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Quantum Radar Report

October, 2024

Introduction

The rapid progress of global technology has pushed quantum technology, notably quantum radar, from lab research to practical applications, driving innovation in multiple industries. Quantum radar, leveraging quantum properties for high-precision target detection, boasts high sensitivity, stability and anti-interference capabilities. Since its inception in the late 20th century, it has evolved from initial concepts to commercial airborne lidar systems and continues to advance.

This report examines the development history, current status and future trends of quantum radar, highlighting its potential applications and challenges across various sectors, including military, energy, environmental protection and biomedicine. It outlines key industrial milestones, analyzes the current product landscape with a focus on performance and application scenarios, and showcases the contributions of major research institutions and enterprises.

Looking ahead, quantum radar is anticipated to adopt "classical-quantum dual-channel" systems, with Rydberg atom antennas and AI technologies enhancing performance and driving innovation. The integration of cutting-edge technologies, such as AI, will facilitate broader adoption in practical fields.

Overall, this report aims to provide valuable insights for governments, enterprises, research institutions and society, fostering the innovation and application of quantum radar technology.

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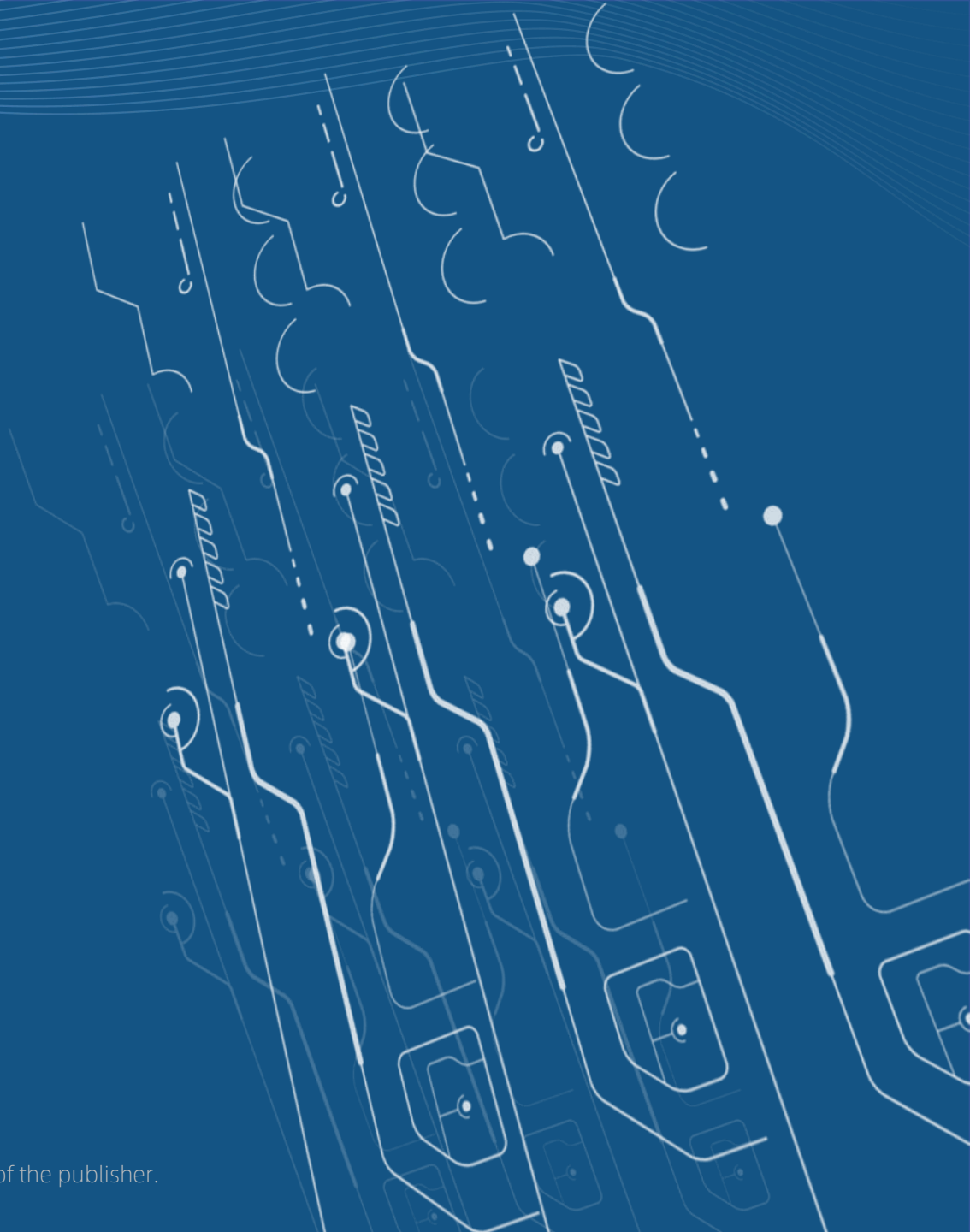
PART ONE

Development of the Industry



Global technology's rapid advancement has propelled quantum radar from theory through experiments to commercialization and practical use.

Challenges remain in the detection of diverse targets

Validation and initial commercialization

1997 Ultrashort pulse combined with TCSPC

- Highly accurate ranging solutions
- One of the key technologies to realize single-photon lidar

2008 Quantum Remote Detection System

- Quantum illumination radar scheme
- Applicability of quantum mechanics to long-range target detection

2012 Quantum Radar Systems

- Quantum polarization secure quantum lidar scheme
- The world's first anti-interference quantum radar system

2015 Commercialization of Quantum-Enhanced Lidar

- Based on Geiger-Mode Avalanche Photodiodes
- Development of the first commercial airborne lidar system

Exploration of practical application

2016 Single-Photon Lidar

- Overcoming challenges in real atmospheric environments
- The world's first single-photon detection quantum radar system

2016 Atmospheric Wind Field

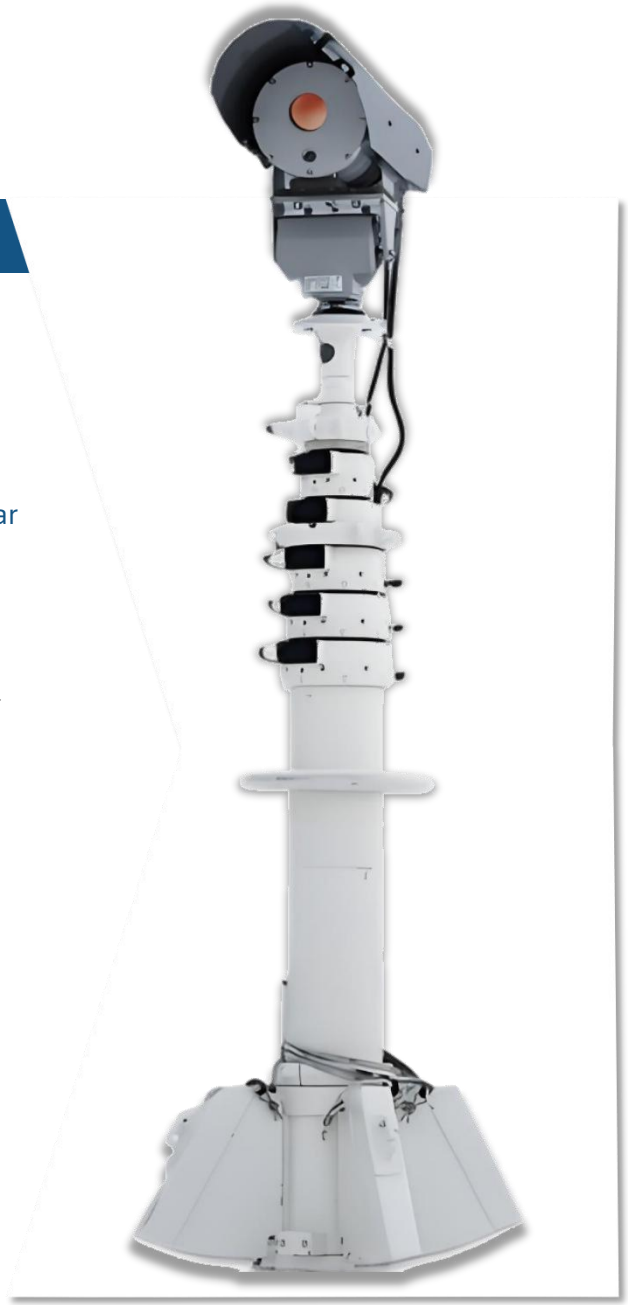
- Achieving continuous day-and-night observations
- The world's first single-photon frequency upconversion quantum wind lidar

