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BOSTON CONSULTING GROUP

Riding the deep tech wave

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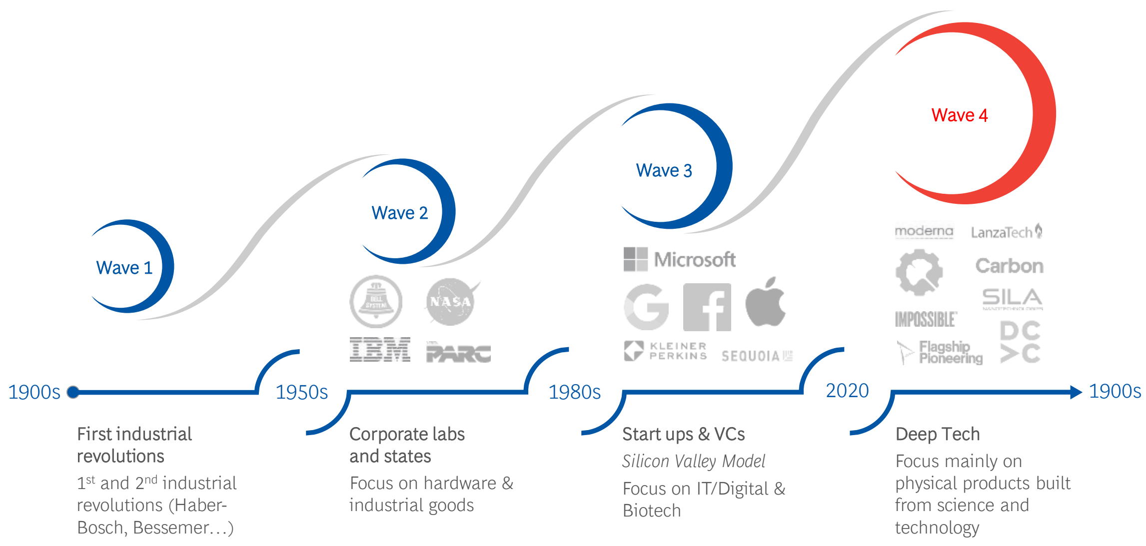
1 Deep tech: The fourth wave of innovation

INNOVATION HAS EXPERIENCED MAJOR DISRUPTION IN THE LAST TEN YEARS. After a decade dominated by the development of digital and incremental innovation, a new wave of innovation which merges several breakthrough technologies together (quantum computing, nanotechnology, biotech, etc.) together, has been in development since 2010, driven by start-ups and incumbent companies.

An unprecedented wave of innovation is rising, building on the previous ones



SUCCESSFUL DEEP TECH VENTURES SHARE FOUR MAJOR CHARACTERISTICS:

- They focus **on solving fundamental issues** rather than optimizing or incrementally improving existing innovations (e.g. building self-driving cars rather than enhancing fuel efficiency)
- They leverage the **convergence of disruptive technologies** (97% mobilize at least two[1]). Patrice Caine, Chairman and CEO of Thales Group, points out that "*Deep tech results from the convergence of several disruptive digital technologies, such as cloud and IA, together with equally disruptive hardware technologies such as quantum and nanotechnologies, paving the way for the next era of innovation and applications that will have an unprecedented economic and societal impact.*"
- They develop mainly **physical or hybrid products** and not just software or marketplace platforms. Dr. Roland Busch, President and CEO of Siemens AG highlights that for him, "*the key characteristic of this wave of innovation is to combine both the physical and digital worlds. This combination can only be achieved through deep domain knowhow, a leading technology portfolio and a strong ecosystem.*"
- Their growth model is based **on central positioning within ecosystems** (research, governments, investors and companies) rather than growth based solely on massive financing from VC or PE investors. As mentioned by François Jacq, General Administrator of the French Alternative Energies and Atomic Energy Commission (CEA), "*this wave of deep tech requires very close, seamless collaboration between fundamental research, applied research and industry. It is important to remember that such a dynamic is nothing new: the development of the laser or the maser was already based on this type of collaboration over 60 years ago. The intensity of development and the weight of societal issues are what has obviously changed*".

