SAGE-HPC

Smart strateGies for multi-fidelity optimization in Exascale HPC Environments

Laetitia Giraldi

AG Exa-MA
21/01/2026

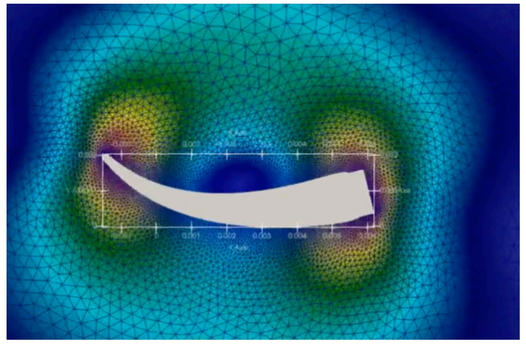
Consortium of SAGE-HPC

2 Institutions

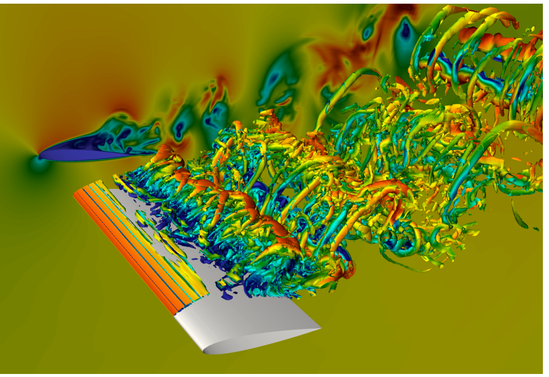
- Acumes - Calisto - Maasai	- Makutu	Cemosis, IRMA UMR 7501	5 Teams
Sophia-Antipolis	Bordeaux/Pau	Strasbourg	4 Sites 3 Universities

Scientific core of SAGE-HPC

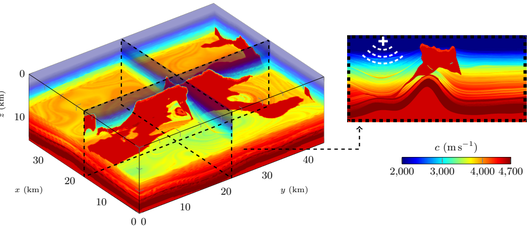
Applications



Swimming



Aeronautics



Geophysics

Dynamics derived from applications

$$\inf \mathcal{C}[X;\mu] \quad \textit{subject to} \quad \psi[X;\mu] = 0$$

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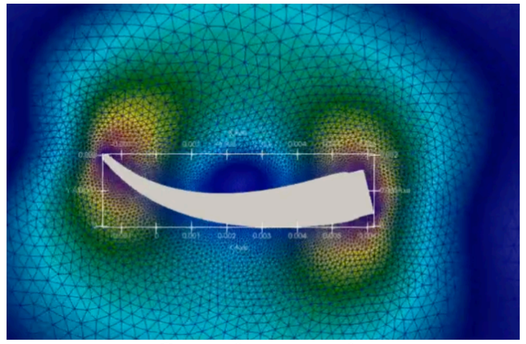

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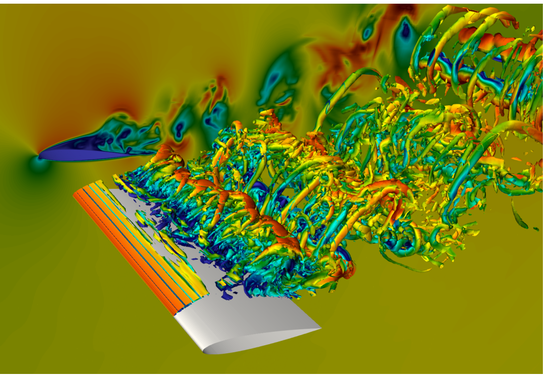

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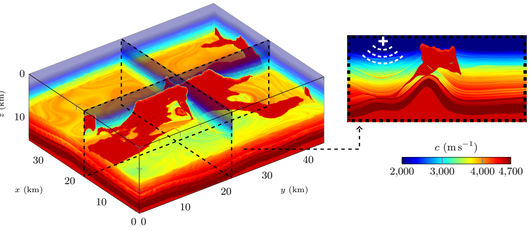

