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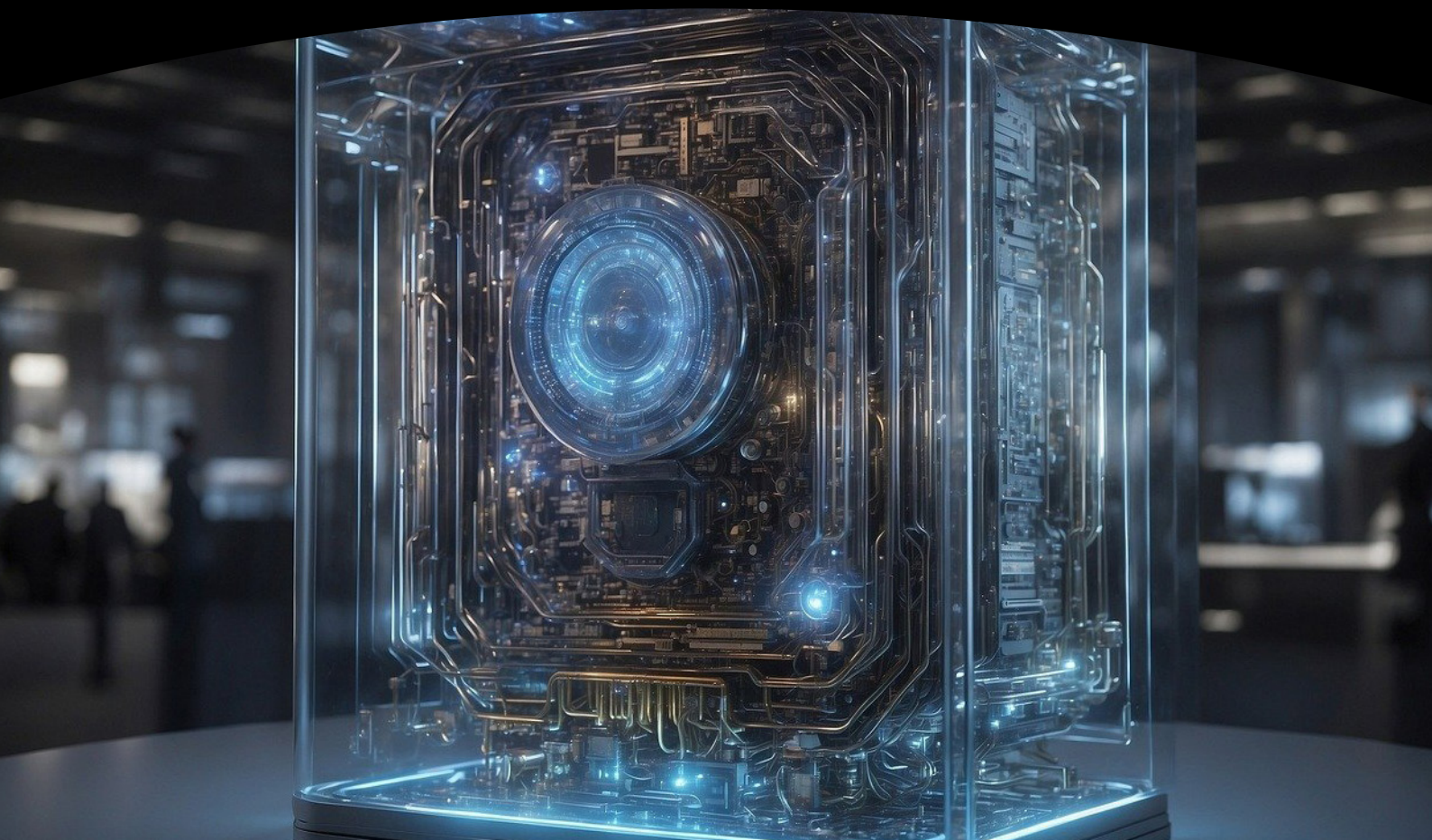
CONFERENCE SUMMARY REPORT

2024 Innovations Dialogue:

Quantum Technologies and Their Implications for International Peace and Security

DONGYOUN CHO



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The 2024 Innovations Dialogue, co-hosted by UNIDIR's Security and Technology Programme and the Geneva Science and Diplomacy Anticipator (GESDA), marked the sixth edition of this flagship event. UNIDIR and GESDA extend their sincere gratitude to all speakers, moderators and participants for their insightful presentations, comments and contributions, which form the foundation of this report. For detailed information on the speakers and moderators, refer to the conference agenda included in the annex.

About UNIDIR

UNIDIR is a voluntarily funded, autonomous institute within the United Nations. As one of the few policy institutes worldwide that focus on disarmament, UNIDIR generates knowledge and promotes dialogue and action on disarmament and security. Based in Geneva, it assists the international community in developing the practical, innovative ideas needed to address critical security problems.

About the Security and Technology Programme

Contemporary developments in science and technology present both new opportunities and challenges to international security and disarmament. UNIDIR's Security and Technology Programme aims to build knowledge and awareness about the international security implications and risks associated with specific technological innovations. It also convenes stakeholders to explore ideas and develop new approaches to address these issues.

Note

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Her research focuses on the convergence of security and emerging technologies, including artificial intelligence, autonomy, cybersecurity and quantum technologies. A former major in the Republic of Korean Army, she has more than 20 years of experience in intelligence, military strategy, defence policy, and the aerospace and defence industry. Her extensive expertise is complemented by her role as an Assistant Professor in the Department of Military Studies at Seokyeong University, where she established and was director of the Centre for Future Defence Technology and Entrepreneurship. Dongyoun is a graduate of the Korea Military Academy and holds a master's degree in public administration from the Kennedy School of Government at Harvard University. She was also recognized as a World Fellow at Yale University in 2018.

Abbreviations

AI	Artificial intelligence
GNSS	Global navigation satellite system
LMIC	Low- or middle-income country
OQI	Open Quantum Institute
QKD	Quantum key distribution
SDG	Sustainable Development Goal
UNESCO	United Nations Educational, Scientific and Cultural Organizations

Contents

Executive Summary

The 2024 Innovations Dialogue explored the transformative potential of quantum technologies and their implications for international peace and security. With this theme, the conference provided a unique platform for multidisciplinary discussions on how quantum advancements could reshape global governance, international security and equitable access to technology. Co-organized by UNIDIR and GESDA with the support of global partners, the event underscored the importance of collaboration in addressing both the opportunities and challenges posed by quantum technologies.

Key Takeaways

1. **Quantum technologies at a crossroads**: Quantum technologies are poised to revolutionize fields such as computation, secure communications and sensing, offering unprecedented potential to address global challenges. However, they also present risks such as destabilizing cryptographic systems, amplifying inequalities and worsening geopolitical tensions.
2. **A multilateral call for governance**: Governance frameworks are critical for managing the dual-use nature of quantum technologies. Proactive governance must balance innovation, regulation and security to foster equitable and responsible development. The conference emphasized the importance of learning from past experiences with artificial intelligence (AI) to avoid fragmentation and delays in governance.
3. **Capacity-building and equity**: Ensuring equitable access to quantum technologies has emerged as a central theme. Speakers highlighted the risk of a quantum "digital divide" and advocated for capacity-building initiatives, particularly in the Global South. The proposed models, which aim to democratize quantum innovation, include regional quantum hubs and remote access to quantum research tools.
4. **Multi-stakeholder collaboration**: Effective governance requires inclusive and structured dialogue among governments, industry leaders, scientists and civil society. Institutions such as the Open Quantum Institute (OQI) were commended for fostering collaboration among diverse stakeholders and aligning quantum advancements with the Sustainable Development Goals (SDGs).
5. **Strategic and ethical considerations**: Discussions highlighted the ethical and security implications of quantum technologies, including the need for frameworks to manage potential misuse and address the ethical dilemmas posed by dual-use applications. International collaboration is essential to secure critical supply chains, develop global standards and mitigate the risks of technological monopolies.

Key Recommendations Emerging from the Discussions

1. **Leverage existing multilateral forums to further explore the potential impact of quantum technologies on international peace and security, disarmament and arms control**: The application of quantum technologies is evolving and, in many cases, experimental. However, the impact of such applications will be highly contextualized to individual use cases (e.g. ICT security, biology, chemistry, etc.) and would thus require tailored analysis.

2. **Develop inclusive governance frameworks**: Structured international cooperation should align quantum technologies with global priorities, such as peace, security and the SDGs. These frameworks must also address the specific challenges associated with dual-use technologies and equitable access.

3. **Promote capacity-building and education**: Tailored initiatives – such as the remote laboratory platforms of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and public–private partnerships – are crucial for empowering under-represented regions. Targeted training for policymakers and scientists alike on quantum technologies and their ethical implications is essential to ensure informed decision-making.

