Valuing Superconducting Quantum Firms beyond Qubit Count

An Evidence Framework for Fidelity, Error Correction, Control Systems, Customers and Cash Runway

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Abstract

Superconducting quantum firms are often described by physical-qubit count. That measure is visible and easy to compare, but it cannot establish useful computational performance, manufacturability, customer value or financial durability. A smaller system with higher fidelity, stable calibration, deeper executable circuits and a credible error-correction path can carry more economic value than a larger device whose useful workload collapses under noise. The valuation decision therefore concerns the conversion of technical evidence into commercial capability and financeable milestones.

This paper develops an evidence-led valuation framework for superconducting quantum firms. It builds a metric hierarchy from physical-qubit quality through logical-error performance, system throughput, calibration burden, control electronics, software orchestration, manufacturing yield, customer acceptance, revenue quality and liquidity. It converts that hierarchy into a milestone tree, a technical-evidence ledger, a control-stack dependency map, a cash-runway model and a probability-weighted discounted-cash-flow analysis.

The evidence includes NIST work on reproducible superconducting-device characterisation and scaling measurement, Google's published error-correction results, IBM's public processor and roadmap documentation, US National Quantum Initiative material and securities filings by public quantum companies. These sources show why the valuation unit must move from installed qubits toward repeatable logical progress, integrated-system capacity and accepted customer outcomes. Vendor statements are identified as company-reported information and are not treated as independently verified operating results.

A wholly hypothetical company illustrates the method. Management reports a 144-physical-qubit superconducting system, a two-qubit gate-fidelity programme, a modular control stack, annual revenue of USD 18 million, unrestricted cash of USD 185 million and annual cash use of USD 62 million. The central valuation assigns USD 220 million to reproduced hardware and process capability, USD 140 million to control and software, USD 125 million to specialist teams and know-how, USD 80 million to contracted customers, USD 75 million to fabrication and test infrastructure and USD 140 million to probability-weighted roadmap options. Every amount, metric, scenario and probability is a management assumption created solely to demonstrate the framework; it is not an observed company result, forecast, valuation or market benchmark.

The central conclusion is that qubit count is an inventory measure rather than a valuation method. Economic value should follow reproduced error performance, the cost and time required to reach logical milestones, ownership of the control and manufacturing stack, customer acceptance, revenue quality and funded survival through the next decisive gate. A probability-weighted DCF can support board judgment when its scenarios are anchored to falsifiable technical and commercial milestones and when option value is capped by liquidity and dilution.

JEL Classification: G12, G24, G32, L86, O32, O33, O38

Keywords: superconducting quantum computing, valuation, fidelity, quantum error correction, control stack, customer evidence, cash runway, probability-weighted DCF, technology diligence, quantum hardware

Introduction

Superconducting quantum computing combines fabricated circuits, millikelvin cryogenics, microwave control, calibration, classical computing, software and error-correction research. Several well-funded organisations have demonstrated systems above one hundred physical qubits. The commercial threshold depends on useful workload performance, reproducibility, service reliability and cost. The large gap between a physical device and a valuable computing service creates the principal valuation challenge.

The practical decision is how much capital to commit today for evidence that may mature through several dependent milestones. The investor must distinguish a laboratory result from a repeatable device, a repeatable device from an integrated system, an integrated system from accepted customer use and accepted use from durable cash generation. Each transition has a different probability, timing, capital need and dilution effect.

This paper treats technical progress, commercial evidence and financing capacity as linked value drivers. It does not predict which firm will achieve useful quantum advantage or when. It provides a diligence and valuation method for boards, investors, lenders, corporate-development teams and technical advisers assessing superconducting quantum firms.

1 Define the valuation decision

The board should state the decision the valuation will support. A primary financing, secondary sale, strategic investment, acquisition, employee-equity grant and impairment test require different standards and control premiums. The analysis should identify the security, ownership rights, liquidation preferences, dilution, future funding obligations and decision horizon.

The valuation should identify the capability available today, the milestones required for the next value state and the counterfactual if progress is delayed. Management should separate achieved evidence from plans, signed customer value from pipeline, unrestricted cash from committed expenditure and core intellectual property from third-party rights. The model should show the capital required before the next independent financing decision.

Market-growth projections provide limited support for firm value. The valuation should rest on measurable technical progress, addressable workloads, customer acceptance, unit economics, capital intensity and probability of surviving to the next gate. The investment case should specify the evidence that would reduce or increase value at each milestone.

2 Separate physical scale from useful capability

Physical-qubit count describes the number of implemented quantum elements under a defined architecture. Useful capability depends on error rates, connectivity, readout, leakage, crosstalk, calibration stability, executable circuit depth, throughput, compiler performance and workload evidence. A larger chip can increase engineering learning while providing limited customer value if noise and operating burden prevent useful execution.

The valuation should use a metric hierarchy. Device metrics support component quality. System metrics support operability. Logical metrics support an error-correction path. Workload metrics support useful computation. Customer metrics support willingness to pay. Financial metrics support survival and scaling.

Evidence at a lower level cannot substitute for the next level, although it can improve the probability assigned to future states.

These layers interact. Better fabrication can improve fidelity and reduce calibration burden. Better control can increase throughput without changing physical-qubit count. Error correction can consume many physical qubits to create a smaller number of more reliable logical qubits. The model should identify where evidence converts engineering progress into commercial capacity.

3 Value superconducting systems through their operating chain

Superconducting systems use fabricated electrical circuits at cryogenic temperatures and can support fast gate operations and semiconductor-style process learning. Their economic system includes materials, wafer processes, Josephson junctions, packaging, cryogenics, microwave lines, control electronics, firmware, calibration, compilers, orchestration and classical resources. A firm may own some layers and depend on suppliers or partners for others.

The valuation should map every critical layer to ownership, capacity, replacement time and technical performance. Proprietary fabrication can shorten iteration cycles and protect process knowledge while increasing fixed cost. Purchased control systems can accelerate deployment while concentrating supplier risk. A full-stack claim should be decomposed into components that are owned, licensed, contracted or still under development.

