



# New Mexico is a Quantum State:

Development of Sandia's QIS program

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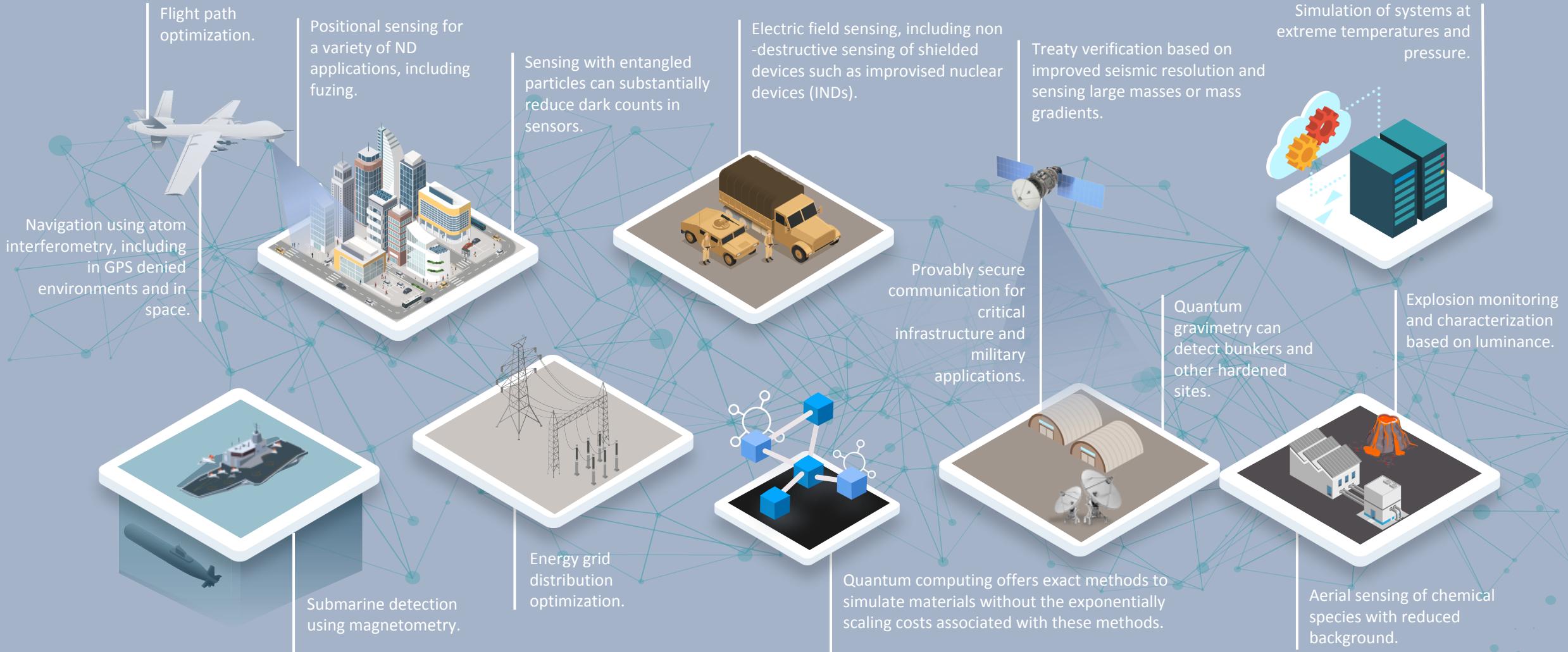
