Quantum Technologies @ Leonardo Labs

Massimiliano Proietti

Massimiliano Dispenza

Alberto Bianchi

Electronics

Helicopters

Aircraft

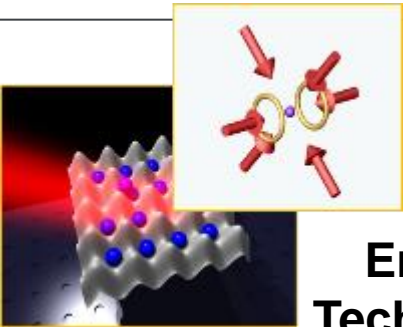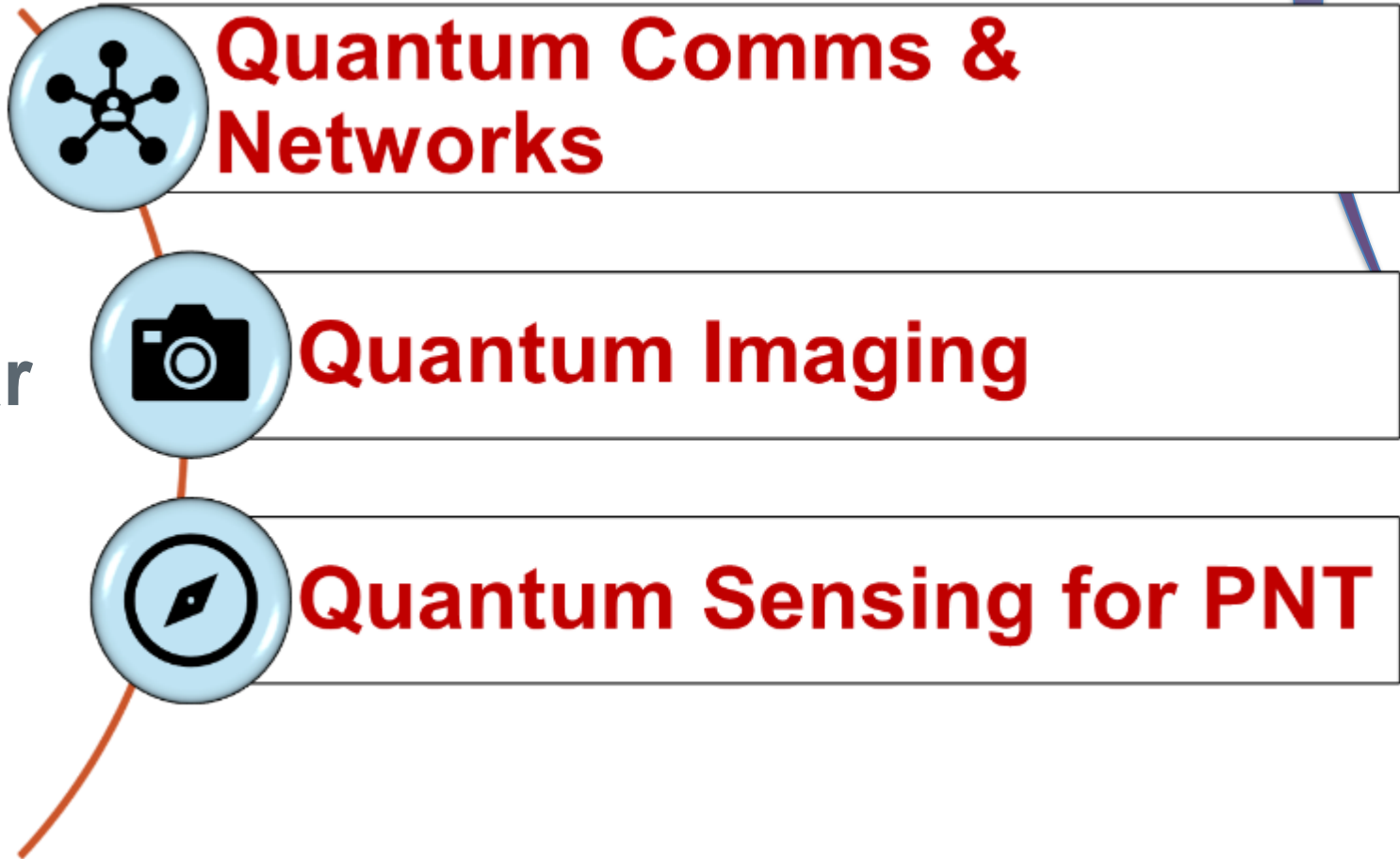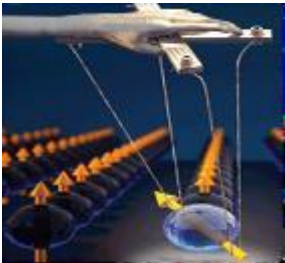Cyber & Security

