Photonic Quantum Company Valuation: Manufacturing Yield as the Hidden Driver

An Evidence Framework for Foundry Control, Optical Loss, Packaging, Commercial Proof and Funded Scale

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Abstract

Photonic quantum companies promise a route from semiconductor-scale manufacturing to fault-tolerant computation, yet their economic value can be dominated by a less visible variable: manufacturing yield across the complete optical system. A wafer may contain functional sources, interferometers, switches and detectors while failing to produce enough known-good dies, packaged modules or accepted systems at the required optical-loss budget. Valuation therefore depends on the conversion of fabricated devices into repeatable, networked and commercially usable machines.

This paper develops an evidence-led valuation framework for photonic quantum companies. It separates wafer yield, known-good-die yield, optical loss, source indistinguishability, detector efficiency, fusion fidelity, packaging yield, module yield, system availability and accepted customer outcomes. It converts those measures into a manufacturing evidence ladder, a yield-cost model, a capital plan, a milestone tree and a probability-weighted valuation.

The analysis uses primary and authoritative evidence from peer-reviewed photonic-quantum research, DARPA and public transaction filings. A 2025 Nature paper reported a feature-complete silicon-photonics platform fabricated through a 300-millimetre GlobalFoundries process, with conditional benchmarks for state preparation and measurement, independent-source interference, fusion operations and chip-to-chip interconnection. The paper expressly reported those performance measures as conditional on photon detection and excluding loss. A separate Nature paper described a modular photonic system spanning 35 photonic chips, 84 squeezers and 36 photon-number-resolving detectors, while identifying optical loss as the dominant obstacle. These results provide strong technical evidence under stated conditions; commercial yield, installed-system economics and recurring demand require separate proof.

A wholly hypothetical company illustrates the method. Management reports a qualified 300-millimetre foundry process, 18 characterised photonic modules, 52 percent known-good-die yield, 68 percent packaged-module yield, annual revenue of USD 20 million, unrestricted cash of USD 220 million and annual cash use of USD 78 million. Its central valuation allocates USD 260 million to the qualified platform and process rights, USD 185 million to packaging, test and control capability, USD 155 million to software and orchestration, USD 160 million to specialist teams and know-how, USD 95 million to contracted customers, USD 75 million to laboratory and deployment infrastructure and USD 120 million to probability-weighted roadmap options. Every figure, scenario and probability in the worked model is a management assumption created solely to demonstrate the framework.

The analysis concludes that fabrication scale creates value when it increases accepted system output within a controlled loss and reliability budget. Investors should test distributions across wafers, dies, packages, modules and systems; trace optical loss through every interface; reconcile foundry and packaging dependencies; and connect technical acceptance to cash runway. A probability-weighted *valuation can support a financing or acquisition decision when each value state has a falsifiable manufacturing gate, a defined capital requirement and a commercial acceptance test.*

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

Keywords: photonic quantum computing, valuation, semiconductor yield, optical loss, packaging yield, foundry control, quantum error correction, customer evidence, technology diligence

Introduction

Photonic quantum computing combines photon sources, interferometers, switches, delay lines, detectors, fibre or free-space interfaces, packaging, calibration, control electronics, compilers, classical processors and error correction. Its attraction includes compatibility with semiconductor manufacturing and room-temperature optical routing. Scale introduces cumulative optical loss, component variation, source quality, detector integration, packaging alignment, thermal stability, electronic control and test-volume challenges. The commercial threshold depends on accepted system output, repeatability, service reliability and total cost.

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 manufacturing evidence, technical progress, commercial acceptance 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 photonic 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 fabricated volume from useful capability

Wafer starts describe fabrication activity. Functional-device yield, known-good-die yield, packaged-module yield and accepted-system yield describe different economic states. Useful capability depends on source purity, indistinguishability, switch and interferometer fidelity, detector efficiency, fusion performance, cumulative optical loss, calibration stability, executable circuit depth, throughput, compiler performance and workload evidence. Higher wafer volume can increase engineering learning while providing limited customer value when device variation, loss or packaging failures prevent usable system output.

