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C12

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# Pioneering precision: C12 makes a carbon-based quantum breakthrough

C12 is a Paris-based startup developing the next generation of quantum computers. The company was launched in January 2020 as a spin-off from the physics laboratory of the École Normale Supérieure (ÉNS) to supercharge the lab's promising new development in quantum technology. C12 uses carbon nanotubes as the fundamental building block of their processor.
By 2025 C12 had raised over € 28 million in equity funding, grown to more than 60 employees and built a diversified portfolio of more than ten patent families.

The company generates revenues by offering clients a way to start their quantum computing user journey towards solving the most complex calculation problems they face.

Figure 1: The C12 team.

## Academic roots and twin founders

Figure 2: Matthieu (left) and Pierre (right) Desjardins, co-founders of C12

C12's story began at the intersection of academic research and entrepreneurial vision. The company was founded by twin brothers Matthieu and Pierre Desjardins, whose complementary backgrounds played a key role in getting it off the ground. Matthieu, a quantum physicist, focused on the core science, while Pierre brought business insight that helped secure early funding and shape the company's direction. Their combined expertise enabled C12 to move rapidly from lab results to a venture-backed company. Early strategic decisions – for example, investing in an in-house cleanroom for nanofabrication – proved critical for maintaining qubit quality and accelerating development. That mix of deep science and business foresight allowed C12 to compress a process which might normally take many years into a short timeframe of just a few months.

With a strong scientific foundation in place, C12 quickly attracted funding to fuel its growth. The company raised a €10 million seed round in 2021, followed by an €18 million Series A in 2024. These were led by venture investors specialising in deep tech, with additional non-dilutive support from French innovation grants and competitions such as i-Lab and Bpifrance. The financing enabled C12 to grow from just two founders in 2020 to a team of more than 60 by 2025 – including over 20 PhDs drawn from top academic institutions and industry in fields like nanofabrication, quantum physics, software and engineering. By building a full-stack team and internal lab capability early on, C12 laid the groundwork for its fast progress. Scientific depth ensured technical credibility, while business planning and financing enabled quick lab build-out and talent acquisition, speeding up the development significantly.

*"We founded C12 because we believed quantum needed a fresh start, just as AI did, by reimagining how quantum hardware is built. Combining scientific depth with entrepreneurial urgency was the only way to turn that vision from lab research into real-world impact."*
**Pierre Desjardins, co-founder and CEO of C12.**

Deep tech startups often need substantial early stage funding because they rely on costly, long-cycle R&D, specialised technology talent and capital-intensive infrastructure, with long paths to technical validation and broad adoption. Customers must be able to integrate and use the new technology widely across their organisations before meaningful revenues can be generated. In quantum computing this is amplified by the need for highly engineered hardware and working environments to reach fault tolerance and utility, making progress dependent on significant upfront capital before commercial scaling is possible.

**TAKEAWAY**

**Science meets strategy**

Deep tech commercialisation demands rigorous scientific excellence paired with focused entrepreneurial rigour. This combination is critical for developing a sustainable competitive edge defined by speed, technological lead and proprietary IPR protection.

## Breakthrough invention & IP foundations

The genesis of C12 was a pivotal experiment at the ÉNS physics laboratory, where a team of researchers led by Matthieu Desjardins successfully coupled a carbon nanotube's electron spin with a microwave photon – effectively creating a highly stable quantum bit (qubit). This breakthrough addressed a major challenge in quantum computing by demonstrating a qubit with exceptional stability (long coherence) suitable for error correction. Recognising its significance, Matthieu and Pierre, with support from the ÉNS and CNRS Innovation (the tech transfer office of the Centre national de la recherche scientifique), swiftly moved to file for patent protection in 2018 (co-owned by ÉNS and CNRS).

CNRS Innovation handled the filing of the patent application and negotiated exclusive licensing rights for C12. That core patent application covering the carbon nanotube spin qubit architecture laid the groundwork for spinning the project out. With an exclusive licence agreement based on an initial lump sum to enter into the contract, as well as royalties on future revenue, C12 was formed to commercialise the technology. Securing the rights to the nanotube qubit patent gave C12 a protected foundation and immediate credibility, which proved essential for recruiting investors and new employees. In addition, the exclusively licensed patent ensured that academic and industrial R&D collaborations could be pursued by C12. This balanced IP risks, enabling secure exploitation of joint project results.

From the outset, C12 adopted a "patent-first, publish-second" philosophy to safeguard its inventions. Behind this principle stood a well-defined internal process, which began with the inventors drafting an innovation memo capturing the essence of the new idea. The IP manager then carried out a detailed prior-art study and presented both the findings and a proposed IP strategy to the internal IP committee. Only after that committee had approved the approach did the IP manager move ahead, working closely with the inventors and an external patent attorney to prepare and file a patent application. At the same time, the IP strategy does not rely solely on patents: C12 also protects valuable know-how through trade secrets, with multiple technical disclosures already filed and safeguarded within the company. Whenever a protection route other than a patent is more appropriate, the IP manager oversees the process directly.

**TAKEAWAY:**

**IP as a catalyst**

Strategic IP management can be the decisive factor in turning breakthrough research into a successful deep tech venture – protecting innovation early builds credibility, attracts investors and enables sustainable collaboration between science and industry.

For example, when C12 later achieved a milestone result with a record coherence time, they first ensured a patent application was on file before submitting for publication in a scientific journal. This approach preserved the novelty of C12's invention in the patent system while still allowing scientists to publish and engage with the academic community afterwards. Once published, their research results become part of the state of the art, raising the bar for others seeking patent protection and, in turn, strengthening C12's freedom-to-operate (FTO). Continuing to publish remains important for C12, as fostering engagement in science is one of its core missions.

