# Capacity Building Workshop on Testing Methods for Internet of Things (IoT) Products

APEC Sub-Committee on Standards and Conformance

December 2024

Asia-Pacific
Economic Cooperation

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APEC Project: SCSC 05 2021A

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## Table of Contents

## 1. GLOSSARY AND ACRONYM LIST

### Glossary

| Terms | Definition |
|---|---|
| Internet of Things | The interconnection via the internet of computing devices embedded in everyday objects, enabling them to send and receive data. |
| Proficiency Testing | Evaluation of participant performance against pre-established criteria by means of inter-laboratory comparison. |
| Round Robin Test | An interlaboratory test (measurement, analysis, or experiment) performed independently several times. |
| ISO/CASCO | CASCO is the ISO committee responsible for conformity assessment in ISO |
| Intralaboratory comparison | Organization, performance and evaluation of measurements or tests on the same or similar items, within the same laboratory in accordance with predetermined conditions |
| LoRa | A long range, low power wireless platform that has become the de facto wireless platform of Internet of Things (IoT) |
| NB-IoT | Narrow Band-Internet of Things |

### Acronyms

| Acronyms | Definition |
|---|---|
| ILC | Inter-laboratory comparison |
| IoT | Internet of Things |
| PT | Proficiency Testing |
| PTP | Proficiency Testing Provider |
| MSLIMS | Laboratory Information Management System |
| MS | Management System |
| RTC | Request, Tenders and Contracts |
| IOMT | Industry of Medical Things |
| AGV | Automated Guided Vehicles |
| EMF | Electro-Magnetic Field |
| KCRV | Key Comparison Reference Value |

## 2. EXECUTIVE SUMMARY

The Capacity Building Workshop on Testing Methods for Internet of Things (IoT) Products (SCSC 05 2021A) consists of different activities designed to build on and enhance the capacity on the testing methods for Internet of Things (IoT) Products of the participants from the developing economies in which IoT products are still in quite an early stage. This is due to the current situation and global trends where the IoT products are expected to be tripled in number in the very near future. These activities will be run by the experts from those economies with much more advancement in IoT products to ensure that the participants are

able to develop their knowledge and skills in terms of testing methods employed in verifying the product's quality no matter what their original resources are, what kind of instrument the product is of and in which economic context they are from. These IoT products should be verified of their quality through globally acceptable standards or criteria and the way these products are to be verified also needs to be conformed with the international standards.

This report has provided information on the project overview, a summary of each activity; the three seminar sessions, the three workshop and training sessions, as well as the summary of the round robin test. The summary of the seminar and workshop and training sessions includes the agenda, the session overview, the summary of each session's discussion and the speaker of each activity.

The report has also included the summary of discussion and the key result of the activities as well as future recommendation for further improvement in organizing any other related or similar activities or project.

## 3. INTRODUCTION

The project of Capacity Building Workshop on Testing Methods for Internet of Things (IoT) Products (SCSC 05 2021A) was, therefore, initiated and conducted to ensure that the participating economies especially APEC would have access to the right knowledge and skills to implement an appropriate testing method for their IoT products based on the internationally accepted standards and policies.

Once equipped with testing skills and relevant knowledge, APEC participants should be able to achieve and increase certain level of expertise to be at the similar standard implemented globally or at least be able to use the common test method more efficiently. Furthermore, a better and a more thorough understanding of the round robin test will also be a useful tool when it comes to expanding the testing skills of IoT products.

## 4. BACKGROUND & OBJECTIVES

With the current trends and situation in which the pandemic has accelerated and provoked a significant increase in the new normal of remote or virtual work, the number of Internet of Things or IoT products is simply forecasted to be tripled within a very near future. This also includes phones with 4G technology, different products, and modules with wireless technology such as NBIoT, LoRa, and SigFox based on the frequency of 920-925MHz. The quality of these products will need to be verified; however, as they can be from different resources, of a variety of instruments and even from multiple economic contexts, the testing

method will have to be of an acceptable global standard to really have some benchmark as a reference. This might also include some kind of assessment process of a similar standard to ensure these testing methods are followed in an appropriate manner.