Space

Unmanned Systems

Aerostructures

Quantum Technologies Research Lab

3 Research Units

- Quantum Comms & Networks
- Quantum Imaging
- Quantum Sensing for PNT

Enabling Technologies

Manipulation Techniques

Products

Quantum Technologies Search Areas

- **Quantum communications and networks**

Integrated components such as quantum key distribution devices and quantum random number generators, the building blocks of the large quantum networks secure solutions

- **Quantum Imaging**

Quantum imaging solutions based on quantum entanglement to detect distant targets with better resolution and coverage, as well as devising quantum imaging techniques for seeing around corners or behind obstacles.

- **Quantum Sensing for Positioning, Navigation and Timing (PNT)**

Next generation miniaturised atomic clocks based on quantum principles, for improved accuracy and stability in security applications.

Q Comms & Computing   *Q Imaging & PNT sensing*

EDA PADR QUANTAQUEST
Topic: Quantum Communication & Sensing for Defence
Partner: Thales (FR - Leader), Leonardo, CNRS (FR), Telespazio, UniPD, CNR, Lionix BV (SME-NL), QuiX BV (SME-NL), Thales Alenia Space France (FR)

EC Project EuroQCI GROUND SEGMENT - OQTAVO
Topic: Terrestrial Segment per una Infrastruttura di Quantum Communication Europea
Partner: Airbus (FR - Leader), Leonardo, Telespazio, CNR (FR), INRIM, Orange (FR), PwC (FR)

ESA Project EuroQCI SPACE SEGMENT - SAGA
Topic: Space Segment per una Infrastruttura di Quantum Communication Europea
Partner: OHB (D), Thales Alenia Space Italia (Leader), Leonardo, Telespazio, Thales Alenia Space France, Thales Alenia Space Switzerland (CH), Fraunhofer HHI (D), ecc.

DIGITAL EUROPE: QUID
Topic: Deployment of Italian Quantum Comms Infrastructure
Partners: INRIM, ASI, CNR, Leonardo, Telecom, Telespazio, TAS-I, UNIRM1, UNINA, UNITS, …

PNRM Q4SEC
Topic: A national Supply chain for per Quantum Communication Components and Systems
Partner: Leonardo, Telespazio, Telsy, UniPD, UNiRM1 (FISICA), INRIM, CNR

Italian Recovery Fund (PNRR): National Quantum Science and Technology Institute
Topic: Italian Quantum Supply Chain from Basic Research to Technology Transfer

LEONARDO Solvers Wanted Challenge
Contract 1: **Noisy Photonic Quantum Computing**
Partner: Univ. Trieste

EDF Quantum Sensing: ADEQUADE
Topic (for LDO): Quantum Sensing for Optronics and PNT (Quantum Clocks)
Partner (33): Thales (FR), Leonardo (IT), Diehl (GER), Telespazio (IT), MBDA (IT/FR), Elettronica (IT), INRIM, CNR, TNO (NL), Fraunhofer (D), etc.

EDA: Project QUANDO
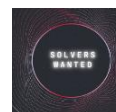Contract 1: Quantum Technologies for Defence in Optronics sensing
Contract 2: Quantum Technology for Defence in RF sensing
Partners: CNR, Leonardo, Thales, Onera, Hensoldt, Flyby, DLR

HORIZON EU: MUQUABIS
Topic: Quantum Ghost Imaging for New Vision Systems
Partner: CNR, Max-Planck Institute (GER), Leonardo (IT), Hebrew University of Jerusalem (ISR), Element6 (UK), etc.