## Growing the IP portfolio

The very first patent application (filed in early 2021 by CNRS Innovation) protected C12's fundamental carbon nanotube qubit design, and the exclusive licence enabled the startup to spin off. This signalled to the world (and investors) that C12 controlled a distinct, high-potential technology, adding to its reputation. As research progressed, the company systematically filed additional patent applications focusing on critical advances: new fabrication methods for its qubits, novel qubit readout techniques and supporting software innovations. When an invention arose from ongoing collaboration with CNRS and one of its researchers was a co-inventor, the institution was included as a co-applicant. However, C12 enjoys exclusive rights to commercialisation in line with the collaboration framework. Under this arrangement, if C12 wishes to exclusively commercialise co-invented technology, a lump sum must be paid to the CNRS to secure and maintain that exclusivity. The smooth transfer of critical IP from academia to startup – and the ongoing addition of new patents around that core – has been a key enabler of C12's success. Negotiations with the technology transfer office took only around six months, allowing the company to start with a clear FTO from the CNRS and develop its patent portfolio over time. This was well received by investors and partners in the quantum hardware space.

**TAKEAWAY:**

**Spin-off IP strategy**

The smooth transfer of critical IP from academia to startup to protect core technology first and then develop a patent portfolio aligned with the business roadmap is an essential success factor for a spin-off

Figure 3: C12's cleanroom

Extensive patent landscape mapping and FTO analyses played a central role in C12's progress. These activities are carried out internally by the company's IP manager and form part of an established process. Patent landscapes are reviewed every six months across major quantum computing verticals – from quantum error correction to hardware and cryogenics. This systematic approach helped guide patent filings, allowing C12 to identify genuine undeveloped areas in the quantum IP landscape and avoid overlap with existing third-party patents. Each patent was chosen to secure a key aspect of the technology, strengthening the company's overall market and technology position. The tactic allowed C12 to build a focused portfolio of more than ten patent families across Europe, the US and Asia – a lean but formidable shield around its core technologies.

In parallel, C12 implemented trade secret management through detailed invention memos that describe new ideas and how they work, providing an additional layer of protection for its know-how. Any expertise not suitable for patenting (for example, process refinements or software algorithms) was maintained as trade secrets within the company and active steps taken to keep it confidential, complementing the protection by patents.

## Technology profile

### Box 1: A quantum hardware platform

A quantum computer is a new kind of machine that uses quantum bits or qubits, which can be in multiple states at once (a property called superposition) and influence each other through entanglement. This allows them to explore many possibilities at the same time, making them especially powerful for problems like simulating molecules or optimising complex systems – tasks classical computers struggle with. The description is an over-simplification, but captures the core intuition behind quantum advantage. The main obstacle today is errors, as qubits are fragile and easily disrupted by their environment. This is where C12's approach comes in. By using carbon nanotubes, which are atomically perfect cylinders of carbon, the company creates spin qubits that are naturally more isolated from noise. This leads to better stability and longer coherence times – both essential to making quantum computing practical. Improving the qubit itself is a critical step towards scalable, fault-tolerant quantum machines. Competing quantum hardware platforms each have their challenges. Superconducting qubits (used by players like IBM and Google) can be manufactured with existing chip technology but suffer noise and cross-talk that grow worse as more qubits are added. Trapped-ion systems (pursued by IonQ, Quantinuum and others) and neutral atoms (pursued by QuEra, Pasqal and others) offer very stable qubits but rely on complex laser and vacuum setups that are hard to miniaturise.

Photonic quantum computers use light rather than matter for qubits, avoiding some decoherence but requiring precise optical components. C12's carbon nanotube spin qubits stand out by combining some of the strengths and avoiding many of the weaknesses of these approaches. First, they offer intrinsic stability; the carbon nanotube qubits are almost defect-free and naturally isolated, enabling coherence times significantly beyond what typical superconducting circuits achieve. Second, the C12 design leverages proven techniques: each qubit is coupled to a microwave resonator on the chip for control and readout, borrowing from established superconducting qubit methods. This means the company's novel qubits can still use well-understood electronics and cryogenic systems for fast operation and measurement, blending innovation with reliability. Third, the nanotube qubits are integrated on silicon chips using processes compatible with standard CMOS semiconductor fabrication. This industry-friendly approach allows C12 to envision scaling up production via existing manufacturing infrastructure (for example, through its partnership with the advanced chip facilities of CEA-Leti), unlike some platforms, which need entirely bespoke hardware. Additionally, C12 has patented a unique nano-assembly process to precisely place pre-selected, high-quality nanotubes onto circuits at scale – solving a key fabrication challenge for making large numbers of qubits that perform consistently.

### Box 2: Software solutions

In 2023 C12 launched Callisto, a cloud-based quantum emulator developed with the cloud provider OVHcloud. Callisto simulates the behaviour and performance characteristics of C12's quantum processor (including the noise profile of nanotube qubits) on classical computing resources. It incorporates proprietary noise models, hardware integration methods and performance-tuning algorithms that are protected through a combination of patents and trade secrets, ensuring external users can work with realistic simulations without access to the underlying implementation. This serves multiple strategic purposes: it allows algorithm developers to experiment and optimise for C12's architecture; it provides C12 with feedback on which use-cases and features are most important; and it helps "democratise" access to C12's technology so expertise and interest grow in parallel with hardware development. Callisto is also part of a professional services programme where C12 works directly with companies to explore how quantum computing (emulated for now) could address their toughest computational challenges. By the time C12's physical quantum processors come online, a suite of compatible software tools, for example algorithms, and a base of early adopters will already be in place.

### Box 3: C12's key innovations

(a) **Suspended nanotube qubits:** Qubits are formed on carbon nanotubes suspended above the chip substrate, eliminating interference from surface defects and vibrations. This design choice yields exceptionally high coherence.

(b) **On-chip resonator coupling**: Each qubit is coupled to a microwave resonator and readout circuit on the chip, operating at millikelvin temperatures. This setup enables fast qubit control, accurate state readout and even long-range two-qubit interactions (by connecting qubits via resonators) using well-established circuit QED techniques.

(c) **Full-stack integration**: C12 has developed its control electronics and software stack to interface its hardware seamlessly with cloud-based quantum programming tools. Developers can program the nanotube qubits through familiar frameworks via Callisto, which eases adoption and allows algorithm co-design specifically tailored to C12's hardware architecture.

**2015–2019**
- Academic research yields the first proof-of-concept: coupling a nanotube spin qubit to a photon and initial experiments on coherence.

**2020**
- Spin-out founded; a single-qubit device is demonstrated outside the lab, proving that the technology works in principle.

**2021–2022**
- Pilot fabrication line established in Paris (including a cleanroom and nanotube growth lab).
- Focus on repeatably fabricating qubits and improving coherence.
- Patents filed on fabrication and readout methods.

