)

Do all the above in an **open-source CFD** code using **open-source tools** to:

- Guarantee that the technologies advances are readily accessible by European industry
- Assure that the improvements are easily verifiable



## 12 Partners / 7 European countries + Stakeholders & Supporters

1. ESI Group (France) - **Principal Investigator**
2. CINECA Consorzio InterUniversitario (Italy)
3. E4 Computer Engineering SpA (Italy)
4. Politecnico di Milano - DAER (Italy)
5. University of Zagreb (Croatia)
6. Technische Universitaet Darmstadt (Germany)
7. Wikki (Germany)
8. Upstream CFD (Germany)
9. Universitaet Stuttgart, HLRS (Germany)
10. Barcelona Supercomputing Center, BSC (Spain)
11. National Technical University of Athens, NTUA (Greece)
12. University of Minho (Portugal)



• Experts in HPC CFD algorithms and industrial applications  
• Universities, HPC centres, SMEs and code release authority  
OpenCFD Ltd as a linked third party to the PI



**EuroHPC**  
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## Stakeholders (13)

Resources commitment and/or test case challenges provided



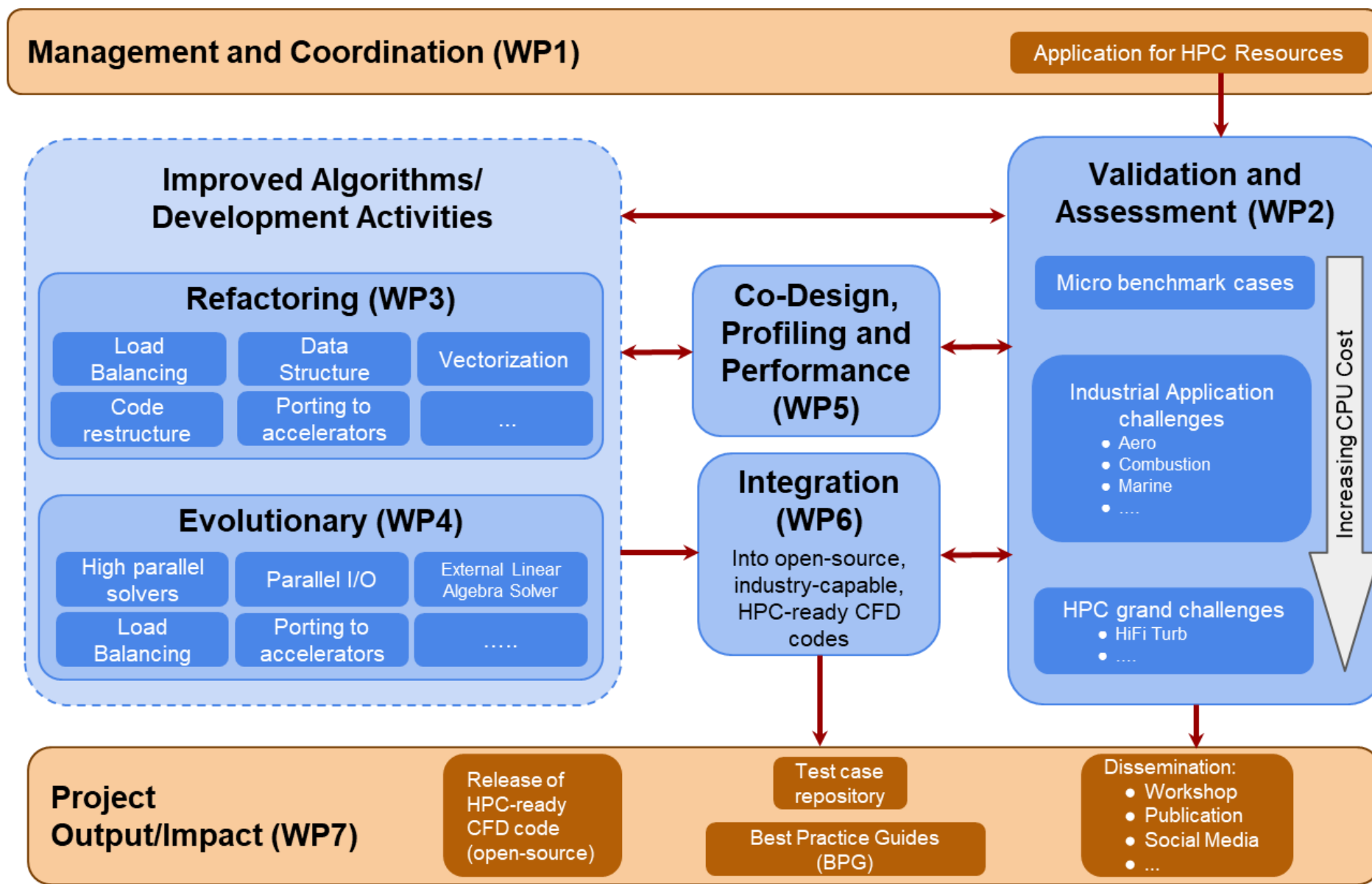
## Supporters (5)