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 source and detector integration can reduce coupling loss and assembly steps. Passive alignment, wafer-level test and known-good-die screening can improve package yield. Lower propagation, switch and connector losses can increase the probability that enough photons survive an operation. Error correction consumes physical photons, optical components and classical decoding capacity to create more reliable logical qubits. The model should identify where each engineering gain converts into accepted module output and commercial capacity.

3 Value photonic quantum systems through their manufacturing chain

Photonic systems create, transform, route, interfere and detect quantum states of light. Their economic system includes source materials, silicon or compound-semiconductor processes, waveguides, modulators, switches, interferometers, resonators, delay structures, photon-number-resolving detectors, electronic control, fibre attach, packaging, automated test, calibration, compilers, schedulers, decoders and classical compute. Modular architectures may connect multiple chips or cryogenic detector assemblies through optical fibre.

The valuation should map every critical layer to ownership, qualified capacity, replacement time, yield and technical performance. Proprietary process modules, circuit layouts, packaging recipes and test methods can shorten iteration cycles and protect know-how while increasing fixed cost. A commercial foundry can provide industrial process control while concentrating allocation, change-control and intellectual-property risk. Optical packaging and automated calibration can reduce manual assembly; the investor should verify achieved yield, loss, cycle time and rework cost. 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 photonic quantum 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, resource states, fusion operations, error detection, decoding, switching, synchronisation and system engineering. The target should show how source, circuit, detector and loss performance convert into logical capability, which error model applies, what overhead is expected and which milestones have been demonstrated. The buyer should examine sensitivity to photon loss, distinguishability, fusion error, detector error, switch loss, interconnect loss, decoder latency and the duration of an error-correction cycle.

Company roadmaps can support diligence when reconciled with peer-reviewed results, internal test data and engineering plans. Fusion-based architectures provide a formal route from photonic resource states and measurements to fault-tolerant computation. Published work has estimated photon-loss thresholds under stated architectures, while modular demonstrations have shown large optical networks and real-time decoding with sub-threshold component performance still required. DARPA selected Xanadu for Stage B of the Quantum Benchmarking Initiative and identifies PsiQuantum in the final phase of the Underexplored Systems for Utility-Scale Quantum Computing programme. These programmes test utility-scale claims against cost and schedule evidence; they do not substitute for investor diligence.

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 quantum circuit layout. Source engineering, foundry process modules, device design, detector integration, fibre attach, optical packaging, cryogenic interfaces, electronic control, calibration software, firmware, compilers, decoders, test methods and process-control 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 foundry non-recurring engineering, mask sets, wafer reservations, automated wafer probing, optical packaging capacity, cryogenic detector integration, burn-in, reliability test and a system-assembly line 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 circuit from a repeatable manufacturing process. Evidence should include wafer maps, parametric distributions, known-good-die yield, packaging yield, optical-loss budgets, failure modes, component life, rework, acceptance testing and performance distributions across systems. The diligence sample should cover multiple wafers, lots, packages and production periods where available.

Manufacturing plans should identify which steps are internal, outsourced to foundries or packaging houses, or shared with research institutions. Intellectual property may protect device design while yield-learning and packaging know-how remain concentrated in a small team or external supplier. The buyer should assess whether process-control records, design kits, tooling, supplier relationships and quality systems can survive staff turnover, a process migration 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.

Xanadu's SEC-filed transaction materials provide a useful public example. The proposed transaction was announced at a USD 3.0 billion pre-money equity value and approximately USD 3.1 billion pro forma enterprise value, subject to transaction assumptions. A later SEC filing reported that the business combination closed on 26 March 2026 with approximately USD 301.6 million of gross proceeds, including USD 275 million from the private placement and approximately USD 26.6 million from the SPAC. The same filing reported approximately USD 276 million of cash at closing. Xanadu's filed 2025 financial information reported USD 4.617 million of revenue, USD 16.164 million of year-end cash and a USD 70.667 million net loss. These disclosures illustrate why transaction value, proceeds, revenue, cash and operating loss require separate analysis before they support a comparable-company conclusion.