4. **Foster international collaboration**: The global community should prioritize collaborative approaches to tackle challenges in governance, standardization and equitable access. Initiatives such as regional quantum hubs and interdisciplinary research programmes are key to building an inclusive quantum ecosystem.

5. **Address security and ethical risks**: Mitigating misuse and proliferation risks is critical. Frameworks for monitoring and regulating applications of quantum technologies must strike a balance between fostering innovation and preventing harm, particularly in the domains of cybersecurity and international peacekeeping.

6. **Advance proactive policy development**: Policymakers should anticipate the societal, economic and geopolitical impacts of quantum technologies. The development of adaptable, forward-looking governance structures is vital for managing the exponential effects of quantum advancements on other technologies and industries.

Conclusion

The 2024 Innovations Dialogue emphasized the need to foster inclusive, collaborative and forward-thinking approaches to quantum governance. By uniting global stakeholders and leveraging innovative ideas, the conference explored possible pathways to responsibly harnessing the transformative power of quantum technologies. It laid the groundwork for future multilateral discussions aimed at shaping secure, equitable and innovative quantum advancements.

1. Introduction

Quantum technologies are attracting significant investment all around the world, from governments and the private sector alike. While the field of research is not new, the injection of capital and the growing number of national and regional quantum strategies and policies is propelling this disruptive innovation forwards, accelerating research and development and the progressive adoption of quantum-based solutions. This is true in both the civilian and the military worlds. As testimony of the growing relevance of quantum technologies, the United Nations has declared 2025 to be the International Year of Quantum Science and Technology.[1]

In this context, UNIDIR dedicated the 2024 Innovations Dialogue, held in Geneva on 22 November 2024, to exploring "Quantum Technologies and Their Implications for International Peace and Security" in an effort to provide the international peace and security community with an initial glimpse of the potential promises and perils of this rapidly evolving field. This edition of the Dialogue was organized in partnership with the Geneva Science and Diplomacy Anticipator (GESDA).[2]

Launched in 2019 and organized by UNIDIR's Security and Technology Programme, the Innovations Dialogue is one of UNIDIR's flagship annual events. The conference provides a unique multi-stakeholder forum for examining developments in science and technology with significant implications for international peace and security.

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1 UNESCO, "International Year of Quantum Science and Technology", 7 June 2024, https://quantum2025.org/en.

2 GESDA is dedicated to addressing the intersection of science anticipation and global governance. It fosters multi-stakeholder action by convening experts from diverse geographical and professional backgrounds, including the diplomatic and policy communities, the scientific and technical sectors, industry, academia and civil society.

In an era of rapid scientific acceleration, quantum technologies are emerging as a strategic focus for many governments because of their potential to revolutionize information processing, communications and sensing.[3] Although most applications remain in the early stages of development, significant progress has been made in recent years. Having once been confined to academic research, quantum technologies are now approaching commercialization, with profound implications for defence strategies and international security.

Given the multifaceted potential of quantum innovations, it is essential to comprehensively explore their possible impacts on global security, including their military applications and the resulting geo-political dynamics. This need has been highlighted in various international forums, including the United Nations Open-Ended Working Group (OEWG) on Security of and in the Use of Information and Communications Technologies, where several Member States have expressed concerns about emerging threats posed by quantum technologies.[4] The United Nations Secretary-General also emphasized these risks in his annual report on current developments in science and technology, calling for broader dialogue among states, technology experts and international security scholars.[5]

Building on the success of the 2023 multi-stakeholder dialogue on quantum technologies and their implications for international peace and security hosted by UNIDIR,[6] the 2024 Innovations Dialogue convened technical, legal and policy experts to further examine the implications of quantum computing, quantum communications and quantum sensing for international peace and security.

Section 2 of this report summarizes the key themes and points from the discussions at the event. The six sub-sections reflect the event structure. After summarizing the opening in Subsection 2.1, Subsection 2.2 provides a general framing of the discussion, including an introduction to quantum technologies. Subsection 2.3 provides an overview of the practical applications of quantum technologies, while Subsection 2.4 examines the impact of quantum technologies on international peace and security. Subsection 2.5 discusses diverse perspectives on equitable access, the challenges associated with achieving "access for all", and strategies for advancing capacity-building. Finally, Subsection 2.6 explores the need for regular and structured dialogue on quantum governance. The report concludes in Section 3 with suggestions for future research.

This report is not intended to be a detailed account of the conference proceedings, but rather an easily accessible reference point. Readers interested in learning more of the detailed discussions held during the day can access the full conference recording on UNIDIR's website and YouTube channel.

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3 Zhanna L. Malekos Smith and Giacomo Persi Paoli, *Quantum Technology, Peace and Security: A Primer* (Geneva: UNIDIR, 2024), https://unidir.org/publication/quantum-technology-peace-and-security-a-primer.

4 United Nations Office for Disarmament Affairs, "Open-Ended Working Group on Security of and in the Use of Information and Communication Technologies", n.d., https://meetings.unoda.org/open-ended-working-group-on-information-and-communication-technologies-2021.

4 United Nations Office for Disarmament Affairs, "Open-Ended Working Group on Security of and in the Use of Information and Communication Technologies", n.d., https://meetings.unoda.org/open-sended-working-group-on-information-and-communication-technologies-2021.

5 United Nations, "'Our World Is in Big Trouble', Secretary-General Warns General Assembly, Urging Member States to Work as One United Nations", Statement by Secretary-General, Press Release SG/SM/21466, 20 September 2022, https://press.un.org/en/2022/sgsm21466.doc.htm.

6 UNIDIR, "Quantum Technologies and Their Implications for International Peace and Security", 30 November 2023, https://unidir.org/event/multi-stakeholder-dialogue-on-quantum.

Dr. Robin Geiss, Director of UNIDIR, opening the 2024 Innovations Dialogue

2. Summary of the Conference Discussions

2.1 Conference Opening

The conference was opened by remarks from Dr. Robin Geiss, Director of UNIDIR, and Maricela Muñoz, Director of Strategic Partnerships at GESDA. Below are some key highlights of these interventions.

The transformative potential of quantum technologies: The rapid evolution of quantum technologies from theoretical constructs to practical applications is poised to redefine diverse sectors, including secure communications, advanced computation and materials science. Quantum technologies promise to revolutionize computational capabilities, tackle complex global challenges and provide innovative solutions across diverse domains, such as healthcare, agriculture and cybersecurity. However, these advancements also pose risks, particularly in terms of threatening current encryption systems and contributing to potential strategic instability in the global arena.

Key Insights from the Discussion Include:

Security and ethical implications: While quantum technologies potentially promise immense benefits, their security implications are profound. The United Nations Secretary-General's 2022 address to the General Assembly underscored the risks that quantum computing poses to cybersecurity and complex systems. The absence of a global framework to address these challenges highlights the urgency of developing governance structures to manage the risks associated with quantum advancements.

Quantum's dual-use nature demands proactive policies and international cooperation to mitigate inequalities, address ethical dilemmas and prevent misuse. The pursuit by states of quantum dominance could disrupt supply chains and alter global power balances, necessitating the development of frameworks that prioritize collaboration and shared progress.

The need for a proactive approach to governance: To harness the benefits and mitigate the risks, there is a need for foresight and proactive governance. The designation of 2025 as the International Year of Quantum Science and Technology by UNESCO and the General Assembly provides a unique opportunity for collaborative, action-oriented dialogue aimed at establishing an efficient and effective governance framework.

UNIDIR's role in informing quantum governance: UNIDIR can play a unique role in advancing the global understanding of quantum security. Through multi-stakeholder dialogues, research and resources, UNIDIR provides evidence-based, multidisciplinary and multi-stakeholder perspectives on the policy, security and ethical dimensions of quantum technologies. Notable recent contributions include the Compendium on Enabling Technologies and International Security[7] and an upcoming research brief addressing the implications of quantum technologies for global supply chains.[8]

UNIDIR's initiatives aim to equip policymakers with the tools necessary to navigate quantum transformation while addressing associated challenges. As part of its commitment to capacity-building, UNIDIR plans to integrate quantum technologies into its training programmes in 2025, ensuring that stakeholders are prepared to harness the benefits of quantum advancements.

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7 Wenting He, *Enabling Technologies and International Security: A Compendium, 2023 edition* (Geneva: UNIDIR, 2024), https://unidir.org/wp-content/uploads/2024/03/UNIDIR_Enabling_Technologies_and_International_Security_A_Compendium_2023_Edition.pdf.

8 A forthcoming report from UNIDIR, *Quantum Technologies, Global Supply Chain, and International Peace and Security: A Framework for Assessing Vulnerabilities in the Quantum Supply Chain*, will provide further analysis of the field of quantum supply chain and its relevant implications for international security.

