GISC 2025

Global ICT Standards Conference 2025

(세션 2) 후세대 전문가를 위한 국제표준 노하우 가이던스

경계를 허무는 표준(디지털에서 양자로)

박성수
연세대학교

ICT Standards and Intellectual Property:
AI for All

주최 과학기술정보통신부 지식재산처 주관 국립전파연구원 TTA IITP KEA kista ETRI

Index

01 양자기술의 발전동인

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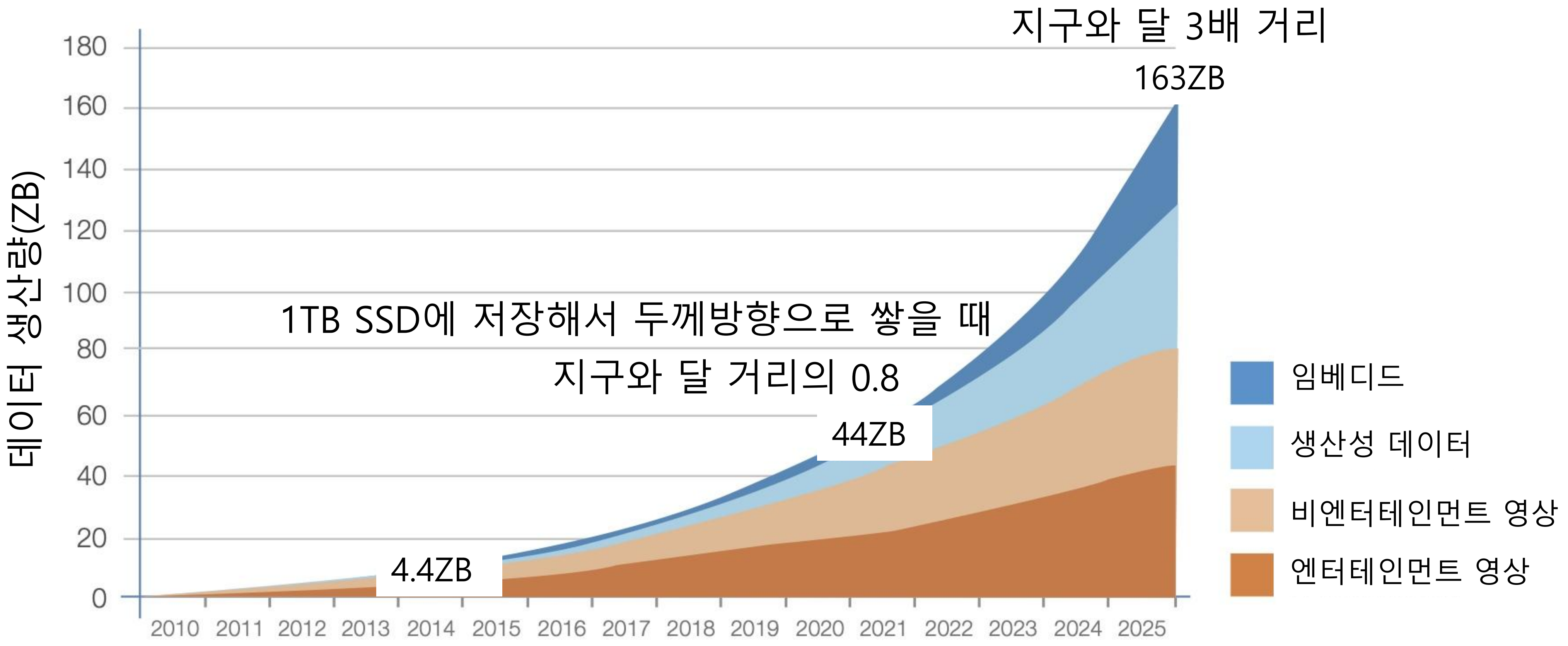
03 양자기술환경

04 양자기술 표준화

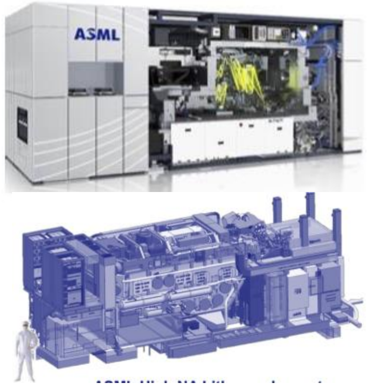
GISC 2025
Global ICT Standards Conference 2025

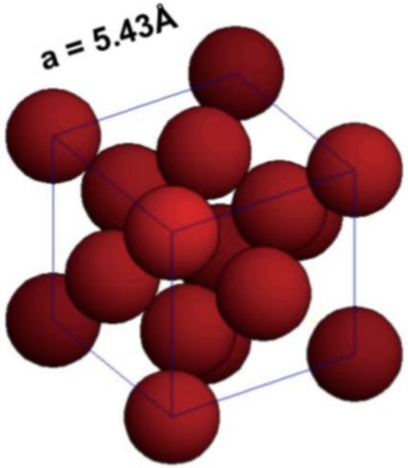
01. 데이터 급격 증가



Source: IDC's Data Age 2025 study, sponsored by Seagate, April 2017

02. 반도체 공정기술의 한계 (선폭 nm, 구조)





Si 원자구조

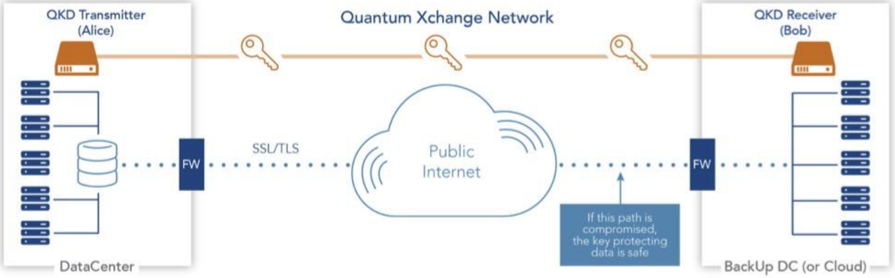
* ASML, "EUV: Enabling cost effieciency, tech innovation and future industry growth", BAML 2019 APAC PMT Conference, Taipei, March 20, 2019.

03. 학문의 발전에 따른 컴퓨팅 기술

Christopher Savoie, ITU Workshop on Quantum Information Technology, 2019 의 재구성

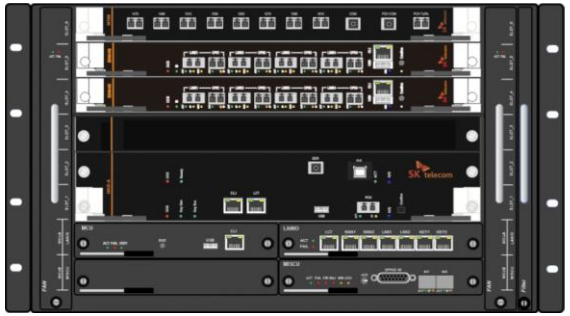
02. 현황

2016년 10월 북경-진안-허페이-상해 QKD백본 완성
(중국산업상업은행, 신화사통신, 은행감독원 등이 사용)



2018년 10월 월가-뉴저지백오피스간 QKD서비스
QuantumXchange사(미국)

IDQ 장비 (스)
(CERBERIS)



SKT 장비

MagiQ 장비 (미)
(NAVAJO)

Qasky 장비(중)

