

Harvest Now, Decrypt Later (HN DL)

Quantum Threat, Privacy Risk, and
Post-Quantum Cryptography (PQC) Mitigations

Presented to the Australian Chapter of
Quantum Security Defense (QSECDEF)
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HN DL

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Agenda



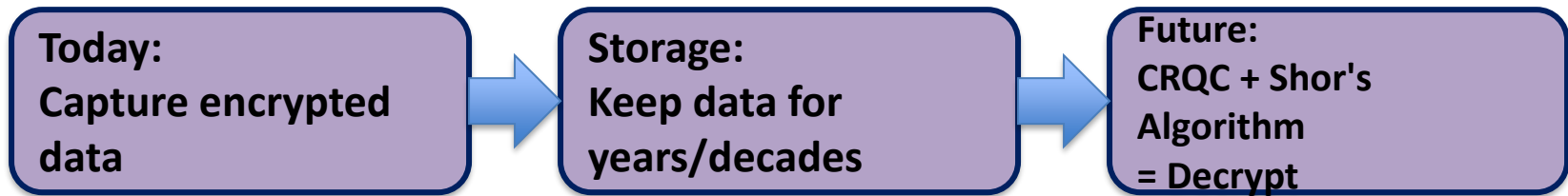
- What Is HNDL?
- An Internet Minute
- Why HNDL Is Serious
- Quantum Computers and Shor's Algorithm
- PQC as a Defense Against HNDL
- Illustrative PQC Readiness
- Who Has Started their PQC Migrations
- PQC Readiness with Timeline
- Key Mitigation Steps to Reduce HNDL Risk
- HNDL Mitigation Lifecycle
- Illustrative Quantum Risk Timeline
- Cryptographic Agility
- Key Takeaways and a Call to Action
- Questions and Answers
- References



Enter the Quantum Zone



HNDL in One Picture



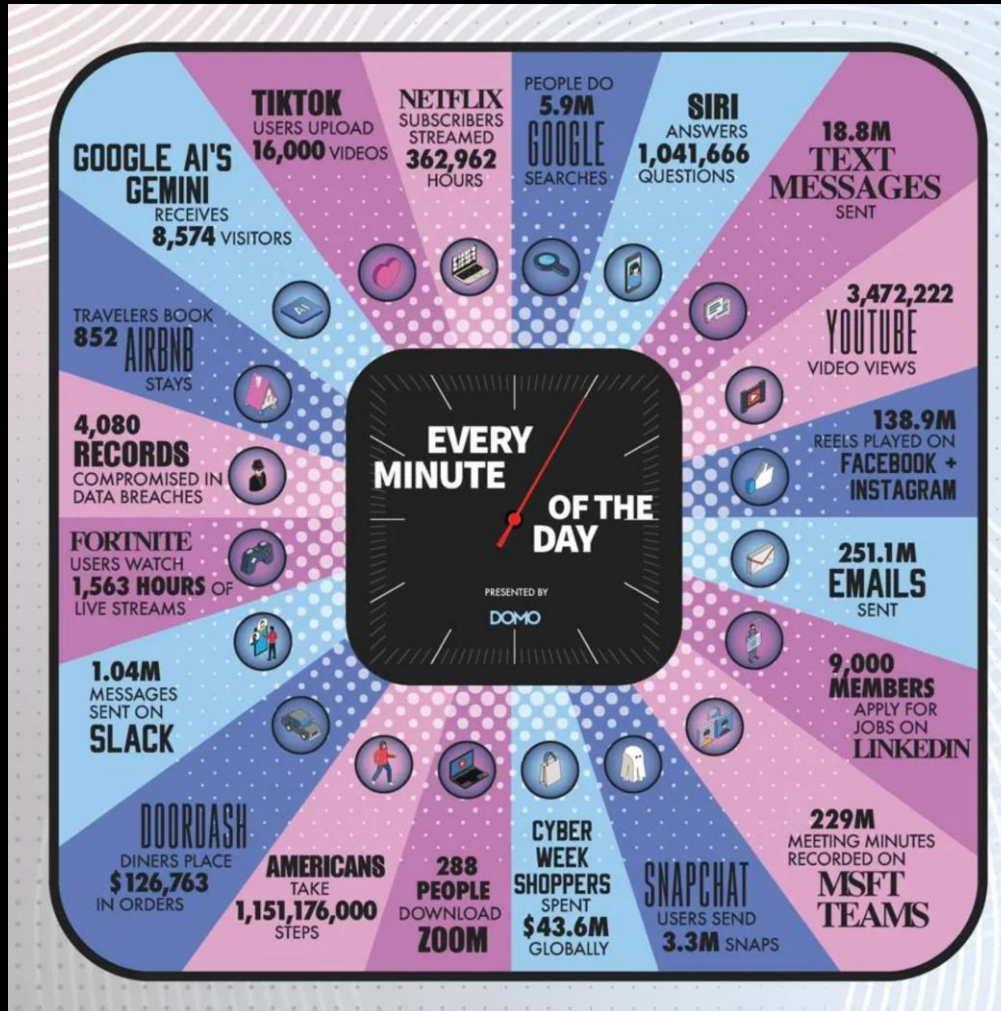
HNDL = Adversaries harvest encrypted data now and decrypt it later when quantum computers become powerful enough.



What is Harvest Now, Decrypt Later (HNDL)?

- Adversaries capture encrypted traffic and data today.
- They store it for years or decades, waiting for stronger compute.
- A future cryptanalytically relevant quantum computer (CRQC) can use Shor's Algorithm to break RSA/ECC keys.
- Result: Long-term confidentiality is lost even if systems appear secure today.