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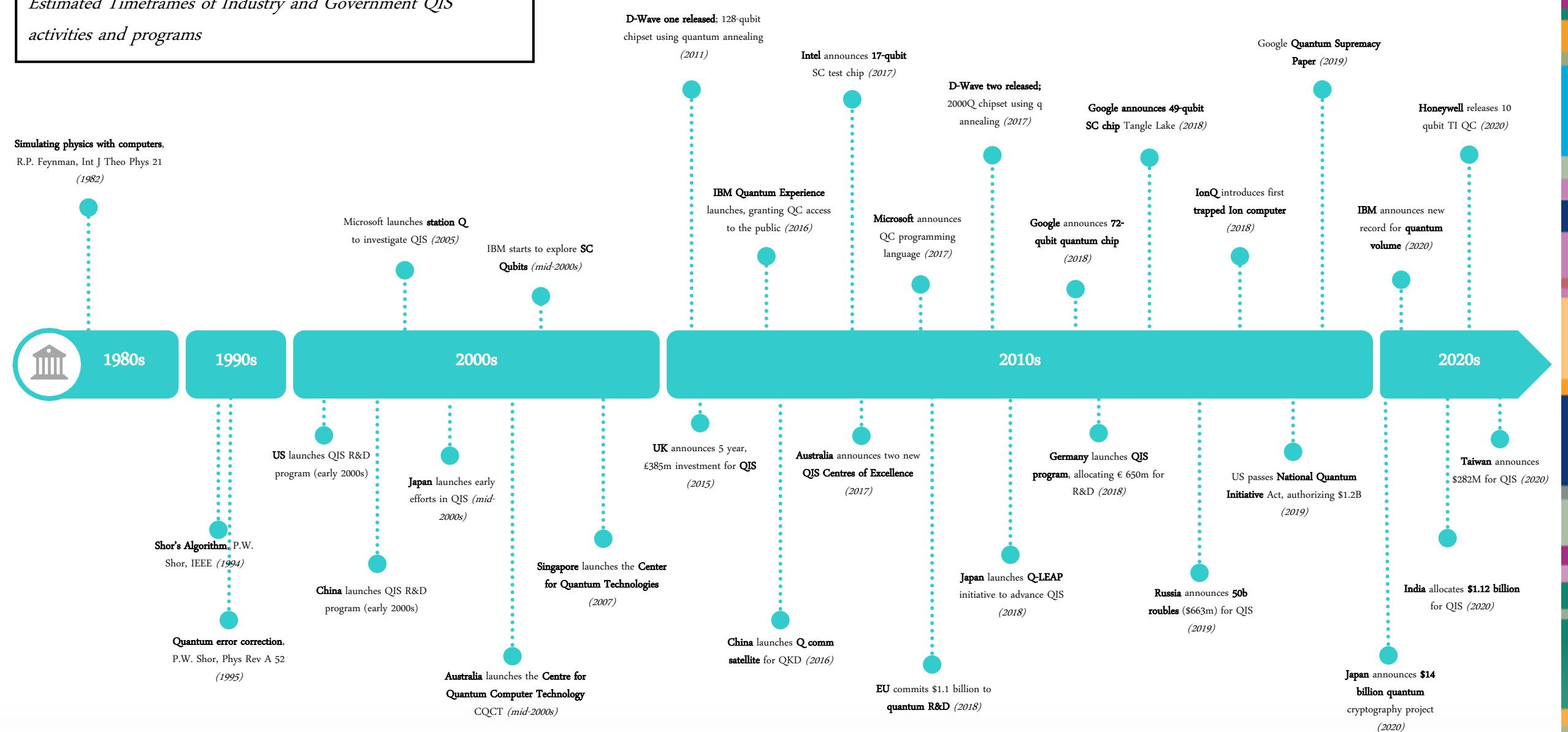
# QIS Impacts Many Key Areas of National and Economic Security