Letter of support during the proposal phase

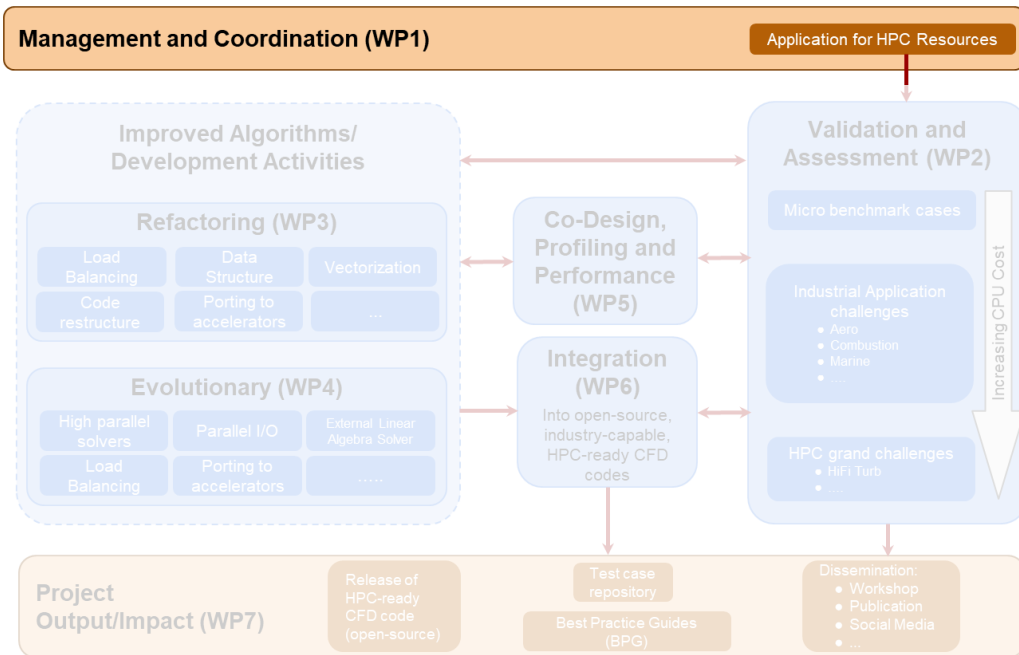


**How to become a supporter?**  
<https://exafoam.eu/become-a-supporter/>





# Work Package Structure



## WP1 – Management and Coordination

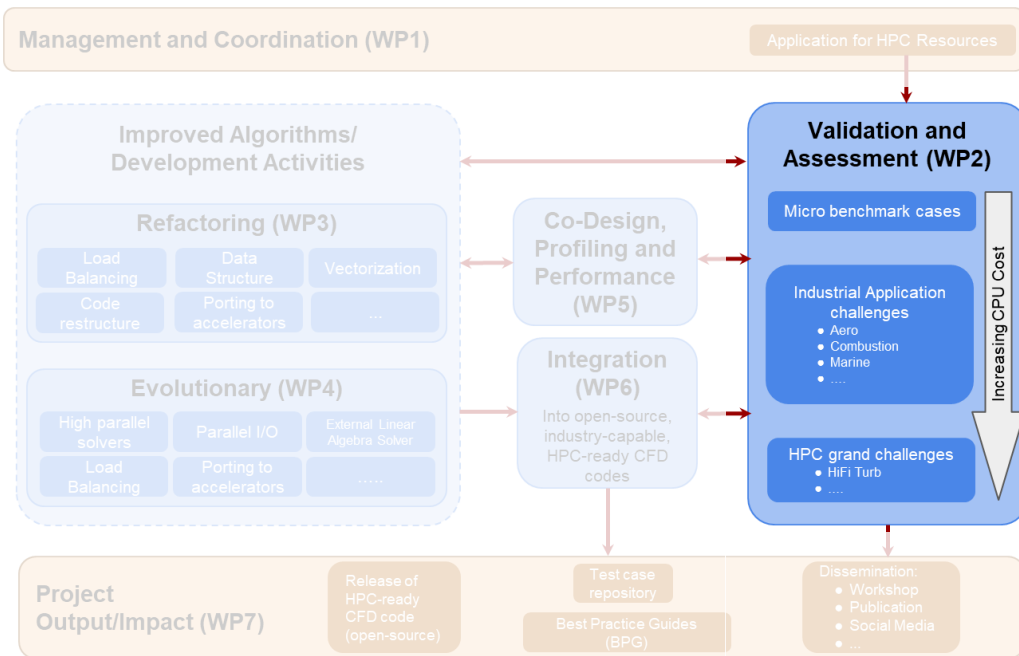
Lead Beneficiary: 

### Objectives:

- Ensure effective management, resource monitoring and reporting
- Management of Intellectual Property
- Ongoing risk assessment, resolution strategy and management of resolution actions;