Internet Minute - 2025



Source: <https://bondhighplus.com/blog/what-happens-in-an-internet-minute/>

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Internet Minute – 2015 to 2025



Year	Emails Sent	Google Searches	YouTube Views	TikTok Views	Online Spend	App Downloads	Instagram Activity
2025	231M+	6.3M+	3.47M	625M videos watched	\$43.6M+	174K	66K photos shared
2024	231M	6.3M	3.47M	625M videos watched	\$43.6M (peak minute)	174K	66K photos shared
2023	231M	5.9M	3.67M	167M videos watched	\$1.5M+ (est.)	174K	694M songs streamed
2022	231M	5.9M	508 hrs uploaded	1B+ interactions	\$443K (Amazon only)	437K transfers	527K photos shared
2021	225M (est.)	5.7M (est.)	5.0M (est.)	167M (est.)	\$1.3M (est.)	450K (est.)	800K (est.) scrolling
2020	190M	4.1M	4.7M	N/A	\$1.1M	400K	694K scrolling
2019	188M	3.8M	4.5M	N/A	\$996K	390K	347K scrolling
2018	187M	3.7M	4.3M	N/A	\$862K	375K	174K scrolling
2017	156M	3.5M	4.1M	N/A	\$751K	342K	46K posts uploaded
2016	150M	2.4M	2.78M	N/A	\$203K	51K	527K photos shared
2015	204M	2M+	1.3M	N/A	\$83K	47K	3,000 uploads

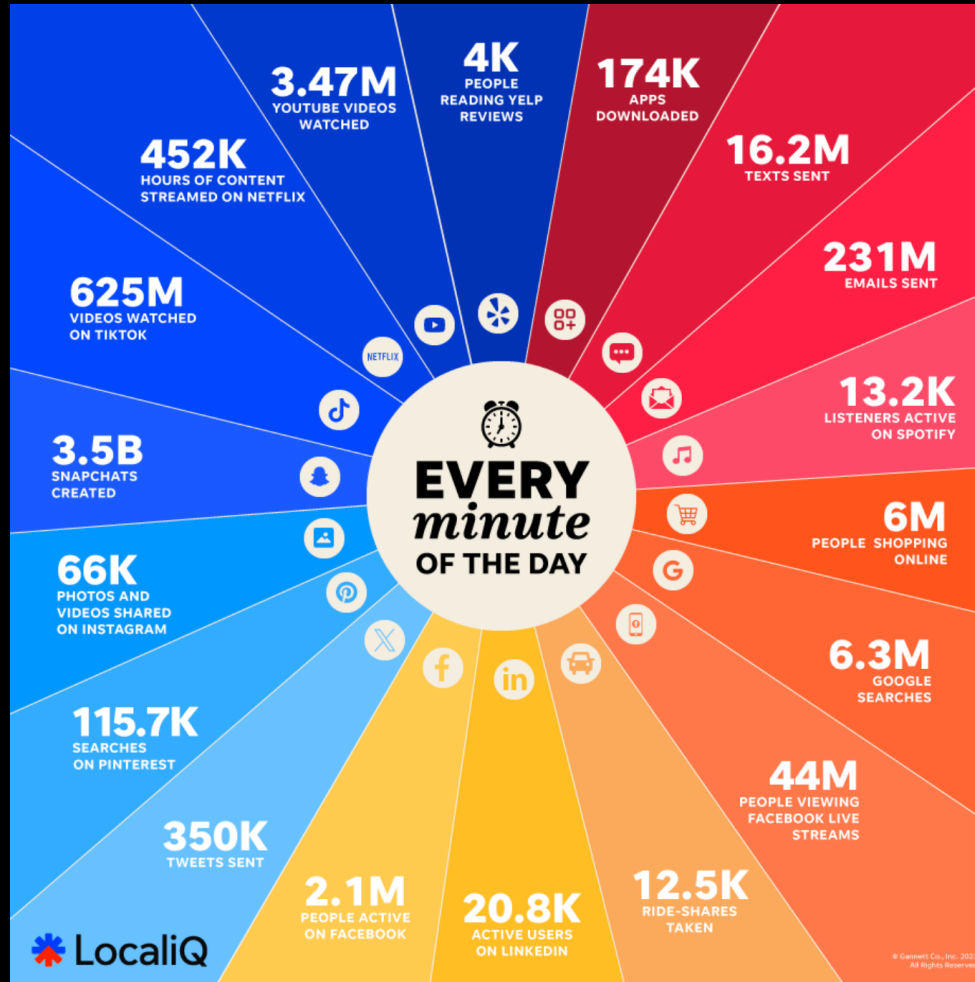


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Internet Minute - 2025



Source:
<https://localiq.com/blog/what-happens-in-an-internet-minute/>

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Why HNDL is a Serious Privacy Threat



- Targets data with long sensitivity lifetimes: PII, medical records, biometrics, financial histories, IP, classified data.
- Once decrypted, historical communications can be searched, correlated, and profiled without the victim ever knowing.
- Bulk HNDL harvesting enables mass surveillance and retroactive exposure of past behavior.
- Trust in digital records, contracts, and identities can be undermined when historic data is silently decrypted.

