

Early Quantum Use Cases



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Notes & Acknowledgements

“All quantum use cases discussed are experimental, POC, and not in production”

“All data is publicly available”

“Some use quantum inspired technologies, including simulation”

Use case categories:

- ❖ *quantum computing: optimization*
- ❖ *quantum computing: non-optimization*
- ❖ *quantum technologies (not computing)*



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“Contact us for more information and to create your own use case”

Demonstrated Early Use Case List: Optimization

- ❖ Optimizing travel routes
- ❖ Optimizing vehicle dispatch
- ❖ Online new car ordering configurator (recommender system)
- ❖ Analysis to increase automotive paint line capacity
- ❖ Waste & recycling truck scheduling
- ❖ Ordering items for sale on a website
- ❖ Digital advertisement recommender
- ❖ Portfolio optimization to minimize risk or cost vs. expected return
- ❖ Scheduling robots to seal joints and seams
- ❖ Scheduling complex repair shops

Demonstrated Early Use Case List: Non-Optimization

- ❖ Verification & Validation
- ❖ Molecule and material discovery (structure, function and comparisons) for batteries, pharmaceuticals, and commercial compounds.
- ❖ Accurate calculation & prediction of molecular properties (included excited states and chemical reactivity)
- ❖ Price equities, options and derivatives (e.g., quantum monte carlo)*
- ❖ MRI scanner improvements (faster and/or more sensitive)
- ❖ Quantify client risk in new ways
- ❖ Radio Access Network signal processing (connect mobile user device to core network)

Demonstrated Early Use Case List: Quantum Technologies

- ❖ Secure terrestrial communications from space
- ❖ Enhanced radar detection
- ❖ Navigation without GPS
- ❖ Ultra-secure communications using photonics codes (using Quantum Key Distribution)
- ❖ Another way to securely communicate (via the Earth's magnetic field)
- ❖ Detect movement and activity (over long distances) and within the human body (e.g., brain activity)
- ❖ Picking lottery winners (QRNG ensures randomness)
- ❖ Atomic Clocks (very accurate)
- ❖ Better TVs, LED displays, and lighting solutions (using quantum dots)

Client Use Cases: Computing & Optimization

Organization	Challenge/Use Case	Benefit

Airbus	Flight routes	Large-scale flight coordination
Volkswagen	Traffic management system	Reduce road congestion and wait times
Volkswagen	Customer vehicle configuration errors	Help customer configure a functional and satisfying vehicle
Denso & Toyota	Taxi dispatch in busy cities	Reduced congestion and delay
Denso	Autonomous Guided Vehicle (AGV) speed up	Factory efficiency gains
Fujitsu IT Products	Factory pick lists took too long to fill	Cut walking time by 20%
EMEA Automotive Manufacturer	Increase automotive paint line capacity by 30%	Defer \$1B investment in a new paint line
Mitsubishi Estate & Groovenauts	Collecting garbage and recycling in Marunouchi, Tokyo	Less travel and fewer workers
Ocado Retail	Accelerate grocery order picking	Schedule 200 robots to avoid collisions & speed up orders

All cases are experimental, one-time analyses, research projects, or consulting projects. All are non-production systems. Some cases are using quantum inspired technologies, including simulation

Client Use Cases: Computing & Optimization

Organization	Challenge/Use Case	Benefit

Recruit Communications	Sell more online (what order to show items for sale)	Better eCommerce sales
Recruit Communications	Recommend online advertisements to avoid overspending	Recommender gave ~ same CTR but with 30% lower variation
German Aerospace Center (DLR)	Airport flight/gate assignment to reduce passenger travel time	Optimized airport travel time for passengers
NatWest & parent Royal Bank of Scotland (RBS)	Portfolio Optimization (liquid assets)	Faster run-time for job Institutional knowledge
Nomura	Portfolio Optimization (equities) & stock price forecasting	Learning and testing capabilities
Standard Chartered Bank	Portfolio Optimization (60 assets)	Learned how to use a QC; classical systems worked better
Barclays Bank	Optimization (e.g., settlement batch process)	Build institutional capabilities in QC running 'toy solutions'
JPMC	Options pricing	NA
BMO & Scotiabank	Speed up pricing of financial derivatives (simulation)	QC benchmark process & learning

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Client Use Cases: Computing & Optimization

Organization	Challenge/Use Case	Benefit

Ford Motor Company	Reduce wear on commercial vehicles by optimizing routes	Learning QC, potential to reduce fuel consumption
BMW Group	Scheduling robots to seal automotive seams with PVC	Manufacturing efficiency as it scales
GE Research (for GE Aviation)	Scheduling order backlog into a repair shop	Accelerate the earning of \$2B in repair backlog (cash flow)

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Client Use Cases: Computing & Non-Optimization

Organization	Challenge/Use Case	Benefit

Biogen	Compare molecules to discover new pharmaceutical candidates	Faster and qualitatively better answers to chemist
DowDupont	Speed up the discovery of new materials and products	Learnings...no business benefits identified
JSR Corporation	Calculate excited state energy levels of molecules	Simulation of larger, more complex chemistry applications
BOSCH Research	Better hybrid models for fluid and thermo dynamic challenges	Learning and capability building
BASF	Calculate molecular energies, study & predict chemical reactivity	QC learning (and QC are not big enough to do this usefully)
Ericsson (Sweden)	Radio Access Network (RAN) signal processing & fault prediction	Working towards an edge for 5G network capacity and reliability
British Telecom	Build an ultra-secure data network	Learn multi-vendor QKD to create an 'un-hackable' network
Willis Towers Watson	Quantify risk with less computing power	Gain orders of magnitude performance acceleration in Azure

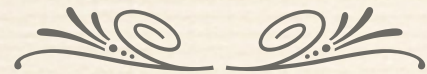
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Client Use Case: Quantum Technologies

Organization	Challenge/Use Case	Benefit
UK National Savings & Investments Bank	Pick monthly lottery (3 million from 79 billion bonds) w/ QRNG	Job ran in 12 minutes, down from 9 hours, for the monthly draw
General Dynamics Mission Systems	Offensive and defense battle situations - secure communications	Space-based terrestrial communications
General Dynamics Mission Systems	Offensive and defense battle situations - navigation without GPS	Passive and autonomous navigation
General Dynamics Mission Systems	Offensive and defense battle situations - enhanced radar sensing and stealth	Enhance radar capability & reduce detection ability
Lockheed Martin (LMT)	Dark Ice(TM) for navigation	Navigate without GPS and track moving objects passively
China Shipbuilding Industry Corporation (CSIC)	Mobile navigation, communication and detection for naval platforms	Navigate w/out GPS, track objects, & communicate passively on high seas
Wuhan Institute & State Key Laboratory & CSIC	Miniature atomic magnetometers to detect weak magnetic fields	Detect motion far away, or activity within the human body
Case Western Reserve University & EU CORDIS (separately)	How to make an MRI scanners faster and more sensitive (resolution)	For Case Western, scans were 3x faster or 30% more accurate

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In conclusion...we see:



- ❖ *Strong success and intuition for optimizing repetitive processes with a large set of potential options; calculations vs. heuristics.*
- ❖ *Growing interest in portfolio optimization and risk management.*
- ❖ *Significant interest & investment in materials sciences.*
- ❖ *Advances in 5G network infrastructure & secure communications.*
- ❖ *Use of randomness in a private lottery.*
- ❖ *Finally, dual-use, national security applications are intriguing.*

Optimization is an attractive area for research and development, with 21 out of 37 use cases.