Public roadmaps and demonstrations describe direction; they do not establish reproducibility, scale, cost or commercial timing. The investor should connect each claimed advantage to the company's current product, test data, manufacturing records, customer use and funded plan. The comparison should use workload and evidence gates rather than a league table of physical qubits.

4 Build a capability map rather than a qubit league table

A qubit count can describe system size without describing useful performance. The buyer should map physical qubits, logical qubits, gate fidelity, connectivity, circuit depth, error-detection and correction, uptime, calibration burden, job throughput, latency, software compatibility and workload results. Each measure should state test conditions, date, version and independent verification.

The map should distinguish scientific demonstration, engineering prototype, available product and contracted service. A result obtained on a selected device under laboratory conditions may be strategically important. Its transaction value depends on whether the target can reproduce it across devices, maintain it over time and expose it through an operable service.

Peer comparison within superconducting systems still requires caution because device topology, gate sets, control methods, compiler choices and test conditions differ. The investor should use workload-level tests and resource estimates where possible. A conclusion should explain the trade-off rather than compress unlike systems into a single score.

5 Test the path to fault tolerance

Fault tolerance is a programme of architecture, codes, logical operations, decoding, control, fabrication and system engineering. The target should show how physical performance converts into logical capability, which error model applies, what overhead is expected and which milestones have been demonstrated. The buyer should examine the assumptions behind resource estimates and the sensitivity to fabrication yield, loss, crosstalk, control error and decoder performance.

Company roadmaps can support diligence when reconciled with published results, internal test data and engineering plans. Google's Willow publication describes below-threshold error correction on increasing surface-code arrays. IBM's public roadmap describes fault-tolerant modules and a longer-term system path. Rigetti's securities filings describe its superconducting architecture, operating model, revenue and liquidity. These sources address different evidence categories and should not be treated as directly comparable performance claims.

The valuation model should value achieved evidence separately from future milestones. A large portion of roadmap value may depend on a fault-tolerance claim that remains unproven at the required scale. Staged financing or contingent consideration can align capital with independently defined demonstrations.

6 Diligence the full hardware stack

The target's moat may sit outside the qubit device. Control electronics, lasers, cryogenics, vacuum systems, packaging, photonics, calibration software, firmware, compilers, test methods and manufacturing recipes can determine performance and cost. The diligence team should identify each critical component, its owner, supplier, replacement time and qualification status.

The buyer should request a system bill of materials and dependency graph. It should identify single-source items, export-controlled components, custom tooling, university licences, foundry agreements and long-lead equipment. Supply agreements should be reviewed for change-of-control rights, volume commitments, price resets, exclusivity and access to failure analysis.

Capital expenditure should be linked to roadmap milestones. A target may need a new fabrication line, cleanroom, cryogenic facility or optical assembly capability before it can deliver the forecast system. The purchase price and integration budget should include that requirement rather than treating it as ordinary post-close growth investment.

7 Verify reproducibility and manufacturing evidence

The buyer should distinguish one high-performing device from a repeatable process. Evidence can include yield, variation, calibration time, failure modes, component life, rework, acceptance testing and performance distribution across systems. The diligence sample should cover multiple devices and production periods where available.

Manufacturing plans should identify which steps are internal, outsourced or shared with research institutions. Intellectual property may protect device design while manufacturing know-how remains concentrated in a small team. The buyer should assess whether process records, tooling, supplier relationships and quality systems can survive staff turnover or a site disruption.

Reproducibility can be made a closing or payment condition. An independent team can build or qualify a device using controlled documentation. The test should protect sensitive technology while demonstrating that the acquired capability is organisational rather than personal.

8 Diligence intellectual property by dependency

Patent counts do not show freedom to operate, enforceability or operational importance. The buyer should map patents, applications, trade secrets, copyrights, licences and know-how to the product architecture and roadmap. It should identify inventors, assignees, prosecution status, geographic scope, government support, university rights and encumbrances.

The map should show which claims protect the current system and which address future architectures. It should also identify design-around risk and blocking rights held by others. Where the moat depends on trade secrets, the buyer should examine access controls, employee agreements, laboratory records and the extent to which knowledge is documented.

Government-funded and university-originated work may carry licence, reporting, march-in or data-rights considerations depending on the instrument. Qualified counsel should confirm the applicable rights. The transaction should not value an asset as exclusive until ownership and third-party rights are clear.

9 Assess talent as a technical system

Quantum hardware companies can depend on a small number of physicists, device engineers, control specialists and application leaders. The buyer should identify who owns each critical decision, relationship and undocumented method. An organisation chart should be supplemented by a capability and succession map.

Retention design should reflect the work required after closing. Founders may be essential for architecture, but senior engineers, technicians, programme managers and customer scientists can carry equally important knowledge. Retention instruments should use service, transfer and milestone conditions that are achievable and consistent with employment law.

The buyer should evaluate cultural and scientific governance. A large corporate process can improve quality and scale while slowing experimentation. Integration should preserve protected research paths with accountable milestones, peer review and access to shared engineering resources.

10 Define customer access precisely

Customer access can mean a signed contract, cloud listing, reservation, funded research award, pilot, application partnership, reseller arrangement or informal relationship. Each category has different economics and transferability. The buyer should classify the portfolio and avoid treating all named counterparties as revenue customers.

For each material relationship, diligence should cover legal counterparty, product, term, committed and optional value, cancellation, acceptance, pricing, renewal, data rights, intellectual property, exclusivity, security, change of control and required personnel. Usage data should show jobs, reservations, support demand and movement from experimentation toward recurring workloads.

Customer access is valuable when it shortens the buyer's path to paid, repeatable use. A relationship that depends on the target's independent status, founder or modality may weaken after acquisition. The buyer should validate transfer through contract language and customer conversations conducted under an approved process.

11 Separate cloud distribution from customer ownership

Cloud platforms broaden access and reduce the need for customers to procure each provider directly. Amazon Braket publishes task, shot and reservation economics for supported quantum systems. Azure Quantum documents access and development workflows across multiple hardware providers. These channels can create discoverability, workflow integration and billing infrastructure.