Quantum Computers & Shor's Algorithm



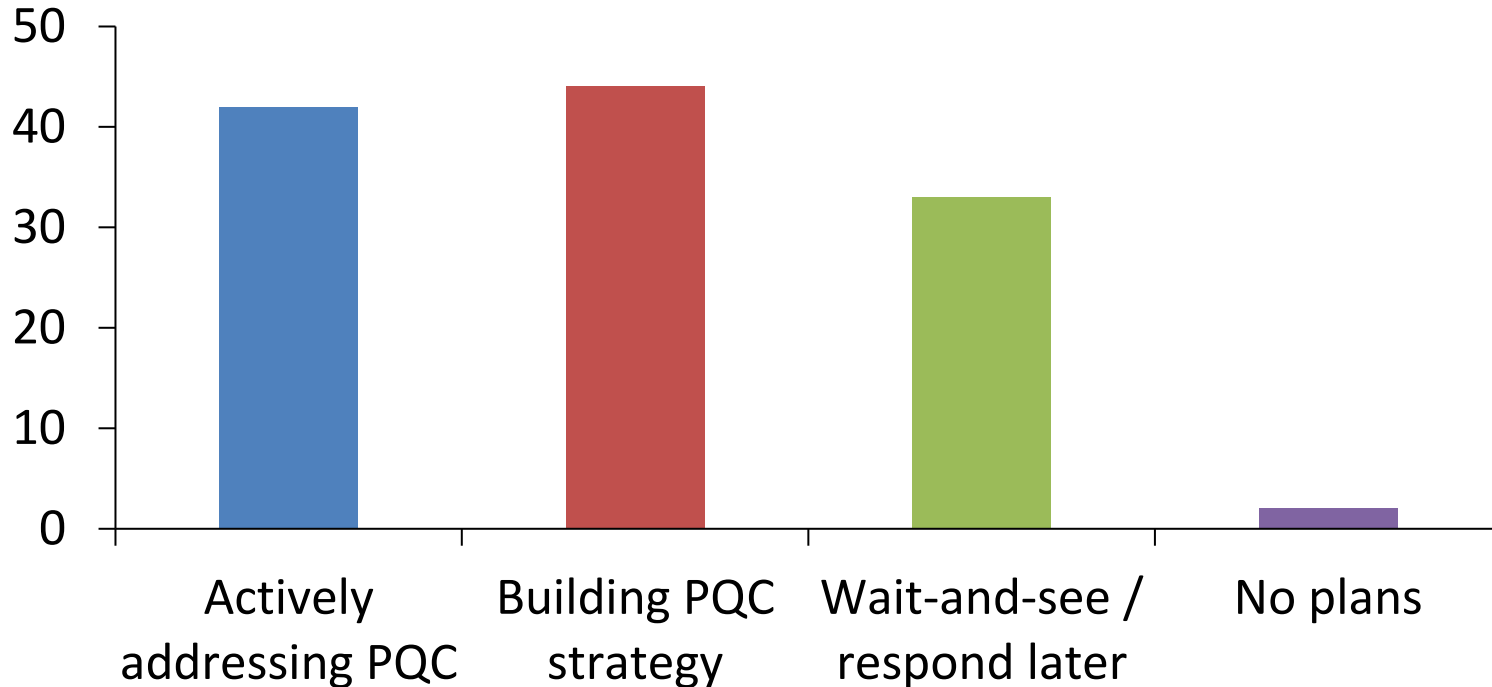
- Shor's Algorithm can efficiently factor large integers and solve discrete log problems.
- This breaks widely deployed public-key schemes such as RSA, Diffie–Hellman, and ECC.
- A CRQC could decrypt stored sessions protected only by these algorithms.
- Symmetric algorithms (e.g., AES) are less impacted, but key sizes may need to increase.

PQC as a Defense Against HNDL



- Post-Quantum Cryptography (PQC) algorithms are designed to resist both classical and quantum attacks.
- NIST has standardized PQC algorithms (e.g., Kyber for key establishment, Dilithium and SPHINCS+ for signatures).
- NSA CNSA 2.0 and other national standards require quantum-resistant algorithms by the early 2030s.
- Encrypting with PQC today ensures that harvested ciphertext remains secure even after Q-Day.

Illustrative PQC Readiness (Selected Survey Metrics)



Note: Values are illustrative and based on multiple industry surveys. Many large organizations are still in early planning stages.

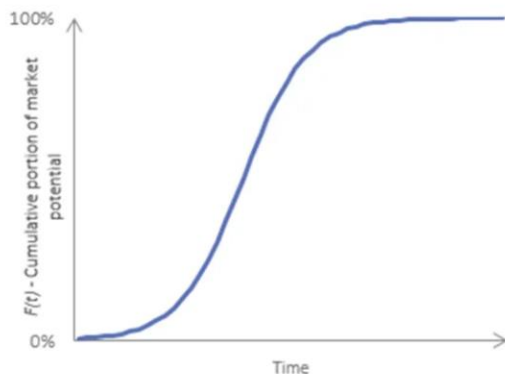


Equation

$$\frac{f(t)}{1 - F(t)} = p + \frac{q}{m} A(t)$$

- m - market potential
- p - coefficient of innovation
- q - coefficient of imitation
- $f(t)$ - the portion of the market potential that adopts at time t
- $F(t)$ - the cumulative portion of the market potential that has adopted at time t

Representative Curve



Bass Diffusion Model

Who Has Started Their PQC Migrations?

🔒 The Quantum Deadline: Good, Bad & Ugly of PQC Adoption

By 2033, a cryptographically relevant quantum computer (CRQC) could emerge - yet most systems won't be ready.

Using the Bass model ($p \approx 0.03$, $q \approx 0.32$), we forecast:

~50% PQC adoption by 2033

Group 1 (defense, core infra): ~70% ready

Group 2 (critical sectors): ~55%

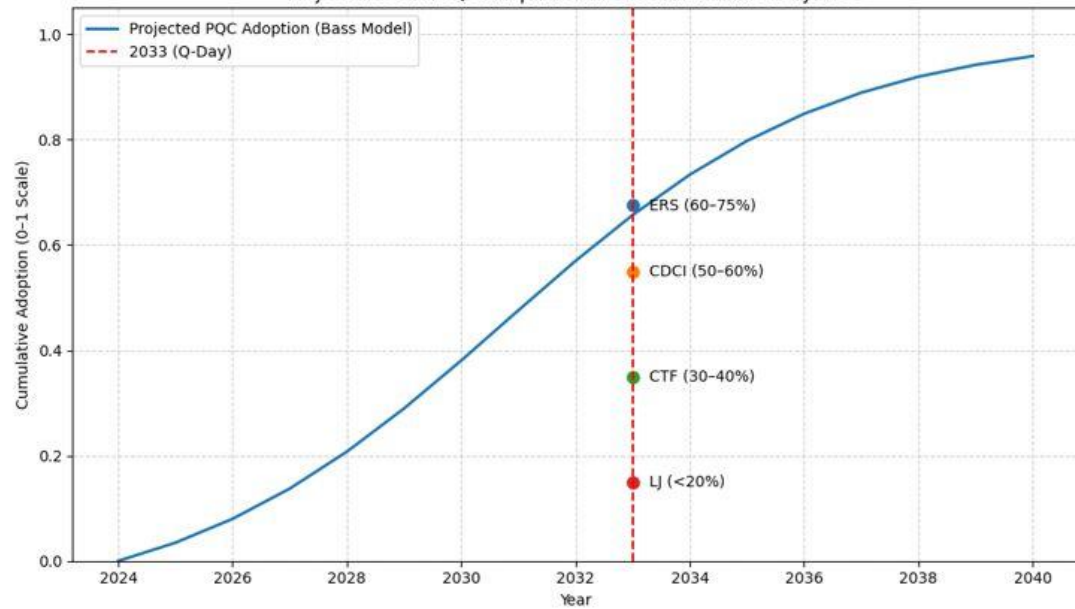
Group 3 (commercial tech): ~35%

Group 4 (legacy systems): ~<20%

The risk? A fragmented, vulnerable internet—unless we act now.

Tehrani, M. (2025). "The Quantum Deadline: The Good, The Bad, and The Ugly of PQC Adoption", published d at Medium and retrieved from: https://medium.com/@madjid.tehrani_17692/the-quantum-deadline-the-good-the-bad-and-the-ugly-of-pqc-adoption-baf0348812e4 .

Projected Global PQC Adoption and Sectoral Readiness by 2033



PQC Readiness



The Quantum Deadline: Good, Bad & Ugly of PQC Adoption

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 - Group 1 (defense, core infra): ~70% ready
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 - Group 4 (legacy systems): ~ <20%
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IonQ Roadmap for Large-Scale, Fault-Tolerant Quantum Computers

Built on pioneering trapped ion research, IonQ's roadmap is enabled by the nearly 1,000 patented hardware and software breakthroughs that were developed at IonQ, integrated from strategic acquisitions.

Original IonQ #AQ Roadmap

2024	2025	2026	2027	2028
36 Algorithmic Qubits	64 Algorithmic Qubits	256 Algorithmic Qubits	384 Algorithmic Qubits	1,024 Algorithmic Qubits

Updated Technology Development Roadmap

2024	2025	2026	2027	2028	2029	2030
35+ Physical Qubits 99.90% Physical Qubit Fidelity	66-100+ Physical Qubits 99.99% Physical Qubit Fidelity	100-256+ Physical Qubits 99.99% Physical Qubit Fidelity 12 Logical Qubits <1.00E-7 Logical Error Rate	10,000 Physical Qubits 99.99% Physical Qubit Fidelity 800 Logical Qubits <1.00E-7 Logical Error Rate	20,000 Physical Qubits 99.99% Physical Qubit Fidelity 1,600 Logical Qubits <1.00E-7 Logical Error Rate	Commercial Quantum Computers 200,000 Physical Qubits 99.99% Physical Qubit Fidelity 8,000 Logical Qubits <1.00E-12 Logical Error Rate	Commercial Quantum Computers 2,000,000 Physical Qubits 99.99% Physical Qubit Fidelity 80,000 Logical Qubits <1.00E-12 Logical Error Rate

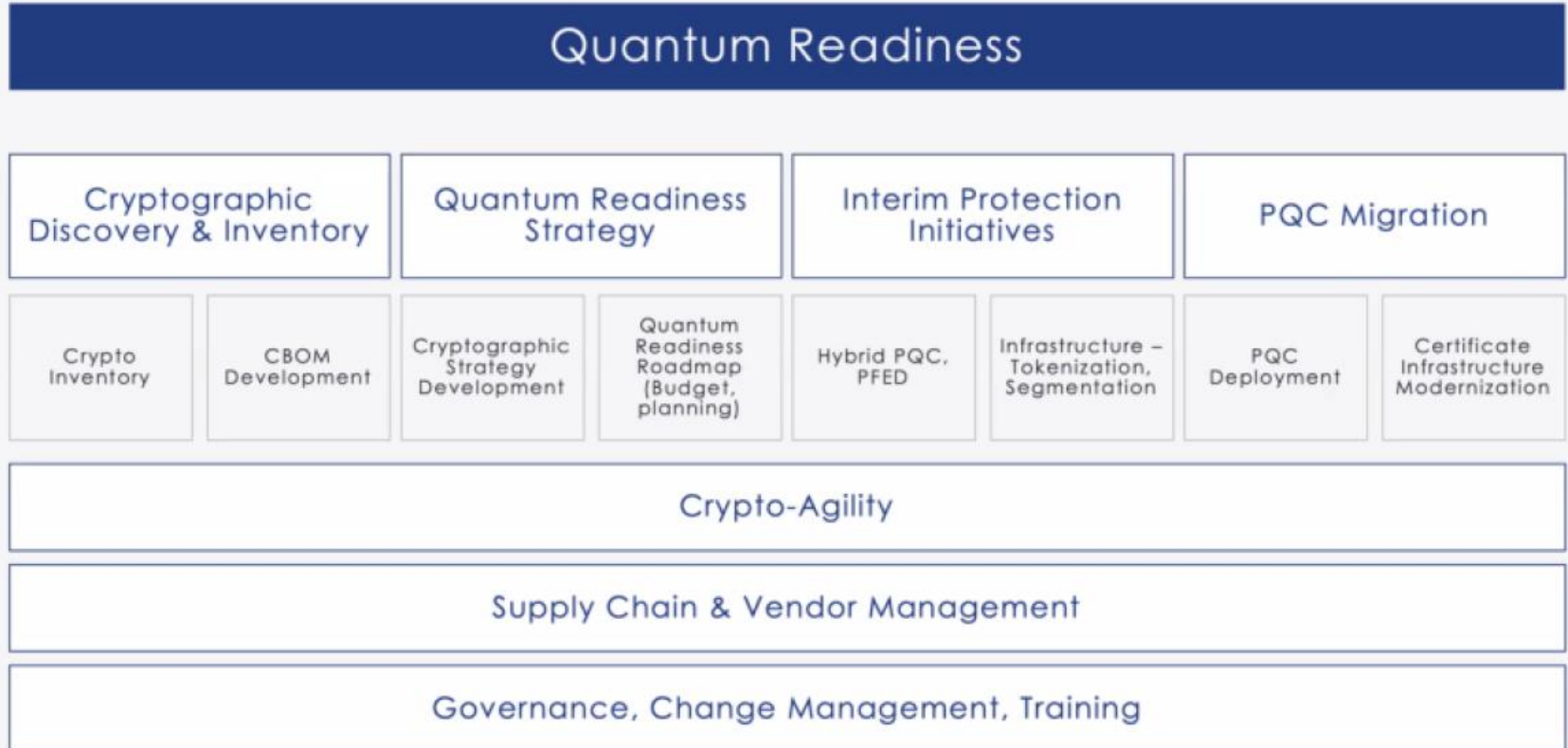
Tehrani, M. (2025). "The Quantum Deadline: The Good, The Bad, and The Ugly of PQC Adoption", published d at Medium and retrieved from: https://medium.com/@madjid.tehrani_17692/the-quantum-deadline-the-good-the-bad-and-the-ugly-of-pqc-adoption-baf0348812e4 .

