Quantum meets AeroSpace and Sustainability

Dr Cathy Foley
Australia's Former Chief Scientist and Quantum E0641nthusiast!

12 August 2025

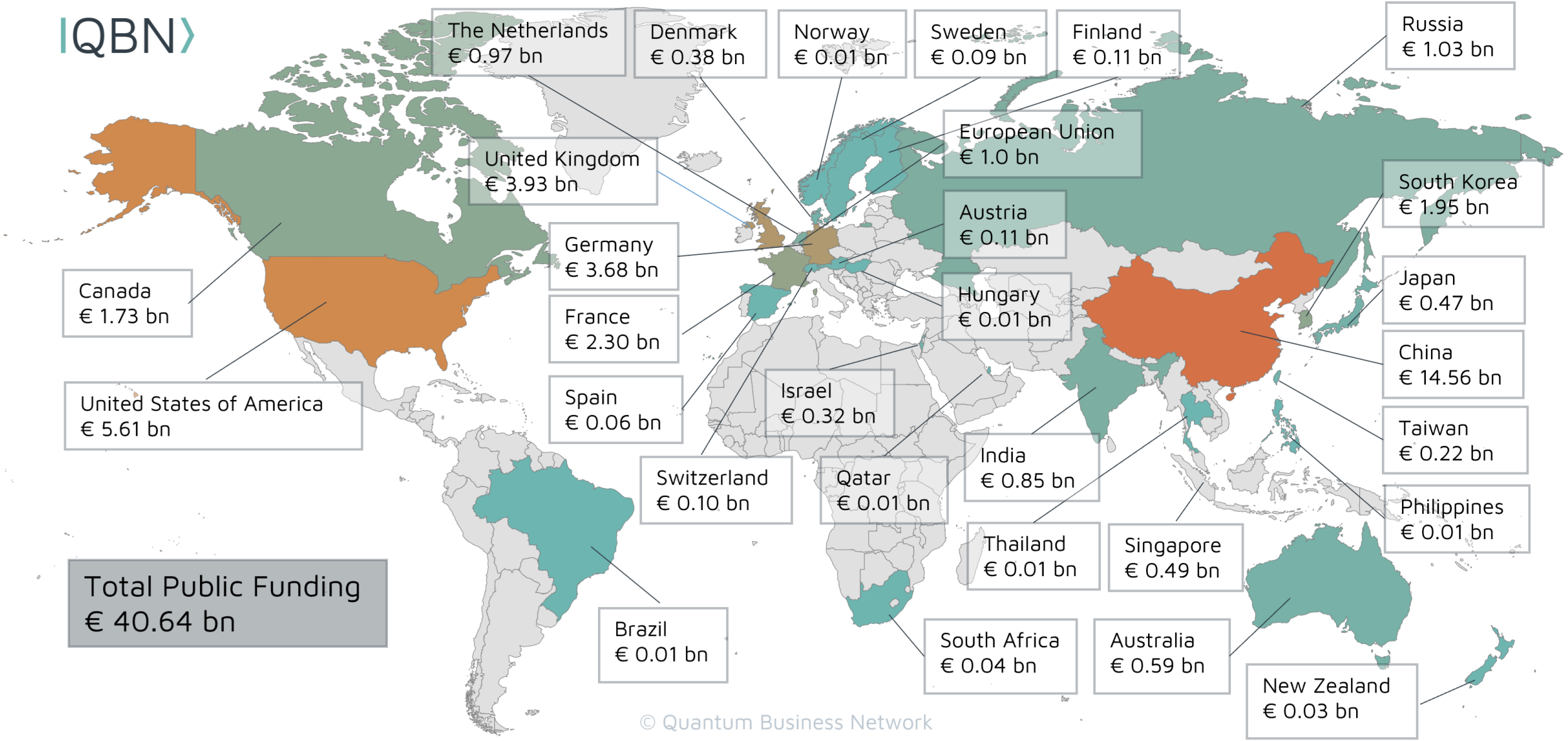
SCIENCE

Why the world is now in a race to achieve 'Quantum Superiority'

By Eric Spitznagel

Published May 3, 2025, 2:00 p.m. ET

Global Quantum Initiatives



Who's backing quantum?

Corporate investors:

- Intel, Google, IBM, Microsoft, AWS and many others
- Private investment reached >$2B in 2024
- Generated $650-750M revenue in 2024 – expect >$1B in 2025

Governments:

- Considered **"urgent"** and **"critical"**
- **Strategies produced** by China, USA, UK, Europe, Japan, Canada, S. Korea (>20 countries)
- **Public investment** increased >50% in 2022
- Global public funding now $44.5B
- **Singapore hub** collaborates with businesses on use cases.
- **UK 5 quantum hubs** to speed up commercialisation

  - Govt GBP 606M - industry GBP 54M
- **Australia's investment** $1.2B through multiple programs

