Quantum Diplomacy: India's Position in the Global Race for Quantum Communication and Computing

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Quantum communication and quantum computing sit at the intersection of science policy and geopolitics. Quantum communication, especially quantum key distribution (QKD), promises information-theoretic security for key exchange, while quantum computing threatens today's public key cryptography and promises new capabilities in optimisation, materials, and AI acceleration. Both arenas demand standards, interoperability, and trusted supply chains —making them inherently diplomatic.

Two dynamics make the present moment decisive. First, the cryptographic transition has begun, the U.S. National Institute of Standards and Technology (NIST) has finalised the first post-quantum cryptography (PQC) standards, shaping global vendor and government adoption. Aligning with these standards is both a technical and diplomatic act because compatibility determines who can trade, interconnect, and certify.

Second, flagship demonstrations are shaping narratives. China's *Micius* satellite anchored the case for space-based QKD and intercontinental quantum links, signalling national capability, resetting expectations in international negotiations, and inviting coalition responses.

For India, with its track record of mission-mode execution (space, digital public infrastructure) and coalition-building with both advanced economies and the Global South, quantum technology is a natural arena to blend technical progress with strategic outreach.

India's Policy Architecture

The National Quantum Mission (NQM), approved in April 2023 with a budget of ₹6,003.65 crore through 2030–31, anchors India's efforts.[1] It targets the full stack, computing, communication, sensing, and materials. Beyond funding, the mission's explicit goal is to seed, nurture, and scale an ecosystem, specialised hubs, testbeds, and public–private partnerships that translate science into systems.

NQM sits atop a distributed institutional base: DST (mission stewardship), MeitY (compute and road-mapping), DRDO (defence applications), ISRO/Department of Space (free-space and satellite links), and leading academic centres (IISc, IITs, IISERs). This architecture matters diplomatically because it creates negotiating capital. India can bring deployable testbeds and market scale to joint pilots and standards, rather than offering only lab-scale results.

Quantum Communication: From Lab to Field

India's most visible gains are in free-space and fibre-based quantum communication, the part of the quantum stack closest to immediate national security and critical infrastructure use. In June 2025, DRDO and IIT Delhi demonstrated entanglement-based free-space quantum secure communication over >1 km distance, validating optics, pointing, synchronisation, and error-handling under real-world conditions.[2,3] The official release frames it as a step toward quantum cyber security and future quantum networks. In 2024, DRDO reports also referenced entanglement distribution and QKD over ~8 km of optical fibre within IIT Delhi's campus, a complementary test that stresses interferometric stability and integrated control.

Though short of backbone scale, these results show India's capability to move from optics tables to field systems, paving the way for airborne and satellite relays. China's *Micius* satellite mission[4] illustrates how one flagship project can reset diplomatic leverage, while Singapore's National Quantum-Safe Network (NQSN) shows how metro-scale pilots can anchor global credibility. India could achieve similar outcomes either independently or through coalition projects.

Quantum Computing: Ambition, Access, and the Long Game

On the compute side, India is pursuing a twin-track strategy to build indigenous hardware stacks while securing access diplomacy to near-term systems for talent training and algorithm development. The NQM and related government communications outline time-phased targets to build domestic systems in the tens to hundreds of qubits over the mission horizon, across platforms such as superconducting and photonic qubits. In parallel, public institutions have discussed a quantum computing reference facility to integrate with national HPC assets, an access point for researchers and industry to prototype algorithms as domestic hardware matures.

Membership in global networks and joint research with foreign vendors helps India bootstrap talent and benchmark algorithms without waiting for homegrown hardware to catch up. This dual approach is not a substitute for domestic capability, but it is a force multiplier. It shrinks learning cycles, improves curriculum relevance, and positions Indian teams to contribute to open-source tooling and error mitigation techniques that travel well across hardware. The diplomatic payoff is reciprocity: India becomes a meaningful contributor to the global quantum software commons, not only a consumer of hardware.

