Airbus Quantum Computing Challenge FAQ

For external use on the Airbus Quantum Computing Challenge webpage

Last updated: February 2019 (Q6, 8, 18) / April 2019 (Q4) / June 2019 (Q11, 12) / July 2019 (Q4, 21) / August 2019 (Q4) / September 2019 (Q4)

I. WHAT IS THE AIRBUS QUANTUM COMPUTING CHALLENGE, AND HOW DO I GET INVOLVED?

1. What is the Airbus Quantum Computing Challenge?

The Airbus Quantum Computing Challenge aims to deliver solutions to aerospace flight physics problems by looking at opportunities to test and assess the newly available computing capabilities to solve some of our hardest and most complex problems, and thus further legitimise and fuel progress of this technology. The challenge puts forward 5 distinct flight physics problems with varying degrees of complexity, ranging from a simple mathematical question to a global flight physics problem.

2. Why did Airbus launch the Quantum Computing Challenge?

As an active user of advanced computing solutions, Airbus is at the forefront of a paradigm shift in the computing world and exploring how Quantum Computing (QC) can help solve key questions for the aerospace industry. Airbus is taking a step forward by launching a global competition in Quantum Computing and challenging experts in the field to join forces for a Quantum era in aerospace. Airbus has a long history in deploying state-of-the-art High Performing Computing (HPC) solutions for many challenging aerospace problems. With classical computers gradually approaching their limit, the Quantum Computer promises to deliver a new level of computational power.

3. What does the Quantum Computing Challenge involve?

The Challenge puts forward 5 distinct flight physics problems with varying degrees of complexity, ranging from a simple mathematical question to a global flight physics problem.

a) Problem Statement 1: Aircraft Climb Optimisation

For short-haul flights, climb and decent are key phases to optimise in order to reduce fuel burn and subsequently the cost to the airline. The ability to simultaneously consider the interdependencies of the parameters in the **trajectory** that govern fuel burn will be highly beneficial to Airbus and Customers

b) Problem Statement 2: Computational Fluid Dynamics (CFD)

At the moment **CFD calculations are complex and resource intensive**. it is currently solved utilising HPC, however, Airbus is keen to understand the ability and potential benefits (in comparison to classical computing) of a **QC to fulfill the same function with less resource/time intensity**.

c) Problem Statement 3: Quantum Neural Networks for Solving Partial Differential Equations

Linked to Problem Statement 2, part of the complexity with CFD calculations is associated with the **partial differential equations (PDE) require to solve**. One of the methods currently assessed to reduce the cost of simulations is by using a **surrogate model which uses machine learning** to solve the PDE. This requires building an artificial Neural Network. While this is still a field of study with classical computing, Airbus is keen to **understand how this is applied to a QC**.

d) Problem Statement 4: Wingbox Design Optimisation

The key aspect of this problem statement is **weight optimisation while maintaining structural integrity**. the lighter the aircraft, the less thrust and fuel required to make it fly and subsequently

lower cost and lower environmental impact. However, the difficulty is optimising multiple parameters while considering a variety of constraints. Currently, the process is rigid with built-in conservatism to ensure structural integrity. Airbus wants to **evaluate the potential benefit of QC algorithm to solve this multi-disciplinary problem and thereby reducing the need for a conservative approach**.

e) Problem Statement 5: Aircraft Loading Optimisation

The loading of an aircraft requires a variety of considerations such as where on the aircraft and the weight of where it will be located on the aircraft. This **impacts the centre of gravity** which subsequently affects the aircraft performance such as fuel burn and speed and ultimately the cost. This optimum needs to be calculated while consider limitations based on maximum payload capacity, shear limits of the structure and centre of gravity. this can be solved by classical computing, however, **Airbus is keen to evaluate the problem resolution on a QC and the potential scalability towards more complex problems**.

Comprehensive technical dossiers are available online to registered participants.

4. What updates have been made to the challenge Problem Statements?

Following feedback from participants and questions for further clarification, the problem statements were reviewed by Airbus experts who provided necessary updates to the problem statements.

