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Forum Teratec 2021

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Report of | Plenary Sessions

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Forum Teratec 2021
Unlock the future !

The challenges of HPC / HPDA, AI and quantum
European cooperation & new uses

As the world enters the quantum era while politicians define the future face of a digital Europe, High Performance Computing (HPC) shape the necessary and expected post-Covid rebound. Held from June 22 to 24, 2021, the 16th Forum Teratec highlighted the major challenges facing the entire HPC sector and the European community: autonomous production of supercomputers, democratization of HPC uses, and pooling of knowledge and skills at the European level.

With the interventions of:

Agnès Pannier-Runacher, French Minister in charge of Industry

Alessandro Profumo, CEO, Leonardo

Gilles Le Saux, Senior Vice President Foresight & Research, Essilor International

Satoshi Matsuoka, Director, Riken/R-CCS

Yves Ubelmann, Co-founder and CEO, Iconem

Jensen Huang, Chairman & CEO, NVIDIA

Ghislain Lescuyer, General Manager, Saft

Anders Dam Jensen, Executive director, EuroHPC

Bruno Sportisse, CEO, Inria

Wolfgang Marquardt, Chairman of the Board of Directors, Forschungszentrum Jüliche

Elie Girard, CEO, Atos

Catherine Jestin, CIO, Airbus

Théau Peronnin, Co-founder and CEO, Alice & Bob

Eric Labaye, Président, École polytechnique et Institut Polytechnique de Paris

Neil Abroug, Director, National Quantum Plan

Daniel Verwaerde, President, Teratec

Agnès Pannier Runacher
French Minister in charge of Industry

Setting up Europe as center of gravity for quantum computing

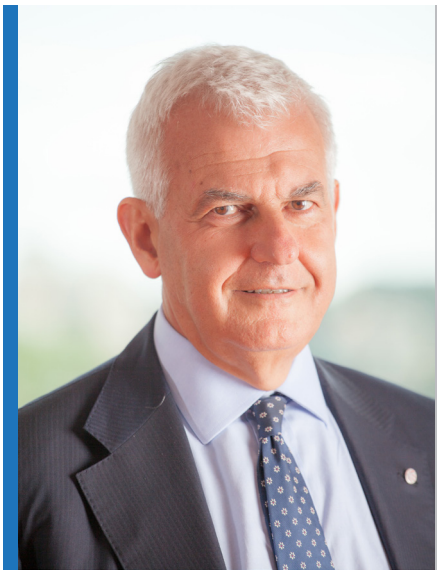
In a rather political speech, the Minister recalled the French state efforts to develop digital technologies promising a better world. Stressing the need for Europe to becoming the center of gravity of these technologies in the world, she particularly insisted on quantum computing as French ecosystem ranks at the peak.

Minister in charge of Industry, **Agnès Pannier Runacher** opened the first plenary session of the **Teratec 2021 Forum**. She emphasized the need to implement a dual transition both digital and ecological as the upcoming of 5G, Cloud, HPC, AI and quantum will transform ways of producing and shaping our future, processing billions of data and involving know-how that we master only very partially today.

According to her, France must be among countries within the first circle to master these technologies on which depends our ability to treat ourselves, better fight climate change, and move around or protect ourselves more easily. She recalled French State efforts in this direction: 35 Billion € for Recovery Plan devoted to industry; 20 B€ for the 4th Future Investments Plan; 840 M€ for cybersecurity; 1.8 B€ for the National Quantum Program...

She believes Quantum computing to be a technological big bang, shortening computing times by a factor of one billion within the next 5 to 10 years and which will have significant societal impacts in many areas: health; environment; energy... She welcomed the excellence of our research achievements, both public (**CNRS**, **Inria**, **CEA**, **Onera**...) and private (**Atos**, **Thales, Orange, Air Liquide, Orano, STMicroelectronics**...) providing such a suitable ecosystem for expansion of start-ups such as Pasqal or Alice & Bob. She also stressed the need to create a pool of specialists.

With the support of European Commissioner **Thierry Breton**, French CEA also wants to become involved in quantum technology at the European level, in order to position the world's center of gravity for quantum technologies in Europe. A first step will be taken with the installation of the first hybrid computer prototype integrating a quantum accelerator of at least 100 qubits by 2023 at the CEA's TGCC site in Bruyères-le-Châtel.