Department for Science, Innovation & Technology

QUANTUM FLAGSHIP European Union

NATIONAL QUANTUM OFFICE SINGAPORE

Australian Government
Department of Industry, Science and Resources

⟨quantum|gov⟩

内閣府
Cabinet Office

G-QuAT

UKQuantum

Quantum Computing Outlook 2025

5.24%
Industry Growth in the last year

13 000+
Total Companies in the database

59 000+
Employee Growth in the last year

The map highlights the global distribution of **368** quantum computing startups

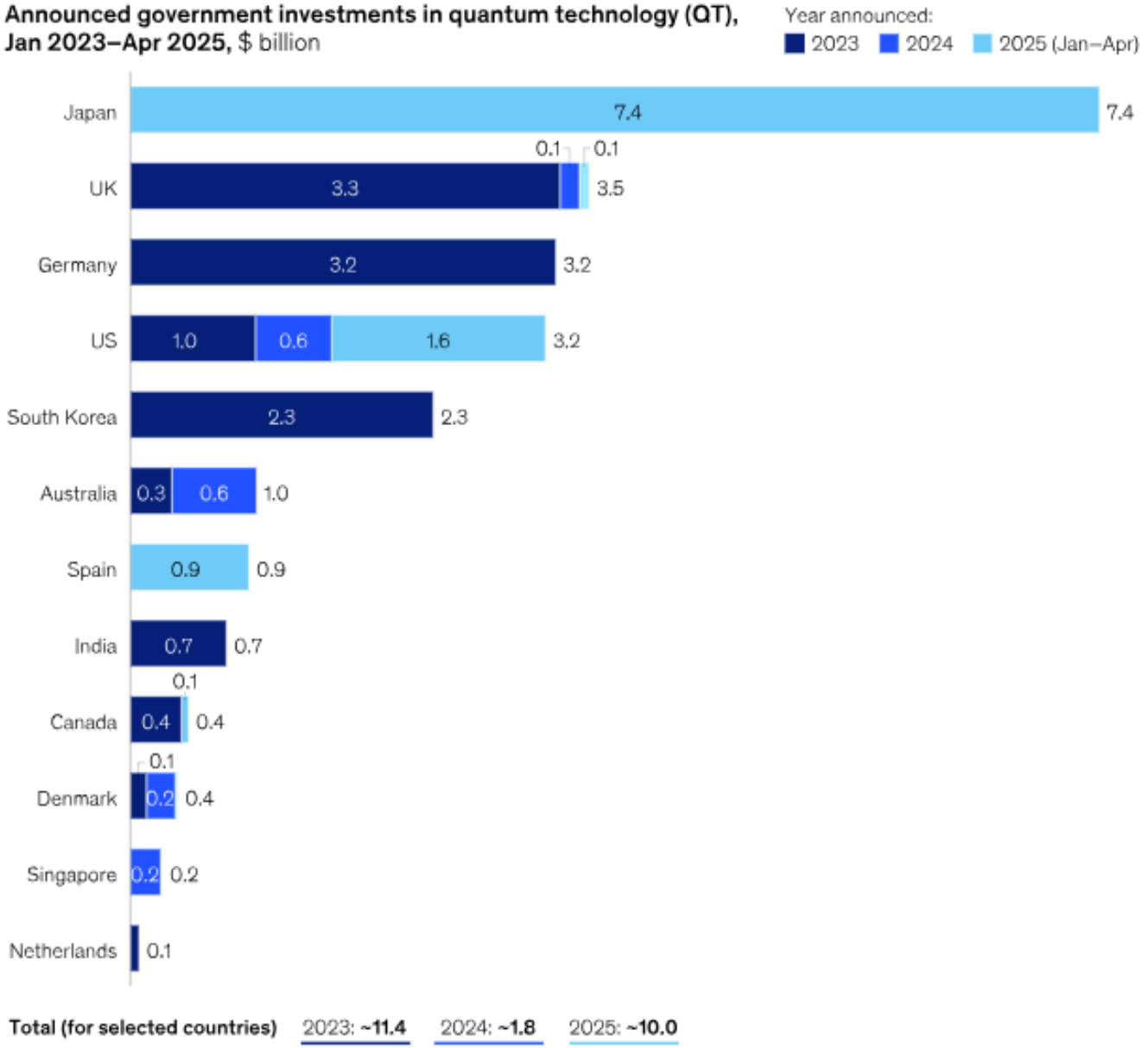
5 Innovative Quantum Computing Startups

BlueQubit	SuperQ	Qool	QC Design	TreQ
USA	India	Denmark	Germany	UK

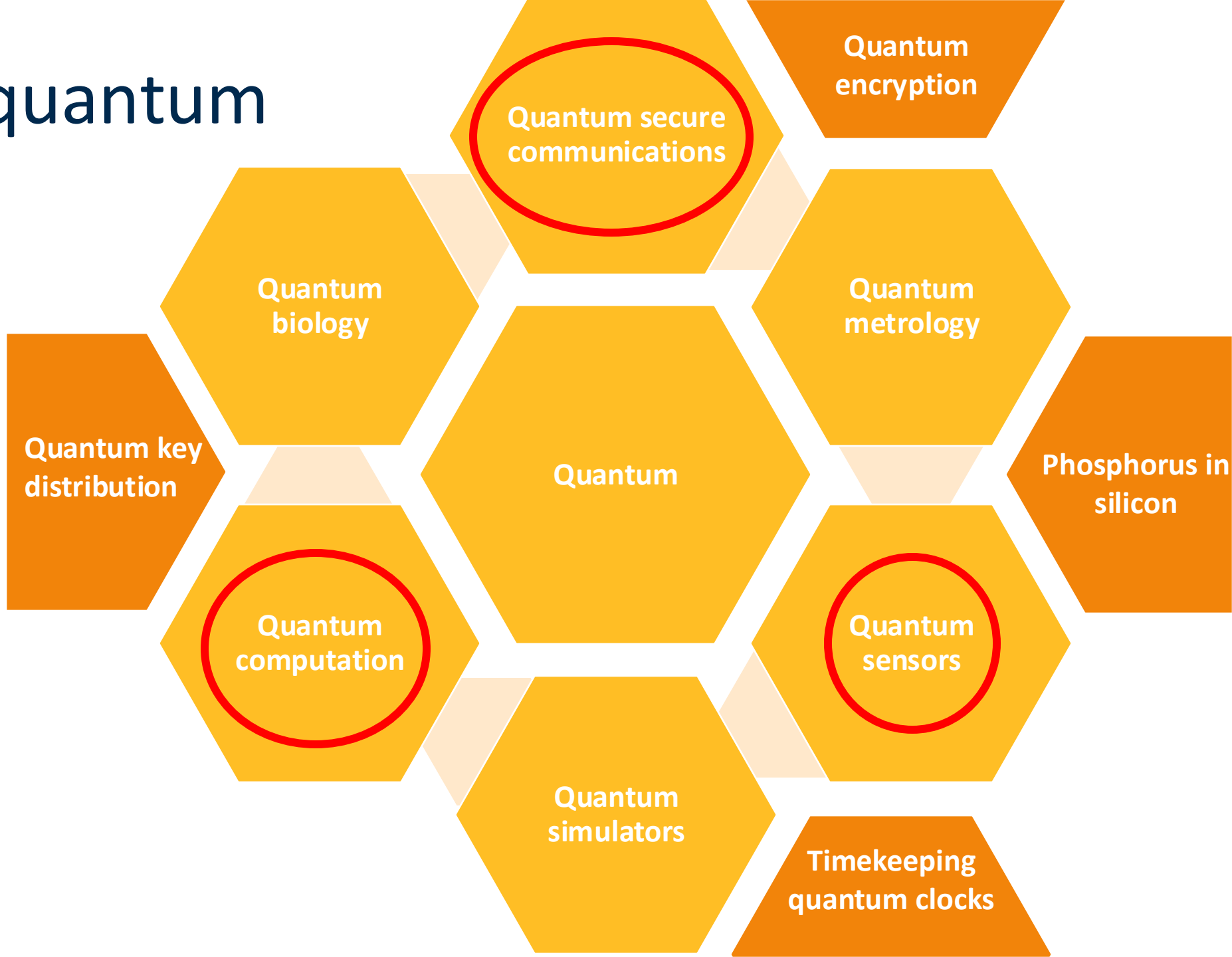
No. of **Patents**	**296000+**
No. of **Grants**	**3500+**
Global **Manpower**	**1 million+**
Top 5 **Country Hubs**	USA, UK, India, Germany, Canada
Top 5 **City Hubs**	London, NY City, Singapore, Sydney, Toronto

StartUs insights

Announcements of public investments in quantum technology reached $10 billion in early 2025, with Japan accounting for nearly 75 percent.

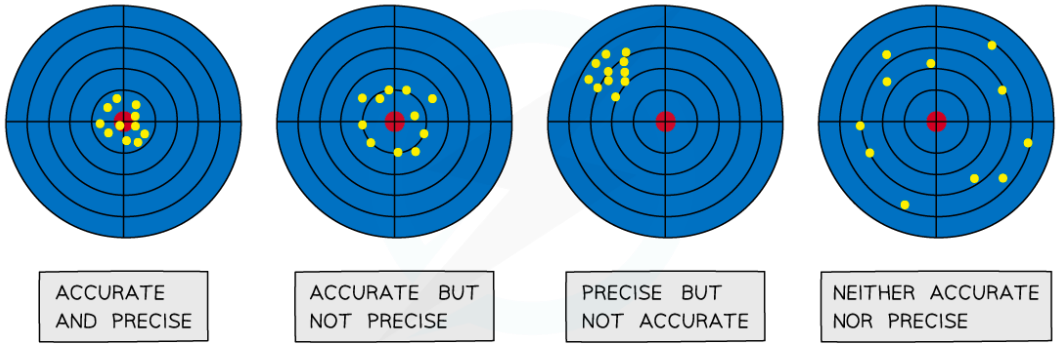


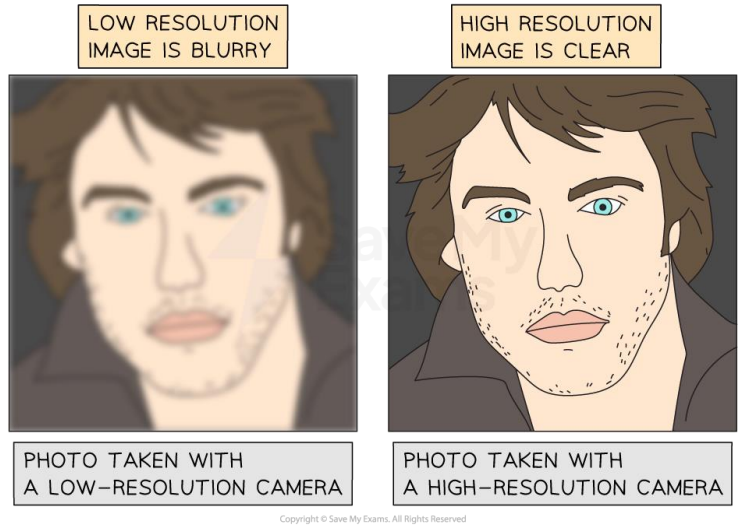
What will quantum deliver?



Quantum sensors

- Higher sensitivity
- Better accuracy
- Precision
- Size weight power
- Atomic to macro size
- Spatial resolution
- They can measure physical quantities:
  - Magnetic fields
  - Electric fields
  - Temperature
  - Pressure
  - Chemical composition
  - Gravity
  - Shapes





Quantum Sensing

Quantum Sensors

leverage quantum phenomena to measure fields, forces, or time

Electric Fields
- Atomic electric field sensors
- Solid-state defects

Time and Frequency
- Atomic clocks

Magnetic Fields
- Atomic magnetometers
- Superconducting magnetometers
- Solid-state defects

Acceleration due to Gravity
- Atomic gravimeters
- Superconducting gravimeters

Inertial Acceleration
- Atomic accelerometers and gyros
- Superconducting accelerometers and gyros
- NMR gyros

WHY BUILD QUANTUM SENSORS?