**2023–2024**
- Experimental work towards multi-qubit operations (including a two-qubit logic gate using nanotube qubits) is underway in the lab, guiding the next steps toward demonstrating entanglement and basic quantum algorithms.
- The Callisto emulator is launched to external users.
- Research results (e.g. the record spin-qubit coherence time) are published in peer-reviewed journals.

**2025–2033** (planned):
- Scale the number of qubits per chip while maintaining low error rates.
- Implement error correction techniques at the hardware level (e.g. demonstrate a small logical qubit using several physical qubits).
- Develop modular architectures that can link multiple chips.

By around **2033**
- Aim for a fault-tolerant module of perhaps several dozen logical qubits that can serve as the building block for larger quantum computers.

Figure 4: C12's technology development roadmap

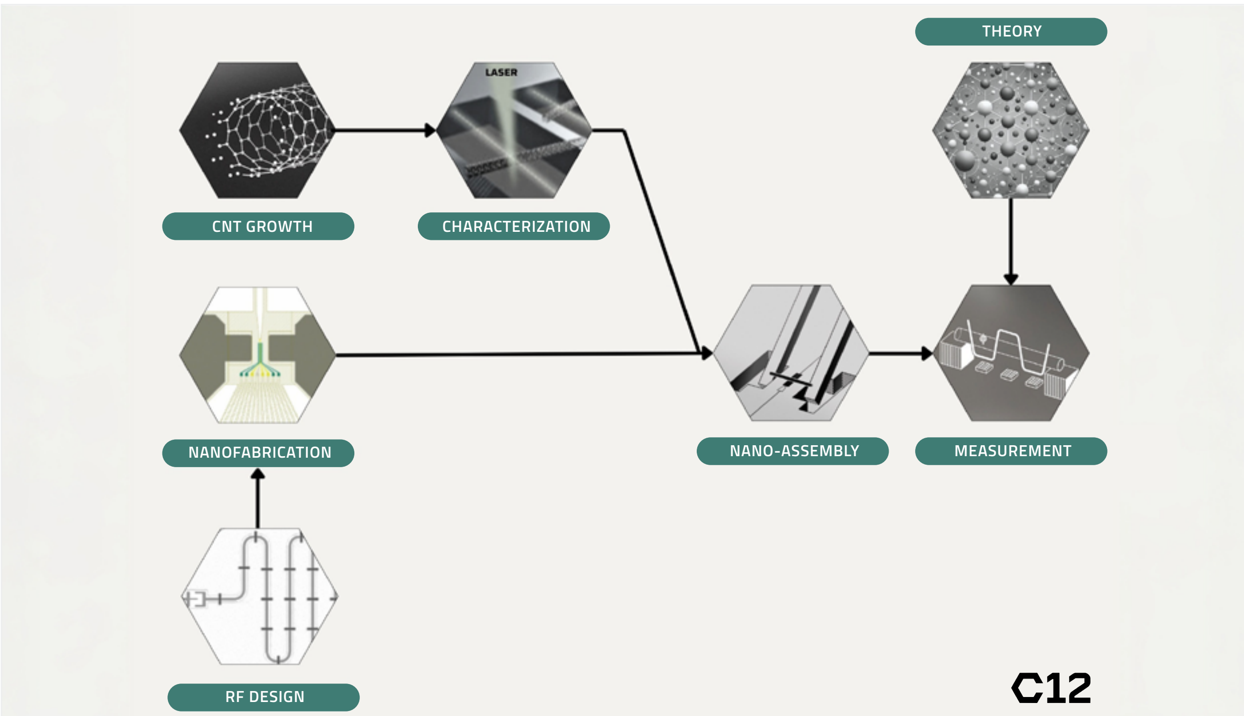


Figure 5: C12's end-to-end fabrication flow – from carbon nanotube synthesis to quantum measurement – has been fully developed in-house to ensure qubit quality and scalability.

Throughout the technology development timeline, C12's guiding principle has been "quality first" rather than rushing to have the most qubits, the company prioritises making each qubit as stable and controllable as possible and proving error correction on a small scale. This strategy extends beyond technical innovation and aims at ensuring performance advantages can be reliably reproduced at scale. By keeping critical fabrication steps – such as nanotube growth, device assembly and quantum characterisation – in-house the company maintains full control over process quality and develops trade secrets.

At the same time C12 protects its most visible and replicable innovations, including its nano-assembly and qubit readout methods, through patents.

This combination of internal know-how retention and external IP protection ensures that C12's technology remains both defensible and scalable. It allows the company to demonstrate consistent device performance while preserving a competitive edge as quantum hardware moves toward industrial production.

**TAKEAWAY:**

**Dual IP model**

To convert technical excellence into a sustainable market advantage, employ a strategic IP protection model: utilise patents to secure the visible, reproducible aspects of the invention, while rigorously protecting the critical enabling know-how and proprietary processes as trade secrets.

