REPORT ON THIRD INTERNATIONAL QUANTUM COMMUNICATION CONCLAVE

held on 25th April, 2025 at Vigyan Bhawan, New Delhi

TEC 91038: 2025

TELECOMMUNICATION ENGINEERING CENTRE
Department of Telecommunications
Ministry of Communications
Government of India

"Do not lower your goals to the level of your abilities, instead raise your abilities to the height of your goals".

-Swami Vivekananda

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1. About the event

1.1 Telecommunication Engineering Centre (TEC) under the Department of Telecommunication (DoT) organised the Third International Quantum Communication Conclave in collaboration with Centre for Development of Telematics (C-DOT) on 25th April 2025 at Hall No 06, Vigyan Bhawan, New Delhi.

The information about the functions, roles and responsibility of the organisations holding the Quantum Communication Conclave is enclosed in **Annexure-A**.

1.2 The Quantum Communication Conclave was conducted by the TEC in collaboration with C-DOT. The objectives of the conclave were as follows:

i. To bring together the researchers and the industries working in Quantum Technologies and foster the creation of a community among academia, R&D Institutions, and industries.
ii. To create awareness among all the stakeholders about the significant research and innovation being carried out in the areas of Quantum Communication and motivate them to contribute in this field.
iii. To identify the challenges and opportunities for India to take the lead in the development of Quantum Technologies.
iv. To focus on the importance of standardisation, testing and certification framework and push for contributions towards the standards development and IPR creation in the areas of Quantum Technologies.
v. To identify gaps in the standardisation of the existing and upcoming Quantum products and services in the niche technology area, where standardisation would play a vital role in QT ecosystem.
vi. To identify the applications and use cases of Quantum Technologies in the communication networks (e.g. Integration of Quantum Technologies in Mobile Network, Space, Defence, Healthcare, Power, Infrastructure, BFSI sector etc).
vii. To identify the challenges in the deployment of Quantum products and services in the communication networks and devices.

1.3 The Conclave was attended by around 500 members joined in-person, around 200 persons attended online and gathered more than 500 views on the live casting on YouTube. The recording of the event is available on YouTube platform of DoT and C-DOT and the details are mentioned in **Annexure-G**.

1.4 The following talk was delivered by the national and international subject matter experts.

Name of the Speaker	Title of the Talk
Dr. Rajkumar Upadhyay, CEO C-DOT	C-DOT initiatives in the area of Quantum Communication
Dr. Anandaraman Sankaran - Senior Manager, QKD Technical Marketing, Japan	Toshiba Quantum Technology: Preparing Your Organization for the Quantum Era
Dr. Ray Harishankar – IBM Quantum Safe, USA	IBM advancement in Quantum Computing and Post Quantum Cryptography
Dr. Kaveh Delfanazari – Senior Lecturer (Electronic & Nanoscale Engineering) University of Glasgow, UK	Engineering Large-Scale Quantum Communication: The Next Leap
Prof. Anil Prabhakar, IIT Madras	Quantum Communications beyond QKD
Mr. Rowan Högman (Advanced technology Director) M/s Ericsson, Sweden	Navigating the Quantum Frontier: Ericsson's Vision and Insights
Shri Kamal Kr. Agarwal, DDG (Quantum Technology),TEC, DoT	361^{o} perspective on Quantum Communication and TEC's Role in Standardization, testing and certification
Shri Dilip Singh, CTO, QuNu Labs	Leveraging Hybrid Approach to accelerate adoption of Quantum communications technology
Dr. Vipin Rathi, Delhi University	Quantum-Resilient 5G and 6G Networks
Prof. Urbasi Sinha, Raman Research institute, Bengaluru	Advances towards free space quantum communications and device independent random number generation.
Dr. Goutam Paul,ISI Kolkata	Quantum AI: How Quantum Computing Could Revolutionize Artificial Intelligence
Shri G Narendra Nath, JS, NSCS, **Moderator**	**Panel Discussion :** Leveraging Quantum Technology to Secure Digital Public

Shri A.G. Giridharan, General Manager, Reserve Bank of India	Infrastructure
Shri Praful Kumar Sigtia, DDG Information Security, UIDAI	
Shri Chandra Prakash Sharma, Scientist G, Space Application Centre	
Dr. S. Venkataraman, Director, C R RAO	
Shri Sanjeev Dhallam, VP, Bharti Airtel	
Dr. Shravani Shahapure, Deloitte India	

2. Inauguration of the Quantum Communication Conclave:

The conclave was inaugurated by Shri Jyotiraditya M. Scindia, Hon'ble Minister of Communications and Development of the Northeastern Region in the august presence of **Dr. Pemmasani Chandra Sekhar,** Hon'ble Minister of State for communications and Rural Development; **Prof. Ajay Kumar Sood**, Principal Scientific Adviser to the Govt. of India; **Dr. Neeraj Mittal,** Chairman Digital Communication Commission and Secretary (T) and **Ms. Tripti Saxena**, Sr. DDG and Head, TEC.

3. Release of TEC Standards

Hon'ble Minister of Communications along with the dignitaries on the dias released the standard and technical reports prepared by the TEC. These standards and technical reports will enable the Indian companies for accessing national and international markets. It is important that quantum products and services should be tested and certified to ensure their functional capabilities, reliability, safety, compliance of security

services and interoperability with other subsystems and technology and compatibility in multi-vendor environment.

To achieve this objective, the following standard and technical reports prepared by the TEC were released:-

i. Standard on "**Quantum Random Number Generator"** (TEC 91020:2024):

This standard will help to validate the Quantum Random Number Generator.

ii. Technical Report on **"Migration to Post Quantum Cryptography"** (TEC 91018:2025):

The purpose of the technical report is to sensitize the organizations to secure and identify their critical digital infrastructures including data and applications beforehand and be ready for a smooth transition to quantum safe cryptography due to sudden deployment of cryptographically relevant quantum computers in the network.

iii. Technical Report on **"Quantum Secure 5G / beyond 5G Core using Post-Quantum Cryptography"** (TEC 91028:2025)

The technical report will serve as guideline for industries, government departments, and network operators to safeguard their telecom network by preventing cyber threats due to advancement of quantum computers.

4. The Key Takeaway points are as follows:

Based on the deliberations and interactions among various speakers, delegates, and subject matter experts from diverse stakeholder groups, the following actionable key takeaways are as follows:

S. No	Take away points	Responsibility Centre
1.	Sensitisation of the critical ministries, organisations to identify their critical digital infrastructures (including data and applications) for smooth migration to quantum safe cryptography due to sudden deployment quantum computers in the network	DoT, MeitY, DST and other critical ministries to form a joint working group to monitor and extend help in migration to PQC*
2.	Development of standards for testing & certification of quantum products and services for accessing the global market	The development of standards, testing, validation and certification of Quantum products and solution with the collaboration of TEC (DoT), BIS, TSDSI, NPL-CSIR.
3.	Establishment of Test beds to validate the indigenously developed quantum products/ services in-line with the 5G test bed wherein start-ups, researchers can test their innovations/solutions	TEC, DoT, NPL
4.	Development of fibre based QKD (terrestrial communication) , free space QKD and satellite based QKD (non-terrestrial communication) systems	DoT, ISRO
5.	Preparation of standards and test guides for the products of quantum technologies developed through funding under the NQM	DST and TEC (DoT)
6.	Integration of quantum-safe layers (PQC) in addition to classical cryptography in 5G Core and beyond for enhanced data security	DoT and Telecom Service Providers*
7.	Development of Indigenous, Crypto agile**,** Quantum-safe Algorithms (PQC based) for mission-critical communication	DoT, DRDO, and DST
8.	Promotion for creation and protection of IPs and SEPs (Standard Essential	DoT, DST, Department of Commerce