- Application for HPC resources
- Establish links and promote interactions with other H2020- and EuroHPC-funded projects







## WP2 – Validation and Assessment

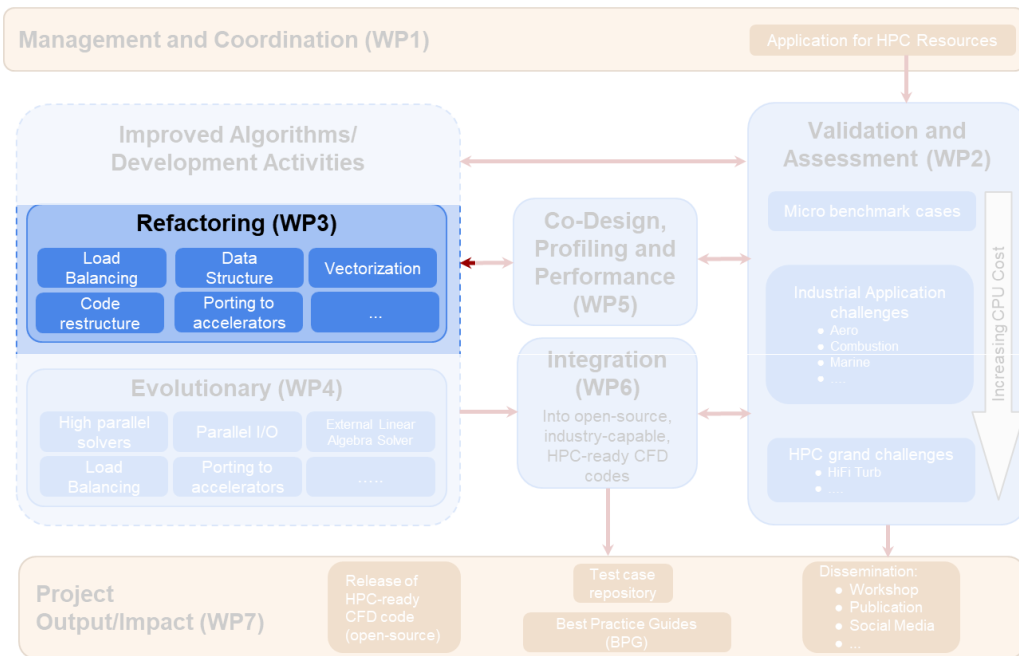
Lead Beneficiary: **WIKKI**

### Objectives:

- Analyse the **industrial and high-impact applications** as well as **HPC Grand Challenges** to derive **micro benchmarks** suitable for continuous assessment
- Define acceptance criteria
- Validate the developed software

