

QC @ BMW GROUP: FROM TECHNOLOGY RADAR TO A QC APPLICATION PORTFOLIO



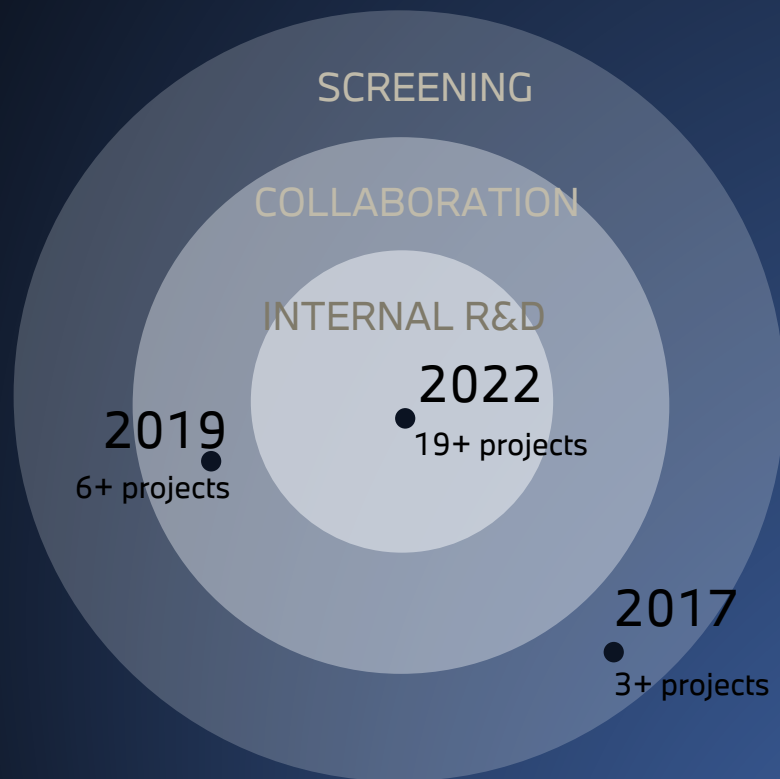
Dr Elvira Shishenina
EURO HPC Summit Week '22

**BMW
GROUP**



ROLLS-ROYCE
MOTOR CARS LTD

FROM TECHNOLOGY RADAR TO A QC APPLICATION PORTFOLIO



BMW QC - Gradual Shift in Emphasis

USE-CASES IN BMW GROUP'S SCOPE

Chemistry

Development of new materials for electric batteries, efficient hydrogen storage and fuel cells...

50+

Machine Learning

Automated driving, automated quality assessment, generative modeling, ...

Optimization

Range of activities in development and production, e.g. supply chain, sensors placement setup, robot path...