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→ *High-dimensional complex cost functional*

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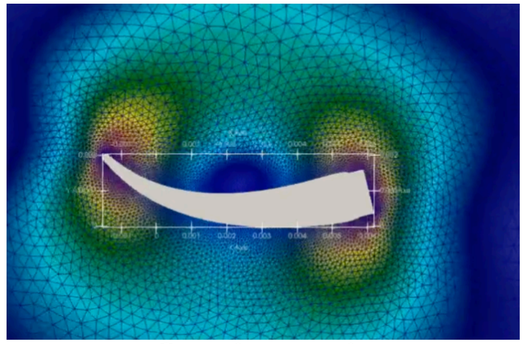

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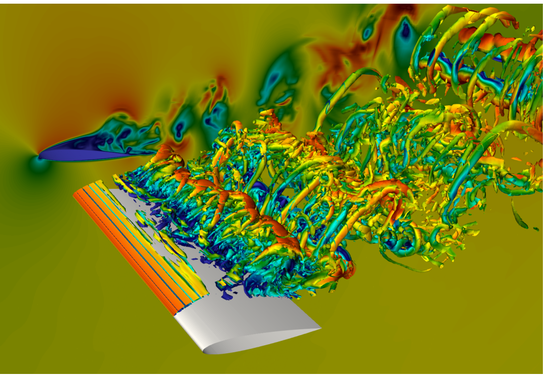

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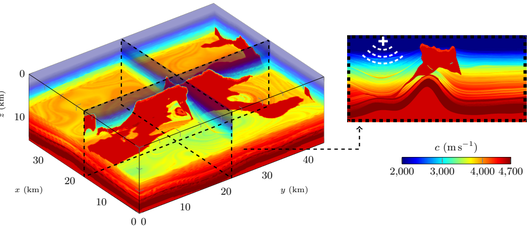

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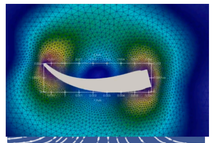
→ *High-dimensional complex cost functional*

→ *Simplify*

Hierarchy of model

Giraldi et al. (2025)



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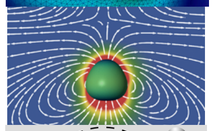

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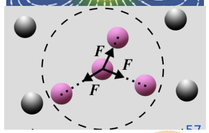

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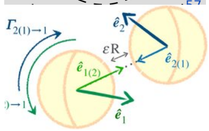

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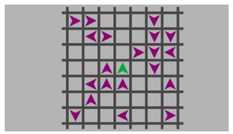

decreasing realism

increasing complexity / cost

- *Fully resolved deformation + fluid-structure interactions*
- *Squirmers + fluid dynamics*
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Scientific core of SAGE-HPC

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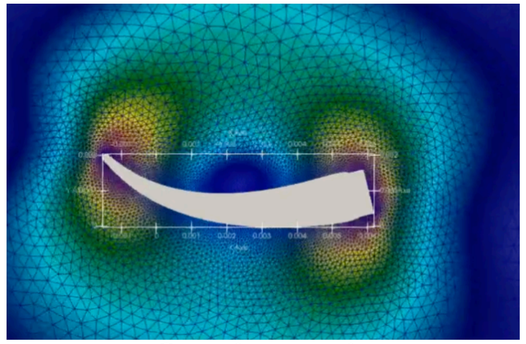

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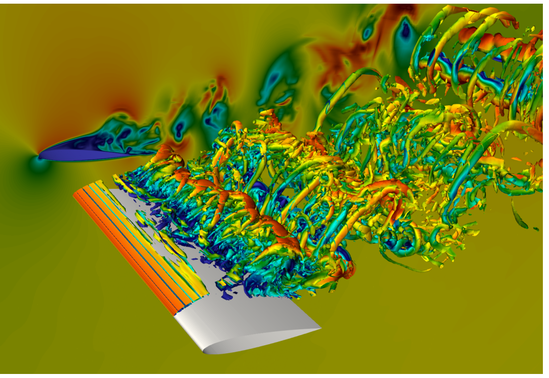