Alessandro Profumo
CEO, Leonardo

We need one European synergy around HPC

In his speech, CEO of the Italian industrial group Leonardo, formerly Finmeccanica, showed the critical importance of taking the leadership in high performance computing to boost innovation and guarantee European independence.

The group created **Leonardo Labs** to tackle the exponential challenges of digital, working on AI, intelligent autonomous systems, Big Data, HPC, digital twins, advanced simulation and quantum, among others. The convergence of technologies is being used to create digital twins for design, validation and operation of Leonardo's products while quantum will be at the heart of its upcoming communications systems.

He considers that maintaining Europe's competitiveness requires technologies such as HPC now to be disseminated to SMEs. However, he deplored the fact that only a small proportion of these technologies are developed in Europe, while other world regions are heavily investing in these areas and gaining a considerable competitive advantage.

The main European industrial players must therefore collaborate more on HPC, as desired by the President of the European Commission **Ursula von der Leyen**, along with the **European Council** which invited the **Commission** to draw up a «digital compass» and a proper roadmap for Europe's digital ambitions until 2030.

This is a common vision from Leonardo since computing and storage capabilities of its davinci-1 supercomputer serve all Group's technological areas, but these are also shared as part of the **European Digital Innovation Lab** and partnerships with other manufacturers. This machine, built by **Atos Bull**, boasts a power of over 5 PFlops and storage capacity of 20 PBytes (ranked 88th in the Top 500).

Leonardo wants to assert its position with its entire ecosystem, as a driver of innovation in this new digital era with HPC as a key element. He concluded by reminding us that it is up to everyone to shape Europe's digital future, in terms of digital autonomy and technological sovereignty.

Gilles Le Saux
Senior Vice President Foresight & Research Essilor International

Innovation for ophthalmic industry relies on calculation

Gilles Le Saux, head of R&D and Foresight at Essilor International a specialist in ophthalmic and optical equipment, explained why and how high-performance computing has become essential for the design and production of corrective lenses or the development of real-time corrective devices, beside to understanding the new ophthalmic diseases.

When purchasing glasses, from the medical consultation in ophthalmology determining the necessary visual correction to the definition of the adequate equipment by the optician, multiple physical eye measurements are carried out in order to create one digital eye-glass compatible model being essential to the calculation of the final equipment.

All these data are used to determine the lens geometry best suited to one's optometric profile. For each order, a constrained optimization calculation integrating several hundred variables and several thousand targets is being launched. These calculations on the design of the lens converging in a few tens of seconds will be best suited to you. These complex geometric data are then transmitted to the machining and surfacing machines to manufacture every glass.

Beyond such one-off measurements, developments are underway to create intelligent and connected devices integrated into the eyewear, which will individually characterize each user behavior in real life. These devices will then act directly on active optical components, adapting their shade or power to real time needs. Once again, this requires high computing power. For example, one electrochromic glass coupled with a GPS system will anticipate the arrival in a tunnel, so that the luminous transition is smooth at the entrance as well as at the exit. Such «*Smart Glasses*» will arrive in 2022.

In addition to the creation of equipment that is increasingly adapted to needs, high-performance computing tools are also used to understand certain pathologies, such as myopia being favored by constant use of screens. The eyeball shape is changing among young people, particularly in Asia. Research is underway at the **Institut de la Vision** in Paris to model these processes, using digital twins of the eye and retina as well as AI algorithms.

Satoshi Matsuoka
Director, Riken/R-CCS

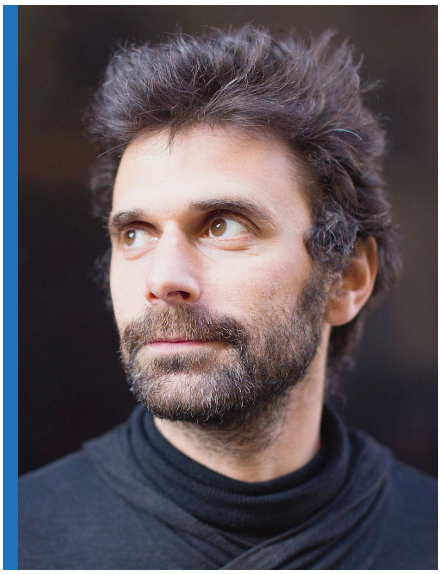
Our exascale machine foreshadows supercomputers in the next 20 years

Japan has just released Fugaku, the first exapflop machine. Satochi Matsuoka explained the genesis of this machine, the nature of its performance which goes up to 4.3 Eops in 8 bits Integer, and predicted disappearance of Flop-Centric Monolithic Systems keeping with Moore's Law, in favor of ''Cambrian'' Heterogeneous Systems.