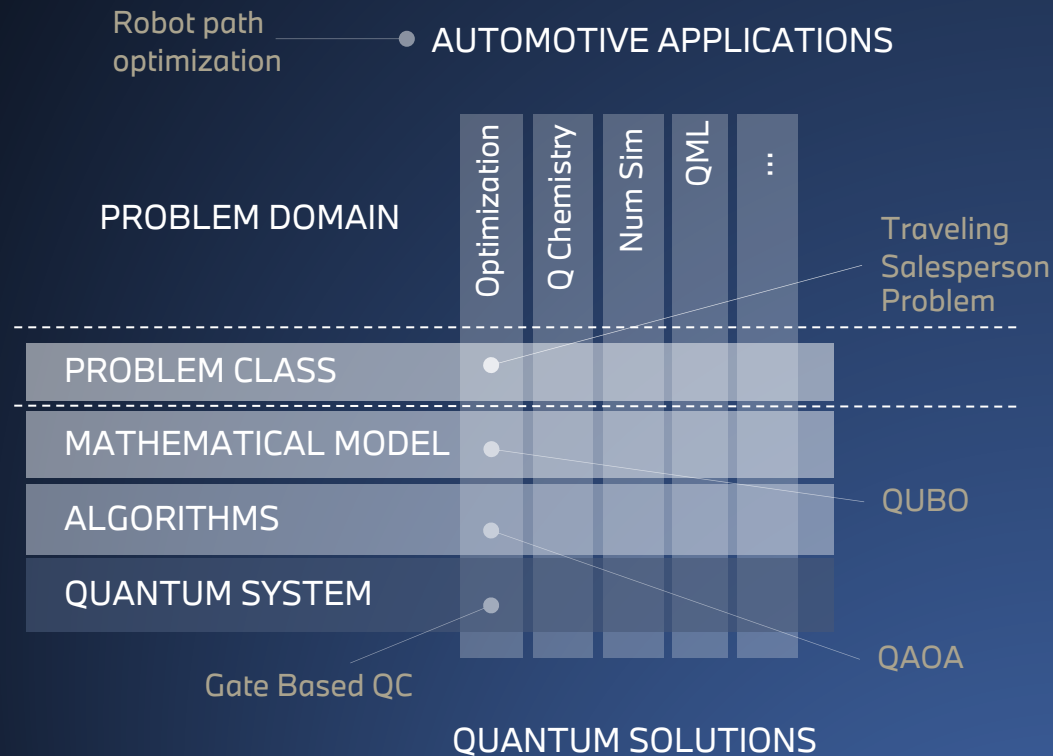
Finance

Portfolio risk management...

Numerical Simulations

Structural analysis for crash simulations, production, aerodynamics and design, heat transfer in batteries and engines, ...

