Business plan for a DIN SPEC project according to the PAS procedure on **"Benchmarking quantum computers with determined KPIs"**

Status:
For developing the DIN SPEC after adoption on 18 October 2022

Requests to participate in the project and/or comments on the business plan are to be **submitted by 6 October 2022** to marius.loeffler@din.de[1]

Recipients of this business plan are requested to name **all patent rights** known to them to be relevant to the project and to make available all supporting documents.

Berlin, 25 October 2022 (Version 2)

[1] Applications for participating in the project and comments on the business plan that are not received by the deadline do not need to be taken into consideration. Once constituted, the project workshop will decide whether or not to consider the comments received in good time.

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1. Status/version of the business plan

- **For public commenting (Version 1)**

  This business plan is intended to inform the public of a new DIN SPEC project. Any interested party can take part in this project and/or comment on this business plan. Please send any requests to participate or comments by e-mail to marius.loeffler@din.de.

  Once this business plan is published, the Chairman of DIN's Executive Board decides whether or not the project is to be carried out.

  If the project is accepted, all those who have applied for participation or have commented on the business plan by the deadline will be invited to the kick-off meeting of the project consortium.

- **For developing the DIN SPEC after adoption on 18.10.2022**

  Changes to the previous version 1:
  - Updating version of the business plan in frontpage and section 1;
  - Section 2: Deleted table of organizations that have registered for participation and updated table of organizations that have adopted this business plan (known as consortium members);
  - Section 4: Updated information regarding the kick-off meeting;
  - Section 4: The language in which the elaboration takes place (meetings, reports, etc.) was changed to English;
  - Section 7: Updated Information regarding the consortium leader;
  - The business plan was translated into English.

2. Initiator and other consortium members

- Initiator:

Person/Organization	Short description
Johannes Verst Quantum Business Network	The Quantum Business Network (QBN), is the international quantum technology innovation network founded in 2020 with now around 40 members from business, academia and government, building a strong quantum industry in Europe. As an independent organization, QBN promotes the networking, creation and development of QT companies and institutions and their value chains, offering its members unique hands-on support, working groups and a trusted environment for growth acceleration, industry collaboration, knowledge exchange and technology transfer.

- Other potential participants:

This DIN SPEC will be developed in a consortium (temporary body) that is open to any interested party. The participation of other experts would be helpful and is desired. It is recommended that

– Developers in the field of quantum computing;

– Manufacturers, integrators and providers of quantum computers

– End users of quantum computers;

– Investors;

– Certifiers and auditors as well as test laboratories

– etc.

take part in the development of this DIN SPEC.

- Organizations[2] that have adopted this business plan (consortium members):

Person	**Organization**
Roman Bansen	Agentur für Innovation in der Cybersicherheit GmbH
Luminita Mihaila	BWI GmbH
Matthias Heller	Fraunhofer IGD
Nico Piatkowski	Fraunhofer IAIS
Colin Kai-Uwe Becker Nikolay Tcholtchev	Fraunhofer FOKUS
Mazen Ali Valeria Bartsch Isacco Gobbi	Fraunhofer ITWM
Michael Marthaler	HQS Quantum Simulations GmbH
Thomas Klein	IBM Deutschland GmbH
Sebastian Luber	Infineon Technologies AG
Markus Bendele	IQM Germany GmbH
Thorsten Last	Orange Quantum Systems B.V.
Christian Ertler	ParityQC Germany GmbH
Thomas Gerster	Physikalisch-Technische Bundesanstalt (PTB)
Nils Hermann	Quantum Brilliance GmbH
Johannes Verst Ingolf Wittmann	Quantum Business Network UG (QBN)

3. Objectives of the project

3.1. General

Benchmarking of quantum computers is currently receiving a lot of attention, which is reflected in the number of publications related to this area. This is partly due to the fact that in recent years the first quantum advantages have been demonstrated by benchmarking the Sycamore and Zuchongzhi quantum processors using randomly generated quantum circuits. A comparable benchmark - the quantum volume - is used by IBM as one of the main characterization features to assess the performance of in-house quantum computers and is therefore well known. Furthermore, research on new quantum algorithms and associated applications is ongoing, and their functionality and utility is often tested using simple benchmarks on simulators or real hardware. Some overlap with benchmarking can also be seen with the active research area of quantum characterization, verification and validation. Quantum characterization is concerned with determining and measuring concrete performance metrics of the controlled qubits (e.g. speed, gate errors, coherence times, etc.), which are determined as characteristic values very deep in the hardware during synthesis and creation. Verification deals with the goodness with which desired ideal states can be prepared by controlled manipulation of the qubits, and validation deals with the holistic ability of a QPU (quantum processing unit) to solve specific problems sufficiently well.

