Te Whai Ao
Dodd-Walls Centre
for Photonic and Quantum Technologies

# Quantum Solutions in Space

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# Quantum Communication

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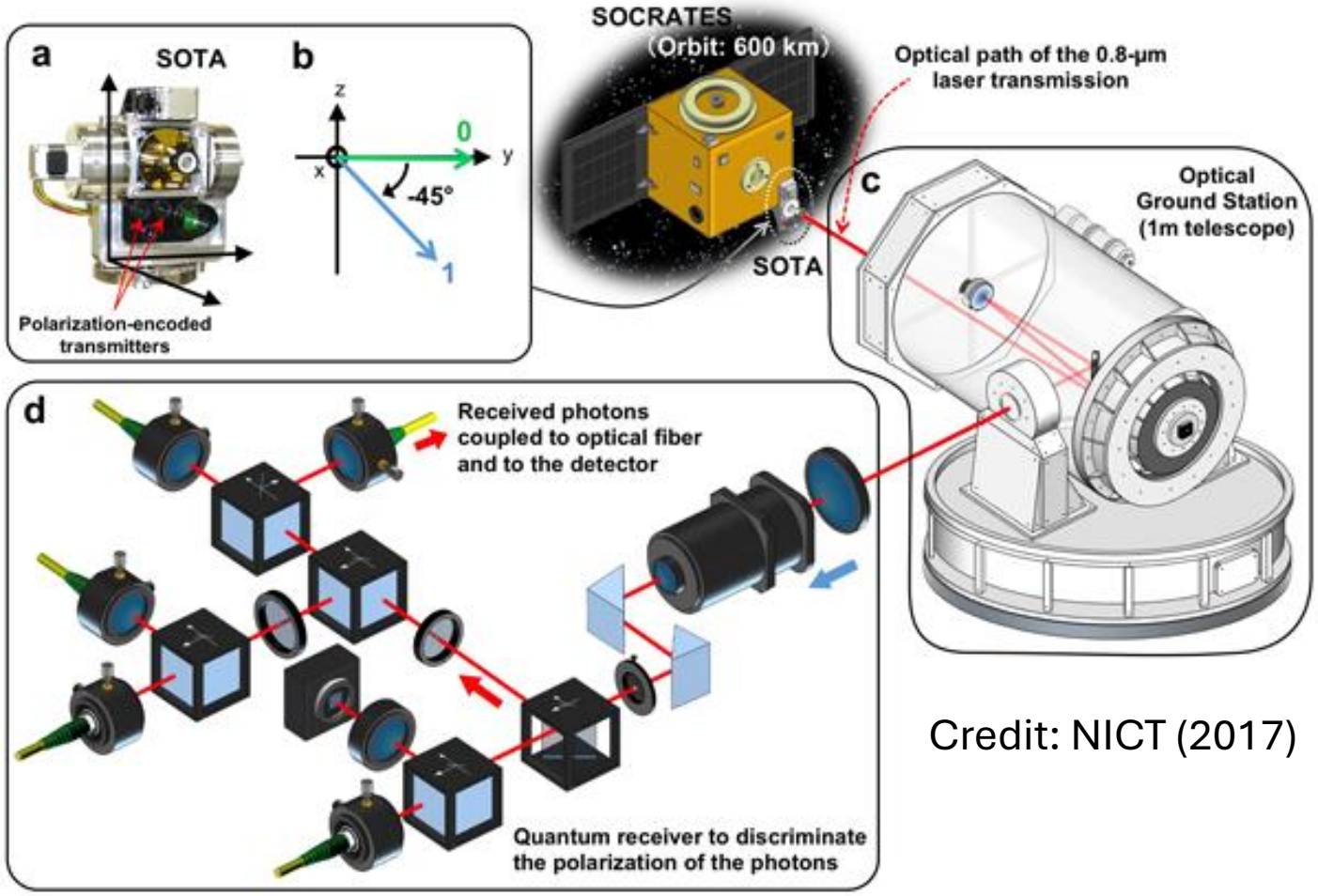
Quantum communication can be mathematically demonstrated to be secure, though implementations are not perfect

- A significant application is Quantum Key Distribution (QKD)
  - This uses the quantum properties of photons to distribute keys or one-time-pads for symmetrical cryptography, 2 main types:
  1. Using properties such as polarization to generate shared keys
  2. Distributing entangled photons
- Benefits of using photons: *Faster, more secure networking*
- QKD has limited transmission distances in fibre (~200km)
  - ➢ To overcome this, ‘free-space’ channels must be used