Compared to traditional sensors, quantum sensors offer the potential for:

Improved Performance **and/or** **Smaller SWaP (size, weight, and power)**

Quantum communications

- Quantum networks with space links
- Quantum satellites
- Date security
- Improved energy efficiency for optical communications
- Improved bandwidth efficiency for optical communications
- Positioning, navigation and timing without GPS

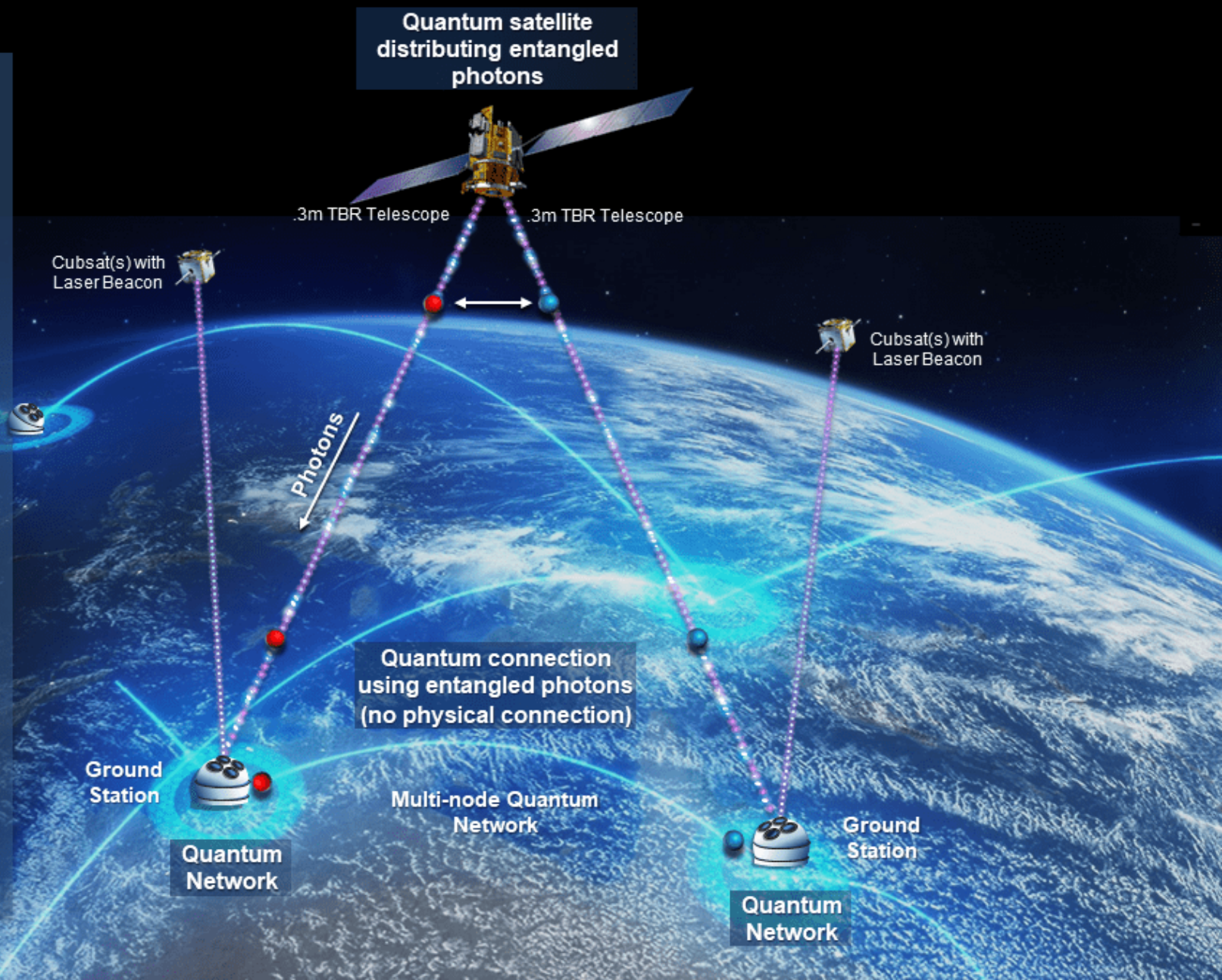
Quantum Communications

Information can now be encoded (represented) by multi-state quantum bits (qubits)

- Entangled photons as qubits can interact with each other at any distance
- By having a satellite distribute entangled photons via optical links to well separated stations on Earth, those stations can "talk" to each other via the entangled photons - without needing to be physically connected

Benefits

- Quantum networks with space links
- Data security
- Improved energy efficiency for optical communications
- Improved bandwidth efficiency for optical communications



Quantum Computers

Global race

- Exponential computational speedup for specific problems
- Ability to simulate quantum systems,
- Potential breakthroughs in cryptography and materials science

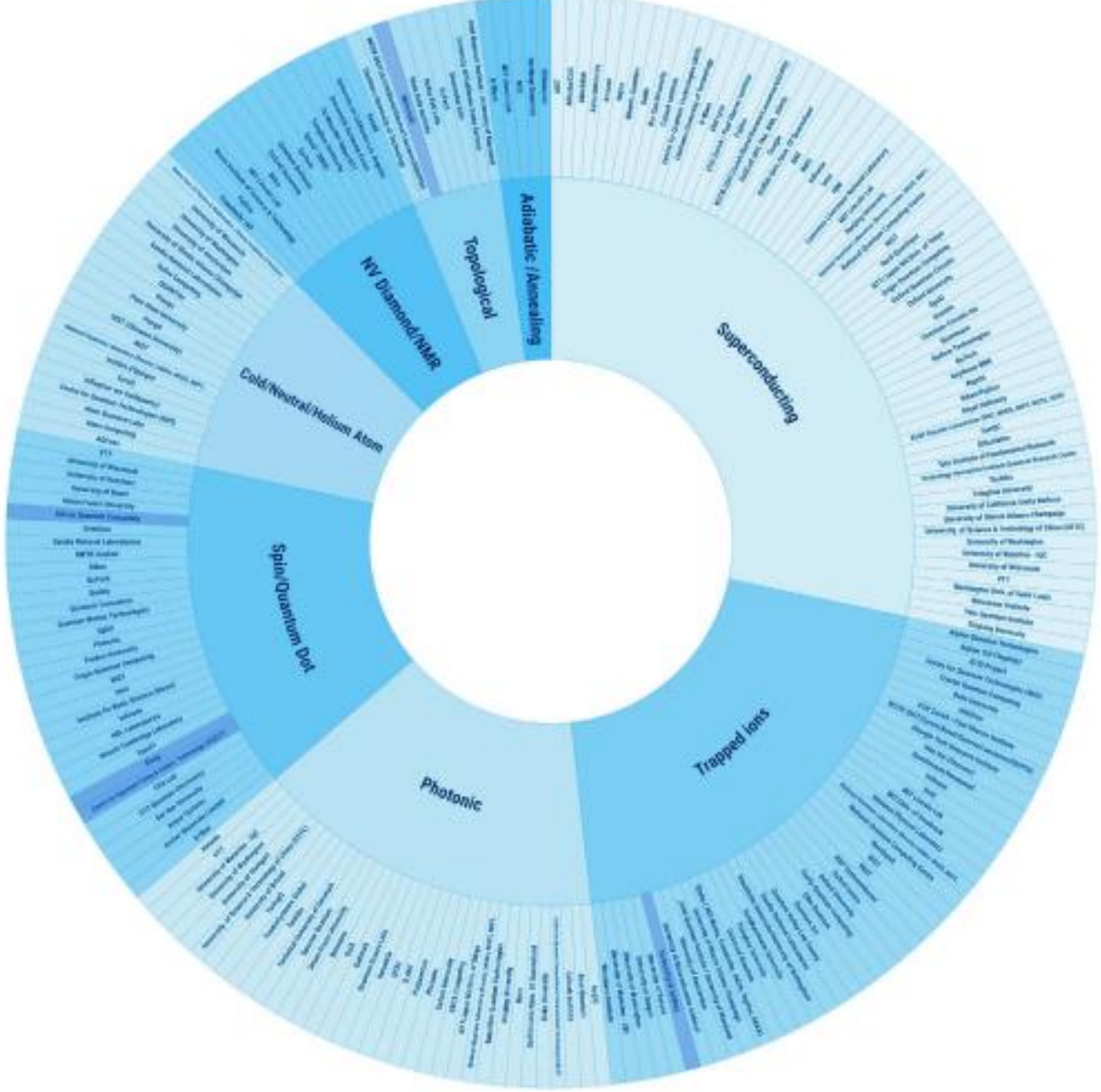


Figure 1. Global summary of the companies and academic programs developing the eight major quantum hardware technologies. Sourced from the Michel Kur, CEO of Multiverse Systems SAS,[46] and modified to highlight companies and academic efforts specific to NSW. Companies specific to NSW