A listing does not by itself create a defensible customer asset. The platform may control the billing relationship, usage data, placement and commercial terms. Customers can compare or switch providers. The target's value depends on contractual rights, differentiated performance, support relationships and the ability to convert platform usage into durable demand.

The buyer should map who owns customer identity, workload metadata, application code, results and support records. It should test whether the acquisition creates a conflict with a platform or other hardware participants. Channel continuity and equal-treatment provisions can matter to valuation.

12 Classify customer evidence by economic quality

Quantum customer evidence can include an announced collaboration, funded research award, government development contract, cloud-access agreement, reservation, system sale, acceptance milestone, recurring usage or renewal. Each category has different gross margin, cash timing, technical obligation and proof of willingness to pay. The valuation should classify each relationship before applying a revenue multiple or customer premium.

The contract schedule should state the legal counterparty, product, committed value, options, deliverables, acceptance tests, cancellation, pricing, collection, intellectual-property rights, data use, personnel dependency and change-of-control terms. A funded programme can validate technical relevance without establishing repeatable commercial demand. The model should distinguish development revenue from product, service and access revenue.

Customer value should follow executed rights, acceptance and observed use. Pipeline should remain outside contracted backlog until the customer is legally committed. Public-sector and research customers can provide credible technical validation; their budgets, procurement cycles, termination rights and concentration should be reflected in cash-flow scenarios.

13 Map public-funding, data and intellectual-property rights

Publicly funded work can create value and restrictions simultaneously. Technical data, software, reports, interfaces, patents and test results may be subject to grant terms, consortium agreements, procurement clauses, university rights or negotiated licences. The target may own foreground intellectual property while another participant or authority holds access, use or dissemination rights.

The diligence team should trace each material capability to its funding source and executed instrument. It should examine background rights, foreground ownership, access rights, publication obligations, exploitation commitments, location conditions, reporting, repositories, subcontractor flow-downs and change-of-control provisions. Inconsistent records can weaken the assumed exclusivity or transferability of an asset.

The buyer should identify rights needed to reproduce, improve and commercialise the technology. A public customer's or consortium partner's rights may facilitate alternative suppliers or constrain exclusivity. The resulting asset may remain valuable, with a different durability, pricing and integration path from wholly proprietary technology.

14 Analyse revenue quality and concentration

Quantum revenue can include hardware sales, cloud usage, reservations, consulting, development contracts, grants and milestone awards. The buyer should separate each stream by margin, cash conversion, recurrence, cancellation and technical dependency. Reported growth can be driven by a small number of awards or acquisitions.

Rigetti's 2025 annual filing reports that most current revenue came from development contracts, alongside continuing losses and significant cash and investment balances. Those company disclosures illustrate the need to value revenue with its delivery cost, concentration, funding source and liquidity rather than applying a mature software multiple.

The buyer should build customer cohorts and contract waterfalls. It should identify how much revenue depends on one agency, platform, research partner or application team. Concentration can be acceptable when the relationship creates technical learning and renewal evidence; it should still be reflected in scenario analysis and liquidity planning.

15 Test application evidence and willingness to pay

The transaction thesis should name the workloads that the combined system is expected to serve. Chemistry, materials, optimisation, machine learning and security are broad categories. The buyer should identify the problem instance, classical baseline, quantum resource requirement, accuracy, total workflow cost and decision value.

Scientific advantage, computational advantage and commercial value are separate tests. A benchmark can show performance beyond a classical method under defined conditions without establishing a paid workflow. An application pilot can show customer interest without establishing scalability or renewal.

Customer diligence should ask what decision changed, what classical method was displaced or complemented, which budget funded the work and what evidence would support expansion. Willingness to pay should be based on contracts and observed behaviour where available. Future application value should remain a scenario until supported.

16 Apply regulatory and accounting boundaries to value

Quantum firms can face export controls, foreign-investment screening, government-contract restrictions, public-funding conditions, cybersecurity, sanctions and research-security requirements. The perimeter depends on technology, ownership, customers, locations, end use and information access. Qualified counsel should confirm the current requirements for a specific investment or transaction.

Technology classification affects diligence access, customer eligibility, engineering collaboration, cloud environments and future sales. Accounting classification also matters. Development expenditure, acquired intellectual property, warrants, earn-outs, stock-based compensation and government awards can alter reported results without resolving technical value. The valuation bridge should reconcile enterprise value, net cash, derivative liabilities, preferences and fully diluted ownership.

Restrictions and mitigations should be converted into cost, delay, market-access and governance effects before the board approves value. The model should separate accounting presentation from cash use and should identify obligations that rank ahead of common equity.

17 Use market comparables as a reasonableness check

Public quantum companies provide observable market capitalisations, financial statements and disclosures. They differ materially by modality, stage, capital structure, government exposure, cash balance, revenue mix and technical evidence. A headline enterprise-value-to-revenue multiple can magnify small revenue denominators and hide the capital required to reach future products.

The comparable set should normalise unrestricted cash, debt, derivative and earn-out liabilities, preferred rights, stock-based compensation, dilution, acquisitions, revenue recognition and continuing research expenditure. Technical comparison should use evidenced fidelity, logical progress, system availability, manufacturing and customer acceptance. Management roadmaps should remain separate from achieved results.

Comparable companies can support a range or detect an inconsistent conclusion. They should not determine value without scenario and financing analysis. The investor should record the observation date, security prices, shares, options, warrants, cash and liabilities used so the calculation can be reproduced.

18 Design technical diligence around falsifiable tests

Technical diligence should begin with management's most consequential claims. Each claim should have a test, dataset, version, owner, acceptance threshold and failure implication. Examples include a reproducible fidelity level, logical-error trend, calibration time, job throughput, manufacturing yield or workload result.

The investor should use independent experts who can evaluate the architecture without disclosing restricted information improperly. Clean-room or staged access may be necessary. The diligence report should state what was observed, what was reproduced, what was reviewed only as documentation and what could not be verified.

Claims that cannot be tested before signing can move into transaction mechanics. Holdbacks, milestones, access rights and termination provisions can allocate the uncertainty. A generic warranty that all technology works as intended provides limited protection against roadmap risk.