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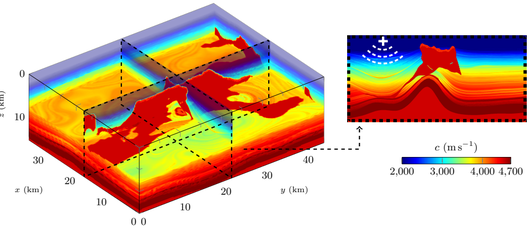

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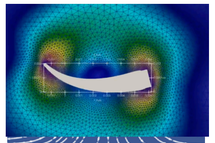

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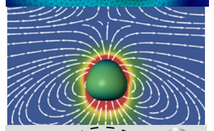

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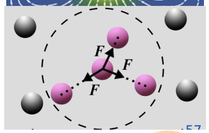

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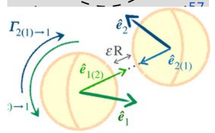

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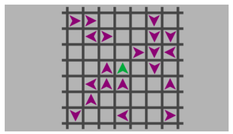

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Optimization methods

Hybrid *Deterministic* *NN* *BO* *DRL*

IA

How to jointly orchestrate the fidelity selection, optimization methods?

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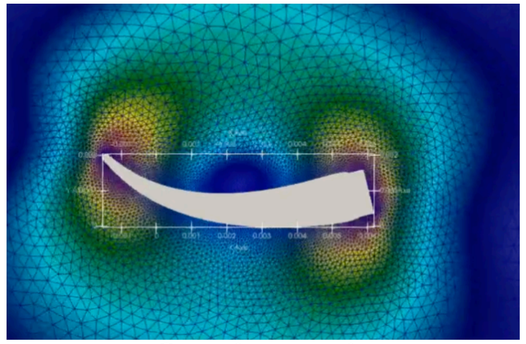

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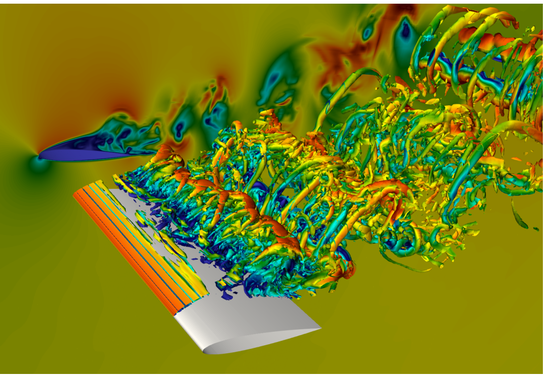

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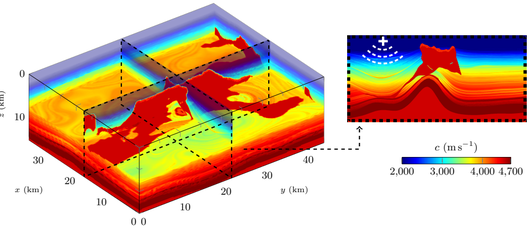

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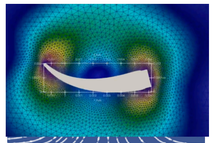

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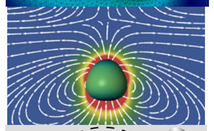

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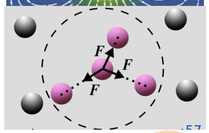

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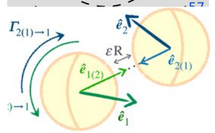

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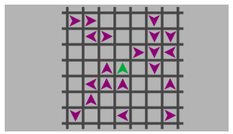

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HPC

Parallel and high performance computing

How to jointly orchestrate the fidelity selection, optimization methods and ressource allocation in exascale environnement?

Challenges

How to jointly orchestrate the fidelity selection, optimization methods and ressource allocation in exascale environnement?

