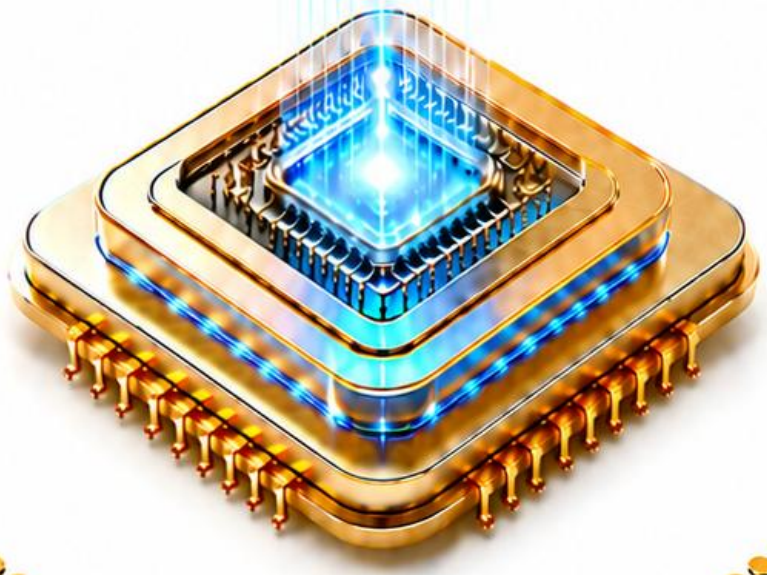
Quantum Computing
Cyber Risk



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You assess risk for a living. Most findings on your worksheets are fixable in a quarter. Quantum computing is different: a **dated, funded engineering program** that will make the cryptography underneath nearly everything you assess obsolete, on a timeline the industry is now publishing openly.

Today's security depends on mathematical locks that are effectively impossible for ordinary computers to pick. Encrypting data with a public key means an attacker would have to work out which prime numbers were multiplied together to produce it, a vexing task classically. But quantum computers spot certain mathematical patterns and excel at factoring very large numbers, which is why **RSA, Diffie-Hellman, and ECC** — the algorithms behind TLS/HTTPS, VPNs, code signing, and most digital certificates — are the exposure.[1] Symmetric encryption (AES) and password hashing are far more resilient and need only modestly longer keys.

2029
IBM's target for a real-world quantum computer

2030
US federal PQC compliance deadline

91%
of security pros have no formal quantum roadmap

What Actually Breaks: Eight Exposure Categories

"Encryption breaks" is too abstract to scope an assessment against. In practice the failure surfaces in eight distinct ways, and each maps to a different part of an environment.[2]

Exposure	What It Means in Practice
Broken public-key encryption	RSA, Diffie-Hellman, and ECC become breakable — the foundation beneath TLS, VPNs, and key exchange
Harvest-now, decrypt-later	Data stolen today is decrypted once quantum capability matures
Forged digital signatures	Attackers impersonate trusted vendors and sign malicious software as legitimate
Secure boot compromise	Firmware trust checks are bypassed, undermining every control layered above them
Financial transaction risk	Payment authorization and ledger integrity are threatened
Exposed historical backups	Old encrypted archives become readable retroactively
IAM and certificate failure	Certificate-based authentication is spoofed; attackers impersonate identities
Legacy and IoT exposure	Embedded, medical, and building systems that cannot be updated stay vulnerable permanently

"Q-Day": A Window, Not a Date

"Q-Day" is the hypothetical moment quantum computers become powerful enough to break standard-key encryption. There isn't expected to be one fixed date — it is likely to occur over several months or years, according to Scott Aaronson, a computer-science professor at the University of Texas at Austin.[1] Quantum computers exist today but mostly under highly restricted lab conditions, still ill-equipped for everyday practical use. What has changed is that the milestones are now dated and public: **IBM has said it plans to deliver the first quantum computer for real-world applications by 2029**, and global quantum investment is running near $2 billion annually, up roughly 50% year over year.[1,2]

Harvest-Now, Decrypt-Later: The Risk That Is Already Here

The single most important point for a client conversation is that this risk does not wait for Q-Day. In a **harvest-now, decrypt-later** (HNDL) attack, adversaries download large sets of encrypted data they cannot crack today — and unlock it once quantum algorithms are good enough.[1] The theft has already happened; only the decryption is on a delay.

> *That's particularly threatening to intellectual property and sensitive government intelligence, which remain valuable long after they are harvested.*
>
> **— Andrew McLaughlin, Chief Operating Officer, SandboxAQ (WSJ)**

The attack runs in five stages: **steal** (traffic or files exfiltrated), **store** (ciphertext held in cold storage, often for years), **wait** (quantum computing matures), **decrypt** (a future machine breaks the key), and **exploit** (the data is read, sold, or used). Only the first stage requires anything of the attacker today, which is what makes the economics so favorable — storage is cheap and intelligence-grade data holds its value.[2]

For any assessment touching data with a multi-year sensitivity window — PHI, PII, IP, legal and M&A records, defense intelligence — **HNDL exposure is a present-tense finding**, regardless of when Q-Day actually lands.