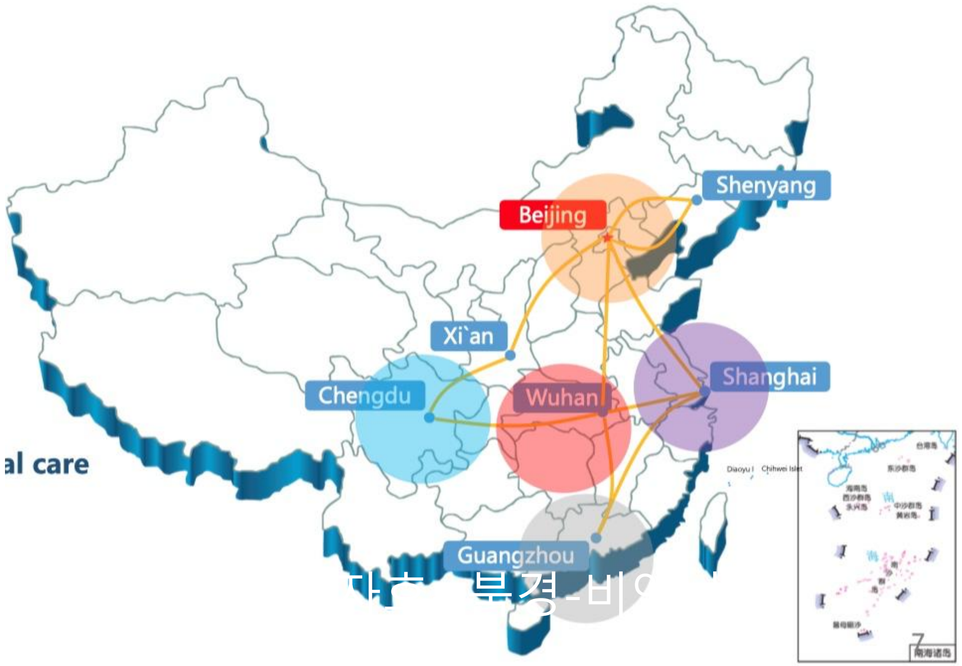
Anhui 장비(중)

Huawei 광전송 장비(중)

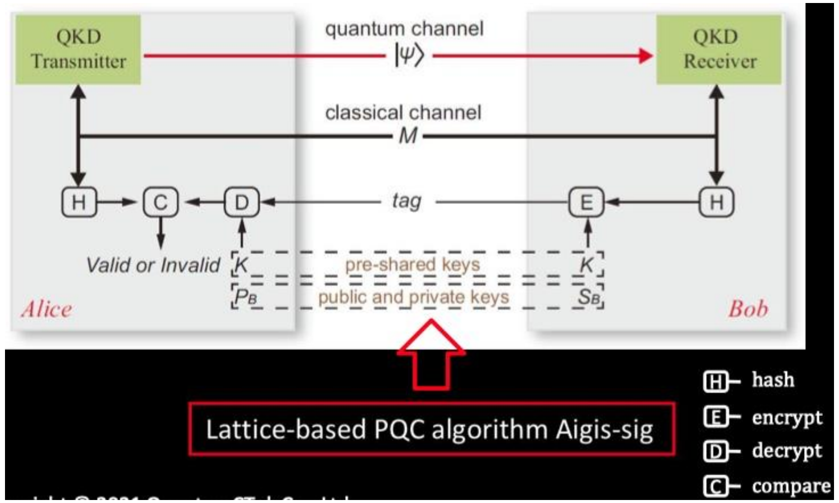
Toshiba 장비(영)

QuantumCTek 장비(중)

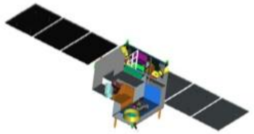
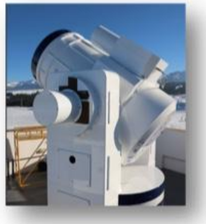
03. 중국의 최근 동향

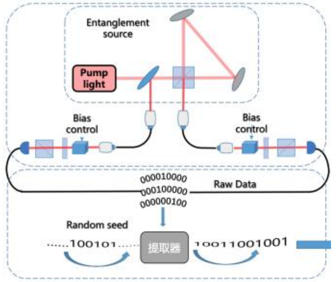


양자백본 총4,000km



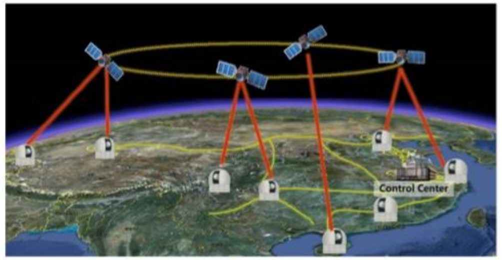
PQC(양자내성암호) 인증에 의한 QKD

Micius	Micro Quantum Satellite
	
• Weight: ~640kg • Power: ~560W • Frequency: 100MHz	• Weight: ~100kg • Power: ~100W • Frequency: >300MHz
	
• Weight: ~10 Tons • Power: ~60kW	• Weight: ~100kg • Power: ~300W



DI–QRNG 공공 서비스

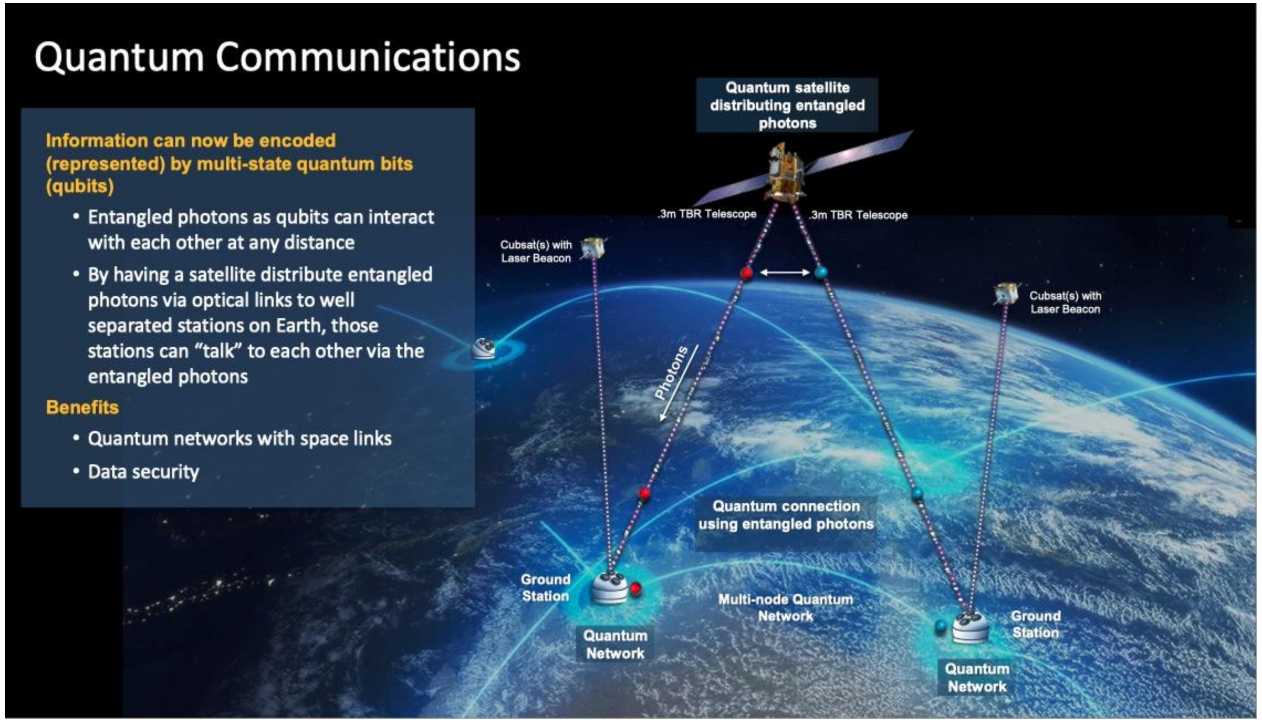
- 랜덤 비콘 (512bit pulse/min)
- 복권
- 전자서명에 의한 전자계약
- **인증 및 암호분배**

