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| **Contact:** | Arnaud TaddeiSymantec CorporationUnited States of America | Tel: +41 79 506 1129E-mail: Arnaud\_Taddei@symantec.com  |

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| **Abstract:** | This document carries the final report from the chairman of the quantum adhoc sessions to the TSAG closing plenary. |

# Introduction

At the TSAG opening plenary, based on contribution [C54](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-C-0054) from China proposing the establishment of a Focus Group on Quantum Information Technology for Networks (FG-QIT4N), TSAG created an adhoc discussion on Quantum. Its mandate is to investigate the scope of interest/responsibility of ITU-T in Quantum matters and discuss options for carrying the work forward. M. Arnaud Taddei accepted his nomination as Chairman for this adhoc discuss with the secretary support from Mrs Xiaoya Yang from ITU-TSB.

# Method Followed

Considering that there are gaps between:

* Quantum experts who are however not familiar with ITU-T
* ITU-T experts who were not Quantum experts,

the Chairman felt it was necessary to work and develop a method to allow the team to achieve the best possible understanding l within the time constraints to digest information and positions of all parties in a step-by-step approach and to encourage bilateral consultations.

As such the Chairman proposed an incremental approach with the following steps:

* Delivery of a presentation to introduce terms, concepts, status, proposals,
* A specific questionnaire methodology to clarify the argumentation for a Focus Group
* A proposition of the proposed FG ToR
* Finally a decision-making process

This incremental approach, with adequate time for all parties to consult, reflect and reconcile, allowed:

* A good quality exchange of views and understanding/learning from all parties
* An emerging engagement and evolution of positions
* Enough time to allow bilateral consultations and rework or development of new materials
* A shared understanding of the group’s final position

# Identification of documents relevant to these adhoc sessions

The following documents were identified, reviewed, created and developed during the work of the Quantum adhoc sessions

Table 1 - Documents relevant to the Quantum adhoc sessions

|  |  |
| --- | --- |
| Reference | Title |
| [C54](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-C-0054) | Proposal to set up a new ITU-T Focus Group on Quantum Information Technology for Networks (FG-QIT4N) |
| [TD433R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0433) | Revision of C54: “Proposal to set up a new ITU-T Focus Group on Quantum Information Technology for Networks (FG-QIT4N)” |
| [TD406R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0406) | LS on Response to proposal to set up a new ITU-T Focus Group on Quantum Information Technology for Networks (FG-QIT4N) [from ETSI ISG QKD] |
| [TD416R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0416) | Tutorial – Introduction to Quantum Information Technology and Network Evolution |
| [TD424R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0424) | Minutes of the first adhoc session on Quantum |
| [TD425](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0425) | Agenda of the second TSAG adhoc session on Quantum |
| [TD426](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0426) | Entities interested in ITU-T work on quantum communication |
| [TD434](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0434) | Minutes of the second adhoc session on Quantum |
| [TD435](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0435) | Agenda of the third TSAG adhoc session on Quantum |
| [TD439](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0439) | Agenda of the fourth TSAG adhoc session on Quantum |
| [TD444](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0444) | Minutes of the third TSAG adhoc session on Quantum |
| [TD445](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0445) | Minutes of the fourth TSAG adhoc session on Quantum |

# Execution

The execution of the above methodology took four adhoc sessions interspaced with many bilateral consultations

## First adhoc session

The first adhoc session happened on Tuesday 11th of December at 8:00 in room C

No agenda could be prepared for this first adhoc but minutes were produced as [TD424R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0424) which documents the agenda that was verbally proposed by the Chairman and so approved.ion

In this adhoc session a tutorial was delivered in order to help the team understand and learn the terms, the concepts, the currents and future statues, the projects examples, etc.

It was followed by a first set of questions and answers. Participants demonstrated their positions and opinions. There was gap between proponents for and against the creation of Focus Group but as well the recognition of the requirement for a coordination model for the coordination of the work already started at SG13, SG17 and ETSI ISG QKD.

Chairman came out with a innovative methodology under the form of a questionnaire with 12 questions that China could answer in order to give the maximum clarity and allow a systematic review of the argumentation.

## Consultations after the first adhoc session

Many consultations happened especially between Japan and China where Japan proposed a first revision of the ToR

The other important consultation was for the Chairman to spend time with China to explain the method he proposed as the questionnaire. As the result, China delivered in a very short amount of time a high quality answers to all the questions asked.

## Second adhoc session

The second adhoc session happened on Wednesday 12th of December at 13:15 in room C

The agenda is in [TD425](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0425) and the minutes are in [TD434](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0434)

In this session, essentially China spelled out its answers to the questionnaire for the argumentation, which allowed the team to enter really in the topic and on the debate. The discuss was dense with questions and answers. It could not be possible to take a decision right then as there was a persistent divide of opinions.