- ***AI for HPC:*** *dynamic orchestration of simulations by learning*

- *Optimization methods : BO, DRL, NN and hybrids*

- *Advanced multi-physics demonstrators*
- *Exascale capacity (European machines)*
- *Hybrid CPU/GPU computing (MPI/Kokkos)*

Objectives

- *How to design optimization methods for multi-fidelity framework ?*
- *How to build a benchmark library to evaluate the behaviors of the methods?*
- *What are the best optimization strategies ?*
- *How to deploy a scalable library on exascale HPC systems?*

Objectives and Work Packages

- *How to design optimization methods for multi-fidelity framework ?* — *WP1*

- *How to build a benchmark library to evaluate the behaviors of the methods?* — *WP2*

- *What are the best optimization strategies ?* — *WP3*

- *How to deploy a scalable library on exascale HPC systems?* — *WP4*

Objectives and Work Packages

- *How to design optimization methods for multi-fidelity framework ?* — WP1
- *DRL, BO, NN, deterministic approach, hybrids*

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- *Swimming*
- *Aeronautics*
- *Geophysics*

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Analysis and comparison

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- *What are the best optimization strategies ?* — *WP3*
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- *How to deploy a scalable library on exascale HPC systems?* — *WP4*
- *Hybrid CPU/GPU architectures, MPI/Kokkos, dynamics orchestration, ensemble simulations*

Skills

The scientific outcomes rely on three key domains of expertise:

- Skill Hub Ⓐ: ***AI-driven Optimization***
  DRL, BO, NN, deterministic approach and hybrids

- Skill HubⒷ: ***Mathematical modeling and simulations***
  FEM, CutFEM, DG, spectral methods

- Skill Hub Ⓒ: ***HPC & Exascale***
  Hybrid CPU/GPU architectures, MPI/Kokkos, dynamics orchestration

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Acumes Calisto Maasai	
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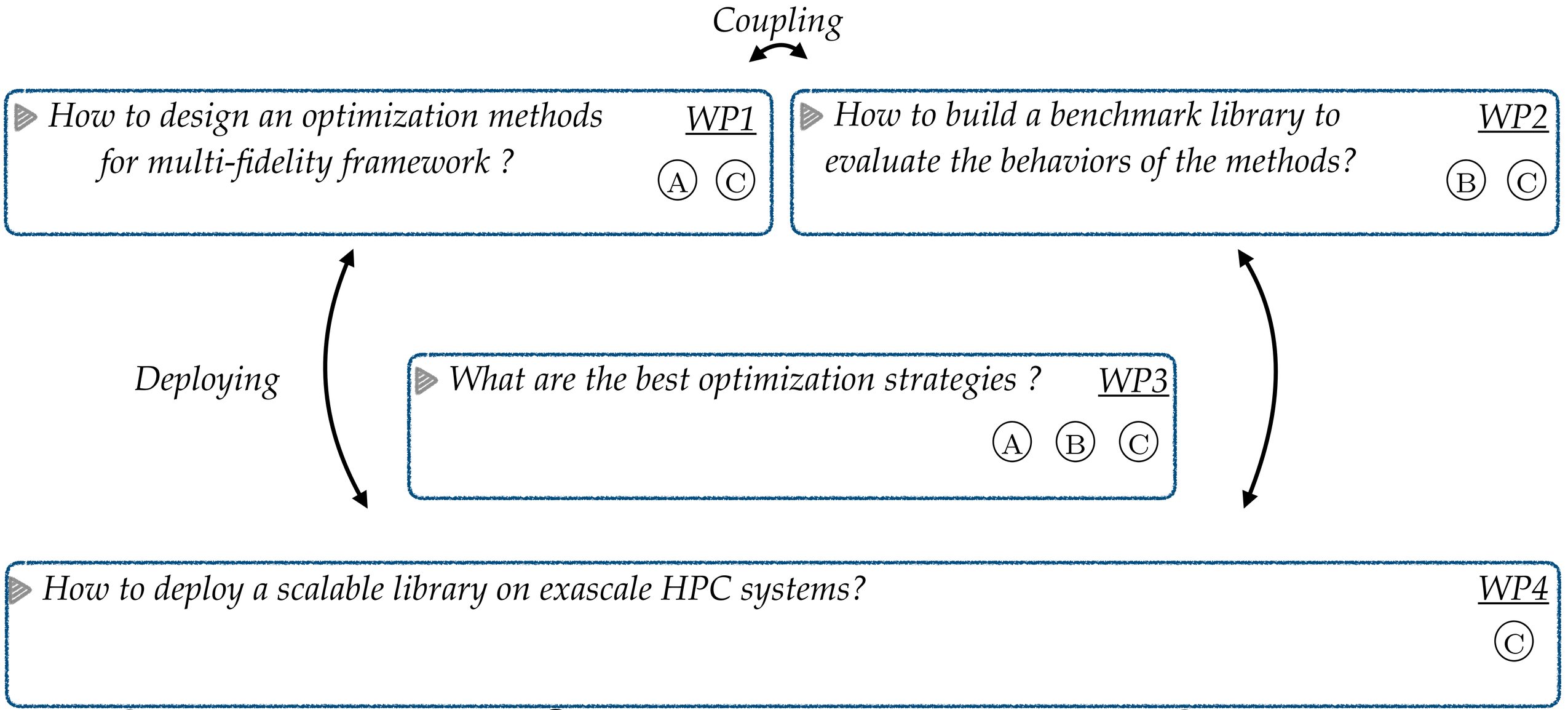
Integrated view