FROM TECHNOLOGY RADAR TO QC APPLICATIONS



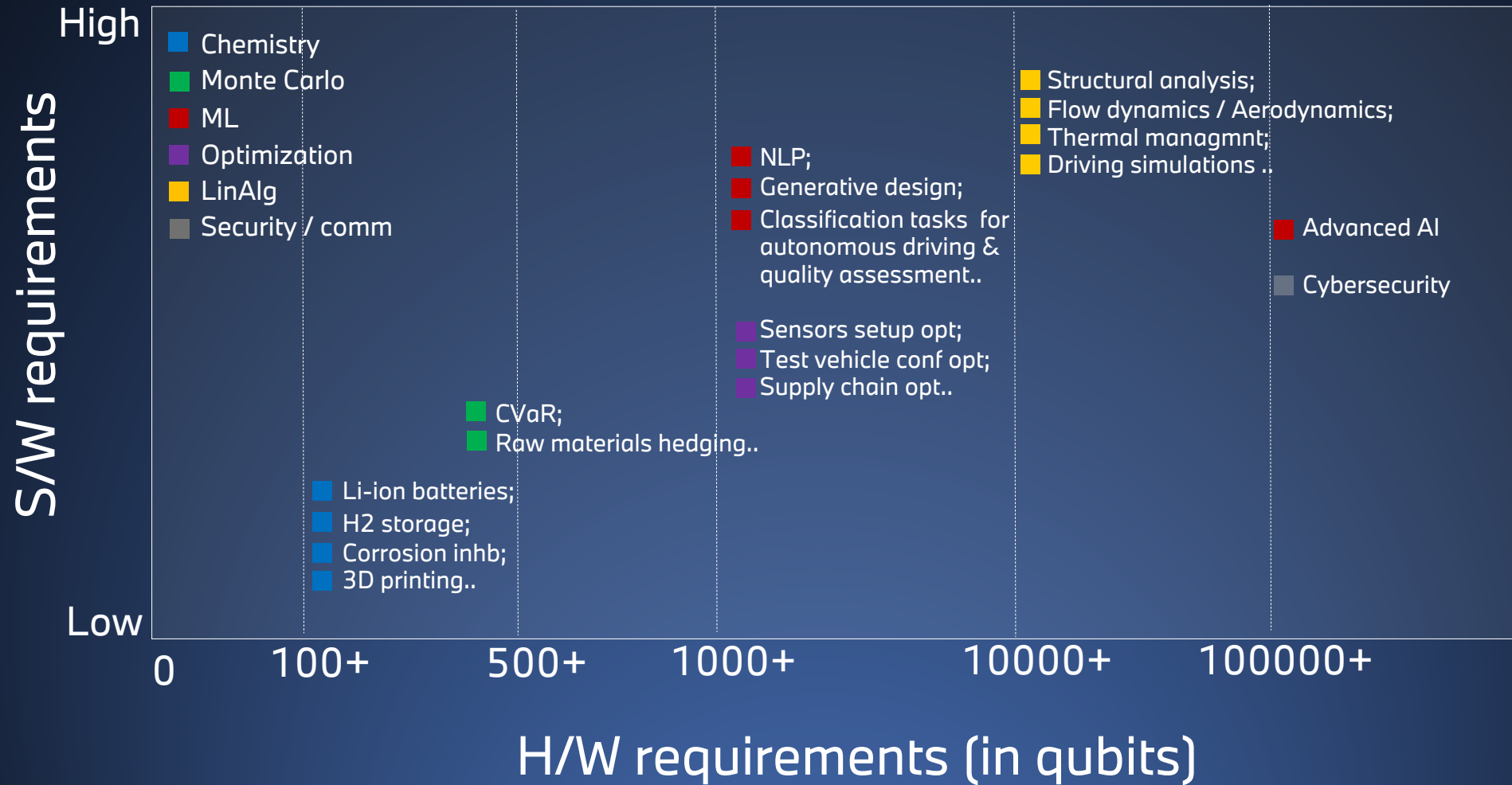
STRATEGIC GOALS

Reference Problems: as an enabler for comprehensive benchmark suites; essential to guide progress