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Amaravati Quantum Valley — India's National Quantum Mission Takes Shape

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WHY IN NEWS

Amaravati, Andhra Pradesh's upcoming greenfield capital, will host India's first Quantum Valley — a dedicated tech park anchored by an IBM Quantum System Two facility, with TCS as a development partner. The announcement marks a significant milestone in the implementation of India's National Quantum Mission approved in April 2023.

WHAT IS QUANTUM COMPUTING?

Quantum computing harnesses the principles of **quantum mechanics** — specifically **superposition** and **entanglement** — to perform computations that would take classical computers millions of years to complete.

Classical computers store information as **bits** (0 or 1). **Quantum computers** use **qubits** (quantum bits) that can exist in a superposition of 0 and 1 simultaneously, exponentially expanding the computational space. When qubits are **entangled**, the state of one qubit instantly affects others, enabling massively parallel computations.

Why it matters for India: Quantum computers can break current RSA encryption standards in minutes. Conversely, **quantum key distribution (QKD)** can create theoretically unbreakable encryption. Nation-states that achieve quantum supremacy will have decisive advantages in both cybersecurity offence and defence.

Quantum processors currently operate at temperatures near **absolute zero** (approximately -273°C) in dilution refrigerators to maintain qubit coherence.

IBM QUANTUM SYSTEM TWO — WHAT IT IS

IBM Quantum System Two is IBM's most advanced superconducting quantum processor architecture. Key features:

- Multi-cryostat design allowing scaling to **thousands of qubits**
- Integrated classical computing infrastructure for hybrid quantum-classical algorithms
- IBM's proprietary **Eagle, Heron, and Condor** processor families designed for system two
- Remote access via **IBM Quantum Network** for researchers and enterprises globally

The Amaravati facility will be IBM's first Quantum System Two installation in South Asia, giving Indian researchers direct access to cutting-edge quantum hardware.

TCS AS DEVELOPMENT PARTNER

Tata Consultancy Services (TCS), partnering with IBM, will focus on:

- Developing **quantum algorithms** for specific Indian industry use cases (pharmaceuticals, logistics, financial modelling)
- Building **quantum applications** optimised for the IBM hardware platform
- **Workforce development** — training the next generation of Indian quantum engineers and scientists
- Contributing to the **National Quantum Mission's** human capital goal of building a quantum-ready workforce

NATIONAL QUANTUM MISSION (NQM) — INDIA'S STRATEGIC FRAMEWORK

The **National Quantum Mission** was approved by the **Union Cabinet** in **April 2023** under the Department of Science and Technology (DST). It is one of the National Missions under India's Science, Technology and Innovation Policy.

Parameter	Details
Budget	Rs 6,003 crore
Period	2023-24 to 2030-31 (8 years)
Nodal ministry	Department of Science and Technology (DST)
Apex body	National Mission Steering Committee (under Principal Scientific Adviser)
Technology hub	T-Hub Quantum under each of the 4 mission areas

FOUR PILLARS OF NQM

1. Quantum Computing:

- Target: Develop **50–1,000 qubit** intermediate-scale quantum computers
- Applications: Drug discovery, materials science, climate modelling, logistics optimisation, cryptography
- Hardware targets: Superconducting qubits (IBM/Google path) and photonic qubits (alternative path)

2. Quantum Communication:

- Target: **Quantum Secure Communication** networks using Quantum Key Distribution (QKD)
- 2,000 km inter-city QKD by 2031

Satellite-based quantum communication (linking with ISRO's space-based QKD programme)

Goal: A quantum-secured communication backbone for defence, government, and critical financial infrastructure

3. Quantum Sensing and Metrology:

Ultra-precise **atomic clocks** (relevant to NavIC/navigation sovereignty — see separate article)

Quantum gravimeters for underground mineral/water mapping

Quantum magnetometers for medical imaging

4. Quantum Materials and Devices:

Develop indigenous fabrication of quantum devices

Reduce dependence on foreign quantum hardware

Build ecosystem of quantum-grade materials manufacturers

AMARAVATI — WHY THIS CITY?

Amaravati is Andhra Pradesh's planned greenfield capital (following the 2014 bifurcation of AP and Telangana under the AP Reorganisation Act). Located on the banks of the Krishna River in Guntur district, it is being built as a world-class smart city.

Factors making Amaravati suitable:

TIDCO (Andhra Pradesh Industrial Infrastructure Corporation) has designated land within the Quantum Valley Tech Park

Proximity to established tech corridor between Hyderabad (Cyberabad) and Amaravati

State government's aggressive investment in emerging technology parks (semiconductor, quantum, data centres)

AP Capital Region Development Authority (APCRDA) driving rapid infrastructure development

STRATEGIC AND SECURITY IMPLICATIONS

Post-Quantum Cryptography (PQC): Current public-key cryptography (RSA, ECC) will be vulnerable once quantum computers achieve sufficient scale. India's **NCIIPC and CERT-In** are already working on PQC migration roadmaps for critical government systems.