Panel 1 on the Agenda and Framing of Quantum Technologies in the Context of International Peace and Security

2.2 The Agenda and Framing of Quantum Technologies in the Context of International Peace and Security

The opening panel, moderated by Maricela Muñoz, Director of Strategic Partnerships at GESDA, featured the following speaker:

- **Jungsang Kim**, Co-founder of IonQ; Professor of Physics, Duke University; Associate Director, Quantum Centre

The first panel served as a springboard for the day's discussions, introducing participants to the foundational concepts and challenges associated with quantum technologies. The session ended with an invitation for participants to reflect on the "what", "so what" and "now what" of quantum advancements, encouraging them to actively engage in shaping a secure, equitable and innovative future.

Key Highlights include:

Understanding quantum's unique potential: The extraordinary potential of quantum technologies can be equated to possessing "superpowers". Phenomena such as superposition and entanglement defy conventional logic but hold the promise of profound capabilities. These "superpowers" enable quantum technologies to redefine computation, cryptography and problem-solving paradigms. However, it is important to acknowledge the chaotic and unpredictable nature of early quantum developments.

Dual-use implications: Quantum technologies offer immense benefits but also pose significant risks. On the positive side, they could revolutionize fields such as healthcare, agriculture and cybersecurity by enabling groundbreaking solutions. However, misuse by malicious actors can disrupt secure communications, exploit vulnerabilities and intensify existing security challenges. This double-edged nature underscores the urgency of developing robust governance frameworks, promoting ethical use and fostering international collaboration to maximize the benefits of quantum technologies while effectively mitigating associated risks.

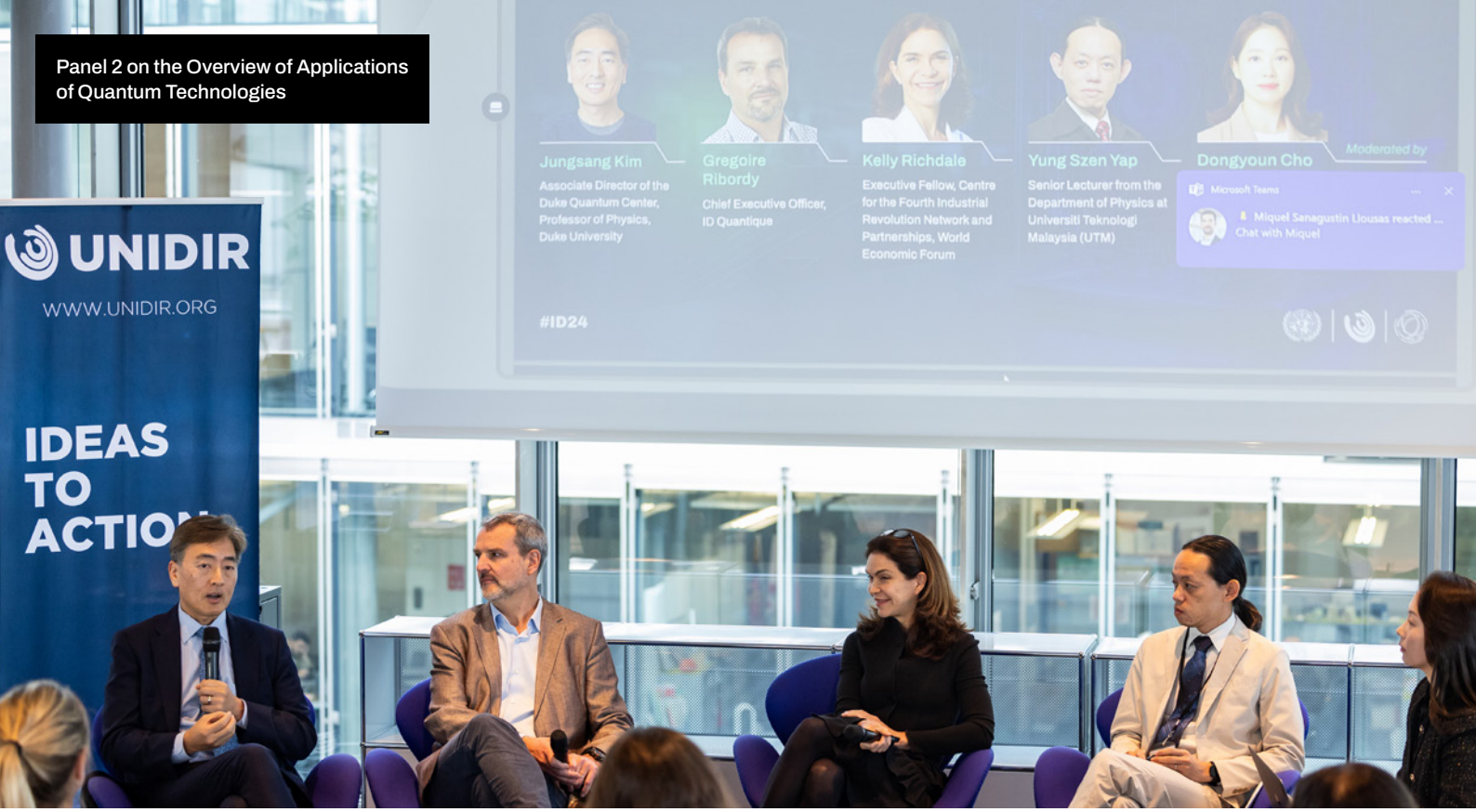
Early-stage challenges and opportunities: Addressing the misconception that quantum technologies remain a distant prospect, the speaker highlighted the accelerating pace of development driven by substantial investments from both the public and the private sectors. A possibly fitting comparison is between quantum technologies and the early evolution of computers and the Internet; these both initially served niche military and scientific purposes before being transformed into integral components of daily life. Computers were initially developed for military purposes, such as calculating projectile trajectories and decrypting codes during World War II. They then gradually evolved into indispensable tools for modern life. In contrast, the Internet originated from the collaborative efforts of the European Organization for Nuclear Research (CERN), beginning as a platform for scientists to share data. It then went on to become a global communications network that underpins today's digital economy. Similarly, quantum computing is expected to transition from specialized use cases to broad societal impacts, although this journey will require time and innovation.

Accelerating innovation through collaboration: The vital role of interdisciplinary collaboration in the advancement of quantum technologies was also emphasized. While quantum physicists conduct foundational research, the involvement of engineers, software developers and policymakers is essential for translating discoveries into scalable, practical applications. Early commercialization efforts demonstrate how cross-disciplinary teams can address technical challenges, build reliable systems and identify real-world use cases, thus fostering a virtuous cycle of innovation and progress.

Balancing competition and collaboration: The panellist also explored the delicate balance between strategic competition and international collaboration. Quantum technologies present significant opportunities for states to achieve strategic advantages; however, isolationist approaches risk impeding innovation and leaving countries more vulnerable. The panellist advocated for a global leveraging of collective talent and resources, while addressing critical concerns about security, equity and access.

Final thoughts and recommendations:

The panellist emphasized the critical importance of proactive engagement and collaboration in shaping the trajectory of quantum technologies. The panellist also highlighted the necessity of fostering international partnerships, integrating ethical foresight and encouraging innovative approaches to harness the transformative potential of quantum technologies. As these technologies continue to evolve, their adoption rates are expected to surpass historical benchmarks. This offers unprecedented opportunities to redefine the future across numerous fields.



Panel 2 on the Overview of Applications of Quantum Technologies

2.3 Overview of Applications of Quantum Technologies

The second panel of the 2024 Innovations Dialogue focused on the transformative applications of quantum technologies across the healthcare, finance, energy and security sectors. Moderated by Dongyoun Cho, a Senior Researcher with UNIDIR's Security and Technology Programme, the discussion explored how quantum technologies are progressing from theoretical research to practical applications. This transition is fuelled by substantial investments from both the public and the private sectors. Despite the immense opportunities, the panellists underscored the complex challenges that must be addressed – ranging from technical barriers to ethical dilemmas and geopolitical considerations – to ensure responsible development.

The panel featured:

- **Jungsang Kim**, Co-founder of IonQ; Professor of Physics, Duke University; Associate Director, Duke Quantum Centre
- **Gregoire Ribordy**, Chief Executive Officer, ID Quantique
- **Kelly Richdale**, Executive Fellow, Centre for the Fourth Industrial Revolution Network and Partnership, World Economic Forum
- **Yung Szen Yap**, Senior Lecturer, Department of Physics, Universiti Teknologi Malaysia (UTM)

Key Insights from the Discussion Include:

The evolution of quantum technologies – Transitioning from research to application: The current state of quantum technologies is rapidly progressing from foundational research to commercial viability. The field's growth will depend on identifying impactful applications, much like artificial intelligence (AI) gained momentum with breakthroughs such as large language models. The industry's success will hinge on delivering tangible real-life value, rather than simply competing with other technological paradigms.