19 Construct an evidence-adjusted valuation

Valuation should separate achieved assets from roadmap options. Achieved value can include functioning systems, patents, software, contracts, qualified facilities and reproducible know-how. Option value can include future fault-tolerance milestones, manufacturing scale, application breakthroughs and new markets. The discount rate or probability should reflect technical and commercial dependencies.

The model can use cost, income and market evidence selectively. Replacement cost may support specialised facilities and documented development, although it does not measure the probability of success. Income analysis can support contracts and customer relationships when cash flows are identifiable. Market transactions require careful normalisation because consideration, stage, architecture and strategic context differ.

The board should see a value bridge by capability. A single enterprise value can conceal whether management is paying for technology, talent, channel, contracts, strategic defence or market signalling. Each component should have evidence and a post-close owner.

20 Use milestone-based financing and valuation

Quantum roadmaps create a strong case for milestone-based financing when gates are objective, material and controllable. Technical milestones can include independently reproduced fidelity, an improving logical-error trend, manufacturing yield, continuous operation, system delivery or customer acceptance. Commercial milestones can include funded awards, product revenue, renewals, usage or gross-margin thresholds.

The financing plan should define the test environment, responsible evaluator, permitted changes, data access, timing and capital released at each gate. A milestone should be technically meaningful and should not be created solely to support the next financing. Investors should see the resources and dependencies required to achieve it.

Capital can combine ordinary equity, preferred equity, strategic funding, government awards, customer prepayments and asset finance. The model should distinguish operating cash from restricted programme funding and should incorporate dilution, preferences and transaction costs. Qualified advisers should confirm accounting, legal and tax treatment.

21 Protect the roadmap through capital-allocation governance

The company needs one accountable roadmap connecting technical evidence to capital. Research teams may retain protected experimentation, while shared cash, facilities, customers and engineering dependencies require explicit governance. The plan should identify which milestones unlock spending, which capabilities remain exploratory and which decisions require board review.

A technical-capital council can reconcile hardware, control, software, error correction, manufacturing and application priorities. It should own interfaces, resource conflicts, milestone evidence and capital gates. Commercial teams should not promise capabilities outside the approved roadmap.

Governance should preserve useful scientific independence while preventing open-ended capital commitments. Early closure of laboratories, toolchains or supplier relationships can destroy evidence and slow development. Funding sequence should follow technical dependencies and liquidity thresholds.

22 Convert customer evidence into valuation support

The investor should reconcile customer claims to executed contracts, invoices, acceptance records, usage, collections and renewals. Government and research counterparties may fund valuable development while retaining termination, security or data rights. Commercial partners may supply technical learning without committing production revenue.

The customer schedule should identify legal counterparty, workload, contract status, technical dependency, next decision and risk. It should separate committed backlog from options and pipeline. Pricing and renewal assumptions should follow observed acceptance and capability rather than the existence of a logo or memorandum.

Customer evidence can raise scenario probability, shorten commercial timing or support a separate contract value. The metric should use collected or contractually committed value, defined margin and a clear attribution period. Pilots and non-binding collaborations should not receive the same treatment as recurring paid workloads.

23 Govern security and controlled information

Quantum companies can hold controlled technology, government information, customer data, source code, fabrication records and sensitive research. The integration perimeter should classify repositories, identities, laboratories, devices and collaboration tools before broad access is granted.

The buyer should preserve least privilege, export-control restrictions, contractual access limits and incident evidence. Employees and contractors should be mapped by nationality, location, role and authorisation where legally relevant. Sensitive diligence material should not migrate automatically into ordinary integration systems.

The Day One plan should define security authority, incident escalation, key custody, logging and continuity. A transaction can create risk if two strong control environments are connected without a common design. Security integration should follow a documented architecture and regulatory advice.

24 Build the capital and liquidity plan

Current enterprise value is one part of the capital requirement. The company may need to fund facilities, equipment, foundry commitments, component inventory, research programmes, retention, customer support and operating losses. The model should show liquidity and dilution under technical delay and customer-conversion scenarios.

Equity can absorb roadmap risk. Debt may suit predictable assets or contracted cash flows when covenants recognise development volatility. Government awards and customer prepayments can support milestones, subject to restrictions and performance obligations. The financing mix should not force a premature technical claim to satisfy a near-term covenant.

The board should approve a runway reserve for technical and commercial remediation. It should identify conditions that trigger capital reallocation, partnership or programme closure. Strategic importance does not remove the need for portfolio discipline.

25 Define the first 100 days of valuation diligence

The first 100 days should establish evidence, ownership, customer quality and roadmap accountability. Day One priorities include the data request, security protocol, technical test plan, cash definition, fully diluted cap table and decision rights. The diligence team should preserve system and financial baselines before relying on management adjustments.

By Day 30, the team should reconcile the capability map, contracts, intellectual property, controlled information and capital plan. By Day 60, it should complete independent technical tests, customer sampling and scenario design. By Day 100, it should deliver a reproducible valuation range, milestone baseline, financing plan and board decision record.

The plan should include explicit limitations. A restricted data room, incomplete customer access or untested roadmap should appear as a valuation limitation rather than an assumed success. Delay can be a controlled decision when a near-term test can resolve uncertainty.

26 Monitor value through an evidence dashboard

The board dashboard should connect technical, commercial and financial evidence. Measures can include independently verified performance, system availability, job throughput, manufacturing yield, roadmap spend, critical retention, contract value, customer conversion, gross margin, government eligibility and integration risk.

Each measure should state baseline, target, owner, source and decision threshold. Metrics should remain comparable across periods and system versions. A technical improvement that increases cost or reduces availability should be visible as a trade-off.

The dashboard should separate observed results from management forecasts. It should also show scenario probability, financing need, dilution and liquidity exposure. The purpose is to support capital allocation and intervention rather than to present a favourable narrative.

27 Prepare downside and exit paths

The investor should plan for technical delay, architecture reprioritisation, customer loss, regulatory restrictions and key-person departure. The downside plan can include licence structures, asset sales, team carve-outs, partnerships, research discontinuation and preservation of transferable intellectual property.