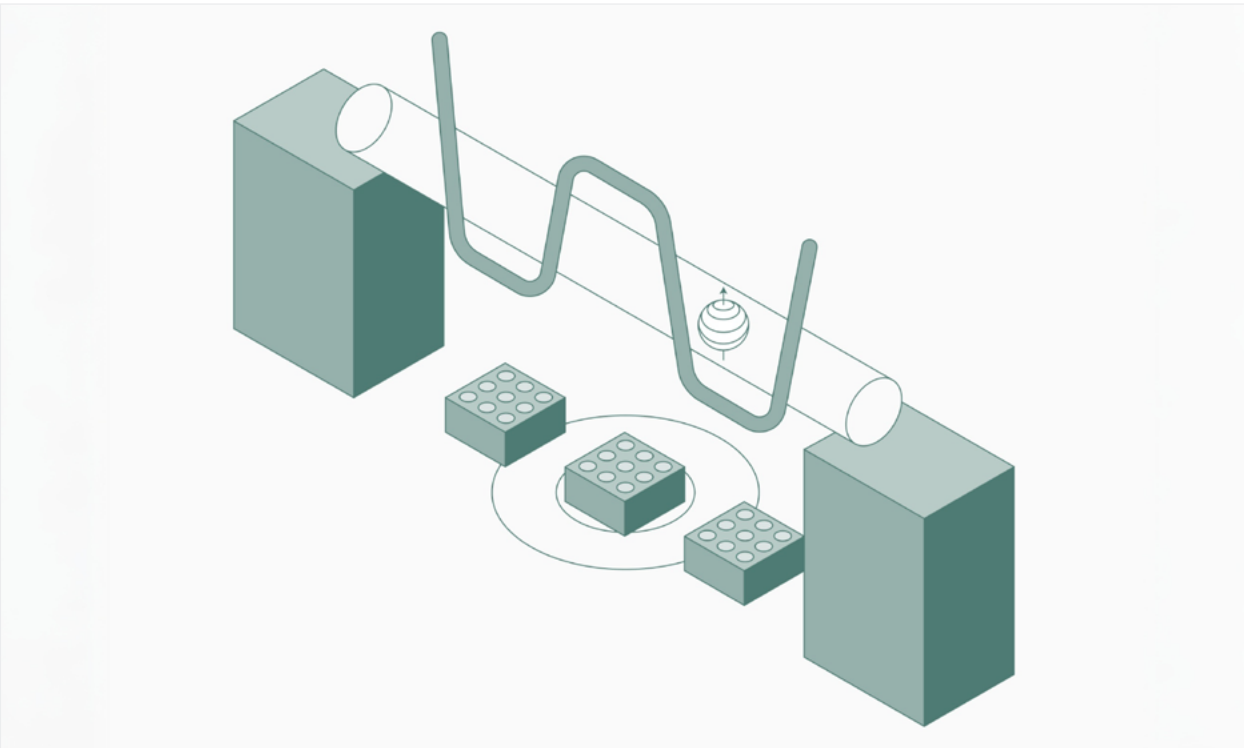

Figure 6: Illustration of C12's modular architecture – spin qubits are coupled via a microwave resonator to enable fast, long-range quantum gates.

## Business model and market readiness

Quantum technology has broad potential across industries that require extreme computational power. In quantum chemistry, for example, C12's qubits could simulate complex molecular interactions or reaction mechanisms far beyond the reach of classical supercomputers, accelerating drug discovery and materials science. In logistics and optimisation, quantum algorithms running on C12 hardware might solve intricate routing or scheduling problems more efficiently than today's best classical methods, benefiting transportation networks, supply chains and energy grids. In the defence and security arena, C12's platform could be applied to enhance secure communications (quantum encryption) or run large-scale strategic simulations – such as complex scenario modelling – that currently overwhelm classical systems. In the longer term, as technology scales, it could enable new approaches to machine learning by solving the hard optimisation tasks that underline advanced AI models.

While C12 is not limited to a single vertical, it prioritises early use-cases where its ultra-low-error, high-coherence qubits provide a clear advantage, such as high-precision chemical simulations or complex optimisation scenarios. The company actively works with experts like Artelys (in operations research) and TotalEnergies (in the energy sector) to validate these applications on its emulator. Consequently, C12 ensures that its quantum hardware matures in tandem with the development of validated solutions and the readiness of a receptive user base positioned to leverage its quantum processors.

C12's business model reflects the realities of an emerging industry and the still immature state of quantum computing. The company engages intensively in co-development projects with partners and provides cloud access to its Callisto quantum emulator. The IP regulations for these collaborative projects depend on their type and structure, but the most common model stipulates that results are shared among all participants in proportion to their contributions.

By offering Callisto to researchers and industry early – initially free of charge and accessible via a web interface or API – C12 is cultivating a community of users and allowing them to experiment with quantum solutions and potential customers at an early stage, before its hardware is fully ready. These activities generate initial revenue and, critically, help the company refine its technology alongside real use-case feedback. In the longer term, C12 plans to monetise its hardware, for example by selling or leasing carbon-based quantum processor units to high-performance computing centres, and offering hosted quantum-as-a-service cloud access when its systems are operational.

The company's strong IP position also provides flexibility to license parts of its technology (such as certain fabrication techniques or software tools) if this creates additional revenue streams. While no licenses have yet been granted to competitors, more complex agreements could be negotiated with them in broader use-cases if strategically beneficial. In essence, C12's business model is evolving in step with the technology: first building engagement and know-how, then positioning to scale up commercially once the hardware delivers quantum advantage.

Quantum computing remains pre-commercial in 2025. A few large players offer access to noisy intermediate-scale quantum processors via the cloud, but these machines are limited by high error rates and can only handle small problem instances. Achieving true quantum advantage, solving problems that classical supercomputers cannot, is still believed to be years away. C12 has deliberately chosen not to chase the run of improvements in the current generation of quantum offerings. Instead, it is focusing on solving the next-generation challenges – qubit scalability and error correction – so it can leapfrog into a leadership position when the market enters its next phase. The company's bet is that by the time industries like pharmaceuticals, logistics or finance genuinely need quantum hardware to tackle critical problems, C12's platform will be ready to meet that demand with far superior performance. This "second wave" strategy aligns well with European and French national quantum initiatives, which emphasise building fault-tolerant quantum machines, rather than just noisy prototypes, to secure technological sovereignty.

## Patents enabling partnerships

C12's patent portfolio is a cornerstone of its business strategy, especially in terms of building trust with partners. Because the company holds the core IP for its technology through an exclusive licence and own patents as well as documented trade secrets, it can enter collaborations without fear of losing control of its core technology. Partners can work with C12 knowing that its technology is protected from copycats – an assurance that encourages open and honest collaboration. Having strong IP also means C12 can negotiate partnerships on favourable terms, with the option to grant licenses for non-core applications or securely integrate its technology into others' systems. Where needed, sublicensable back-licenses can be obtained for partner improvements or jointly developed IP – for example, cross-licensing arrangements can be established to ensure freedom-to-operate.

When C12 launched its Callisto emulator, it did so only after securing patent protection on the underlying hardware concepts, ensuring that offering a "virtual" quantum computer did not inadvertently give away any unprotected ideas. All of this has given investors and partners confidence that the business is defensible and joint efforts will have clear ownership and use regimes. For example, its early corporate partners were willing to invest time and resources because they saw that the company's unique hardware was well protected – a critical aspect for any deep tech business model.