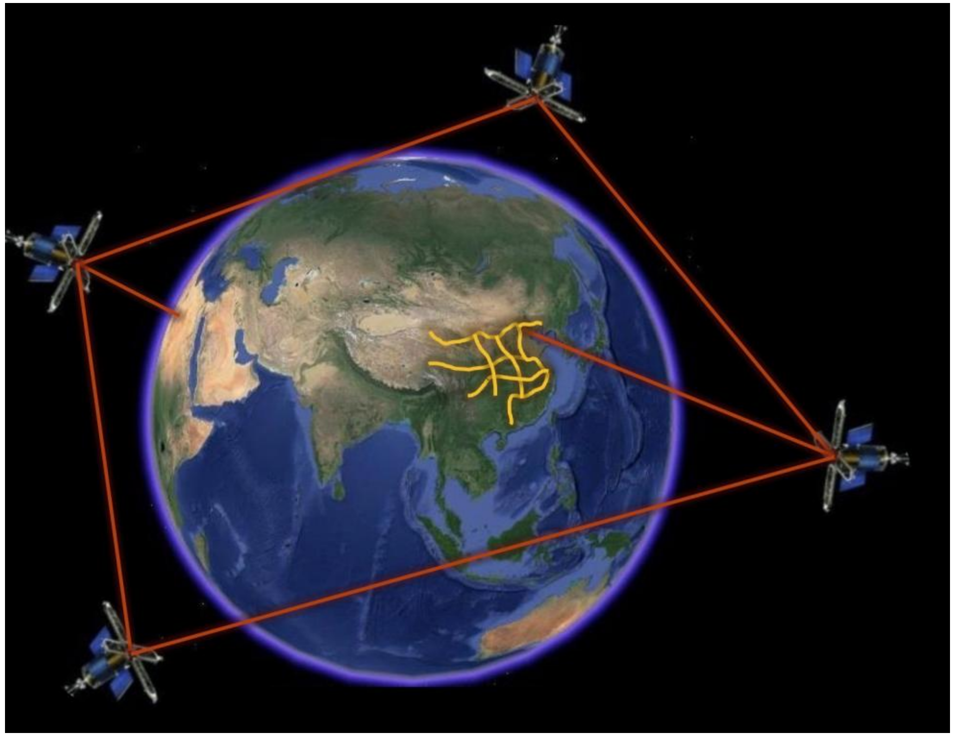


Our Plan
- ~2022: 2 Satellites, 10 Ground Station
- ~2030: 5~8 Satellites, 100 Ground Station