2019 Infrared Quantum Detection Technology

- Achieving the highest spatial resolution in wind field detection
- The world's first company to utilize infrared quantum detection technology

2023 New Research Areas

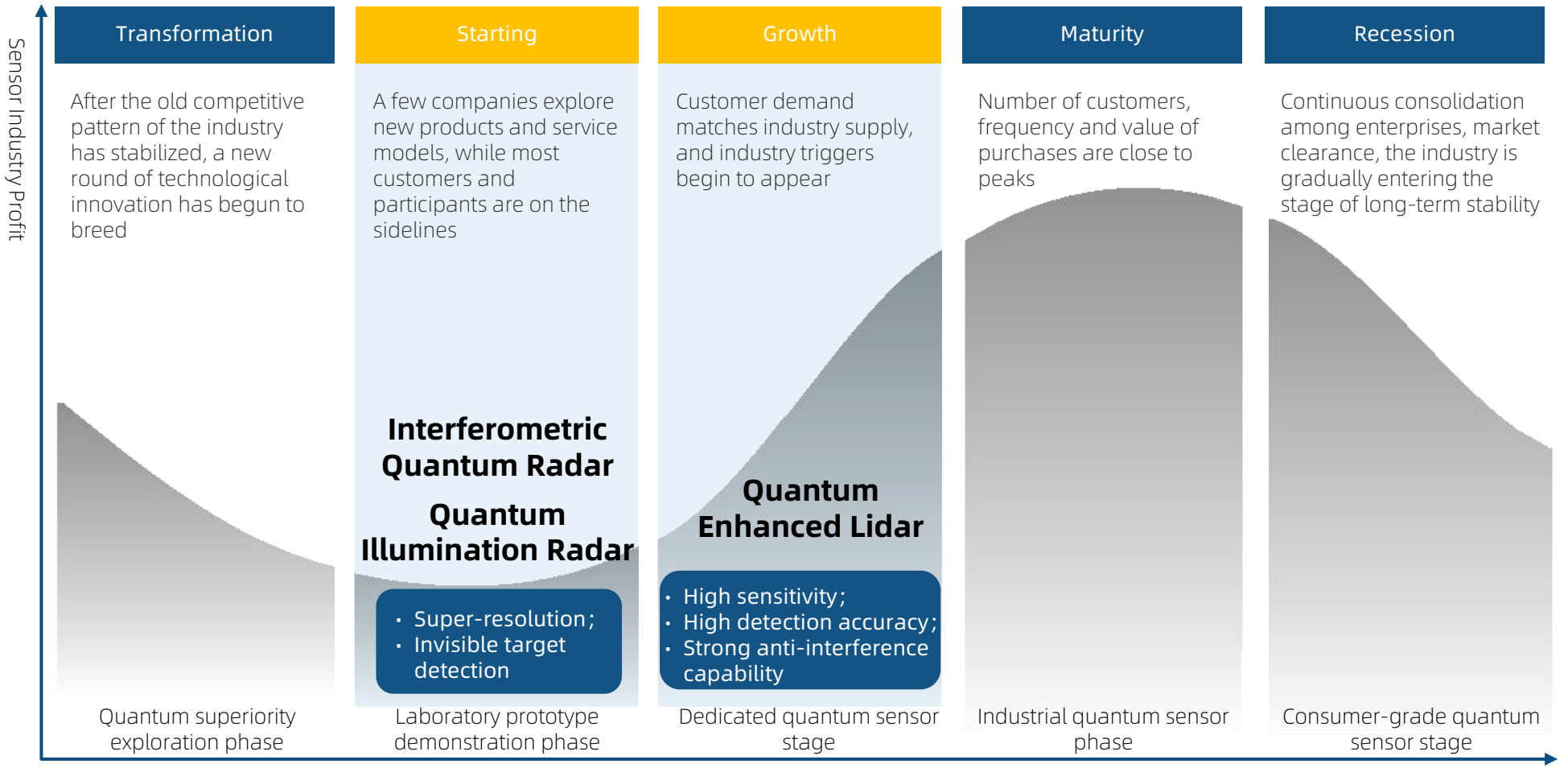
- Breaking the resolution-wavelength trade-off
- Ranging resolution exceeds limits by 100x



Quantum radar products are diversifying, with quantum-enhanced lidar leading in industrialization and high-performance applications across various fields.

Technology innovation will keep boosting quantum radar industry growth

Figure: 2024 Quantum Radar Industry Development Cycle Diagram



Future industrial development

"Classical-Quantum Dual Channel"

In the near future, quantum radars will likely operate as "classical-quantum dual-channel" systems to overcome detection challenges.

- Glory China Quantum Lidar has successfully realized the wide application of quantum LIDAR products in many fields, such as meteorological observation and environmental protection, and delivered nearly 100 standard products.

High sensitivity and long range detection

Organizations improve their technical level and innovation ability in order to achieve breakthroughs in product performance, which in turn promotes the overall development of the industry.

- CEIC greatly improved the detection sensitivity of single-photon detection quantum radar system, obtaining the capability of 100-kilometer detection distance.
- Barzanje has created a quantum radar with a 10.09 GHz microwave entangled light source, enhancing its practical use.

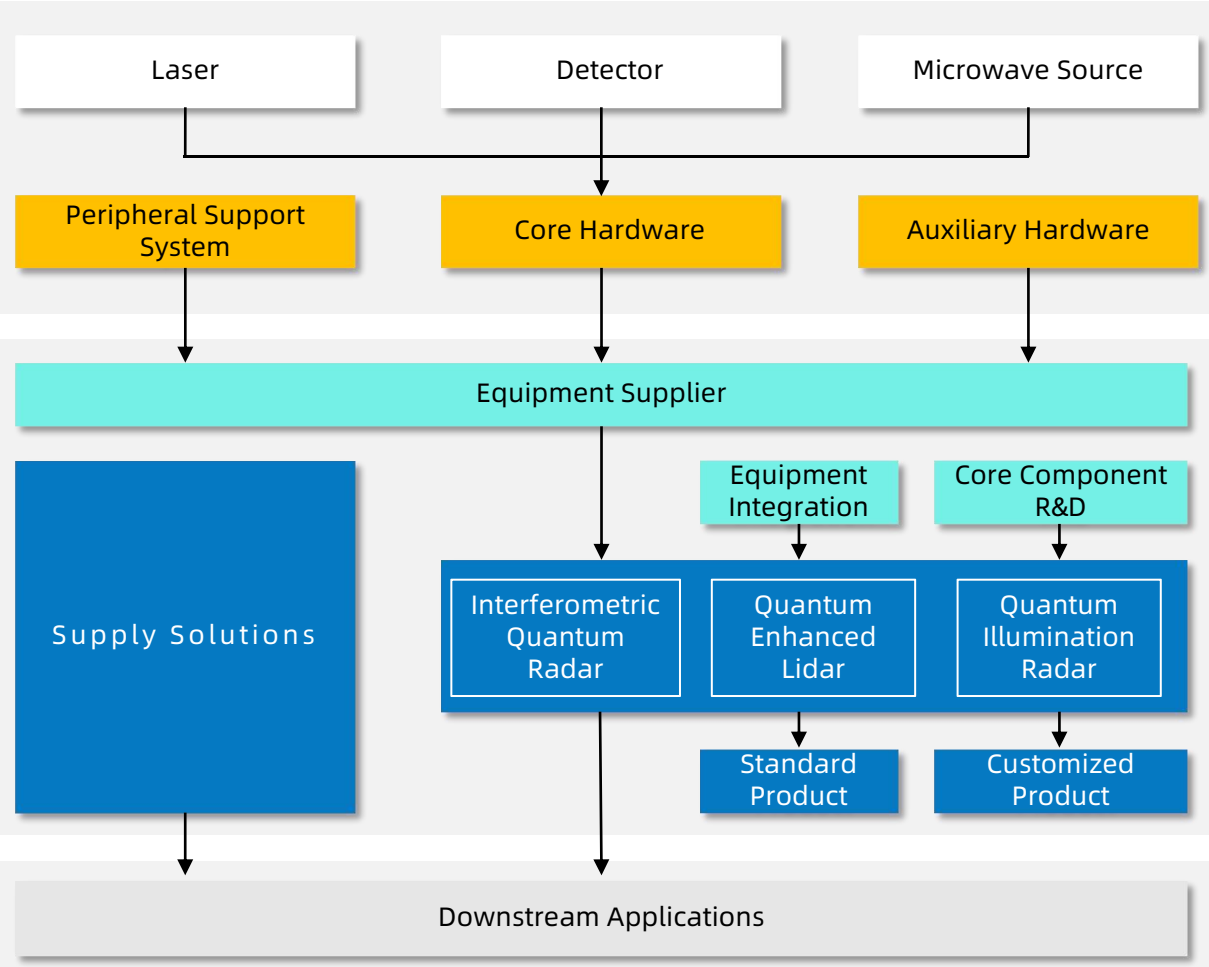
Enterprises and organizations have achieved precise, efficient quantum radar products via policy and technology, showing potential in defense, energy, environment and research.