[1] *Source: BCG and Hello Tomorrow survey, 2019*

THE POTENTIAL OF THIS NEW WAVE OF INNOVATION IS PHENOMENAL. Thanks to the convergence of technologies and its fundamentally multidisciplinary nature, deep tech can lead to making the impossible possible, and fast. Adding a new physical technological dimension to the digital revolution of the 2000s, can open up new areas of innovation for existing products (e.g., Tesla and SpaceX, Lilium) or even create completely new product categories (laboratory "farmed" meat, mRNA, etc.). Falling barriers to innovation (e.g., the cost of prototyping, gene sequencing, open data, etc.) make it easier and faster to run Design-Build-Test-Learn cycles and to build deep tech products. Among deep tech paradigm shifts, Nature Co-Design will profoundly disrupt our industrial tissue, leveraging nature as a design and manufacturing platform. Instead of the raw, forced extraction of natural resources, one will be able to directly generate them from organic (synthetic biology) or inorganic (advanced materials) sources. This will completely reshape value chains into value nets and repurpose industrial waste into feedstock.

FURTHERMORE, DEEP TECH OPENS UP ENDLESS POSSIBILITIES REGARDING SUSTAINABILITY. In the coming years, breakthrough innovations will enhance the energy efficiency of renewables, support smart grids, facilitate carbon capture and storage, and provide environmentally friendly protein sources. By creating new market opportunities, deep tech will create the conditions for forward-looking companies to gain a competitive advantage, while improving their impact on the environment. *"Deep tech shows us that progress and caring for the environment are not contradictory. Systems derived from deep tech can be much more energy efficient than their classic counterparts; the quantum computer, when compared to today's HPC, will be a particularly spectacular example"*, notes Patrice Caine.

However, developing new activities in deep tech, implies answering **four main questions:** Can reality be different (Copernican moment)? Is there a way to make this new reality possible (Newtonian moment)? Can this be implemented today (N. Armstrong moment)? What are the key success factors for the new paradigm to become the "new normal" (Asimov moment)?

THESE ARE THE QUESTIONS THAT WERE PUT TO A DOZEN CEOS WHEN PLANNING THIS 2021 EDITION OF THE *CHOOSE FRANCE* SUMMIT.

These Deep Tech fundamental principles are reflected in 4 moments of truth

Copernicus Moment
Frame the **Paradigm**

What is it?

- How to be problem oriented, and only then derive the best strategy to address the ultimate goal?
- How to adopt a hypothesis-driven approach?
- How to reimagine value chains, while also refining collective imaginary

Newton Moment
Forge the Theory

Could it work?

- How to bring cross-disciplinary technological bricks together?
- How to align goals and organize interactions within the ecosystem?

Armstrong Moment
Take the first step

Does it work?

- How to identify key assumptions to be tested first to reduce risk upfront?
- How to get quickly to a working prototype?

Asimov Moment
Change reality

Will it win?

- How to always keep the economics in mind by following a design-to-cost approach?
- How to achieve long-term value from all dimensions, and achieve resilience?

How to *anticipate the friction points* that could occur at every stage of the lifecycle to bring appropriate solutions?

2 Meeting the challenges of Deep tech requires change from all stakeholders

THE PIONEERS OF DEEP TECH all share two ways in which they are meeting the challenges of this new wave of innovation. Whether they be companies (e.g., Ginkgo Bioworks, Lilium Aviation, Moderna…), investment funds (e.g., Flagship Pioneering, Breakthrough Energy Ventures, Prime Movers Lab, C4 Ventures, etc.) or ecosystems and government policies (Silicon Valley in the USA, Beijing-Tianjin, Sichuan or Yangtze Delta hubs), they all require: **changes in the way each of the players views innovation and changes in the way interfaces between the stakeholders in the world of innovation work** (between entrepreneurs, with the world of research, between start-ups and major corporations, etc.).