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 and SEC-filed de-SPAC transactions 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 improve yield, reduce optical loss and reach accepted 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 photonic quantum company should be valued as an evidence-producing manufacturing and computing system. Wafer starts and component counts are inputs. Known-good-die yield, optical loss, source quality, detector efficiency, packaging yield, module acceptance, system stability, repeated logical performance, customer acceptance, intellectual-property ownership and funded runway determine whether the system 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 Photonic metric hierarchy

The metric hierarchy starts with component evidence: source efficiency and purity, photon indistinguishability, propagation and coupling loss, switch loss, interferometer fidelity, detector efficiency, dark counts and variation across wafers. These measures require test conditions, distributions and repeated results. A selected device, die or package cannot stand in for system performance.

The second level is manufacturing and system performance. It covers known-good-die yield, package yield, accepted-module yield, cumulative loss, executable circuit depth, throughput, latency, uptime, calibration overhead, compiler performance and the control stack. The third level is logical progress: syndrome extraction, decoder performance, repeated correction cycles, logical operation quality and resource overhead. 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 reproducible source quality, low component and interconnect loss, stable detectors, scalable switching, real-time decoding, qualified foundry processes, repeatable packaging and sufficient deployment 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

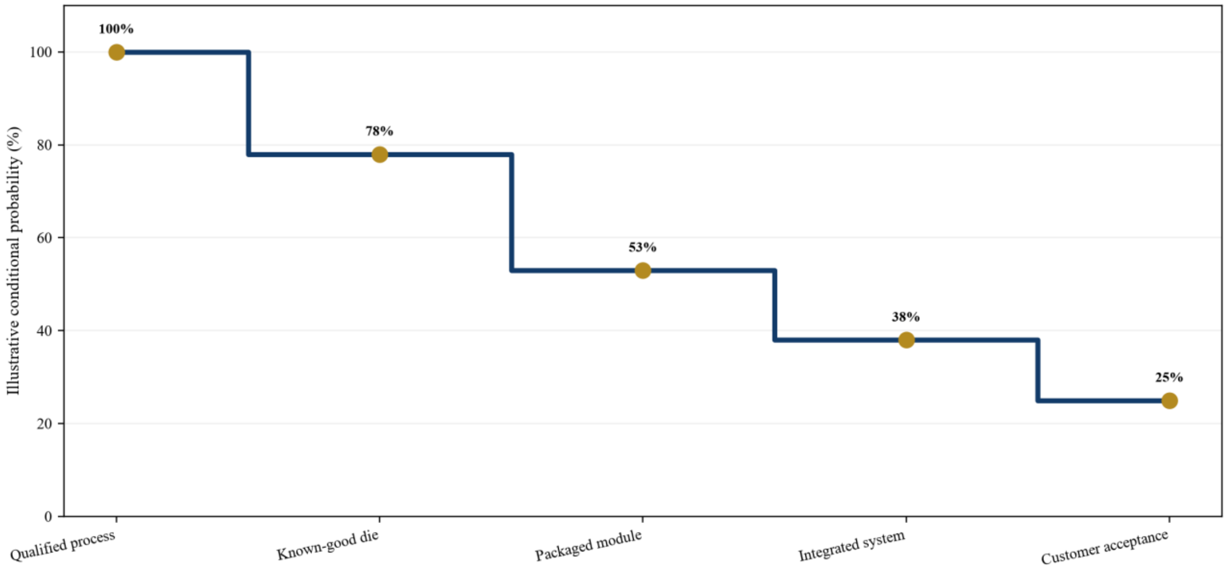
The valuation data room should contain wafer maps, raw and processed device results, statistical process-control records, design-of-experiment reports, optical-loss budgets, source and detector characterisation, known-good-die yield, package and module yield, system availability, test protocols, failed runs, bills of materials, foundry and packaging agreements, 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.