Investment documents should secure reporting, inspection and governance rights proportionate to the risk. Financing tranches should adjust when milestones fail for defined reasons. Retention packages should avoid trapping capital in a programme that the board has rationally discontinued.

Exit value depends on clean ownership and separability. The asset map should record which rights, systems, facilities and contracts belong to each programme. Excessive technical entanglement can make a future sale, licence or partnership difficult.

28 Set the board decision agenda

The board should ask whether the valuation decision is defined, whether technical capability has been reproduced, whether logical progress is supported by data, whether the control stack and rights are owned, whether customers have accepted and paid, whether regulatory paths are viable and whether the roadmap can be funded. It should understand the portion of value attributable to achieved evidence, contracts, infrastructure, team and future options.

Approval conditions should include technical tests, intellectual-property confirmation, material contract consents, regulatory analysis, retention, security controls and a funded integration plan. The decision record should identify unresolved matters and the mechanism that prices or controls each one.

The final question is accountability. One executive should own the integrated technical roadmap, named leaders should own hardware, control, error correction and customer conversion, and one board process should reconcile capital with evidence. The governance system should state which experiments remain protected, which resources are shared and which evidence triggers concentration, additional funding or withdrawal.

Conclusion

A superconducting quantum company should be valued as an evidence-producing system. Physical qubit count is one input. Device quality, reproducibility, error-correction progress, control architecture, customer acceptance, intellectual-property ownership and funded runway determine whether those qubits can become a reliable product and an investable business.

The valuation should separate achieved evidence from future options. Achieved capability can support conventional asset, income and market analysis where evidence permits. Roadmap value requires explicit milestones, conditional probabilities, timing, follow-on capital and dilution. Customer evidence should distinguish paid acceptance from experimentation, grants and unsigned interest. Infrastructure should be valued through replacement cost, bottleneck value and utilisation rather than prestige.

Boards can use this framework to decide whether to invest, acquire, partner, finance or wait. The core discipline is traceability. Every material valuation component should point to an observed result, a contractual right, a controlled asset or a clearly identified management assumption. That discipline makes technical disagreement visible, concentrates diligence on value-moving questions and preserves the ability to revise the valuation as evidence changes.

Appendix A Superconducting metric hierarchy

The metric hierarchy starts with device-level evidence: coherence, one- and two-qubit gate error, readout error, connectivity, leakage, calibration stability and wafer or device yield. These measures require test conditions, distributions and repeated results. A best device or selected run cannot stand in for fleet performance.

The second level is system performance. It covers executable circuit depth, throughput, latency, uptime, queueing, calibration overhead, compiler performance and the control stack. The third level is logical progress: syndrome extraction, decoder performance, repeated error-correction cycles, error suppression as code distance grows and the presence of an error floor. The fourth level is customer evidence: accepted deliverables, repeat usage, paid revenue and a credible path from experimental access to production economics.

Valuation should identify the highest level supported by evidence. A company with excellent devices and limited system reliability may have valuable technical assets while remaining distant from recurring commercial revenue. A company with customer-funded development may possess strong relationships while retaining technical delivery risk. The hierarchy prevents a single headline metric from obscuring those differences.

Appendix B Milestone probability and roadmap value

Each roadmap milestone should have a defined technical test, baseline date, responsible owner, required capital, decision date and consequence. Probability estimates should be conditional. The chance of a commercially relevant logical system depends on prior milestones such as reproducible device quality, scalable control, real-time decoding, stable repeated cycles, manufacturable packaging and sufficient cryogenic capacity.

The model should avoid multiplying unsupported point estimates through a long chain. Use ranges, dependency maps and periodic reassessment. A financing round can be linked to a bounded evidence package. A strategic buyer can use contingent consideration or staged investment. A board can discontinue an option when the next evidence gate no longer justifies its capital requirement.

Roadmap value should reflect dilution and time. A technically successful programme that requires several large financings may create less value for current holders than a smaller but better funded programme. The model should therefore reconcile enterprise value, new capital, ownership dilution and liquidity under each scenario.

Appendix C Valuation data room

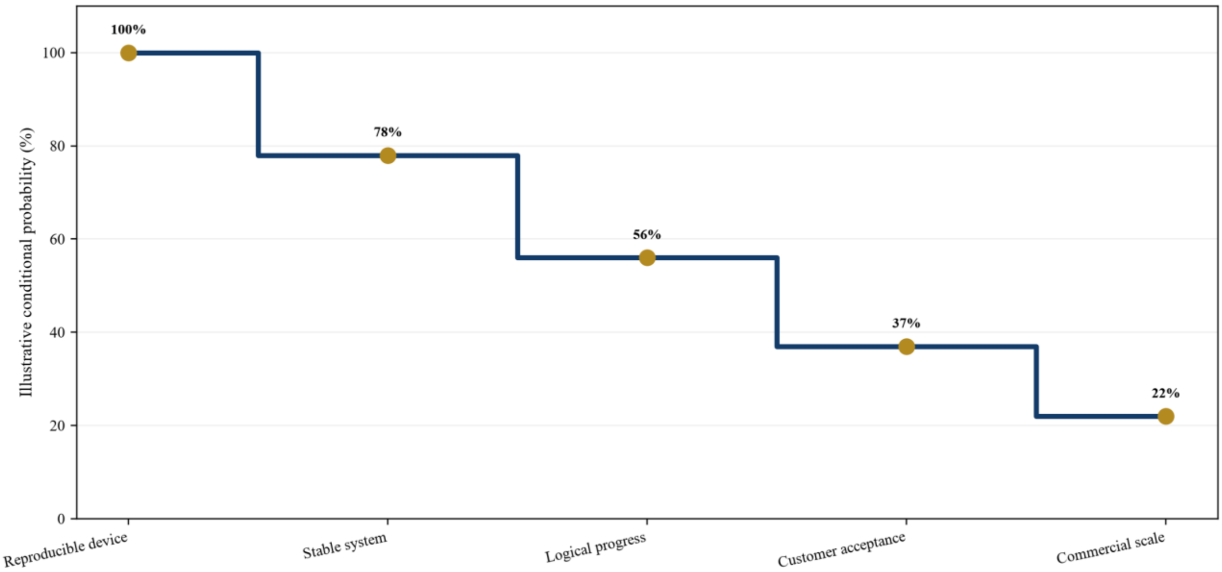
The valuation data room should contain raw and processed device results, calibration histories, system availability records, test protocols, failed runs, fabrication lots, yield distributions, packaging and cryogenic specifications, bills of materials, supplier agreements, control electronics, firmware, software repositories, decoder evidence, patent schedules, invention records and third-party rights.