# Free-Space Optical Comms, FSOC

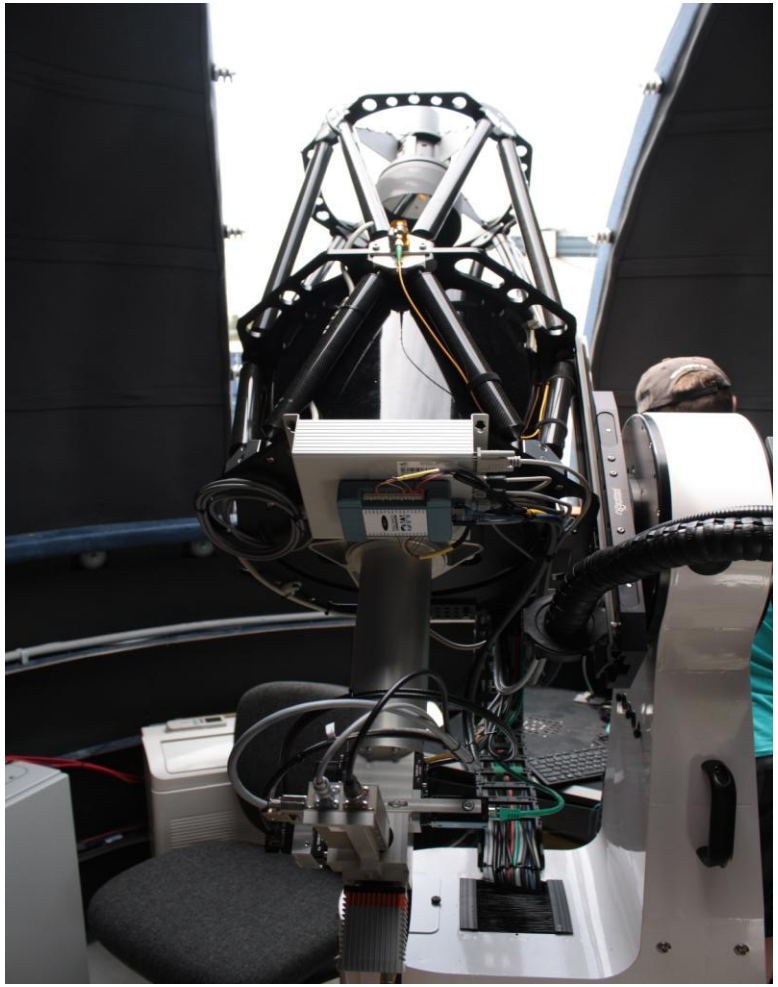
FSOC is a necessary precursor to satellite QKD




Credit: NICT (2017)