Quantum Computers

diraq

Silicon Quantum Computing

PsiQuantum

QUANTUM BRILLIANCE

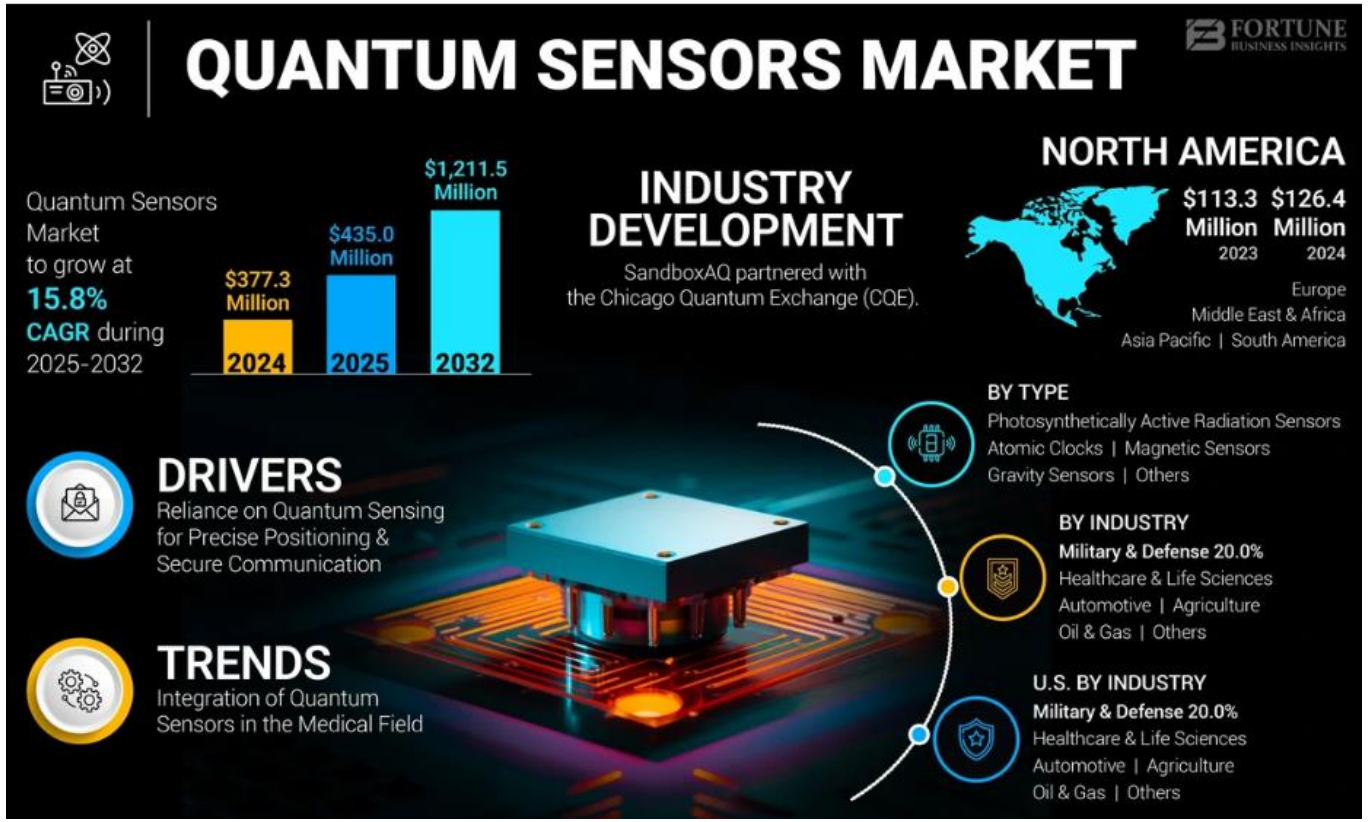
Global race

Different types of quantum computers:

- Useful/Fault Tolerant – here soon
- Fully error corrected – different views on when that will be delivered
- Annealers – available now on the cloud - D-Wave
- Analogue quantum simulations
- Noisy Intermediate Scale Quantum (NISQ) Computer – available now via cloud - AWS, Rigetti, Xanadu, IBM, Google
- Quantum accelerator on HPC – available now Quantum Brilliance on Pawsey high-performance computer

Industry sectors

- Health and biotech
- Resources
- **AeroSpace**
- Communications
- Transport
- **Environmental protection**
- Defence
- Infrastructure
- Agriculture
- Energy
- Research
- Sport
- Financial services



Economic Insights April 02, 2025 | Simon Hunt

New Zealand’s ascent in the space industry

Humble New Zealand may be on the forefront of the new space economy

Aerospace in Canterbury

Lay the foundations for growth

Priority 1: Building the aerospace hub infrastructure

Priority 2: Attracting global companies and R&D programmes to Canterbury

Priority 3: Shaping a world-class workforce

Grow a thriving ecosystem

Priority 1: Leveraging our global regulatory advantage

Priority 2: Supporting local and national aerospace businesses to grow and scale

Priority 3: Creating a rich and diverse investment environment

Priority 4: Fostering collaboration and partnerships

Priority 5: Advancing decarbonisation and sustainability in aerospace

Tell our story

Priority 1: Promoting aerospace in Canterbury

Priority 2: Highlighting the benefits of aerospace for Waitaha Canterbury

Priority 3: Inspiring and educating the next generation

New Zealand's Unique Advantages and Opportunities

A. Building on Existing Strengths

- **Rocket Lab's Launch Capabilities**: Deploying quantum-enabled small satellites
- **Geographic Position**: Ideal location for Southern Hemisphere quantum-space operations
- **Regulatory Environment**: Progressive space law supporting innovation
- **Engineering Excellence**: Precision manufacturing capabilities for quantum systems

New Zealand's Unique Advantages and Opportunities

B. Strategic Partnerships and Collaborations

- **Trans-Tasman Quantum-Space Initiative**: Collaboration with Australia's space program
- **Pacific Quantum Network**: Connecting island nations through quantum satellites
- **International Space Station Experiments**: Quantum technology demonstrations
- **Commercial Partnerships**: Working with global aerospace companies

New Zealand's Unique Advantages and Opportunities

C. Niche Market Leadership

- **Small Satellite Quantum Systems**: Miniaturized quantum sensors and computers
- **Launch Services for Quantum Missions**: Specialized deployment capabilities
- **Ground Station Networks**: Quantum-enabled tracking and communication
- **Space Manufacturing**: Zero-gravity quantum material production

FORBES > BUSINESS > POLICY

The Quantum Space Race Is Here

Arthur Herman Contributor ⓘ

I comment on quantum computing and AI, and American national security.

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Oct 20, 2022, 04:30pm EDT

How can New Zealand use quantum to propel you to lead the world in aerospace and sustainability?

Quantum represents the next frontier for New Zealand’s aerospace ambitions

Quantum Sensing: Transforming Space-Based Observation

A. Next-Generation Earth Observation

- **Quantum Magnetometers**: Ultra-precise magnetic field measurements from orbit
  - Geological survey applications for New Zealand's mining and energy sectors
  - Enhanced navigation and positioning services
  - Space weather monitoring and prediction
- **Quantum Gravimeters**: Detecting minute gravitational variations
  - Climate change monitoring through ice sheet measurements
  - Resource exploration and geological mapping
  - Monitoring ground water and sea level changes around the Pacific

Quantum Sensing: Transforming Space-Based Observation

B. Scientific and Research Applications

- **Quantum-Enhanced Telescopes**: Improved sensitivity for astronomical observations
- **Atmospheric Sensing**: Precise greenhouse gas monitoring and climate science
- **Seismic Monitoring from Space**: Enhanced earthquake prediction capabilities
- **Ocean Current and Temperature Mapping**: Critical for New Zealand's marine environment

Quantum Sensing: Transforming Space-Based Observation

C. Defence and Security Applications

- **Quantum Radar**: Stealth-resistant detection capabilities [not sure this actually works yet]
- **Secure Positioning**: GPS-independent navigation systems
- **Space Situational Awareness**: Enhanced tracking of space debris and objects

Our work

Earth observation

Geospatial data enabled by a new generation of quantum sensors

Convert tiny signatures into new insights

Hyperspectral imaging and synthetic aperture radar have expanded our tools to measure and map our planet, but a revolutionary new capability is coming online. We are making the next generation of quantum sensors a reality by augmenting our toolkit for earth observation through magnetism and gravity detection.