Chairman proposed to run offline consultations and asked for 2 new more adhocs anticipating clearly that the team needed significantly more time to resolve.

## Consultations after the second adhoc session

Many consultations happened which resulted in essentially China changing the FG ToR with the great support and work from Japan.

## Third adhoc session

The third adhoc session happened on Thursday 13th of December at 8:00 in room C

The agenda is in [TD435](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0435) and the minutes are in [TD444](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0444)

The meeting reviewed the new ToR with changes in drafting mode. Yet, despite the work done, the team’s divide increased.

Many good remarks were made in particular SG15 Chairman considered it was a bit too early for SG15 to participate whereas SG2 Chairman made a point that SG2’s participation need to be considered for operational aspects.

Chairman called for a last chance to further revise the FG ToR text with more specific consultations.

## Consultations after the third adhoc session

Many consultations happened which resulted in essentially China making a new ToR final proposal in TD433R1.

## Fourth adhoc session

The fourth adhoc session happened on Thursday 13th of December at 18:00 in room C

The agenda is in [TD439](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0439) and the minutes are in [TD445](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0445)

Chairman called this session for decision after he asked China for a high level view of the latest changes of the ToR. He gave the floor for limited discussions but rather essentially asked if the delegations were objecting with this new ToR.

As there were still objections voiced even after this new ToR resulting from consultations, the chairman noted that there was no consensus and proposed a way forward by which China could consider:

* organize a workshop to allow all participants to be prepared and prepare participation
* send contributions to SG13 and SG17
* write a technical report to detail the content behind the presentation in [TD406R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0406)
* potentially and based on this discussion already happened, propose perhaps a new FG at the next TSAG in September 2019

As well chairman offered China the chance to write a statement for this report.

The idea of a workshop

* Was supported by SG13, SG17 and several delegations in particular US
* TSB offered the possibility to run it in the aegis of ITU
* SG13 will have 2 meetings in 2019 with a possibility to put a workshop in one of its interim SG13 meetings
* SG17 will have 2 meetings in 2019 and offered a mini-workshop for Quantum at the next SG17 meeting in January 2019

Finally Chairman proposed a way forward regarding the coordination between the SG2, SG13, SG17 and when SG15 feels to:

* Encourage to strengthen the relationship with ETSI ISG QKD and potentially other SDOs like ISO/IEC
* Decide the best way to organize the coordination using any possibilities offered by ITU-T mechanisms, including Liaison Statement.

## General Atmosphere

The sessions were well attended with around 40-70 delegates including at very early in the morning.

The atmosphere of the team was very good, each party was respectful of each other, with a strong recognition of the work done here especially by China. Delegations were very engaged with a very good participation level and a civilized and vivid fighting spirit.

Bilateral consultations were encouraged allowing the team members to have the chance to discuss and even develop materials but as well, hopefully, meet and create perhaps new relationships.

# Chairman’s Analysis

Chairman sensed that both sides had good intentions with China strongly willing to help the ITU and the other side willing to invite China to contribute to current Study Group work. There was unfortunately no agreement on the way to connect this offer and this demand.

One side thought a Focus Group was the right vehicle but the other side saw a risk of duplication of work for one aspect (in short QKD) and a too premature engagement for another aspect in short QIT and QIN).

Unfortunately the sequence of events didn’t help here with timing. The release of the contribution [C54](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-C-0054) took a number of delegations by surprise with no time for them to share, align or even find a different position with Capitol, with all the constituencies and agencies required in such a case in each administration

On the other and whilst no consensus could be find, the journey itself was fruitful and allowed the whole team to learn a massive amount of new information but as well assess the situation and the work provided by China was phenomenal given the time constraints, everyone appreciated it.

A ‘no consensus’ in this adhoc discussion is actually not the end but the beginning of the journey, there is now a path forward for the whole team to mature together with multiple possibilities to interlock until the next TSAG meeting

# Quote from China

“Dear Mr. Chairman:

You kindly provided some key proposals at the end of the fourth ad-hoc quantum meeting, including:

1. Since no consensus has been reached among all member states, FG-QIT4N will not be established at this ITU-T TSAG meeting and will be further discussed at the next TSAG meeting in September 2019.

2. At the appropriate time in 2019, organized by ITU-T, host by China, a quantum information technology workshop will be held in China.

After careful consideration and full discussion, the China delegation would like to reply the following suggestions:

1. The rapid development of quantum information technology and its impact on the network cannot be ignored. It is urgent for ITU-T to carry out technical and standardization research in related field as soon as possible. The China delegation deeply regrets that FG-QIT4N could not be established at this TSAG meeting.