However, the large number of benchmarks for a technology that is still so young and complex has some drawbacks. There are many metrics, some of which are very similar or very different, for which it is not clear which property is really being measured quantitatively without in-depth mathematical considerations and an understanding of the variable parameters in the hardware and software of a quantum computer. These parameters include, for example, the qubit topology, the average gate errors, the quality of the calibration, but also the software-controlled hardware-related circuit optimization. Thus, it is often unclear which statements the results of a benchmark provide and which parameters influence them. Thus, the same benchmarks on different systems and similar benchmarks on the same systems are difficult to relate and compare sufficiently and fairly. Thus, in R&D, there is no standard language and tests that anyone can refer to. From the above considerations, the need for a standardized set of metrics for the field of gate-based quantum computing that openly and transparently represents what is to be measured and evaluated on a quantum computer or algorithm with associated software-side implementation and how, in order to enable comparability of different technologies and vendor solutions, can be identified.

(Potential) users of cloud-based quantum computers want to know what capabilities and advantages they have in relation to different application areas. To this end, they would also like to be able to meaningfully compare the various systems from different manufacturers for this area of application and be able to identify whether there is a suitable system for the intended use. The latter is also of particular interest for (potential) end users from industry and R&D.

Researchers and developers in the field of quantum computing would like to be able to assess current capabilities of quantum hardware in a measurable way in order to improve and use them in a targeted manner. Investors want to make business decisions based on robust data and not rely on marketing claims.

3.2. Planned scope

This document specifies requirements for criteria for the evaluation of various quantum computers, quantum algorithms and their implementations, and implementation against a standardized set of core metrics (KPIs) and associated benchmark specifications. The implementation of these specifications in a benchmark suite is intended to make the developed standard practical. This document addresses the following actors in a quantum technology ecosystem: users of the numerous quantum computers accessible via cloud services, industrial customers interested in quantum computers, investors, developers, manufacturers, certifiers and auditors in conjunction with potential test laboratories.

3.3. Related activities

The subject of the planned DIN SPEC is not at present the subject of a standard. However, there are committees, standards and/or other technical rules that deal with related subjects and thus need to be taken into account - and involved or incorporated, where necessary - in this project:

- DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE;
- DIN-Normenausschuss Informationstechnik und Anwendungen (NIA);
- ISO/IEC JTC 1/WG 14 Quantum Computing;
- IEEE P7131, *Standard for Quantum Computing Performance Metrics & Performance Benchmarking*.

4. Work programme

The aim of the project is to develop a DIN SPEC according to the PAS procedure (see www.din.de/go/din-spec-en). The DIN SPEC shall be consistent with the body of German standards and shall not be in conflict with any DIN Standard.

The kick-off meeting took place on 18 October 2022 as a web conference. The project duration will be about 6 months.

At this kick-off meeting, the consortium for developing the DIN SPEC will be constituted, further organizational issues will be decided on and clarified, and, where possible, work on the subject matter will be begun.

A draft for public commenting will not be published.

A total of 2 project meetings (kick-off meeting and work meetings) and 4 web conferences will be held, during which the content of the DIN SPEC will be presented, discussed and approved. The content of the DIN SPEC can be drawn up by individual consortium members or in working groups.

Dates of further meetings and/or web conferences are to be agreed on within the consortium in consultation with DIN.

The DIN SPEC will be drawn up in English (language of meetings, minutes, etc.). The DIN SPEC will be written in English.

NOTE The calculation covers only one language version. Please keep in mind the fact that other language versions involve additional expenses; for this reason, they shall be agreed on separately. If another language version is desired, Beuth/DIN can provide a translation. Requests for translations are to be submitted after the DIN SPEC manuscript has been approved for publication.

5. Resource planning

Each consortium member shall bear the expenses he/she incurs as a result of participation in the project.

Consortium membership and participation in the project meetings is free of charge, as the costs incurred by DIN throughout the performance of this project will be financed by funding from the DIN-Connect project " Benchmarking quantum computers with standardized KPIs" – sponsored by DIN.