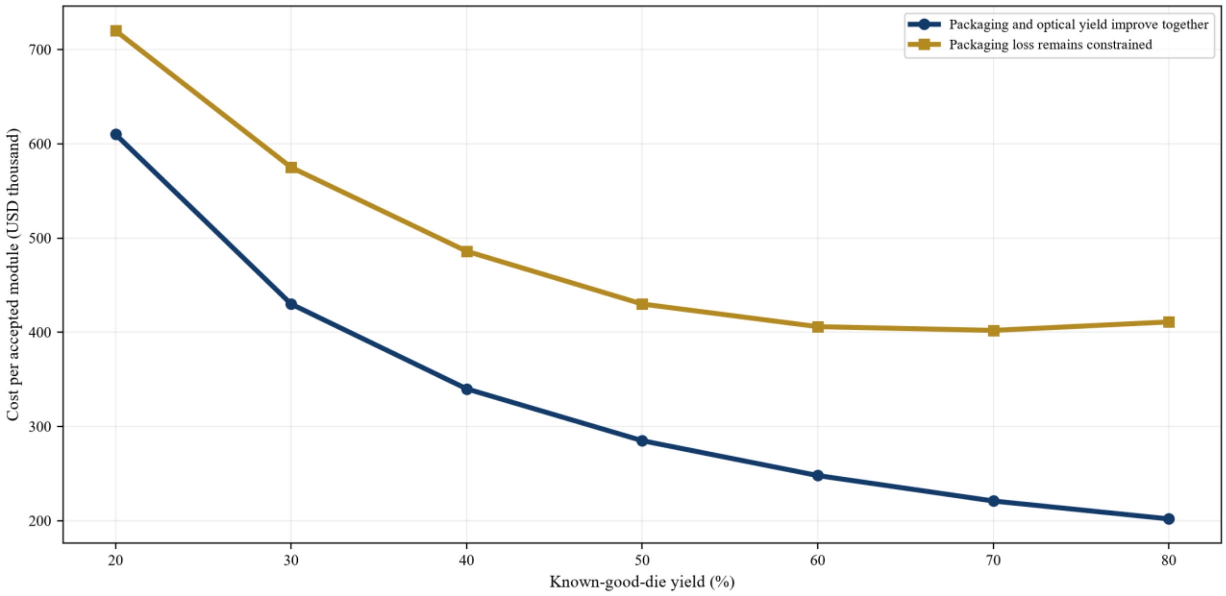
Appendix D Decision figures and tables

Figure 1. Photonic milestone tree from qualified process to accepted system output