2. According to your proposal, China is willing to cooperate with ITU-T and to hold a quantum information technology workshop in China in the proper time of 2019. We are also willing to make our further contribution to ITU-T in this field.”

# Highlights for the TSAG Report

According to the ToR for the Quantum adhoc session, chairman reports that 4 adhoc sessions were hold this week following a specific methodology. As a result:

1. No consensus was reached to establish a new Focus Group as per a revised version of the ToR ([TD433R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0433)) proposed initially in [C54](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-C-0054)
2. It had been proposed to China to consider
	1. organize a workshop to allow all participants to be prepared and prepare participation
	2. send contributions to SG13 and SG17 on current work
	3. write a technical report detailing the content behind the presentation in [TD406R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0406)
	4. potentially and based on this new experience propose perhaps a new FG at the next TSAG in September 2019
3. A strong need for coordination between SG13, SG17 with the current consideration of SG2 and maybe perhaps later SG15 was recognized. Chairman recommends to these SGs:
	1. strengthen their relationship with ETSI ISG QKD and potential other relevant/interested SDOs
	2. discuss between themselves the best appropriate way to coordinate their work with considering any possibilities offered by ITU-T mechanisms
	3. report to the next TSAG on their coordination method decision and status

# Annex 1 – Latest draft ToR status

For reference the latest draft ToR text as per [TD433R1](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=T17-TSAG-181210-TD-GEN-0433)

[Proposed Terms of Reference:
ITU-T Focus Group on “Quantum Information Technology for Networks” (FG-QIT4N)

**1. Rationale and Scope**

Research and applications of quantum information technology (QIT) are accelerating globally. The computation power brought by quantum computing has a threat on the security of ICT networks. On the other hand, quantum key distribution provides long-term security guaranteed by the principles of quantum mechanics. Quantum teleportation could connect distributed quantum computing processors, quantum sensors and other quantum information processing nodes to form a QIN, and distribute quantum information in a long distance. New applications of QIN, such as distributed quantum computing and quantum sensors network, might be provided in the future. It is necessary to perform comprehensive investigations and analysis of the impact of QIT on networks.

The metro/backbone QKD network construction and satellite-based quantum communication experimental application have been realized in last decade. These developments provide specific requirements for QKD standardization, including QKD equipment reliability and practical security, QKD network survivability and robustness, inter-domain operation and management, and QKD integration with existing optical communication networks. These requirements involve the scope of several study groups of ITU-T which have already been working on “Framework for Networks to supporting Quantum Key Distribution” in SG13, “Security framework for Quantum Key Distribution in Telecom network” in SG17, and “Quantum Noise Random Number Generator Architecture” in SG17 and are essential for the future application of QKD technology.

Apart from QKD, tremendous efforts had been devoted to the realization of other QIN technologies. In recent years we have witnessed a rapid development of quantum teleportation, quantum repeater, and quantum computing, whose feasibility has been demonstrated through various prototypes and experiments. Thus it is urgent and essential to conduct relevant technical progress investigation, impact assessment, and standardization possibility analysis.

The ITU-T Focus Group on “Quantum information technology for networks” (FG-QIT4N) would provide an important platform to study the impact of QIT on networks and QIN related technologies. It engages researchers, engineers, practitioners, entrepreneurs and policy makers, to take full advantages of ability and potential of QIT in networks.

**2. Objectives of the FG-QIT4N**

The objective of the Focus Group is to provide a platform to facilitate global collaboration for investigating impact of QIT on networks and QIN related technologies, and to conduct relevant analysis in order to identify gaps and issues in standardization and application.

1. To analyse and evaluate the impacts of QIT on the existing and future networks.
2. To identify the challenges for QKD network development, and to study the status and issues of QKD networks standardization.
3. To study key features, enabling technologies, network architecture, application scenarios, development trends, and potential standardization aspects of QIN.
4. To establish liaisons and relationships with other SDOs and between the study groups (SGs) in ITU-T.

**3. Structure**

The FG-QIT4N may establish sub-groups if needed.