towards high-value applications

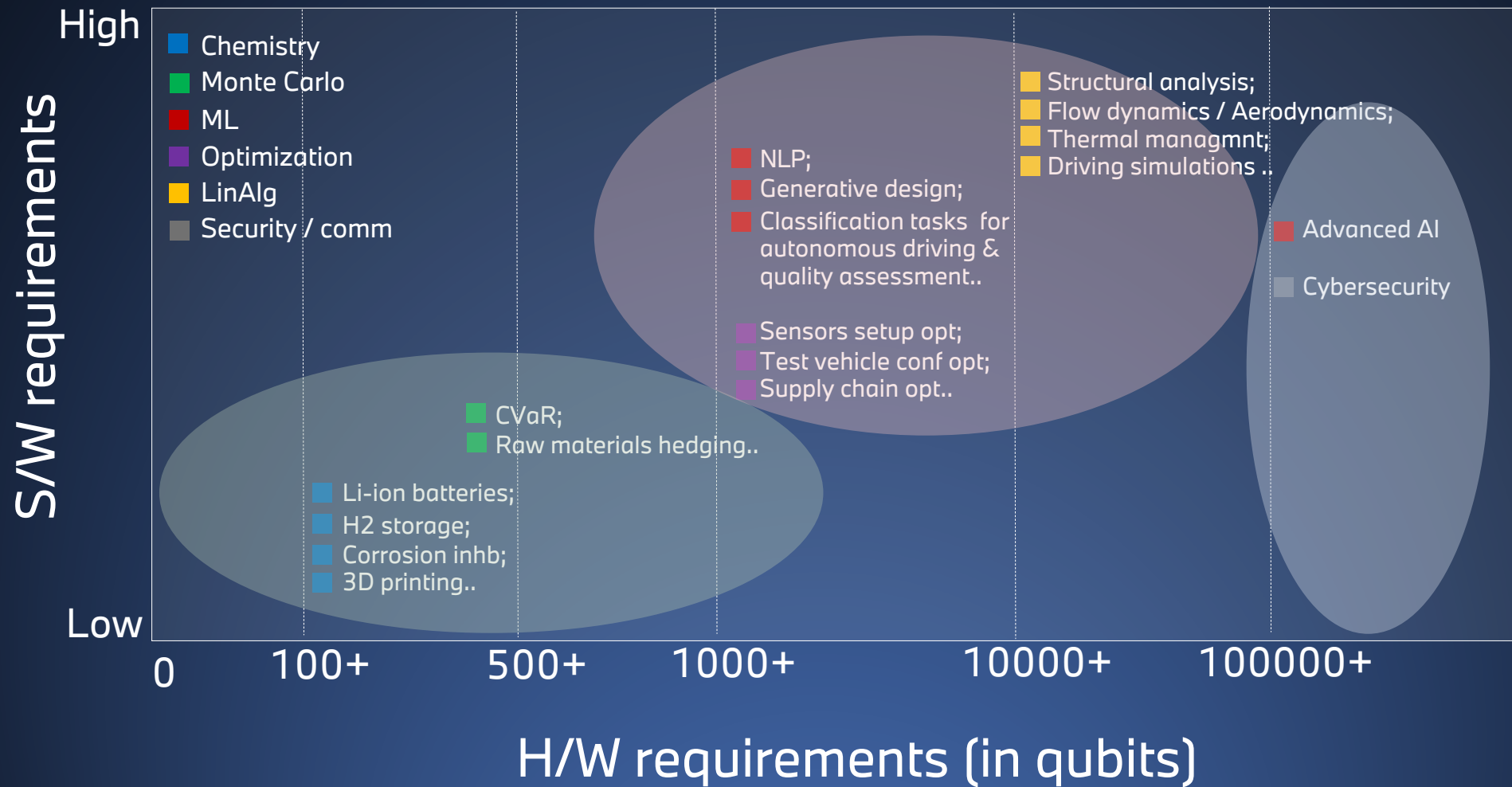
Requirements: formulate consolidated requirements towards partners (academic & business) to enable targeted applied research