**TAKEAWAY:**

**Integrated IP framework**

A robust IP framework that strategically integrates a strong patent portfolio with clearly defined trade secrets enjoying established ownership regimes and defensive publications fosters trust, prevents disputes and multiplies impact across technology and markets. This is essential for a sustainable collaborative business model.

Developing quantum hardware requires significant infrastructure, which can be challenging for a startup. C12 tackled this by investing strategically in key in-house facilities, while also leveraging external resources. The company built a custom nanofabrication lab in Paris to have direct control over chip fabrication – including its own cleanroom, equipment for carbon nanotube growth and placement, and multiple dilution refrigerators for cryogenic testing. This gave C12 the ability to prototype and iterate quickly on its qubit designs internally. At the same time the company partnered with CEA-Leti, a leading semiconductor R&D centre, to access advanced fabrication processes such as 300mm wafer technology. This partnership allows C12 to piggyback on state-of-the-art fab capabilities without the prohibitive cost of building them from scratch. Similarly, on the software side C12 uses cloud computing support from OVHcloud to host its emulator and run large-scale simulations, avoiding the need to maintain massive computing clusters in-house. This hybrid approach – a core internal lab plus strategic use of partner infrastructure – gives C12 the equivalent of "big lab" resources on a startup budget. It ensures the company can push its technology forward rapidly while keeping capital expenditure under control.

Even if quantum hardware is not ready to solve practical problems today, a key element of C12's market readiness plan is to work closely with potential end-users well before standardised and commercial quantum hardware is available. Through its Callisto Professional Program and other pilot projects, C12 collaborates with companies in sectors like energy, aerospace and logistics to identify where quantum computing could eventually provide significant value. By jointly exploring algorithms and use-cases on the emulator now, the company learns which problems are the most promising and what performance metrics will be required for success. Insights from these collaborations can lead to new inventions or proprietary methods, which C12 evaluates for patentability or protects as trade secrets.

This ensures that co-developed solutions enhance C12's IP position while safeguarding commercially sensitive know-how. This helps shape C12's development priorities by building the features customers will care about and primes those industries for adoption. The partners, in turn, gain experience with quantum algorithms and can assess the impact on their workflows ahead of time. This co-development of applications means that by the time C12's hardware is ready for deployment there will be proven prototype solutions and informed customers ready to integrate them. Essentially, C12 is creating its future market as it develops its product – a smart approach in a field where the technology is advancing faster than most end-users' ability to understand or implement it. The company is living out the main principles of open innovation by including research partners, suppliers and customers in the R&D process.

**TAKEAWAY:**

**Strategic co-development**
In deep tech it is important to consider early strategic collaborations with potential users. This process simultaneously generates valuable IP assets and a primed, informed user base, guaranteeing your technology is ready for immediate adoption the moment it is deployed.

### Table 1: Selected patent applications

| Title | Priority date | Patent number | Comment |
|---|---|---|---|
| Method and device for depositing a nano-object | 2018-10-18 | EP19791211A | Licensed, co-owned by ÉNS and CNRS |
| Method and system for depositing a nano-object on a receiving surface and fastening system incorporating such a deposition system | 2022-05-23 | EP23729059A | |
| Magnetic component, in particular quantum component | 2022-09-08 | EP23764966A | |
| Method for calibrating and/or assisting in the design of a spin-qubit or two-level quantum system and quantum component | 2022-03-16 | EP23712498A | |

## IP strategy and management

C12 places IP at the centre of its business strategy. The company is not yet generating meaningful product or service revenues. The business model is still to be validated (e.g. quantum-as-a-service, hardware sales or leasing, quantum-enabled simulation, IP licensing, etc.). The technology roadmap is ambitious, and market pull is still developing. Thus, the IP strategy must support:

- flexibility to pivot the business model or technology focus.
- credibility for investors, funding agencies, partners and collaborators.
- value capture once the business model and market become clearer.
- protection of core innovations so competitors cannot easily copy or circumvent.
- operational excellence to support R&D, collaborations, external funding and scale-up.

The following objectives were therefore defined for **C12's IP strategy**:

- secure protection of core quantum technologies (hardware, algorithms, control, emulation and integration) to support future business models and market entry, and maybe even define technology standards.
- preserve flexibility in business model (pivot capability) by structuring IP so that different paths (hardware sales, cloud quantum, licensing, hybrid) remain open.
- build IP credibility for investors, partners, research collaboration programmes and key customers by demonstrating granted patents, clean IP ownership, and a structured IP management system that supports due diligence and collaboration.
- secure future FTO and minimise risk of being blocked by competitors or standardisation initiatives once products and services are being adopted on a larger scale.
- internalise R&D and production know-how, prevent leakage to competitors or via collaborations and improve value capture potential from IP.

Since 2020 C12 has built a focused IP portfolio aligned with its technical roadmap. The initial priority was to patent the carbon nanotube qubit and assembly method, later expanding to areas like qubit readout and nanotube characterisation. An IP strategy and management advisor joined the team in 2024, introducing structure and discipline to the process. Under their guidance C12 has adopted a quality-over-quantity approach, focusing only on patents that offer long-term strategic value and competitive advantage. IP decisions are made by a small team including the founders, the IP advisor and external counsel. Inventions are documented via structured disclosures and reviewed quarterly. Filing decisions depend on strategic relevance, enforceability and alignment with technical milestones. This ensures patents serve as tangible assets, with unpromising ideas either held as trade secrets or discarded. Although there have been no planned company or IP acquisitions, and none are planned, C12 actively monitors opportunities to strengthen and complement its IP portfolio through technology scouting and IP landscape mapping. The founders are also aware that IP needs will evolve as the business case matures, and the strategy is structured to adapt accordingly, ensuring alignment between technological milestones, business objectives and future market positioning.

As of 2025, C12's portfolio encompasses more than ten patent families filed across key regions. Key filings in Europe, the US, Japan and China cover all essential aspects of its technology without incurring unsustainable costs. These jurisdictions were chosen following a cross-analysis of quantum market evolution combining IP landscape mapping with financial market studies of companies active in quantum (beyond just direct competitors), ensuring that portfolio extensions align with both technological relevance and market potential.