The following updates were made in **March 2019:**

- **Problem Statement 1:** corrections to original equations
- **Problem Statement 2:** Updates to KPIs for further clarification on expected outcomes
- **Problem Statement 3:** Updates to KPIs for further clarification on expected outcomes
- **Problem Statement 4:** Calculation examples and data input to support proposal
- **Problem Statement 5:** Updates to KPIs for further clarification on expected outcomes

The following updates were made to **Problem Statement 1** in **April 2019:**

- All the variables to optimize were added in the final model (page 3)
- The value of the gravitational acceleration g0 was added (page 4)
- The unit of the initial temperature changed from Celsius to Kelvin (page 4)
- The formula of the criterion was updated – minus missing in the exponential term (page 5)
- Updated the Max Climb Thrust formula (page 6)

The following updates were made to **Problem Statement 1** in **June 2019:**

- Definition of Cz_i on page 4 was removed

The following updates were made to **Problem Statement** 1 in **July 2019:**

Section 2 modified with the below:

- The non linear constraints have been rewritten in a standard form ($g_{v_i} = 0$, $g_{VMO_i} \leq 0$) but their mathematical contents remains unchanged
- The order of the variables in the various expressions has been uniformized, namely: $v, \gamma, m, t, s, Cz, \lambda$.
- The calculation of the criterion ϕ has been changed (variables A, B, C, t_B, m_B, s_B, m_F, s_F and ϕ). An example is provided in order to check the implementation.
- The values of g_0 and CI have been provided.

In addition, supplementary information on 'Jacobian of constraints' and 'Gradient of the criterion' have been provided for information only.

The following updates were made in **September 2019:**

- **Problem Statement 1:** b removed (typo) in the definition of s_B (page 5 of PS 1 technical document, within first set of equations) and updated the value of $\phi \approx -58{,}273.65\ \mathrm{kg}.s.^{-1}$ (page 5 of PS 1 technical document, 'CHECK' box)
- **Problem Statement 2:** Simplified mesh and Computation configuration files provided in 'Additional information' (page 9 of PS 2 technical document)

- **Problem Statement 3:** Link to source code provided in 'Additional Information' (page 7 of PS3 technical document)

5. How can I get involved?

Competition entrants will be asked to register their participation, and communicate to Airbus if they will participate as an individual, or as part of a team. We recommend a team size of up to 10 members; if you would like to participate in a team with more than 10 members, please send an email to info@airbusqc.com to request authorisation. All team members need to be registered before the end of the submission period - Airbus will provide the means to register on the competition website.

6. How do I get to submit my entry?

Submissions will take the form of a detailed paper or presentation for one or more of the 5 challenges, which offer different levels of difficulty. Participants should look to address both the quantitative and qualitative KPIs set out in the problem statement for their challenge - particularly the qualitative discussion of the solution. Airbus reserves the right to schedule a 1 to 1 Q&A with the participants if further clarifications are required.

The submission phase will end in October 2019 with live presentations and awards planned for March 2020.

7. What type of Quantum Computer should be used for the submitted solutions?

There is no specifically prescribed quantum computer for the Challenge. Participants are welcome to tailor their solutions to quantum annealers, gate-based quantum computers, hybrid quantum-classical combinations, or available quantum simulators. However, proposals will be in part judged on the ease of their implementation, their 'future-proof' nature (ability to be readily implemented on ever larger quantum processors), and the availability of relevant hardware for Challenge winners in 2020.

8. During the challenge, do participants interact with Airbus staff?

Questions can be sent on info@airbusqc.com, however no guarantee of an answer or an answer time may be given. Furthermore, Airbus reserves the right not to answer the question if it is judged that an answer would give an unfair advantage to certain participants.

9. How will you communicate with us?

If you have registered a team on the Airbus Quantum Computing Challenge website you must appoint a Focal Point. The Focal Point will be the main contact point for communication with Airbus.