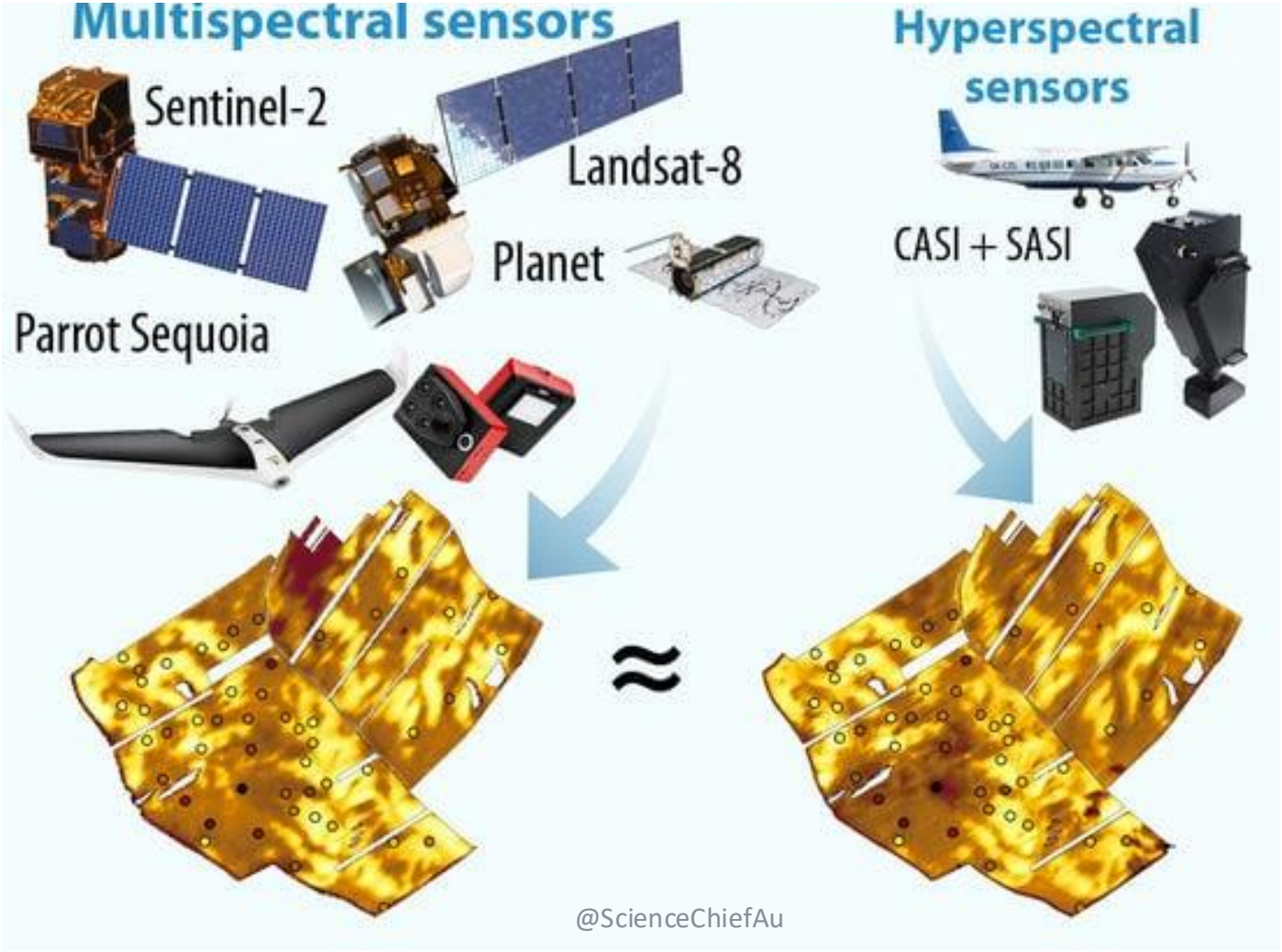
Adding quantum-enabled gravity and magnetic-field observation provides a new set of eyes to see the unseen: measure tiny changes that are currently invisible; map deviations in underground aquifer levels, monitor changes in the ice caps, and detect subsurface impacts from mining or covert activities.

Welcome to OrbitalX.

Unveiling Earth's Riches through Quantum sensing and Quantum Computing for Mineral Exploration

Spacecraft Systems

Mapping Soil Carbon



Quantum sensors in space: measuring a warming world with cold atoms

20 January 2023

Space-borne sensors serve a variety of purposes that are all but essential to our daily lives, from GPS navigation to weather prediction. They also play a key role in the ongoing battle against climate change. For example, space-borne sensors can determine atmospheric pollution levels, monitor global temperatures on the land and in the sea, and track climate-related processes such as deforestation. Every year we launch more and more of these sensors into orbit in the hope of returning ever more accurate results, but we are now reaching the limits of what classical instruments can offer us. As a result, people are starting to look at quantum physics as a way to keep development moving forward.

Quantum Communications: Securing Space Networks

A. Satellite-Based Quantum Key Distribution

- **Quantum-Encrypted Satellite Communications**: Unbreakable encryption for sensitive data
- **Global Quantum Internet**: New Zealand as a key node in international quantum networks
- **Banking and Financial Services**: Secure space-based transactions for the Pacific region
- **Government Communications**: Ultra-secure channels for defence and diplomacy

Quantum Communications: Securing Space Networks

B. Ground-to-Satellite Quantum Links

- **Quantum Entanglement Distribution**: Enabling quantum networks across the Pacific
- **Free-Space Quantum Communication**: Linking New Zealand with Australia, Asia, and beyond
- **Hybrid Classical-Quantum Networks**: Integrating with existing infrastructure

Quantum Communications: Securing Space Networks

C. Space-Based Quantum Networks

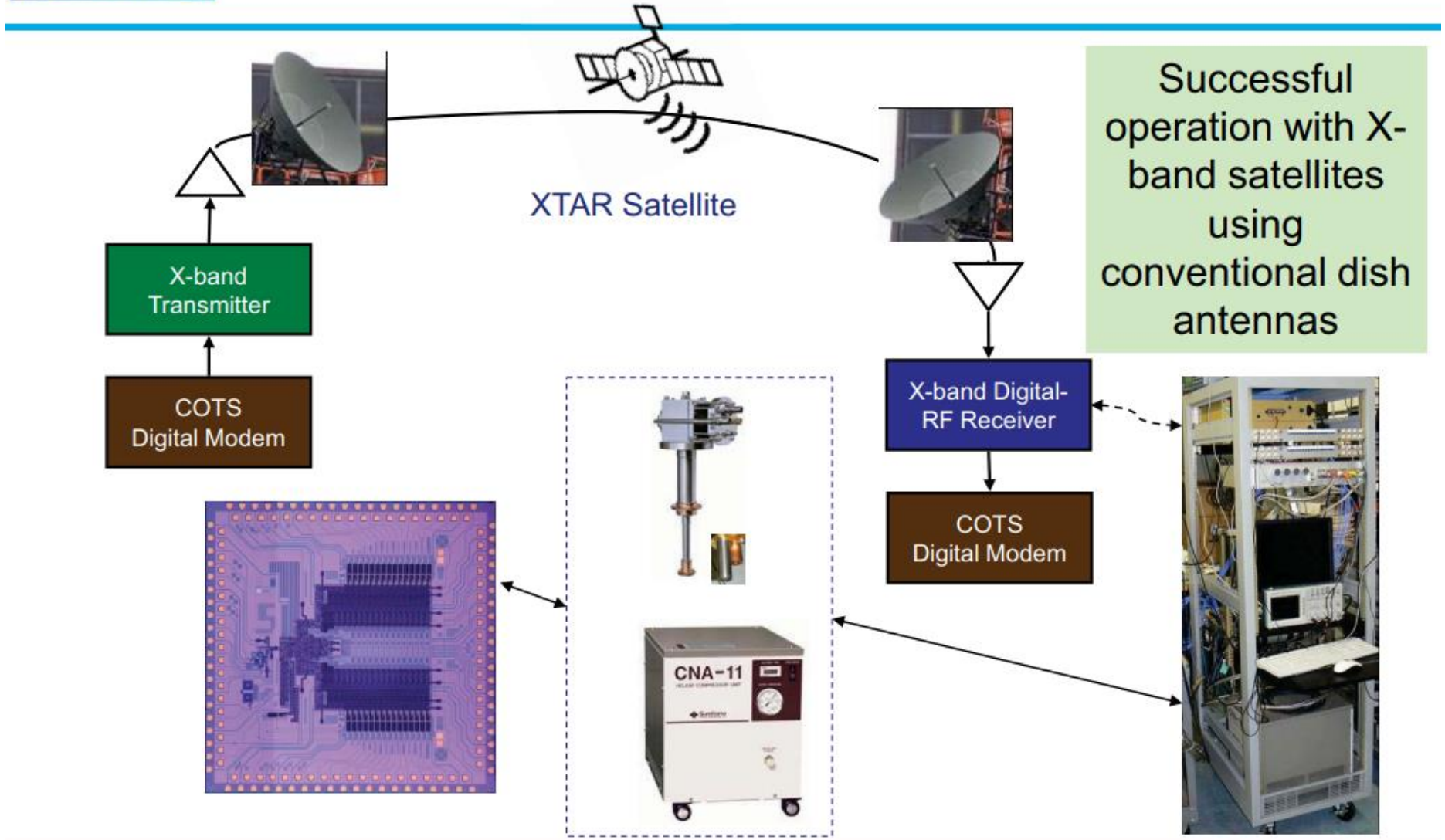
- **Inter-Satellite Quantum Links**: Creating a quantum constellation
- **Deep Space Quantum Communication**: Future missions to Moon and Mars
- **Quantum Clock Networks**: Ultra-precise timing for navigation and science