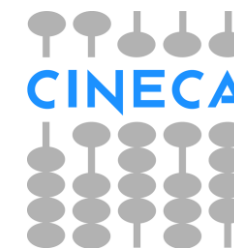


# Work Package Structure



## WP3 – Code Refactoring

Lead Beneficiary:

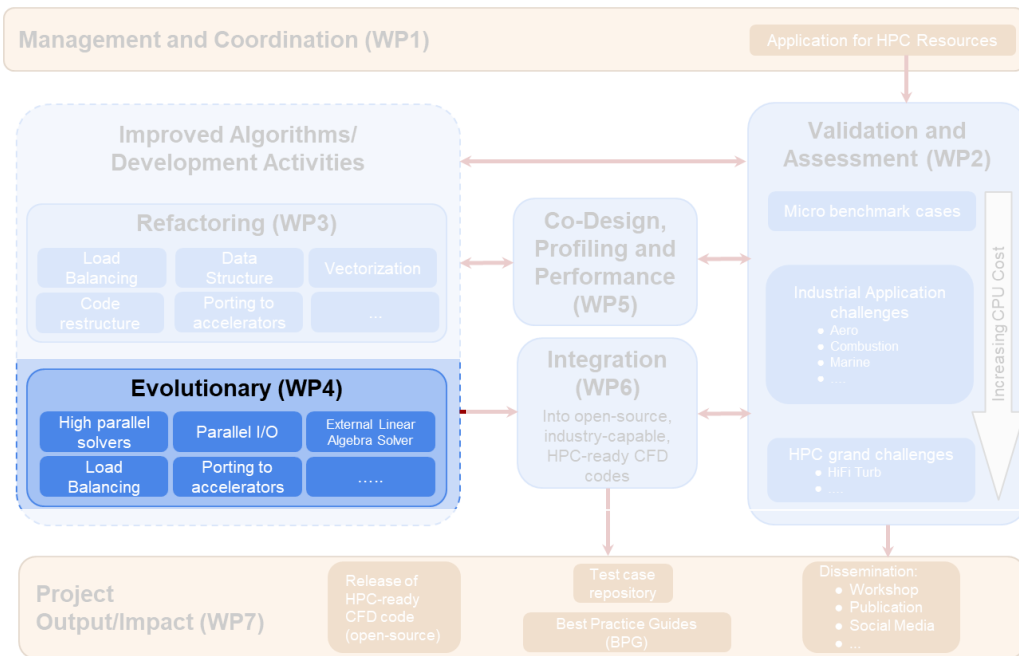


### Objectives:

- Identify a very high efficiency and hardware-independent sparse matrix format
- Refactor the field algebra and matrix assembly to improve the code vectorization/hybridization
- Implement different linear algebra solvers
- Develop efficient parallel I/O scaling strategy
- Propose strategies for porting OpenFOAM to accelerators (GPUs and/or FPGAs).



# Work Package Structure



## WP4 – Evolutionary

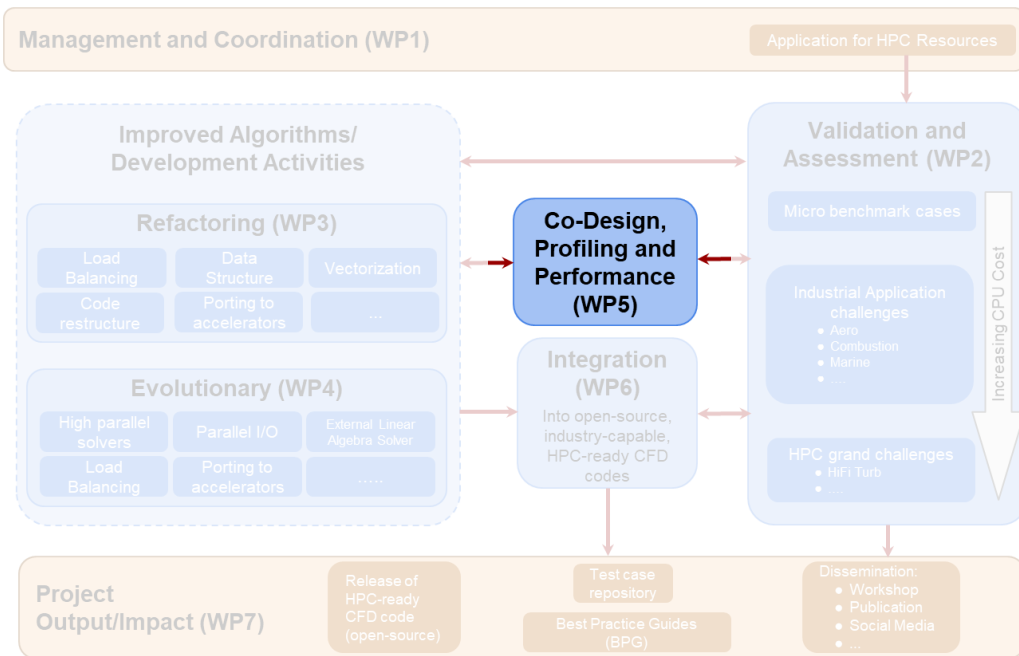
Lead Beneficiary:




