<u>Questions raised by the U.S. in video call July 26th, 2022</u>

In the spirit of our good cooperation over the last years and with respect to this particular issue over the last months, the French and German government is pleased to provide the following written information in addition to the statements given during the video call on July 26th, 2022. We remain for your disposal.

During the WA-EG Summer Session in Vienna, the United States, Germany, the Netherlands and France held a small group dedicated to Quantum issues. Even if the Participating States (PS) of the small group conceded different technical and scientific approaches regarding the proposals on Quantum Coumputing (US 008, FR 004), they recognised,

- *(i) The absence of imminent threat related to Quantum Computing,*
- *(ii) The common objective to set a control text in the Wassenaar Dual-Use List in the short term (2-3 years),*
- *(iii) The necessity to consider the different Quantum ecosytems in the U.S. and the European Union,*
- *(iv) The possibility to reconcile their different technical approaches in order to submit revised proposal(s) for the WA-EG Autumn Session.*

Between June and July, Germany and France gathered Quantum experts in order to assess a criterion based on error-corrected qubits. A tentative wording, shared with the Netherlands and the U.S., has been exposed during the Webex meeting on the July, 26th 2022.

This non-paper aims at addressing the technical questions raised by the U.S. during this meeting.

1. Does the proposal cover also computer with only a very limited number of qubits?

Yes, because a universal set of gates doesn't require more than 2 (in some special cases 3) qubits.

In order to improve the implementation of the text proposed by the export control authorities, we're working on a preliminary draft of 'universal set of gates' and 'physical error' definitions.

2. Does the proposal include all relevant platforms?

Yes, because all relevant platforms require error correction in order to be scalable for practical applicability. Platforms differ from one another in the specific kind of error correcting protocols they require. The proposal subsumes this diversity, focusing on what error correction enables rather than on how it enables it.

3. Does the proposal apply to every universal gate?

Yes, every gate in a universal set needs to meet the requirement to be meaningfully subject to control.

4. Why did you chose factor 10?

Because an order-of-magnitude improvement is necessary to characterize a qualitative step change that represents an inflection point in the ability to scale up quantum computers.

5. How do you measure if a computer is able to reach the required error correction rate?

By performing gate tomography on each gate from the universal set implemented in a particular machine – first on uncorrected (physical) qubits, then on error-corrected qubits, and subsequently comparing the measured gate errors.

6. Which errors are relevant to be considered under the proposal?

Single- and two-qubit (in some cases possibly three-qubit) gate errors, as measured by gate tomography with uncorrected (physical) and with error-corrected qubits according with the specific error-correction protocols that are best suited for a specific platform.

7. Does ever universal gate have to reach the relevant error correction rate or is it an average of gates?

Every gate from a universal set has to reach the relevant error improvement for a given platform to qualify for control.

8. Can you explain the measurement proceeding for the error correction rate?

The procedure to be followed is quantum process tomography and is explained in Section 4 of the Wikipedia entry https://en.wikipedia.org/wiki/Quantum_tomography.

A Technical Note on the error calculation methodology will also be introduced for more clarity. A first draft will be submitted shortly.

9. Why do you think this proposal is better compared to the US proposal?

Because it addresses in a platform-independent definition the actual elements needed to substantiate an inflection point in the ability to engineer a scalable quantum computer, unlike the prescription of a given number of physical qubits, which has no significance without a platform-dependent specification of error rates.