Key Mitigation Steps to Reduce HNDL Risk



- Create a **cryptographic inventory (CBOM)** (where public-key crypto is used, which algorithms, key sizes, and data lifetime).
- Identify "long-lived" data and high-value targets (citizen data, health, finance, critical infrastructure, defense).
- Upgrade protocols (**TLS/VPN/email/IoT/PKI**) to **PQC** and, in the near term, hybrid (classical + PQC) modes.
- Implement **crypto-agility** so algorithms, key lengths, and certificates can be swapped quickly without redesign.
- Encrypt sensitive **data at rest** with quantum-safe keys and strong access controls.
- Continuously monitor standards, vendor roadmaps, and quantum threat intelligence.

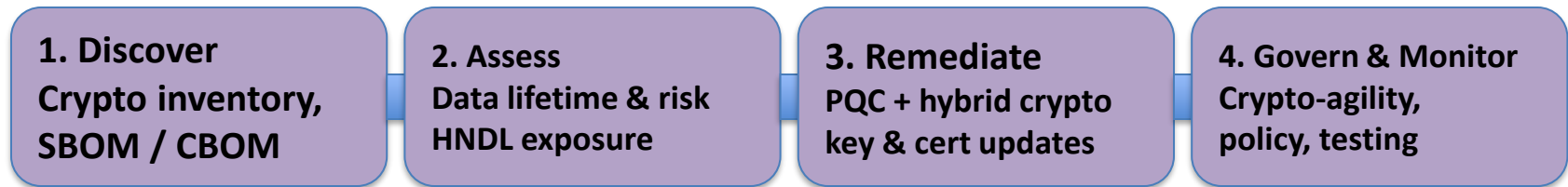
Quantum Readiness



Slide Source: Mr. Marin Ivezic, 2025.



HNDL Mitigation Lifecycle





Cryptographic Agility is a measure of an organization's ability to adapt cryptographic solutions or algorithms (including their parameters and keys) quickly and efficiently in response to developments in cryptanalysis, emerging threats, technological advances, and/or vulnerabilities.

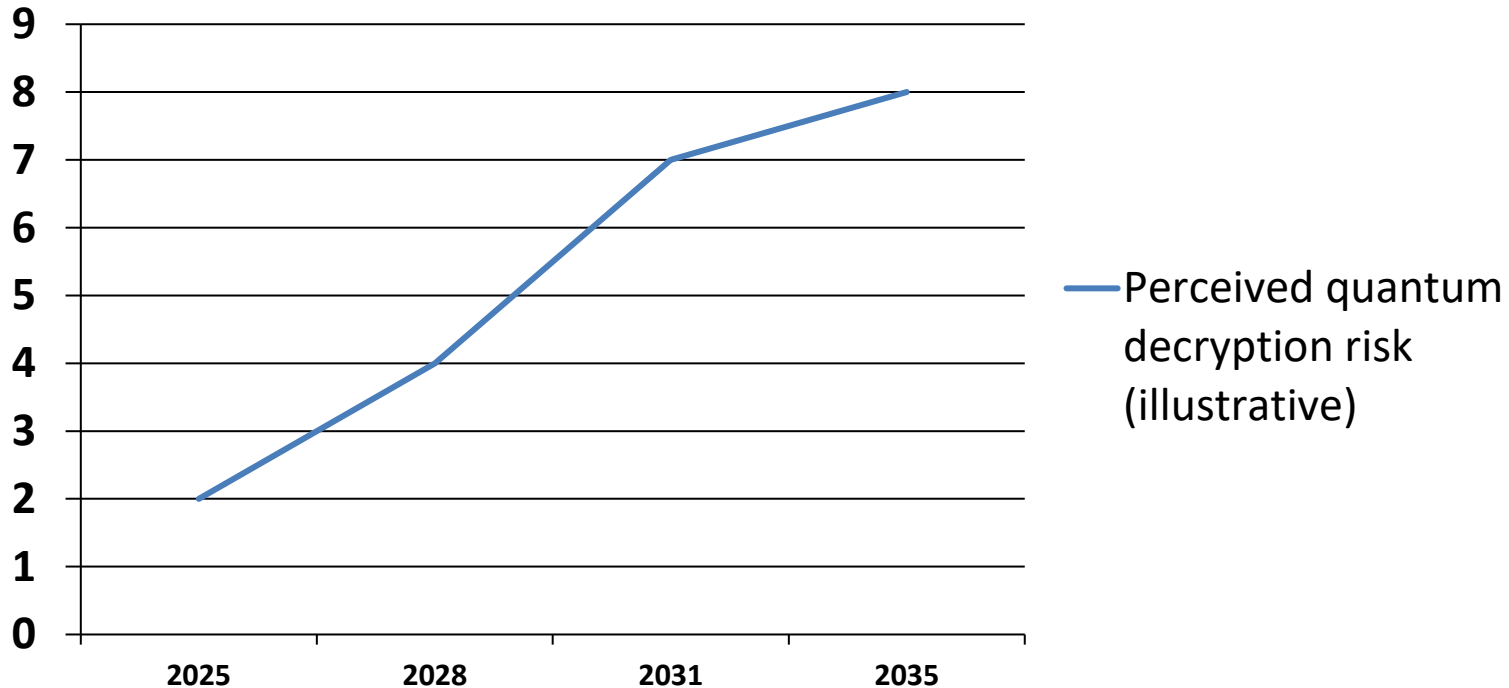
It is also a design principle for implementing, updating, replacing, running, and adapting cryptography and related business processes and policies with no significant architectural changes, minimal disruption to business operations, and short transition time.