Commercial records should include executed customer contracts, acceptance criteria, usage logs, invoices, cash receipts, renewal or expansion evidence, cloud-provider arrangements, government awards and restrictions. Financial records should reconcile revenue recognition, backlog, remaining performance obligations, research funding, capital expenditure, commitments, cash, investments and monthly cash use.

The diligence report should state which claims were reproduced, which records were sampled and which information could not be reviewed. Sensitive technical material can be examined through clean teams, controlled repositories or independent experts. Any unresolved evidence gap should appear in the valuation, financing terms or approval conditions.

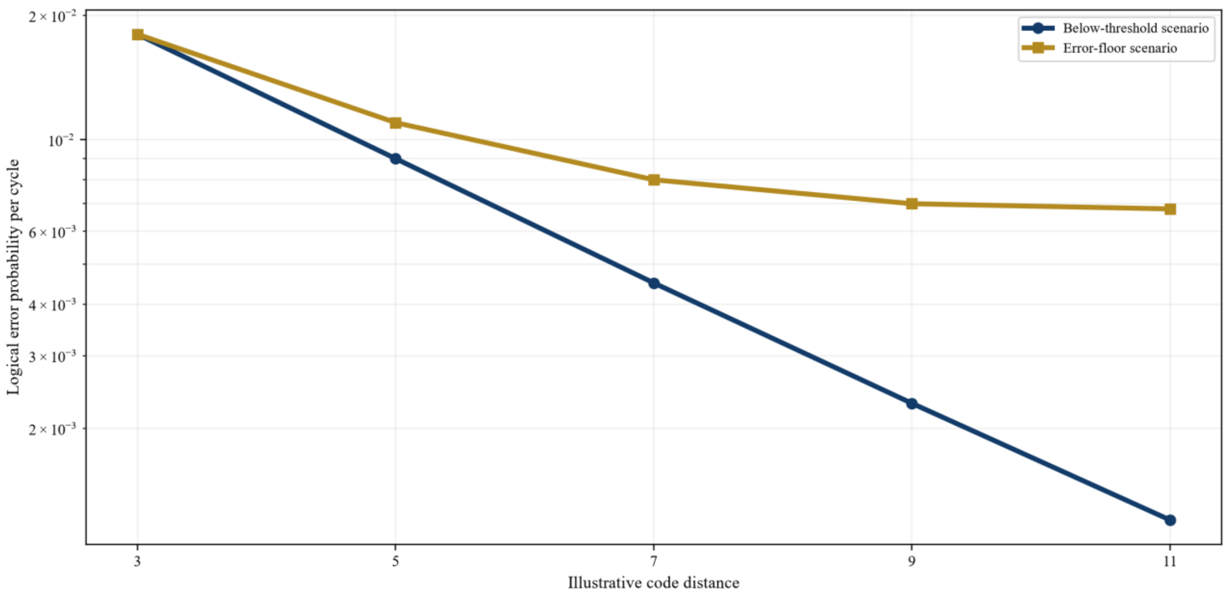
Appendix D Decision figures and tables

Figure 1. Superconducting quantum valuation milestone tree



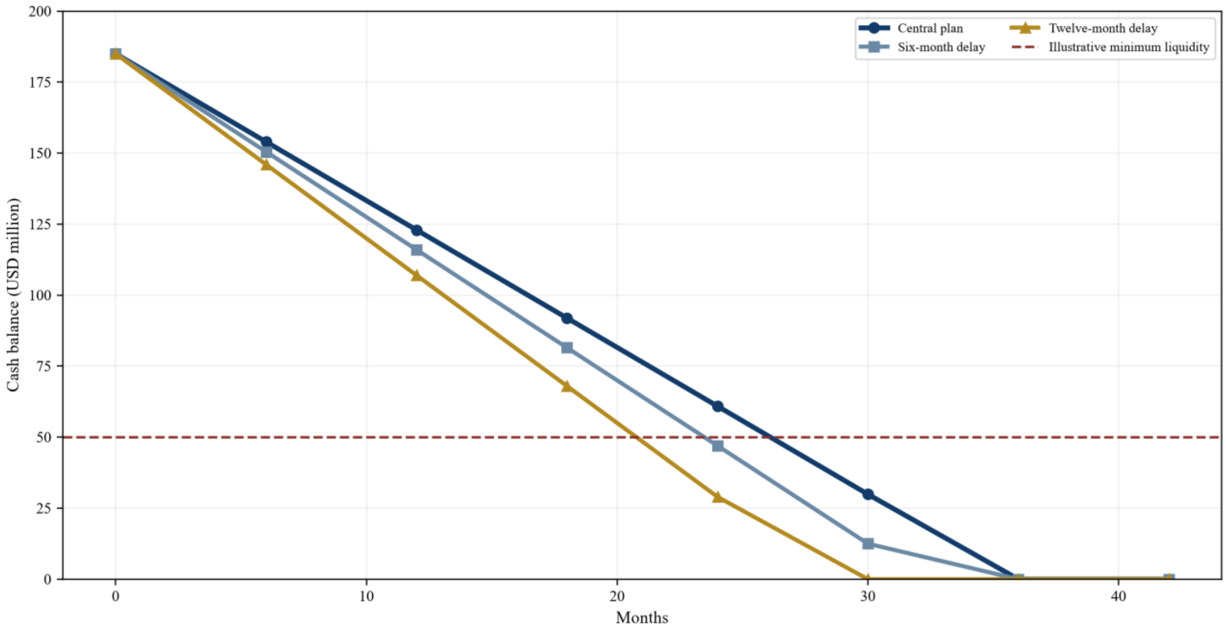
Proposed evidence sequence. Each branch requires a defined test before additional roadmap value is recognised.