	Patents)	
9.	Capacity Building through educational programs such as Masters, PhDs, and specialized diploma courses on quantum technology	DST, NCA-T (DoT) and Ministry of Education
10.	Establishment of Centre of Excellence (CoEs) and incubation centres for start-ups.	DoT
11.	Indigenisation of Hardware Components of Quantum Technologies	C-DOT, DST, DoT
12.	Collaboration with the leading international organisations to exchange knowledge, strength and weakness in development of product/ solution, and to promote indigenous solutions	DoT along with other ministries
13.	Conducting pilot studies and PoC Test Trials for indigenously developed quantum products across various strategic sectors like telecom, banking, defence sectors etc.	TEC, C-DOT, DST, NPL and user agencies
14.	Spreading awareness about the Quantum Communication Technology	TEC, DoT
15.	Constitution of a Focus Group to keep abreast of the current development by the different ministries	TEC, DoT, DST, MeitY and other ministries

** A technical report for migration to Post Quantum Cryptography (PQC) and quantum-secure 5G/ beyond 5G Core using PQC has been released by TEC.*

5.1 Welcome address by Ms. Tripti Saxena, Sr. DDG and Head of TEC

Sr. DDG and Head of TEC welcomed all the dignitaries on the dias, eminent speakers from India and abroad, delegates, exhibitors, and other stakeholders in the event. She highlighted that the conclave would provide a platform to connect, share advancements and challenges, networking with the peer organisations etc to develop secure communication technologies. She explained about the roles and responsibilities of Quantum technology division of TEC in the formulation of standards, test guides, certification of products & technologies, technical reports etc.

to have secure communication in close co-ordination with the academia, Research organisations, subject matter experts, Govt. organisations, industry and start-ups.

5.2 Opening address by Dr. Neeraj Mittal, Chairman Digital Communication Commission and Secretary (Telecom), Department of Telecommunications

Dr. Neeraj Mittal emphasized about the benefits of the Quantum technology along with taking caution about the capability of quantum computer in breaking the classical cryptographic algorithms presently in use in financial sector. He mentioned that quantum technology is a "double-edged sword" and should be handled with care. He encouraged children and students to study about the quantum technology in the school itself to have deep understanding about the technology. He mentioned about the 'Q node OS' published in the nature magazine which will be helpful to connect different type of Quantum computers, which will lay the foundations for the quantum internet to come. He wished that the Quantum Conclave would help in redefining boundaries, foster collaboration especially since this is an interdisciplinary field, develop recommendations so that the government will be able to take appropriate decisions while formulating policies.

5.3 Keynote address by Prof. Ajay Kumar Sood, Principal Scientific Adviser to the Government of India

Prof. Ajay Kumar Sood apprised about the readiness of India and on-going research across four verticals in National Quantum Mission which is a part of the report "India ready for a Quantum Leap, our preparedness for Quantum Technologies". He said, "*Today we are in the second revolution of Quantum Mechanics of the newest technology frontier where we now have the tools to control the quantum systems*". He mentioned about the NQM mission having 14 technical groups, 17 project teams and 152 researchers from 43 institutions along with critical ministries MeitY, DoT, DAE and DRDO in Mission Governing body and executive council. He emphasised that India has potential to be a global player in the quantum technology supply chain. *He drew attention on reducing the imports by developing industries for the hardware's used in quantum technology.* He mentioned the quote of Swami Vivekananda "*Do not lower your goals to the level of your abilities, instead raise your abilities to the height of your goals"*, it's so very well said and for quantum field it is really true. He was confident with the leadership of DoT and C-DOT playing important role in quantum race.

5.4 Special address by Dr. Pemmasani Chandra Sekhar, Hon'ble Minister of State for communications and Rural Development

Dr. Pemmasani Chandra Sekhar deliberated upon the development of quantum chips having lower error rates with greater scalability by the leading technology companies like IBM, Microsoft, and Google. As a result, more logical qubits (good qubits) will be available for quantum computing. The immense computational power of quantum machines threatens the present encryption methods, and can expose sensitive financial, healthcare, and Defence data. The country has already achieved significant milestones, such as demonstrating quantum key distribution over 150 kilometres, developing quantum random number generators, and developing quantum computers with 25 qubits. These accomplishments reflect India's growing leadership and ambition in the quantum domain. The government is also actively supporting the development of standards, testing frameworks and real-world trials to ensure that India not only participates in the quantum revolution but also shapes its direction. He concluded with a call to action, urging researchers, engineers, and entrepreneurs to collaborate fearlessly, innovate relentlessly and expand the horizons of quantum science. He highlighted that collective effort is required for building a secure, sustainable, and sovereign quantum future.

5.5 Inaugural address by Shri Jyotiraditya M. Scindia, Hon'ble Minister of Communications and Development of the North-eastern Region

The Hon'ble Minister of Communications and Development of the North-eastern Region Shri Jyotiraditya M. Scindia along with all the participants observed two-minute silence to pay homage to the innocent people who lost their lives in the terrorist attack in "Pahalgam" on 22nd April 2025.

Afterwards, Shri Jyotiraditya M. Scindia delivered his inaugural address explaining that the quantum computing is not only faster but has capabilities to solve many unsolved complex problems. He mentioned that unlike traditional systems that rely on binary bits, quantum computers use qubits, which can exist in multiple states simultaneously due to quantum superposition. When combined with entanglement a phenomenon, where the state of one qubit can affect another, no matter how far apart, they allow for problem-solving capabilities that are simply beyond the reach of classical computer systems. These properties are not theory anymore; and are already being applied in sectors such as drug discovery, material science, financial services, and urban planning. Its immense

computational power could render current encryption systems obsolete. Shor's algorithm poses a serious threat to traditional RSA-based encryption. In response, India is aggressively developing quantum-safe communication systems. One of the most promising efforts is the development of Quantum Key Distribution (QKD) system by C-DOT, which uses the properties of single photons to transmit encryption keys securely. Any attempt of interception alters the state of the photons, immediately signalling a breach. Currently operational over 100 kilometres, these systems are being extended using trusted relay nodes. He mentioned that internationally, there has already been successful quantum transmission over 158 miles using traditional optical fibre without cryogenic cooling, signalling rapid advancement in this field.

He mentioned about the National Quantum Mission, launched in April 2023 by the Govt. of India with an outlay of ₹6,000 crores, with the objective of development of 1,000-qubit quantum computers, enabling secure quantum communication over 2,000 kilometres and foster research and development.

The efforts of TEC (Telecommunication Engineering Centre) were acknowledged in preparation of new standards and technical reports on quantum-resilient 5G Core and migration to PQC.

He wished that the conclave would bring together policymakers, scientists, entrepreneurs and industry leaders with one mission to build a future where data is not only fast but fortified, where communication is seamless yet secure, and where India's technological leadership reshapes the global digital order. The conference was not just about discussing what quantum can do; it was about building that "*future now, with boldness, with clarity and with a shared sense of national purpose."*

6. Technical Sessions

The summary of the technical sessions/talks delivered during the conclave along-with profile of the speakers is enclosed as **Annexure-B** and details of Panel discussion is enclosed as **Annexure-C.** The Photographs of the conclave are attached in **Annexure-D.**

7. Inauguration of the Exhibition for Quantum Products

The exhibition, showcasing various quantum products developed indigenously was inaugurated by Shri Jyotiraditya M. Scindia, Hon'ble Minister of Communications and Development of Northeastern Region along with Dr. Pemmasani Chandra Sekhar, Hon'ble Minister of State Communications and Rural Development after the Inaugral Addressat Vigyan Bhawan. The details of the products displayed at the exhibition is enclosed as **Annexure-E.**

List of the exhibitors:

1. Centre for Development of Telematics (C-DOT)
2. QNu Labs Pvt. Ltd.
3. C R Rao Advanced Institute of Mathematics, Statistics & Computer Science
4. QuTeSS Lab Pvt. Ltd.
5. New Age Instruments & Materials India
6. QpiAI Pvt. Ltd.

Posters that were shared by the industries, academia and start-ups to showcase their innovations, products and services in this field, were displayed on the display boards (digital standees) outside the hall. Details of the posters displayed on the digital display boards (standee) is enclosed as **Annexure-F.** The list of organisations, who shared their posters are:

1. Centre for Development of Telematics (C-DOT)
2. Bharat Electronics Limited (BEL)
3. C R Rao Advanced Institute of Mathematics, Statistics & Computer Science
4. QuTeSS lab
5. Scytale Alpha Pvt. Ltd.