Quantum communications – The next frontier for security: Quantum communications is one of the earliest practical applications of quantum technologies. Quantum cryptography leverages the principles of quantum mechanics to enhance security by detecting attempted eavesdropping on communications. This approach, known as quantum key distribution (QKD),[9] is already being implemented in critical sectors (e.g., government data networks and financial institutions). This creates the necessity for upgrading cryptographic systems to withstand quantum-enabled decryption attacks, which advocates for proactive global efforts to transition to post-quantum cryptography.

Quantum sensing and the democratization of technology: Quantum sensing may have a transformative impact on healthcare and navigation systems. For example, innovations such as portable magneto-cardiograms and quantum magnetometers are democratizing access to advanced diagnostic tools and enabling navigation in environments where global navigation satellite systems (GNSSs) are blocked. These technologies can bridge gaps in healthcare delivery, particularly in underserved regions, while contributing to the resilience of critical infrastructure in transportation and the defence sector.

Building quantum ecosystems and collaborative innovation: Advancements in supporting technologies (e.g., cryogenic systems and microwave components)[10] are accelerating the progress of quantum computing. As part of this, it is important to develop scalable and cost-effective solutions to make quantum technologies more accessible. To this end, interdisciplinary collaboration plays a critical role in overcoming technical challenges and driving innovations tailored to both local and global needs.

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9 QKD uses the principles of quantum mechanics to encrypt data. In the physical world, a key is used to both lock and unlock systems. In computing, a key can signify a string of 1s and 0s that can be used to encrypt and decrypt information. See Zhanna L. Malekos Smith and Giacomo Persi Paoli, *Quantum Technology, Peace and Security: A Primer* (Geneva: UNIDIR, 2024), https://unidir.org/publication/quantum-technology-peace-and-security-a-primer.

10 Quantum computers require cryogenic systems to maintain ultra-low temperatures near absolute zero, which is essential for the proper functioning of superconducting quantum bits (qubits). Microwave technology has been a cornerstone in the field of quantum computing, significantly impacting how quantum information is manipulated and measured. This technology uses electromagnetic waves in the microwave spectrum to control qubits, the fundamental units of quantum information. These advancements are not limited to computing; they have the potential to reshape neuroscience research by offering new tools and methodologies for understanding complex neural dynamics. See J. C. Bardin, D. H. Slichter and D. J. Reilly, "Microwaves in Quantum Computing", *IEEE Journal of Microwaves*, vol. 1, no. 1 (January 2021): 403–427, https://doi.org/10.1109/JMW.2020.3034071.

Balancing competition and collaboration in the quantum economy: The panel explored the delicate balance between strategic competition and international collaboration in the quantum economy. While countries aim to protect their technological sovereignty, equitable access to quantum technologies and the creation of inclusive supply chains are vital for global stability. Additionally, fostering educational initiatives and proactive strategies can enable under-represented regions to leverage emerging opportunities and actively participate in the quantum ecosystem.

Ethical and regulatory challenges: Quantum technologies also pose ethical concerns and entail regulatory challenges. Guardrails are needed to prevent misuse, particularly in sensitive areas such as biotechnology and cryptography. This will necessitate a balanced regulatory approach that fosters innovation while mitigating risks, along with efforts focused on incentivizing productive uses of quantum technologies.

Final thoughts and recommendations:

Emerging technologies offer opportunities for under-represented regions to rise as key players, provided that they invest in education and innovation-driven strategies.

Key Takeaways:

- International collaboration is essential for the advancement of quantum technologies while avoiding isolationist policies that hinder progress.
- The convergence of quantum technologies and AI will accelerate disruptive innovations, but intelligent regulation is critical to ensure equitable access and prevent misuse.
- Innovations in cryogenic systems and component scalability will shape the future of quantum technologies, enabling opportunities for new advancements and applications.
- Quantum technologies have a deep disruptive potential and need collaborative efforts to address their challenges. Intellectual curiosity and constructive dialogue are crucial for shaping a secure, innovative and inclusive quantum future.

Yung Szen Yap, Senior Lecturer, Department of Physics, Universiti Teknologi Malaysia (UTM)

Panel 3 on the Impact of Quantum Technologies on International Peace and Security

2.4 Impact of Quantum Technologies on International Peace and Security

The third panel of the 2024 Innovations Dialogue, moderated by Sarah Grand-Clément, a Researcher with UNIDIR's Security and Technology Programme, examined the implications of quantum technologies for international peace and security. The panellists highlighted both the opportunities and the challenges posed by quantum advancements in the military, peacekeeping and related fields. They addressed critical questions, including how these technologies might reshape international legal frameworks, destabilize existing power balances, and influence arms control and norms of responsible state behaviour.

The panel featured:

- **Brad Lackey**, Partner and Quantum Architect, Microsoft
- **Min-Ha Lee**, Fellow, Stanford Center for Responsible Quantum Technology; Principal Researcher, Korea Institute of Industrial Technology
- **Giacomo Persi Paoli**, Head of the UNIDIR Security and Technology Programme
- **Constanza Vidal Bustamante**, Fellow, Technology and National Security Program, Center for a New American Security (joining online)

Key Insights from the Discussion Include:

The strategic context of quantum technologies: The panellists framed quantum technologies within the multilateral discourse on international peace and security. Indeed, parallels exist with earlier dialogues on AI, as there are risks linked to underpreparing for transformative technologies. Although quantumtechnologies remain in their nascent stage, they are beginning to gain recognition in cyber-security discussions due to their potential to enhance and disrupt existing systems. Despite this growing awareness, the absence of specific references to quantum technologies in major international frameworks (e.g., the Pact for the Future[11]), where they are still broadly categorized under the umbrella of emerging technologies, is of particular note. Furthermore, the panellists noted the importance of conducting strategic analyses of quantum technologies across distinct domains to better understand their implications and to proactively inform policy solutions.

Quantum technologies and national security dynamics: Quantum technologies could directly and indirectly influence national security. This is true of a varied array of quantum technologies, including sensing, computing and communications.

- *Quantum computing*: A significant concern is the capability of quantum computing to break public key cryptographic systems, potentially compromising critical infrastructure and military communications networks. However, this threat has also spurred international efforts to establish post-quantum cryptography standards.
- *Quantum sensing*: Quantum sensing applications include robust navigation systems in GNSS-denied environments and advanced battlefield technologies. Despite these promises, challenges such as scalability and environmental robustness remain obstacles.
- *Quantum communications*: Innovations in encryption and secure communications systems offer enhanced privacy but also present risks of misuse.

The panellists further emphasized the importance of directing investments towards realistic, high-impact applications, rather than speculative ones, as well as the need for strategic collaborations that advance scientific progress while strengthening national security.

The fragile quantum supply chain: There are some key vulnerabilities in the quantum technology supply chain. Three are of particular note: human capital, financial investment and raw materials. Among these, raw materials present unique challenges because of their limited availability and geopolitical dependencies. Key resources such as indium, germanium and helium-3, which are essential for manufacturing quantum devices, are predominantly sourced from a few countries, rendering the supply chain fragile and prone to disruption. In this context, international collaboration to diversify supply chains and enhance their resilience as well as clear strategies to secure critical materials through proactive policy measures are needed.

The role of quantum communications in cybersecurity: Quantum communications technologies hold transformative potential in cybersecurity and global communications stability. While QKD has already demonstrated its effectiveness in enhancing secure communications, there are also alternative concepts

11 United Nations, General Assembly, "Pact for the Future", Resolution 79/1, 22 September 2024, https://undocs.org/A/RES/79/1.

(e.g., blind quantum computing and anonymous voting). These protocols offer unparalleled privacy and anonymity but raise concerns about potential misuse, such as concealing malicious activities or enabling fraudulent behaviours. The panellists stressed the urgency of addressing these challenges by developing regulatory frameworks to ensure the responsible use of quantum technologies. Moreover, the rapid evolution of the quantum Internet, particularly its integration with cloud computing, could outpace policy development, potentially creating critical security vulnerabilities.

Quantum technologies for peacekeeping and arms control: The panel discussed the promising role of quantum technologies in advancing arms control and peacekeeping operations. Quantum sensors, for example, have the potential to enhance environmental monitoring and verification techniques, thereby strengthening existing arms control regimes. These technologies could, for example, address current limitations (e.g., the dependence on physical access to facilities for inspections) by enabling more robust and remote verification methods.

Risks of proliferation and misuse: The panellists also acknowledged the risks associated with the potential proliferation of quantum technologies to non-state actors. Although the physical size and complexity of current quantum systems make this scenario unlikely in the near term, the emergence of quantum computing as a cloud-based service[12] could significantly lower barriers to access. A multi-stakeholder approach to regulating access is required. Measures such as licensing requirements for both quantum computing service providers and end users should be explored. This approach could mitigate risks of misuse while fostering innovation.