Quantum Sensors for Satellite Control Enable High-Speed Connectivity

COLOGNE, Germany, Aug. 29, 2022 — A German consortium composed of Q.ANT, Bosch, TRUMPF, and the German Aerospace Center (DLR) plans to use **quantum** technology to permanently enhance satellite measurement stability. Reliable transmission of satellite communication signals can only be achieved by constantly maintaining high-precision attitude control of satellites in their orbits. If a satellite moves out of position, the signals get weaker.

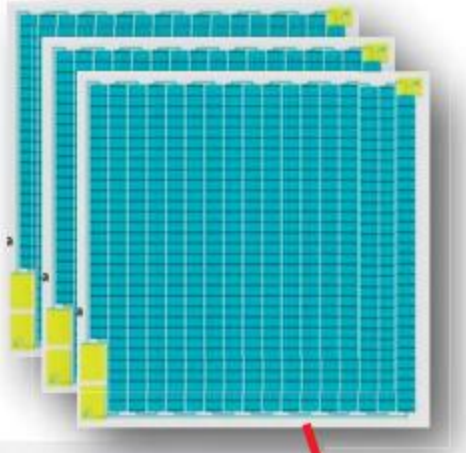
The partners will develop space-qualified attitude sensors in a project will improve internet access, particularly in remote regions, TRUMPF said in a press release. The aim is to use these quantum technology-based sensors to achieve high-precision attitude control of miniaturized satellites. The sensors' ability to maintain precise orientation of the satellites in relation to each other will enable high-speed data connectivity.

Superconducting Digital Receivers



Successful operation with X-band satellites using conventional dish antennas

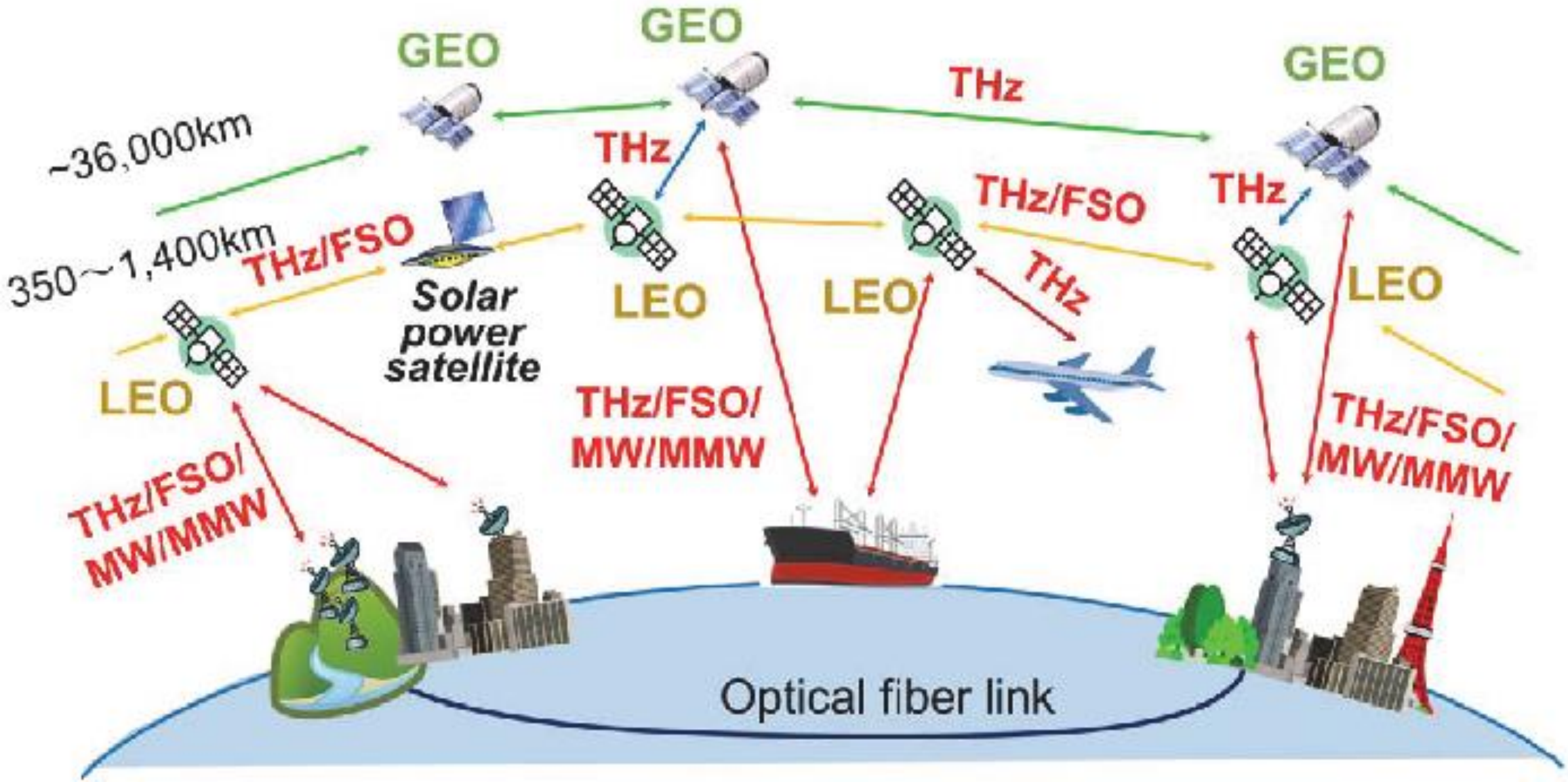
SQUID 2D array for Superconducting Quantum Antennas



Digital-RF Receiver

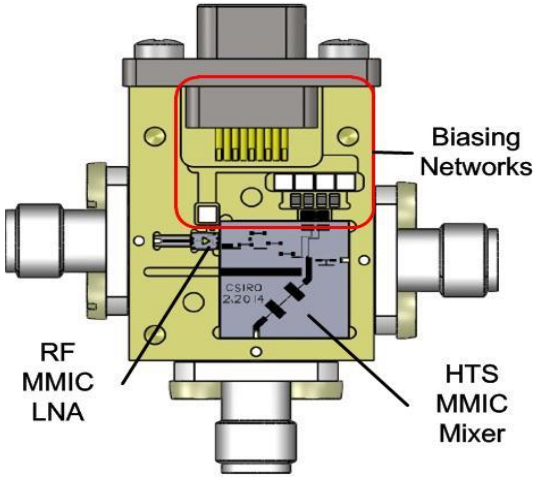
Room-temperature module

Sensitive compact RF system based on Superconductor Quantum Antennas


GEO
GEO
GEO
THz
~36,000km
THz
THz/FSO
THz
350~1,400km
THz/FSO
THz/FSO
Solar
power
satellite
LEO
LEO
LEO
LEO
THz/FSO/
MW/MMW
THz/FSO/
MW/MMW
THz/FSO/
MW/MMW
Optical fiber link