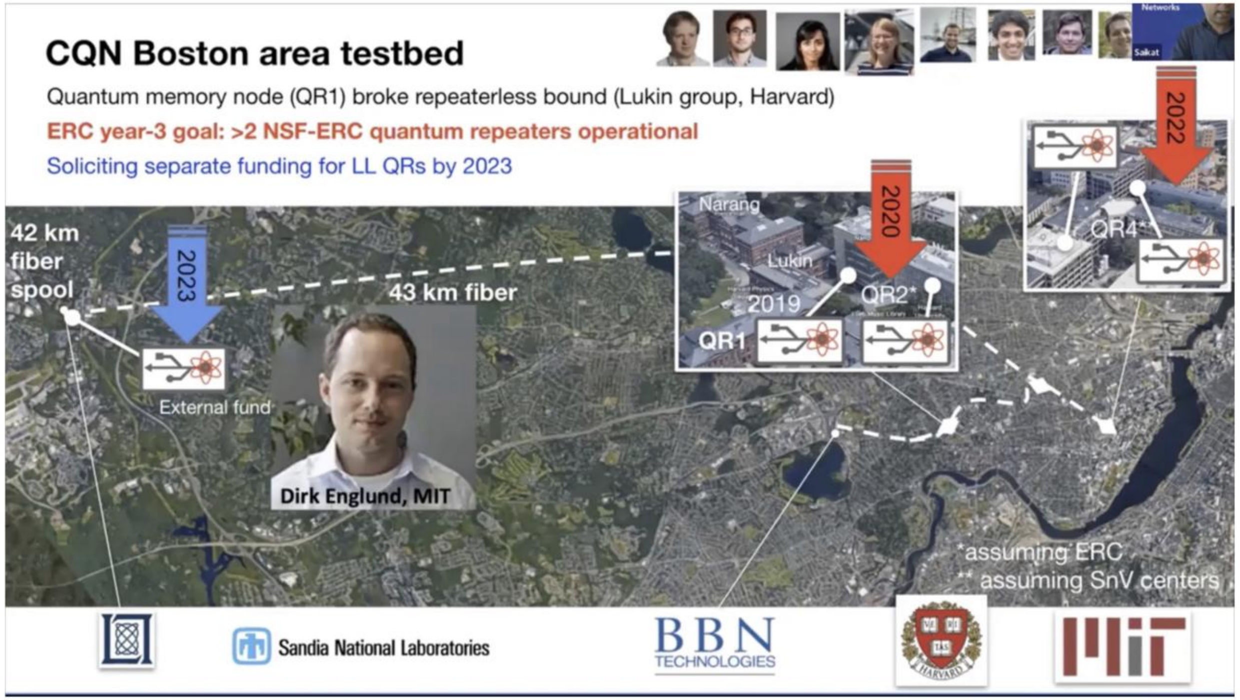
중국 양자위성

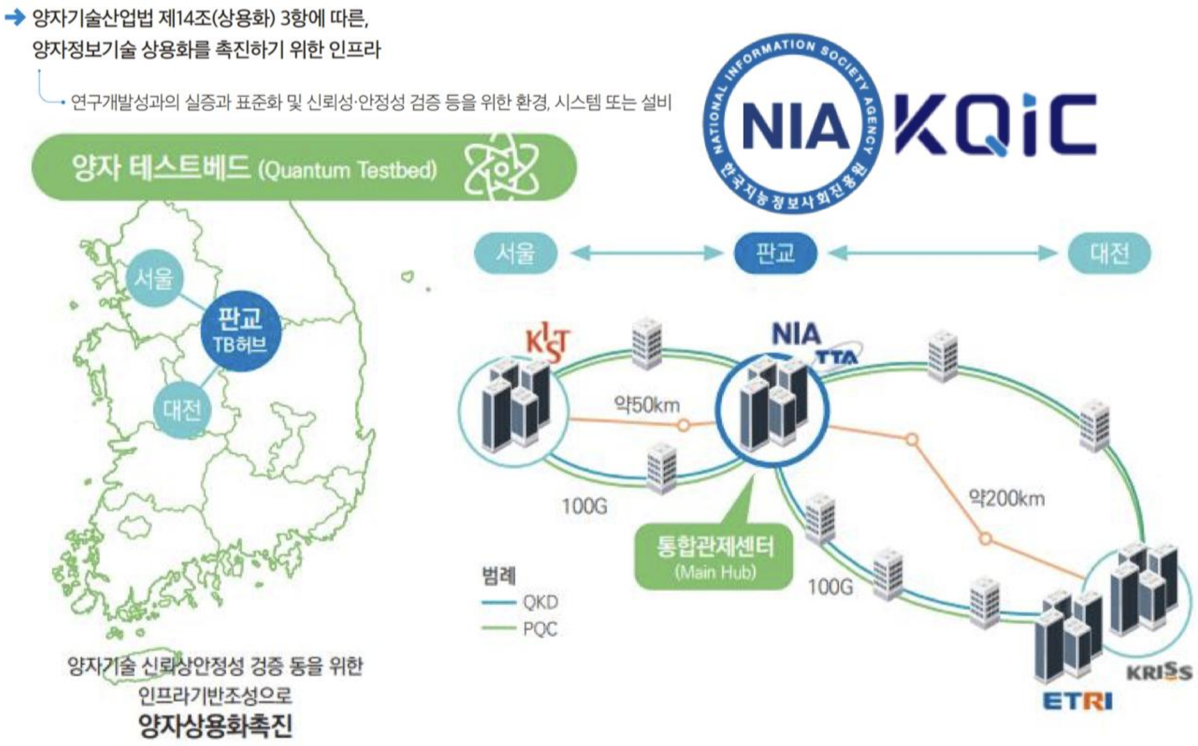
03. 미국/중국의 위성양자통신



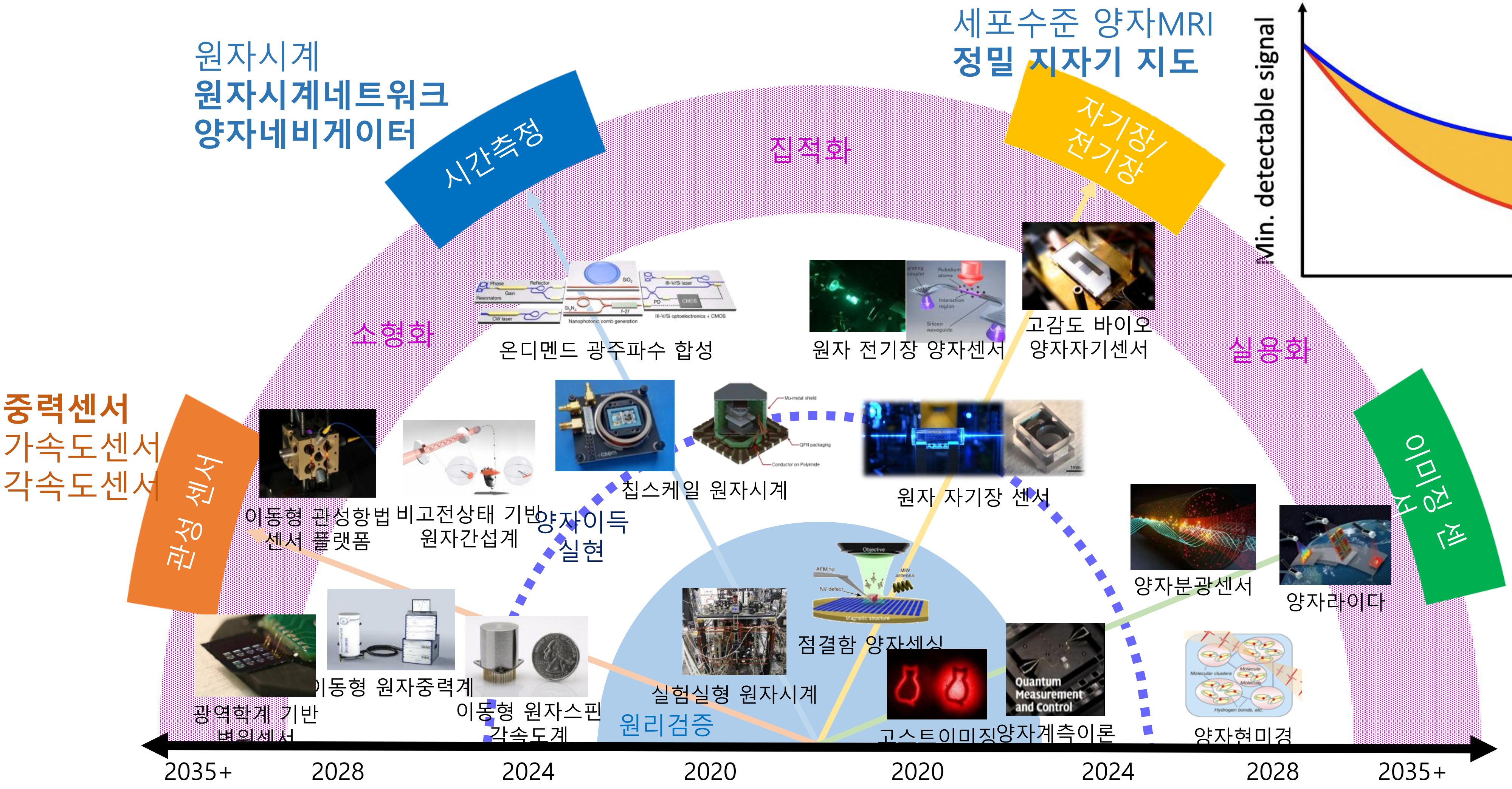


01. 테스트베드


CQN Boston area testbed
Quantum memory node (QR1) broke repeaterless bound (Lukin group, Harvard)
ERC year-3 goal: >2 NSF-ERC quantum repeaters operational
Soliciting separate funding for LL QRs by 2023
42 km fiber spool
2023
43 km fiber
External fund
Dirk Englund, MIT
Narang
Lukin
2019
QR1
QR2*
2020
QR4**
2022
*assuming ERC
** assuming SnV centers
Sandia National Laboratories
BBN TECHNOLOGIES

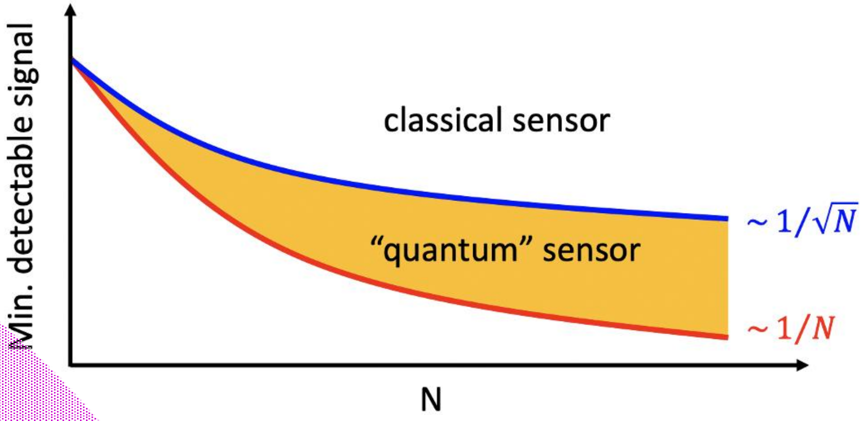

양자기술산업법 제14조(상용화) 3항에 따른,
양자정보기술 상용화를 촉진하기 위한 인프라
연구개발성과의 실증과 표준화 및 신뢰성·안정성 검증 등을 위한 환경, 시스템 또는 설비
양자 테스트베드 (Quantum Testbed)
NIA
KQiC
서울
판교
TB허브
대전
서울
판교
대전
KIST
약50km
NIA
TTA
100G
약200km
통합관제센터
(Main Hub)
100G
범례
QKD
PQC
KRISS
ETRI
양자기술 신뢰성안정성 검증 등을 위한
인프라기반조성으로
양자상용화촉진