- Design principle
- Adapt to ANY future threats to cryptography
- Minimal disruption to business

Good old exit plans, no more set and forget in cryptography

PKY Consortium (2025). PQC Conference, January 2025.

Illustrative Quantum Risk Timeline (2025–2035)



Analysts expect CRQCs capable of breaking today's public-key cryptography sometime in the 2030s, with some forecasts as early as ~2030–2035. Because of HNDL, sensitive data must be protected well before " Q-Day ".

Key Takeaways & Call to Action



- **HNDL** is happening now: adversaries may already be collecting your encrypted data.
- The arrival of **CRQCs** is uncertain, but many experts place **Q-Day** between 2028 and 2033.
- Because of long data lifetimes, waiting until Q-Day is too late—historic data will already be exposed.
- Begin **PQC Planning** and **Migration** immediately, starting with discovery, prioritization, and crypto-agility.
- Treat **PQC Migration** as a strategic, multi-year program, not a one-time IT upgrade.
- Strive for **Cryptographic Agility** to become more effective at maintaining Cryptographic Requirements and Compliance in the Future.

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Questions and Answers



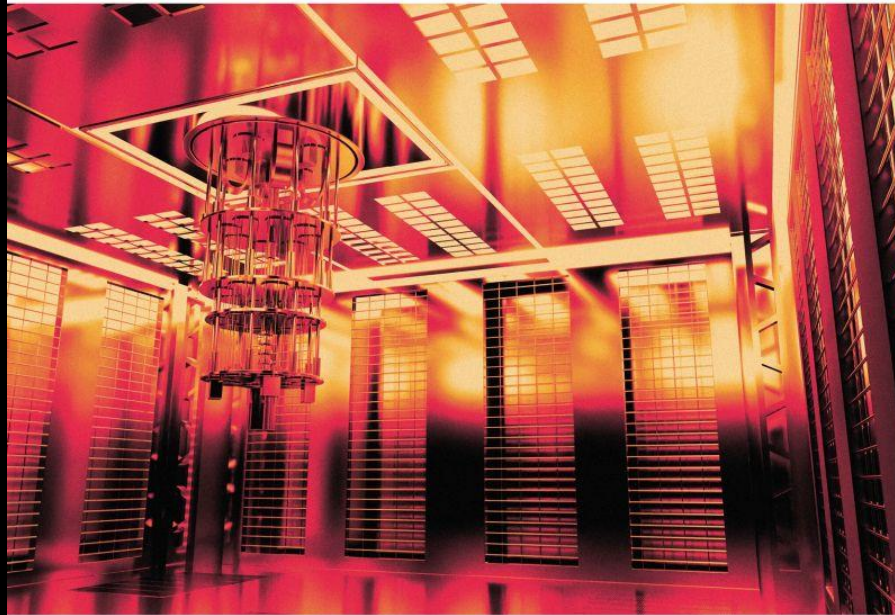
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HAPPY Q-DAY

Warning: It'll be the worst holiday in the history of the world.



