

# From lessons learned on early QPU–HPC integration to a Manifesto for operational and sustained deployment

## Preamble

Quantum computing is no longer a distant promise confined to laboratories. Across Europe, America, and Japan, Quantum Processing Units (QPUs) are now being installed, operated, and exposed to users within real High-Performance Computing (HPC) and cloud environments. These first integrations are imperfect, experimental, and sometimes fragile—but they are real. They mark a decisive transition from speculative research to collective engineering.

This manifesto is rooted in a full day of concrete technical presentations delivered during the *TQCI Seminar: International REX on the First QPU Integrations*. Throughout the day, speakers shared hands-on experience on:

- the physical installation of QPUs in machine rooms,
- hybrid HPC–QC software stacks and schedulers,
- early benchmarks and validation protocols,
- and first application experiments in science and industry.

The concluding debate synthesized these experiences. It exposed converging lessons, unresolved tensions, and strategic choices that can no longer be postponed. This text does not aim to close discussions, but to structure them. It is not a marketing document, but a collective statement grounded in operational reality. Our objective is both simple and demanding: **to make QPUs application-ready within sustainable hybrid classical–quantum ecosystems.**

## 1. Integration Is Already Happening — fine facility-wise, trickier software-wise

Across Europe and beyond, integration is no longer hypothetical:

- At TGCC, multiple QPUs (Pasqal RUBY, Quandela LUCY, and upcoming superconducting systems) are being installed within an operational HPC center, facing real constraints in safety, security, cooling, power, and maintenance.
- In Germany, Euro-Q-Exa and JUNIQ demonstrate long-term strategies where QPUs are treated as first-class modules of modular supercomputers.
- In Japan, RIKEN tightly couples Fugaku with on-premise superconducting and trapped-ion systems, pushing hybrid execution models to their limits.

These experiences converge on one message: **QPU integration is an engineering discipline**, not an abstract research problem. It involves site surveys, acceptance tests, safety files, calibration workflows, availability targets, and continuous software qualification—much closer to HPC operations than to laboratory experimentation.

## 2. Cloud and On-Premises (co-located) Are Complementary by Design

The day's presentations made it clear that the question is not *cloud versus on-premises*, but **which configuration serves which purpose**.

- Cloud platforms (e.g. OVHcloud, JUNIQ QC-PaaS) excel at democratization, training, rapid experimentation, and access to multiple technologies.
- On-premises systems enable deep integration with HPC schedulers, low-latency workflows, security-sensitive use cases, and sovereign control.
- Hybrid models already exist, combining local expertise with remote access and shared European platforms (EuroQHPC-Integration).

At this stage of maturity, forcing a single deployment model would be a strategic mistake.

**Use cases must drive architecture, not ideology.**

## 3. HPC–QC Coupling Is Manyfold

Repeatedly, speakers emphasized that co-location is not an end in itself.

What matters is:

- microsecond-level latency for error correction and tight feedback loops, this is embedded HPC for QEC functioning
- sufficient bandwidth for (reasonably) data-intensive pre- and post-processing , and tightly coupled HPC-QC when relevant (e.g. for variational approaches)
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- coordinated scheduling to avoid wasting expensive HPC cycles.

Concrete solutions already exist:

- sequential or priority-aware QPU schedulers integrated with SLURM,
- asynchronous RPC-based models allowing overlap between CPU and QPU work,
- HPC-based emulation and benchmarking as integral parts of the workflow.

**Integration quality is measured in utilization, not proximity.**

## 4. Software Is the True Bottleneck

Across all initiatives, software emerged as the main limiting factor.

We observe that:

- QC software evolves faster than HPC software and is tightly coupled to hardware specifics.
- Users come from heterogeneous backgrounds: QC experts unfamiliar with HPC, and HPC users new to quantum abstractions.
- Benchmarks and validation protocols (MBQS, G-Score, Q-Score) are essential but difficult to align with real applications.

There is a strong demand for:

- unified software stacks or at least interfaces and APIs across vendors,
- controlled access to lower-level parameters without compromising system safety,
- portability of developments to avoid losing years of work as hardware evolves.

**There will be no quantum utility without serious, long-term software investment.**

## 5. Benchmarks must serve Use, not Illusion

The day's benchmarking efforts—on neutral atoms, photonics, superconducting qubits, and quantum annealers—highlighted a familiar HPC lesson:

Benchmarks are necessary, but never sufficient.

- Performance claims must survive contact with schedulers, noise, calibration drift, and user workflows.
- Early failures are not signs of uselessness, but of insufficient maturity.
- Transparent noise models and reproducible protocols are prerequisites for trust.

**Quantum advantage cannot be declared; it must be demonstrated under realistic conditions.**

## 6. Applications will legitimize the Ecosystem

Promising application paths were demonstrated or outlined:

- Earth observation and climate modeling through hybrid QML workflows,
- optimization problems in logistics, energy, and industry,
- quantum chemistry and materials science using tightly coupled HPC–QC execution.

These applications share a common trait: **they are hybrid by nature**. Quantum computing alone is not the solution; it is an accelerator embedded in a classical pipeline.

Overhype remains a real risk. Disillusionment caused by unrealistic promises could stall adoption for years.

**Credibility grows from modest, reproducible progress.**

## 7. Investment must cover all the steps from technologies development to industrial usages at a much larger scale

The contrast between massive private funding elsewhere and Europe's more constrained ecosystem was openly discussed.

The collective message is clear:

- Access to machines matters more than speculative valuation.
- Early users enable startups to mature, scale, and attract sustainable investment.
- Public procurement and shared platforms (EuroHPC, national centers) are strategic tools.
- Larger funding enables long-term scaling investments and diversification strategies
- Startup access challenges identified, particularly scaling from €1 million to much larger funding such as 500 million €.
- HPC integration grounds quantum development in reality and tempers hype with operational constraints.

## 8. Long and winding road, stiff slope, but shining promises

We are at a stage comparable to artificial intelligence in the 1980s: strong ideas, insufficient machines, and unclear paths to scale.

Europe has a narrow window—measured in a few years—to:

- consolidate operational know-how,
- align HPC, quantum, academic, and industrial communities,
- and translate experience into policy inputs such as the Quantum Act.

This manifesto is a call for patience, coordination, and realism.

**The train is already moving. What remains uncertain is whether we will be ready when it accelerates.**

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This document captures the key insights and discussions that emerged from the debate concluding the TQCI seminar on the first results of QPU implementations on HPC centers, held on December 4th, 2025, in Palaiseau, France.

The seminar was organized by Teratec in collaboration with CEA and BULL. The debate was led by Prof. Tommaso Calarco (Forschungszentrum Jülich, Germany) and Dr. Jean-Philippe Nominé (CEA, France), whose perspectives helped drive a rich and forward-looking discussion.

We warmly thank them, along with Sabine Mehr (GENCI), for their valuable contributions.

<https://teratec.eu/media/tqci-seminar-december-4th-2025/>

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