*Prevent strategic technological surprise associated with quantum sensing, computation, and communications*



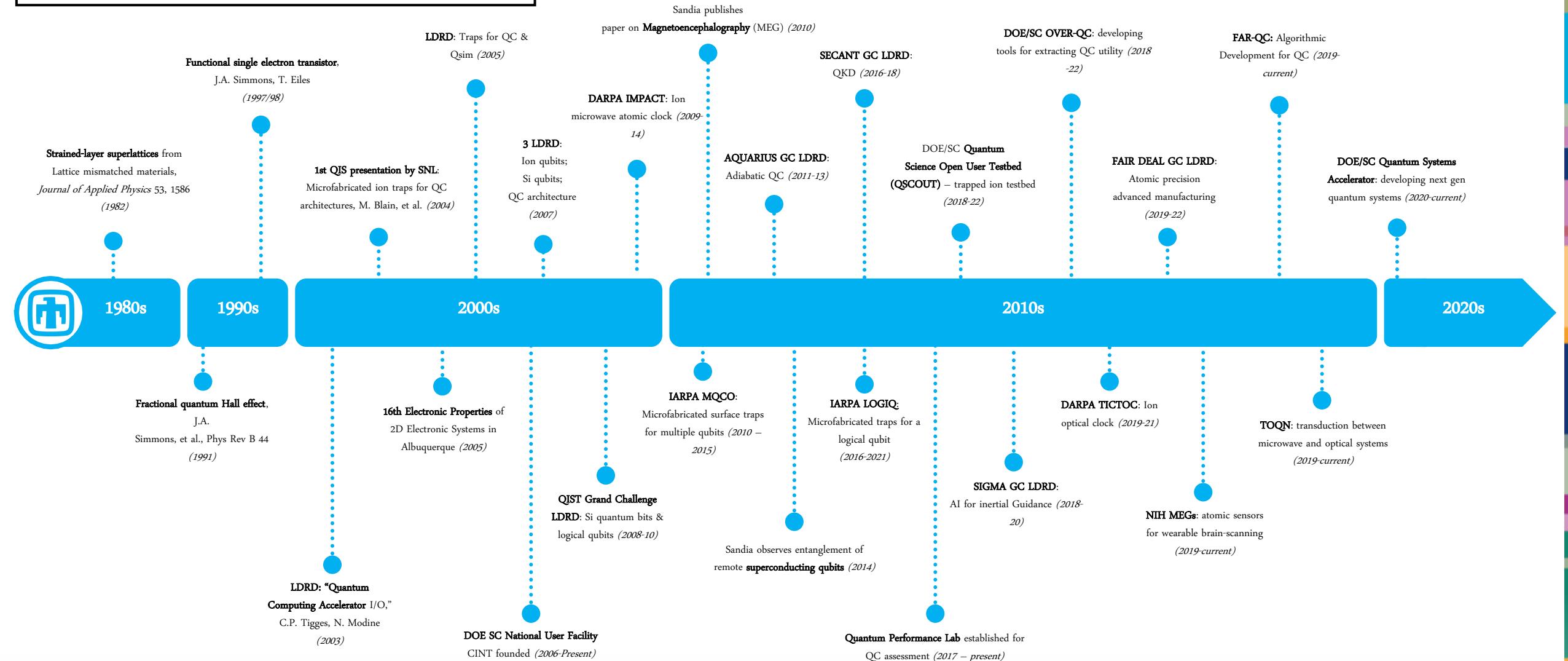
# INDUSTRY AND GOVERNMENT QIS TIMELINE

*Estimated Timeframes of Industry and Government QIS activities and programs*



# SANDIA QIS R&D TIMELINE

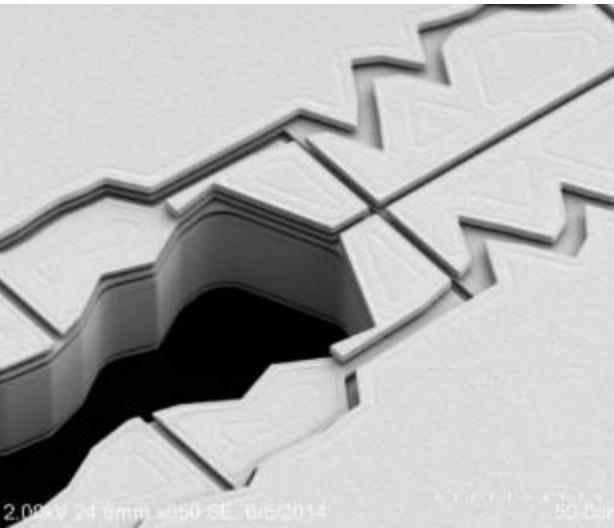
*Estimated Timeframes Sandia QIS activities and programs*



# IARPA Ion Trap Foundry



- Sandia is the world leader in design and realization of microfabricated (MEMS) ion traps, used by the leading ion trapping groups worldwide
  - Development of surface trap by Tigges and Blain
  - Two key IARPA projects: MQCO & LOGIQ
- “Plug and Trap” - standardized package compatible with many chambers
- “known good trap” - eases deployment



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# Sequential GCs Built Sandia QIS Foundations