Satoshi Matsuoka, director of the Japanese **Riken Research Institute** hosting the world's first exascale machine, presented **Fugaku**. It is based on an exascale **A64FX** processor developed in collaboration with **Fujitsu**, in 7nm technology which is two to three times more powerful than a traditional processor, and three times less energy consuming.

Encompassing 160,000 nodes, this machine was developed with the aim of accelerating the applications already running on previous generation of supercomputers (K) by a 100 factor. To achieve this, each chip has 48+4 computing cores representing 8.8 billion transistors and uses the **HBM2** input/output system for the first time. On top of the CPU, this machine also features high-level interconnect systems with a bandwidth of 400 Gbps per node and a response latency of 0.5 µs. Also a first in category, the Ultra-Scale Disaggregated architecture allows any processor to access any data.

In summary, Satoshi Matsuoka reckons that this machine foreshadows the next 20 years of supercomputers. Alike the extinction of the dinosaurs, we will see disappearance of the Flop-Centric Monolithic Systems with Moore's law, in favor of ''Cambrian'' Heterogeneous Systems around 2025.



Yves Ubelmann
Cofonder & CEO, Iconem

Preserving threatened heritage and transmission between generations thanks digital technology

Yves Ubelmann, co-founder and CEO of Iconem explained how his 15-people company came to use and develop digital technologies to preserve the world's cultural heritage.

As an architect assisting archaeologists in the Middle East, he was shocked by the disappearance of archaeological sites as a result of anarchic urbanization, looting and conflicts endemic in these regions. The idea was to use digital technologies as an alternative to physical conservation. **Iconem** has developed techniques for digitizing and capturing images from drones and robotic cameras, as well as algorithms for the detailed sites reconstruction from this data in 3D.

These models are both a means of representation and genuine databases allowing spatial classification from vast archaeological information. This is particularly interesting in areas that have become inaccessible due to many conflicts as it allows the scientific community to continue to produce knowledge, even if the need to visit every site is irreplaceable.

This was useful in Palmyra to document the destruction perpetuated by the Islamic State, noticeably at the Temple of Bel or the Monumental Arch. Mixing these technologies with photogrammetry using photos from the 1930s allowed to create intact 3D models of the destroyed monuments and resettle them on current sites, assessing blocks condition and documenting the feasibility of a reconstruction. These technologies have also been used in Aleppo and Mosul to assess the damage caused by bombing, in order to consider reconstruction of an entire city scale. They are also used on sites threatened by natural phenomena, for example in Libya where the sea is eating away at the Apollonia site.

In addition to preserving the memory of endangered sites and communicating with the scientific community to pass it on to future generations, these hyper-realistic 3D models are also often at the heart of immersive experiences allowing the general public to discover their cultural and artistic wealth.

Jensen Huang
Chairman & CEO, NVidia

Time in on for Industrial HPC

HPC and simulation enabled many sectors to progress yet limits have been reached facing size and complexity of problems to be addressed. GPU acceleration and AI integration allowed us to overcome these limitations and offer new perspectives for getting closer to physical realities. All the more an easier path, since their future coupling with quantum computing promises a tenfold performance increase.

Jensen Huang, Chairman & CEO of **NVidia**, reminded the audience that HPC is an essential tool for science, industry and services which has made it possible to break free from Moore's Law, while it is currently only accessible to a few.

Although many sectors have benefited with progress from simulation and HPC, they reached limits considering the size and complexity of problems to be addressed. However, two major breakthroughs made it possible to overcome these limits: the acceleration of GPU computing and the use of AI. The former enabled us to gain in size of models by a one million factor as well as their resolution speed over 15 years, but for certain phenomena we still need to gain 10 orders of magnitude. This challenge is on the way to being met with the arrival of Deep Learning which has enabled us to gain 4 orders of magnitude in 4 years.