A START-UP WHICH IS DEVELOPING a business model based on deep tech is fundamentally different from a more incremental innovation model in the following ways:

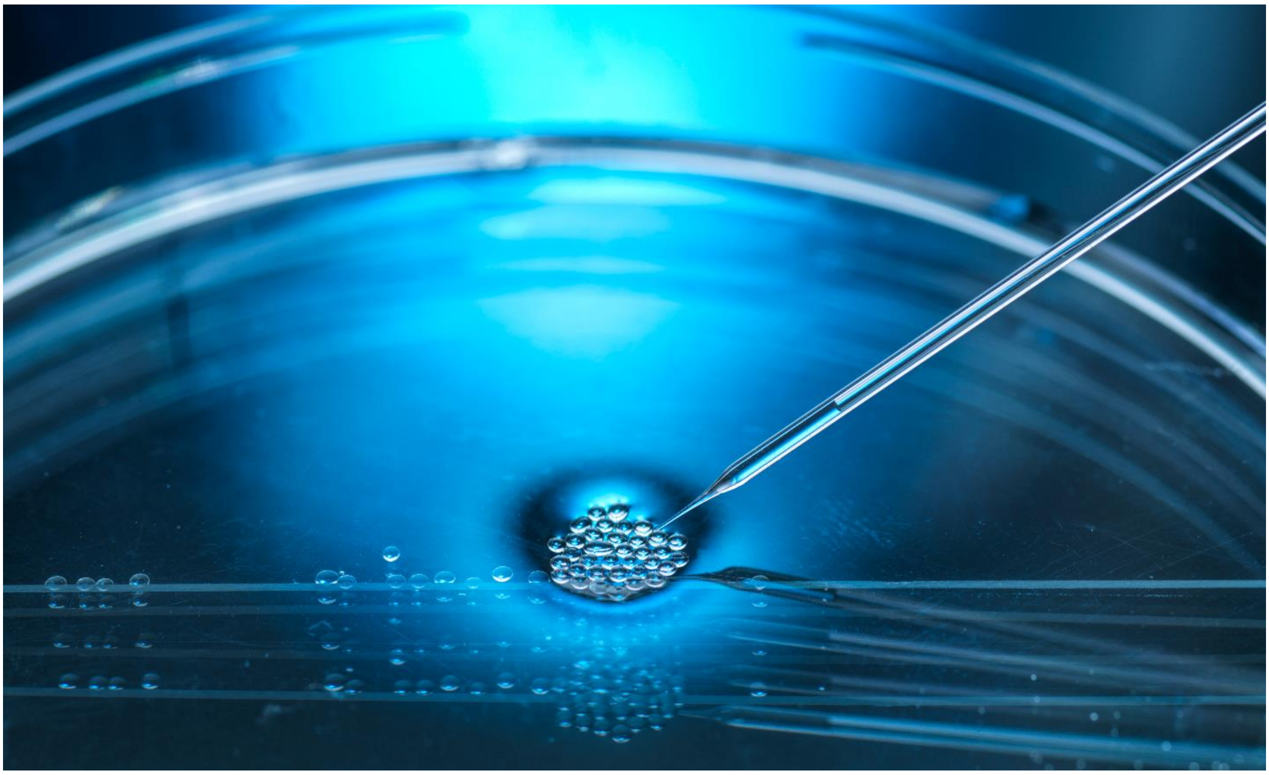
- **Talent:** given the importance of the technological aspects, especially in cutting-edge fields, the ability to attract expert talent and to ensure a good mix of backgrounds, from founders to employees, is essential. This is a key factor in the success of deep tech's pioneers (consider Tesla, who recruits a combination of automotive and software technology specialists, and IOT from the world's leading companies in the sector). From a Management point of view, this means recruiting talent that is working in industries that are potentially completely different from the target industry. It also implies considering different models of full-time employment (researchers and founders, employees and PhD students, etc.) as well as career paths which are suitable to each type of expert. Preferred candidates for such multidisciplinary teams are known as "T-shaped": knowledgeable in several areas of expertise, while fully mastering one specific topic.