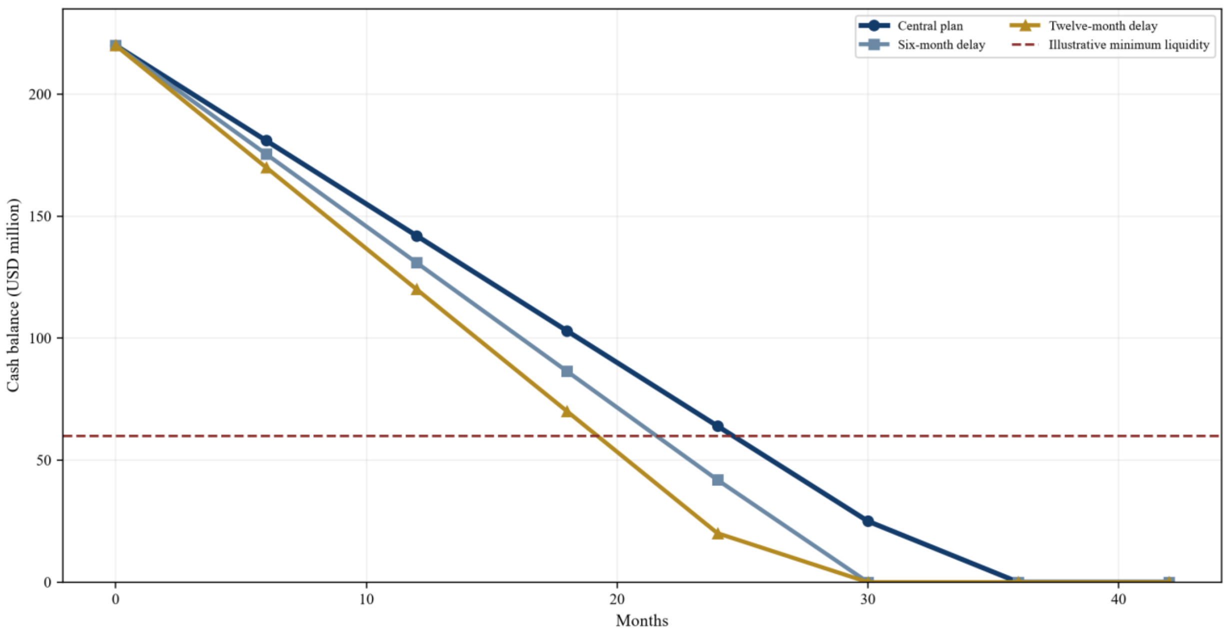
Proposed evidence sequence. Each branch requires a defined test before additional roadmap value is recognised.

Figure 2. Illustrative cost per accepted module as known-good-die yield improves



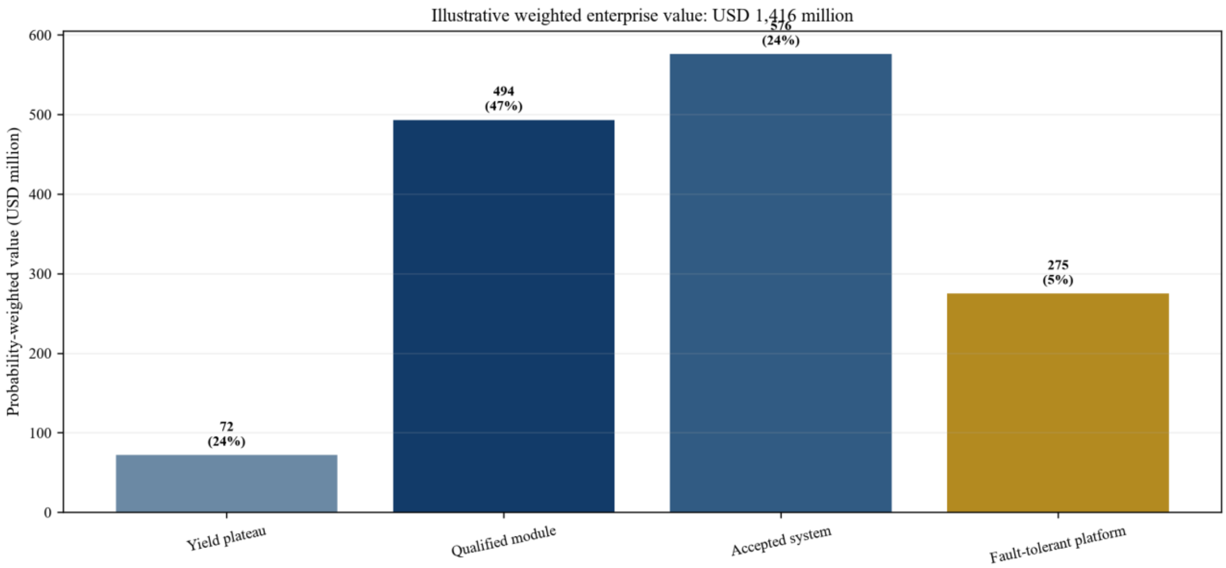
Wholly hypothetical management assumptions; USD thousand per accepted module.