**FY08 – FY10**  
*Si-based qubits*



**FY11-FY13**  
*Alt. Architecture*



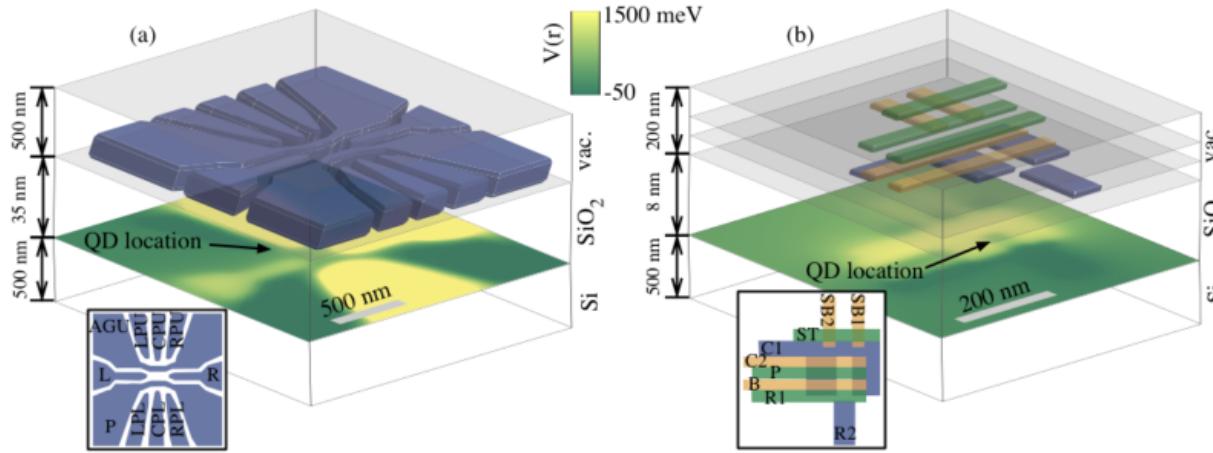
**FY14-FY16**  
*Comms/QKD*



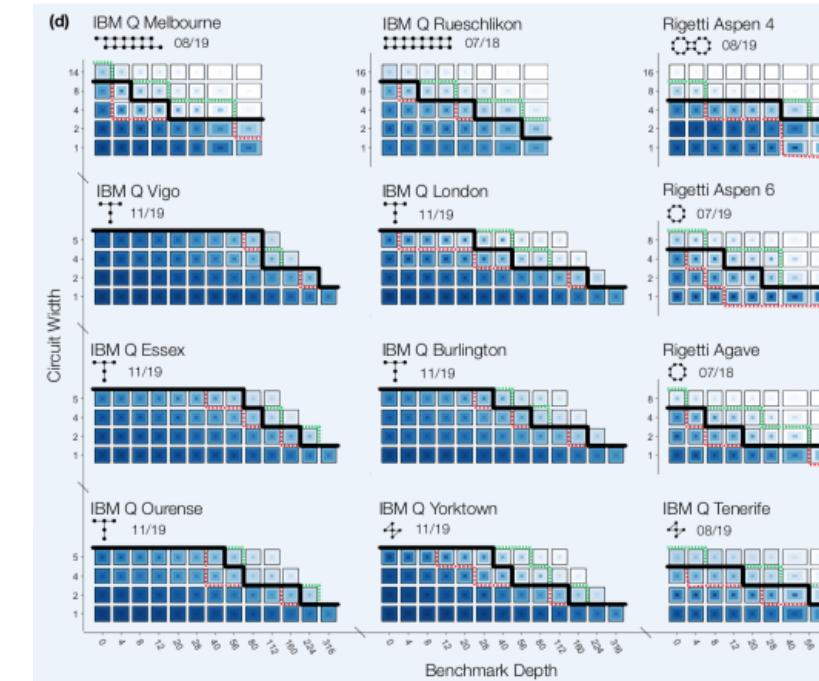
**FY18-FY20**  
*Atom Interferometer*

- Silicon quantum dot qubits
- Architecture & logical qubit design
- Adiabatic architecture assessment
- Atomic precision lithography development
- Neutral atom computation
- Quantum key distribution development
- Photonic communications/networking development
- Develop deployable quantum devices
- Quantum sensing based location determination

# Modeling and Characterizing Quantum Processors



Sandia has developed an extensive **quantum device modeling effort** for different platforms and at different levels of operations that guides the development of quantum devices and the interpretation of quantum experiments.