Final thoughts and recommendations:

The panellists underscored the urgency of proactive policymaking to address the dual-use nature of quantum technologies.

Key Takeaways:

- Developing international standards for post-quantum cryptography to mitigate cybersecurity threats
- Establishing frameworks for monitoring and controlling access to quantum computing services, particularly cloud-based platforms
- Enhancing international collaboration to secure critical supply chains and prevent monopolization of essential resources
- Promoting investment in quantum applications that align with Sustainable Development Goals (SDGs) and contribute to arms control and peacekeeping efforts
- Learning lessons from the developmental trajectory of AI to ensure that ethical considerations and safeguards are integrated early in the evolution of the quantum field
- Fostering global dialogue on quantum technologies to ensure these emerging innovations are harnessed responsibly to promote both technological progress and international peace and security

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12 Federico Mantellassi and Giacomo Persi Paoli, Cloud Computing and International Security: Risks, Opportunities and Governance Challenges (Geneva: UNIDIR, 2024), https://unidir.org/wp-content/uploads/2024/12/UNIDIR_Cloud_Computing_Governance.pdf


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2.5 Access for all and Advancing Capacity-Building

The fourth panel, moderated by Marieke Hood, Executive Director and Impact Translator at GESDA, focused on ensuring equitable access to quantum technologies and capacity-building. The session explored strategies for fostering global inclusivity in quantum science, addressing pressing issues such as mitigating the potential quantum digital divide, creating culturally relevant education programmes, and empowering low- and middle-income countries (LMICs) to effectively influence global quantum policies.

Panellists included:

- **Amal Kasry**, Chief of Section for Basic Science, Research, Innovation and Engineering, UNESCO
- **Barry Sanders**, Professor, Department of Physics and Astronomy, University of Calgary (joining online)
- **Mira Luca Wolf-Bauwens**, Responsible Quantum Computing Lead, IBM Quantum Technical Ambassador and Responsible Technologies Researcher, IBM Research Europe

The panel focused on the following key questions:

- How can equitable access to quantum technologies be ensured, and what steps can mitigate the risks associated with a quantum digital divide?
- What are effective methods for designing agile and culturally relevant capacity-building programmes?
- How can the voices of LMICs be amplified to shape global quantum policies?

Key Insights from the Discussion Include:

Perspectives on equitable access: Quantum technologies present distinctive challenges to equitable access due to their high costs, technical complexity, and the concentration of expertise and infrastructure in developed countries. Quantum's dependency on private-sector funding further intensifies disparities, leaving many regions unable to access these transformative tools. In this context, capacity-building should go beyond traditional education models and include fostering innovative ecosystems in under-represented regions, including start-ups and research collaborations.

However, it must be noted that private-sector initiatives have also contributed to improving access to quantum technologies. Notable examples are the placement of early quantum computers in the cloud and the availability of educational resources, including IBM's open-source textbooks and quantum games, which are freely accessible. However, significant challenges remain, including export controls and high operational costs, which restrict access to many regions. As quantum computing advances, increased public investment is needed to complement private efforts and ensure broader inclusivity and equitable participation.

The panellists stressed UNESCO's commitment to reducing global inequalities through initiatives such as the 2025 International Year of Quantum Science and Technology as well as through strategies to address the disparities. The latter includes the development of remote-access platforms for laboratory equipment and the implementation of capacity-sharing programmes. These programmes enable scientists in low-resource regions to perform advanced research without the need for costly facilities.

Innovations in education and capacity-building: The panel further explored novel approaches to expanding access to quantum education through innovative tools and programmes, such as:

- The University of Calgary's professional master's programme in quantum computing, which bridges the gap between software engineers and data scientists by focusing on practical skills
- IBM's efforts to democratize quantum education through open-source tools, online tutorials and opportunities for collaborative research
- UNESCO's capacity-sharing programmes, particularly its remote laboratory access initiative which allows researchers in Africa to use cutting-edge technologies without leaving their home countries, thereby reducing brain drain and strengthening local research capabilities

Bridging the policy and education gap: Mutual education of and by policymakers and the scientific community is required to address the complex interplay between quantum technologies and policy. In particular:

- To enact informed regulations, policymakers must deepen their understanding of quantum technologies so that policies match technological realities and do not stifle innovation or limit equitable access.
- Scientists and technologists must enhance their awareness of global politics and ethical concerns in order to navigate dual-use challenges and promote equitable and responsible applications of quantum technologies.

Ethical considerations and governance: Ethical and governance frameworks for quantum technologies are key. For example, the World Economic Forum's Quantum Computing Governance Principles emphasize values such as inclusivity, open access and responsible innovation.[13] Ethical challenges unique to quantum technologies must be directly addressed, rather than assumed to mirror those of classical computing or AI. Embedding ethical discussions into capacity-building efforts and focusing on transparency, inclusivity and accountability are particularly important. The panellists stressed that this should be done in a way that considers regional needs while maintaining alignment with global objectives.

Ensuring diverse voices in global policies: The panellists emphasized the importance of empowering LMICs to participate in shaping global quantum policies. To this end, tailored approaches are essential, given the diverse challenges and solutions across regions. UNESCO's decentralization strategies and accessible online platforms are an example of effective mechanisms for enabling stakeholders from under-represented regions to contribute ideas and initiatives.

Final thoughts and recommendations:

The panellists provided actionable insights to promote equity and innovation in quantum technologies, underscoring the fact that achieving "access for all" in quantum technologies is a multifaceted challenge that requires a coordinated, inclusive and forward-thinking approach.

Key Insights Include:

- Strengthen public–private partnerships to balance accessibility with innovation
- Promote interdisciplinary education that integrates ethics, governance and technical expertise
- Facilitate collaboration across sectors and regions to build an inclusive quantum ecosystem
- Expand capacity-sharing models, such as UNESCO's remote laboratory initiative, to address disparities in resources and expertise

2.6 Regular, Structured Dialogue on Quantum Governance

The fifth panel was moderated by Giacomo Persi Paoli, Head of the Security and Technology Programme at UNIDIR, and focused on governance in quantum technologies – a pivotal topic in discussions on innovation. The panellists emphasized that governance provides the structure within which innovation intersects with practical application, particularly in contexts requiring careful policymaking. Among the critical questions linked to governance addressed by the panel were: How can emerging governance frameworks for quantum technologies avoid the pitfalls encountered in other technological domains? Can global governance provide a foundation applicable across all sectors, including national security, while accommodating the unique sensitivities of quantum technologies?

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13 Quantum Delta NL released the Exploratory Quantum Technology Assessment to guide companies, governments and organizations in exploring and navigating the ethical, legal and societal implications of quantum technologies. See Quantum Delta NL, "Launching the Exploratory Quantum Technology Assessment", 14 April 2023, https://quantumdelta.nl. The World Economic Forum Quantum Computing Governance Principles also emphasize the importance of ensuring the development and use of quantum computing. The principles include transformative capabilities, access to hardware infrastructure, open innovations, creating awareness, workforce development and capability-building, cybersecurity, privacy, standardization, and sustainability. See World Economic Forum (WEF), *Quantum Computing Governance Principles*, Insight Report (Geneva: WEF, January 2022), https://www3.weforum.org/docs/WEF_Quantum_Computing_2022.pdf. The Stanford Center for Responsible Quantum Technology and nine universities across the United States and Europe published a paper, "Ten Principles for Responsible Quantum Innovation", to propose a set of guiding principles for responsible quantum innovation. The principles are organized into three functional categories – safeguarding, engaging and advancing (SEA) – and are linked to central values in responsible research and innovation. See Mauritz Kop, "Ten Principles for Responsible Quantum Innovation", *Quantum Science and Technology*, vol. 9 (2024), https://doi.org/10.1088/2058-9565/ad3776.

The panel featured:

- **Beyza Unal**, Head of Science, Technology and International Security Unit, United Nations Office for Disarmament Affairs (joining online)
- **Ambassador Fernando Espinosa**, Deputy Permanent Representative of Mexico to the United Nations Office at Geneva
- **Prince Koree Osei**, Lead Scientist and Director, Quantum Leap Africa (QLA)
- **Mira Luca Wolf-Bauwens**, Responsible Quantum Computing Lead, IBM Quantum Technical Ambassador and Responsible Technologies Researcher, IBM Research Europe

Key Insights from the Discussion Include:

Governance as a catalyst for innovation and collaboration: The panellists noted Mexico's leadership in promoting the 2025 International Year of Quantum Science and Technology, reflecting its commitment to raising awareness and fostering collaboration. Furthermore, they highlighted the challenge of aligning priorities between scientists and policymakers, which is a critical issue in science diplomacy. To this end, multilateral institutions (e.g., the Open Quantum Institute (OQI)) promote inclusive dialogue among governments, academia and private actors to ensure that development of quantum technologies aligns with the SDGs.