Advanced HTS Receiver Technology for Ka band high-speed, long-range communications

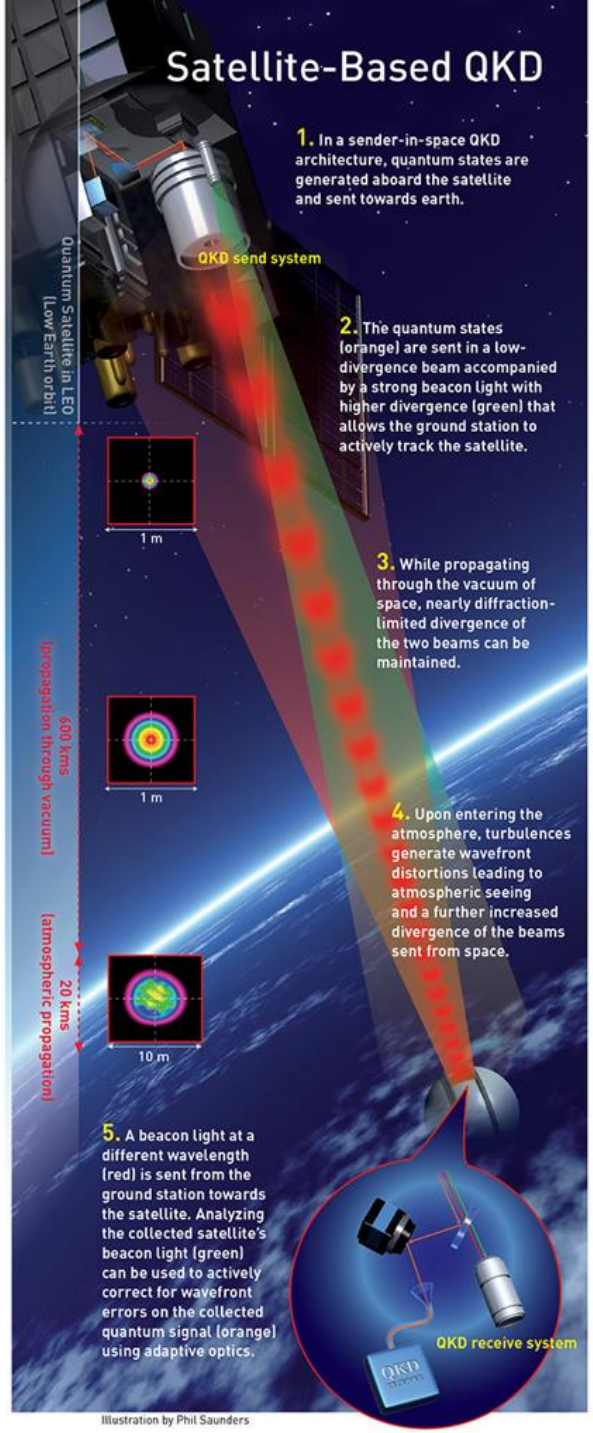
Demonstration of a HTS receiver integrated with a mini cryocooler – a cryogen-free portable instrument box



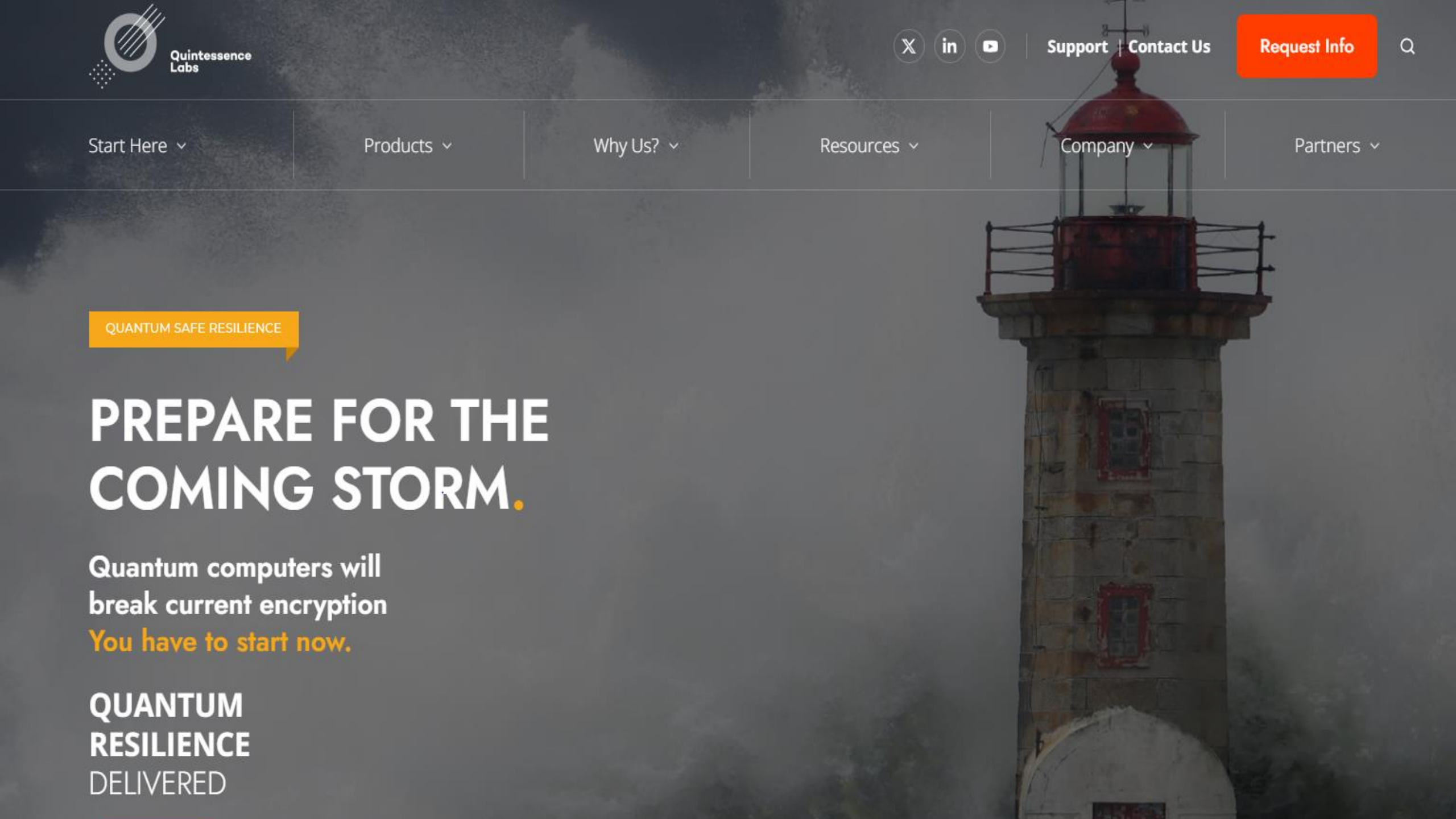
A CSIRO compact, high-gain (40 dB) and low noise (~ 0.1 dB) Ka band HTS receiver front-end module.

Zhang et al. *IEEE Trans Appl. Supercond*. **25** (2015) 1500404.
Du et al. *IEEE Trans Appl. Supercond*. **25**, (2015) 1400605.

Demonstration of 6G



Cyber security



QUANTUM SAFE RESILIENCE

PREPARE FOR THE COMING STORM.

Quantum computers will break current encryption
You have to start now.