8. Vote of thanks and concluding remarks:

Vote of thanks was given by Sh. Kamal Kumar Agarwal, DDG (QT), TEC, DoT. He concluded the event with a note of importance of migration from classical system to PQC based system by various organisations and critical ministries. He mentioned that TEC has taken a note about the requirement of standardization, testing and certification of the technology and products of quantum communication in particular. He also reiterated about the importance of revision of standards to keep pace with the fast development in this technology domain. He thanked all the speakers, delegates, participants including those who joined online, for actively participating and contributing in the event and making it a success.

***** End of the report *****

Annexure-A

Functions of TEC

i. TEC is a technical body representing the interest of Department of Telecom, Government of India.
ii. Prepare specification of common standards with regard to Telecom network equipment, services and interoperability.
iii. Specifications released as Generic Requirements (GRs), Interface Requirements (IRs) and Service Requirements (SR).
iv. Issuing Interface Approvals, Certificate of Approvals, Service Approvals & Type Approvals.
v. Formulation of Standards and Fundamental Technical Plans.
vi. Interact with multilateral agencies like APT, ETSI and ITU etc. for standardisation.
vii. Develop expertise to imbibe the latest technologies and results of R&D.
viii. Provide technical support to DoT and technical advice to TRAI & TDSAT.
ix. Coordinate with C-DOT on the technological developments in the Telecom Sector for policy planning by DoT.

Functions of C-DOT

i. C-DOT is an autonomous Telecom R&D centre of DoT, Govt. of India.
ii. Conducts research and development in various telecom areas, including optical, switching, wireless, security, and network management.
iii. Develops solutions for telecommunication and converged networks, including those related to rural applications, strategic sectors, and security agencies.
iv. Facilitates technology transfer to Indian manufacturers, strengthening the domestic telecom manufacturing base.

Annexure-B

SESSION-I:

Speakers of the session:

a) **Dr. Rajkumar Upadhyay** CEO, C-DOT
b) **Dr. Anandaraman Sankaran** from Toshiba Quantum Technology
c) **Dr. Ray Harishankar** from IBM Quantum Safe
d) **Dr. Kaveh Delfanazari** from University of Glasgow, UK

Name of the Speaker	Profile of the Speakers
Dr. Rajkumar Upadhyay	Dr. Rajkumar Upadhyay is the CEO of C-DOT. C-DOT is actively involved in the development of quantum technologies, particularly in quantum communication and has developed Quantum key distribution systems and Post Quantum Cryptography Systems, which enable the secure transmission of information. He is an officer of the Indian Telecommunication Services of the Government of India. He has a Ph.D. in Corporate Strategy & Policy from the Indian Institute of Management Bengaluru and is also an alumnus of IIM Bangalore's Post Graduate Programme in Public Policy & Management. He also possesses a certificate in International Public Policy from Syracuse University, USA. He has won many awards which include J. C. Bose award by Ministry of Defence, the National e-Governance award, CIO 100 award by International Data Group, and Deepak C. Jain Award by IIM Bengaluru.
Dr. Anandaraman Sankaran	Dr. Anandaraman Sankaran is the Senior Manager of QKD Marketing at Toshiba Asia Pacific Pte Ltd, Singapore, where he leads the Quantum Key Distribution (QKD) market and business development efforts. With Toshiba at the forefront of QKD technology, Anand is driving the adoption of quantum-safe solutions across industries. In this session, he shared valuable insights into deployment strategies, real-world use cases, and Toshiba's commercialization journey empowering organizations to build secure, future-ready networks in the emerging Quantum Era.

Dr. Ray Harishankar	Dr. Ray Harishankar is an IBM Fellow and Vice President within the Quantum team focused on Quantum Safe. He is responsible for driving the overall strategy for IBM Quantum Safe, quantum safe products and product engineering. Ray leverages the deep technical expertise of IBM in security services, post quantum cryptography and pragmatically applies it at clients. He advocates IBM capabilities and leadership in Quantum Safe with clients.
Dr. Kaveh Delfanazari	Dr. Kaveh Delfanazari, is a Research Fellow of the Royal Academy of Engineering and an Associate Professor at the University of Glasgow. His group develops hybrid superconducting-semiconducting quantum circuits, scalable quantum hardware, coherent light sources, and integrated quantum systems for computing, communication, and sensing. Their work also extends to energy-efficient quantum technologies and green energy applications. Through a multidisciplinary approach, they advance high-coherence quantum devices, driving next-generation quantum technologies with a focus on scalability, efficiency and system integration.

SESSION-II:

Speakers of the session:

a) **Prof. Anil Prabhakar** from IIT Madras
a) **Mr. Rowan Högman** from M/s Ericsson
b) **Shri. Kamal Kumar Agarwal** from TEC, DoT
c) **Shri Dilip Singh** from QNu Labs Pvt Ltd
d) **Dr. Vipin Rathi** from Delhi University

Name of the Speaker	Profile of the Speakers
Prof. Anil Prabhakar	Prof. Anil Prabhakar teaches Electrical Engineering at IIT Madras. He received his PhD in 1997 from Carnegie Mellon University with a dissertation on Nonlinear Spin-wave Optical Interactions. He is a co-founder of QNu Labs and Quanfluence and is currently the Project Director for the NQM Hub on Quantum Communications. Prof. Prabhakar has authored over 50 research publications and co-authored a book on Spin Waves. He holds 18 patents on a range of devices in the fields of photonics, magnonics, as well as assistive devices.
Mr. Rowan Högman	Rowan Högman is Director of Advanced Technology APAC at Ericsson, overseeing long-term technology plans and strategy for Ericsson in India. He manages Ericsson's commitment in research

	programs and forums like 6G Bharat covering topics like AI, quantum, XR etc. He was previously Director of Ericsson Research Partnerships and Ecosystems and has been the Chairman of the Ericsson Whitepaper Board, and the editor-in-chief of Ericsson Business Review. Mr. Högman has held leading roles in the communications industry the past 28 years and obtained a Master of Science in Industrial Engineering and Management from the Royal Institute of Technology in Sweden 1996.
Shri Kamal Kr. Agarwal	Kamal Kr. Agarwal is currently leading the Quantum Technology division at the Telecom Engineering Centre (TEC), New Delhi, focusing on standards, testing, and certification in quantum communications. He has 27 years of experience in various units of the Department of Telecom, also active contributor to the ITU-T on quantum topics, he is also an expert in cyber security, having managed the Telecom Security Operations Centre (TSOC) and projects like the Centralised Monitoring System (CMS) and Internet Monitoring System (IMS) to safeguard India's cyberspace. He served as Chief Information Security Officer (CISO) at the Election Commission of India and played a key role in establishing and operating BSNL's billing Data Centre in Kolkata for over a decade.
Shri Dilip Singh	Dilip Singh is the Chief Product and Technology Officer at QNu Labs. He is a pioneer in innovating, developing and commercializing Quantum Communication products. He has been the leader in developing complete QKD product suite at QNu Labs. He has over 30 years of experience in the digital product engineering space across Telecom, Media Platform, Industrial IOT, Datacom and Defence Electronics.
Dr. Vipin Rathi	Vipin Rathi is an Assistant Professor at the University of Delhi, specialising in 5G/6G, cryptography, blockchain and distributed computing. He serves as the Chairperson of the Hyperledger Telecom Special Interest Group under the Linux Foundation and is a Board Member at the OpenInfra Foundation Asia. Additionally, he is the Vice President of the Emerging Open Tech Foundation. He actively organises various technology communities, including OpenStack India, Magma India, NgKore, CNCF, Open Edge Computing, and Hyperledger. His research interests encompass 5G networks, multi-domain orchestration, post-quantum encryption, and blockchain-defined networking. Furthermore, he advises various startups and enterprises on next-generation technologies.