LEONARDO Solvers Wanted Challenge
Contract 2: Quantum Radar / Lidar
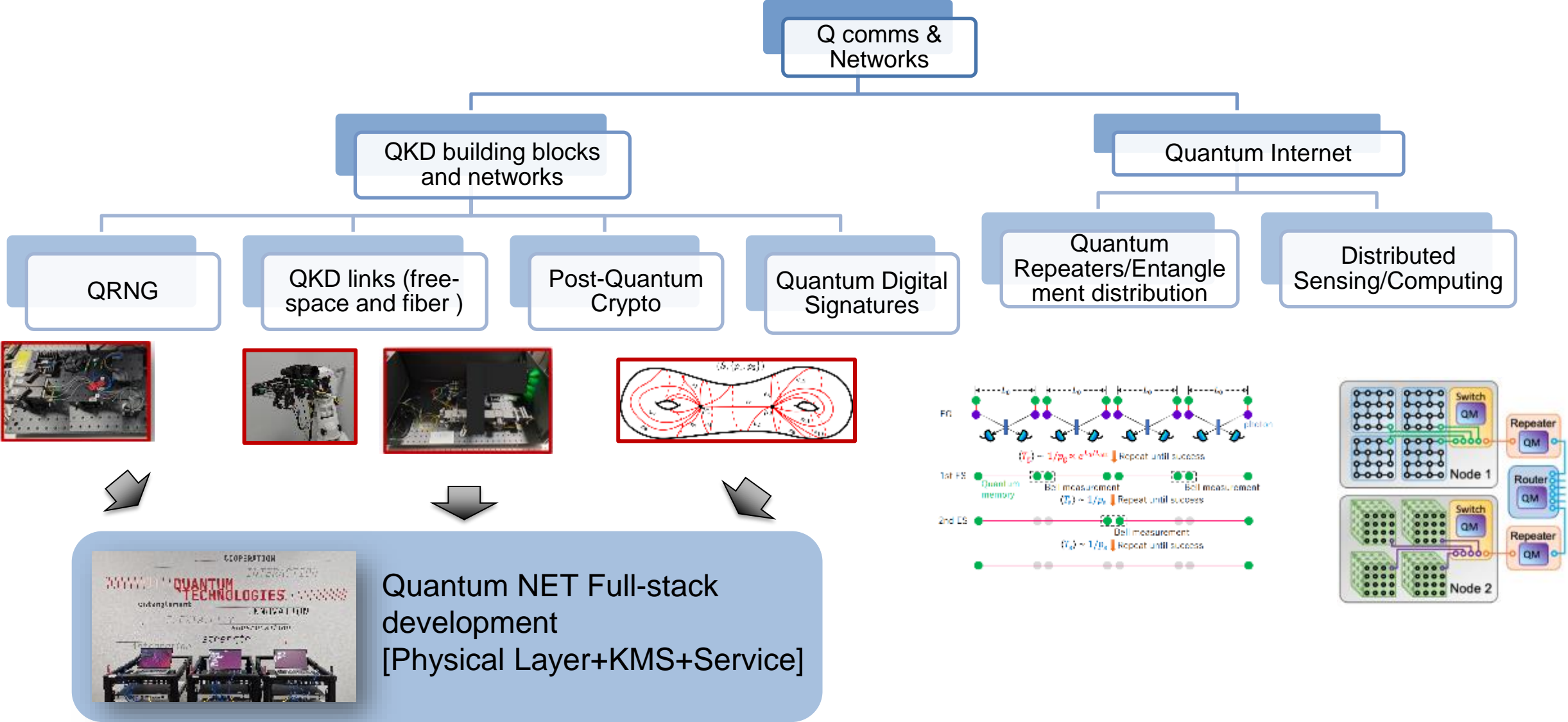Partner: CNIT-RASS