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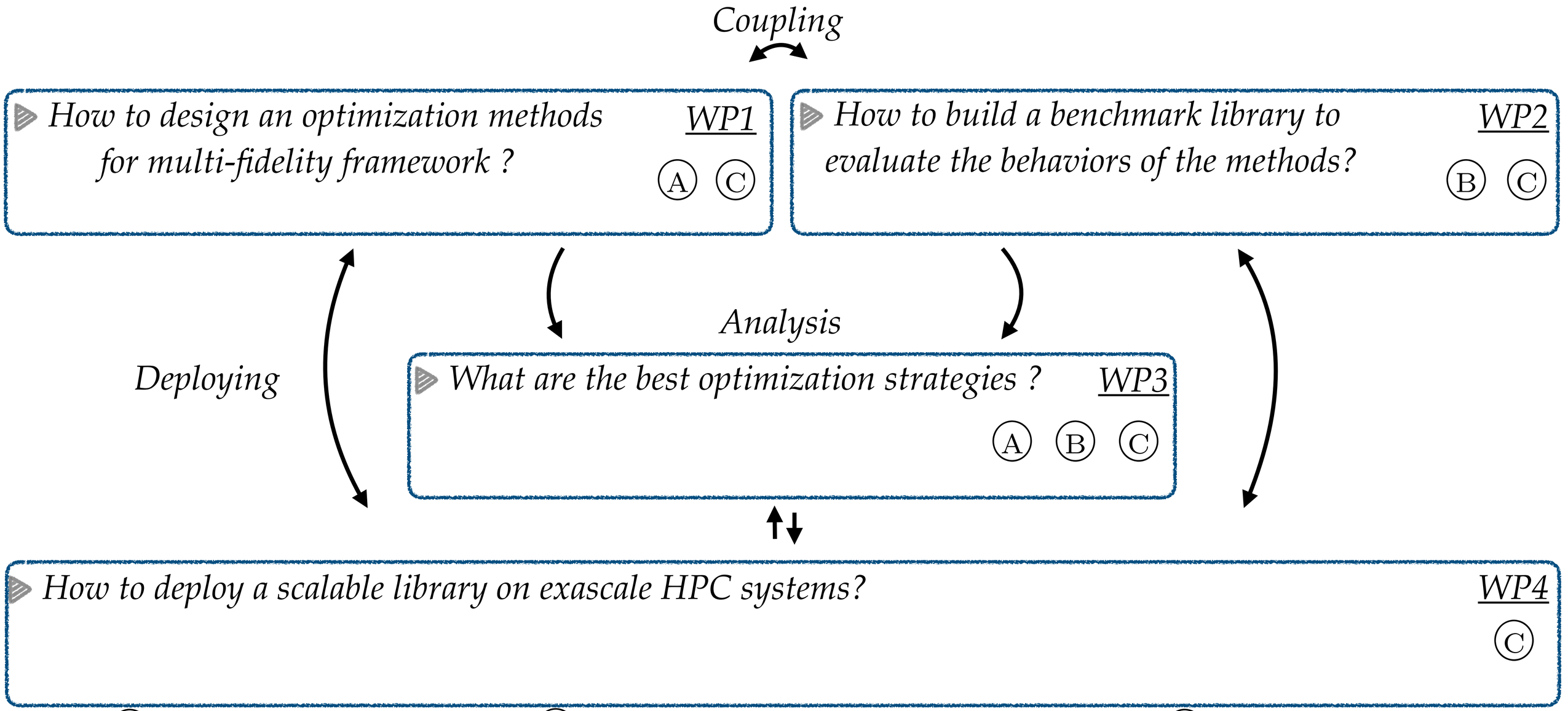