Industrialization roadmap: prioritization tool to evaluate what use cases are possible and when; enable timely preparation for the maturity of technology.

IT'S NOT JUST A QUESTION OF QUBITS



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OVERSELLING QC V.S. BEING AWARE OF ITS CHALLENGES

10 000+
qubits

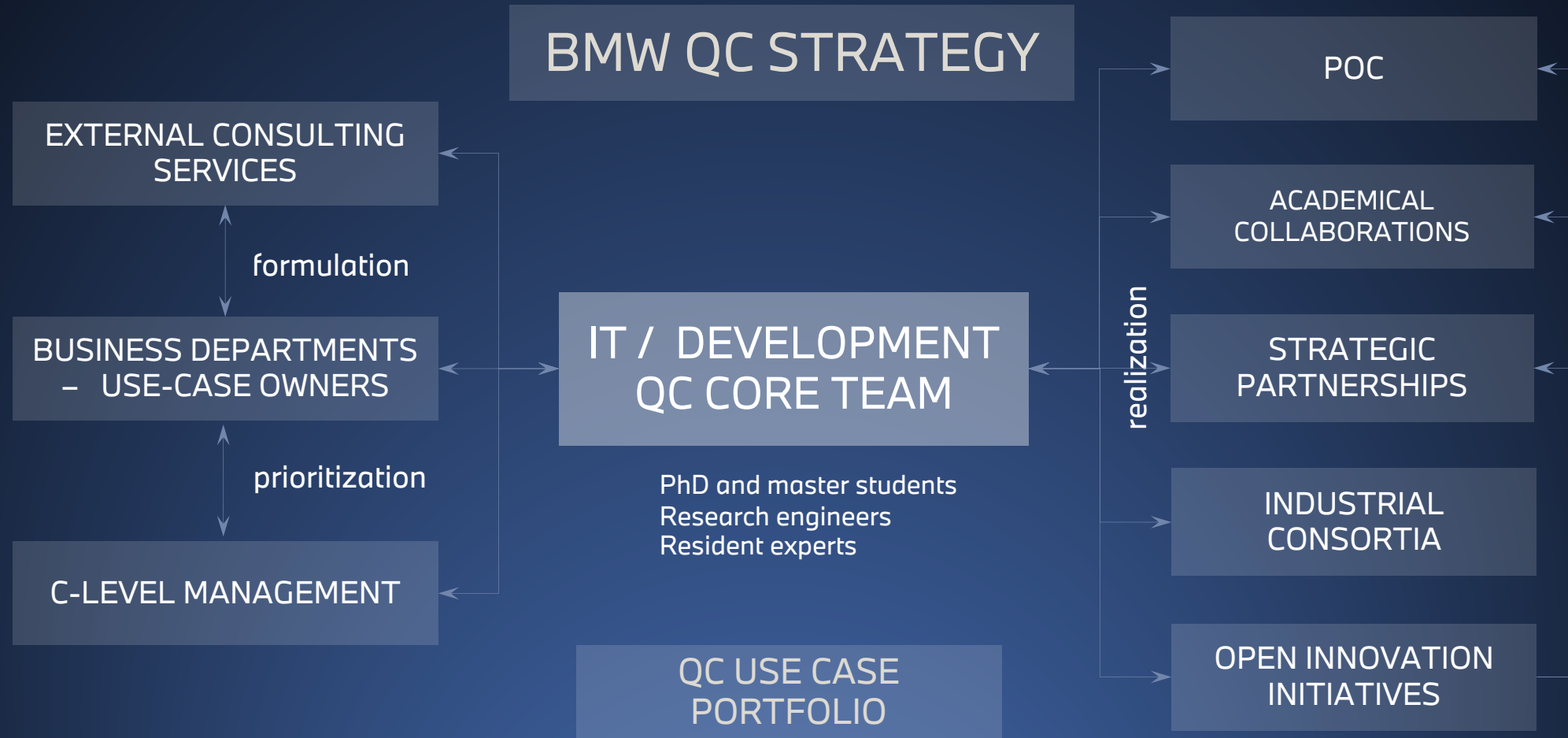
Technical challenges

- Restricted amount of architecture-specific operators
- Impact of noise / quantum error correction
- Lack of efficient data loading /state preparation
- Integration of non-linearities within quantum operators ..

Business challenges

- High pace of QC industry suggests second-mover advantage (strategic)
- Lack of risk pooling for QC projects (investment)
- Search for problematics relevant on the same time horizon (operational)
- Matching QC and domain-specific experts, competencies (operational) ..

BMW GROUP QC INITIATIVE



BMW GROUP QC INITIATIVE IN ACTIONS (2022)

ACADEMIA



Research collaboration
Quantum Science & Engineering



Endowed chair
Quantum Algorithms & Applications



Endowed chair
Quantum Information Systems

CONSORTIA



Quantum Technology & Applications Consortium
QC for large-scale industrial applications to shape new digital future



Quantum AI for Automotive Industry
Exploring QML applications relevant for BMW Group development and production activities



Tailored Applications of Quantum Optimization for Planning and Control of Assembly & Manufacturing
NISQ solutions for production & logistics