The project aims to provide a capacity building activity by experts from the economy with more advancement in IoT to the developing economies. Workshops are also organized to collectively looking at the existing standards, testing methods and current status and to eventually ideate a more standardized protocols as well as testing methods for the economies along with the relevant training courses within the economy with testing laboratories and experts. Moreover, the Round Robin test will also be trialed by the project participants within their home economies with the expert's supervision and conformity checks. All these activities would eventually and hopefully promote even more cross-border trade in IoT products.

After the participation in the project, the participants are expected to improve APEC participating laboratories' competency as they will be equipped with the right knowledge and skills on testing IoT products. Moreover, the activities in this project should be a starting point for further technical skills transfer especially across APEC economies. Eventually, the overall standard within the economies would be improved and that would, in turn, have an impact on a wider circle such as the policy makers, relevant decision-making parties, accreditation bodies as well as the IoT product manufacturers.

## 5. OVERVIEW OF PROJECT

The project of Capacity Building Workshop on Testing Methods for Internet of Thing (IoT) Products (SCSC 05 2021A) consists of different activities designed to build on and enhance the capacity on the Testing Methods for Internet of Things (IoT) Products of the participants from the developing economies in which IoT products are still in quite an early stage. This is due to the current situation and global trends where the IoT products are expected to be tripled in number in the very near future. These activities will be run by the experts from those economies with much more advancement in IoT products to ensure that the participants are able to develop their knowledge and skills in terms of testing methods employed in verifying the product's quality no matter what their original resources are, what kind of instrument the product is of and in which economic context they are from. These IoT products should be verified of their quality through a globally acceptable standards or criteria and the way these products are to be verified also needs to be conformed with the international standards

The project has included 3 seminar sessions, 3 workshops and training sessions and

the round robin test. While the first seminar introduces the overall project and the second seminar provide a discussion on the round robin test which is the second phase of the project, the 3 workshop and training sessions are organized to provide knowledge and enhance the participants to be equipped with the relevant knowledge and skills of the testing methods for Internet of Things (IoT). These workshops and training include different standards of the testing laboratory such as ISO/IEC 17025, ISO/IEC 17043 as well as the round robin test and other IoT technologies. After these workshops, the participants will get to participate in the round robin test the result of which will be discussed in the 3rd seminar session. An overview of each activity can be found below.

### 5.1 The 1st Seminar

Date and time**:** Monday, 21 August 2023, 08:30 - 12.00 (Thailand Time)

| **Time** (UTC+07:00) | **PROGRAMME** |
|---|---|
| 08:30 – 09:00 | **Login and System Checks**<br>- Delegates to login using the assigned usernames<br>- Check audio and visual connections |
| 09:00 – 09:05 | **Introduction** *by Dr. Chutima Eamchotchawalit, Governor, TISTR* |
| 09:05 – 10.45 | **Introduction to the project** *by Dr. Prawate Kluaypa, TISTR* |
| 10.45 – 11:00 | BREAK |
| 11.00 – 12:00 | **The Importance of PT in Accreditation** *by Mr. Nick SLAWSON, PTP/RMP Program Manager, A2LA, United States* |
| END OF The 1st Seminar | |

### 5.2 The 1st Workshop and Training

Date and time: Tuesday, 22 August 2023, 08:30 - 12.00 (Thailand Time)

| Time (UTC+07:00) | PROGRAMME |
|---|---|
| 08:30 – 08:50 | **Login and System Checks**<br>- Delegates to login using the assigned usernames<br>- Check audio and visual connections |
| 08:50 – 08:55 | **Introduction** *by Dr. Prawate Kluaypa, TISTR* |
| 08:55 – 10.25 | **Training on ISO/IEC 17025 and IoT Testing Laboratory** *by Mr. CHEN Di, Senior Manager, China National Accreditation Service for Conformity Assessment (CNAS), People's Republic of China* |
| 10.25 – 10:30 | **BREAK** |
| 10:30 – 12:00 | **Training on ISO/IEC 17025 and IoT Testing Laboratory (cont.)** *by Mr. Roger SHENG, Deputy Director, Taiwan Accreditation Foundation (TAF), Chinese Taipei* |
| **END OF The 1st Workshop and Training** | |