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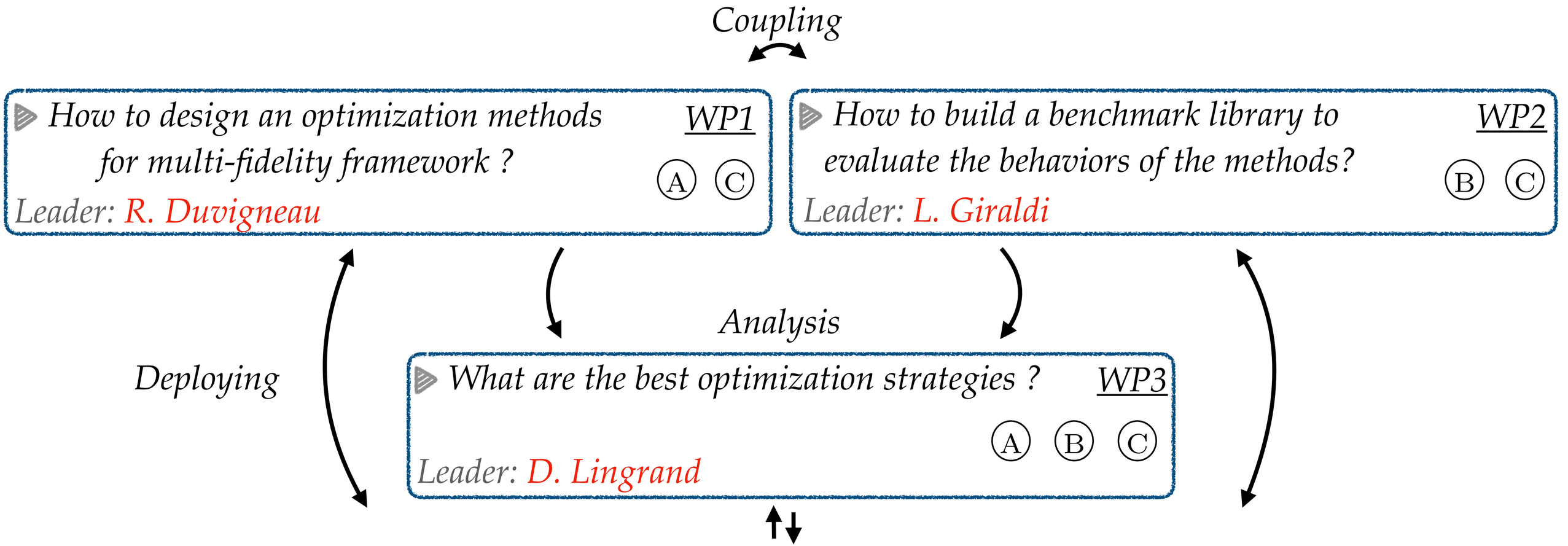
Integrated view and Leaders



Ⓐ = optimization skills Ⓑ = modeling and simulation skills Ⓒ = HPC Exascale skills