Figure 2. Illustrative logical error-rate response to increasing code distance



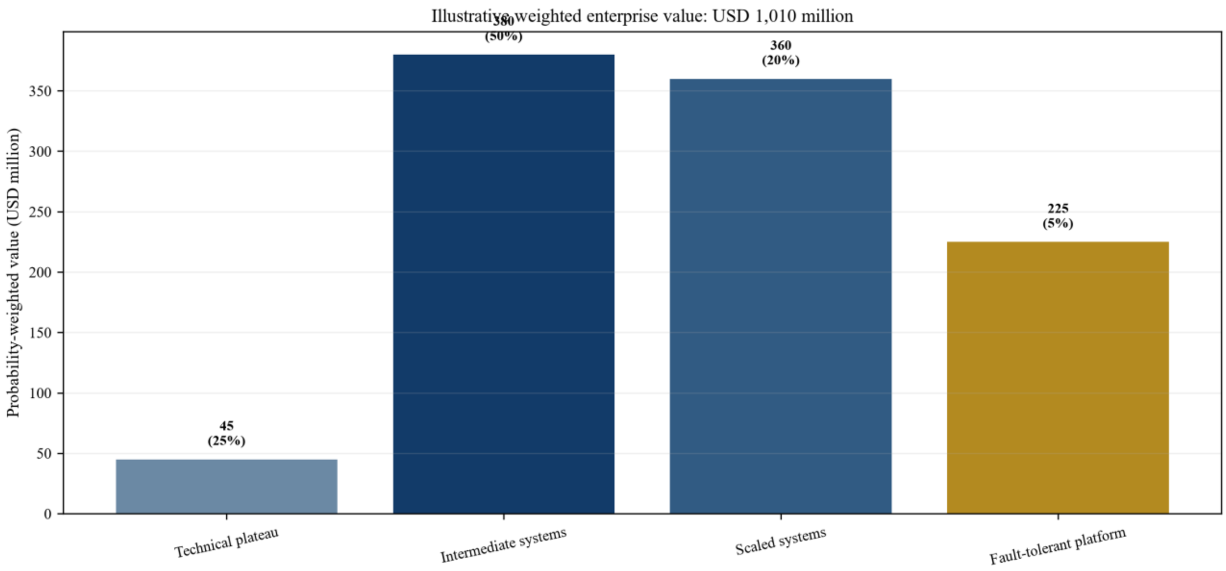
Hypothetical management assumptions for valuation discussion; not observed technical performance.

Figure 3. Illustrative cash runway under technical-delay scenarios



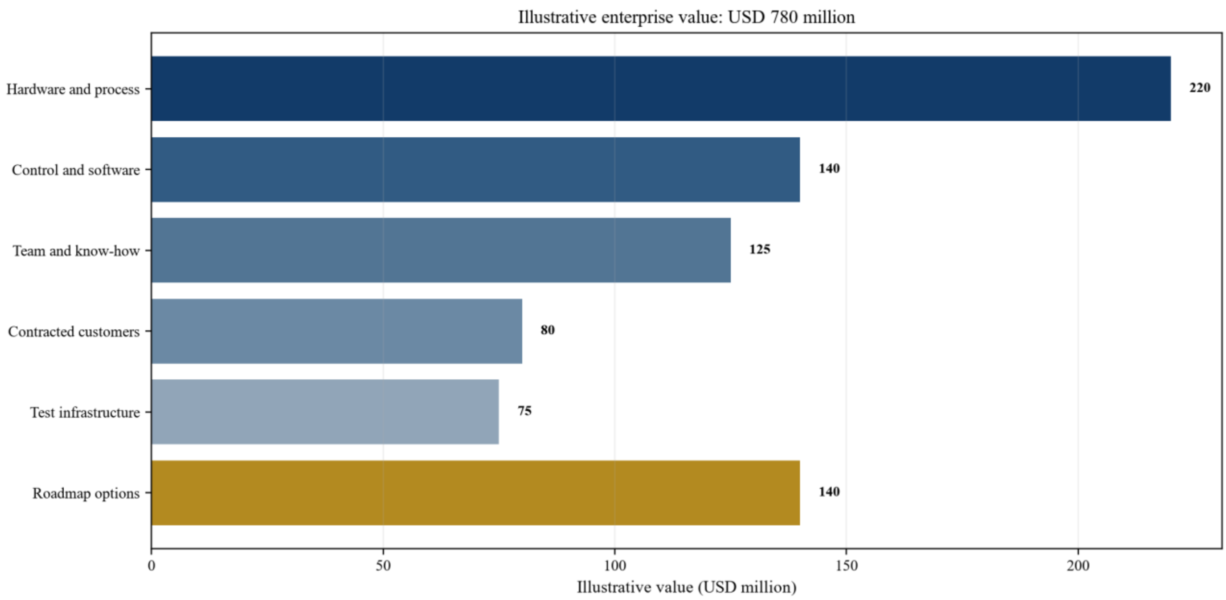
Hypothetical management assumptions; USD million. Financing proceeds are excluded.

Figure 4. Hypothetical probability-weighted enterprise value



Wholly hypothetical management assumptions; USD million present value.

Figure 5. Hypothetical evidence-based valuation bridge



Wholly hypothetical management assumptions; USD million.

Table 1. Metric hierarchy for superconducting quantum valuation

Level	Evidence	Valuation question	Common failure
Device	Coherence, gate and readout error, leakage, yield	Is performance repeatable across devices and lots?	Selected best result presented as fleet performance
System	Circuit depth, throughput, uptime, calibration and control	Can the system execute useful work reliably?	Hardware metric excludes operating overhead
Logical	Syndrome cycles, decoder latency, suppression and error floor	Does added code distance improve logical performance?	Small demonstration extrapolated without dependency analysis

Level	Evidence	Valuation question	Common failure
Commercial	Accepted deliverables, paid usage, renewal and expansion	Do customers pay for repeatable outcomes?	Collaboration or grant treated as recurring demand

Proposed hierarchy; metrics require test conditions and distributions.