Researchers from the Sorbonne working with **Genci**, **CNRS** and **NVidia** were able to simulate the action of **Covid-19** spicular protein over 38 microseconds with the **Tinker-HP code**. According to researcher **Jean Philippe**, « *Such result would have required years or several million CPU cores to work.*»

As regards AI, benefits come from multiple researches in which NVidia participates in the field of models (**Transformers, BERT, BioMegatron**...) or, languages (**BigScience project** gathering 500 researchers from 45 countries to develop an open source language model) or, even codes such as **SimNet** which uses a neural network based on physics to solve multi-varied problems.

Finally, NVidia also wants to be active in the quantum field to: simulate quantum circuits; provide a platform for algorithm development; design the architecture of hybrid quantum/standard systems; accelerate existing quantum solvers in research.

So the question is no longer about what HPC will be capable of, but who will use it first to revolutionize their industry.

Ghislain Lescuyer
General Manager, Saft

HPC will contribute to the rise of a European champion for batteries

Batteries are everywhere in our economy, from our smartphones to the storage of renewable energies, including mobility and the Internet of Things. These are complex products that require mastery of thermochemistry and advanced manufacturing processes to ensure safety and the right cost-performance ratio. HPC can help meet these challenges.

Ghislain Lescuyer reminded the audience that there are hundreds of different types of batteries, depending on the materials and chemistry used, as well as the type and conditions of use, in terms of operating temperature, electrical values and the number of discharge cycles envisaged. All this is being done while meeting stringent safety criteria with optimal cost/performance ratio.

Also worth noting, our economies are now very dependent on batteries, whether for transportation, communication and digital usage, Internet of Things or renewable energy storage. Digital technology enables status check as well as charge level and temperature of batteries to be constantly monitored. Such data are needed to control proper operation, to monitor charging systems and perform predictive maintenance.

In conclusion of his speech, Ghislain Lescuyer mentioned the contribution of HPC in terms of modeling and simulation, both in the design and in starting-up of batteries. In the first case of simulating their thermochemical behavior, switching from simple PCs to HPC made it possible to reduce such a process by a factor of 100. In the second case, it is a question of simulating final elaboration of a battery, the last stage in the manufacturing process where the first charge is completed and its quality and performance are checked. This is a 10 to 15 day process in which HPC linked to AI can detect battery quality defects as early as possible, improve the overall process and reduce costs.

These tools will be brought to full use within ACC (Automotive Cells Company), the joint venture set up between **Stellantis** and **Saft**, with financial support of the **European Commission** to develop a European battery champion facing the current Chinese hegemony.

Anders Dam Jensen
Executive director, EuroHPC

European HPC has one brilliant future

Initiated in Rome in 2017, the EuroHPC Joint Undertaking aims to make Europe as one leader in HPC both in terms of technology and advanced operation. To achieve this, it finances the acquisition of machines making them available to industrialists enabling development of new technologies both hardware and software. Their dissemination to industry and especially to SMEs as well as training of capable specialists intends to spread their development and use to their full potential.

Anders Dam Jensen, Executive Director of **EuroHPC** recalled the goal of EuroHPC to: bring HPC computing capabilities forward to Europe; improve cooperation in advanced scientific research; raise industrial competition; ensure European technological and digital autonomy. The **European Commission** and **member states** have already invested €358M in the Joint Undertaking since 2017.

In April, EuroHPC's first Petascale supercomputer Vega, based in Slovenia went live and MeluXina a second HPC located in Luxembourg was launched in June. Five other machines will soon be accessible via **PRACE**. By then, Europe will have 670 PFlops available for research and innovation.

EuroHPC has also funded 24 projects around new HPC technologies and applications for a total of €80M, and is finalizing its participation in the **European Processor Initiative**, a €70M project to provide Europe with low-power, high-performance processors. Multiple other projects are underway to support the convergence of HPC, Big Data and AI.

Within the framework of the **Horizon program**, it is planned to invest €900 million in HPC technologies both in research and in their dissemination to industry and particularly to SMEs, relying on **Centers of Excellence** and **HPC Competence Centers** to understand and assess needs in the field. Similarly, funding from the **Digital Europe program** will enable the training of specialists capable of developing these new technologies in Europe and using European supercomputers to their full potential. This work will then lead to the production of Petascale and Exascale supercomputers in Europe early on 2022, as well as implementing specific infrastructures through partnerships with the private sector.