- **Collaborating with the research ecosystem:** the relationship with the players in the innovation ecosystem also needs to be reinvented. Beyond the previously mentioned question of backgrounds, which should lead to the integration of researchers as founders, freelancers or part-time employees, one should also consider the question of access to equipment. Consider that none of the start-ups working on quantum programming will be able to acquire a computer anytime soon. The same is true of start-ups developing technological building blocks for satellite imagery. Thus, from the very start of the project, the terms for collaboration with the world of research are much more profound than they were during the previous waves of innovation.

LARGE COMPANIES who want to develop products using deep tech, should also change their approach. Most companies with a strong technological aspect consider R&D as a core capability, which leads them to use most of their R&D expenditure on internal expenses.

THIS APPROACH, HOWEVER, HAS LIMITATIONS IN THE CONTEXT OF DEEP TECH FOR SEVERAL REASONS:

- As with start-ups, success in **deep tech requires incorporating high-level talent in advanced technologies** and research. The R&D team model that you sometimes see in major corporations does not work well for these types of professionals, as they tend to better fit into start-up environments.
- **It is difficult for major corporations, especially listed companies, to accept significant financial risk on a technology gamble.** The emerging deep tech venture capital financing ecosystem is a better match. The risk for large companies is that their internal R&D can only focus on mature technologies, often limited to incremental improvements, or that they do not have enough resources to put into breakthrough technologies.
- Uncertainty regarding winning choices in technology requires considerable resources to be deployed **to competing technologies** over a potentially long period. No company can bear such risks within its R&D department.



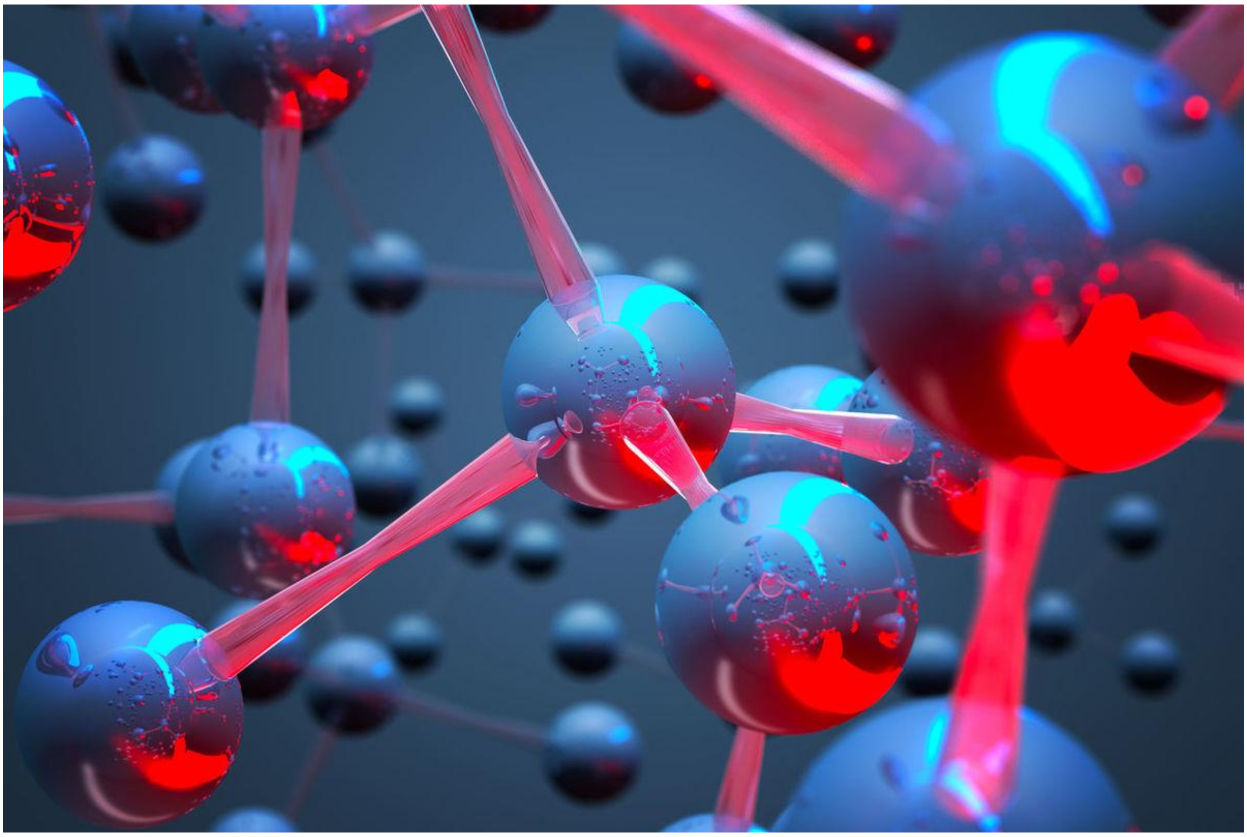
IN ORDER TO SUCCEED IN DEEP TECH, LARGE COMPANIES MUST THEREFORE RETHINK THEIR RELATIONSHIP WITH EXTERNAL INNOVATION. This requires a shift from a light collaboration process, in which companies turn a few POCs and investments into start-ups, to a more systemic, problem-oriented collaboration. It also requires changing large companies' perspectives on ecosystems, as highlighted by Mr. Busch *"It is no longer tier 3 suppliers working with tier 2 and tier 1, working with OEM it's really working together. You have to realize that in an ecosystem, you have to give if you want to receive!"*.