	WHO	WHAT	HOW
Policy	• 2022, the European Quantum Flagship published a Strategic Research and Industrial Agenda (SRIA) • 2023, Korea's Ministry of Science and ICT released the National Quantum Science and Technology Strategy.	• Planned implementation of enhanced commercial quantum radar and lidar products in 2027-2030. • South Korea to collaborate with firms on GPS, industrial sensors, and quantum radar development.	• Enhanced precision and efficiency in measurement and detection through product advancements. • Advancing quantum sensors to surpass traditional sensor limitations.
Technology	• 2022, University of Science and Technology of China • 2023, Ecole Normale Supérieure de Lyon	• A prototype with a 1550.1 nm operating wavelength and 40 kg of equipment. • Quantum radar based on built-in microwave photon counter detection.	• High-speed wind field observation at 3m spatial and 0.1s temporal resolution. • Quantum advantage at Q=1.2 indicates a 20% faster detection rate than classical radar.
Products	• 2023, QLM Technology (USA) • 2023, Quantum Computing Inc (UK)	• Introduced QLM Cloud, a patented quantum gas lidar for emissions data analysis and management • Released the inaugural Quantum Photon Vibrometer (QPV), the market's longest-range and most sensitive vibrometer.	• Achieved global certifications, leading in METEC performance, offering continuous emission monitoring and management for oil and gas. • Products are commercialized and set for delivery in military, commercial, and industrial testing sectors.
Applications	• 2023, SK Telecom partners with Busan Port • 2023, QLM partners with UK water companies	• Demonstration of safety control using developed quantum LIDAR and quantum sensing technologies • Plans to deploy quantum gas lidar systems at multiple sites	• Used in ports and other large-area places to protect the security of port security • For continuous monitoring of methane emissions

Quantum radar devices comprise interference-based, quantum laser, and illumination types, offered in standard or custom forms to meet a range of applications.

Quantum radar products face technical challenges, requiring more R&D and innovation to speed up commercialization

Figure: Quantum Radar Corporate Business Models



Upstream Core Devices

- The industry's upstream involves multiple fields such as quantum physics, optics, and electronics, requiring interdisciplinary knowledge and technical support.
- The performance requirements for detectors are stringent, including high sensitivity, high stability, and strong anti-interference capabilities.
- The upstream hardware market has begun to take shape, with some companies now offering specialized hardware support and services.

Midstream Machine

- Quantum radar primarily supplies products and technology to military, aerospace, environmental protection, and related research institutions, government agencies, and enterprises.
- Compared to high-performance classical radars, quantum radars have not yet shown a clear cost advantage, which limits their market promotion.
- At present, the industrialization process of quantum-enhanced lidar is the most advanced. Interferometric quantum radar and quantum illumination radar products are still in the research and development and laboratory stages and have not yet been commercialized on a large scale.
- The realization of quantum radar requires solving a series of technical challenges, including the generation, transmission, detection, and processing of quantum states.

APP

- Currently, quantum radar has been applied in national defense, energy monitoring, and transportation sectors.

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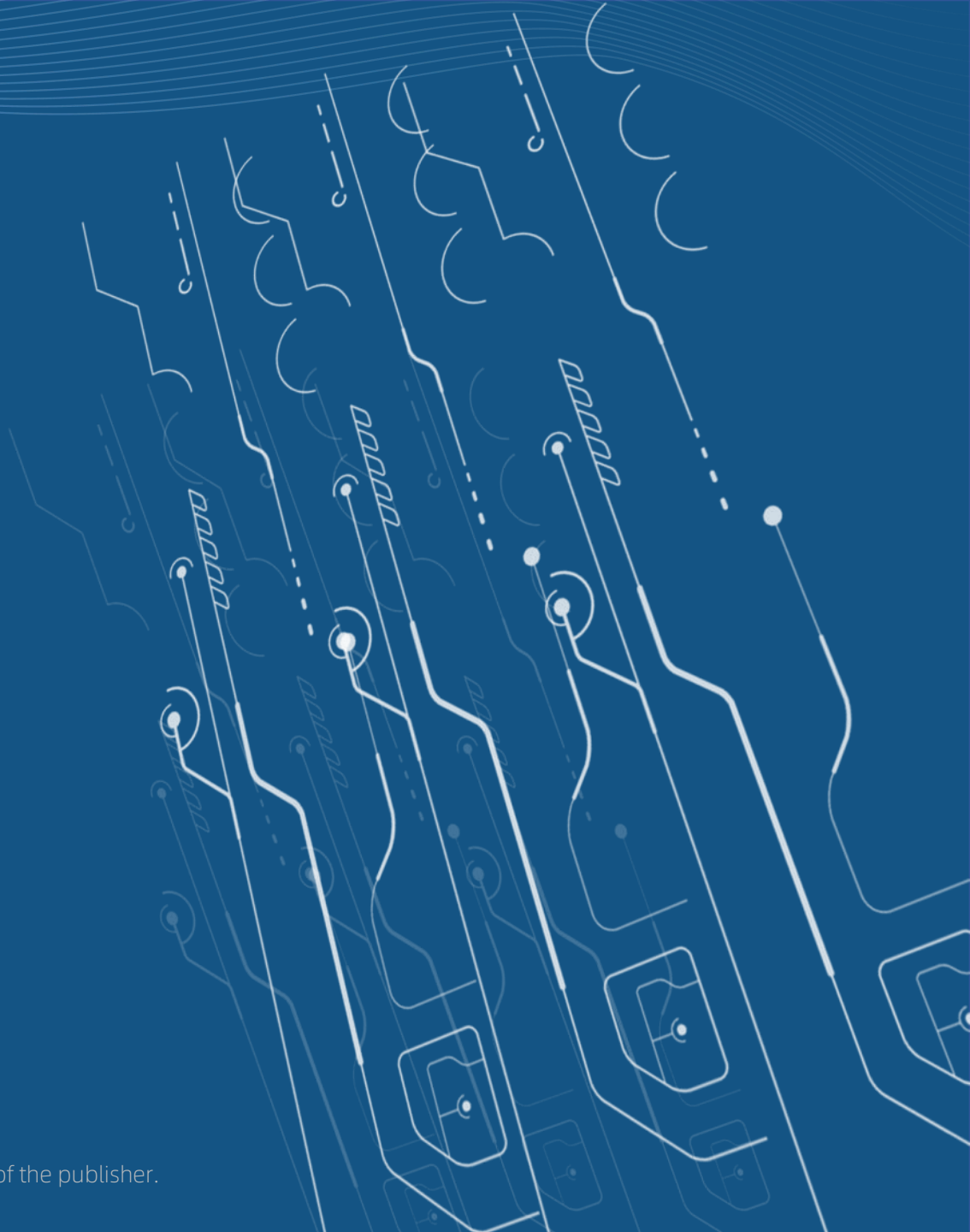