Q PROVIDERS



Research collaboration & Open Innovation Initiative
PVC sealing, QC Challenge



Research collaboration
Quantum Chemistry

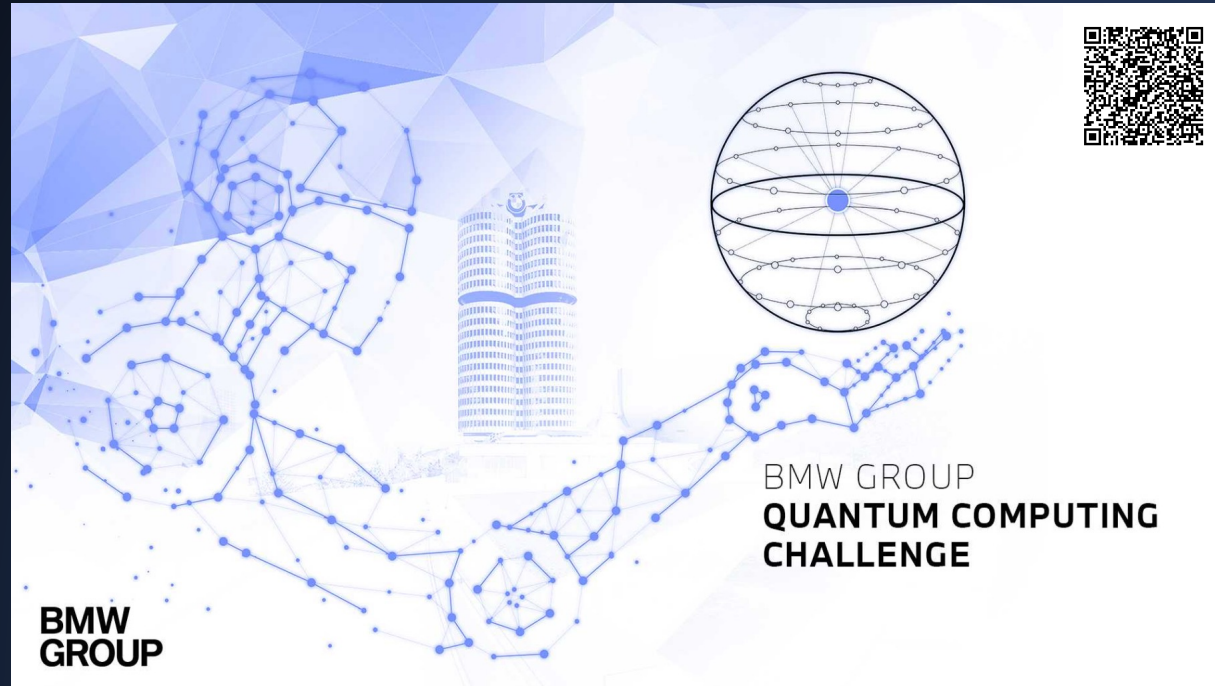


PhD Research project
Development of QC approach to solve transient PDEs



Contribution to PennyLane

BMW QUANTUM COMPUTING CHALLENGE



PARTNER

- Signed Statement of Work
- Amazon invests 100 days + free QC credits



CORE TEAM

- Elvira Shishenina (QC Applications)
- Oliver Wick (TechOffice, TechScout)
- Benedict Jaeger (TechOffice, OpenInnovation)
- Johannes Klepsch (QC Product Owner)
- Ingmar Stapel (IT Strategy)
- Anil Thurimella (Purchase, Supplierthon)
- Martin Thoulund (BMW Communication)

GOALS

- Position BMW as an innovation and pioneering company
- Find new insights and solutions for specific BMW use cases on longer term
- Identify and onboard new partners
- Enable BMW suppliers for using Quantum Computing



QUANTUM COMPUTING USE-CASES

SENSOR POSITION OPTIMIZATION



Optimize the setup of increasing number of sensors for better performance and safety

MATERIAL DEFORMATION IN PRODUCTION



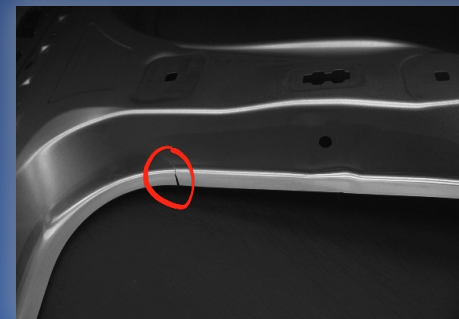
Simulate the material response on metal-forming process using discrete element or AI-based solutions

PRE-PRODUCTION VEHICLE CONFIGURATION



Improve the efficiency of the tests of different vehicle components, meeting the safety and performance requirements

AUTOMATED QUALITY ASSESSMENT



Enhance the objective quality inspection based on ML assessment of vehicle components produced by metal-forming

QUANTUM COMPUTING USE-CASES

SENSOR POSITION OPTIMIZATION



Optimize the setup of increasing number of sensors for better performance and safety

ACCENTURE

MATERIAL DEFORMATION IN PRODUCTION



Simulate the material response on metal-forming process using discrete element or AI-based solutions

PASQAL

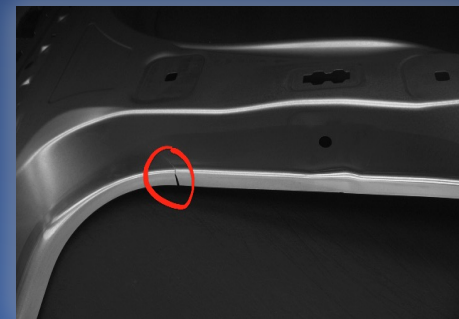
PRE-PRODUCTION VEHICLE CONFIGURATION



Improve the efficiency of the tests of different vehicle components, meeting the safety and performance requirements

1QBIT & NTT

AUTOMATED QUALITY ASSESSMENT



Enhance the objective quality inspection based on ML assessment of vehicle components produced by metal-forming

QCWARE

SOLVING PARTIAL DIFFERENTIAL EQUATIONS FOR NUMERICAL SIMULATION OF PHYSICAL PROCESSES

Structural Analysis (non-linear elasticity eqn)

- Crashworthiness simulations;
- Metal-forming for production;
- 3D printing ...

Thermal Management (heat transfer eqn)

- Heat propagation in batteries;
- Engine heat transfer ...

Many-Body Dynamics

- Driving simulation;
- Crashworthiness simulations ...



Fluid Dynamics (Navier-Stokes eqn)

- Aerodynamic vehicle design & anls;
- Internal / external combustion;
- Convecive heat transfer ...

Wave Propagation (acoustics/electromagnetics/... eqn)

- Vehicle acoustics improvement;
- LIDARs / automotive radar sensors ...

PREDICTIVE NUMERICAL MODELING IS A FIRST STEP TOWARDS ZERO-PROTOTYPING

CONCLUSION

- Depth of collaborations : emphasis on co-creation and internal research
- QC & BMW value chain : growth of use-case portfolio scope
- Strategic approach : nurturing QC ecosystem and strategic alliances

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