EuroHPC ensures that Europe will become a leader in HPC both in excellence and autonomy, thanks to a new way of working where participating EU states invest together for a shared purpose.

Bruno Sportisse
CEO, Inria

We remain open to partnerships with key players in the field of HPC

HPC is at the heart of Inria's activities, particularly in order to meet the new challenges brought by AI and quantum computing. In addition to the research work already underway, Inria is participating in key actions such as the Quantum Plan, the National AI Research Program, the PariSanté Campus initiative and EuroHPC.

HPC is one of **Inria**'s key investment sectors as it is strategic for computing along with digital transformation of our economies, in light of new challenges such as AI and quantum computing.

Significant investments have thus been made to strengthen the capacity of supercomputers, such as the **Jean Zay** machine used by **Genci** in order to meet the challenges of AI. For quantum computing, while we do not know when and how these large-scale machines for conventional algorithms will be realized yet, we do know that intermediate approaches such as the **NISQ** (Noisy Intermediate-Scale Quantum) computer will be put in place.

These two fields are strategic for Inria which is carrying out key actions such as the **Quantum Plan** and the **National AI Research Program** alongside organizations such as the **CEA** and **CNRS**.

Inria is also convinced that HPC ecosystem dynamics must be supported thanks to intensification of its policy of strong partnerships with key players capable of establishing and strengthening digital sovereignty for France and Europe. This involves technology transfers, the establishment of joint technology roadmaps and coordinated research teams. This was the case in the defense sector with Naval Group 18 months ago and with Atos last June, in order to establish a common roadmap for quantum computing and HPC.

Another major challenge is about health where the maturity of HPC will have a strong impact. Inria has invested in this area acting as one of the founders of the **PariSanté Campus** initiative launched at the end of 2020.

At the European level finally, Inria is involved in a number of **EuroHPC projects** with partners such as the **CEA** and **Atos** to create exaflopic supercomputers which will be crucial to our digital sovereignty in the decades to come. Inria also fully supports **Teratec's action** in the **EuroCC project** which aims to create a national HPC competences center.

Wolfgang Marquardt
Chairman of the Board of Directors, ForschungsZentrum Jülich

Towards combining supercomputer with data center in single modular sets

The Jülich Supercomputing Center is at the center of European HPC developments. It has just commissioned Juwels, the world's 7th most energy-efficient supercomputer. It is also very active in the DEEP, HPCQS and EuroHPC projects. It has a modular vision of the future where supercomputers and data centers will become one and will be able to integrate heterogeneous technologies such as quantum or neuromorphic.

After recalling the **Jülich Supercomputing Center**'s partnerships with the **Leibniz Computing Center** and the **Stuttgart HPC Center** within the **Gauss Centre for Supercomputing**, **Wolfgang Marquardt** welcomed the partnership with **Bull Atos** (France) and **ParTec** (Germany) which resulted in the **Juwels** supercomputer, now ranked 7th in the Top 500 and 1st in terms of energy efficiency.

Developed within European-funded **DEEP projects** since 2012 and **EuroHPC initiatives**, such performance due to its dynamic modular architecture facilitates the direct, low-latency integration of emerging technologies such as quantum and neuromorphic computing. This anticipates **Nupacs**, the European Exascale prototype project developed with **CEA, Atos** and the **BSC, Genci** and **Cineca** centers.

He also welcomed the success of the **HPCQS project** which will enable the piloting of a pan-European hybrid quantum/HPC infrastructure. Two **Pasqal** quantum computers will be deployed in parallel at **CEA/Genci** and **Jülich**, accompanied by the establishment of a European platform for quantum programming.

This will lead to modular ensembles where supercomputer and data center become one and heterogeneous resources being allocated, accessed and used dynamically and optimized by scientists. All this is conducted with high energy efficiency, optimal workflow management and maximum application diversity in the three core areas of large-scale simulation, big data analysis, and large-scale machine learning.

Developments anticipating the Exascale are made in close collaboration with European scientific and industrial players to help them progress in their disciplines, whether they be computing or applications. Jülich is also a candidate to become one of the first two European Exascale sites.

Elie Girard
CEO, Atos

Our offer is meant to be both secure and carbon-free

HPC and AI are the pillars of companies' digital transformation as well as states' digital autonomy, and Atos intends to make it more secure and decarbonized. This orientation is central to the research conducted within Atos ecosystem focused on HPC, AI and quantum computing. Quantum computing herein already provides one objective, simple, fair and hardware-autonomous efficiency measurement system.