As for portfolio size and focus, C12's strategy has been to keep the portfolio focused and high-value. The company is mindful of patenting costs; even a single application in multiple jurisdictions is expensive, so they aim to ensure each patent covers a broad and commercially relevant range of protection. As part of this approach, C12 is also evaluating the use of the Unitary Patent, which provides uniform, cost-effective patent protection valid across participating EU Member States and centralised enforcement against infringement in that territory, mainly in response to competitor strategies.

Currently, C12 balances cost and value by leveraging international filings (via PCT) to postpone expenses, and in selected cases by using programmes like the Patent Prosecution Highway[1] (which is free of charge) to accelerate examination. While this brings costs forward, C12 has used accelerated examination strategically to strengthen investor confidence – since a granted patent is a more mature and defensible asset – and send a clear competitive signal to the market, thereby reinforcing its positioning.

For example, when filing a priority application at the EPO, C12 has the option of either paying the search and examination fees immediately or deferring these by filing the application without them. The decision whether to pay immediately or defer is influenced by several factors:

1. Strategic timing: If the invention is at a critical stage where the technology needs to be protected quickly, paying the fees immediately can expedite the search and examination process. This is particularly important in fast-moving fields like quantum computing.
2. Budget considerations: Immediate payment of fees incurs costs upfront. If budget constraints exist, it may be prudent to defer examination. This allows financial flexibility while still securing priority.
3. Assessment of patentability: Before incurring the costs of search and examination, it may be beneficial to assess the patentability of an invention. If there are uncertainties about novelty or inventive step, deferring the fees allows further development or refinement of the technology.
4. Market timing: If the technology is expected to enter the market soon, paying the fees immediately ensures C12 has the necessary patent granted early, enabling enforcement.
5. Future strategy: Consideration of how the application fits into the broader IP strategy is essential. If it is part of a larger portfolio, aligning the timing of examinations can be beneficial.
6. Waiting for partner or investor input: C12 can defer fees while awaiting funding or strategic decisions from stakeholders.

Not every invention at C12 is patented. The company uses trade secrets strategically to protect certain internal know-how, especially related to software and fine-tuned processes. For example, proprietary calibration algorithms for optimising qubit performance and the detailed recipes for growing and selecting nanotubes with specific properties are often kept confidential rather than disclosed in a patent. C12's general rule is to patent inventions that would be visible or easily reverse-engineered in the final product, and keep secret those aspects that can remain hidden. The code and other technical solutions behind the Callisto emulator, for instance, are not released publicly – clients can run computations on Callisto, but they cannot access the emulator's source code or detailed noise models, preserving C12's unique insights. Similarly, the exact parameters of the company's nanotube fabrication process are known only to the teams that need to know, and shared with partners under strict NDAs. This approach maximises protection: patents guard against competitors duplicating C12's externally observable technologies, while trade secrets safeguard the behind-the-scenes techniques that give it an additional performance edge. By layering patents and secrecy, C12 ensures that whether a competitor tries to emulate its design or its process, they will face significant barriers.

This balanced IP strategy has also been communicated clearly within the company and translated into an IP management system – employees document all inventions and then work with the IP committee to decide the best form of protection for each. The result is a culture that values IP and integrates it into the innovation process, rather than treating it as an afterthought or a mere legal topic.

1 This allows faster patent examination in one office based on a positive result in another.

## Shaping an ecosystem via strategic partnerships

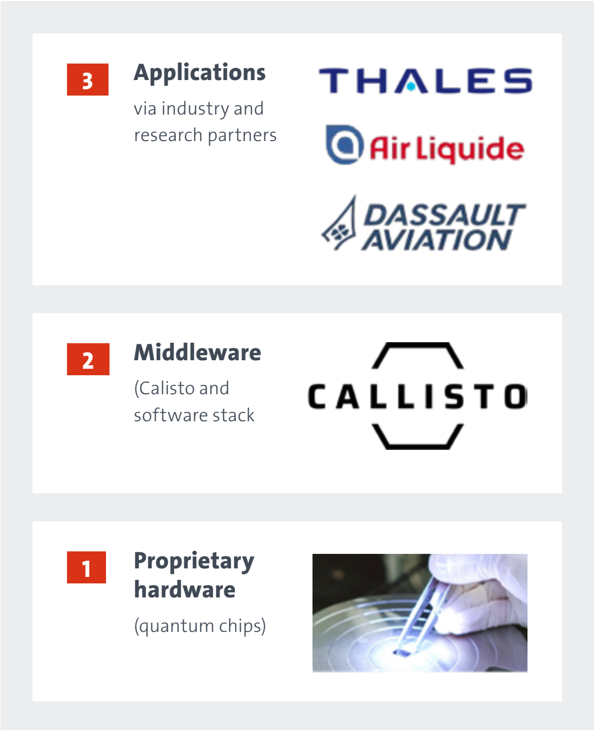


Figure 7: The C12 ecosystem

C12 structures these efforts around an integrated three-layer ecosystem: (1) proprietary hardware (quantum chips), (2) middleware composed of its Callisto emulator and software stack, and (3) applications co-developed with industry and research partners.

C12 maintains strong ties to academia, reflecting its origins and ensuring it stays at the forefront of scientific developments. The startup collaborates with its alma mater institutions – notably ÉNS and CNRS in Paris – through joint research projects, sponsored PhDs and regular knowledge exchange. These alliances give it ongoing access to cutting-edge scientific expertise, advanced measurement equipment and a pipeline of young talent. In return, the academic labs gain industry perspectives and additional funding, creating a win-win situation. Beyond its founding labs, C12 is a participant in broader European research initiatives and consortia.

A standout partnership is with CEA-Leti, France's renowned microelectronics research centre. Through Leti, C12 can prototype aspects of its technology using state-of-the-art semiconductor processes and get guidance on scaling its fabrication methods to industry standards. This helps ensure the company's hardware development does not happen in a vacuum, but is informed by decades of semiconductor know-how.

C12 also works with established companies to explore early applications of its quantum technology. One example is the collaboration with OVHcloud, a major European cloud services provider. Together they deployed the Callisto emulator on OVHcloud's platform, which immediately broadened access to C12's quantum tools and lent them industrial reliability. OVHcloud benefited by offering a novel quantum service to its client base, while C12 gained user reach and operational support.
In the aerospace and defence sector, C12 has engaged with partners like Thales to investigate how quantum computing could optimise complex systems (e.g. flight routing or radar signal processing) in the future. With Air Liquide, a large industrial and gas technology firm, it has been exploring quantum methods for materials discovery and supply-chain optimisation. By working with such domain experts, C12 ensures that its R&D efforts align with actual market needs. These partners often provide co-funding, data and real-world problem sets, and in exchange they gain an early understanding of quantum solutions that could give them a competitive edge down the line.

