BERLIN SCIENCE WEEK.COM 1–10 NOV 2016

Flagship Quantum Technology Industry contribution

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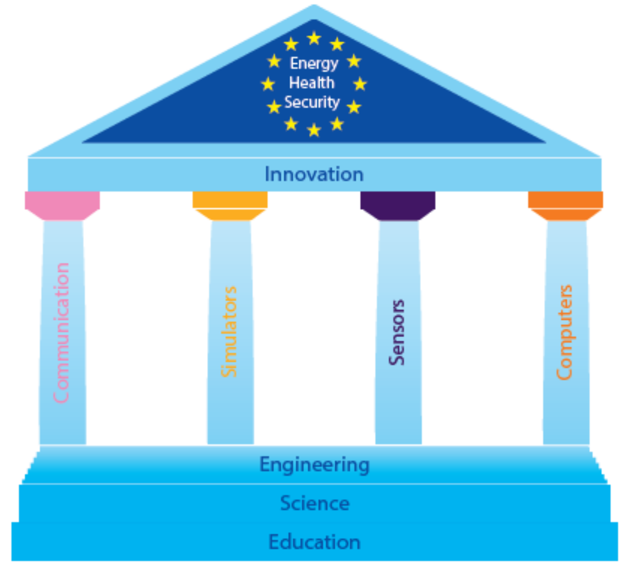
Quantum technology Flagship

- Quantum Manifesto:
  - Computing,
  - Simulation
  - Communication
  - sensing



- “*Now I see a new challenge ahead of us: to turn our scientific successes into benefits for our industry and society, while also maintaining our world-class scientific excellence*”.

  G. Oettinger, Commissionner for Digital Economy & Society
  Amsterdam, May 17, 2016

- A strong collaboration industry / academia is required

Community consultation

- Academia consultation
- Industry consultation
  - Airbus, ATOS, Bosch, e2v, IBM Zurich, IDQuantique, Innovate UK, MuQuans, Qubiz, Single Quantum, Thales, Toptica, Toshiba UK, Wellington Partners, 3-5 lab
- Mostly sensors, communication and enabling technologies

- Presented to the HLSC (Berlin Nov 10, 2016)

Industry motivation

- New products resulting from basic research
  - Improved performances
  - New functionnalities with no classical counter-part
- Various applications:
  - gravity, accelerations, rotations
  - Time & frequency
  - Magnetic and electric field
  - RF spectral analysis ...
- Several markets to address :
  - aerospace, defence & security, medical, geophysics, industrial metrology…
- Operational exploitation of these quantum technologies still remains at a very early stage today

Requirements

- Technical
  - Performances : sensitivity, stability, accuracy
  - Robustness vs environmental conditions.
  - Mass & compactness, transportability
  - Low electrical power consumption
- Product
  - cost-efficiency,
  - reliability,
  - manufacturability

- Performances are not necessarily the most important factor for a commercial success

Market

- Market accepting high cost for technology with unique unprecedented performances (space, defence)
  - First small volumes market
  - Larger markets in a second step

- Need for well-focused application-oriented projects with high level of maturity
  - Industry led projects involving industry / academia collaboration

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Synergy academia / industry

- Convergence between technology push (academia) and market requirements (industry)
  - Develop a complete value chain between research and product
- Cross fertilization between the pillars and different level of maturity between them
  - Early developed technology as an asset for long term developments
- Develop a complete ecosystem including education
  - Training of quantum engineers

Computing and simulation

- hardware
  - Start with small-scale quantum systems
    - logical qubits, simple molecular simulations
  - Show quantum advantage in medium-size applications
    - quantum simulation, quantum optimization
  - Develop test beds for universal quantum computers
- Software
  - Develop a quantum software platform
  - Further develop understanding of quantum information
    - algorithms, complexity classes, error correction codes
- Challenges: scalability, control and coherence of large systems, cost

Quantum Communications

- 5 – year vision
  - European network usind trusted nodes
  - Multiple users connectivity
  - Integration with conventional infrastructure
  - Combine QKD and quantum resistant algorithms
- 10 – year vision
  - Long distance QKD based on quantum repeaters
  - Intercontinental QKD based on satellites
  - Device independant implementations
  - Distributed quantum computing

Quantum sensing

- **Objective**:
  - full commercial deployment of first generation quantum sensors exploiting coherence properties of the elementary quantum system
- Inertial sensors
  - field and airborne/seaborne gravity and gravity gradient sensors,
  - Inertial sensors for navigation : 3D accelerometers, gyroscopes
- Time & frequency :
  - European CSAC
  - High performance microwave clocks (CPT, cold atom based)
  - Optical clocks
  - European frequency transfer network
- Magnetic field :
  - Compact atom vapor and NV centers magnetometers
  - Array of magnetic sensors for magnetic imaging

Enabling technologies

- Laser technologies
  - Improved laser sources (spectral characteristics, robustness…)
  - Integration of advanced optical functions on a photonic circuit
- Integrated experience chambers
  - Atom chips
  - Atom cells
  - More compact vacuum chambers
- High quality material (e.g. low cost diamond)
- Electronics & microwave
  - Improved power consumption
  - Reduced mass and volume
  - High performance DAC/ADC
- Signal processing
  - Data fusion
  - Real-time processing

Conclusion

- Very promising perspectives in many domains of application
- Importance to demonstrate economic impact at the end of the flagship
- Very significant R&D effort to conduct for a full deployment of 1st generation quantum sensors
- Collaboration between industry and academic research will be key to our success