Atos contributes in HPC and AI ecosystems via strong links with European research in order to address the future challenges of industry. It has strengthened its cooperation with the **CEA** around global warming, digital moderation, quantum computing and a common roadmap for AI. Another partnership with **Inria** focuses on digital responsibility, AI, HPC, cybersecurity and quantum computing.

By leveraging internal and external research, Atos has equipped five research centers participating in **EuroHPC**, and provided **Jülich** with Europe's fastest supercomputer in Europe also valued as most energy-efficient of the **Top 100**.

As Europe's number one supercomputer manufacturer and the fourth largest in the world, Atos is engaged in the race to exascale by taking up the challenge of energy consumption and decarbonization, integrating low-power processors and using hydrogen in a partnership with **Hydrogène de France**. The goal is to reduce its carbon emissions by 50% by 2025 and fully offset them by 2028. Such a know-how will directly benefit all of its customers.

Combination of HPC and AI is necessary to analyze an ever-increasing amount of information making more sense of it, also gives rise to ever more numerous and sophisticated attacks. Cybersecurity is therefore at the heart of Atos' approach which is recognized by **Gartner** as the world's second largest player in this area.

For the past four years, Atos has also been fully committed to the quantum revolution through the development of accelerators for the next generation of HPC. Its ecosystem includes start-ups such as **IQM** or **Pasqal** and large corporations such as **EdF** or **Total,** as well as a research program around post-quantum cryptography offerings in partnership with the **CEA** dedicated to hardware equipment or the **Institut Fourier** and **Inria** on software.

Finally, Atos offers **Q-score** a simple, hardware-independent, objective efficiency measurement for quantum systems, available to industry.

Catherine Jestin
CIO, Airbus

Bringing quantum computing where the industrial world needs it

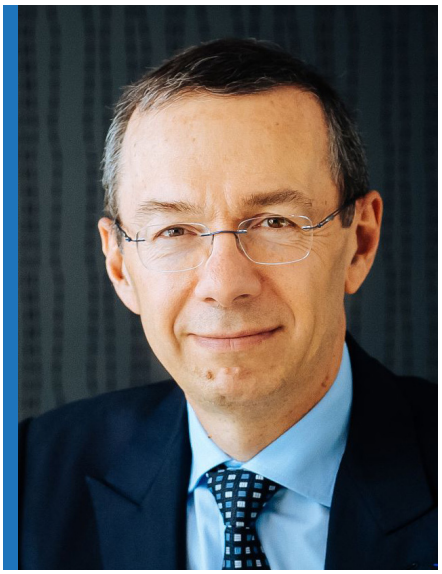
After pioneering the digitization of its engineering tools and processes, Airbus intends to leverage digital technology to meet the challenges of carbon free aviation and autonomous flight. To do this, it will make massive use of Big Data, AI, HPC and quantum computing. This evolution will also be achieved through skills training and recruitment of new talents.

Airbus has been a pioneer in digital transformation of engineering tools and ways of thinking, organizing and working, as essential prerequisite for any successful digital transformation. It now intends to use digital technology to meet its major challenges, namely carbon free aviation and autonomous flight.

To do this, it will use intelligent data analysis enabling the right person to access the right information at the right time adequate with context, regardless of their position in the company. All set within its overall lifecycle, suppliers, various departments and airline customers will operate in **Skywise** the open data sharing platform. This digital continuity brings enormous gains in operational efficiency for customers, processes and of course for innovation. Within a decade, all Airbus processes will be data-driven and interconnected, as the ambition of the **DDMS project**.

The next step will be AI, already being tested in factories with computer-aided vision and in products to assist pilots or enable autonomous flights. The biggest challenge is the certification of these systems. AI is embedded on HPC platforms, which will evolve as we attend to their limits. We are thus moving from a CPU-centric to a data-centric architecture. The infrastructure will be distributed both on local and cloud computing, dealing with simulation (aerodynamic optimization, noise reduction, etc.) as well as real-time processing of flight test data

Quantum computing will allow us to go beyond the current limits. It is now being tested for flight plan optimization and satellite imaging. Airbus has launched a **Quantum Computing Challenge** to stimulate the development of this technology and above all to bring it out of the laboratory, moving it into the industrial world.