Some sectors have already taken this step. The pharmaceutical industry, for example, in which major corporations are so familiar with working with research institutes and biotech start-ups, that they sometimes end up buying them, for the above-mentioned reasons (the lengthy development cycles of drugs, the need to outsource financial risk and to bet on competing technologies). Biotech benefits from a mature blueprint in terms of risk (low market risk, high technology risk) and milestones (clinical trial gates). The ongoing development of COVID vaccines provides some good examples. Companies should act as acceleration platforms for deep tech ventures, leveraging their assets (e.g., production capacity, laboratories, go-to-market channels) to help them scale up. Another example would be ICT (low technology risk, high market risk), where companies develop external innovation through active M&A (e.g., Apple has made 100 deals over the past 6 years), thus providing attractive outcomes for private investors. Corporations need to build the relevant expertise in their CVC arms to assess the potential of deep tech investments.

In the semiconductor sector, Jean-Marc Chery, President and CEO of STMicroelectronics, states that *"continuing to develop joint efforts between actors in the value chain is crucial, as is reinforcing cooperation with manufacturers working in industries that we are leaders in and in which we have strong players and a market. Those who know to rely on these kinds of partnerships will succeed."*

The challenge now is for other strategic sectors such as automotive, energy, aeronautics and defense to switch to this type of innovation model.

GOVERNMENTS AND PUBLIC PLAYERS ARE ALSO SEEING THEIR METHODS OF INTERVENTION IN THE FIELD OF INNOVATION QUESTIONED BY DEEP TECH:



- **Financing needs:** the financing of deep tech encompasses both science risk in laboratories through grants and subsidies, and engineering risk in ventures through equity or debt. Public financing can play both sides of the coin, but in different ways. On the science end, it often remains the sole risk taker to finance fundamental research. On the engineering and venture end, it stands alongside private investors. Deep tech venture equity needs are on average greater than for software models in the early years, though they become lesser over time. However, while deep tech development cycles are accelerating (e.g., quantum, synthetic biology, space rockets), deep tech ventures often experience longer timeframes to market and a much steeper J-curve than digital / SaaS ventures. To further encourage the emergence of a deep tech investment ecosystem, Governments should be able to intervene directly (as an investor through blended finance, or as a limited partner in funds or funds of funds) or indirectly (through de-risking mechanisms) further along the financing process. Moving from support in the seed phase to support in the scale or growth phase is therefore one of the challenges facing public players when it comes to deep tech.
- **Incentives at the ecosystem level:** public actors also have a central role to play in encouraging and catalyzing ecosystem dynamics. This involves both encouraging public research institutions to open up to innovation (opportunities for researchers to be entrepreneurs, financial incentives for laboratories based on business indicators, support for simplified technology transfer processes and structures, etc.), and encouraging large companies to adopt innovation policies that are open to third parties (conditioning of tax or subsidy aid, etc.).
- **Finding the right level of focus for public intervention:** adopting a central planning approach where Governments would pick one technology in the way some countries chose nuclear energy in the 1970s, would be doomed to fail because of the need to place bets on competing technologies (a characteristic of deep tech). François Jacq notes that *"a subject such as the development of quantum technologies should be approached neither via a top-down plan (such as a new computing plan) nor via a bottom-up plan (by adding up a multitude of small local initiatives). The complexity lies in the need to find hybrid models, to set a strategic framework, to stimulate cooperation between the players, to give space to the initiative and to be able to support it massively when the time comes".* On the other hand, adopting a restricting policy, as many Governments have done since the 1990s, would be incompatible with the magnitude of the financing needs which require that choices be made. Governments must therefore find the right balance in terms of focus. This requires initially prioritizing the strategic issues at the state-level (e.g., increase the competitiveness of industrial activities, move to sustainable mobility, etc.); second, identifying the key science and technology fields required to support them; and third, assessing which ones Governments should invest in, in order to become leaders or rather, partners to more advanced nations.
- Beyond questions around the choice of technologies and the concentration of capital, another emerging issue is that of the geographical concentration of investments. **In this respect, operating as an ecosystem requires the emergence of a limited number of territorial innovation clusters.** Mr. Jacq is right in pointing out that *"we cannot have 10 Stanford campuses in France, or even in Europe. Together, European countries must agree to the emergence of a few large European campuses. This also means that research players should not see themselves as competitors but should capitalize on what makes them complementary".* Europe and France stand out from the USA and China in this area, with much more scattered support leading to a plurality of clusters that are struggling to reach a critical size.
- In addition to funding, institutions have two important roles to play. First, to build and spread the narrative of deep tech investment with ventures and private investors, highlighting both its potential risks and its success stories. Second, because disruption is accelerating, to prepare for and oversee the regulatory and ethical framework for deep tech applications (e.g., genetically modified organisms, job replacements, etc.), in the same way Europe took the lead with GDPR.

3 Europe and France's position

HISTORICALLY, THE DEEP TECH ECOSYSTEM HAS BEEN DOMINATED BY THE UNITED STATES. Yet similarly to overall progress in R&D, China is catching up. It has already overtaken Europe with higher fundraising results (on average, investments are twice the amount of those in the US), through massive development of accelerators/incubators, through major public financial support and through a concentration of efforts on prioritized technologies and geographies, as announced in the 14th Five Year Plan (e.g. quantum computing, gene editing, deep space).

EUROPE, AND FRANCE IN PARTICULAR, have competitive advantages in the global competition to host and develop deep tech ecosystems. These include their research and education systems as well as a large number of deep tech start-ups in France (around 1,700[2]).