QUANTUM RESILIENCE DELIVERED

Quantum Computing: Optimising Space Operations

A. Mission Planning and Optimisation

- **Orbital Mechanics**: Complex trajectory calculations for multi-satellite missions
- **Constellation Management**: Optimising satellite positioning and coverage
- **Launch Window Optimisation**: Maximising payload efficiency and success rates
- **Resource Allocation**: Balancing power, bandwidth, and computational resources

Quantum Computing: Optimising Space Operations

B. Data Processing and Analysis

- **Real-Time Earth Observation Processing**: Quantum algorithms for image analysis
- **Climate Modelling**: Enhanced weather prediction and climate science
- **Space Traffic Management**: Preventing collisions and optimising orbital slots
- **Signal Processing**: Improved communication and navigation systems

Quantum Computing: Optimising Space Operations

C. Autonomous Spacecraft Operations

- **AI-Quantum Hybrid Systems**: Intelligent decision-making in space
- **Fault Detection and Recovery**: Self-healing satellite systems
- **Formation Flying**: Coordinated multi-satellite operations
- **Deep Space Autonomy**: Independent operation for distant missions

Other areas

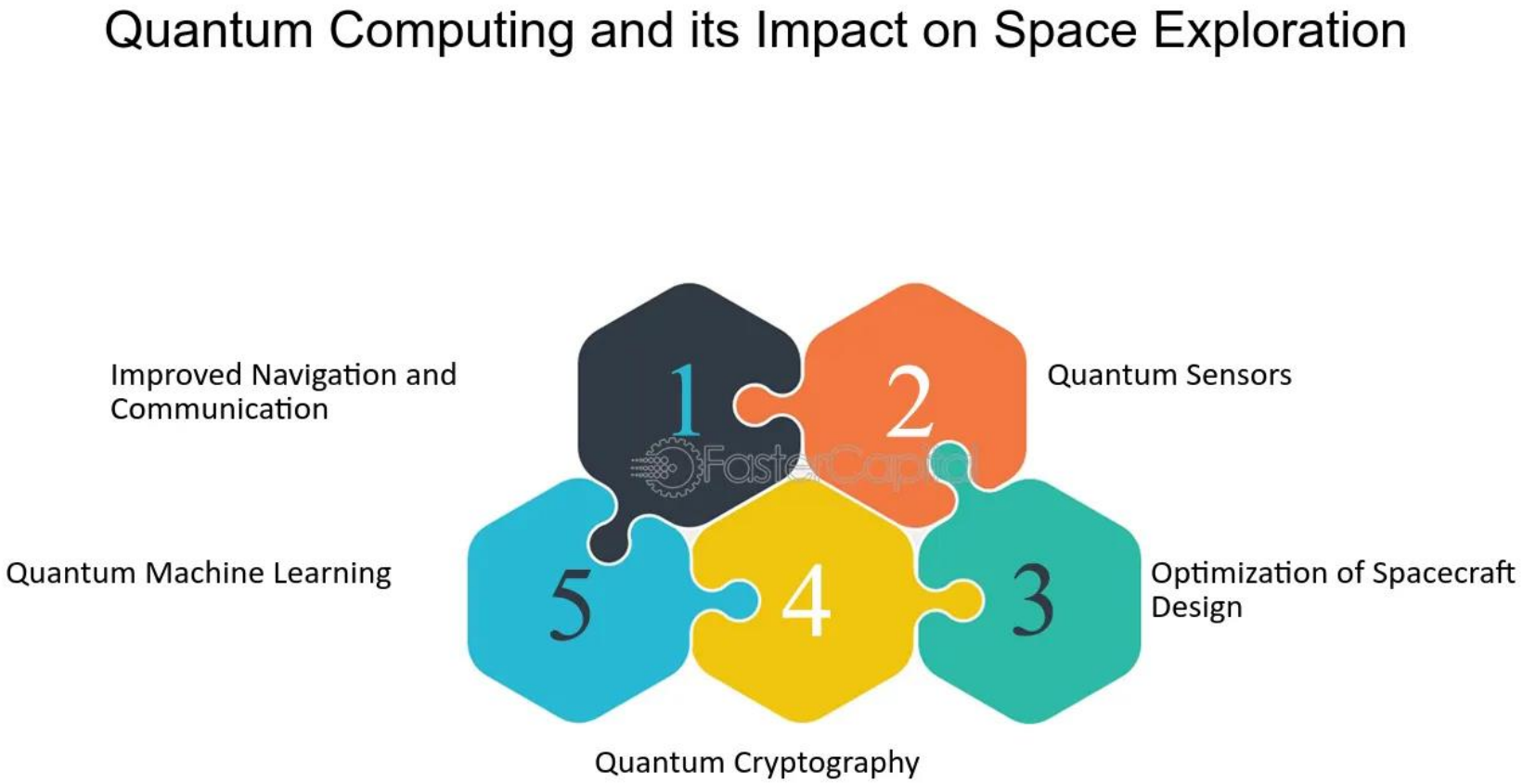
Modelling

Optimisation

Logistics

Design

Materials development



Technical Challenges and Solutions

A. Space Environment Considerations

- **Radiation Hardening**: Protecting quantum systems from cosmic radiation
- **Temperature Extremes**: Operating in the harsh space environment
- **Vibration and Launch Stresses**: Maintaining quantum coherence
- **Power Constraints**: Energy-efficient quantum systems

Technical Challenges and Solutions

B. Miniaturisation and Integration

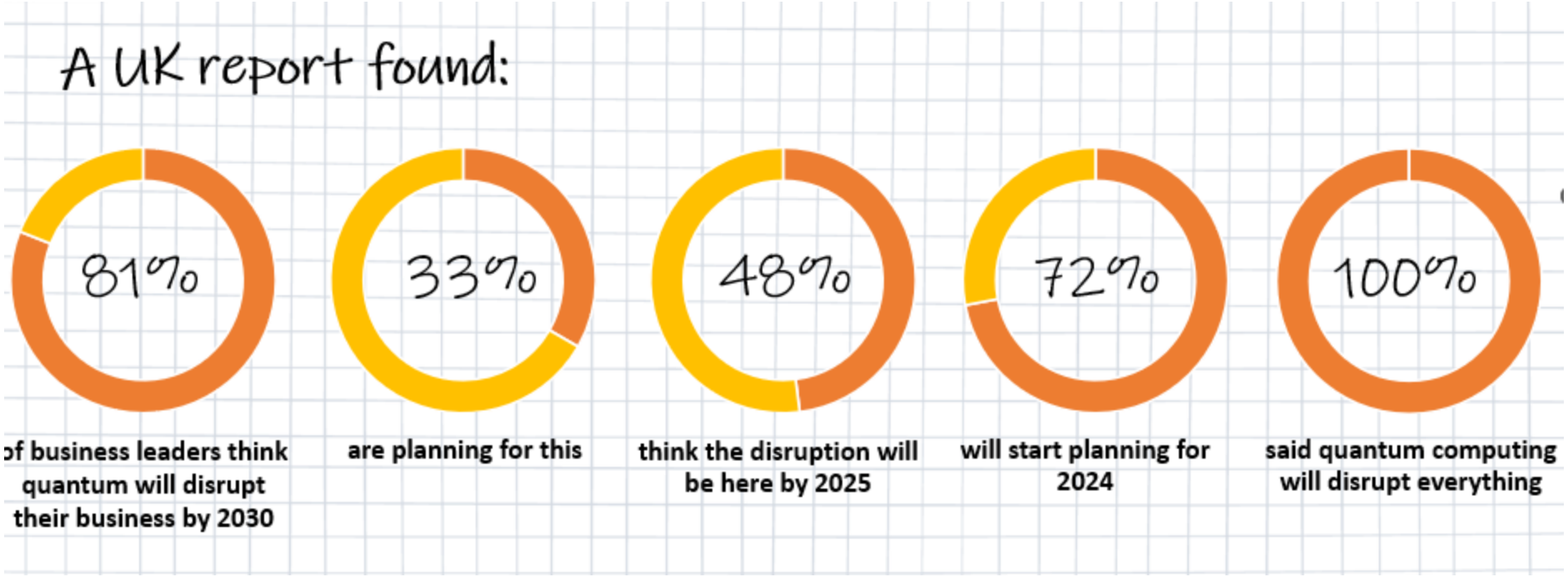
- **CubeSat-Compatible Quantum Systems**: Fitting quantum tech into small satellites
- **Weight and Size Constraints**: Optimizing for launch costs
- **Multi-Function Integration**: Combining quantum capabilities with traditional systems
- **Scalable Manufacturing**: Moving from lab to production

Technical Challenges and Solutions

C. Ground Infrastructure Requirements

- **Quantum-Compatible Ground Stations**: Upgrading existing facilities
- **Atmospheric Interference**: Mitigating effects on quantum signals
- **Precision Pointing Systems**: Maintaining quantum communication links
- **Network Integration**: Connecting space and terrestrial quantum systems

Quantum impact and readiness?



Today

- Could quantum tech help support the aero space and sustainability sectors?
- Looking for great ideas
- Start to link up the aerospace and sustainability sect
  - Speed dating
  - Fall in love?
- What are some specific projects?
- Where could these projects get funding?
- Are there business opportunities for any start-ups?


Thank you