In addition, the panellists discussed the parallel between intellectual property challenges in quantum innovation and AI. They stressed the need for cooperative frameworks to balance innovation with equity and to avoid worsening global digital divides.

Balancing core values in quantum regulation: Due to the disruptive potential of quantum technologies, governance models should be rooted in core values such as accessibility, accountability and "quantum for good". Inclusive capacity-building initiatives to address technological disparities, particularly in the Global South, will be key. These could materialize in regional quantum hubs or in specialized training programmes for young scientists. Importantly, regulations and standards across the full range of applications of quantum should be harmonized globally, ensuring responsible innovation while adhering to shared principles.

Learning from the past and embracing complexity: The panellists identified three foundational principles for effective quantum governance: learning from the past, embracing complexity and adopting principled frameworks as guiding tools. Drawing on historical examples, governance should not be confused with overregulation. Instead, it should encompass a range of approaches that foster deeper collaboration between technical and policy communities in order to bridge knowledge gaps and avoid the pitfalls of siloed efforts.

Relatedly, broader stakeholder engagement – particularly in industries where quantum applications are emerging – will be key to ensuring that quantum governance frameworks are informed by diverse perspectives. To avoid duplication of efforts and to prevent fragmented initiatives, discussions of governance that are currently separated should be integrated.

Inclusivity and structured dialogue: The intersection of quantum technologies with international peace and security raises the critical need for structured and inclusive dialogues to address risks, particularly in dual-use technologies. Here too, capacity-building initiatives (e.g., regional quantum hubs) are key to promoting equitable access to quantum technologies and research opportunities.

Existing governance frameworks, such as the approaches taken by the United Nations to other emerging technologies, could provide valuable insights into quantum governance. However, the unique challenges posed by quantum technologies must be addressed, including their exponential impact on other fields and their cascading societal and economic implications.

Emerging challenges in quantum governance: Some additional key governance challenges specific to quantum technologies are:

- *Access and equity:* Both technological and epistemic access must be ensured, particularly for the Global South, to prevent the digital divide from widening and to ensure inclusivity.
- *Balancing national interests and innovation:* This balance is necessary to address the tensions between national security, intellectual property rights and commercial interests as quantum technologies mature.
- *Exponential impact:* Quantum's cascading effects on other technologies and industries must be acknowledged, which will necessitate proactive governance to mitigate unintended consequences.
- *Collaboration and coherence:* Bridging divides among various stakeholders – including technical experts, policymakers and end-users – will create governance frameworks that reflect shared values and align with long-term objectives.

Final thoughts and recommendations:

The panellists emphasized the importance of proactive and inclusive governance for quantum technologies, focusing on collaboration across regions, sectors and stakeholder groups. As quantum technologies progress, governance must balance innovation, security and inclusivity to ensure that their benefits are shared globally as well as to address these complex technologies' ethical, legal and societal challenges.

3. Conclusion and Suggestions for Future Research

The 2024 Innovations Dialogue explored the transformative potential and critical implications of quantum technologies for international peace and security. The conference highlighted the dual-use nature of quantum technologies, emphasizing their capacity to revolutionize fields such as secure communications, computation and sensing, while also posing risks to global stability through the disruption of cryptographic systems, the shifting of geopolitical dynamics and ethical challenges.

Key themes that emerged from the discussions included the needs for structured governance frameworks, inclusive capacity-building initiatives and proactive policy development to ensure equitable and responsible quantum advancements. The event underscored the importance of collaboration across disciplines and geographies, emphasizing that governments, academia, the private sector and civil society must work together to responsibly harness the transformative power of quantum technologies.

The Dialogue demonstrated that, although quantum technologies remain in an early stage of development, their potential impact on global security, economic systems and societal structures is profound and far-reaching. This emphasizes the urgency of anticipatory governance and multi-stakeholder engagement.

Looking ahead, the following suggestions can be identified:

- **Leverage existing multilateral forums in order to further explore the potential impact of quantum technologies on international peace and security, disarmament, and arms control**
  - Monitor advances in quantum technologies and specific applications in order to identify relevant use cases relevant to the mandate of existing international peace and security multilateral forums
  - Conduct more tailored analysis of identified applications in order to highlight specific risks and opportunities brought by quantum technologies

- **Strengthen global governance mechanisms**
  - Establish a comprehensive and inclusive governance framework for quantum technologies in order to address both their opportunities and their risks
  - Align governance frameworks with international peace and security priorities and ensure consistency with the United Nations Sustainable Development Goals
  - Leverage multilateral platforms, such as the OQI, to facilitate structured and ongoing dialogues with stakeholders

- **Promote equitable access and capacity-building**
  - Address the risk of a "quantum divide" by developing initiatives to ensure access to quantum technologies for under-represented and developing regions
  - Expand capacity-building programmes, such as UNESCO's remote laboratory platforms, to enable scientists from resource-constrained regions to participate in cutting-edge quantum research
  - Support interdisciplinary education that integrates the technical, ethical and geopolitical dimensions of quantum technologies in order to prepare the next generation of innovators and policymakers

- **Encourage multi-stakeholder collaboration**
  - Foster partnerships between governments, industry, academia and civil society to develop scalable and ethical quantum solutions
  - Support the creation of regional quantum hubs and collaborative research networks to drive innovation and shared progress across geographies
  - Amplify the voices of low- and middle-income countries in global quantum policymaking in order to ensure their inclusion in shaping future governance structures

- **Consider ethical and security implications**
  - Develop clear ethical guidelines and regulatory frameworks to address dual-use concerns and prevent the misuse of quantum technologies
  - Prioritize the development of post-quantum cryptography to mitigate the cybersecurity risks associated with quantum computing advancements
  - Monitor and regulate the proliferation of quantum technologies to ensure that they are deployed responsibly and equitably

- **Advance research and innovation with a forward-thinking approach**
  - Invest in fundamental research to overcome technical barriers and accelerate the commercialization of quantum technologies
  - Encourage interdisciplinary research to explore quantum applications in areas such as healthcare, climate change and sustainable development
  - Align that innovation with global priorities by incentivizing research that supports societal and economic resilience

Building on the insights and recommendations in this report – and by fostering inclusive and anticipatory discussions that prioritize equity, security and innovation – the international community has the opportunity to shape a secure, equitable and innovative quantum future that benefits humanity as a whole.

Annex: Conference Agenda

2024 Innovations Dialogue

Quantum technologies and their implications for international peace and security

22 November 2024, Campus Biotech

08:30 REGISTRATION

09:00–09:10 WELCOME

Opening Remarks

Robin Geiss: Director, UNIDIR

Maricela Muñoz: Director Strategic Partnerships, GESDA

09:20–09:50 PANEL 1

Agenda and Framing of the Discussion on Quantum Technologies in the Context of International Peace and Security

Jungsang Kim: Associate Director of the Duke Quantum Center, Professor of Physics, Duke University

Mira Wolf-Bauwens: Responsible Quantum Computing Lead, IBM Research Europe

Moderated by **Maricela Muñoz**: Director, Strategic Partnerships, GESDA

09:50–11:10 PANEL 2

Overview of Quantum Technology Applications

Jungsang Kim: Associate Director of the Duke Quantum Center, Professor of Physics, Duke University

Gregoire Ribordy: Chief Executive Officer, ID Quantique

Kelly Richdale: Executive Fellow, Centre for the Fourth Industrial Revolution Network and Partnerships, World Economic Forum

Yung Szen Yap: Senior Lecturer, Department of Physics, Universiti Teknologi Malaysia (UTM)

Moderated by **Dongyoun Cho**: Senior Researcher, Security & Technology Programme, UNIDIR

11:10–11:30 COFFEE BREAK

11:30–12:50 PANEL 3

Impact of Quantum Technologies on International Peace and Security

Brad Lackey: Partner, Quantum Architect, Microsoft

Min-Ha Lee: Fellow, Stanford Center for Responsible Quantum Technology, Stanford University, Korea Institute of Industrial Technology

Giacomo Persi Paoli: Head of Programme, Security & Technology, UNIDIR

Constanza Vidal Bustamante: Fellow, Technology and National Security, Center for a New American Security

Moderated by **Sarah Marie Clement**: Researcher, Security & Technology Programme, UNIDIR

12:50–13:50 LUNCH BREAK

13:50–15:10 PANEL 4

Access for All & Advancing Capacity Building

Amal Kasry: Chief of Section for Basic Science, Research, Innovation and Engineering, UNESCO

Barry Sanders: Professor, Faculty of Science, Department of Physics and Astronomy, University of Calgary (online)

