

Research Review 2021

# Quantum Advantage Evaluation Framework

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# Document Markings

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# QIS and DOD



Adam Schultz, Official White House Photo

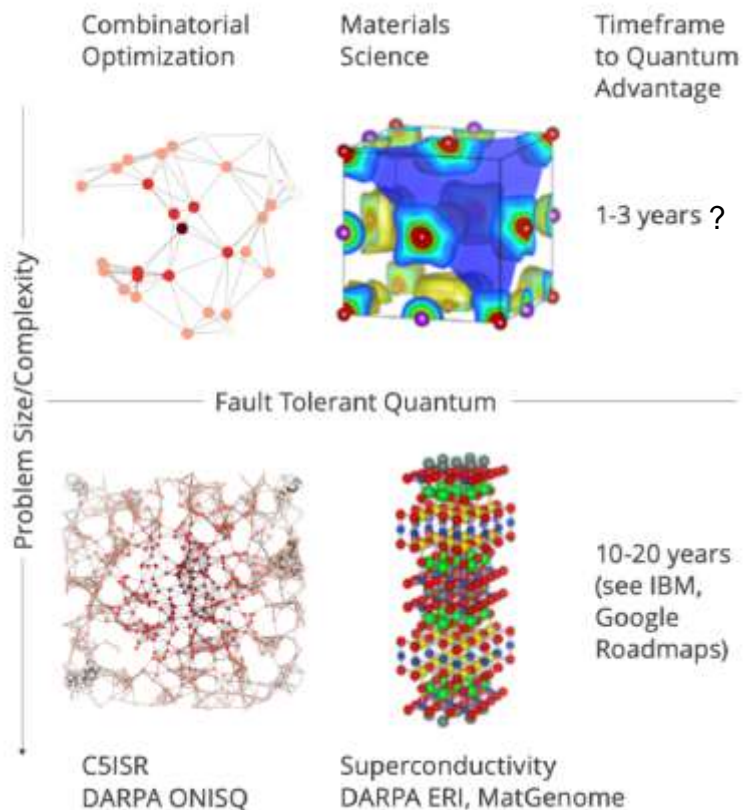
*The future lies in who can, in fact, own the future as it relates to technology, [for example] **quantum computing...***

– President Biden, March 2021

Office of the Under Secretary of Defense, Research, & Engineering (OUSD R&E): SEI to provide research and analysis to “develop and annually update a list of technical problems and research challenges which are likely to be addressable by quantum computers.”

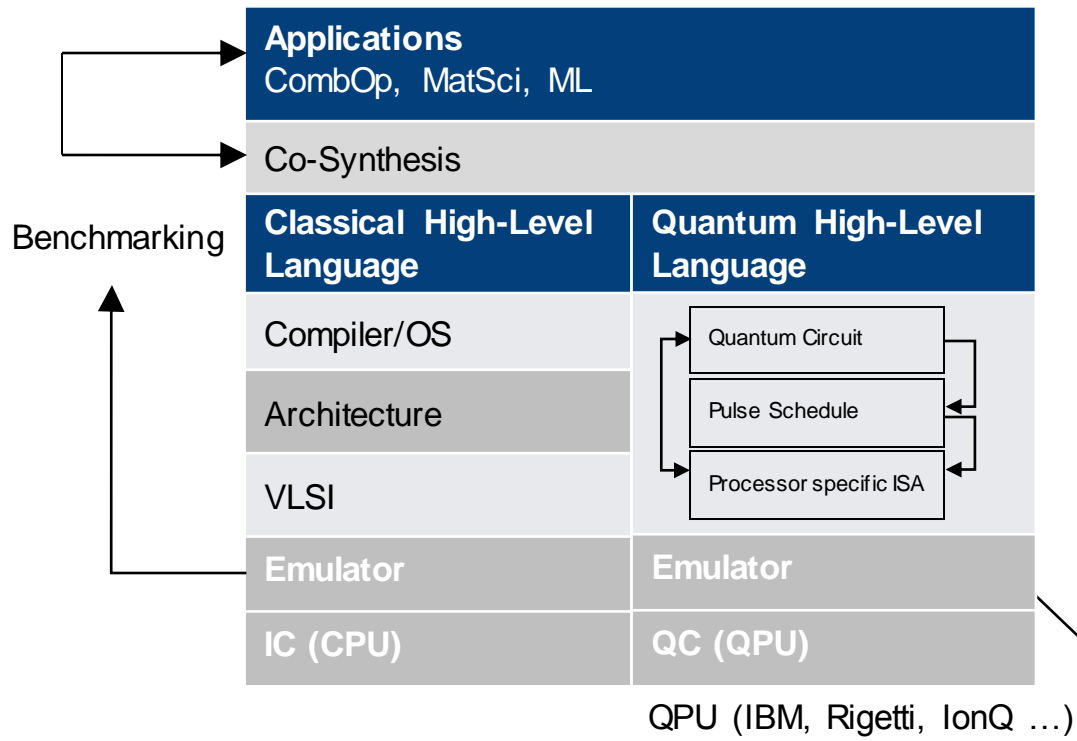
When/where quantum advantage (QA) is to be found = solving some practical DOD problem faster/to higher quality than any other alternatives (e.g., classical State of the Art (SOTA)).