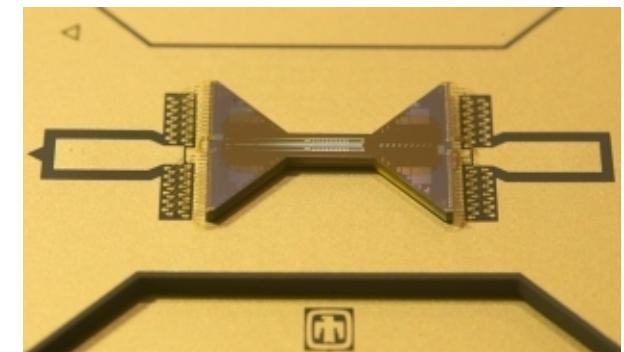
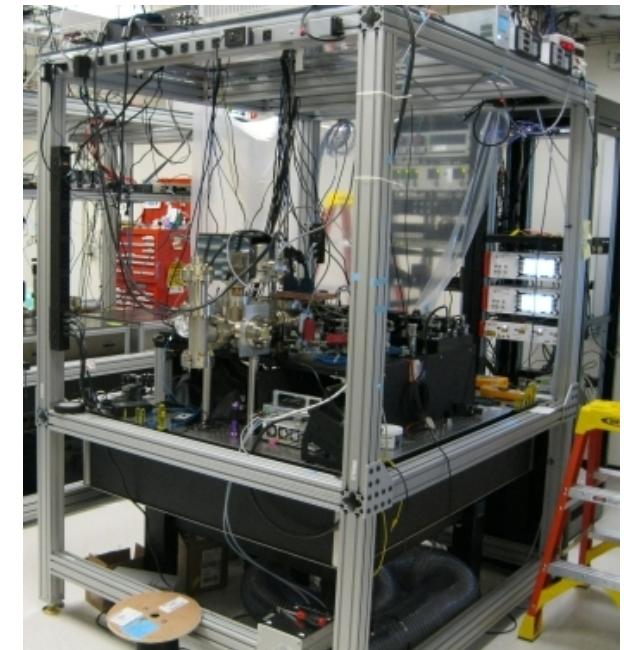
The **Quantum Performance Laboratory** provides tools and technologies to characterize qubits, benchmark quantum processors, and analyze the sources and types of errors that occur in quantum devices.