Figure 3. Illustrative cash runway under technical-delay scenarios



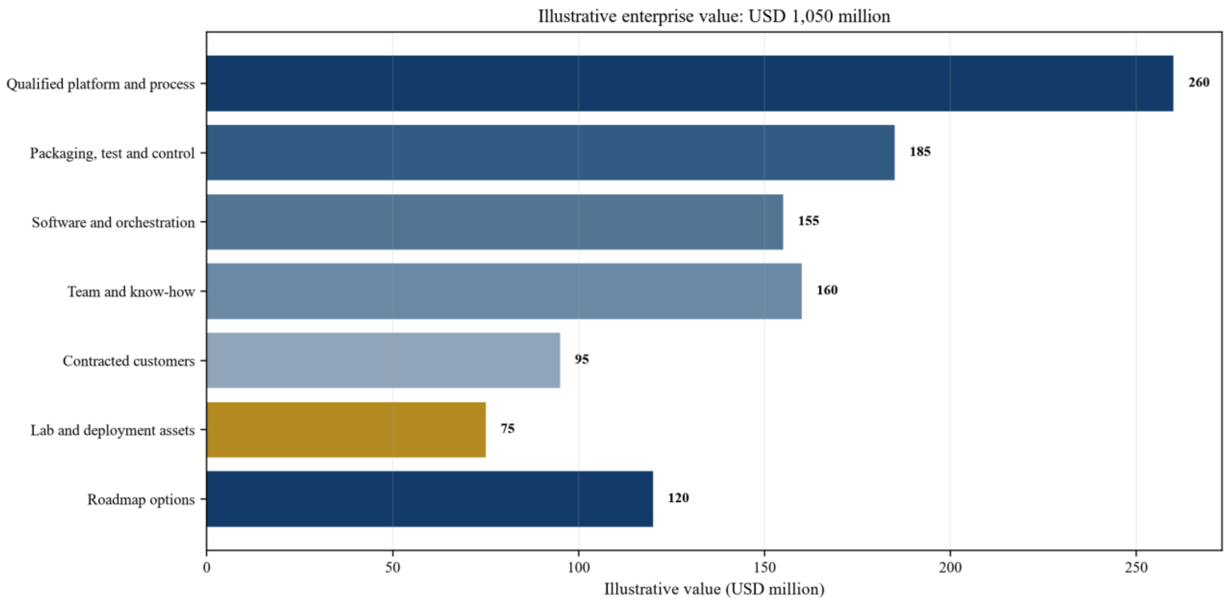
Hypothetical management assumptions; USD million. Financing proceeds are excluded.

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 photonic company valuation

Level	Evidence	Valuation question	Common failure
Component	Source quality, propagation loss, switching, detection and wafer variation	Is performance repeatable across devices, dies, wafers and time?	Selected best device presented as process performance
Manufacturing	Known-good-die, package, module and accepted-system yield	Can the process convert wafers into usable systems at forecast cost?	Best wafer or package extrapolated to volume output
System	Parallel operations, circuit depth, throughput, uptime and calibration	Can the service complete useful work at acceptable cost?	Fidelity reported without runtime or operating burden
Logical	Syndrome cycles, decoder latency, logical gates and resource overhead	Does error correction improve the workload?	Encoded state extrapolated to universal operation
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	Source, circuit, switch, detector and measurement records	Re-run selected tests	Asset and know-how value
Known-good die	Wafer maps and parametric distributions across lots	Reproduce screening on a held-out wafer	Conditional process value
Packaged module	Coupling, alignment, loss, reliability and rework distributions	Sample raw test and failure-analysis records	Yield and scale adjustment