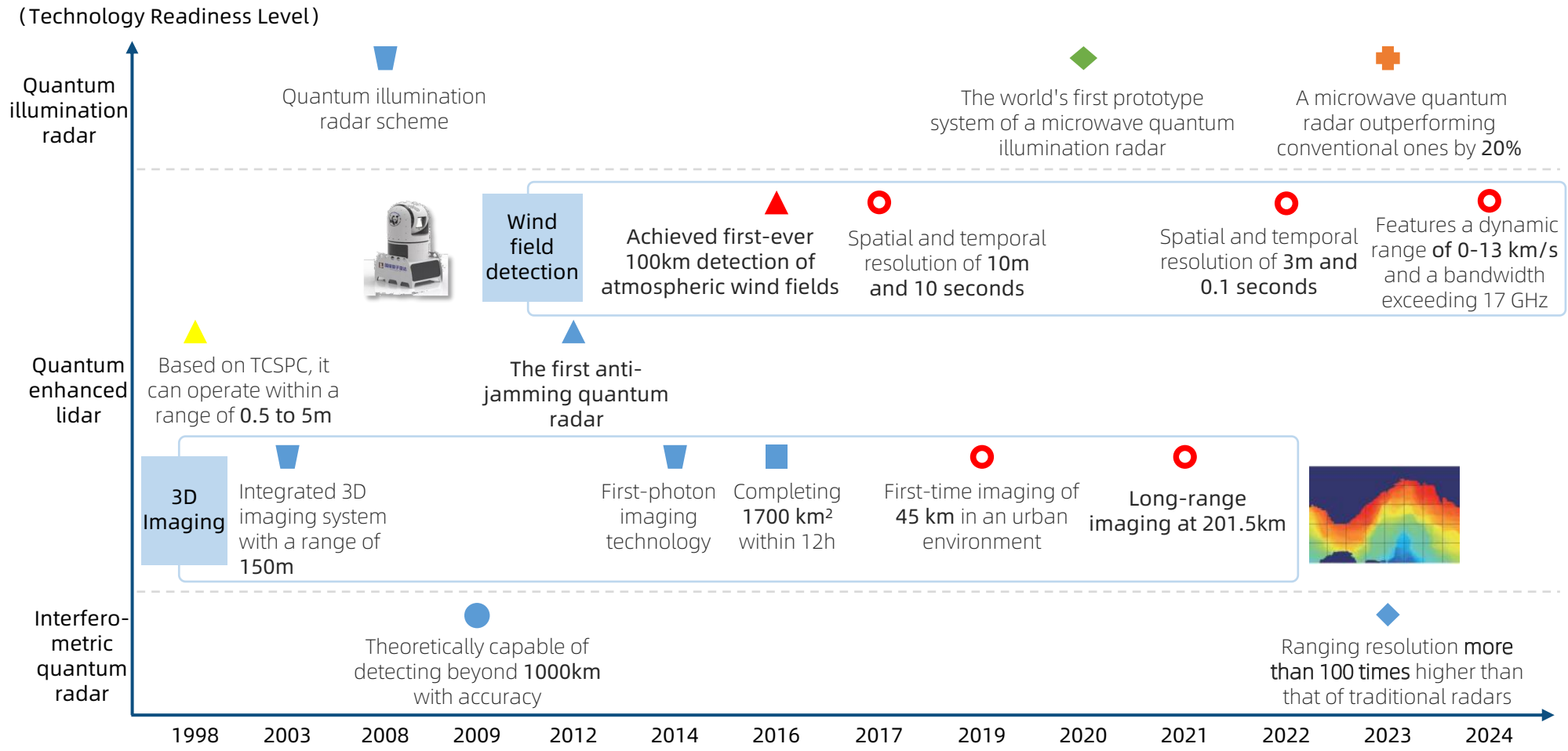
PART TWO

Development of Products

Quantum radar offer substantial improvements in sensitivity, resolution, and anti-interference over classical radars and are poised to revolutionize various fields.

Quantum radar will start as "Dual-Channel" systems, advancing to high sensitivity and broad bandwidth

Figure: The Development Path of Quantum Radars in Global Organizations



	Quantum Radar	Conventional Radar
Research Time	Approx. 30 years	Approx. 100 years
Principles	Quantum entanglement	Electromagnetic wave
Limitations	Heisenberg limit	Classical electromagnetism
TRL	Not widely used	Widely used in

- Heriot-Watt University (UK)
- Massachusetts Institute of Technology (USA)
- Naval Research Laboratory (USA)
- University of Rochester (USA)
- University of Maryland (USA)
- Chapman University (USA)
- China Electronics Technology Group Corporation (PRC)
- University of Science and Technology of China (PRC)
- University of Calgary (CAN)
- Ecole Normale Supérieure de Lyon (FR)

The industrialization of quantum-enhanced radar is advancing swiftly, with receiving ends categorized into single-photon detectors for laser signals and atomic antennas for microwaves.

Quantum radar: single-photon for sensitivity, atomic antennas for microwave

Figure: Current Status of Quantum Radar Industrialization Development

Enterprise	Country	Product type	Product model	Product parameters	Operating temperature	Dimensions	Application	Appearance
国耀量子	China	Based on single-photon detectors	Particulate Optical Quantum Radar	• Temporal resolution • Scan data refresh rate	-℃	cm	Atmospheric environmental protection testing	
			High-Resolution Velocity Azimuth Display (VAD) Lidar	• Wind speed measurement accuracy • Wind speed range	℃	cm	Atmospheric wind field and wake measurement	
QLM	UK	Based on single-photon detectors	Quantum Gas	• Detection range • Detectable methane leakage rate	℃	cm	Greenhouse gas leak detection	
QCi	USA	Based on single-photon detectors	Quantum Photonic Vibrometer	• Accuracy • Frequency range	℃	cm	Remote monitoring and detection	
天之衡科技	China	Based on atomic antennas	Quantum Radio Receiver	• Response frequency：100kHz~40GHz • Dynamic range ： 10nV/cm~0.2V/cm	℃	cm	Radio	
Infleqtion	USA	Based on atomic antennas	Quantum Radio Frequency (QRF) Aperture/Receiver system(SqyWire)	• Ultra wideband RF receiver • Real time spectrum adaptation	℃	cm	Rydberg atomic antenna	

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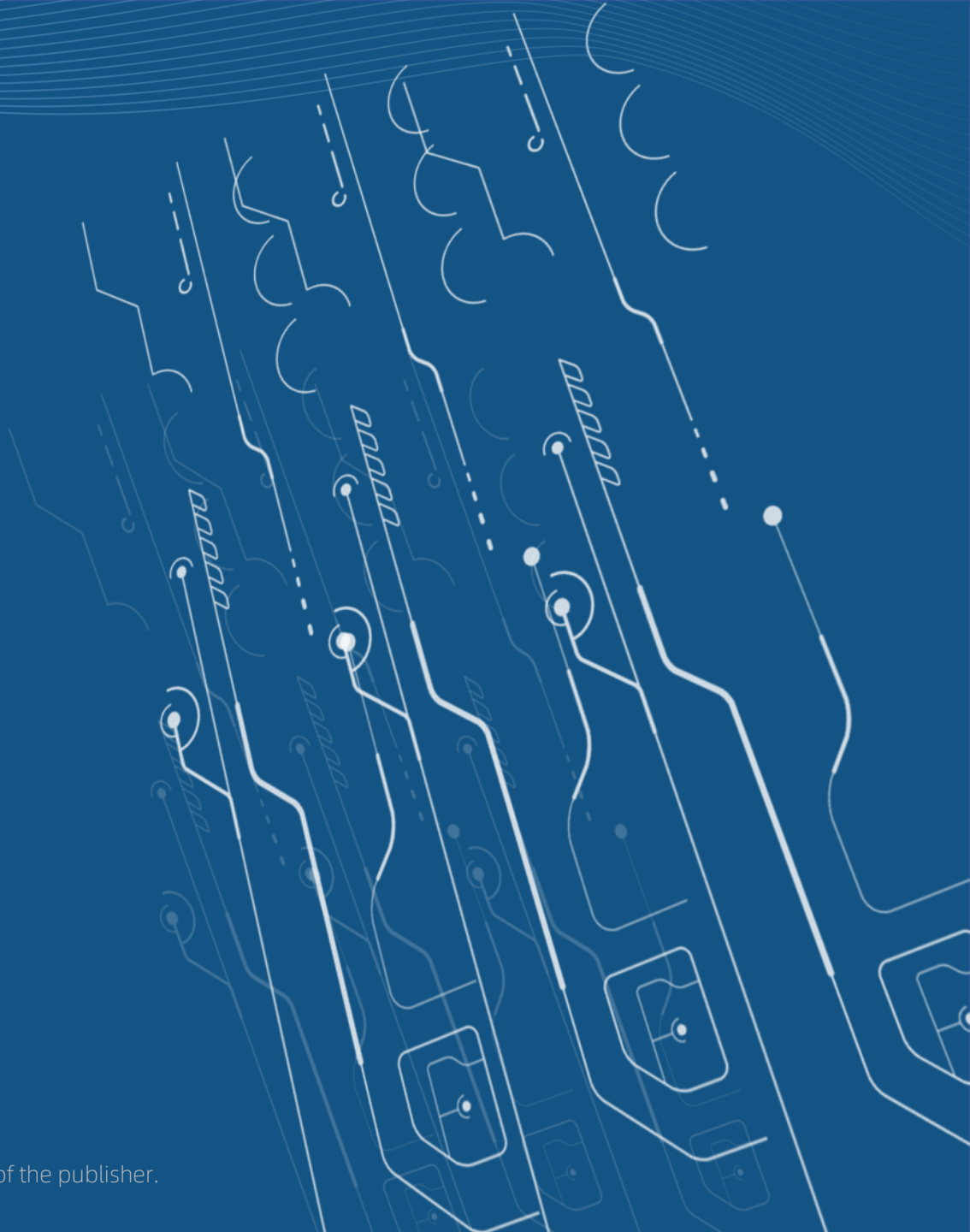
PART THREE

Development of the Market



Quantum radar technology has broad applications and value in military defense, energy, environmental protection, biomedicine, traffic management and scientific research.