01. 기술방향

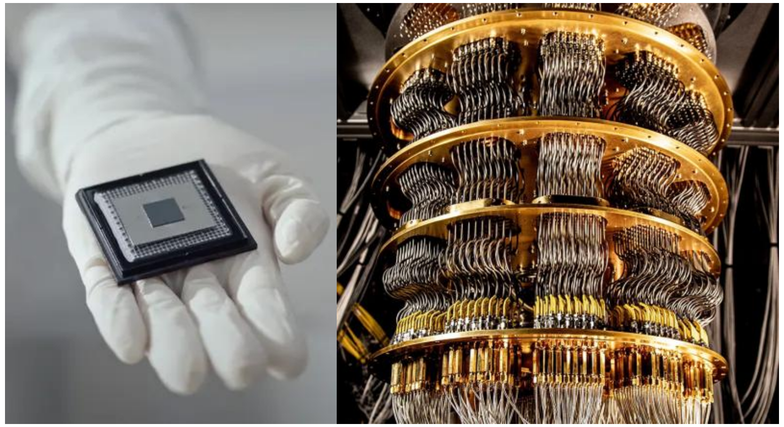


양자현미경
원거리 양자망원경
양자 히든이미지
양자 레이다
양자 라이다

집적화/안정성 향상, 크기/무게/전력/비용 감소 등을 통해 소형화된 센서로 발전

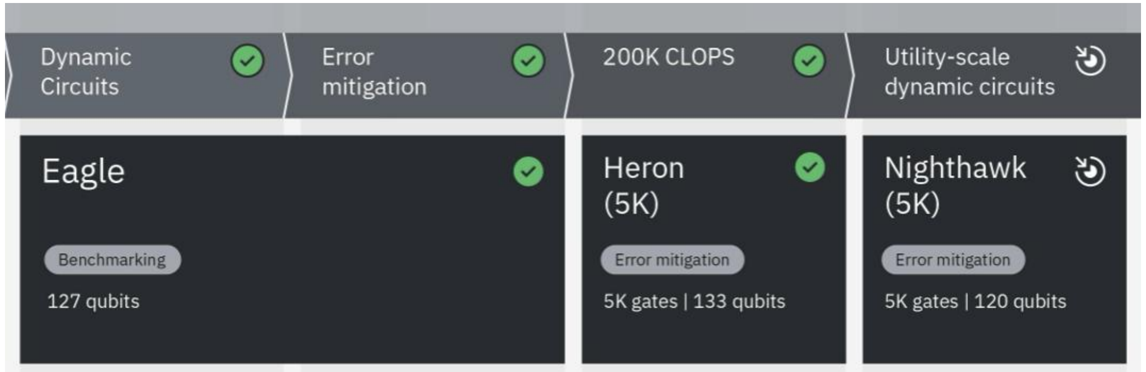


01. 큐비트 카운트



구글 Willow (105큐비트)

Nature **volume 638**, pages 920–926 (2025)



IBM 로드맵

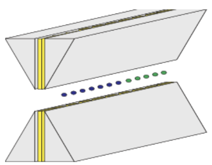
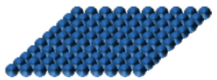
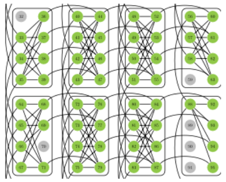
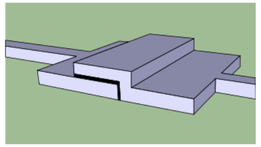
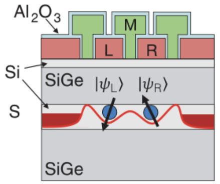
176큐빗 초전도 양자컴 ('23.5.22) 및
초전도 504 큐빗 양자칩 ('24.4.26.)

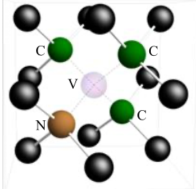
https://english.news.cn/20230531/0946675301284c1786b4ee27251c89a3/c.html

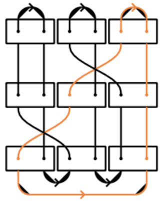
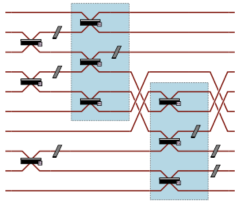
https://www.chinadaily.com.cn/a/202404/26/WS662b15dfa31082fc043c431e.html

02. HW 기업현황

atoms		electrons controlled spin and microwave cavities					photons



trapped ions

1 QUANTINUUM, AQT, NEQXT, ZuriQ, Quantum Art, FOXCONN, 华翊量子

2 IONQ, eleQtron, QUDORA TECHNOLOGIES

3 CRYSTAL QUANTUM COMPUTING

cold atoms

4 QuEra, Pasqal, Infleqtion, QUANTier, planqc, logiqal

5 atom computing

6 Atom Quantum Labs

annealing

D-Wave The Quantum Computing Company™, QILIMANJARO QUANTUM-TECH, NEC

superconducting

7 IBM, rigetti, IQM, Google, 本源量子 Origin Quantum, ANYON, OQC, QOLAB, QuamCore, Peak Quantum

8 ALICE & BOB, Nord Quantique, amazon, qci, ATLANTIC QUANTUM, Z-Axis Quantum

silicon

9 diraq, quobly, QUANTUM MOTION

10 Groove Quantum, equal1.labs, ARQUE, intel

11 Silicon Quantum Computing, EeroQ, C12, ARCHER

vacancies

12 QUANTUM BRILLIANCE, TURING, XEED, SaxonQ, Quantum Transistors, FUJITSU

13 photonic

topological

Microsoft, QUOHERENT, QUANTUM GRAVITY RESEARCH, NOKIA

photons

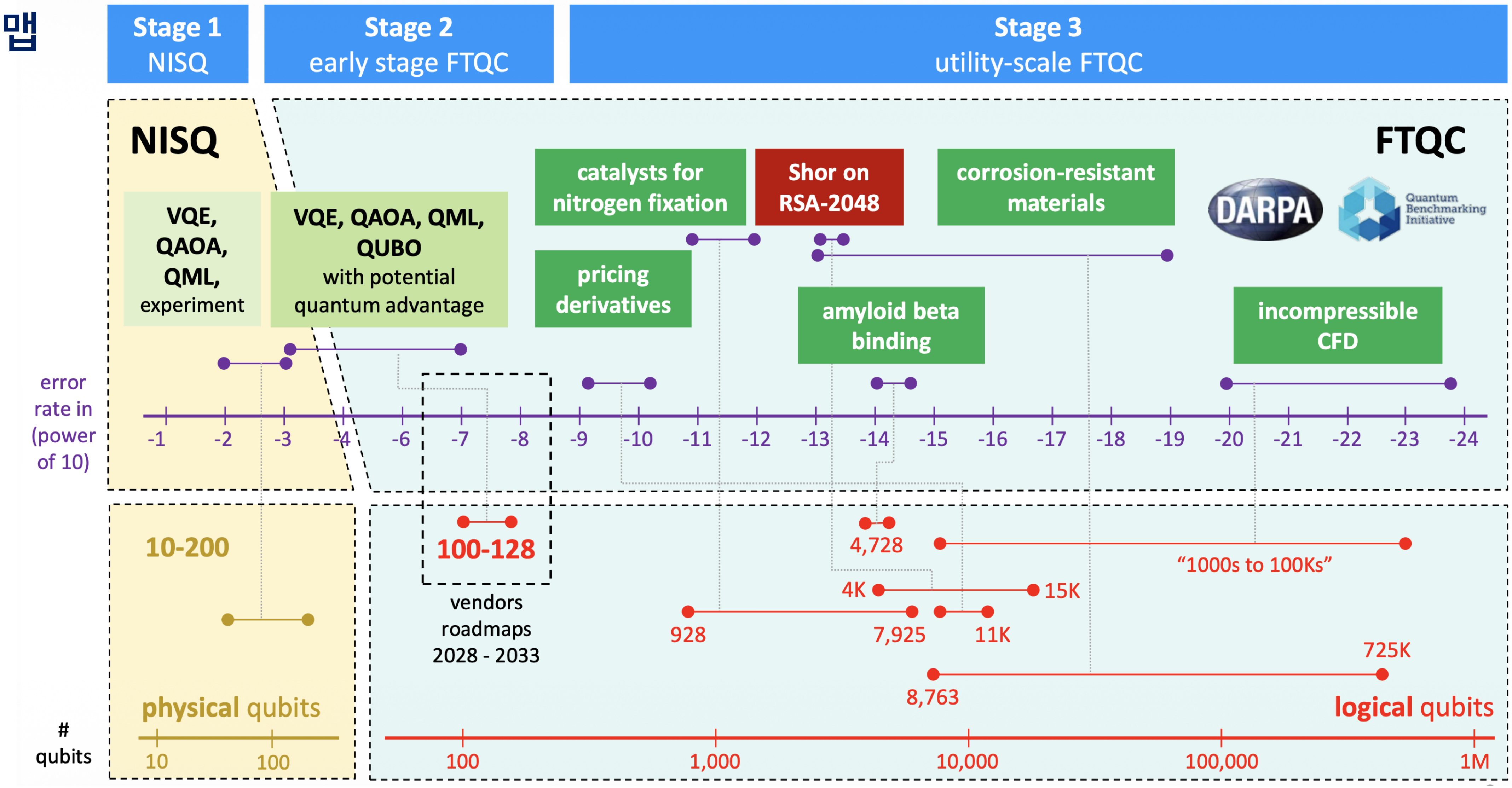
14 PsiQuantum, QUANDELA, QUIX QUANTUM, ORCA COMPUTING, DUALITY QUANTUM PHOTONICS, aegiq, TUNDRASYSTEMS GLOBAL LTD.