Alongside qubits, supply chains for cryogenics, detectors, and photonics are chokepoints. Prosaic as it sounds, supply-chain diplomacy, co-development agreements, vendor-qualification frameworks, and offsets in space/defence procurement can be as impactful as qubit breakthroughs in the near term.

Standards, Security, and the PQC Inflection

The cryptographic transition is the near-term battleground. In August 2024, NIST finalised Federal Information Processing Standards (FIPS 203/204/205), setting the de facto global baseline.[5] Nations adopting them early can reduce "harvest-now, decrypt-later" risks while shaping global conformance tests. For India, aligning with NIST while creating India-specific profiles for Aadhaar, UPI, and national PKI would have a significant diplomatic impact across the Global South.

Notably, standards diplomacy is not just picking algorithms. It includes protocols for crypto-agility, migration schedules for sectors (telecom, power, finance), and hybridisation guidance (PQC + classical + QKD where justified). Publishing these as open playbooks, with reference implementations and procurement language, is a form of norm setting that aligns technological choices with India's broader role as a provider of digital public goods.

Comparative Landscape: Where India Stands

The United States, with algorithmic leadership via NIST and the largest commercial hardware ecosystem,

wields outsized influence over global quantum technology baselines, leveraging export controls and research security policies to define what can be shared internationally. For India, collaboration through mechanisms such as the Initiative on Critical and Emerging Technologies (iCET) working groups on quantum and telecom remains a diplomatic priority, enabling access to cutting-edge research, active participation in standards setting, and supply-chain stability.

The European Union's (EU) Quantum Flagship program, coordinating multi-billion-Euro investments and nurturing specialised industrial clusters such as photonics, presents a natural avenue for India to co-develop standards and establish interoperability labs, particularly in areas like QKD profiles and PQC deployments for critical infrastructure.[6]

China's achievements, most notably the *Micius* satellite and associated ground networks demonstrate early leadership in space-based quantum links and shape global strategic narratives.[4] While India need not replicate China's path exactly, it can pursue coalition satellites and interoperable testbeds with partner nations to share costs, accelerate capability, and influence standards.

The United Kingdom's national quantum strategy, backed by long-term funding and a robust university–industry bridge, makes it a strong candidate for collaboration in device research and talent exchange, domains in which India can rapidly strengthen its position.[7] Singapore's NQSN and NQSN+ projects offer a practical model for taking quantum-safe networking from concept to operational service, with active regulator participation and industry co-funding. India's metropolitan hubs could adapt this model to create live quantum corridors that serve as regional benchmarks.

In this global landscape, India's strengths lie in mission orientation, systems engineering capabilities derived from ISRO's heritage, and the scale of both its market and talent pool. The key gaps remain in space-based quantum links and the development of mid-scale domestic quantum computers, which can be addressed through targeted diplomatic initiatives and well-structured industrial partnerships.

Converting Technology into Diplomacy: Four Levers

India's quantum diplomacy can be advanced through four mutually reinforcing levers. First, standards and interoperability leadership offer a direct route to soft power through engineering. By convening and co-authoring QKD network interface profiles, India can align these efforts with PQC migration and crypto-agility principles. Hosting international plugfests and conformance testing events in India, backed by third-party certification, would position New Delhi as a gravitational center for the Global South seeking technical guidance and implementation models.

Second, joint demonstrators on both ground and space platforms can yield rapid gains. A collaborative small satellite QKD mission with Quadrilateral Security Dialogue (QUAD) or EU partners would produce three dividends: (a) hard technical learning in optics, precision pointing and key relay, (b) embedding shared standards directly into hardware and ground infrastructure, and (c) sending a strong symbolic signal of a trusted coalition in emerging technology. Domestically, establishing inter-city quantum-safe communication corridors, such as Delhi–Mumbai–Bengaluru, integrated with banks and telecom operators, could mirror Singapore's NQSN approach. These corridors could generate publishable playbooks, serving as practical models for replication in other countries.