- With ongoing technological progress, quantum radar will bolster societal advancement

Application Areas

Figure: Advantages/Disadvantages of Radar by Tech Maturity and Application Area

Military Defense

Leveraging quantum radar's precision allows for detailed perception and evaluation of military environments and targets, enhancing its importance in defense applications.

Environment/energy (Oil, Gas, Atmosphere)

Quantum radar is crucial in energy and environmental monitoring, helping to assess emissions and atmospheric conditions.

Biomedical

Using high-resolution imaging and anti-interference techniques, quantum radar offers precise diagnostic and detection capabilities for the biomedical field.

Transportation (Aviation Shipping, Unmanned Vehicles)

Leveraging high-precision measurements and quantum entanglement, it offers safe and efficient transportation systems for aviation, shipping, and autonomous driving.

Scientific research (Mine Detection, Satellite Observation)

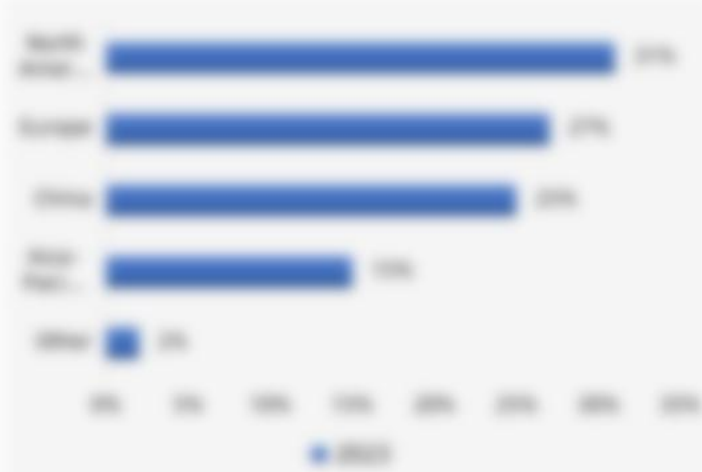
With its high-precision measurement capabilities, quantum radar deeply explores the distribution of landmines and satellite observation targets, providing crucial data support for scientific research.

Quantum radar has vast potential in military and civilian sectors, with a growing market driven by technological progress.

Quantum radar excels in defense, scientific and civil sectors

Figure: Global Quantum Radar Industry Size Forecast (2023-2035E) (Units: Billion USD)

Figure: Quantum Radar Major Application Share and Private Segment Share (Units: %)



In terms of regional distribution, North America has always been the main region in the quantum radar application market, with its share increasing from 37% to 39% in 2023. At the same time, China's share rose from 25% to 28%, highlighting the growth potential of the Asia-Pacific region in the quantum radar market.

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Quantum radar technology is cutting-edge and experimental, and its products have not yet achieved large-scale commercial application.

Quantum technology will attract more capital injections

Figure: Global Quantum Radar Enterprise Financing Consolidation (2020-2023) (Units: Million USD)

Seed	A	B	Others
1	3	1	2
$14.6M	$36.3M	$110.8M	$30.4M

Global Quantum Radar Company Investment and Financing (2020-2023)

Round/ Times	2020	2021	2022	2023
Seed		Qu-Ze QUZE		
A	Inflexion	Inflexion	Qu-Ze QUZE	
B			Inflexion	
Others			QCI Inflexion	

Technology maturity drives the need for capital

- Quantum radar technology is still in the stage of experimental and application exploration, and has not yet fully matured.
- Investment and financing activities in the field of global quantum radar are gradually increasing. For example, United Kingdom QUR has completed multiple rounds of financing between 2021 and 2023, and the amount of financing is also increasing.

Emergence of Quantum Radar Commercialization

- The year 2022 witnessed a funding peak in the field of quantum radar, primarily due to the emergence of quantum technology's commercial potential.
- Quantum radar shows promise in fields like military and environmental monitoring. QUR, for example, launched the first quantum gas LIDAR for methane monitoring.

Jointly driven by policy and market conditions

- Governments worldwide are increasing support for innovative fields such as quantum technology, creating a favorable environment for investment and financing activities in the quantum radar market.
- Trends of resource integration and optimization within the industry are gradually emerging, exemplified by mergers and acquisitions such as QCI's acquisition of the AI company Mirzatech.

Note: As is merged to Series A, angel rounds and pre-seed rounds are merged to seed rounds; debt financing and government grants are merged to other.

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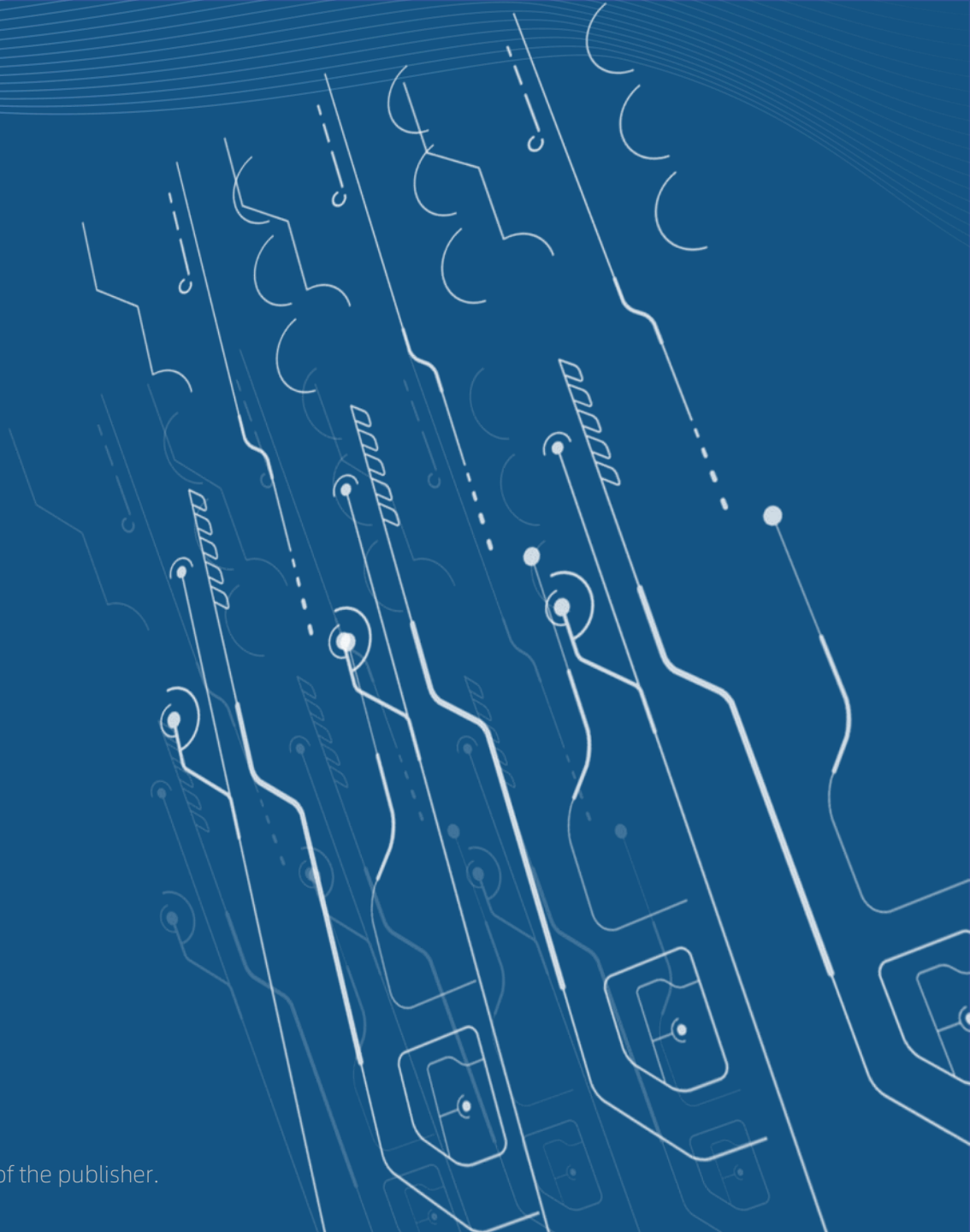


PART FOUR

Research Institutes & Core Enterprises

The US and China lead in quantum radar research institute and core enterprises, with the UK, Canada and France emerging to drive progress.