Amb James Ndirangu Waweru with Mira Wolf-Bauwens: Responsible Quantum Computing Lead, IBM Research Europe

Moderated by **Marieke Hood**: Executive Director Impact Translator, GESDA

15:10–15:30 COFFEE BREAK

15:30–16:50 PANEL 5

Regular, Structured Dialogue on Quantum Governance

Beyza Unal: Head of Science, Technology and International Security Unit, United Nations, Office for Disarmament Affairs (online)

Amb Fernando Espinosa: Deputy Permanent Representative of Mexico to the United Nations Office at Geneva

Prince Koree Osei: Lead Scientist & Director, Quantum Leap Africa (QLA)

Mira Wolf-Bauwens: Responsible Quantum Computing Lead, IBM Research Europe

Moderated by **Giacomo Persi Paoli**: Head of Programme, Security & Technology, UNIDIR

16:50–17:00 CONCLUDING REMARKS

Conference Closing

Maricela Muñoz: Director, Strategic Partnerships, GESDA

Giacomo Persi Paoli: Head of Programme, Security & Technology, UNIDIR

Featured Speakers

Opening Remarks

Robin Geiss

Director, UNIDIR

Dr Robin Geiss is the Director of the United Nations Institute for Disarmament Research (UNIDIR). He was appointed by Secretary-General António Guterres and assumed the post in April 2021. As Director, Dr Geiss charts UNIDIR's strategic direction, mobilizes resources and manages the Institute's staff. He brings to the position over 20 years of experience in peace, security and international affairs. Previously, he served as tenured Professor and Director of the Glasgow Centre for International Law and Security at the University of Glasgow. He was also the Swiss Chair of International Humanitarian Law at the Geneva Academy of International Humanitarian Law and Human Rights and Visiting Professor at the Paris School of International Affairs, Sciences Po, Paris. He served as Legal Adviser and delegate to the UN Human Rights Council for the International Committee of the Red Cross (ICRC). He is an ex officio member of the UN Secretary General's Advisory Board on Disarmament Matters and remains (affiliate) Professor at the University of Glasgow.

Maricela Muñoz

Director, Strategic Partnerships, GESDA

Mrs Muñoz currently serves as the Director of Strategic Partnerships for GESDA (Geneva Science and Diplomacy Anticipator Foundation), a Swiss public-private foundation that anticipates future scientific and technological developments to maximize benefits for society. She has worked as a diplomat, serving as Minister Counsellor and Chargé d'Affaires a.i. at the Permanent Mission of Costa Rica in Geneva, Switzerland. Prior to that, she held regional positions at the United States Agency for International Development(USAID), The Nature Conservancy, the U.S. Department of State, Singkee Consulting, and AVINA Stiftung.

Panel 1

Jungsang Kim

Associate Director of the Duke Quantum Center, Professor of Physics, Duke University

Dr Jungsang Kim is the Schiciano Family Distinguished Professor of Electrical and Computer Engineering and Professor of Physics at Duke University. He is also a co-founder of IonQ, and served as the Chief Technology Officer. He is a leading expert in quantum computing and quantum networking with atomic systeMs Professor Kim received his BS degree in Physics from Seoul National University, and Ph.D. in Physics from Stanford University. He served as a Technical Manager at Bell Laboratories working on developing optical and wireless communication technologies before joining Duke University in 2004.

Mira Wolf-Bauwens

Responsible Quantum Computing Lead, IBM Research Europe

Dr Mira Wolf-Bauwens is Responsible Quantum Computing Lead and Technical Quantum Ambassador at IBM Research, and one of the foremost leaders in the Responsible Quantum Computing movement, championing the use of the technology for societal good and benefit. Mira's team collaborates to tackle business and socio-economic challenges through technological innovation. They address the societal questions arising from the development of Quantum Computing and Quantum-safe technologies. As a leading expert in quantum computing and its ethical implications, Mira is highly sought after for her insights on the intersection of emerging technologies and societal impact. Among others, she has co-authored the first Quantum Computing Governance Principles with the WEF, is on the Advisory Board of the Open Quantum Institute and served as ans expert on the UNESCO World Commission on the Ethics of Scientific Knowledge's panel on Quantum Ethics.

Maricela Muñoz

Director, Strategic Partnerships, GESDA

Mrs Muñoz currently serves as the Director of Strategic Partnerships for GESDA (Geneva Science and Diplomacy Anticipator Foundation), a Swiss public-private foundation that anticipates future scientific and technological developments to maximize benefits for society. She has worked as a diplomat, serving as Minister Counsellor and Chargé d'Affaires a.i. at the Permanent Mission of Costa Rica in Geneva, Switzerland. Prior to that, she held regional positions at the United States Agency for International Development(USAID), The Nature Conservancy, the U.S. Department of State, Singkee Consulting, and AVINA Stiftung.

Panel 2

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Associate Director of the Duke Quantum Center, Professor of Physics, Duke University

Dr Jungsang Kim is the Schiciano Family Distinguished Professor of Electrical and Computer Engineering and Professor of Physics at Duke University. He is also a co-founder of IonQ, and served as the Chief Technology Officer. He is a leading expert in quantum computing and quantum networking with atomic systeMs Professor Kim received his BS degree in Physics from Seoul National University, and Ph.D. in Physics from Stanford University. He served as a Technical Manager at Bell Laboratories working on developing optical and wireless communication technologies before joining Duke University in 2004.

Gregoire Ribordy

Chief Executive Officer, ID Quantique

Mr Ribordy is a pioneer in the field of quantum technologies. After obtaining his PhD in physics from the University of Geneva in the late 1990's for his research on quantum communications, Mr Ribordy co-founded ID Quantique (IDQ) and has been its CEO since then. IDQ was the first company to exploit quantum physics to enhance data security, with several world premieres. He was a member of the High-Level Group on Quantum Technologies, in charge of advising the European Commission on technology and innovation aspects related to this field in 2016 to 2017. Mr Ribordy is the author of more than 30 scientific papers in the field of quantum technologies and cited as an inventor on more than 20 patents. He is the recipient of several innovation awards, such as the University of Geneva Innovation Medal (2017) or the Digital Shaper Switzerland Award (2018).

Kelly Richdale

Executive Fellow, Centre for the Fourth Industrial Revolution Network and Partnerships, World Economic Forum

Kelly Richdale is a Senior Advisor for SandboxAQ, Alphabet's AI and Quantum spin off, and an Executive Fellow – Quantum at the World Economic Forum. She has 20+ years' experience in cybersecurity and transformative technologies (quantum, AI, blockchain). She also holds roles as Venture Partner with Amadeus, a European deeptech investor, and is a board member for a Swiss insurance company. Previously she was on the Innovation Council for Innosuisse, the Swiss federal government's agency for technology innovation, as well as on the executive team of Libra, Meta's blockchain-based payment project. Prior to that she was EVP for Quantum Safe Security at ID Quantique, a Swiss leader in QKD and QRNG. Her extensive track record includes board governance, strategic leadership, entrepreneurship and building high growth international businesses. She holds an MBA from INSEAD and a CISSP in Cybersecurity.

Yung Szen Yap

Senior Lecturer, Department of Physics, Universiti Teknologi Malaysia (UTM)

Dr Yap is currently a senior lecturer at Universiti Teknologi Malaysia (UTM), a specially appointed associate professor with the Center of Quantum Information and Quantum Biology (QIQB), Osaka University and a researcher with Prof. Rainer Dumke Lab, Centre for Quantum Technologies (CQT). He worked on Electron Spin and Superconducting Quantum Computers at millikelvin temperatures. Since 2023, he is also an active member of the quantum community Malaysia Quantum Information Initiative (MyQI), which functions to help promote and advocate quantum information in Malaysia.

Dongyoun Cho

Senior Researcher, Security & Technology Programme, UNIDIR

Dongyoun Cho is a senior researcher in the Security and Technology Programme at the United Nations Institute for Disarmament Research (UNIDIR). Her research focuses on the convergence of security and emerging technologies, including artificial intelligence, autonomy, cyber, and quantum. As a former Major in the Republic of Korean Army with over 20 years of experience in intelligence, military strategy, defense policy, and the aerospace and defense industry, she brings a wealth of expertise. Additionally, she serves as an Assistant Professor in the Department of Military Studies at Seokyeong University, where she established and led the Center for Future Defense Technology and Entrepreneurship as a director. Dongyoun graduated from the Korea Military Academy and holds a master's degree in public administration from the Kennedy School of Government at Harvard University. She was also recognized as a World Fellow (2018) at Yale University.

Panel 3

Brad Lackey

Partner, Quantum Architect, Microsoft

Dr Brad Lackey is a quantum architect and leads the quantum networking program at Microsoft. Prior to Microsoft, he was a senior technical leader in the U.S. DoD, specializing in design and analysis of quantum and post-quantum cryptography, and adjunct Professor of Computer Science at University of Maryland. His research interests include quantum information science, quantum algorithms and error correction, quantum cryptography and cybersecurity, and foundations of quantum theory.