Third, a nation-scale PQC migration program would allow India to lead by example. This would involve mandating comprehensive cryptographic inventories, prioritising the migration of high-risk systems with long data confidentiality lifetimes, and publishing sector-specific transition timelines. Providing reference implementations, standardised procurement templates, and tailored training for small and medium enterprises (SMEs) would not only secure domestic infrastructure but also create an exportable governance toolkit that partner nations could adopt.

Finally, talent and supply-chain compacts are essential to sustaining momentum. India can negotiate

reciprocal fellowship programs, establish joint intellectual property (IP) frameworks, and create attractive re-entry incentives for Indian researchers working abroad. On the hardware side, coupling defence and space procurement offsets with local manufacturing of critical quantum components, such as cryogenic systems, single-photon detectors, and advanced photonics, would strengthen domestic capacity. Coordinating trusted vendor lists with allied nations would further reduce embargo risks and ensure resilient supply chains in strategic technologies.

India's Recent Proof Points

India's recent advances in quantum communication provide tangible platforms for science diplomacy and technical collaboration. The DRDO–IIT Delhi free-space entanglement demonstration, achieving distances beyond 1 km, serves as a strong foundation for proposing air-to-ground or even air-to-air quantum link trials with international partners. Similarly, fibre-based entanglement demonstrations over ~8 km provide a practical sandbox for testing interoperability and key-management schemes essential for real-world deployments.

From a strategic funding perspective, the predictable eight-year envelope of the NQM allows India to plan recurring interoperability events and commit to multi-year co-development projects. Such long-term budgeting sends strong signals to potential partners, reassuring them of India's sustained engagement and reliability in joint quantum ventures. With the U.S. NIST's PQC standards finalised, India has an opportunity to brand itself as "quantum-safe by design", reinforcing its role as a trusted technology partner.[8]

The Diplomatic Theatre

India's quantum strategy gains significant strength through its network of minilateral and bilateral partnerships, which serve as both innovation platforms and diplomatic channels. The U.S.– India Initiative on Critical and Emerging Technologies (iCET) includes dedicated working groups on quantum and telecom, fostering alignment on standards and enabling structured research exchanges. In the near term, this collaboration can yield practical outcomes such as coordinated PQC roadmaps and mutually beneficial supply-chain agreements for critical components like cryogenic systems and quantum detectors, reducing deployment risks.

The QUAD working groups provide another powerful avenue for cooperation, particularly in developing joint pilot projects such as a QUAD small satellite QKD payload and establishing interoperability laboratories, long term infrastructure that can endure beyond political shifts. Similarly, the EU's Quantum Flagship ecosystem[6] and the UK's National Quantum Strategy[7] present India with valuable opportunities for collaboration in device physics, foundry access, and facilitating talent mobility through dedicated visa schemes.

Partnerships with ASEAN nations, especially Singapore, offer operational benefits by enabling replication of quantum-safe communication corridors similar to the NQSN, alongside exchanges on regulatory frameworks and commercial models. These collaborations are not symbolic but operational channels to secure market access and shape global governance.

A Playbook for India's Quantum Diplomacy

India can strengthen its global quantum diplomacy by leading decisively. It should:

- Lead PQC migration by example.
- Establish joint QKD demonstrators (ground and space).
- Create interoperability and certification labs.

- Negotiate talent reciprocity and secure supply chains.
- Export policy toolkits and training under a Quantum-Safe India brand.

Quantum progress will be incremental—not a single Sputnik moment but a chain of demonstrations, pilots, and standards. India has the ingredients: mission orientation, proof-of-concept field results, and pragmatic partnerships. The task ahead is to turn these ingredients into structured influence: (a) lead the crypto transition by example, (b) lock in interoperability through joint ground and space pilots, (c) become a certification and training hub for the region, and (d) build supply-chain resilience in the unglamorous but essential sub-systems.

If India executes on this playbook, its contributions will be felt beyond its borders, not only in qubits and key rates but also in the rules, norms, and trusted supply chains that shape the quantum era. That is quantum diplomacy in practice: science and engineering, scaled by partnerships, to build a secure and open future.

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