Deliverables

- *Mid-term report and final report*

- *Code library for multi-fidelity optimization* WP1

- *Code library of physics-based benchmarks with multiple fidelity levels* WP2

- *Code library on systematic performance analysis* WP3

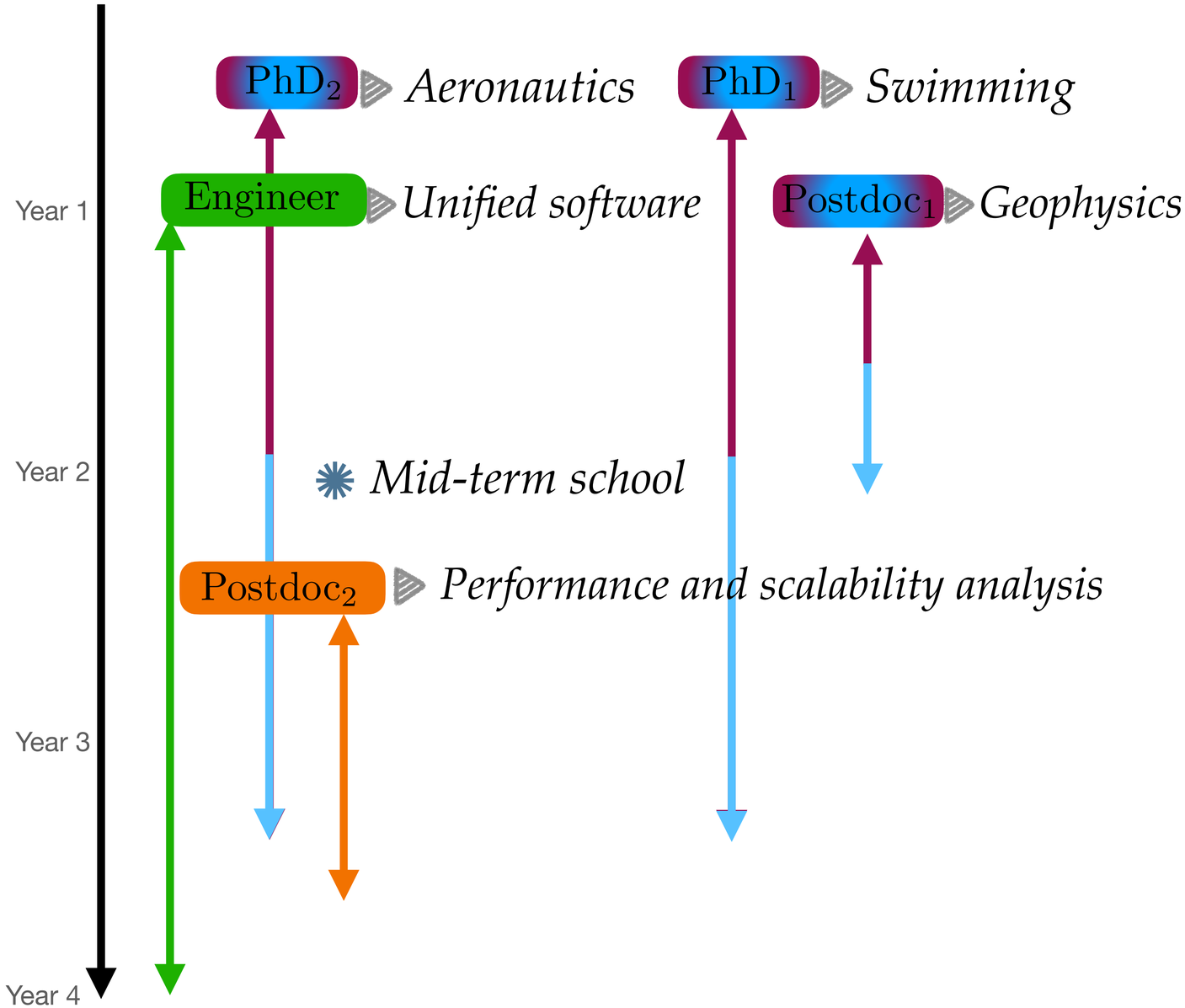
- *Exascale-ready open-source software platform* WP4

Unified, modular, and portable framework deployable on hybrid CPU–GPU HPC architectures.

Project timeline and ressources

Deliverables

- *WP1: Code library for multi-fidelity optimization (T0+2)*
- *WP2: Code library of physics-based benchmarks with multiple fidelity levels (T0 + 2.5)*
- *Mid-term report (T0 +2)*
- *WP3: Code library on Systematic performance analysis (T0 +4)*
- *WP4: Open-source software platform unified, modular, and portable framework deployable on hybrid architectures (T0+4)*
- *Final report (T0 +4)*



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Thanks to your attention

Coordination with NumPEx