Global quantum radar research institute lead through interdisciplinary collaboration and deep research

Figure: Global Quantum Radar Regional Distribution

- Quantum radar technology is gaining attention and being researched globally. The US and China lead in development and investment, while the UK, Canada, and France are also actively advancing the technology.
- The US leads in quantum radar technology with multiple institutes and companies researching and products already in use.
- China is actively investing in and researching quantum radar, focusing on improving detection and anti-interference capabilities.

Currently, quantum radar is in the experimental stage, with organizations crucial in developing and exploring technologies like quantum imaging, single-photon detection and microwave quantum radar.

- **Research organizations' exploration is continuously enhancing quantum radar product performance**

2018

In 1998, Heriot-Watt University researchers created the world's first TCSPC -based single-photon LiDAR, operating within 0.1-1 meters. In 2023, quantum detection was used for the first time to capture 3D underwater images.

2019

In 2012, SIOM developed a quanta-constrained ghost imaging LiDAR, imaging targets 960m away. In 2022, SIOM & NUDT introduced Dual- FOR tracking to improve moving target tracking.

2020

In June 2023, French scientists developed the first microwave -based quantum radar, achieving a 20% performance improvement over traditional radars and demonstrating "quantum supremacy".

2021

In 2017, USTC achieved the first dual-frequency Doppler wind LiDAR. In 2024, they developed a dual- photon interference atmospheric LiDAR prototype with a 0-12 km/s velocity range and 1x increased sensitivity.

2022

In 2021, MIT Lincoln Lab designed a 3D LiDAR system with Geiger- mode detectors. In 2023, Fujian tests successfully imaged and reconstructed trees and camouflaged tanks at hundreds of meters.

2023

In 2020, Baicanas at the University of Calgary developed the first quantum radar prototype using entangled microwave photons, marking a significant step towards practical quantum radar applications.

2024

The Beijing Academy of Quantum Information Sciences is researching quantum sensing and monitoring of QM spectra using Rydberg atoms. They've created the world's most integrated Rydberg atom detector. It was showcased at the 2024 Zhongguancun Forum on April 25.

Enterprises in the quantum radar field worldwide are driving the development and application of products such as quantum lidar, gas imaging, and detection systems through innovative technologies.

Enterprises' innovations and explorations in quantum radar technology indicate steady market demand growth

Glory China Quantum Lidar is a company specializing in the R&D, production, and sales of near- to mid-infrared optical quantum radars. With technology from the University of Science and Technology of China and Wuhan University, the company has established the country's first particulate optical quantum radar network in Jinan, achieved the construction of the first domestic atmospheric monitoring LIDAR production line in 2021, and deployed particulate optical quantum radars in multiple locations across the country in 2022.

Technology

Company's technology originates from the University of Science and Technology of China, achieving a full integration of near-infrared quantum technology and lidar technology. We have developed and produced optical quantum lidars, mastering multiple core technologies in quantum detection and lidar systems.

Application areas

The application areas of the company's quantum radar products span both military uses, such as military target detection and tracking, as well as weather observation, and civilian sectors, including environmental monitoring, geological exploration, ground transportation management, and airport weather support, thereby demonstrating broad market prospects.

Infleqtion, formerly ColdQuanta, is a leader in quantum technology systems development, focusing on quantum components, computers, software, and sensors. With over 17 years of R&D experience, the company is creating an ecosystem of quantum technologies and commercial products. It offers high-value quantum information and software configurations that deliver enhanced precision and power for businesses and government entities in the U.S. and allied nations. Infleqtion's collaboration with Lockheed has led to breakthroughs in quantum RF technology, surpassing traditional high-excitation Rydberg state limitations, and providing new possibilities in RF sensing with continuous tuning, interference resistance, and high sensitivity.

Technology

QRF Solves a Much Needed Problem in RF Networks

Atomic Replacement for Antennas — Quantum Radio Frequency (QRF) exploits Rydberg states of atoms in room-temperature atomic vapor to detect RF signals without the need for traditional antennas and solid-state receivers.

- Ultra-Wideband Frequency Coverage — Atomic transitions and photon interactions allow RF performance to surpass the constraints of conventional receivers related to frequency, bandwidth, size, and thermal limitations.
- Cost-Effective 5G Expansion — SigWire is compact and offers a cost-effective solution for extending 5G to remote areas, enabling system integration and enhancing next-generation and military-grade communication and sensing architectures.

QRF technology, utilizing Rydberg atoms, surpasses RF limits with ultra-wideband coverage, extends battery life in remote areas, and maximizes processing while minimizing hardware, enabling efficient network expansion.

Significance

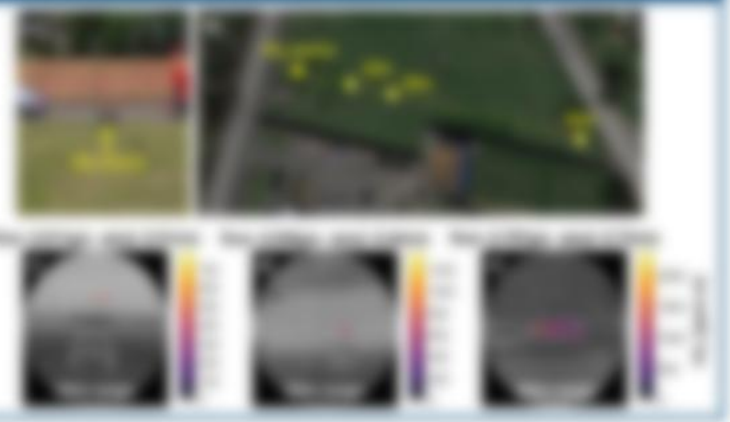
In October 2024, SigWire, Infleqtion's quantum RF system, demonstrated interoperability with EW and SINCGARS during Army's NetModX23 evaluation.

QLM Technology (QLM) specialises in photonics-based solutions, utilising quantum technology from the University of Bristol's Quantum Technology Enterprise Centre. QLM has developed a gas imaging camera that combines lidar and gas absorption spectroscopy with single photon detection to quickly and sensitively identify greenhouse gas leaks, tackling climate change. Its scalable lidar technology enables low-cost mass production, promoting widespread deployment.

Exploratory Phase

2019 – QLM works with the National Physical Laboratory to verify emission quantification performance

QLM seeks to work with recognized measurement institutes and industrial partners to field test equipment against known controlled CH_4 emissions. QLM's long-standing collaboration in these field tests is the United Kingdom National Physical Laboratory (NPL), which has its own controlled release facility for validating LDAR technology. NPL conducted a field trial to image the controlled release of CH_4 in an outdoor environment using a prototype quantum gas lidar.



Experimental Phase

2020 – Industrial trials with QLM and TotalEnergies

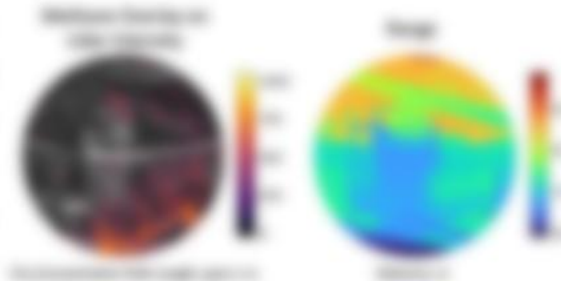
TotalEnergies has a dedicated testing facility at TADI in Lacq, France. QLM was invited to participate in a blind CH_4 emissions monitoring test conducted by TotalEnergies on its TADI platform in Lacq in October 2020.

Validation Phase

2021 – Monitoring and quantification of emissions from national gas transmission

National Gas Transmission (NGT) maintains nearly 8,000 kilometers of natural gas (NG) pipelines in the United Kingdom, serviced by more than 600 above-ground stations. On the eve of COP26 in October 2021, QLM, with the support of NPL, conducted the first trial of quantum gas lidar at a real site at NGT's Barton terminal.

To reduce fugitive emissions, Repsol Sinopec uses methane lidar camera technology for tunable diode laser imaging, detection, and ranging technology to visualize and quantify methane emissions. Lidar technology has proven to help identify and quantify fugitive methane emissions from the Flotta oil terminal off the coast of Scotland.