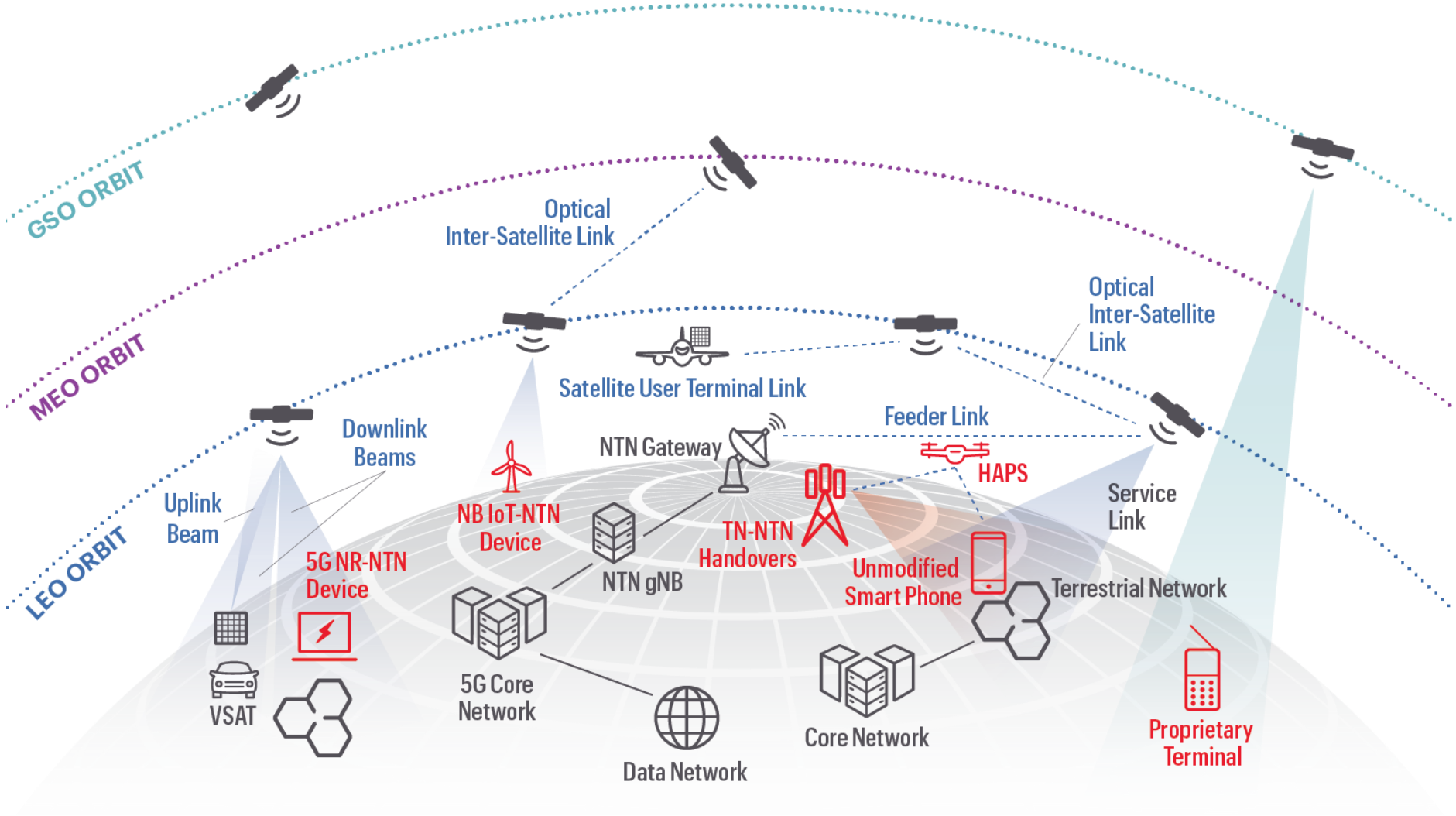
# FSOC in New Zealand

- UoA are working with ANU & the DLR to develop a trans-Tasman network
  - Atmospheric disturbances are a challenge
    - Adaptive optics developed at UC
  - The same infrastructure can be used for space domain awareness
- Rocket Lab has recently bought FSOC company Mynaric GmBH
- FSOC nodes also enable high precision timing/frequency transfer using bi-directional lasers



Taiaho Observatory. Credit: University of Auckland

# Quantum Network




Adapted from: https://www.keysight.com/us/en/cmp/topics/non-terrestrial-network-basics-advantages-and-challenges.html

# Quantum Sensing in Space

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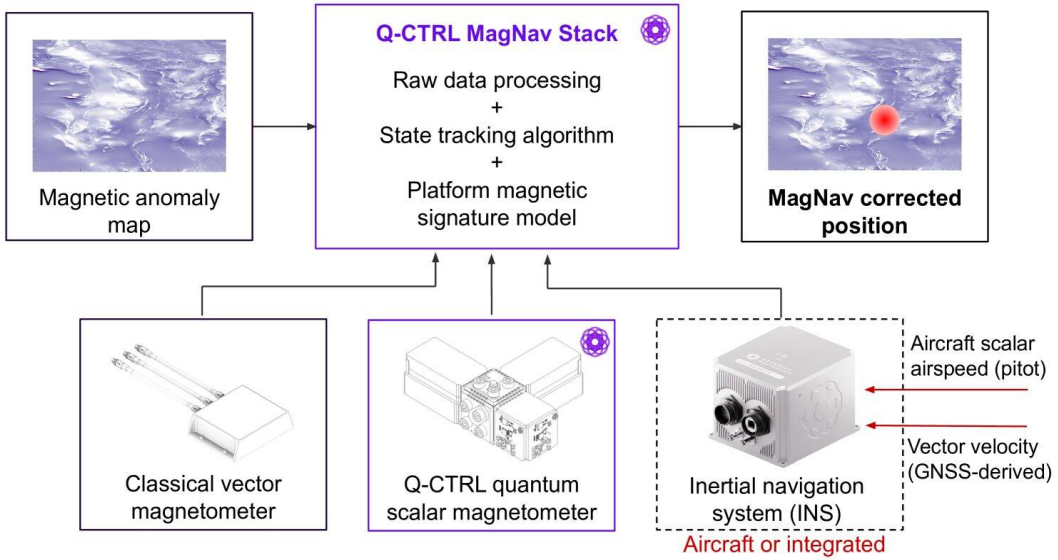
- Quantum Lidar uses quantum-linked-light (entangled photons) to illuminate objects
  - This can significantly reduce noise (from the atmosphere) and improve position/velocity accuracy, cf. classical lidar
  - Enhanced tracking of fast-moving objects with low reflectivity
  - Real-time 3D images have been acquired under water!
  - Quantum Radar uses microwaves (mostly uses quantum PNT)
- Fragile quantum states can be used to create extremely high sensitivity sensors for magnetic fields, temperature, gravity, etc.
  - Precise gravity measurements (using cold-atom interferometry) can map small changes in sea levels, or detect underground minerals