# DOD Applications for Quantum Computing

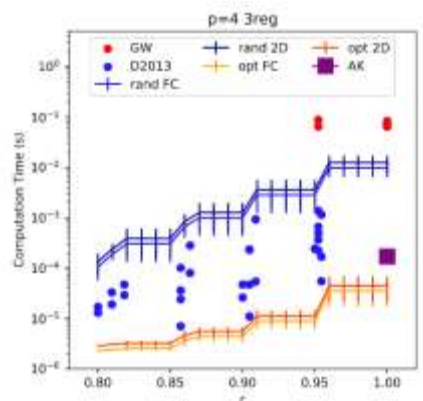


For these **applications**, what are the quantum computing resources necessary for **quantum advantage**?

# Quantum Advantage Evaluation Framework (QAEF)



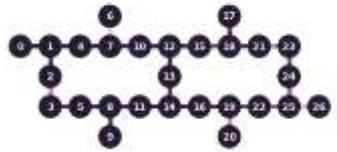
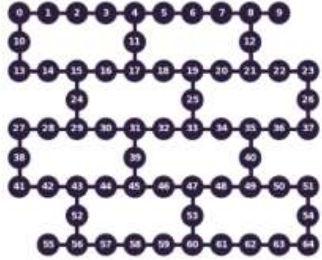
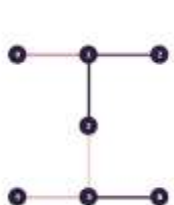
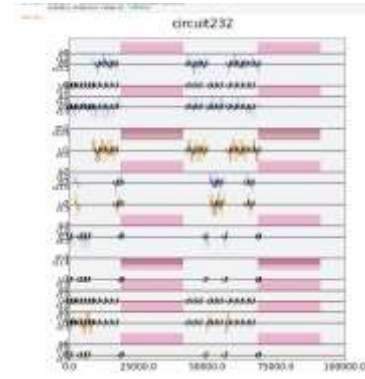
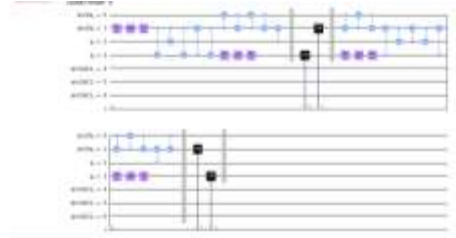
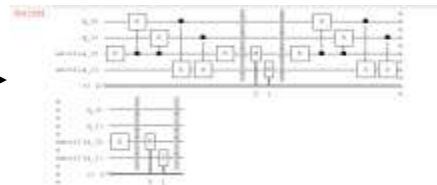
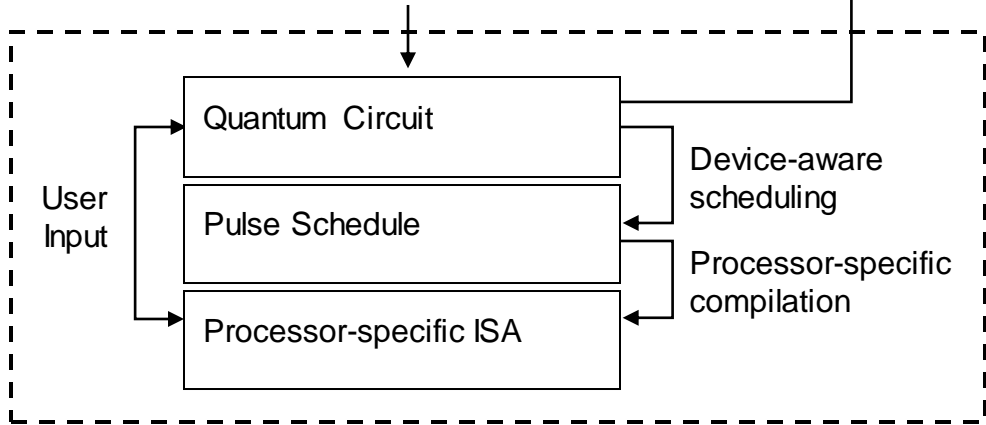
QAEF compares benchmarks for Applications on both quantum and classical SOTA computing to determine quantum advantage.