Quantum Computing Inc. (QCI) is the first full-stack optical quantum computing solution company to go public. QCI products are designed to provide easy-to-use, affordable quantum computing solutions. Its products are designed to operate at room temperature with low power consumption, and its core technologies and product portfolio offer unique capabilities in areas such as high-performance computing, artificial intelligence, cybersecurity, and remote sensing applications. The company has developed a variety of quantum information technologies and systems, such as entropy quantum computing, reservoir post quantum computing, quantum imaging and sensing. In April 2024, Quantum Computing Inc (QCI), a quantum optics and nanophotonics technology company, announced that its quantum LIDAR (LIDAR) prototype has been successfully sold to Johns Hopkins University.

Climate Field

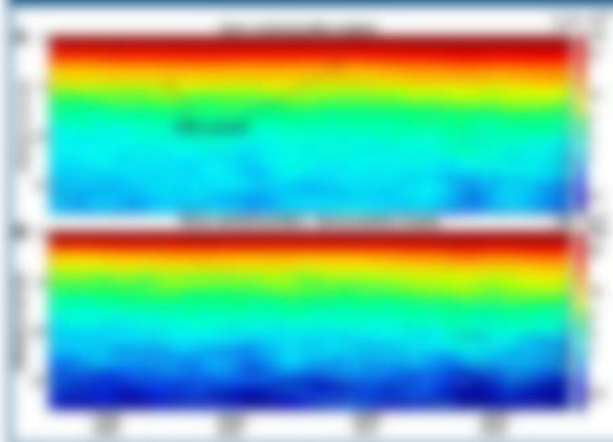
In 2023, QCI was awarded a subcontract by SSAI

QCI announced that it has been awarded a subcontract by SSAI to support NASA in testing one of their proprietary quantum photonic systems for remote sensing applications. QCI, through its wholly owned subsidiary focused on government projects, QI Solutions, will execute this work under a subcontract from SSAI, a leading provider of science, engineering and IT solutions.

Technical features:

- Single-photon sensitivity: The QCI system has high sensitivity and is capable of accurate measurements in challenging environments.
- Noise Suppression: Noise Suppression: Spatial resolution and image fidelity for long-range high-resolution during the day or night.
- Multi-functional: The system design is simple, scalable, and suitable for a variety of application scenarios.

Underwater Field



In 2024, QCI received an order for a revolutionary underwater LIDAR prototype

QCI's successful sale of its quantum LIDAR prototype valued at $200,000 to Johns Hopkins University marks a significant advancement in underwater LIDAR technology that will be used for testing and evaluation in Johns Hopkins' highly regarded R&D program.

Technical features:

- Accuracy: QCI's quantum LIDAR system has a resolution of 3 mm, which is a very high accuracy in underwater imaging technology.
- Depth: The ability to operate at depths of up to 30 meters below the surface of the water.
- Single-photon detection technology: The system utilizes single-photon detection technology to increase sensitivity and be able to identify and measure weak reflected signals.

TZH Quantum Tech is a national high-tech enterprise with quantum precision measurement as its core technology. The company's core team originated from the Guangdong Provincial Key Laboratory of Quantum Control Engineering and Materials of South China Normal University. The team has undertaken a series of national key major scientific research projects. The atomic radio receiver developed by the company can be used for microwave field strength meter and quantum radar, and there are commercial products at present. In addition, the company is developing the Rydberg antenna and the quantum radar based on the Rydberg antenna, which has not yet been industrialized.

Technology

TZH Quantum Tech focuses on technologies such as atomic radio, atomic terahertz spectrum analysis and imaging, precision optoelectronic measurement and control, and integration.

Applications

The company mainly serves microwave communications, radar detection, aerospace and other industries, and is committed to providing related services for colleges and universities, industrial enterprises, etc.

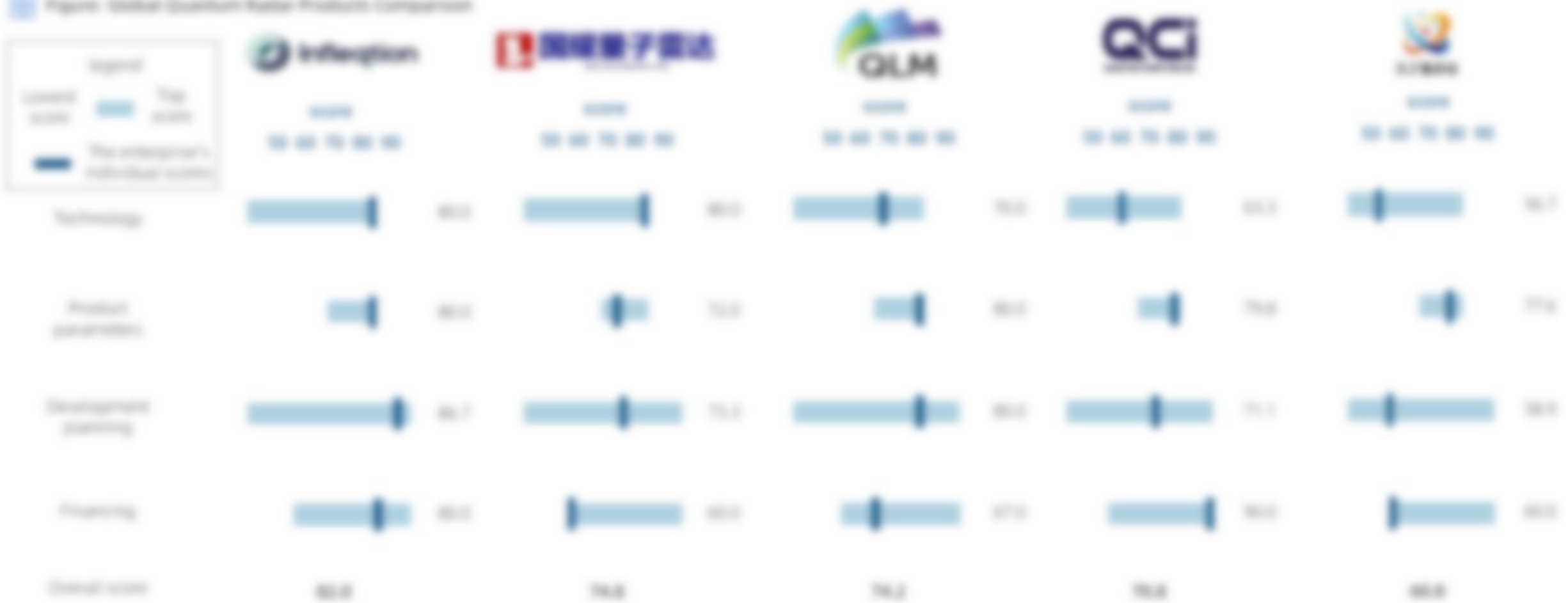
Important Breakthrough

- In November 2021, TZH Quantum Tech released China's first set of quantum microwave measurement system, breaking the international monopoly in the field of high-end metrology. This technology is currently mainly used in metering systems, and in the future it can also be used in the field of electromagnetic spectrum for defense and civil use, as well as in the field of security and medical imaging.
- In August 2023, the ultra-stable optical resonator was launched, filling the gap in China. The ultra-stable optical resonator can be used in the laboratory and high-precision optical signal processing, to achieve ultra-narrow linewidth and ultra-stable laser locking, high-Q optical filters, etc., to provide subsystems and customized solutions.
- In January 2024, TZH Quantum Tech successfully developed a terahertz camera based on the Rydberg atomic quantum effect, marking that China's atomic terahertz camera research is at the forefront of the world. The newly developed atomic terahertz camera can shoot objects ranging in size from a few centimeters to several meters, and its spatial resolution can reach 0.1 mm, which is an order of magnitude improvement of 1 to 2 orders of magnitude compared with the resolution of about 1 mm for terahertz cameras developed based on semiconductor technology.

With the continuous optimization of the performance of global quantum radar products, the pace of corporate financing continues to accelerate.