Min-Ha Lee

Fellow, Stanford Center for Responsible Quantum Technology,
Stanford University, Korea Institute of Industrial Technology

Dr Min-Ha Lee is Fellow at the Stanford Center for Responsible Quantum Technology at Stanford University and a Principal Researcher at the Korea Institute of Industrial Technology (KITECH) and a Professor at the University of Science and Technology (UST) in South Korea. He earned his PhD in Metallurgical Engineering at Yonsei University (2004) and has developed a comprehensive expertise that bridges the disciplines of engineering and policy development, underpinned by rigorous analytic assessment. A pioneer in his field, Min-Ha has been at the forefront of advocating for comprehensive studies and policies regarding the sustainability and accessibility of CRMs and Rare Metals. His tenure as a Senior Researcher at the Korea Materials and Components Industry Agency (KMAC) within South Korea's Ministry of Trade, Industry, and Energy (MOTIE). He was a Senior Scientist & Research Professor at Leibniz Institute for Solid State and Materials Research Dresden in Germany.

Giacomo Persi Paoli

Head of Programme, Security & Technology, UNIDIR

Dr Persi Paoli is the Head of the Security and Technology Programme at UNIDIR. His expertise spans the science and technology domain with emphasis on the implications of emerging technologies for security and defence. His recent work focused on arms control, technology horizon scanning, AI and cyber security. Before joining UNIDIR, Giacomo was Associate Director at RAND Europe where he led the defence and security science, technology and innovation portfolio as well as RAND's Centre for Futures and Foresight Studies. He served for 14 years as warfare officer in the Italian Navy and has been extensively engaged in small arms and light weapons research in support of UN processes. He holds a PhD in Economics from the University of Rome, Italy and a master's degree in Political Science from the University of Pisa, Italy.

Constanza Vidal Bustamante

Fellow, Technology and National Security, Center for a New American Security

Constanza M. Vidal Bustamante, Ph.D. is a Fellow with the Technology and National Security Program at the Center for a New American Security, a bipartisan think tank in Washington, D.C. She leads the Center's quantum technology policy research, with a focus on national security applications, strategic investments, and technology protection.

Sarah Marie Grand-Clement

Researcher, Security & Technology Programme, UNIDIR

Sarah Grand-Clément is Researcher in the Conventional Arms and Ammunition Programme and the Security and Technology Programme of the United Nations Institute for Disarmament Research (UNIDIR). Her work examines the intersection of technology and conventional arms, exploring both the benefits of technology for arms control and violent conflict prevention, as well as the challenges and threats technology can pose to international security. Prior to joining UNIDIR, Sarah was a Senior Analyst in defence and security issues at RAND Europe.

Panel 4

Amal Kasry

Chief of Section for Basic Science, Research, Innovation and Engineering, UNESCO

Dr Amal Kasry is currently the Chief of Section for Basic Sciences, Research Innovation and Engineering, which is part of the Division of Science Policy and Basic Science, Natural Sciences Sector at UNESCO. Her major role is to Design, implement, monitor, and evaluate basic and engineering sciences programme in order to ensure the delivery of the expected results approved by UNESCO's governing bodies in the fields of basic and engineering sciences capacity development for research, education and innovation. She also delivers expert advice and comprehensive programmes to Member States.

Barry Sanders

Professor, Faculty of Science, Department of Physics and Astronomy,
University of Calgary

Barry Sanders is Scientific Director of Calgary's "Quantum City", hosted by the University of Calgary and tasked with building a strong quantum ecosystem in Alberta. Barry's theoretical research includes quantum sensing and metrology, quantum and quantum-resilient communication, quantum computing and quantum optics. He has held numerous distinguished international visiting professorships and affiliations in Canada, the USA, China, India, Israel, Austria and elsewhere, and is a Scientist with the Creative Destruction Lab sites at the Universities of Toronto and Calgary. Sanders served as an Expert with the Canadian Council of Academies and is a member of the Scientific Board for the Banff International Research Station.

Ambassador James Ndirangu Waweru

Deputy Permanent Representative of Kenya to the United Nations
and other international organizations in Geneva

Ambassador James Ndirangu Waweru, EBS, is the Deputy Permanent Representative, at the Permanent Mission of the Republic of Kenya to the United Nations Office in Geneva. He is the immediate former Registrar of Treaties, Office of Registrar of Treaties in the Ministry of Foreign and Diaspora Affairs. An Advocate of the High Court of Kenya, and Certified Secretary, Amb. Waweru received an LL. B from Nagpur University, India, (1999), and an LL.M from Warwick University, United Kingdom, (2002), specializing in International Economic Law.

Marieke Hood

Executive Director Impact Translator, GESDA

Marieke is the Executive Director Impact Translator of GESDA. She joined the foundation at its inception in 2019. Her role is to implement the most advanced science diplomacy solutions ideated by GESDA, working towards their spin-off as independent institutions. This involves prototyping real-world activities, framing their governance and securing their funding. Marieke led the incubation of the Open Quantum Institute, culminating with its launch in March 2024 as part of CERN with the support of UBS.

Panel 5

Beyza Unal

Head of Science, Technology and International Security Unit,
United Nations, Office for Disarmament Affairs

Dr Beyza Unal is the Head of Science and Technology Unit at UNODA. She specializes in the interaction between emerging technology applications and their impact on international peace and security. Before joining UNODA, Beyza was the Deputy Director of the International Security Programme at Chatham House. She formerly worked in the Strategic Analysis Branch at NATO Allied Command and Transformation, taught International Relations at Old Dominion University, and served as an international election observer during the 2010 Iraqi parliamentary elections. She has published numerous research papers in the areas of cyber security, outer-space security, protection of critical national infrastructure, nuclear weapons policy, and other emerging technology areas.

Ambassador Fernando Espinosa

Deputy Permanent Representative of Mexico to the United Nations Office at Geneva

Since 2022, Deputy Permanent Representative of Mexico in Geneva. Has served as Deputy Head of Mission at the Embassy of Mexico in Switzerland and DPR before the UPU. Held diplomatic assignments in Canada and Sao Paulo, Brazil. Has served as Deputy Director General for the Division of Europe, at the Legal Affairs Division, Foreign Policy Planning Unit, Division of Consular Affairs, Bilateral Economic Affairs and American Regional Organizations in the Mexican Foreign Ministry.

Prince Koree Osei

Lead Scientist & Director, Quantum Leap Africa (QLA)

Dr Prince K. Osei is the Centre President of the African Institute for Mathematical Sciences (AIMS) Ghana. He is also the Lead Scientist and Director for Quantum Leap Africa (QLA) in Kigali, Rwanda. Previously, he was a Fields-Perimeter and Perimeter Institute Postdoctoral research fellow and the Academic Manager for AIMS Ghana. As a lecturer and researcher, Prince has taught over 20 courses across all levels in the university. With his extensive experience in multiple fields of life, he is trusted to sit on academic boards, with the task of overseeing academic quality assurance and aiding in the creation of masters and Ph.D. prograMs He serves on the WEF council for the Future of Quantum Economy and the Advisory Committee for OQI at CERN.

Mira Wolf-Bauwens

Responsible Quantum Computing Lead, IBM Research Europe

Dr Mira Wolf-Bauwens is Responsible Quantum Computing Lead and Technical Quantum Ambassador at IBM Research, and one of the foremost leaders in the Responsible Quantum Computing movement, championing the use of the technology for societal good and benefit. Mira's team collaborates to tackle business and socio-economic challenges through technological innovation. They address the societal questions arising from the devel- opment of Quantum Computing and Quantum-safe technologies. As a leading expert in quantum computing and its ethical implications, Mira is highly sought after for her insights on the intersection of emerging technologies and societal impact. Among others, she has co-authored the first Quantum Computing Governance Principles with the WEF, is on the Advisory Board of the Open Quantum Institute and served as an expert on the UNESCO World Commission on the Ethics of Scientific Knowledge's panel on Quantum Ethics.

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Concluding Remarks

Maricela Muñoz

Director, Strategic Partnerships, GESDA

Mrs Muñoz currently serves as the Director of Strategic Partnerships for GESDA (Geneva Science and Diplomacy Anticipator Foundation), a Swiss public-private foundation that anticipates future scientific and technological developments to maximize benefits for society. She has worked as a diplomat, serving as Minister Counsellor and Chargé d'Affaires a.i. at the Permanent Mission of Costa Rica in Geneva, Switzerland. Prior to that, she held regional positions at the United States Agency for International Development(USAID), The Nature Conservancy, the U.S. Department of State, Singkee Consulting, and AVINA Stiftung.

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