Session-III:

Speakers of the session:

a) **Prof. Urbasi Sinha** from Raman Research Institute, Bengaluru
b) **Dr. Goutam Paul** from ISI Kolkata

Name of the Speaker	Profile of the Speakers
Prof. Urbasi Sinha	Urbasi Sinha is a Professor at the Raman Research Institute (RRI), a Canada Excellence Research Chair at the University of Calgary, Canada and is the co-founder of a deep tech quantum start-up, QuSyn Technologies. She heads the Quantum Information and Computing lab at RRI and is an associate faculty member at IQC and Perimeter Institute, Canada. Her research focuses on quantum information processing, secure quantum communication, and precision tests of quantum mechanics using single and entangled photons. She is also associated with India's National Quantum Mission (NQM).
Dr. Goutam Paul	Dr. Goutam Paul was a faculty of Jadavpur University for 7 years and has been a faculty of ISI Kolkata for the last 12 years. His professional research area is Classical Cryptography, as well as Quantum Computation & Communication. Since 2024, Dr. Paul is also serving as the Regional Coordinator of the Mathematical Olympiad for West Bengal Region, under National Board of Higher Mathematics (NBHM), India. Dr. Paul received the prestigious Alexander von Humboldt Award from Germany, and the Young Scientist Award from the National Academy of Sciences, India (NASI), along with other accolades.

SESSION-IV: ***PANEL DISCUSSION:*** *Leveraging Quantum Technology to Secure Digital Public Infrastructure.*

Moderator of the Discussion: **Shri. G Narendra Nath,** Joint Secretary from NSCS.

Shri A.G. Giridharan from Reserve Bank of India
Shri Praful Kumar Sigtia from UIDAI
Shri Chandra Prakash Sharma from Space Application Centre
Dr. S. Venkataraman from C R RAO AIMSCS
Shri Sanjeev Dhallam from Bharti Airtel
Dr. Shravani Shahapure from Deloitte India

SESSION – I

C-DOT initiatives in Quantum Communication

Dr. Rajkumar Upadhyay, CEO, C-DOT talked about the global trends towards the quantum technology, its adoption and acceleration. He talked about different countries that are setting deadlines for the migration plan towards quantum safe ecosystem. He highlighted that many of the countries have already announced about their immediate quantum requirements for example Canada has planned to introduce quantum inventory by 2025-26, USA & UK by 2035 and China has a program of $15 million for quantum. He explained about the product advancements done by C-DOT in quantum communication area such as QKD system based on COW (Coherent One Way) and DPS (Differential Phase Shift), MDI – QKD (Measurement Device Independent Quantum Key Distribution), 100G quantum safe layer 1 encrypter which reduces bandwidth, latency and can be used in optical network without actually moving to encryption in Layer 3. Key developments include:

i. Quantum Communication Networks using technologies like SDM (Space Division Multiplexing) for cost-effective quantum-safe systems, tested successfully in India.
ii. Collaborations with BSNL to create secure quantum networks for organisations.
iii. Partnerships with IIT Madras under the National Quantum Mission (NQM) to drive innovation in quantum technologies.

The global shift to quantum requires nations to prioritise quantum-safe infrastructures, enhance bandwidth, and reduce costs. India has the potential to lead in this area by fostering innovation, collaborating internationally, and securing its critical sectors from quantum threats.

Preparing your organisation for the Quantum Era

Dr. Anandaraman Sankaran, Senior Manager, Toshiba Quantum Technology from **Japan** talked about how Toshiba is helping the organisations to prepare for the quantum era. *He emphasised the idea to switch from digital economy to quantum economy for government, healthcare, finance, enterprises and critical sector.* He shared the *vision to deploy and develop a global secure or quantum safe network which provides a platform where multiple technologies like fibre based QKD, satellite QKD and quantum resistant algorithms (PQC) would help to secure the data*. He further said that *in the upcoming years the*

organisation will pervasively use quantum secured network which include quantum internet, quantum secured processor, advanced QIT security tasks, distributed quantum computer with vast processing power. He shared that the organisation has spent around ten million dollars in this technology in the last three decades and has world's fastest as well as furthest QKD system. He provided information of Toshiba's commercial grade QKD system (150 Km distance with 300 kilobits/seconds) and multiplexed QKD system that enables communication on quantum channels and conventional channels in the same fibre. The organisation showed the Twin Field QKD system with 600 kilometres or 96 dB loss setup in lab. This was practically experimented for 256 KMs or 56 dB loss with normal detectors for easy deployment of commercial grade detectors (not superconductor). From the past 3 to 4 years Toshiba is working with the *British Telecom for quantum safe solutions* and also working with *European Union for EuroQCI project*. Toshiba's on-going contributions to key sectors of India's infrastructure, including water treatment, power generation, transmission & distribution, and electric vehicle batteries.

IBM advancements in Quantum Computing and Post

Dr. Ray Harishankar, IBM Quantum Safe from **United States of America** shared IBM roadmap for providing useful quantum computing to the world (for solving business problems). In this regard he explained the five targets which are:

i. Building and updating a development and innovation roadmap that will help us scale quantum computing (using error correction transition)
ii. Maintaining the industry's largest fleet of utility-scale quantum systems
iii. Nurturing a community of clients and partners.
iv. Developing Qiskit, an open-source toolkit and world-class user experience
v. Making the world quantum safe with technologies that will secure enterprises in the quantum future.

He also highlighted that whatever goals the organisation has targeted, they have achieved on time for example making 27 qubit machines. He emphasized the confirmation of 'quantum utility' in 2023, supported by research such as the paper *'Evidence for the Utility of Quantum Computing Before Fault Tolerance.*' This work demonstrates that quantum systems can offer practical value and real-world application methods even before achieving full error correction, marking a transition into the Utility era and paving the way toward true quantum advantage.

He provided the information that 2300 research papers have been published in around past two decades. At last, he called for action to *increase your awareness, begin*

an inventory, find out where things are weak and then begin prioritising them. What you need to attend then begin addressing them in that priority.

Engineering Large-Scale Quantum Communication: The Next Leap

Dr. Kaveh Delfanazari, Senior Lecturer (Electronics & Nanoscale Engineering) University of Glasgow from United Kingdom provided a comprehensive overview of the UK's national efforts in quantum mission, highlighting the strategic, technological, and research advances positioning the UK as a global leader in the quantum sector. He explained about the UK government is focussing on critical technologies like semiconductors, quantum technologies, telecom sector, artificial intelligence, medical technology. He emphasised UK's national strategy (2023) which is a ten-year plan building on the foundations laid by the National Quantum Technologies Programme since 2014 with four pillars which are:

i. Ensure UK is home to world-leading quantum science and engineering.
ii. Make the UK the go to place for quantum businesses.
iii. Drive the use of quantum technologies in the UK to benefit the economy, society and security.
iv. Create a national and incremental regulatory framework that supports innovation and ethical use of quantum.

In this programme they have invested £1.1bn till now in the area of Research (for making centre of excellence), innovation (to accelerate commercialisation and driving public sector solutions), infrastructure (testing and assurance) and skill development (to develop, attract and retaining talent e.g. PhDs, fellowship).

Dr. Delfanazari presented about national mission for development of UK based quantum computer which are accessible and capable of running a significant number of operations, making it most advanced quantum network by the year 2035. Their goal is to have quantum-enabled sensing solutions ready by 2030, primarily focusing on healthcare. He mentioned about his research work done focuses in the chip generation of coherent continuous and pulsed terahertz waves. He further elaborated that these THz light sources are pivotal for the development of secure quantum communication systems, offering compact, efficient, and scalable solutions for future communication networks.

Dr. Delfanazari highlighted on-going research opportunities in the field of quantum communication and encouraged collaboration among academia, industry, and government institutions. He emphasised the importance of interdisciplinary approaches to address the challenges in developing secure and scalable quantum communication systems.