The market size of quantum radar products will continue to accelerate

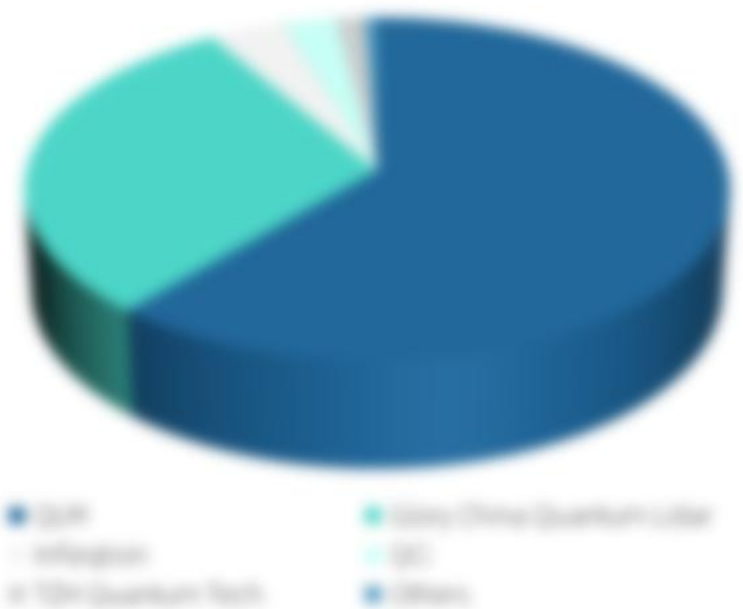
Figure: Global Quantum Radar Products Comparison



The quantum radar market is currently dominated by a small number of enterprises and a number of enterprises compete together.

Quantum radar prices in Europe are one-third higher than those in China

Figure： Global Market Share of Quantum Radar Enterprise Products （2024E）



QUA's quantum gas lidar dominates. The quantum gas lidar technology has shown significant advantages in the field of gas monitoring. This technology enables rapid and accurate detection and quantification of greenhouse gas leaks such as methane through tunable diode laser absorption spectroscopy, differential absorption lidar, and single photon counting techniques. In the Colorado State University test, the accuracy was 2.4 meters, even in the face of extreme weather conditions, showing extreme adaptability and reliability.

QUA's lidar system excels at continuously monitoring methane leaks, successfully detecting and quantifying a large number of leaks. Its performance is expected to exceed the United States Environmental Protection Agency's expected requirements for emissions monitoring in the oil and gas industry, demonstrating its leadership in the industry. The $12 million funding round in Series A is further evidence of the market's recognition of the potential of its technology.

The QUAntum, with their extensive experience, has successfully developed this technology. QUA's presence in the United Kingdom and United States reflects its international outlook. Overall, QUA's quantum gas lidar technology provides an efficient and reliable solution for greenhouse gas emissions monitoring.

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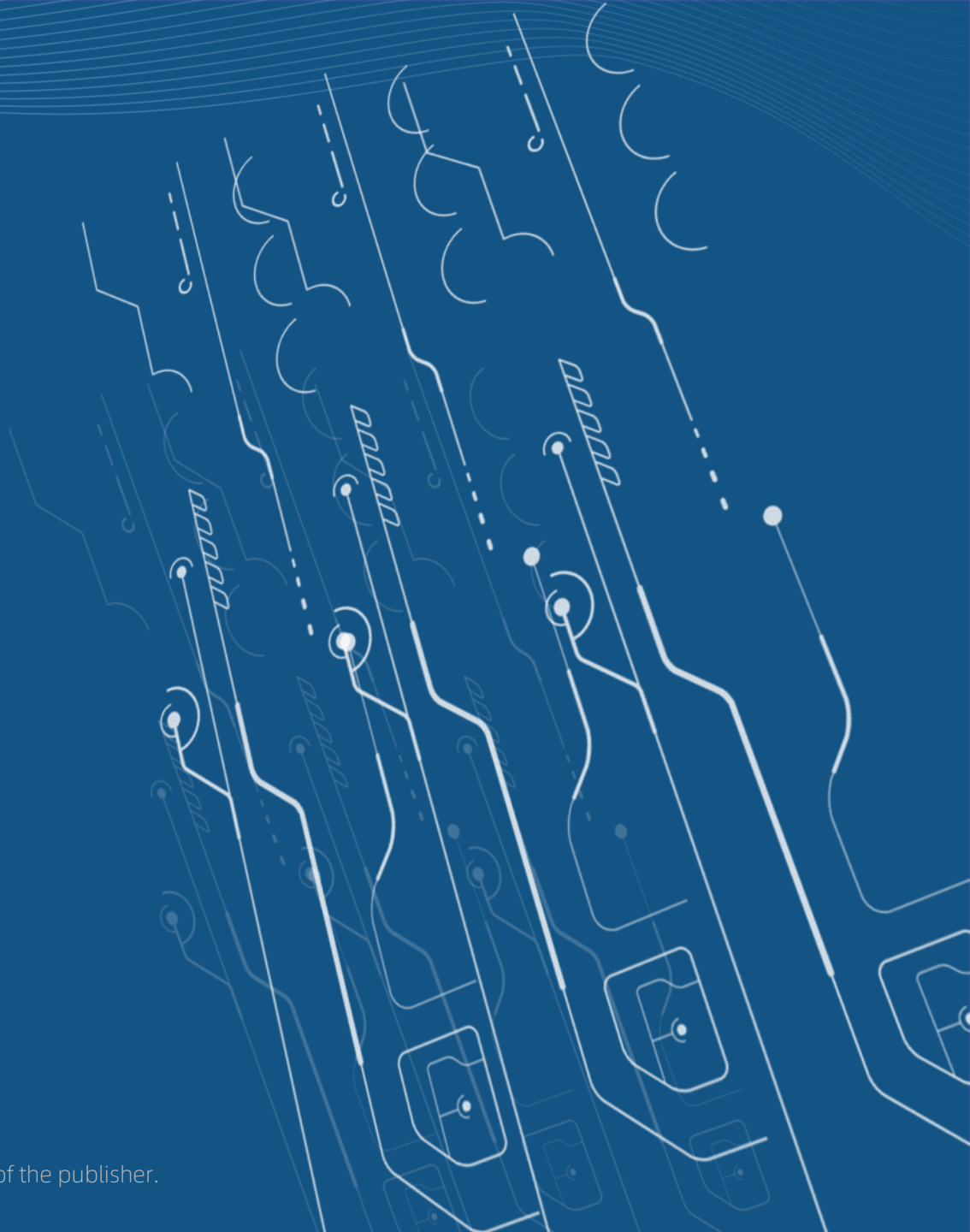
PART FIVE

Future Outlook of the Industry



In the short and medium term, quantum radar will be presented in the form of a "classical-quantum dual-channel" system, and its performance will be improved by Rydberg atomic antenna and AI.

In the future, quantum radar will have a profound impact on many fields

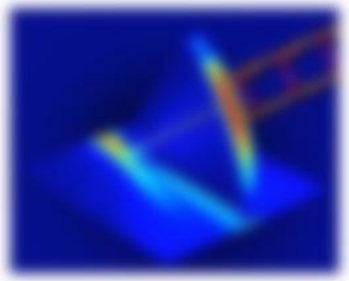
Dual-Channel System Morphology

Fusion of quantum and classical radar technologies

- On the basis of maintaining radar application scenarios and technical capabilities, the high precision and high sensitivity characteristics of quantum channels are used to improve radar performance.

Advantages of the dual-channel system architecture

- The dual-channel system architecture allows quantum radar to better adapt to various complex environments and extreme weather conditions. This design enhances the radar system's flexibility and adaptability.



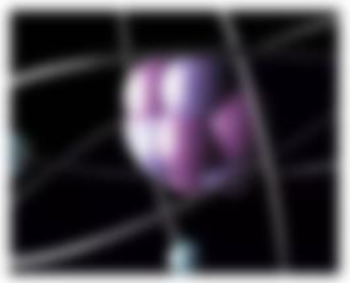
Quantum Radar Technological Innovation

Innovations and advancements in the global quantum radar industry

- Institutions and enterprises worldwide are working to enhance technological capabilities and innovation to achieve significant breakthroughs and continuous optimization in quantum radar performance.

Rydberg atomic antennas will drive innovation in quantum radar technology

- As a key technology for quantum radar, Rydberg atomic antennas significantly enhance sensitivity in the microwave frequency range, having a profound impact across military, communications, and astronomy fields.



Deep AI integration

The potential of integrating AI with quantum radar

- The innovative combination of AI and quantum radar merges advanced AI algorithms with the unique advantages of quantum technology, significantly enhancing the overall performance and intelligence of radar systems.

Progress in practical applications and research

- The U.S. NIST began exploring the use of advanced AI technology to improve radar signal detection accuracy in 2019. Sunyaev Quantum Technology has made significant strides in this field, successfully developing an AI-based real-time dynamic tracking algorithm for laser radar using optical quantum particles.

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