Evidence stage	Minimum record	Independent check	Valuation treatment
Logical experiment	Decoder, syndrome, logical-gate and overhead data	Verify end-to-end logical operation	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
Foundry process and PDK	Process records, design rules, wafer maps and change control	Capacity, migration, process drift and supplier leverage	Replacement cost and yield sensitivity
Sources, circuits and detectors	Schematics, layouts, firmware, rights and reliability records	Heterogeneous integration and scarce suppliers	Cost, uptime and manufacturability adjustment
Packaging, fibre attach and calibration	Recipes, logs, loss distributions, rework and recovery	Architecture-specific undocumented methods	Transferability and accepted-output adjustment
Compiler and scheduler	Benchmarks, licences, routing and customer use	Hidden switching, loss and serialisation overhead	Margin and time-to-solution adjustment
Decoder and orchestration	Latency evidence, interfaces and rights	Unproven real-time performance at scale	Milestone option value

Proposed minimum ownership review.

Table 4. Hypothetical valuation allocation

Value component	Illustrative amount	Evidence gate	Downside treatment
Qualified platform and process	USD 260 million	Multi-lot process capability, known-good-die yield and rights	Technical holdback
Packaging, test and control	USD 185 million	Package yield, loss budget, reliability and automated test	Remediation reserve
Software and orchestration	USD 155 million	Rights, build, calibration and scheduler performance	Remediation reserve
Team and know-how	USD 160 million	Critical-role retention and documented transfer	Service-based retention
Contracted customers	USD 95 million	Acceptance, renewal, usage and cash evidence	Conversion adjustment
Laboratory and deployment assets	USD 75 million	Ownership, condition, capacity and utilisation	Replacement-cost cap
Roadmap options	USD 120 million	Funded yield, scale and logical 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

Evidence	What it proves	What it does not prove	Valuation use
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 220 million	USD 78 million	34 months	Fund next gate with moderate buffer
Six-month delay	USD 220 million	USD 89 million	30 months	Earlier financing and dilution
Twelve-month delay	USD 220 million	USD 100 million	26 months	Reduced negotiating leverage
Protected liquidity	USD 220 million	USD 78 million plus USD 60 million floor	25 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 wafer, die, package, loss, system and logical evidence	Limited lot sample with funded validation	Selected device or package 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, yield cost and roadmap options separated	Probability range remains wide but bounded	Headline fidelity or wafer volume drives price

Proposed decision framework.

Frequently asked questions

Q: Why are wafer starts and device counts insufficient for valuation? A: Wafer starts and device counts do not establish known-good-die yield, package yield, optical loss, source and detector quality, module acceptance, system availability, logical performance, scaling cost or customer value. Valuation requires the full evidence chain from process capability to accepted commercial delivery.

Q: Which technical metrics matter most? A: The relevant set depends on the architecture and intended workload. For photonic quantum systems it commonly includes source efficiency and purity, photon indistinguishability, propagation and coupling loss, switch loss, interferometer fidelity, detector efficiency, fusion performance, known-good-die yield, packaging yield, throughput, uptime and repeated logical performance.

Q: How should an investor treat very high reported fidelity? A: The investor should identify whether the result is conditional on photon detection, which loss mechanisms are excluded, the devices and lots sampled, the calibration state, the sample period and the error bars. Value increases when strong performance is reproduced across wafers, packages and systems. A best result from a selected device remains one evidence point.

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 do optical loss and packaging yield matter? A: Each source, waveguide, switch, connector, fibre attach and detector contributes to the probability that photons survive and produce a valid result. Packaging can add loss, variation, drift and rework even when the die passes wafer test. The valuation should test the cumulative budget and the cost of producing an accepted module.

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 reproduced wafer, die, package, optical-loss, detector and system evidence; rights to the foundry, packaging and control stack; customer and cash reconciliation; a yield-cost model; a funded runway; downside paths; retention arrangements; and a valuation bridge separating achieved capability from roadmap options.

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