BY AMIT KATWALA

ILLUSTRATIONS BY NICHOLAS LAW

Q Day is the finish line for PQC readiness



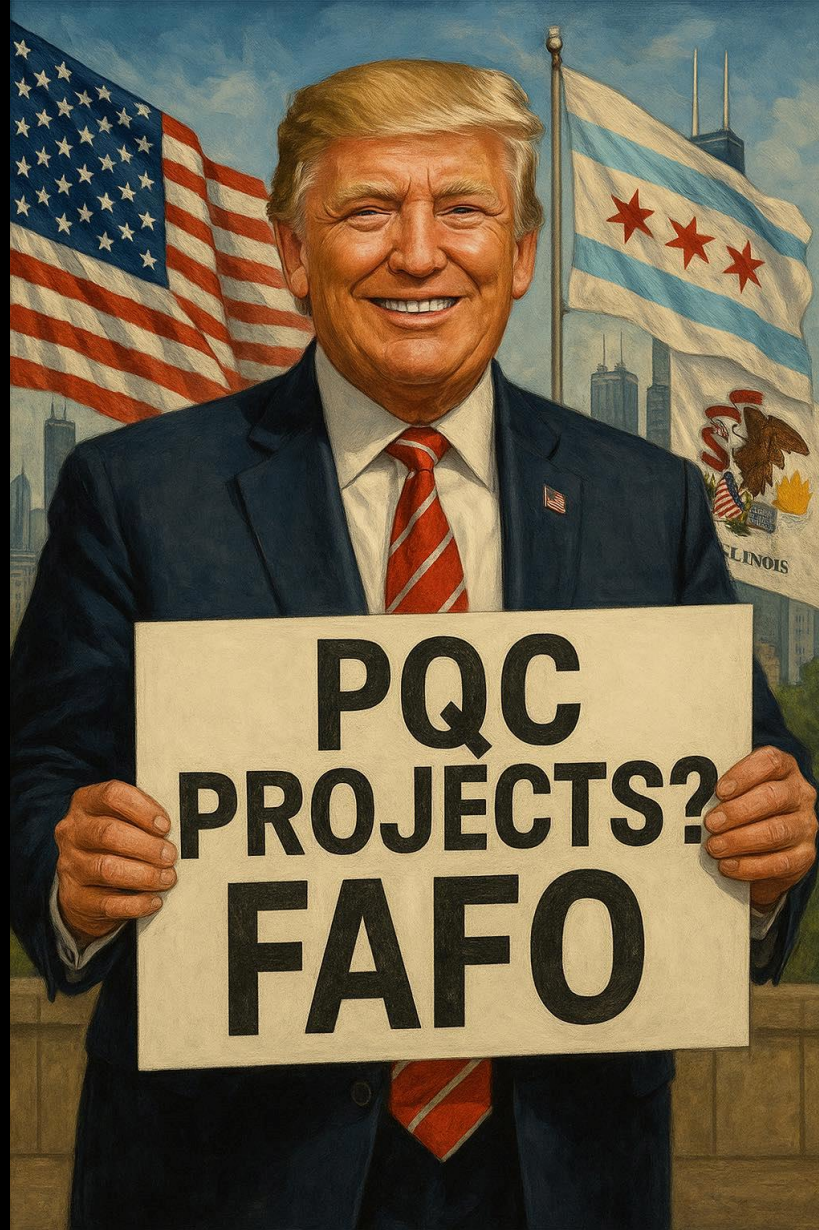
digitally remastered

**IT'S NOW
OR NEVER**

ELVIS PRESLEY

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Supplemental Slides

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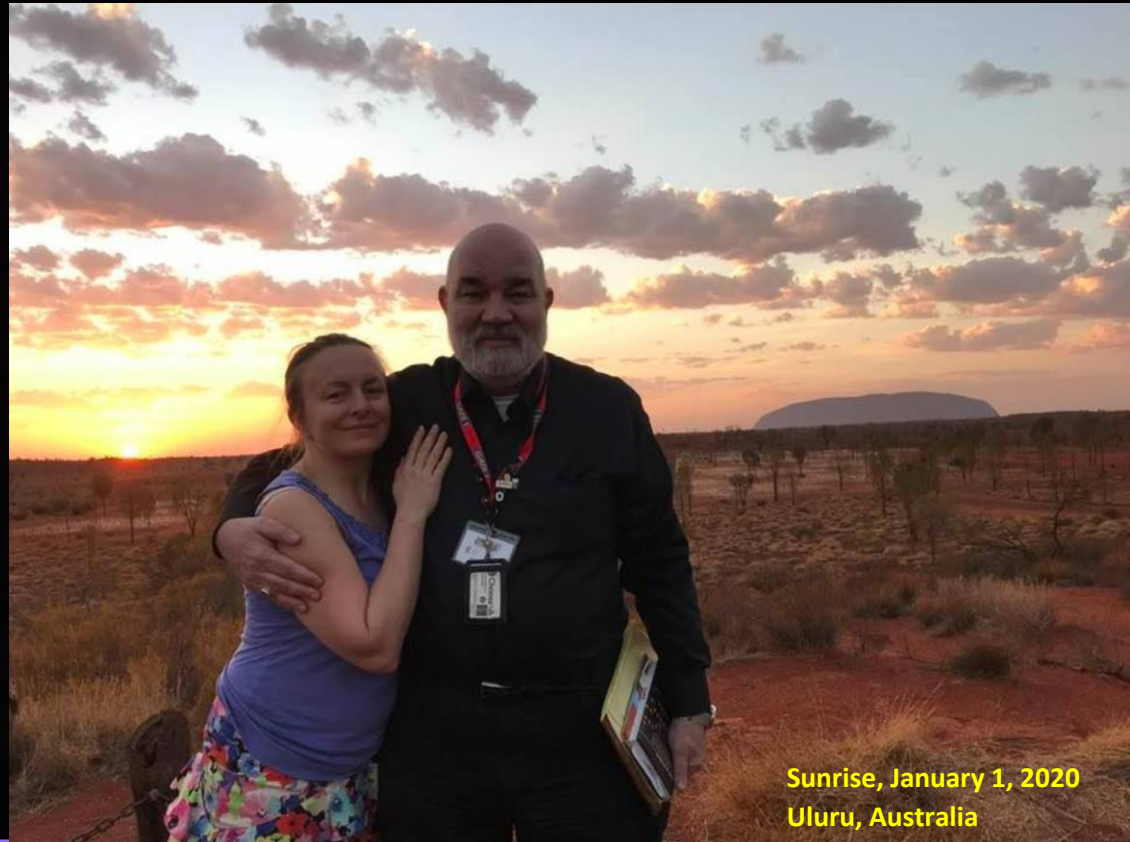
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HNDL

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8. 3 Graduate Degrees
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 - MS Cybersecurity
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13. Published Author: <https://billslater.com/writing>
14. Working with QSECDEF since September 2024.
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18. Voracious Reader with 18,000 physical books and 8000 digital books.
19. Meyers-Briggs: INFP.
20. Non-Denominational Christian (since 1973).