# Quantum Scientific Computing Open User Testbed

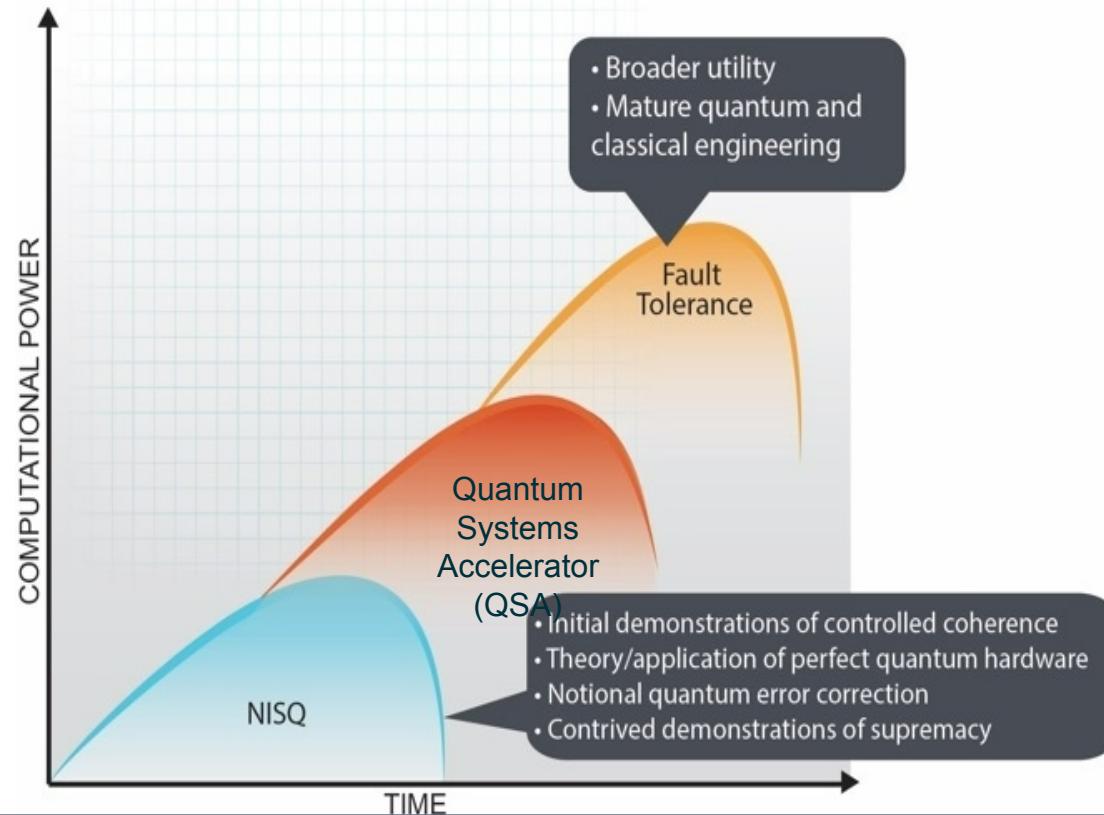
PI: Susan Clark

- DOE/ASCR quantum testbed to understand promise of quantum computing platforms for DOE science problems
- Low-level access provided by QSCOUT is not available in existing commercial systems and enables researchers to study the behavior of quantum hardware
- Access to high-fidelity quantum operations
  - Qubit coherence time  $\approx 14\text{s}$
  - Parallel single qubit gates on all qubits, target fidelity 99.5%
  - Serial two-qubit gates between any pair of qubits, target fidelity 98%
- Jaqal Quantum Assembly Language offers low-level access, control of gate scheduling and execution, and extensible native gates.
- QSCOUT serving users:
  - 5 projects for first round (2021), 5 projects for second (2022)



Peregrine Trap

# Quantum Systems Accelerator



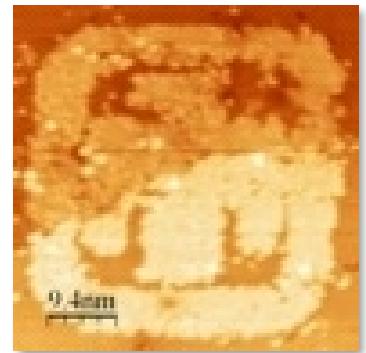
Catalyzing national leadership in quantum information science to co-design the algorithms, quantum devices, and engineering solutions needed to deliver certified quantum advantage in Department of Energy scientific applications.



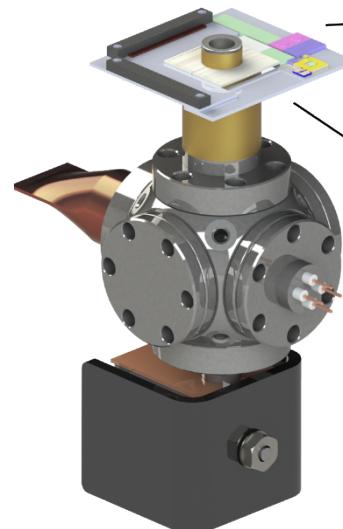
# Sandia's Future Vision is Integrated Quantum Science



- The critical bottleneck to achieving quantum goals is *integration*.
  - The only way to simultaneously increase qubit capacity and fidelity is to modularize and integrate repeatable units.
  - Challenge: what *capabilities* can be integrated for hybrid quantum devices?
  - Challenge: how to we create, distribute, and maintain quantum resources?
  - Challenge: what opportunities are available with integrated computing and sensing?
- 5 Year Vision: Quantum device integration for national impact.
  - Build on the high fidelity and full connectivity available with trapped ions
  - Integrate chip-based photonic elements and electronics with existing physics devices.
  - Develop algorithms and protocols to deal with connectivity limitations
  - Extend to other Sandia quantum systems



Advanced fabrication



Advanced Integration