15 XANADU, QUANFLUENCE

16 QCi, Boson

Riverlane, QEC Report (2024)

03. 로드맵


Stage 1
NISQ
Stage 2
early stage FTQC
Stage 3
utility-scale FTQC
NISQ
FTQC
VQE, QAOA, QML, experiment
VQE, QAOA, QML, QUBO with potential quantum advantage
catalysts for nitrogen fixation
Shor on RSA-2048
corrosion-resistant materials
DARPA
Quantum Benchmarking Initiative
pricing derivatives
amyloid beta binding
incompressible CFD
error rate in (power of 10)
-1 -2 -3 -4 -6 -7 -8 -9 -10 -11 -12 -13 -14 -15 -16 -17 -18 -19 -20 -21 -22 -23 -24
10-200
100-128
vendors roadmaps 2028 - 2033
4,728
"1000s to 100Ks"
4K
15K
928
7,925
11K
725K
8,763
physical qubits
logical qubits
qubits
10
100
100
1,000
10,000
100,000
1M

01. 기술규제

중국(DOC, 2021-11-26)

- DOC 산업안전보장국의 거래제한 명단 'Entity List'에 중국, 일본, 파키스탄, 싱가폴 등 27개 기업 추가
  - 암호해독 가능성이 있는 양자관련 기술 접근 저지 목적
  - Hefei연구소 및 QuantumCTek 관련 중국 기업들 포함
    1. Hefei National Laboratory for Physical Sciences at Microscale (허페이 마이크로스케일재료과학국가연구센터)
    2. QuantumCTek Co., Ltd.,
    3. HKUST National Shield Quantum Technology Co., Ltd.
    4. HKUST Guodun Quantum Technology Co., Ltd.;
    5. National Shield Quantum
    6. Anhui Quantum Communication Technology Co., Ltd
    7. Shanghai QuantumCTek Co., Ltd.
    8. Shanghai Guodun Quantum Information Technology Co., Ltd.

러시아(산업안보국, 2023-03-03)

제제 기업/기관은

- International Center for Quantum Optics and Quantum Technologies LLC
- Russian Quantum Center (RQC)
- SP Kvant 의 Limited Liability Company Joint Venture Quantum Technologies and Joint Venture Quantum
- Moscow Institute of Physics and Technology (MIPT)

02. 기술패권 보고서

Chinese Efforts in Quantum Information Science: Drivers, Milestones, and Strategic Implications

Testimony for the U.S.-China Economic and Security Review Commission

March 16th, 2017

John Costello

We are in the midst of a "second quantum revolution," one that enables disruptive new technologies that have the potential to change long-held dynamics in commerce, military affairs, and strategic balance of power.[1] Within the foreseeable future, the realization of quantum computing will result in revolutionary computing power, with wide-reaching applications. The employment of quantum cryptography can create quantum communications systems that are theoretically unbreakable and unhackable. Quantum sensing enables the capability to conduct extremely precise, accurate measurements for new forms of navigation, radar, and optical detection.

Although the future trajectory of quantum technologies is hard to predict, their revolutionary potential and promise has intensified international competition. The U.S. remains at the forefront of quantum information science, but its lead has slipped considerably as other nations, China in particular, have allocated extensive funding to basic and applied research. Consequently, Chinese advances in quantum information science have the potential to surpass the United States.[2] Once operationalized, quantum technologies will also have transformative implications for China's national security and economy. As the United States has sustained a leading position in the international affairs due in part to its technological, military, and economic preeminence, it is critical to take swift action to reverse this trend and once again place the United States as a frontrunner in emerging technologies like quantum information science.

This testimony will address the following topics:

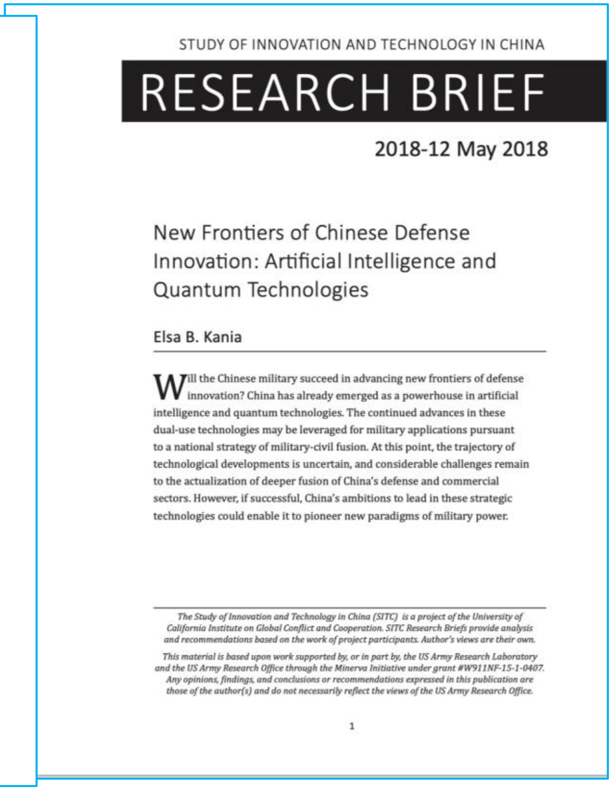
[1] Jonathan P. Dowling and Gerard J. Milburne, "Quantum Technology: the Second Quantum Revolution," *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences* 361, no. 1809 (2003): 1655-1674, https://arxiv.org/pdf/quant-ph/0206091.pdf

[2] This testimony builds upon prior research and writings by the author, including: Elsa Kania and John Costello, "Quantum Leap (Part 1): China's Advances in Quantum Information Science, *China Brief*, December 5, 2016. Elsa Kania and John Costello, "Quantum Leap (Part 2): The Strategic Implications of Quantum Technologies, *China Brief*, December 21, 2016.

1

미국의 양자투자활성화 촉구('17)

[Chinese Efforts in Quantum Information Science- Drivers, Milestones, and Strategic Implications - March 15, 2017 (1) (uscc.gov)]



STUDY OF INNOVATION AND TECHNOLOGY IN CHINA

RESEARCH BRIEF

2018-12 May 2018

New Frontiers of Chinese Defense Innovation: Artificial Intelligence and Quantum Technologies

Elsa B. Kania

Will the Chinese military succeed in advancing new frontiers of defense innovation? China has already emerged as a powerhouse in artificial intelligence and quantum technologies. The continued advances in these dual-use technologies may be leveraged for military applications pursuant to a national strategy of military-civil fusion. At this point, the trajectory of technological developments is uncertain, and considerable challenges remain to the actualization of deeper fusion of China's defense and commercial sectors. However, if successful, China's ambitions to lead in these strategic technologies could enable it to pioneer new paradigms of military power.