Intel Quantum Simulator, Qiskit Simulators, etc.

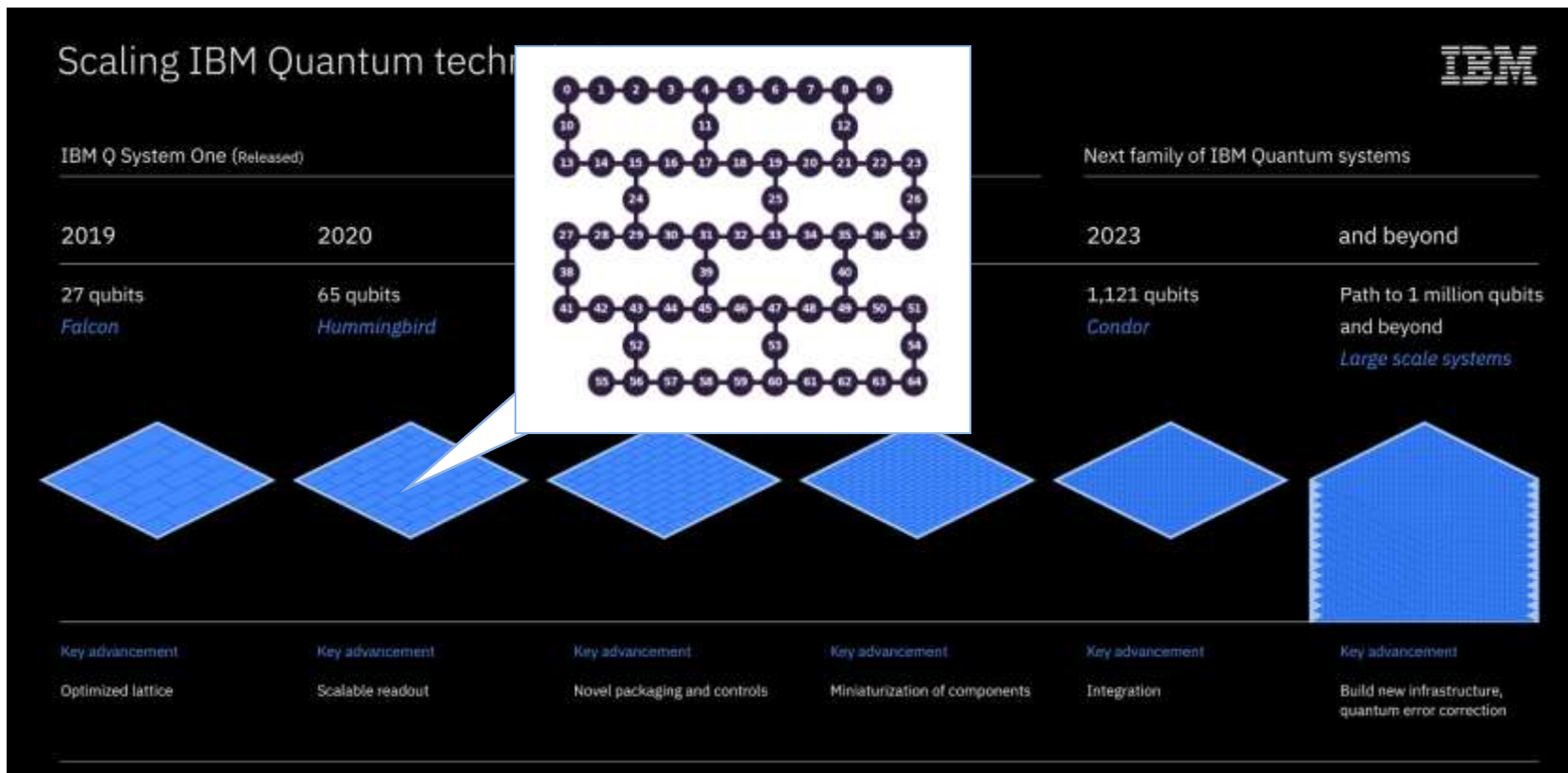
# Example Quantum Computing Full Stack

Applications: CombOp, MatSci, ML



# IBMQ Hardware: Right Now

## Quantum Error Correction?



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# IBMQ Roadmap

**Quantum  
Systems**

**Falcon**  
27 qubits

**Hummingbird**  
65 qubits

**Eagle**  
127 qubits

**Osprey**  
433 qubits

**Condor**  
1121 qubits

**Beyond**  
1K – 1M+ qubits



IBM Research

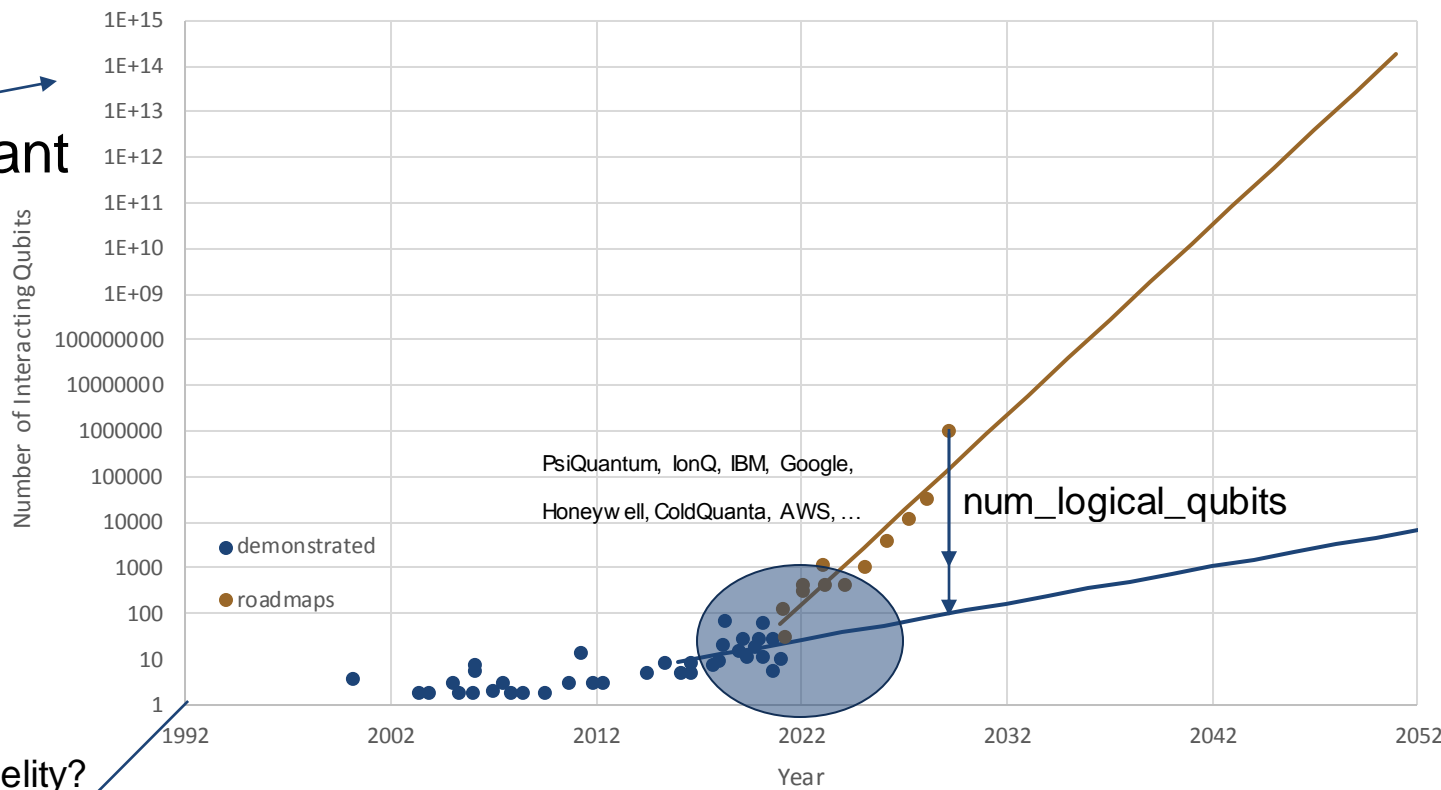


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# Roadmaps

Fault-Tolerant Apps?

Fidelity?



NISQ Apps??

# Summary

**Goal:** Our Goal is quantum advantage (QA); we want to solve practical DOD problems faster and to higher quality than any other alternatives (e.g., classical SOTA).

**Actions:** Determine which applications have the best chance of developing QA and when in order to become “quantum ready.”

**Collaboration:** We are working on QuantumHub at CMU where we have access to quantum software and simulation tools, and a workspace for researchers (contact me for more info).

# SEI Team



**Mark S Sherman**  
Technical Director, Cyber  
Security Foundations



**Charles Holland**  
MTS - Principal Researcher



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**Brent Frye**  
Software Engineer

# CMU Collaborators



**Franz Franchetti**  
Professor of Electrical and  
Computer Engineering CMU



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Engineering CMU



**Matias Johnson**  
CS/Physics Student

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