Harvest Now, Decrypt Later: Adversaries may currently be harvesting encrypted Indian government communications to decrypt them once they have quantum capability. This makes quantum-secure communication an urgent national security imperative, not a distant future concern.

Defence Applications: Quantum sensing for submarine detection, nuclear site monitoring, and underground facility mapping has direct strategic value.

INDIA'S COMPETITIVE POSITION

Country	Quantum Programme	Status
USA	National Quantum Initiative (2018), $1.8B	Leading in superconducting qubits (Google, IBM)
China	15-year quantum plan, estimated >$15B	Leading in quantum communication (satellite QKD)
EU	Quantum Flagship, €1B	Strong in quantum sensing and photonics
UK	National Quantum Technologies Programme, £2.5B	Strong research base
India	NQM, Rs 6,003 crore (~$720M)	Early-stage; Amaravati as first anchor

India's NQM budget (~$720 million) is significantly smaller than China and USA, but the IBM partnership and TCS involvement give India access to cutting-edge hardware without building quantum fabrication from scratch.

UPSC RELEVANCE

National Quantum Mission (April 2023, Rs 6,003 crore, DST), IBM Quantum System Two, qubits vs. bits, superposition and entanglement, Quantum Key Distribution (QKD), post-quantum cryptography, NCIIPC, Amaravati (AP capital, Krishna River, Guntur district), TCS, AP Reorganisation Act 2014. **Mains GS-3:** *Science and technology; emerging technologies and national security; critical infrastructure cybersecurity; India's technology diplomacy; government spending on R&D; Make in India in deep technology.*
Interview: *"China has invested over $15 billion in quantum technology while India's National Quantum Mission is budgeted at Rs 6,000 crore. Is this a strategic gap India can afford? What should India prioritise — quantum computing, quantum communication, or quantum sensing?"*

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NATIONAL QUANTUM MISSION:

Approved: **April 2023** (Union Cabinet) | Budget: **Rs 6,003 crore** | Period: 2023-24 to 2030-31

Nodal ministry: **Department of Science and Technology (DST)**

4 pillars: Quantum computing, quantum communication, quantum sensing, quantum materials

Qubit target: **50-1,000 qubit** intermediate-scale quantum computers by 2031

QKD network target: **2,000 km** inter-city quantum secure communication by 2031

AMARAVATI QUANTUM VALLEY:

IBM Quantum System Two + **TCS** as development partner

Location: Amaravati, Andhra Pradesh (AP capital city, Krishna River, Guntur district)

India's **first** Quantum Valley tech park

IBM Quantum System Two: Multi-cryostat architecture; scales to thousands of qubits

QUANTUM COMPUTING CONCEPTS:

Qubit: Quantum bit; can be 0, 1, or superposition of both simultaneously

Superposition: Qubit exists in multiple states until measured

Entanglement: Two qubits linked — state of one instantly determines state of the other

Quantum supremacy: When quantum computer solves a problem classical computer cannot do in practical time

Operating temperature: Near **absolute zero** (-273°C) in dilution refrigerators

SECURITY IMPLICATIONS:

Post-Quantum Cryptography (PQC): Encryption resistant to quantum attacks; NIST (USA) standardised PQC algorithms in 2024

Harvest Now, Decrypt Later: Adversaries store encrypted data now; decrypt once quantum capability achieved

QKD: Quantum Key Distribution — theoretically unbreakable encryption using quantum states; any interception alters the quantum state (detection built in)

COMPETITIVE LANDSCAPE:

USA NQI: National Quantum Initiative 2018; $1.8B | Leaders: Google, IBM, Intel

China: $15B+ investment; Micius satellite (world's first quantum satellite, 2016); achieved quantum communication over 1,200 km

EU: Quantum Flagship €1B

India NQM: ~$720 million (Rs 6,003 crore)

ANDHRA PRADESH CAPITAL FACTS:

Amaravati: AP capital post-2014 bifurcation | AP Reorganisation Act 2014

Location: Krishna River, Guntur district

Smart city design by Singapore-based firms

APCRDA: Andhra Pradesh Capital Region Development Authority (created 2014)

OTHER RELEVANT FACTS:

Quantum gravity sensing: Can map underground water tables, mineral deposits, enemy tunnels — strategic for Himalayas/J&K

> Quantum atomic clocks: 100-1,000× more accurate than current atomic clocks; critical for NavIC satellite navigation system
>
> India's other deep tech missions: National AI Mission, Semiconductor Mission, Deep Ocean Mission — all approved 2023-24

Sources: GKToday, DST, PIB

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