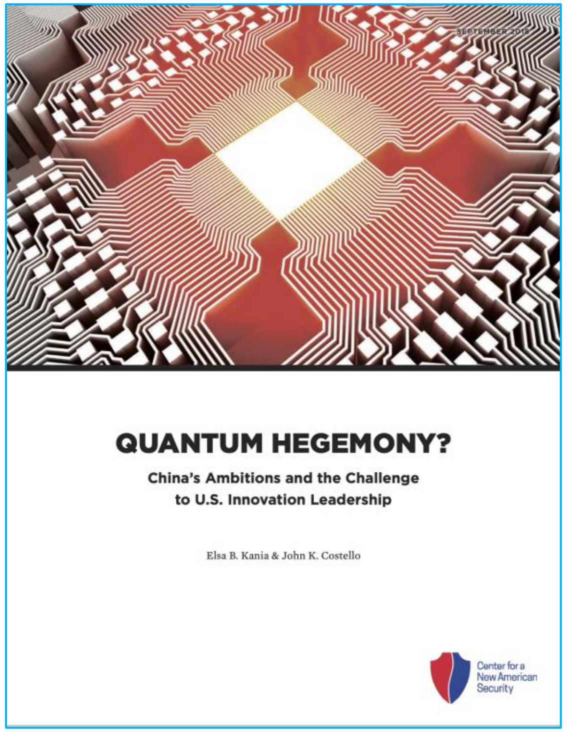
The Study of Innovation and Technology in China (SITC) is a project of the University of California Institute on Global Conflict and Cooperation. SITC Research Briefs provide analysis and recommendations based on the work of project participants. Author's views are their own.

This material is based upon work supported by, or in part by, the US Army Research Laboratory and the US Army Research Office through the Minerva Initiative under grant #W911NF-15-1-0407. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the US Army Research Office.

1

현황업데이트('18)

[New Frontiers of Chinese Defense Innovation: Artificial Intelligence and Quantum Technologies (escholarship.org)]



QUANTUM HEGEMONY?

China's Ambitions and the Challenge to U.S. Innovation Leadership

Elsa B. Kania & John K. Costello

Center for a New American Security

퀀텀헤게모니('18)

[Quantum Hegemony? | Center for a New American Security (en-US) (cnas.org)]

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

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"Chines

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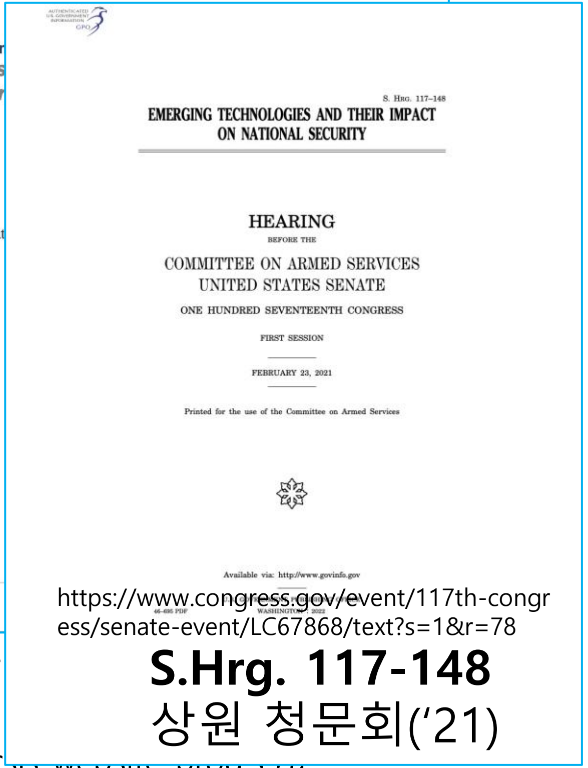
Deput



S. Hrg. 117–148

EMERGING TECHNOLOGIES AND THEIR IMPACT ON NATIONAL SECURITY

HEARING

BEFORE THE

COMMITTEE ON ARMED SERVICES

UNITED STATES SENATE

ONE HUNDRED SEVENTEENTH CONGRESS

FIRST SESSION

FEBRUARY 23, 2021

Printed for the use of the Committee on Armed Services

Available via: http://www.govinfo.gov

https://www.congress.gov/event/117th-congress/senate-event/LC67868/text?s=1&r=78

S.Hrg. 117-148

상원 청문회('21)

중

미

https://c website prod.s3.amazonaws.com/s3fs-public/congressional_testimony/ts180109_Carter_Testimony.pdf

01. 양자통신 SDO

ETSI	ITU	ISO JTC1 IEC INFORMATION TECHNOLOGY STANDARDS	IEEE SA	IRTF
2008	2018	2017	2022	2018
ETSI ISG QKD	SG17 Q15 SG13 Q16, Q6 SG11 Q2	ISO/IEC JTC1 SC27	P1913	QIRG - Quantum Internet Research Group
QKD Usecases, Vacaburery, QKD Component QKD KeyDelivery, SDN APIs QKD Security evaluation	QKDN Architecture QKDN Security Requirement QKDN Interface specification	QKD Security Requirement & Evaluation method	Software-Defined Quantum Communication	Application Senario, Application Principle, Multiplane Architecture

양자암호통신 (ETSI, ITU, ISO/IEC JTC1, IEEE SA)

양자인터넷 (IRTF)

02. IEC/ISO JTC 3 Quantum technologies ('24.5.28~30, 창립총회, 서울)

IEC/ISO JTC 3 Quantum technologies

Scope | Structure | Projects / Publications | Documents | Votes | Meetings | Collaboration Platform

Membership | Officers | Liaisons | P-Members participation statistics | Subgroups

Mr Seong Su Park (kr-se-park) | Log out | en | fr

IEC/ISO JTC 3 Subgroups

Label	Title
Working Groups	
WG 9	Terminology and quantities
WG 10	Quantum sensors
WG 11	Quantum computing supply chain
WG 12	Quantum computing benchmarking
WG 13	Quantum random number generators
WG 14	Quantum technologies - Cross-cutting and enabling devices and technologies: Hanbury-Brown-Twiss interferometry for the characterization of photonic quantum sources
Project Teams	
PT 18157	PT ISO/IEC TR 18157
PT 63622	Quantum Photonics Vocabulary
PT JTC3/68/NP (temporary)	Characterization and measurement of the performance of single-photon sources (To be formally established after the approval of the NP)
PT JTC3/69/NP (temporary)	Characterization and Measurement of the Frequencies of optical frequency standards (To be formally established after the approval of the NP)
Advisory Groups	
AG 1	Strategic planning
AG 8	Chair's Advisory Group
Ad-Hoc Groups	
ahG 4	Quantum Communication
ahG 5	Quantum Computing and simulation
ahG 7	Quantum enabling technologies