SESSION – II

Quantum Communication beyond QKD

Prof. Anil Prabhakar from IIT Madras provided his insights into the development of the country's quantum infrastructure, the challenges involved, and a significant milestone: the first demonstration of quantum money. The presentation also reflected India's strategic and competitive positioning in the global quantum race. He further explained about the Quantum Money Demonstration where quantum money transaction involves three parties: a client (Alice), a merchant (Bob), and a bank (Charlie). The system was built using fibre-optic links of 30+10+10 Km, showcasing the feasibility of secure quantum transactions over metropolitan-scale distances. The setup ensures that even if the measurement device (detector) is compromised, the protocol remains secure, addressing vulnerabilities like back-flash photon attacks.

Prof. Prabhakar explained the development of a 2,000 km long QKD network, named KILA (Quantum Key Distribution Network) which aims to interconnect five major metropolitan quantum networks (i.e. Chennai, Bangalore, Hyderabad, Indore, and Delhi). He said that the metro networks are already operational, with the Chennai metro network being one of the earliest. He shared that the primary goal was to develop secure and interoperable communication channels across cities. He informed about advanced photon-pair generation using four-wave mixing in nonlinear fibres which has been successfully demonstrated. By using classical frequency combs aligned with the ITU grid, India successfully achieved high-quality correlated photon sources, registering a Coincidence to Accidental Ratio (CAR) of 17 among the highest recorded in their experiments.

Navigating the Quantum Frontier: Ericsson's Vision and Insights

Mr. Rowan Högman, Advanced Technology, Director of M/s Ericsson outlined strategic vision for integrating quantum computing into future mobile communication networks, particularly in 6G technologies. He shared about the objective to leverage quantum computing in hybrid systems that combines the strengths of both quantum and classical computing. He revealed that the organisation does not view quantum computing as a replacement of classical computing but rather as a complementary technology. The

organisation has led a strong focus on hybrid computing, where classical and quantum systems are integrated to solve complex problems together. He further added that the effective hybrid systems require software interoperability, middleware frameworks, and direct communication between quantum sensors and processors to maintain the precision of quantum data. The company is also exploring a wide definition of quantum communication that goes beyond just quantum security applications (e.g., Quantum Key Distribution and Quantum Random Number Generation), emphasizing the need for processors and sensors to communicate across both short and long distances. He shared that Ericsson has conducted extensive research using various quantum platforms such as superconducting qubits, trapped ions, and photonic systems. The company has already demonstrated working quantum interconnects, successfully entangling qubits over a microwave waveguide and transmitting photons between labs in Stockholm to reconstruct the Ericsson logo using fewer than 20 photons. These experiments confirm the feasibility of short and long-distance quantum communication and validate the role of quantum processors as distributed co-processors embedded within the network.

He shared that Ericsson is closely monitoring and participating in quantum research in countries where innovation in this field is most advanced, including North America, the UK, the EU, Israel, India, China, South Korea, Japan, and Australia. The company's internal research spans Sweden (focusing on hybrid computing and quantum infrastructure), Canada (working on quantum-inspired communications and addressing schemes), and Hungary (exploring AI integration, quantum machine learning, and distributed learning).

361º perspective on Quantum Communication and TEC's role in Standardisation, Testing and

Shri. Kamal Kr. Agarwal, Deputy Director General (Quantum Technology), TEC, DoT deliberated on different aspects of Quantum Computing and Quantum Communication, advancement in the Quantum technology, efforts of Indian start-ups, Industry, research organisation to bring up Indigenous technologies and products. He emphasised on secure communication and the efforts undertaken by TEC to ensure secure communication. He explained TEC's proactive role in developing national standards for quantum communication, including:

- TEC 91000:2022 – Standard for Quantum Key Distribution Systems
- TEC 91001:2023 – Test Guide for Quantum Key Distribution Systems
- TEC 91010:2023 – Standard for Quantum-Safe and Classical Cryptographic Systems

- TEC 91020:2024 – Standard for Quantum Random Number Generators

These standards are crucial for ensuring the interoperability and security of quantum communication systems. He highlighted the formation of the National working group on Quantum Technologies, ,having 122 members from Academia, industry, startups, R&D organisations, and government entities. This group aims to facilitate a coordinated approach for developing standards on quantum technology, preparation of test guide and technical reports.

Mr. Agarwal underscored India's active participation in international standardisation bodies such as the International Telecommunication Union (ITU). He encouraged stakeholders to contribute to Study Groups 11, Study Group 13, and Study Group 17 of ITU-T dealing in the area of Protocols, functional architecture and security respectively of Quantum communication technology. Further he emphasised to identify the critical IT infrastructure including cryptographic algorithm and data, which needs to be secured first in case of sudden deployment of Quantum Computers in the network by the strategic ministries like healthcare, finance, and Defence. He discussed on ensuring 5G Core Stack by deploying a PQC based cryptography suites in addition to the present classical cryptography. Mr. Agarwal highlighted the present challenges in fully embracing the technologies like availability of Quantum Memories, Repeaters, Transducers, Ultra-low loss OFC cable, Indigenous Quantum safe algorithm for mission critical applications for strategic sectors. He requested for a collaborative approach from the stakeholders to address these challenges.

Leveraging Hybrid approach to accelerate adoption of Quantum Communications technology

Shri. Dilip Singh, Chief Executive Officer of QNu Labs address at the conclave. He highlighted about the QNu Labs' leadership in quantum-safe technologies and strategic initiatives for upgrading India's quantum communication capabilities. His insights underscored the importance of indigenous innovation and collaboration in securing the nation's digital future. He stressed that QNu Labs' is committed to develop world-class, end-to-end quantum-secure communication network. The company's vision aligns with India's broader strategy to lead in quantum technologies and ensure secure communication infrastructures. He showcased QNu Labs' suite of indigenous quantum-safe products, including:

i. Ramos: A Quantum Key Distribution (QKD) system providing secure communication channels.
ii. Troops: A Quantum Random Number Generator (QRNG) serving as a 'Root of Trust' for cryptographic systems.

iii. Shield: A Software-as-a-Service (SaaS) platform offering quantum-secure services such as VPN, messaging, and file sharing.

He explained that the solutions are designed to protect critical communications across sectors like Defence, finance, and healthcare. He highlighted several key collaborations:

i. Indian Navy: QNu Labs secured a landmark contract to supply QKD systems, marking a significant step in securing military communications.
ii. IN-Space: The Company partnered with the Indian National Space Promotion and Authorisation Centre to develop satellite-based QKD systems, aiming to demonstrate a global first in hybrid terrestrial and satellite quantum communication.

Quantum-Resilient 5G and 6G Networks

Mr. Vipin Rathi from Delhi University emphasized the critical need for integrating post-quantum cryptographic (PQC) solutions into next generation 5G and 6G networks. He highlighted the growing quantum threat to classical cryptographic protocols and the urgency of adopting quantum-safe mechanisms to secure future communication systems.

i. Quantum Threats: Quantum computers can potentially break widely used cryptographic protocols like RSA and ECC, risking data confidentiality and integrity.
ii. Post-Quantum Core: Mr. Rathi underscored the importance of transitioning to quantum-resilient cores using PQ-mTLS, PQ-IPsec, and PQ-DTLS for secure communication across network functions (NFs).
iii. Hybrid Cryptography: He discussed the adoption of hybrid approaches, such as combining ML-KEM with classical ECC, to ensure a seamless migration to PQC without compromising existing security.
iv. Zero-Trust Architecture: Mr. Rathi stressed the significance of Zero-Trust frameworks using PQ-JWT tokens for robust authentication and authorization.
v. Future Outlook: He concluded by advocating for collaboration among industry leaders to standardize and implement quantum-resistant technologies for long-term security.

The integration of post-quantum cryptography is essential for securing next-generation networks against emerging quantum threats, ensuring the confidentiality and integrity of global communications.

SESSION – III

Advances towards free space quantum communications and device independent random number generator

Dr. Urbasi Sinha, from **Raman Research Institute (RRI), Bengaluru** discussed RRI's groundbreaking achievements in free-space QKD, including the successful transfer of quantum encryption keys between buildings at RRI. This milestone, accomplished in 2020, marked India's first reported free-space QKD experiment using an atmospheric channel. She emphasised that such advancements are crucial for establishing secure communication channels, especially in the context of quantum computing threats. She shared that in March 2023; team demonstrated secure communication between a stationary source and a moving receiver using QKD. This experiment, conducted at RRI, utilised an indigenously developed Pointing, Acquisition, and Tracking (PAT) system to maintain alignment between the transmitter and the receiver. This achievement is a significant step toward realising ground-to-satellite secure quantum communication.