### Objectives:

- Implement strongly coupled solution algorithms
- Implement numerical algorithms for massive parallelization
- Seek synergies with open-source components (linear algebra solvers or massively parallel I/O)
- Reduce the amount of memory required by each checkpoint to reduce the cost of recomputations
- Optimize the parallel efficiency of the non-conforming mesh interface methodology (GGI/AMI)
- Implement efficient load balancing strategies





## WP5 – Co-design, Profiling and Performance analysis

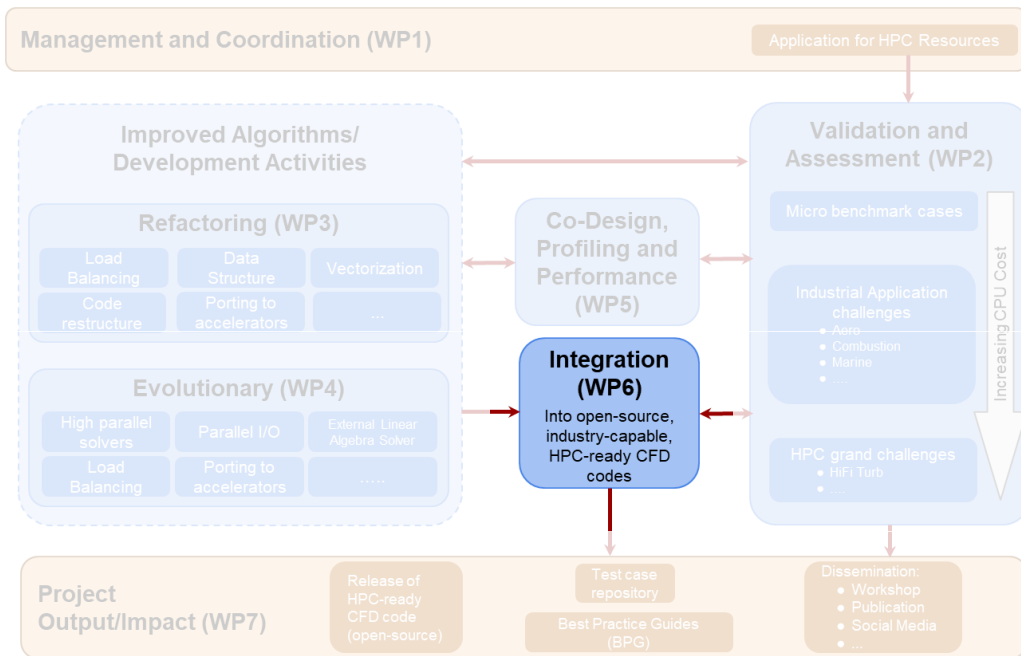
Lead Beneficiary: 

### Objectives:

- Performance analysis of micro-benchmarks and industrial use cases
- To provide feedback to code developers
- To offer continuous, on-demand analysis support
- To gather and communicate best practices and guidelines (program, run and setup)
- To interconnect the developers' requirements with the inputs of computers architecture designers, programming model developers, and system administrators in a truly **co-design process**