Each strategic partnership accelerates C12's progress while also advancing the partner's goals – a true ecosystem approach. Academic collaborations reinforce the scientific underpinnings of C12's technology and help train engineers and scientists fluent in its platform. Industrial partnerships provide validation and a reality-check for C12's technology, as well as the opportunity to co-develop prototype solutions in context (e.g. an algorithm for quantum chemistry with a pharma company, tested on Callisto). Many partnerships have also been formalised through joint participation in government-funded projects (for example, the French Quarbone project, supported by the Île-de-France region and focusing on quantum and carbon-based technologies, which pooled resources from C12 and others). Through these, C12 not only gains financial support but also credibility and networking with key stakeholders in the quantum landscape. By balancing core innovation partnerships (like those with CNRS and Leti for technology development) with application-focused partnerships (like with OVHcloud or Air Liquide for market exploration), C12 is able to push forward on multiple fronts without losing focus on its primary mission of building quantum hardware.

**TAKEAWAY:**

**Collaboration framework**

Strategic partnerships can accelerate the development and commercialisation of products and services, provided the parties' roles, responsibilities and IP rights are clearly defined and contractually agreed.

All partnerships come with clear IP arrangements to protect the company's interests while respecting collaborators' contributions. Typically, C12 retains full ownership of its background IP (everything it brings to the collaboration), and any jointly developed IP is handled under pre-agreed terms. With academic partners, patents resulting from joint research are often co-filed, but C12 secures exclusive licenses to use those patents in its business domain so it can easier commercialise the results. With industry partners, the split is usually by domain: if a collaboration yields an improvement to C12's core hardware or algorithms, it will own that IP; if it results in a specific application solution (for instance, a quantum software tool for a particular industry), the partner may own it (often with C12 obtaining a licence back to integrate it with its system). Sensitive know-how, like proprietary source code or fabrication recipes, is only shared on a need-to-know basis and always under strict NDA. In many cases C12 provides "black box" interfaces – for example, allowing a partner to use the emulator via an API without revealing the code – to enable collaboration without exposing the underlying methods. C12 also schedules periodic IP reviews during ongoing projects to identify any new inventions and trade secrets promptly and determine whether they should be secured (and by whom). This proactive approach has prevented disputes and ensured that the outcomes of partnerships enhance C12's IP position rather than dilute it.

C12's robust patent portfolio has proven to be a key trust-builder in its collaborations. It signals to partners that the company's technology is unique, mature and defensible. For example, Air Liquide's team indicated that a prerequisite for working with C12 was confidence in the startup's IP; they wanted to be sure that the core technology was protected and any joint innovation would not be hampered by legal uncertainties. Similarly, when applying for joint grants or funding, the combination of C12's patents and a plan for generating new IP often strengthens the proposal, since funding agencies are keen on projects that drive innovation with clear ownership. In essence, C12's IP not only protects its technology but also catalyses partnerships: it gives all parties the confidence to invest time and resources together, knowing the innovation can be exclusively and profitably utilised.

## Funding and investment

C12 has attracted a mix of venture capital and public funding from French governmental entities and Bpifrance to support its ambitious development programme. For national investors such as Bpifrance, a strong IP position is essential – it demonstrates real technological progress, shows competitors will face hurdles entering the same space, strengthens valuation and ensures publicly funded innovation can deliver long-term economic value for France.

**Box 4: Why IP matters to Bpifrance**

**Proof of innovation:** Patents and IP filings serve as tangible evidence of technological novelty and market potential.

**Barrier to entry:** Strong IP portfolios help startups defend innovations and deter competitors, which is crucial for scaling.

**Valuation and investment readiness:** IP strengthens a company's valuation and attractiveness to co-investors, especially in the deep tech and hardware sectors.

**Licensing and monetisation potential:** Bpifrance considers whether IP can be monetised through licensing or strategic partnerships.

**Alignment with public interest:** IP ensures publicly funded innovations are protected and can generate long-term economic returns for France.

In 2021 C12 raised roughly €10 million in seed financing, led by 360 Capital, a European VC firm known for backing deep tech startups. In 2024, the company secured an additional €18 million in the pre-Series A round led by Varsity Capital, which focuses on scaling high-potential technology companies. Other participants across these rounds include Airbus Ventures, Bpifrance (Digital Venture fund), the European Innovation Council (EIC) Fund, and several prominent tech investors. In total, by 2025 C12 had raised about €25 million in equity funding, which has been used to build its team, R&D infrastructure and IP portfolio.

From the beginning, C12's investors placed heavy emphasis on its IP. During the seed round, for example, 360 Capital required confirmation that C12 had exclusive rights to the core carbon nanotube qubit technology (via the CNRS Innovation licence and own patent filings) before finalising the investment. Due diligence included patent landscape checks and ensuring key inventors had assigned their IP to the company.

Later, public investors like the EIC Fund similarly scrutinised C12's patenting plans for Europe and its software protection approach. A robust IP portfolio and strategy were seen as a prerequisite for investment and central to why C12 was worth backing. The company's early patents and clear licensing agreements greatly de-risked the investment in the eyes of these backers, who knew that their capital would be building on a solid proprietary foundation.

360 Capital noted that C12 combined world-class scientific innovation with a strong execution-oriented team. The synergy of having a quantum physicist and a business strategist as co-founders was viewed as a major asset – it meant C12 could navigate both technical and commercial challenges effectively. To complement this, C12 also brought in an IP manager to bridge R&D and external counsel, ensuring a coherent IP strategy and disciplined portfolio management from the beginning. Varsity Capital, which led the Series A, highlighted C12's tangible progress on limited resources: the fact that C12 had achieved a record qubit coherence result, assembled an in-house quantum fabrication facility – allowing the company to safeguard trade secrets and continuously refine production processes without relying on external suppliers – and built a strong IP portfolio in just a few years were seen as indicators of deep technical maturity and savvy leadership. Varsity also emphasised the strategic importance of the company for Europe – supporting C12 was not only an investment in a promising company but also in establishing European leadership in quantum hardware.