# Positioning, Navigation & Timing

- Quantum accelerometers and gyroscopes enable GPS-free precision navigation:
  - These devices exist using cooled atoms trapped by lasers, but require miniaturisation
  - Can be used underwater and in space
- Alternatively, quantum sensors can also be used to enhance location accuracy
- Benefits: *More precise, localised quantum positioning systems*




Credit: *arXiv* (2025). DOI: 10.48550/arxiv.2504.08167

# Quantum States in Space

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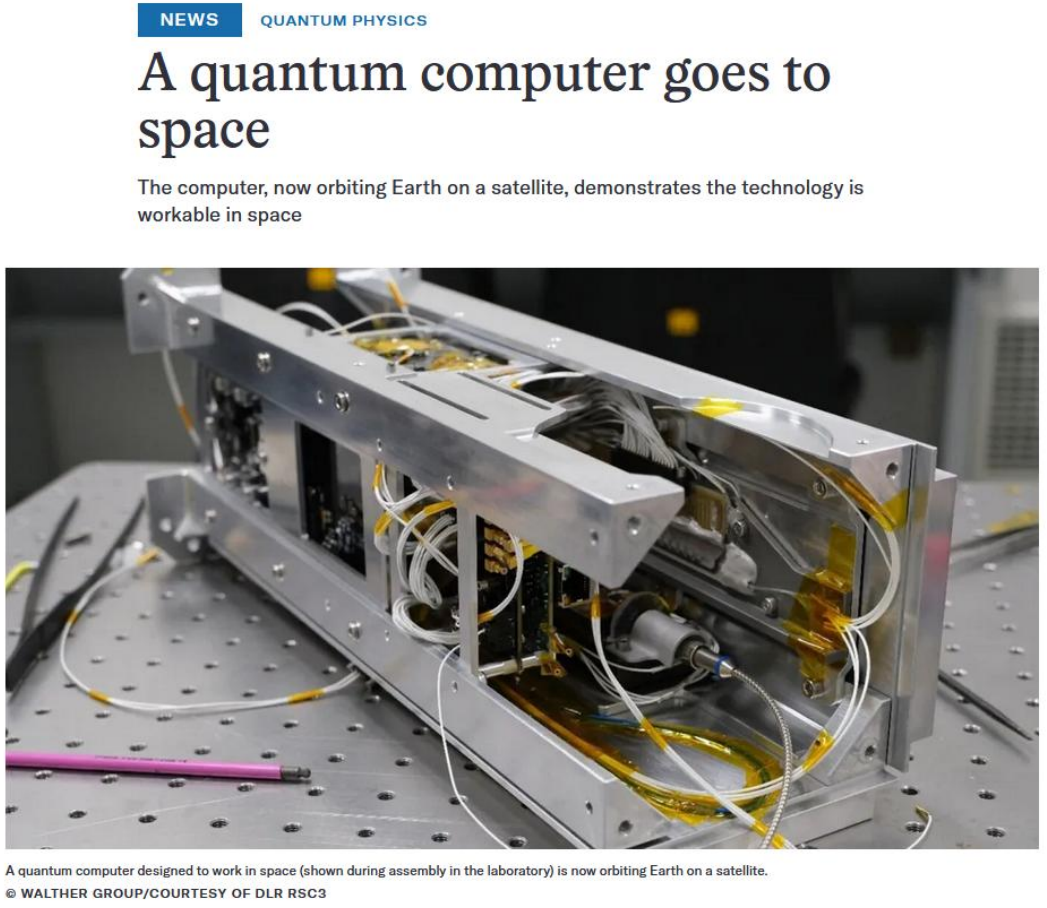
- Miniaturised cryocoolers enable superconducting magnets in space
  - e.g. Heiki mission from Pihau - Robinson Research Institute at VUW
- These also allow quantum states to be maintained:
  - ➢ Quantum computing
  - ➢ Neuromorphic computing (UC)
- Benefits: On-orbit processing of data, generation of entanglement



NEWS QUANTUM PHYSICS

A quantum computer goes to space

The computer, now orbiting Earth on a satellite, demonstrates the technology is workable in space

A quantum computer designed to work in space (shown during assembly in the laboratory) is now orbiting Earth on a satellite.

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