Furthermore, large corporations are developing these technologies. For example, Elie Girard, CEO of Atos, stresses that *"France and Europe have an exceptional pool of skills in quantum technology. As this is a disruptive innovation that is part of a long cycle, European and national support plans are also essential to stay ahead of the rest of the world. But unlike so many technological shifts in the past, this time all the stars are aligning"*. In the same vein, Patrice Caine stresses that *"for several years, and in some cases for decades, French and European companies have learned to cooperate with academia and start-ups. The increasing number of international companies who locate their research in France and the spectacular improvement of universities in international rankings, show that the open innovation ecosystem is becoming more and more competitive and recognized as such internationally."*

NEVERTHELESS, FRANCE IS FACING CHALLENGES THAT THE GOVERNMENT AND THE EUROPEAN UNION HAVE BEGUN TO ADDRESS. THERE ARE FIVE KEY POINTS TO FOSTERING THE DEVELOPMENT OF DEEP TECH IN EUROPE:

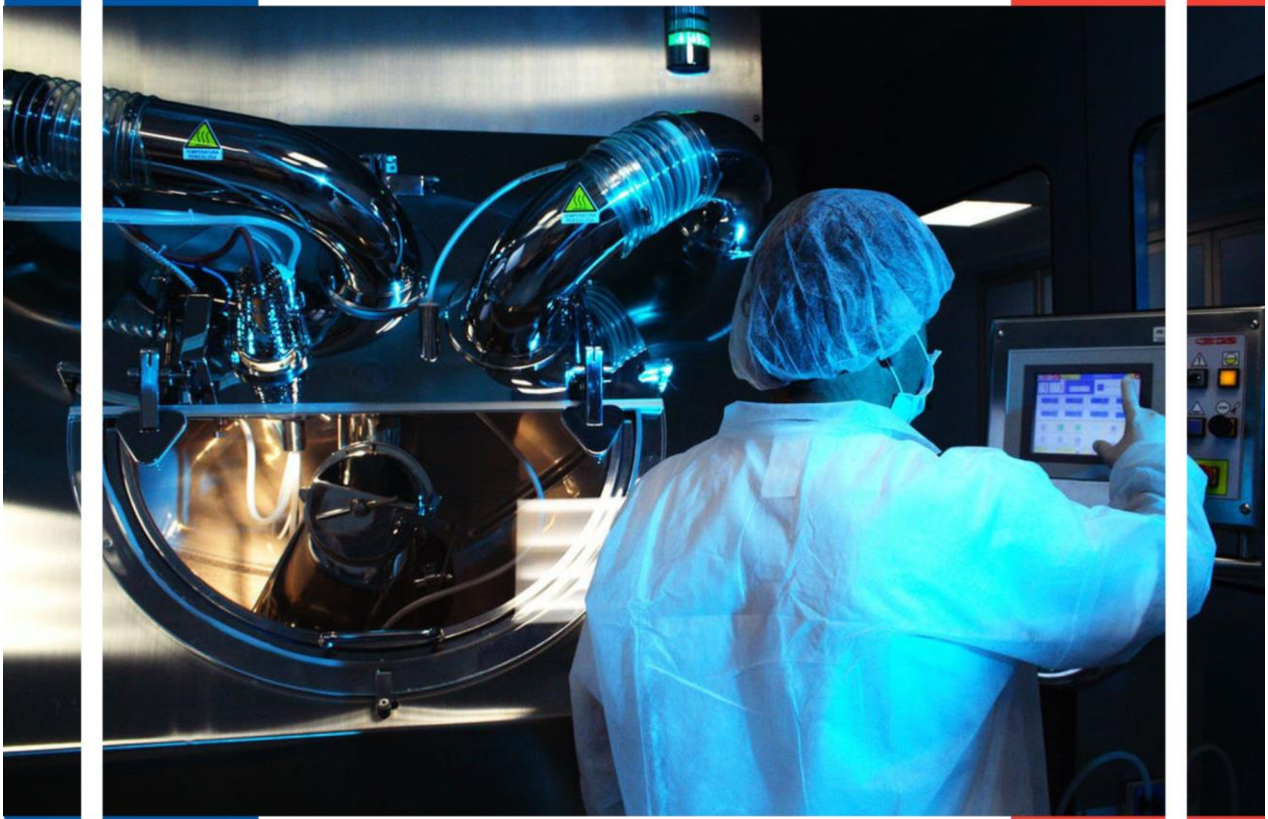
- **Further integrate the high-quality research ecosystem into innovation ecosystems**, building on efforts that have been made with this in mind (e.g., the development of SATT, IRT/ITE in France). On such topic, Jean-Marc Chery, President and CEO of STMicroelectronics highlights that *"Innovation is key to preserving Europe's competitiveness and enabling champions to emerge and to compete in the global markets. Nano plans and future IPCEIs for nanoelectronics are a fantastic way to support innovation through research and development, in order to maintain competitive industry and jobs in Europe."*