**TAKEAWAY:**

**Risk reduction through IP**
For deep tech investors, IP is not a formality but a core criterion. Clear ownership, robust protection and alignment with market potential reduce risk for investors and signal preparedness for the opportunities ahead.

## Future plan and outlook

While challenges remain, C12's clear mission – delivering useful, fault-tolerant quantum computing through physics-driven innovation – and its solid foundation of IP, talent and partnerships position it as a frontrunner in the quest for scalable quantum computing. Over the coming years, C12's focus will be on graduating from foundational research into a commercially viable quantum computing platform. Technically, this means scaling from single-qubit devices to a five-qubit prototype with high-fidelity gates, implementing error correction schemes, and demonstrating a small fault-tolerant module of qubits.

To support this, C12 will continue expanding its in-house fabrication capabilities and deepening its industry partnerships in key fields like pharmaceuticals (for chemistry applications) and aerospace (for optimisation and simulation). The overarching goal is to establish C12 as a global leader in scalable quantum hardware, capitalising on the unique advantages of its carbon nanotube qubit approach as the quantum computing industry moves toward fault-tolerant machines.

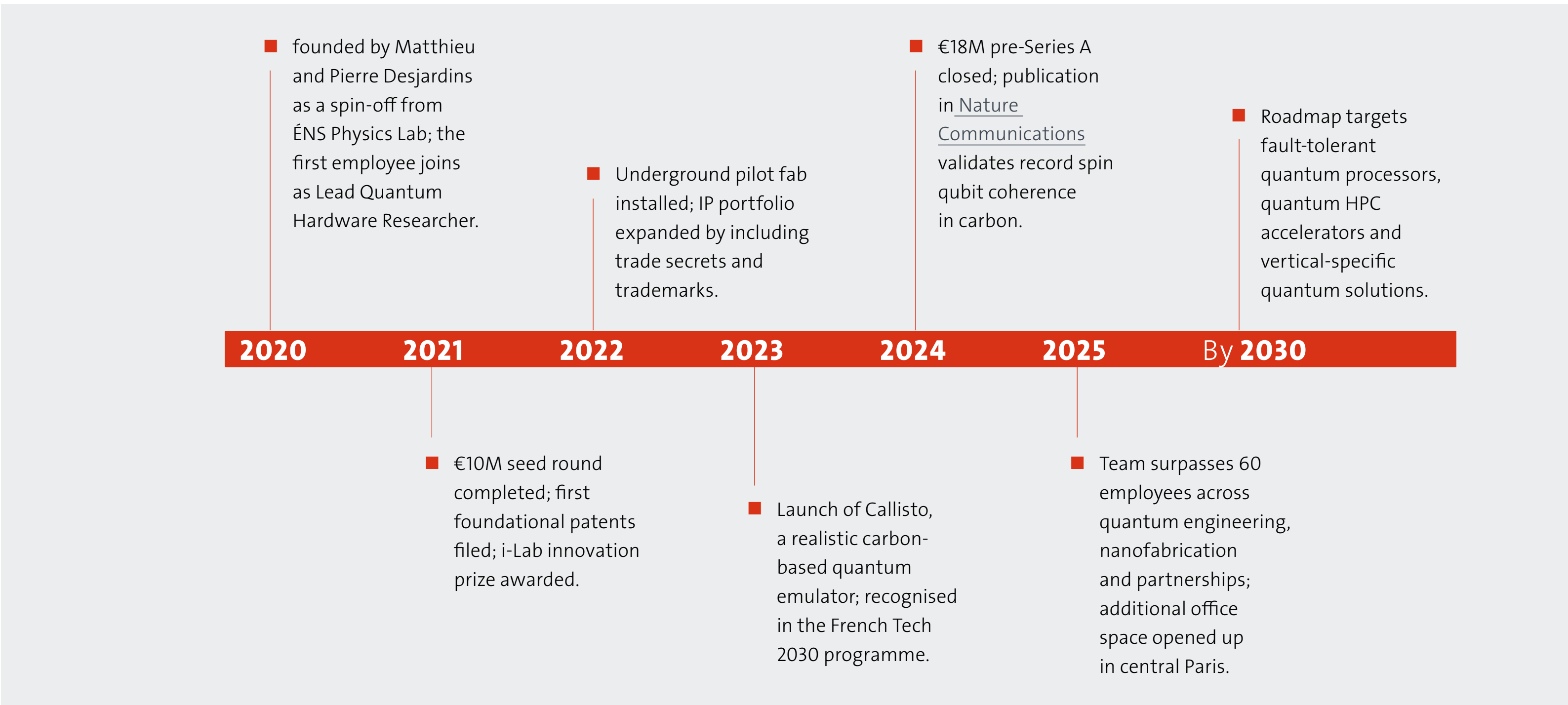


Figure 8: Timeline and key milestones

## Company profile (key facts)

- **Name:** C12 Quantum Electronics (C12)
- **Founded:** 2020 (spin-off from École Normale Supérieure, Paris)
- **Headquarters:** Paris, France
- **Founders:** Matthieu Desjardins (CTO) and Pierre Desjardins (CEO)
- **Employees:** more than 60 (2025)
- **Core technology:** quantum processors based on suspended carbon nanotube spin qubits on silicon chips
- **Initial focus applications:** quantum chemistry and materials simulation; complex logistics and optimisation problems; advanced cryptography and security; (long-term) quantum-enhanced machine learning
- **Funding raised:** approx. €25 million (seed plus Series A)
- **IP portfolio:** around ten patent families (four patents granted/published to date) plus exclusive CNRS licence to foundational patents
- **First patent application in early 2018 (EP19791211A – co-owned by ÉNS and CNRS)**
- **Key partners:** ÉNS & CNRS (academic research), CEA-Leti (fabrication scale-up), OVHcloud (cloud deployment), and corporates (e.g. Thales, Air Liquide, TotalEnergies for use-case exploration)
- **Major awards:** i-Lab Grand Prize (2021); French Tech 2030 laureate (2023); EIC Accelerator (2022); plus Hello Tomorrow Challenge, CDL Quantum Stream, NETVA programme and other national innovation grants

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