MoD-IT Funded Programme
Focus Topic : Miniaturised Quantum Clocks for Airborne
Partner: Leonardo, GEM-Elettronica

Italian Recovery Fund (PNRR): National Quantum Science and Technology Institute
Topic: Italian Quantum Supply Chain from Basic Research to Technology Transfer

Quantum Comms & Networks

Q comms & Networks

- QKD building blocks and networks
  - QRNG
  - QKD links (free-space and fiber)
  - Post-Quantum Crypto
  - Quantum Digital Signatures
- Quantum Internet
  - Quantum Repeaters/Entanglement distribution
  - Distributed Sensing/Computing

Quantum NET Full-stack development [Physical Layer+KMS+Service]

Quantum Comms Systems towards integration: from Quantum devices to deployed Networks

Fully Integrated Quantum Comms Equipments

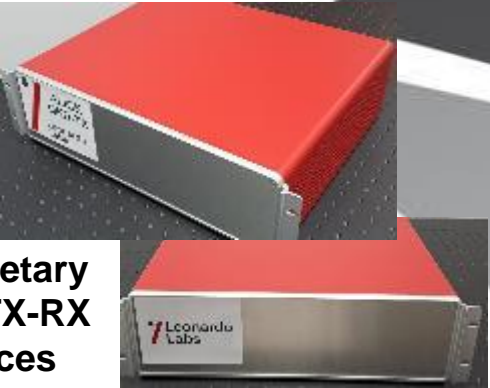**Post Quantum Crypto Algoritms integrated with QKD**