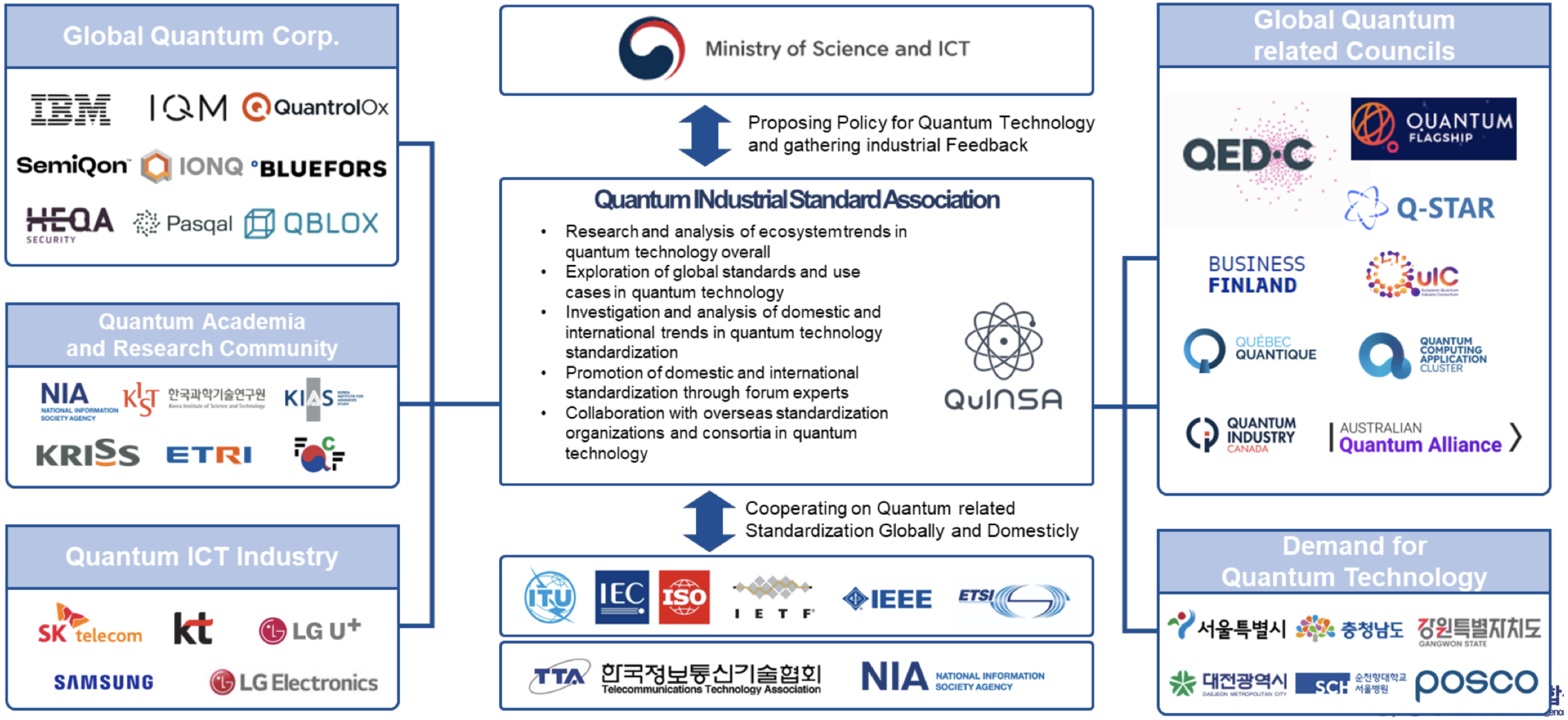
Facts and figures

Secretariat	GB
Participating countries	30
Observer Countries	10

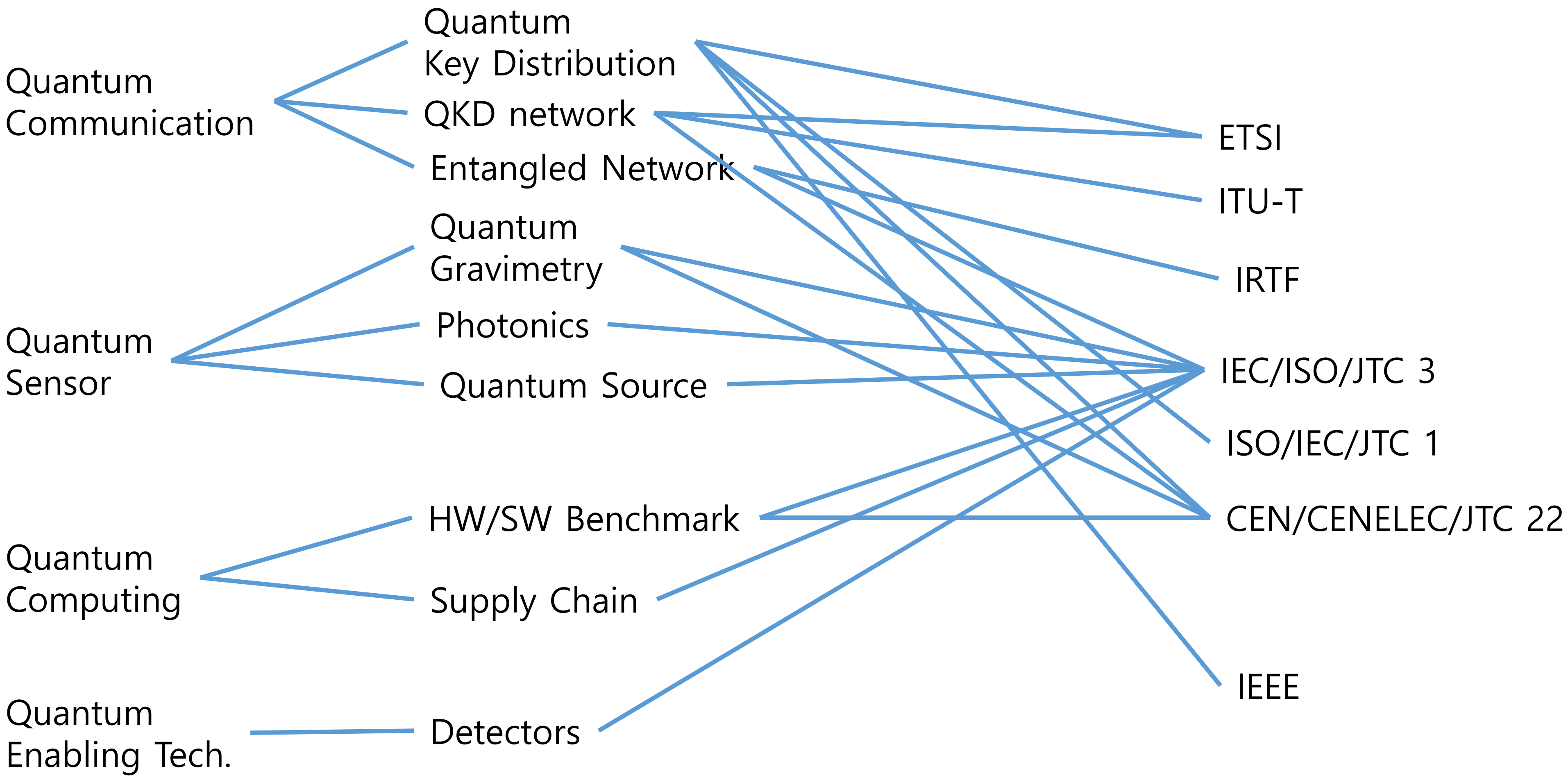
	country
P	Australia, Austria, Brazil, Canada, China, Cyprus, Denmark, Finland, France, Germany, India, Israel, Italy, Japan, Korea, Luxembourg, Malta, Netherlands, Norway, Portugal, Russia, Saudi Arabia, Slovakia, Spain, Sweden, Switzerland, Türkiye, UK, USA
O	Azerbaijan, Belgium, Czech Republic, Greece, Indonesia, Mexico,, Philippines, Singapore, South Africa, Thailand

03. QuINSA ('25.6.25~26, 창립총회)

정부 및 국내외 산학연, 표준화기구와의 협업체계를 구축하여 글로벌사실표준화기구 운영



04. Technology and standardization



GISC 2025

Global ICT Standards Conference 2025

- 감사합니다 -

이름 직위 기관명

이메일주소

ICT Standards and Intellectual Property: AI for All

주최 과학기술정보통신부 지식재산처 주관 국립전파연구원 TTA IITP KEA kisti ETRI