6. Rules of cooperation in the DIN SPEC consortium

This project is governed by the PAS procedural rules. All interested parties and consortium members are to inform themselves of these procedures by going to www.din.de/go/din-spec-en.

The consortium will be constituted during the course of the kick-off meeting. The kick-off meeting will not take place until the business plan has been published and approved by DIN's Management Board. The consortium shall comprise at least three members from different organizations[2]. It is not necessary that these members come from different areas and represent different stakeholders. By approving this business plan, the interested parties declare their willingness to participate in the consortium and will be formally named as consortium members, with the associated rights and duties. Participants at the kick-off meeting who do not approve the business plan are not given the status of a consortium member and are thus excluded from further decisions made during the kick-off meeting and from any other decisions regarding the project.

[2] Organizations are participating legal entities that send the experts to the DIN SPEC consortium and are assigned to a corporate structure as defined by § 15 of the German Stock Corporation Act or § 271 paragraph 2 of the German Commercial Code.

If an organization (e.g. an association) sends someone who is not an employee to the consortium, this person shall be authorized by the organization, who shall provide proof of this to DIN.

Each consortium member is entitled to vote and has one vote. If an organization sends several experts to the consortium, that organization has only one vote, regardless of how many consortium participants it sends. Transferring voting rights to other consortium members is not permitted. During voting procedures, decisions are passed by simple majority; abstentions never count.

As a rule, the consortium is closed once it is constituted. The current consortium members shall decide whether any additional members will be accepted or not.

During the kick-off meeting, the consortium members shall elect a consortium leader, who is responsible for content management and any decision-making and voting procedures. The leader is supported by the responsible DIN Project Manager, whereby DIN will always remain neutral regarding the content of the DIN SPEC. Furthermore, the DIN Project Manager shall ensure that DIN's rules of procedure, rules of presentation, and the principles governing the publication of DIN SPEC have been observed. Should a consortium leader no longer be able to carry out his/her duties, the DIN Project Manager shall initiate the election of a new leader.

The DIN Project Manager is responsible for organizing and leading the kick-off meeting, in consultation with the initiator. Further project meetings and/or web conferences shall be organized by the DIN Project Manager in consultation with the consortium leader.

If consortium members cannot be present when the DIN SPEC or its draft is approved, an alternative means of including them in the voting procedure shall be used (e.g. in writing, electronically).

All consortium members who voted for the publication of the DIN SPEC or its draft will be named as authors in the Foreword, including the organizations which they represent. All consortium members who voted against the publication of the DIN SPEC or its draft, or who have abstained, will not be named in the Foreword.

Any expansion of the consortium at a later date is decided on by the members making up the consortium at that time. It is particularly important to consider these aspects:

a) expansion would be conducive to shortening the duration of the project or to avoiding or averting an impending delay in the planned duration of the project;
b) the expansion would not result in the project taking longer to complete;
c) the new consortium member would not address any new or complementary issues beyond the scope defined and approved in the business plan;

d) the new consortium member would bring complementary expertise into the consortium in order to incorporate the latest scientific findings and state-of-the-art knowledge;
e) the new consortium member would actively participate in the drafting of the manuscript by submitting concrete, not abstract, proposals and contributions;
f) the new consortium member would ensure wider application of the DIN SPEC.

To allow the legal reproduction and distribution of results for the purposes of project work, the consortium members grant DIN rights of use on the basis of the copyright that will accrue to them for the results of their work on the DIN SPEC. The transfer of these utilization rights does not prevent the consortium members from using and further developing the knowledge, experience and findings they bring to the project.

Consortium members are requested to inform DIN of all patent rights known to them to be relevant to this DIN SPEC project.

Subsequent changes to the scope (Section 3.2) or to the resource planning (Section 5) require, in addition to a two-thirds majority of all votes cast, the approval of DIN.

7. Contacts

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Annex: Project schedule

DIN SPEC project	2022												2023											
	Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul	
Initiation																								
1. Request and review																								
2. Business plan drawn up																								
3. Publication of business plan																								
Development phase																								
4. Kick-off meeting/consortium constituted																								
5. DIN SPEC drawn up																								
6. DIN SPEC approved by consortium																								
Publication																								
7. Review and release by DIN																								
8. Publication of DIN SPEC																								
Milestones							**K**		**W**		**W**			**W**		**W**		**M A**						

K Kick-off
M Project meeting
W Web conference
A Adoption of DIN SPEC