Free Space QKD
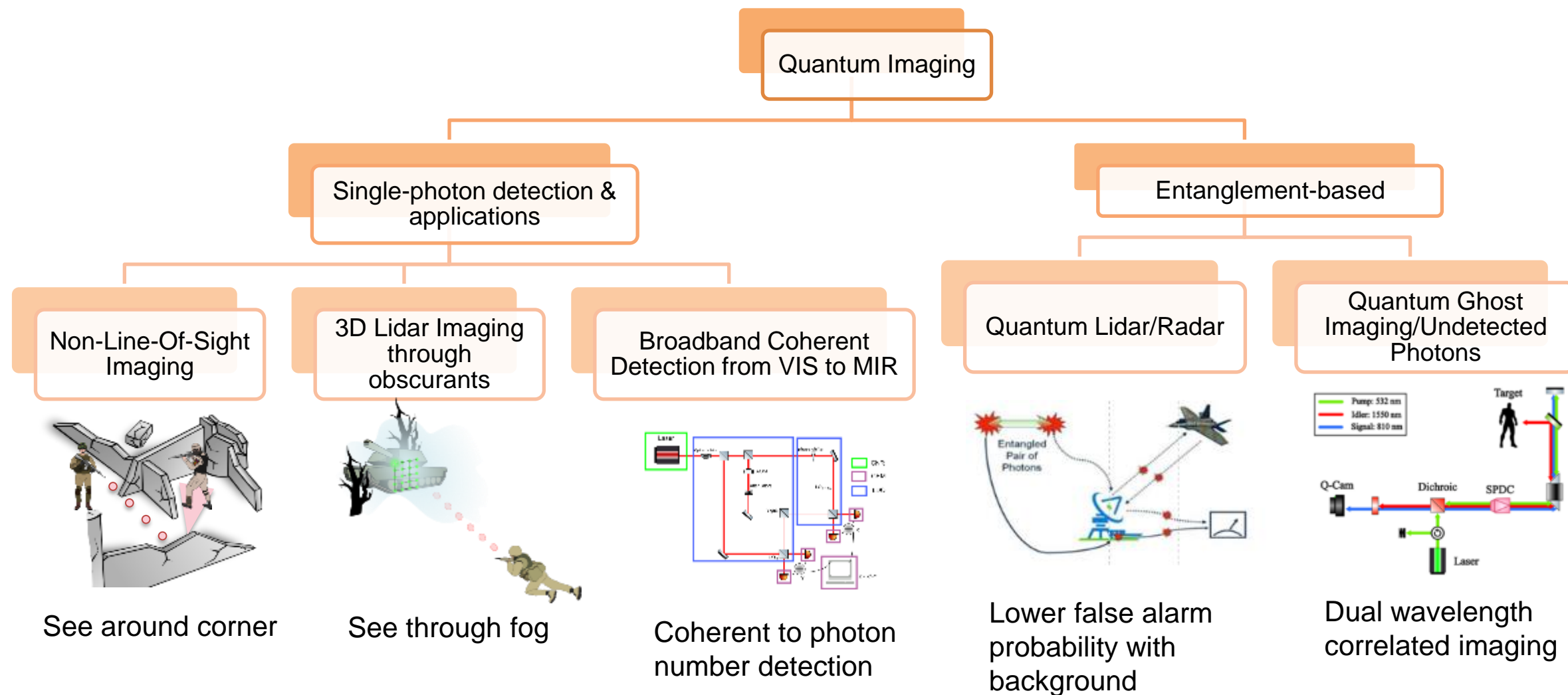
Italian Quantum Backbone

Proprietary QKD TX-RX devices

QMAN (Quantum Metropolitan Area Network) deployed in Rome, connecting Leonardo/ Telespazio plants
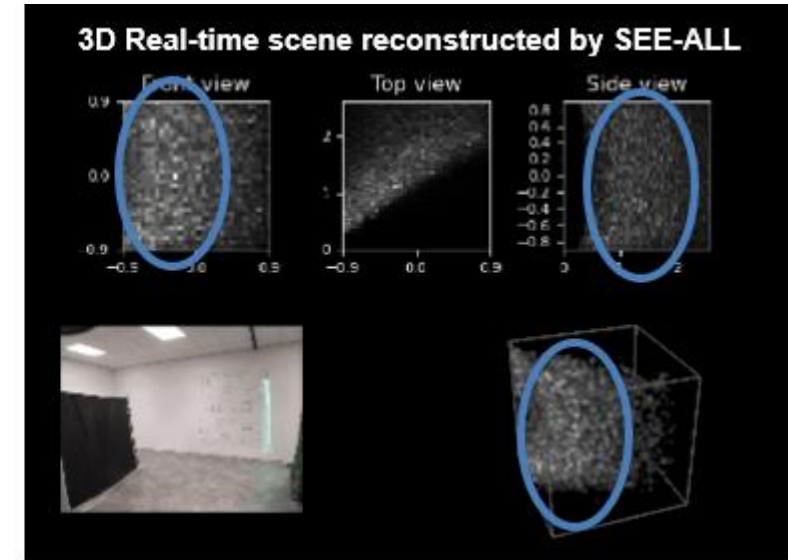
Quantum Imaging

Quantum Imaging

Single-photon detection & applications

Entanglement-based

Non-Line-Of-Sight Imaging

3D Lidar Imaging through obscurants

Broadband Coherent Detection from VIS to MIR

Quantum Lidar/Radar

Quantum Ghost Imaging/Undetected Photons

See around corner

See through fog

Coherent to photon number detection

Lower false alarm probability with background

Dual wavelength correlated imaging

Leonardo SEE-ALL System: seeing behind obstacles + through obscurants (fog, dust, smoke, …)