# Work Package Structure



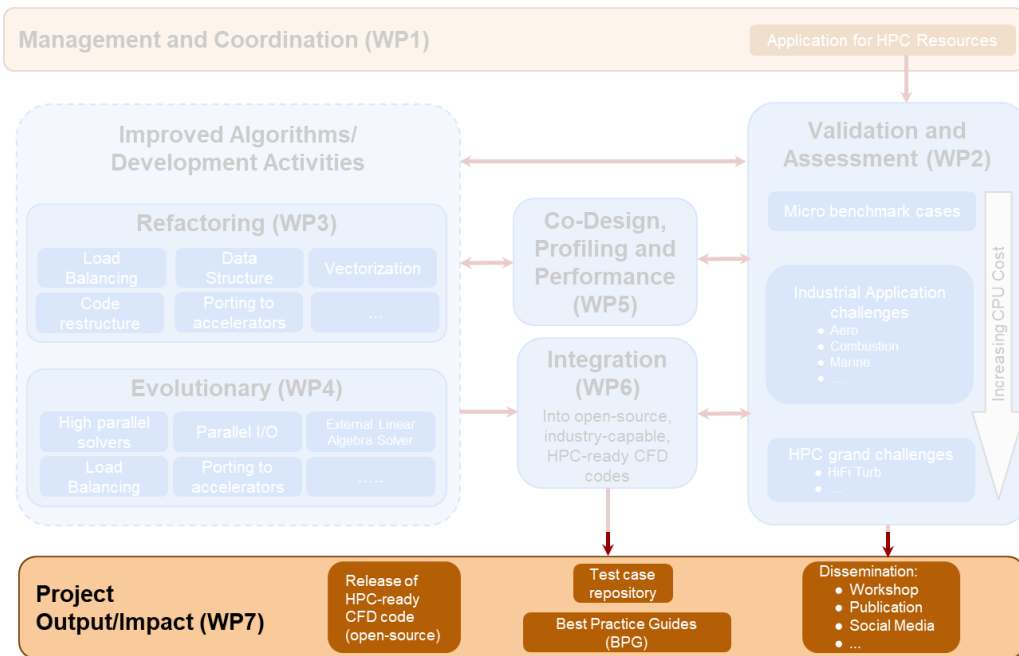
## WP6 – Integration

Lead Beneficiary: 

### Objectives:

- Deliver developments to the public domain in a usable form for portability across several different homogeneous and heterogeneous systems.
- Assure code integration, testing and delivery standards under ISO-9001:2015





## WP7 – Dissemination, Impact and Exploitation

Lead Beneficiary:



Universidade do Minho

### Objectives:

- **General Dissemination:** Website, newsletter, social media, discussion forum
- **Code/Test case repository:** Relevant codes publicly available, including developer guides and tutorials
- **Technical/Scientific dissemination:** Presentations in conferences, workshops, and publication of papers and technical reports
- **Knowledge Transfer:** Summer schools, seminars/workshops, exchange visits
- **Exploitation and Intellectual Property Reports**



EuroHPC  
Joint Undertaking

**Estimated Budget: 5.4 M€**

**Contribution from the EuroHPC JU (Joint Undertaking): 2.4 M€**

## Timetable:

- **Starting date:** April 1<sup>st</sup>, 2021
- **End date:** March 31<sup>st</sup>, 2024
- **Duration:** 36 Months

The screenshot shows the European Commission SEDIA website. The header includes the European Commission logo, the text 'Funding & tender opportunities', and 'Single Electronic Data Interchange Area (SEDIA)'. There are links for 'English EN', 'Register', and 'Login'. A navigation bar contains 'select programme', a grid icon, and a menu icon. The main content area features a blue background with the following text: 'Jul 25, 2019', 'Industrial software codes for extreme scale computing environments and applications', 'ID: EuroHPC-03-2019', 'Type of action:', 'EuroHPC-IA EuroHPC-IA', 'Deadline Model : single-stage', 'Opening: 25 July 2019', and 'Deadline: 14 January 2020 17:00:00 Brussels time'. A green 'Open' button is located at the bottom left of the content area.



# Thank you!!!

## Questions?

*This project has received funding from the European High-Performance Computing Joint Undertaking Joint Undertaking (JU) under grant agreement No 956416. The JU receives support from the European Union's Horizon 2020 research and innovation programme and France, United Kingdom, Germany, Italy, Croatia, Spain, Greece, and Portugal.*