Sunrise, January 1, 2020
Uluru, Australia

William Slater


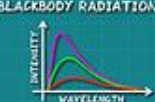



Slater Technologies, Inc
November 5, 2025

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THE MAP OF QUANTUM PHYSICS

PRE-QUANTUM MYSTERIES

ATOMIC SPECTRA

BLACKBODY RADIATION

THE STABLE ATOM

RADIOACTIVITY

PHOTOELECTRIC EFFECT


QUANTUM FOUNDATIONS





THE WAVE FUNCTION

PARTICLE-WAVE DUALITY

THE BORN RULE

INTERFERENCE PATTERN

DOUBLE SLIT EXPERIMENT

THE SCHRÖDINGER EQUATION

$$i\hbar \frac{\partial}{\partial t} \Psi = -\frac{\hbar^2}{2m} \nabla^2 \Psi + V(\mathbf{r}) \Psi$$




THE DIRAC EQUATION

$$i\hbar \gamma^\mu \partial_\mu \psi - mc\psi = 0$$






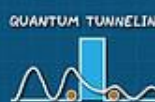









INTERPRETATIONS OF QUANTUM MECHANICS

COPENHAGEN

MANY WORLDS THEORY

CONSISTENT HISTORIES

QBISM

AND MANY OTHERS...
 STOCHASTIC INTERPRETATION
 COSMOLOGICAL INTERPRETATION
 QUANTUM BAHYSEISM
 ALTERNATIVE COLLAPSE
 TRANSACTIONAL INTERPRETATION

QUANTUM GRAVITY

M-THEORY

STRING THEORY

LOOP QUANTUM GRAVITY


QUANTUM PHENOMENA

PARTICLE PROPERTIES
 POSITION, MASS, ELECTRIC CHARGE, WEAK HYPERCHARGE, LEFT/RIGHT FAMILY NUMBER, SPIN, ANGULAR MOMENTUM, COLOR CHARGE, FLAVOR, BARYON NUMBER, LEPTON NUMBER

QUANTUM SPIN

SUPERPOSITION

SCHRODINGER'S CAT

ENTANGLEMENT

QUANTUM TUNNELING

SUPERCONDUCTIVITY
 COOPER PAIRS

QUANTUM NUMBERS
PHASE TRANSITIONS
 QUANTUM CRITICAL REGION, SUPERCONDUCTOR, NORMAL METAL, TEMPERATURE, MAGNETIC FIELD

DECOHERENCE

CASIMIR EFFECT

TOPOLOGICAL PHASE TRANSITIONS
 LOWER TEMPERATURE, HIGHER TEMPERATURE

ZERO-POINT ENERGY

QUANTUM HALL EFFECT

SUPERFLUIDITY

MAGNETIC RESONANCE IMAGING
 NUCLEAR MAGNETIC RESONANCE IMAGING


BELL'S THEOREM







ENERGY QUANTIZATION





QUANTUM THEORY

POSTULATES (PARAPHRASED)

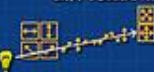

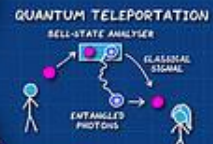



1. WAVE FUNCTION DETERMINES EVERYTHING.
2. ALL OBSERVABLES HAVE OPERATORS
3. OBSERVABLES ARE HERMITIAN
4. EIGENFUNCTIONS OF OPERATORS ARE INDEPENDENT
5. EXPECTATION VALUE INTEGRAL
6. TIME DEPENDENT SCHRÖDINGER EQUATION

PATH INTEGRALS

QUANTUM FIELD THEORY

SYMMETRIES

HILBERT SPACE


PARTICLE PHYSICS

QUANTUM CHROMODYNAMICS
 STRONG FORCE

ELECTROWEAK INTERACTIONS
 ELECTROMAGNETISM + WEAK FORCE
 γ, W^-, W^+, Z^0
QUANTUM ELECTRODYNAMICS


QUANTUM INFORMATION

QUANTUM CRYPTOGRAPHY

QUANTUM COMMUNICATION

QUANTUM TELEPORTATION
 BELL-STATE ANALYSER, CLASSICAL SIGNAL, ENTANGLED PHOTONS

QUANTUM COMPUTING
 QUBITS, QUANTUM SIMULATION

QUANTUM INTERNET

QUANTUM COMPLEXITY
 COMPUTATIONAL COMPLEXITY
 P SPACE, NP PROBLEMS, BQP, P PROBLEMS


THE STANDARD MODEL OF PARTICLE PHYSICS

QUARKS
 u, d, s, c, b, t
LEPTONS
 e, μ , τ , ν_e , ν_μ , ν_τ
GAUGE BOSONS
 γ, W^+, W^-, Z^0
ANTI-MATTER
 PROTON, ANTI-PROTON, P, P-bar
FEYNMAN DIAGRAMS

THE HIGGS BOSON


SOLID STATE DEVICES

BAND THEORY OF SOLIDS

TRANSISTORS
 SOURCE, GATE, DRAIN, N-TYPE, P-TYPE

SOLAR PANELS


CHARGE-COUPLED DEVICES
 CCD SENSOR

LIGHT EMITTING DIODES
 POSITIVE TERMINAL, NEGATIVE TERMINAL






LASERS

ATOMIC CLOCKS



SCANNING TUNNELING MICROSCOPES

ATOMIC FORCE MICROSCOPES

QUANTUM TECHNOLOGY
QUANTUM COMPUTING
 SUPERCONDUCTING MAGNETS, SQUIDS, JOSEPHSON FUNCTION





CONDENSED MATTER PHYSICS

PHOTOSYNTHESIS

SENSE OF SMELL

BIRD NAVIGATION

ENZYMES

HNDL




GOLD ATOM PHYSICS

DEGENERATE ULTRACOLD GASES
 DEGENERATE FERMI GAS, BOSE-EINSTEIN CONDENSATE

RYDBERG MATTER


QUANTUM CHEMISTRY

ELECTRONIC STRUCTURE

MOLECULAR DYNAMICS

QUANTUM MONTE CARLO METHODS


NUCLEAR PHYSICS

NUCLEAR FISSION

NUCLEAR FUSION

RADIOACTIVE DECAY
 ALPHA DECAY, BETA DECAY, GAMMA DECAY