SEE-ALL system

CURRENT STATUS:
- One **single module / dual function:** behind walls + through obscurants
- **3D** reconstruction of R**eal-time** Video of moving Objects / Persons
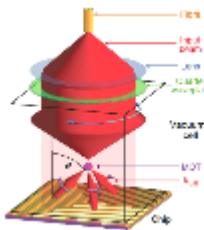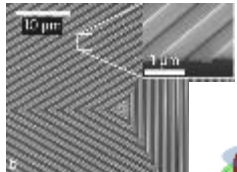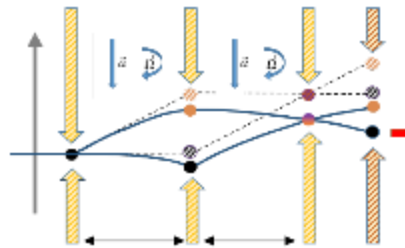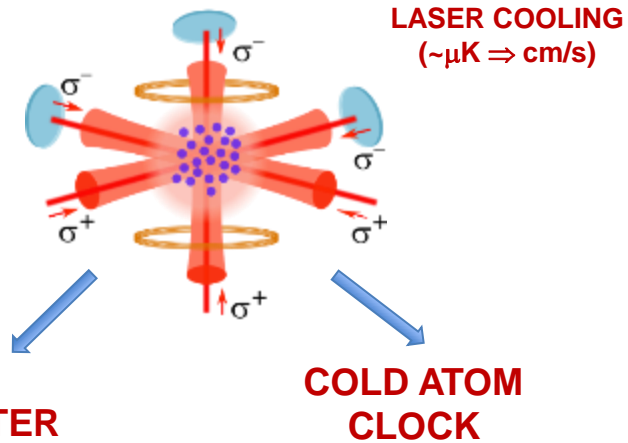- Mounted on **mobile platform**

Quantum PNT

Quantum PNT
├── Quantum Clocks
│   ├── Quantum enhanced Atomic Clocks
│   ├── Miniaturised Cold-atoms Clock
│   └── Microwave to Optical converter
└── INS
    ├── Inertial Navigation System
    └── Hybrid atom-light gyroscope

Target high performance clock for long term stability

Target low SWAP also including PIC

Compact and novel systems to link optical and microwave frequencies

Integration of clock, accelerometer, gyroscope

Novel quantum-enhanced gyroscope

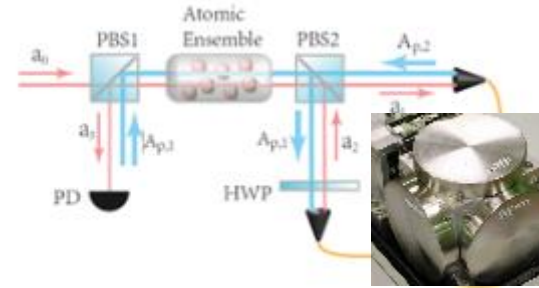# Rb atom as common platform for Quantum IMU – Clock – FOG Integration

COLD ATOMS TECHNOLOGY

LASER COOLING
($\sim\mu K \Rightarrow$ cm/s)

COLD ATOM ACCELEROMETER

COLD ATOM CLOCK

RUBIDIUM BASED HYBRID INTERFEROMETER

QUANTUM ENHANCED FOG

QUANTUM BASED GNSS-INDEPENDENT
INS (Inertial Navigation System)

Planar diffraction grating ⇨ integrated g-MOT

Physics Pkg Design View

- **Cold atoms as a common technology platform** for IMUs and Atomic Clocks development
  - LEONARDO – GEM elettronica synergy as a distributed lab
  - SWaP minimization by sharing:
    - Same Rb platform
    - optical sources for cooling, trapping and atom manipulation
    - Magneto Optical Trap compact solutions (g-MOT chip)
    - PIC (Photonic Integrated Circuits) for optical integration and other miniaturization solutions
- Embedded **Atomic Clock** allows operation in **GNSS denied environment**
- Same **Atomic Clock** can be exploited for **Bi-Static radars to be synchronised and operate**

Leonardo Labs
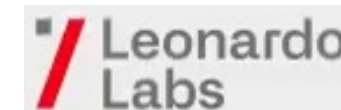
Leonardo Quantum Technologies Lab

- Large Lab Facility in Rome
- >20 researchers including PhD and Master students
- >10 EU and National funded projects

Chips JU collaborations - Position, navigation and timing (PNT)

- PNT systems have an impending **challenge** of:
  - Power consumption reduction and portability
  - Performance stabilization

- **Integrated photonics** intervenes in:
  - Laser signal **generation, stabilization and manipulation**
  - Out-of-plane imaging (**diffractive gratings**) for Magneto Optical traps

- Project proposed: large European consortium in **Quantum JU Pilot Line call**
  - Leading quantum start-ups & companies
  - Leading photonics RTO and companies

THANK YOU
FOR YOUR ATTENTION

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