Eric Labaye
President, École polytechnique et Institut Polytechnique de Paris

Working for Europe's technological and digital sovereignty

The Ecole Polytechnique is one of France's most prestigious educational and research flagships. The School is very much involved in digital sciences and technologies, whether AI, HPC or quantum being at the heart of research conducted in its laboratories, without overlooking the emerging societal, economic and ethical issues related to the growth of data and how it is processed.

The **École Polytechnique** (X) bears a tradition of scientific excellence to service the general interest. Herein work 1,650 researchers within 23 laboratories under joint supervision with the **CNRS**.

With the launch of the Institut Polytechnique de Paris (**IP Paris)** in 2019 and beside **ENSTA Paris, ENSAE Paris, Télécom Paris** and **Télécom SudParis**, the School reaffirms its ambition to change tomorrow's world and act on subjects with a strong societal impact with the aim of helping to shape a resilient, sovereign, innovative **European Union** in five key areas for the future: digital, security, technologies, health and energy/climate.

Eric Labaye put a focus on AI and data science with **HI! Paris**. Launched at the end of 2020 with **HEC Paris**, this interdisciplinary research and teaching center relies on 300 researchers. A partnership with **Inria** promotes all AI research activities.

In terms of HPC, X has a great deal of know-how in modeling and computing techniques made available to SMEs and ETIs through its **Applied Mathematics Center** and its operating subsidiary **FX-Conseil**.

Quantum science and technology is also a field where X has recognized expertise and offers one of the most fundamental and advanced education programs in France. X is also associated with the **University of Paris-Saclay** in **Quantum Paris-Saclay**. Among their most prominent research projects is one led by **Landry Bretheau** and **Jean-Damien Pillet** on quantum circuits as well as material. One of their objectives is to eventually manufacture a Qubit to equip quantum computers. This research reflects a desire for X to be one of the protagonists in the quantum revolution history.

X is also at the heart of multiple initiatives putting digital technology at the heart of research in terms of defense and security or energy efficiency. All such knowledge is shared within the **EuroTech Alliance** bringing five universities together.

Théau Peronnin
Co-founder & CEO, Alice & Bob

Designing the world's first universal, error-free quantum computer

A French start-up, a spin-off from major research labs, is developing a logical Qubit that incorporates error correction and universality using a superconducting chip that is 3,000 times less complex than the systems developed by the tech giants. The first quantum processor should be available in 2024 with first quantum supercomputers delivered in 2026.

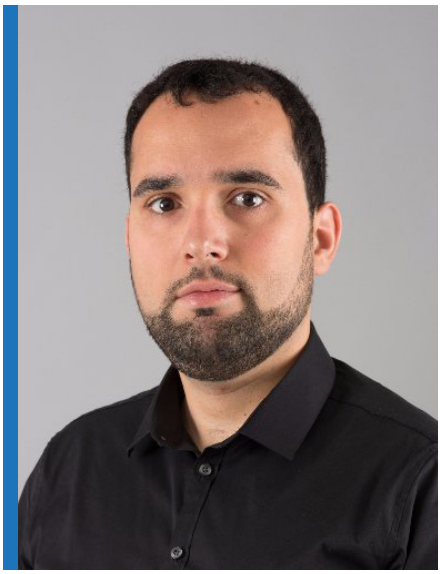
Alice & Bob is a spin-off of 6 French laboratories, created one year ago by **Théau Peronnin** and **Raphael Lescanne**. It aims to develop a universal and error-free quantum computer that will exponentially accelerate the resolution of certain complex problems: high-dimensional optimization; linear algebra problems; resolution of chemical and biological simulations.

Among possible ways to build these machines and echoing the **Nobel Prize** of **Serge Haroche** and **David Wineland**, the most praised relate to superconducting circuits (**IBM, Google, Amazon**... **A&B**) and atomic systems with trapped ions or, neutral atoms (**Honeywell, INQ, Pasqal.**..). But their Qubits are extremely sensitive to noise, which generates errors. As an example, first quantum machines of **Google** or **IBM** generate more errors than classical machines by a 19 magnitude order.