Dr. Sinha's told about her contributions to the quantum communication which garnered international recognition as she appointed as a Distinguished International Associate by the Royal Academy of Engineering in the UK, focusing on quantum communications and collaborations with Professor Adrian Kent from the University of Cambridge. Additionally, she was awarded the Canada Excellence Research Chair in Photonic Quantum Science and Technologies, marking her as the first Indian scientist to receive this honour.

Quantum AI: How Quantum computing could revolutionise Artificial Intelligence

Dr. Goutam Paul from **Indian Statistical Institute (ISI) Kolkata** explored the dynamic relationship between classical and quantum cryptographic techniques. He discussed how these domains, while distinct, can complement each other in enhancing the security of communication systems. This interplay is crucial as quantum technologies evolve and integrate

with existing infrastructures. He introduced the concept of Quantum Rational Secret Sharing, a protocol designed to securely distribute information among multiple parties. This approach leverages quantum mechanics principles to ensure that no single participant can access the entire secret, thereby enhancing security in collaborative environments. Dr. Paul provided an in-depth analysis of the security aspects of QKD systems. He highlighted potential vulnerabilities and discussed strategies to mitigate risks, ensuring the robustness of QKD protocols in practical applications. He shared his contribution to the academic community by teaching various courses related to cryptography and quantum computing at ISI Kolkata. His involvement in education underscores his commitment to advancing knowledge in these critical areas.

Panel Discussion: Leveraging Quantum Technology to secure Digital Public Infrastructure

Moderator of the panel discussion : Shri G. Narendra Nath Joint Secretary from the National Security Coordination Secretariat (NSCS) highlighted that the organisation has been actively involved in quantum communication over the past three to four years. Their work began through internal R&D funding and gradually expanded into multiple funded projects in partnership with private and academic sectors. Despite initial delays linked to the anticipated National Quantum Mission, NSCS maintained its commitment, becoming a key contributor to India's quantum communication efforts. Alongside this, NSCS has focused on strengthening the security of India's Digital Public Infrastructure, emphasizing encryption for data in transit and at rest. With future threats like "harvest now, decrypt later" in mind, the organisation advocates for adopting quantum-resilient encryption. Overall, NSCS plays a vital role in shaping India's secure digital and quantum future.

Shri A. G. Giridharan, General Manager, Reserve Bank of India (RBI) shared insights on the RBI's perspective regarding quantum computing and its impact on the Banking, Financial Services, and Insurance (BFSI) sector. He outlined the RBI's role as a regulator in overseeing cyber security and IT risk management, focusing on the challenges and steps necessary to make the sector quantum resilient. He emphasised that RBI has been proactive in securing cryptographic methods since 2016, aligning with international standards. In 2024, RBI urged banks to inventory their cryptographic protocols and start preparing for quantum resilience. Key expectations for the sector include developing crypto agility to adapt systems for quantum resistance through a hybrid migration from classical to quantum cryptography, alongside robust risk assessment frameworks. He stressed that vendors and OEMs must develop standardised Post-Quantum Cryptography (PQC) algorithms tailored to India's needs. Additionally, mass adoption

of quantum-resilient solutions, especially for platforms like UPI, requires encryption technologies that are scalable, lightweight, and fault tolerant.

Shri Praful Kumar Sigtia, Deputy Director General (DDG) of Information Security at Unique Identification Authority of India (UIDAI) informed that the organisation manages one of the world's largest databases of personal information and bears the responsibility of ensuring its confidentiality and integrity. He informed that the organisation follows a "security by design" approach and the data encryption starts at the point of collection in the field. This information is transmitted through secured and encrypted channels to UIDAI's central repository during this entire process data remains encrypted both at rest and in transit. He explained that the organisation is currently secured using robust RSA (Rivest, Shamir, and Adleman) and ECC (Elliptic Curve Cryptography) algorithms, which could become vulnerable once quantum computers are developed. He further added that current cryptographic standards are based on NIST guidelines hence we should focus for indigenous standards to reduce the dependency on global specifications and to cut costs associated with upgrades. He asked DoT and TEC for developing national cryptographic standards.

Shri. Sanjeev Dhallam, Vice President, Bharti Airtel informed that the organisation is actively preparing for the potential threats posed by quantum computing, focusing on securing both consumer communication and enterprise services. The key initiatives include engaging with quantum solution providers for Quantum Key Distribution (QKD) and Post-Quantum Cryptography (PQC), conducting risk assessments, and prioritizing high-value data protection. The organisation aims to ensure smooth migration to quantum-resistant technologies and implement robust governance structures. Regulatory support will be essential to drive the adoption of quantum-secure products across industries. The organisation is well-positioned to lead in this area, with support from the Telecommunications Commission's guidance documents.

Dr. Shravani Shahpure, Quantum Safe Cyber Security expert from **Deloitte** emphasised about the transition to quantum-resistant technologies is a growing concern in cybersecurity. While industry awareness has increased, many organisations still lack a clear plan to address the threat. Key steps include establishing a governance framework for Post-Quantum Cryptography (PQC), conducting risk assessments,

and prioritising high-value data protection. Organisations must also prepare for the challenges of migrating legacy systems, which are resistant to change. A gradual, well-planned transition is crucial, with a focus on budgeting and regulatory support. India is making significant strides in quantum preparedness, positioning itself to become a quantum-safe nation with the right policies and technologies in place.

Dr. S. Venkataraman, Director of **C R RAO AIMSCS.**

He informed that the institute focuses on promoting cryptographic algorithms and conducts unique "blind crypto analysis" to test algorithms for vulnerabilities without prior knowledge of their details. As quantum computing evolves, it poses a threat to traditional cryptographic methods, leading to the rise of Post-Quantum Cryptography (PQC). NIST sets global standards for PQC, but some countries like China are exploring their own approaches. Industry concerns about constantly changing algorithms highlight the need for hybrid solutions. Education and awareness of cryptography are essential for future professionals. India is progressing well but needs to develop indigenous cryptographic standards for national security.

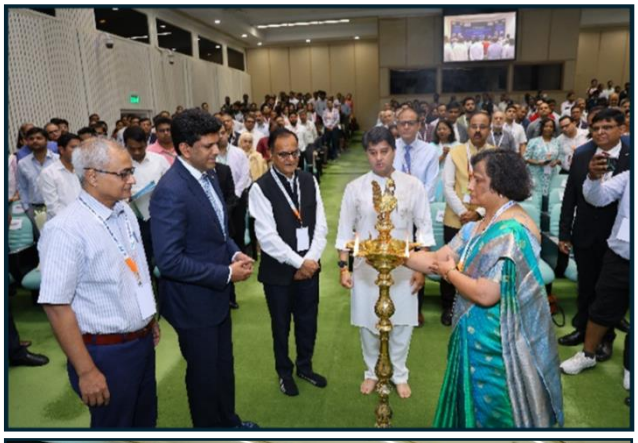
Shri. Chandra Prakash Sharma, Scientist-G from Space Application Centre he informed about the organisations main aim is to develop a satellite-based quantum communication system using QKD (Quantum Key Distribution) protocols. India, being the second-largest digital economy, is heavily reliant on secure systems, and the government must address emerging threats from quantum computing advancements. The solution lies in combining PQC (Post-Quantum Cryptography) with QRNG (Quantum Random Number Generation) and QKD to strengthen algorithm security and ensure key secrecy. To move forward, a clear framework and legal guidelines are necessary for technology adoption, alongside infrastructure development, including quantum sources and fibre networks. Continuous R&D funding and collaboration with academia to build expertise are essential, as is the creation of certification agencies for validating quantum technologies. This approach will ensure India’s preparedness in the face of evolving cyber threats.