**4. Specific Tasks and Deliverables**

Tasks and deliverables developed by the FG-QIT4N may include the following:

1. To draft reports on the impacts of QIT on networks:
	1. To provide a description of key concepts related to QIT, and analysis of their relationship with network.
	2. To analyze the impact of quantum computing to networks, including security threats and enhancements on signal processing and big data analysis.
	3. To analyze the impact of quantum communication technology for its capability of anti-eavesdropping, long term security guarantee, and quantum information transmission.
	4. To study new network applications brought by QIT such as high precision network time reference and distributed quantum computing.
2. To draft reports on the standardization status of QKD networks, new applications, co-fibre transmission issues and the merger with quantum relay and quantum repeater technologies for realizing scalable QKD networks:
	1. To provide comprehensive landscape on the status of QKD technologies and QKD networks standardizations such as by ITU-T (SG13 and SG17), ISO/IEC JTC1 SC27, ETSI ISG-QKD.
	2. To identify and study the new application scenarios and use cases of QKD, e.g., satellite-based wide-area QKD, miniaturized and free space QKD, integration of QKD and classical cryptography including quantum-safe cryptography (or often call post-quantum cryptography: PQC, as well).
	3. To study the solutions and technical requirements for co-fiber transmission of quantum and classical signal.
	4. To study the solutions and technical requirements for quantum relay and quantum repeater technologies to extend the reach of QKD networks and to make them scalable.

*Note: The following items on QKD have already been studied or are under preparation for proposing new work items for standardizations in ETSI ISG-QKD, ITU-T (SG13 and SG17), and ISO/IEC JTC1 SC27. So, these following items should be out of scope of this FG.*

1. *To study security threats on a QKD network, and methods to operate the QKD network securely, including key management, key supply, network management etc., and to work on standardization of QKD network security (ITU-T SG13&17).*
2. *To study the function model, inter-domain managements, interaction interfaces of QKD networks to ensure interoperability, and to work on network architectural issues to integrate QKD networks into conventional networks, and the study on the service models, enabling QKD-as-a-service (QAAS) (ITU-T SG13).*
3. *To propose solutions to ensure practical security and reliability of QKD systems, and interfaces between QKD systems and applications (ISO/IEC JTC1 SC27, ETSI ISG-QKD).*
4. To draft reports on the evolution of QIN including:
	1. To provide description of key concepts related to QIN and relevant terminology.
	2. To study the application requirements and potential use cases for QIN, especially on connecting quantum information processing nodes such as quantum computing processors and quantum sensors to realize quantum information transmission and networking.
	3. To study the state-of-the-art and evolving trends of key components for the above b) and enabling technologies for QIN.
	4. To study the architecture of future QIN, its relationship with existing networks and the evolution roadmaps.
	5. To study and document the technology and market requirements for the potential standardization on QIN.
5. To organize thematic workshops and forums on QIT for networks, which will bring together all stakeholders to promote the FG activities, and encourage both ITU members and non-ITU members to jointly contribute on this work.
6. To make liaison with other SDOs, such as ETSI specific ISGs, IEEE, ISO/IEC.

**5. Relationships**

This Focus Group will work in close collaboration with all ITU-T study groups, especially SG13, SG15, and SG17.

This FG QIT4N will collaborate with relevant entities, in accordance with Recommendation ITU-T A.7. These entities include the following: SDOs, industry forums and consortia (such as ISO/IEC JTC 1, ETSI ISG-QKD, IEEE QuantumComm), tech companies, academic institutions, research institutions and other relevant organizations.

**6. Parent group**

The parent group is ITU-T TSAG.

**7. Leadership**

See clause 2.3 of Recommendation ITU-T A.7.

**8. Participation**

See clause 3 of Recommendation ITU-T A.7. A list of participants will be maintained for reference purposes and reported to the parent group.

It is important to mention that the participation in this Focus Group has to be based on contributions and active participations.

**9. Administrative support**

See clause 5 of Recommendation ITU-T A.7.

**10. General financing**

See clauses 4 and 10.2 of Recommendation ITU-T A.7.

**11. Meetings**

The schedule and location of meetings will be determined by the Focus Group and the overall meetings plan will be announced after the approval of the terms of reference. The Focus Group will work electronically using teleconferences and with face-to-face meetings. Meetings will be held as determined by the Focus Group and the meetings will be announced by electronic means (e.g., e-mail and website, etc.) at least four weeks in advance.

**12. Technical contributions**

See clause 8 of Recommendation ITU-T A.7.

**13. Working language**

The working language is English.

**14. Approval of deliverables**

Approval of deliverables shall be taken by consensus.

**15. Working guidelines**

See clause 13 of Recommendation ITU-T A.7.

**16. Progress reports**

See clause 11 of Recommendation ITU-T A.7.

**17. Announcement of Focus Group formation**

The formation of the Focus Group will be announced via TSB Circular to all ITU membership, via the ITU-T News log, press releases and other means, including communication with the other involved organizations.

**18. Milestones and duration of the Focus Group**

The Focus Group lifetime is set for one and half year from the first meeting but extensible if necessary by decision of the parent group. (see ITU-T A7, clause 2.2).

**19. Patent policy**

See clause 9 of Recommendation ITU-T A.7.]

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