Tech giants want to divide this fault rate by 2 or 3 within 10 years, while A&B wants to go further and faster by rethinking the Qubit to integrates error correction and universality, thanks to the work of **Mazyar Mirrahimi** (**Inria**) in automation and **Zaki Leghtas** (**Ecole des Mines**) in quantum.

This translates into a niobium and aluminum chip on a silicon substrate, controlled by microwave pulses and cooled to very low temperatures. It has demonstrated the exponential suppression of one of the two error channels, being classical Bit Flips (going from 0 to 1 and vice versa) and quantum Face Flips (going from a 0+1 superposition to 0-1) with significant results, one world's first achievement!

The goal is to come up with the first universal, error-free processor with 5 logical Qubits by early 2024. Using a modular architecture well mastered on microwave systems we will get machines with more than 50 Qubits by 2026, quite equivalent to conventional supercomputers. This work is being carried out with **Mines ParisTech, ENS PSL, ENS Lyon, Inria, CEA** and **CNRS.**



Neil Abroug
Director, National Quantum Plan

France invests 1.8 billion euros in quantum technologies

France has decided to invest massively in quantum technologies to develop an ecosystem with capacity of inventing the components, architectures and machines, as well as software leading to major benefits. At the same time, investments are also being made to define potential applications and to prepare industry to gain from this technological leap.

Neil Abroug recalled that France has decided to invest 1.8 billion Euros to develop its innovation ecosystem around quantum technologies, both for fundamental research and industrial development, the training of specialists capable of creating and using them to their full potential, or even the dissemination of their use particularly for quantum computing.

The French strategy in this field has two components. The first one is related to hardware, whether it is for first generation of NISQ machines or the development of the ultimate quantum computer of very large size and error-corrected, which will require major public/private research efforts over the next decade.

The second aspect relates to sectors of use for which to master and own these technologies. High performance computing is one of those sectors to be most affected. Indeed, quite a number of calculations will be accelerated exponentially by quantum machines. Yet, we do not yet know when and to what extent these promises will be fulfilled. This is why we must invest now to explore such uses, as well as develop algorithms for quantum technologies

He thanked **Teratec** for its **TQCI** (Teratec Quantum Computing Initiative) which was started well before the implementation of the **National Quantum Plan**, by uniting a number of industrial users **(EDF, Naval Group, Total**, etc.) around it.

This French quantum effort is in line with the European approach, even more so since the consortium selected was chosen to respond to the **EuroHPC** call for projects aimed to develop a hybrid quantum HPC machine. This consortium includes several French players: **Atos**, the **CNRS, Inria** and the start-up **Pasqal**.

It proves right things are happening for France, so it is necessary to keep moving and develop the quantum computing of the future.

Daniel Verwaerde
President, Teratec

The young Europe of HPC needs our skills

The growth of HPC needs requires a shift to new hybrid technologies using quantum. This will require research and industrial development in both hardware and software. These developments are desired and financed by Europe to guarantee our sovereignty and digital independence from the USA and China. Teratec is committed alongside EuroHPC to participate in this dynamic.

The economy has never used HPC to such an extent and this will increase in the coming years. Many companies, apart from large corporations, are using HPC and Big Data as the basis for their production and sales processes. And they are considering new uses. This will increase the need for computing power and storage capacity, as well as new applications.

The solution lies in hybrid machines combining classical processors and quantum gas pedals. These technologies are promising in terms of performance, even if they are not suitable for all applications. Investments must therefore be made not only in hardware, but also in software, as a new chapter in numerical analysis will have to be written.

Europe, which wants to be a major player in HPC, a strategic area for our development and collective security, is stepping up its efforts with the creation of **EuroHPC**. It will make eight Petaflop-scale supercomputers available to European research and industry starting this year. It is also setting up a supply chain capable of producing these computers and their Exaflopic successors autonomously from 2023.

On the application side, EuroHPC has asked each country to create a Competence Center to democratize access to supercomputers, from start-ups to large organizations, whether they are researchers, industrialists or government agencies. In addition to physical access, it will provide the training and support needed to ensure that every user benefits from HPC. **Teratec** has been designated to be this national Competence Center, in cooperation with **Cerfacs** and **Genci**.

Only Europe has the necessary power to compete on equal terms with the USA and China in the field of HPC. We must commit ourselves at the European level because this young Europe of HPC needs our 60 years of experience. This will increase the chances that the policy decided by Europe will be the one that France needs.