The Fix: Post-Quantum Cryptography

Quantum-safe encryption already exists. The leading approach uses **lattice-based protocols**, which secure data with geometry-based problems that are difficult for both standard and quantum computers to solve.[1] NIST finalized three post-quantum standards on August 13, 2024 — **FIPS 203 (ML-KEM)** for key encapsulation, **FIPS 204 (ML-DSA)** for digital signatures, and **FIPS 205 (SLH-DSA)** as a hash-based backup. A fourth signature standard, **FIPS 206 (FN-DSA, based on FALCON)**, remains in draft, and NIST selected **HQC** in March 2025 as a backup key-encapsulation mechanism built on different math than ML-KEM.[3] Because migration can take years, a **hybrid approach** combining existing and post-quantum cryptography is widely recommended as a bridge during the transition, per Ali El Kaafarani, chief executive of PQShield.[1]

The clock is explicit, and it is now law. The **Quantum Computing Cybersecurity Preparedness Act** (6 USC §1526) requires federal agencies to inventory quantum-vulnerable systems, and a June 2026 executive order sets the dates: federal high-value assets must migrate for **key establishment by December 31, 2030** and **digital signatures by December 31, 2031**, with contractor compliance regulations due by the end of 2030.[6] Separately, NIST IR 8547 deprecates 112-bit-security algorithms such as RSA-2048 beginning in 2030 and disallows them by 2035.[4]

Why this binds private organizations too

No regulation orders a private healthcare entity to adopt PQC. But HIPAA §164.308(a)(1)(ii)(A) requires analysis of *reasonably anticipated* threats to ePHI — and a federally acknowledged, dated threat to the encryption protecting that data meets the bar. The rule did not change; the threat landscape moved underneath it. Federal contractors are pulled in separately through 2030 flow-down.

Who Is Already Moving

Organization	Post-Quantum Status
Google, Cloudflare, Microsoft	Aim to use quantum-resistant encryption across all products, services, and core infrastructure by 2029
Signal, Apple iMessage	Already using post-quantum end-to-end encryption
WhatsApp, Messenger (Meta)	In the process of deploying post-quantum features

Organization	Post-Quantum Status
Keeper Security, 1Password	Have adopted quantum-resistant algorithms
Financial institutions, central banks, card networks	Adopting post-quantum protocols to protect sensitive data

Yet a Trusted Computing Group survey of 1,500 security professionals across the U.S. and Europe found **91% have no formal roadmap** to protect against quantum threats, and 81% believe their crypto libraries and hardware security modules are unprepared for migration.[1,5] That gap between awareness and action is where an assessor adds the most value.

Spotlight: Why IBM Is the Company to Watch

IBM holds a position no other company does: it is simultaneously the most transparent builder of the hardware that creates this threat and a co-author of the standards that neutralize it. IBM Research cryptographers in Zurich co-developed **CRYSTALS-Kyber and CRYSTALS-Dilithium**, the basis for NIST's ML-KEM and ML-DSA standards.[7] On hardware, IBM's Nighthawk processor (120 qubits, 218 tunable couplers) shipped in late 2025, and its Loon module demonstrated the components for fault tolerance — including error-correction decoding under 480 nanoseconds — a full year ahead of schedule. IBM targets verified quantum advantage by the end of 2026 and its fault-tolerant **Quantum Starling** system by 2029.[8,9]

> *IBM is the only company positioned to rapidly invent and scale quantum software, hardware, fabrication, and error correction.*
>
> **— Jay Gambetta, Director of IBM Research**

IBM also ships the most complete migration toolkit on the market — **Guardium Cryptography Manager** for cryptographic asset discovery, **Quantum Safe Explorer** for source-code scanning, and **Quantum Safe Remediator** for hybrid, crypto-agile remediation — plus quantum-safe capability already built into IBM z16, Power10, and IBM Cloud.[10] For an assessor, that dual position is a practical gift: one company's public roadmap tracks both the threat and the fix.

What This Means for Your Assessments

CISA, the NSA, and NIST jointly direct organizations of every size to build a quantum-readiness roadmap, complete a cryptographic inventory, and engage vendors on post-quantum plans now rather than at the last minute.[11] Translated into fieldwork:

- **Add a cryptographic asset inventory** to standard fieldwork — algorithms, key lengths, and protocols across applications, firmware, certificates, VPNs, HSMs, and backup/archive systems. Most clients genuinely do not have one, making this the highest-leverage finding available.
- **Ask directly about roadmap, ownership, and budget.** With 91% of organizations lacking a formal plan, the 2029–2030 vendor and federal milestones give you a defensible benchmark to measure a client against.
- **Prioritize by data longevity.** Flag long-lived PHI, PII, IP, and government or defense data as HNDL-exposed today — not at some future Q-Day.
- **Pilot hybrid cryptography and build crypto-agility** before full rollout, so systems stay protected during migration and future algorithm swaps are routine rather than disruptive.
- **Use vendor commitments as third-party risk checkpoints.** IBM's, Microsoft's, Google's, and Cloudflare's public 2029 targets are a fair, sourced bar to hold a client's own vendors and cloud providers to.
- **Make quantum readiness a standing risk-register item.** This is a multi-year migration; your value compounds if you are the one tracking it release over release.

What to tell people who ask about their personal data

The transition will largely happen behind the scenes, handled by governments, technology providers, and security vendors. Three practical points: **don't fret over passwords** — attackers want automated mass attacks, not individual logins; **keep software updated** so devices and password managers pick up post-quantum upgrades automatically; and **stay informed** — tools such as the PQSpy browser extension flag sites already using post-quantum encryption.[1]

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