Concluding remarks of the Panel Discussion

1. India needs to develop the testing assessment validation framework to test and validate any Post-Quantum Cryptographic algorithms and QKD systems.
2. The design of a system should be Crypto Agile and the system should be resistant from any sea bomb attacks.
3. India should have a national algorithm of its own and the government should start funding in this aspect.
4. During proof of concept trials, organisations should use their least critical assets first in order to avoid any failure of systems.
5. Support educational programs on quantum technology for Masters, PhDs, and specialized diploma courses for capacity building to have a sufficient amount of manpower.

Annexure-D

PHOTO GALLERY



Exhibition: Display of Quantum Products and Services

1. C-DOT Stall

The C-DOT Stall featured a range of breakthrough technologies aimed at securing communication systems against future threats, including those posed by quantum computers:

i. Measurement Device Independent Quantum Key Distribution (MDI-QKD)
ii. QKD Relay System
iii. QRNG Application:
iv. 100G Qsafe Layer-1 Encryptor
v. C-DOT RF DRIVER
vi. PQC-based Network Encryptor
   a) Post Quantum In-Line Network Encryptor (PINE)
   b) Compact Encryption Module (CEM)
vii. Quantum Secure Video IP Phone (QSVIP)

2. QuTeSS Lab

At the QuTeSS Lab Stall, attendees could explore technologies that demonstrate the core principles of quantum mechanics:

i. Quantum Entangled Photon Source
This technology generates pairs of entangled photons, which are essential for secure quantum communication and cryptography.
ii. Quantum Science and Technology (QST) Kits
These educational kits give hands-on experience with quantum science, helping students and researchers

experiment with quantum principles.

3. QNu Labs Stall

The QNu Labs Stall focused on providing quantum-safe solutions for secure communication:

i. ChaQra
   A platform that offers quantum-safe encryption, ensuring that your data is protected even against future quantum computing threats.
ii. QShield
   A key management system designed to protect sensitive data by using quantum-safe encryption methods, ensuring that only authorized parties can access the information.

4. New Age Instruments & Materials Pvt Ltd Stall

The New Age Instruments & Materials Stall displayed technologies critical for securing communication systems:

i. Quantum Key Distribution (QKD) System
   A system that uses the principles of quantum mechanics to create unbreakable encryption keys for secure communication.
ii. Single-Photon Counting Module (SPCM)
   A module that can detect and count single photons, which is crucial for quantum communication experiments.
iii. Time Tagger
   A device that allows precise timing in experiments, ensuring synchronization across quantum systems.
iv. Laser Source
   A high-quality laser that is used to generate quantum signals for experiments and applications.

5. C.R. Rao Advanced Institute of Mathematics, Statistics, and Computer Science (AIMSCS) Stall

The AIMSCS Stall highlighted ground breaking research and innovations in quantum resilience and security:

i. Quantum-Resilient Blockchain (Knuct Layer 1) A blockchain system that is designed to remain secure even in the face of future quantum computing threats, ensuring data integrity in a quantum-enabled world.

ii. K2C – Peer-to-Peer Call & Chat
A secure communication platform that uses quantum-safe encryption, allowing private peer-to-peer calls and chats.

iii. Provenance of Data
A system that ensures data integrity by tracking its origin and changes, providing transparency and accountability.

iv. Post-Quantum Hardware Security Module (HSM)
A hardware module that stores cryptographic keys and performs encryption, designed to be secure against future quantum attacks.

v. Quantum Cryptography & Cryptanalysis
Research into developing quantum-resistant encryption methods and tools to analyse and break cryptography using quantum computing.

vi. Neural Clustering for Crypto Key Randomness
A novel method using neural networks to enhance the randomness of encryption keys, making them more secure against attacks.

vii. SecureVault: BaaS-SaaS for Ransom ware Defence
A cloud-based solution to defend against ransom ware attacks by securing data using quantum-safe encryption.

viii. Digital Rights Management (DRM)
A system designed to protect digital content from unauthorized access using quantum-resistant encryption.

ix. TriPass: Multi-Site Authentication System
A secure, multi-site authentication system that ensures only authorized users can access sensitive systems, even in the age of quantum computing.

6. QpiAi

The QpiAI stall at the Third Quantum Communication Conclave highlighted a range of cutting-edge quantum computing and AI solutions, demonstrating the company's

advancements in the quantum technology field. The following key solutions were featured:

i. QpiAI-Indus: India's most powerful 25-qubit superconducting quantum system
ii. QpiAI-Explorer: Quantum and AI education platform for upskilling and research
iii. QpiAI-Quantum: Quantum algorithms development tool and cloud platform
iv. QpiAI-Opt: Quantum AI solution for industrial optimization
v. QpiAI-AgentHive: No-code multi-agent AI systems builder
vi. QpiAI-Logistics: Quantum AI solution for logistics, supply chain, and transportation
vii. QpiAI-Pharma: Quantum AI solution for life sciences and pharmaceuticals
viii. QpiAI-Matter: AI solution for materials discovery and sustainability technologies

In addition to showcasing its technological offerings, QpiAI emphasized its role in advancing quantum education and highlighted its active participation in India's National Quantum Mission. The stall attracted significant interest from industry stakeholders, underscoring QpiAI's growing impact in the quantum computing and AI sectors.

Annexure-F

Digital Posters: Display of posters on Quantum products/ solutions

At the 3rd International Quantum Conclave, digital standees spotlighted India's rapidly evolving capabilities in quantum communication, post-quantum cryptography, and secure blockchain solutions. The displays illustrated a strong commitment to building a quantum-resilient digital future through innovation.

Key Highlights:

i. Quantum Key Distribution (QKD): Secure key exchange based on quantum principles; supports 100 km distance without a trusted node.

ii. Knuct Block chain: Post-quantum resilient Layer 1 block chain with decentralized identity, zero-knowledge proofs, and atomic NFT transactions.

iii. Digital Rights Management (DRM): Block chain-integrated licensing and content control using NLSS and encrypted IPFS storage.

iv. Qutess Quantum Kits: Experimental kits for B92, BB84 protocols and entangled photon source—ideal for quantum education and R&D.

v. Scytale Alpha Solutions: India’s first quantum-secure apps for messaging, video conferencing, and VPNs with PQC, QRNG, and hybrid cloud integration.

vi. Post-Quantum Hardware Security: FPGA-based deployment of Kyber-KEM and Dilithium digital signatures for secure encryption.

vii. PQC-Based Network Encryptor Solutions:

   a) Post-Quantum In-Line Network Encryptor (PINE): Protects communication infrastructure from quantum-era cyber threats.

   b) Compact Encryption Module (CEM): A space-efficient device delivering robust encryption for secure data exchange.

Post-Quantum Cryptography (PQC) Products

सी-डॉट C-DOT

Post-Quantum In-Line Network Encryptor (PINE)

- End-to-End quantum-safe transfer of critical in-transit data over LAN, WANs and public internet
- Support of NIST FIPS-203 ML-KEM and Static Keys based key generation.
- AES 256 GCM Symmetric Encryption for Ethernet (L2) and IP (L3) data payload with ESP Tunnel Encapsulation @ 1Gbps
- Tamper-proof system design with battery backed active tamper monitoring and side channel leakage resistant FPGA IP Cores

Quantum-Secure Video IP Phone (QSVIP)

- Secure Video and Voice Calling with Conference
- PQC based End-to-End encryption
- Secured media through SRTP
- Biometric and Password based Authenticated system access
- 7" touch LCD display with LED for notifications

Compact Encryption Module (CEM)

- Future proof IP layer Encryptor for security of data in motion
- Support of Hybrid Key exchange mechanism using classical (DH, ECDH) and Quantum-safe (FIPS-203, ML-KEM) algorithms
- Support of classical and Quantum-Safe (FIPS-204, ML-DSA) signature algorithms for authentication
- Support of standard encryption algorithms like AES-256

- Post Quantum Cryptography Team
- Centre for Development of Telematics, Delhi.
- (An Autonomous Telecom R&D Centre under DoT, Ministry of Communications, Government of India)

Quantum Cryptography

AIMSCS

- We conduct extensive research in quantum cryptography and quantum cryptanalysis.
- We use quantum algorithms (Shor's and Grover's) to evaluate cryptographic systems weakness.
- Our in-house QRNG testing ensures rigorous validation for true randomness and independence.