[2] *Source: BPI France https://www.bpifrance.fr/A-la-une/Actualites/Plan-Deeptech-3-chiffres-2-ans-un-seul-but-51866*

- **Concentrate investments on a selected number of technologies and ecosystems linked to the core strategic issues to tackle,** building on the examples of the United States and China who are concentrating their efforts. Failing to apply this will run the risk of multiplying the number of structures and consequently diluting the available funding and losing the benefits of synergy. Tobías Martínez Gimeno, CEO of Cellnex, highlights that *"in order to catch up with the US or China, Europe should not only be just as fast, but rather faster than the others. Nevertheless, we cannot be the fastest in every technology, in every sector and in every geographical area, nor can one country do it all on its own, without including the other Member States. Europe therefore needs to coordinate and focus its policies on a selected number of priorities"*. Among these priorities, Apparao Mallavarapu, Chairman & Managing Director of Centum Group highlights that *"Energy, climate change and healthcare are some of the world's biggest challenges which Governments should focus on in their innovation policies."*
- **Scale-up public and private investment resources:** although France has established itself as the second most popular European destination for deep tech investments after Great Britain, the number of deals as well as the unit amount remain too limited. There is a crucial need for the development of a market for scale-up investment at the European level. Public investments could partner with private deep tech investors to leverage their expertise. Governments could investigate how to facilitate a secondary market for deep tech funds when the time horizon is particularly long. Using public funds to leverage private funds is one way to increase the availability of the several hundred million euros in investments that are required for breakthrough technologies.
- **Focus on selected geographies:** While innovation in the USA centers around two multidisciplinary hubs (Boston and Silicon Valley) and four hubs when it comes to China, the territorial organization of innovation in France and Europe remains fragmented. Although ecosystem efforts have been launched, the construction of major European innovation hubs is still in its embryonic stage. The ability of Member States to build on such a vision, which also implies that each country forgoes the need to develop a center for each technology, is going to remain a challenge in the coming years.
- **Adapt regulatory frameworks and administrative processes** to make it easier for companies to experiment. Despite multiple reforms which have given more leeway to start-ups and large corporations to develop new products (from the clinical trial processes to the regulation on autonomous vehicles), the regulations are, by design, modelled on existing products. Developing disruptive products often requires creating space for experimentation within the regulation. Governments thus have a crucial role to play in this area.

IN JANUARY 2019, THE FRENCH GOVERNMENT LAUNCHED A DEEP TECH PLAN TO ADDRESS THESE ISSUES. This initiative was noticed by the CEOs of international companies, including Mr. Mallavarapu who notes that *"in France, government has made innovation a priority. Beyond subsidies and tax incentives, the clear direction and intent generate momentum in the entire ecosystem and provide visibility to companies"*. With a budget of €2.5 billion by 2023, the Deep tech plan aims at making France a benchmark in disruptive innovation. The plan has mobilized every public policy tool: the development of accelerators, non-dilutive financing - deep tech grants and support to development, increased funding for the i-LAB competition - and equity capital with investments by bpifrance in deep tech funds. It is completed by targeted plans such as the Quantum Plan with €1.8 billion invested over 5 years in quantum computers, sensors, communication, and equipment.

President Macron's decision to put deep tech at the center of the 2021 edition of the Choose France summit illustrates the government's focus on fostering the development of deep tech in France and in Europe. There is no doubt that new ideas will emerge from the discussions that will occur during this event.



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