We ask that the Focal Point keeps the details of all team members recorded as we may ask you to send them to us for verification, as outlined in the terms and conditions.

10. When does the assessment takes place and when are we informed of the results?

The submission period ends October 2019. The assessment period will last until end of January 2020, following which participants will be informed about the results within the first quarter of 2020.

11. What is the relationship between Airbus and QC Ware?

Airbus Ventures, the start-up-venture investment arm of Airbus, became a seed investor in QC Ware in 2016. Since then, the two companies have worked together to investigate potential aerospace industry applications of quantum computing solutions.

12. What is QC Ware's role in the Airbus Quantum Computing Challenge?

QC Ware served as an expert consultant during the creation of the Challenge and the definition of the five problem statements. QC Ware will also partake in the assessment of solution proposals submitted by participants alongside Airbus engineers and reputed members of the quantum-computing academic community. QC Ware is not entitled to submit a proposal solution to any of the problem statements. The company is also not entitled to IP generated by third parties in the frame of the Challenge as it is not an affiliate of Airbus.

II. WHY SHOULD I GET INVOLVED?

13. What is the prize? What can participants win / achieve by taking part?

Winners will be offered unique opportunities for hardware access (scheduled for 2020 and after), and to work collaboratively with our industry experts from the flight physics sector.

And throughout the competition we'll be interacting with the QC Community, answering questions and clarifying the problem.

The exact nature of the prize for each of the 5 problem statements may vary.

The potential benefits gained as an outcome if your solution is selected through participating in the AQCC include access to Airbus and industry experts for the evolution of the proposals, or alternative forms of support to develop the proposals further.

14. Will the winners land a job at Airbus?

The prize mechanism of the Quantum Computing Challenge does not include the offer of a full-time/part-time/internship contract with Airbus. Airbus may choose to work with teams or individuals after the competition, however this is on a case by case basis, and is not part of the prize.

III. AM I ELIGIBLE TO TAKE PART?

15. Who can enter / participate?

The Airbus Quantum Computing Challenge is a worldwide competition open to anyone with the relevant expertise and enthusiasm for the Quantum Computing field (post-graduate students, PhDs, academics, researchers, start-ups, or professionals, for example, but not limited to these categories).
Employees of Airbus, their agents and employees or agents of their partner QCWare are not allowed to enter the Competition.

16. Do all participants within a team have to be from the same academic institution/company?

The Airbus Quantum Computing Challenge welcomes diverse teams from across the globe, and as such, participants in the same team do not need to attend the same academic institution or be employed by the same company.

17. How big can the teams be? How many members are there per team?

We recommend a team size of up to 10 members; if you would like to participate in a team with more than 10 members, please send an email to info@airbusqc.com to request authorisation. For all teams, a Focal Point must be nominated who will be the main point of contact for Airbus.

18. Do all participants within a team have to be of the same nationality?

As a globally minded company, Airbus welcomes applicants from all corners of the earth, and we actively welcome diverse teams that span multiple countries and ethnicities.

19. What language must be used? Can participants work in their own language?

All correspondence with the organisers must be in English.

V. WHO OWNS THE IDEA?

20. Who owns the Intellectual Property of the ideas?

The intellectual property remains with the individual or team who enters. Specific conditions related to the use of the entry are detailed in the Terms and Conditions available on the competition website (where you register). Participation in the AQCC is subject to the acceptance of and adherence to these terms and conditions.

21. Why does Airbus request a non-exclusive license in the submission and any related intellectual property rights?

The additional non-exclusive license gives Airbus contractual protection that Airbus can use the submissions for its research, development and ultimately its products. Non-exclusive in this context means that the license granted to Airbus does not prevent the participants from their own use or from granting other non-exclusive licenses to others.

22. Can the submissions be published?

Yes, Airbus welcomes the publication of the submissions and ideas generated in the Competition. It is in line with the open-innovation spirit of the Challenge. Those publications shall be made only after the submission period concludes (starting November 2019).