Our Framework Capabilities

- A. Quantum computing framework for creating, running, & visualizing quantum circuits on simulators or real devices
- B. Estimates qubits and gates needed to break symmetric key systems using Grover's algorithm.
- C. QRNGs provide high-entropy outputs, ideal for cryptographic keys and security protocols

Quantum Cryptography Explained

Application areas
- National Security
- Financial Services
- Healthcare
- Blockchain
- Critical Infrastructure Protection
- Cloud Computing Security

Notable Projects
- Various Government agencies
- Public Sector Enterprises

Quantum Key Distribution System

Quantum Key Distribution system generates symmetric keys between two distant places based on Quantum physics principles. The QKD system is used mainly for key distribution between two locations in real time. It provides the security based on quantum physics principles namely coherence, and wave function collapse, etc. QKD uses weak coherent laser source as single photon source for transmission of true random bits generated from the true random number generator to derive the quantum key. And, QKD uses single photon detectors to detect the single photon signals.

Salient Features:
- Security with Quantum physics principles
- No Operating System
- Deployable with existing standard G652.D single mode fiber
- Communication distance up to 100km without Trusted node.
- GUI for the configuration of the equipment.
- Status LEDs to monitor the QKD status and connectivity.
- Supports point to point.

Applications:
- Real time key distribution to replace manual key distribution
- Encryption of highly sensitive data using one time pad at low data rate

Technical Specifications:

S. No.	Parameter	Specifications
1.	Equipment	❖Quantum Key Distribution Transmitter ❖Quantum Key Distribution Receiver
2.	Interfaces	❖Quantum interface ▪ SMF-28,FC/APC ❖Classical channel Ethernet Interface Duplex ▪ SMF-28, LC/PC
3.	Quantum Protocol	Distributed Phase Reference(DPR) protocol
4.	Types of communication	P2P
5.	Quantum Bits Source	Weak Coherent Source
6.	Encryption	One time pad encryption with QKD key
7.	Quantum Bit Error Rate	<5%
8.	Throughput	1 to 5kbps
9.	Communication Range	100km

MAKE IN INDIA

भारत इलेक्ट्रॉनिक्स BHARAT ELECTRONICS

SCYTALE ALPHA PVT. LTD.

Quantum Secure Communication Suite

OUR PRODUCTS

1 Q-SECURE MESSENGER (VANI)

VANI MESSENGER (CLOUD/IN-PREMISE)

India's First Quantum Secure Messaging Application.

- 1:1 & Group Chat
- Chat Search & Management
- Secure File Transfer
- Location Sharing
- Voice & Video Calls
- Multi-Account Support

2 Q-SECURE AUDIO VIDEO CONFERENCING

VANI MEETING (CLOUD/IN-PREMISE)

India's First Quantum Secure Video Conferencing Solution.

- HD Video (up to 1080p)
- Interactive Whiteboard
- Screen & File Sharing
- Location Sharing
- High-Quality Audio (echo & noise suppression) & Easy Collaboration

3 Q-SECURE VPN (IN-PREMISE)

India's First Quantum Secure VPN Application.

- Unbreakable Encryption: Quantum technology for ultimate data protection.
- Fast Speeds: Smooth browsing and streaming.
- Multi-Device Support: Secure all devices at once.

Supported Platforms & browsers:

Windows iOS Android

TOT PRODUCTS

SAC Approved – only with Scytale

1 QRNG (DRDO)

Trusted QRNG: Quantum randomness for secure encryption and communication.

- Quantum RNG (Laser Photonic)
- Post-Processing: Von Neumann
- Entropy (Raw): 300 kbps
- Entropy (Processed): 150 kbps
- Compliance: NIST SP 800-22, Dieharder, MULYANKAN 1.0 & 2.0

2 COMPACT ENCRYPTION MODULE

Future-Ready Encryption with Quantum & Classical Security.

- Encryption: AES-128/256, 80 Mbps
- Crypto-Agile: Standards-ready
- Auth: Certificates (PQC & classical)
- QKD Ready: ETSI GS QKD 014
- Hybrid Key Exchange: ECDH + Crystal-Kyber (PQC)

3 QUANTUM SAFE VOIP PHONE (C-DOT)

India's First Quantum-Secure Video Conferencing Solution with Advanced Security and Seamless Control.

- Secure startup with diagnostics
- Password and fingerprint login
- 4-party calls and call transfer
- End-to-end encryption
- Secure updates with audit logs and AI support

In recent years, Quantum Mechanics has increased its horizon beyond pure science to become an important driving force for the next technological revolution. The innovations include, but are not limited to Quantum Computing, Quantum Communication, Quantum Sensing & Metrology, and Quantum Materials & Devices.

In order to train the next generation to become Quantum literate, it becomes imperative to introduce experiments in Quantum Science & Technology (QST) to undergraduate and graduate laboratories. To provide hands-on experience in this emerging field, we have developed QST Kits as follows:

Key Features

- Easy installation
- Compact setup built on an optical breadboard
- Single-photon detectors included in all kits
- Interchangeable components for different experiments

Applications

- Lab Experiments & Demonstrations
- Research in Quantum Science & Technology

- QST Kit-1: Biphoton Source
- QST Kit-2: Polarization-based Entangled Photon Source
- QST Kit-3: B92 Protocol based on Weak Coherent Pulses
- QST Kit-4: BB84 Protocol based on Weak Coherent Pulses

Dr. Pravin Vaity, Qutess Lab, Ahmedabad
Phone: +91 99702 77699 | Contact Us | Website

Annexure-G

Conclave Presentations and Videos

The event was live streamed on YouTube channel, whose recordings links are as below:-

Plenary session of the Event:

The plenary session was streamed on the YouTube Channel of Department of Telecommunications and could be accessed at the link given below or by scanning the QR Code.

https://www.youtube.com/live/u6XfY2e6534?si=5cZT8Pj6O5YAuHRy

Complete Recording of The Event :

The recording of the event is available in YouTube can be accessed at the link given below or by scanning the QR Code.

https://www.youtube.com/live/mR8w2X2ovog?si=qKZ-FiTHumDD8h-F

Speakers

Dr. Rajkumar Upadhyay
CEO C-DOT

Dr. Anandaraman Sankaran
Senior Manager, QKD Technical Marketing, Japan

Dr. Ray Harishankar
IBM Quantum Safe, USA

Dr. Kaveh Delfanazari
Senior Lecturer (Electronic & Nanoscale Engineering) University of Glasgow, UK

Prof. Anil Prabhakar
IIT Madras

Mr. Rowan Högman
(Advanced technology Director) M/s Ericsson, Sweden

Kamal Kr. Agarwal
DDG (Quantum Technology), TEC,DoT

Shri Dilip Singh
CTO, QuNu Labs

Dr. Vipin Rathi
Delhi University

Dr. Urbasi Sinha
Raman Research institute, Bengaluru

Dr. Goutam Paul
ISI Kolkata

Panel Discussion

Dr. G Narendra Nath
JS, NSCS

Shri A.G. Giridharan
General Manager, Reserve Bank of India

Shri Praful Kumar Sigtia
DDG Information Security, UIDAI

Shri Chandra Prakash Sharma
Scientist –G, Space Application Centre

Dr. S. Venkataraman,
Director, C R RAO.

Shri Sanjeev Dhallam
VP, Bharti Airtel

Dr. Shravani Shahapure
Quantum Safe Cyber security expert, Deloitte

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Rakesh Singh Rawat
Scientist F,C-DOT

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Scientist F,C-DOT

Rakesh Goyal -
ADG(TC-III), TEC

Poonam Kumari
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Ratnesh Bharti
Deputy Registrar, C-DOT

B. Bipinbhai Jakharia
Manager(Admin), C-DOT

Nathu Ram Bhimwal
AO(Cash), TEC

Deo Pratap
AD(QT), TEC