Table 2. Technical evidence ladder

Evidence stage	Minimum record	Independent check	Valuation treatment
Component	Raw test data and calibration	Re-run selected tests	Asset and know-how value
Integrated device	Multi-qubit results across repeated runs	Reproduce protocol on held-out device	Conditional system value
Fleet	Distribution across devices and time	Sample availability and maintenance records	Reliability adjustment
Logical experiment	Decoder, syndrome and error-floor data	Verify code-distance response	Probability-weighted roadmap value
Customer acceptance	Contractual test and accepted output	Reconcile invoice, acceptance and cash	Contract and relationship value

Proposed diligence sequence.

Table 3. Control-stack ownership and dependency map

Layer	Evidence	Dependency risk	Value implication
Cryogenic and microwave control	Schematics, vendor rights and service records	Scarce components and field support	Replacement cost and uptime sensitivity
Firmware and pulse control	Repository, build record and employee rights	Key-person and undocumented code	Retention and remediation reserve
Calibration automation	Historical logs and reproducibility	Architecture-specific methods	Transferability adjustment
Compiler and runtime	Benchmarks, licences and customer use	Third-party software or cloud terms	Margin and switching-cost adjustment
Decoder and orchestration	Latency evidence, interfaces and rights	Unproven real-time performance	Milestone option value

Proposed minimum ownership review.

Table 4. Hypothetical valuation allocation

Value component	Illustrative amount	Evidence gate	Downside treatment
Hardware and process	USD 220 million	Reproduced device and yield evidence	Technical holdback
Control and software	USD 140 million	Rights, build and performance evidence	Remediation reserve
Team and know-how	USD 125 million	Critical-role retention and transfer	Service-based retention
Contracted customers	USD 80 million	Acceptance, renewal and cash evidence	Conversion adjustment
Fabrication and test infrastructure	USD 75 million	Ownership, condition and utilisation	Replacement-cost cap
Roadmap options	USD 140 million	Funded milestone tree	Staged capital and probability update

Wholly hypothetical management assumptions; not observed company or transaction data.

Table 5. Customer evidence quality ladder

Evidence	What it proves	What it does not prove	Valuation use
Research collaboration	Access and joint activity	Recurring willingness to pay	Relationship evidence only
Government award	Funded scope and policy support	Commercial product-market fit	Contracted cash with restrictions
Paid pilot	Budget and defined experiment	Renewal or scalable gross margin	Probability-adjusted conversion value
Accepted delivery	Performance against contractual criteria	Long-term retention	Contract value with delivery history
Repeat paid use	Continuing budget and operational relevance	Fault-tolerant market scale	Stronger revenue and relationship evidence

Proposed commercial diligence classification.

Table 6. Hypothetical runway scenarios

Scenario	Starting cash	Annual cash use	Approximate runway	Valuation consequence
Central plan	USD 185 million	USD 62 million	36 months	Fund next gate with moderate buffer
Six-month delay	USD 185 million	USD 69 million	32 months	Earlier financing and dilution
Twelve-month delay	USD 185 million	USD 78 million	28 months	Reduced negotiating leverage
Protected liquidity	USD 185 million	USD 62 million plus USD 50 million floor	26 months to floor	Board intervention before cash exhaustion

Wholly hypothetical management assumptions; financing proceeds are excluded.

Table 7. Board approval thresholds

Decision area	Green evidence	Amber condition	Red condition
Technical	Reproduced distributions and improving logical evidence	Limited sample with funded validation	Selected result without raw evidence
Control stack	Rights, build process and accountable owners confirmed	Remediation plan with cost and date	Critical dependency unavailable or unowned
Customers	Paid acceptance and repeat demand	Funded pilot with clear acceptance	Unsigned interest treated as revenue
Runway	Next decisive gate funded with buffer	Financing required before gate	Liquidity shortfall with no credible plan
Valuation	Achieved value and roadmap options separated	Probability range remains wide but bounded	Headline qubit count drives price

Proposed decision framework.

Frequently asked questions

Q: Why is physical qubit count insufficient for valuation? A: Physical qubit count does not establish error rates, connectivity, uptime, reproducibility, logical performance, manufacturability or customer value. Valuation requires the full evidence chain from device quality to accepted commercial delivery.

Q: Which technical metrics matter most? A: The relevant set depends on the architecture and intended workload. For superconducting systems it commonly includes coherence, one- and two-qubit error, readout error, leakage, connectivity, calibration stability, yield, circuit depth, throughput, uptime and logical error behaviour under defined conditions.

Q: How does logical error performance affect value? A: Evidence that logical error declines as code distance or repeated correction increases can raise confidence in the roadmap. The result should be reproducible, include decoder and system dependencies, and disclose any error floor. A small experiment remains one milestone rather than proof of commercial fault tolerance.

Q: How should a valuation model treat the technical roadmap? A: Define conditional milestones, required capital, timing and probability ranges. Discount each scenario for time, technical dependency, financing and dilution. Reassess the probabilities when evidence changes.

Q: Why does the control stack matter? A: Cryogenics, microwave control, firmware, calibration, compiler, runtime and decoder systems determine whether the device can operate reliably. Ownership, documentation, supplier dependency and key-person concentration affect transferability, operating cost and downside value.

Q: What customer evidence supports valuation? A: Executed contracts, accepted deliverables, invoices, cash receipts, repeat use and expansion provide progressively stronger evidence. Research collaborations, grants and unsigned interest can support relationships or funded scope, but require separate treatment from recurring commercial demand.

Q: How should runway and dilution enter the valuation? A: The model should fund the next decisive technical and commercial gates, maintain a liquidity buffer and show the ownership effect of each financing. Delay can reduce current-holder value even when the long-term technical scenario remains successful.

Q: What should a board require before approving an investment or acquisition? A: Require reproducible technical evidence, rights to the control stack and intellectual property, customer and cash reconciliation, a dependency-aware milestone tree, a funded runway, downside and exit paths, retention arrangements and a valuation bridge that separates achieved evidence from future options.

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