### 5.3 The 2nd Workshop and training

Date and time: Wednesday, 23 August 2023, 08:30 - 12.00 (Thailand Time)

| Time (UTC+07:00) | PROGRAMME |
|---|---|
| 08:30 – 08:50 | **Login and System Checks**<br>- Delegates to login using the assigned usernames<br>- Check audio and visual connections |
| 08:50 – 08:55 | **Introduction** *by Dr. Prawate Kluaypa, TISTR* |
| 08:55 – 10.25 | **Training on ISO/IEC 17043 and round robin test** *by Mr. HE Ping, Senior Manager, China National Accreditation Service for Conformity Assessment (CNAS), People's Republic of China* |
| 10.25 – 10:30 | **BREAK** |
| 10:30 – 12:00 | **Training on ISO/IEC 17043 and round robin test (cont.)** *by Ms. JIA Rujing, Senior Manager China National Accreditation Service for Conformity Assessment (CNAS), People's Republic of China* |
| **END OF The 2nd Workshop and Training** | |

### 5.4 The 3rd Workshop and training

Date and time: Thursday, 24 August 2023, 08:30 - 12.00 (Thailand Time)

| **Time** (UTC+07:00) | **PROGRAMME** |
|---|---|
| 08:30 – 08:50 | **Login and System Checks**<br>- Delegates to login using the assigned usernames<br>- Check audio and visual connections |
| 08:50 – 08:55 | **Introduction** *by Dr. Prawate Kluaypa, TISTR* |
| 08:55 – 09.55 | **Unleashing the IoT Revolution** *by Mr. Danny TAN, Education & Research Business Development Manager, Keysight Technologies Australia, Australia* |
| 09:55 - 10.55 | **Accelerating New Wave of IoT Application with Cellular IoT** *by Mr. Voon YEN LIEW, Field Marketing Manager, Anritsu Singapore, Singapore* |
| 10:55 – 11:55 | **5G Private Networks – The Key to Unlocking Industry 4.0** *by Ms. Guo LING, Regional Sales Manager, Rohde & Schwarz, Singapore* |
| 11:55 – 12:00 | Q&A |
| **END OF The 3rd Workshop and Training** | |

### 5.5 The 2nd Seminar

Date and time: Friday 25 August 2023, 08:30 - 12.00 (Thailand Time)

| **Time** (UTC+07:00) | **PROGRAMME** |
|---|---|
| 08:30 – 09:00 | **Login and System Checks**<br>- Delegates to login using the assigned usernames<br>- Check audio and visual connections |
| 09:00 – 12.00 | **Introduction to Round Robin Test on IoT Product** *by Prawate Kluaypa* - Presentation<br>- Discussion |
| END OF The 2nd Seminar | |

### 5.6 The 3rd Seminar

Date and time: Friday, 31 May 2024, 08:30 - 12.00 (Thailand Time)

| **Time** (UTC+07:00) | **PROGRAMME** |
|---|---|
| 08:30 – 09:00 | **Login and System Checks**<br>- Delegates to login using the assigned usernames<br>- Check audio and visual connections |
| 09:00 – 09:05 | **Introduction** *by Dr. Prawate Kluaypa, Laboratory Director, Thailand Institute of Scientific and Technological Research (TISTR)* |
| 09:05 – 10:20 | **Discuss on the results of Round Robin Test on IoT Product** *by Dr. Dr. Vitawat SIttakul, Associate Professor, King Mongkut's University of North Bangkok, Thailand* |
| 10:20 – 10:35 | BREAK |
| 10:35 – 12:00 | **Discuss on the results of Round Robin Test on IoT Product (cont.)** |
| **END OF The 3rd Seminar** | |

## 6. SUMMARY OF SEMINARS, WORKSHOP AND TRAININGS REPORTS AND ROUND ROBIN TEST REPORT

### 6.1 Summary of 1st Seminar

#### *6.1.1 Project Introduction*

Dr. Prawate Kluaypa, the Project Overseer or PO, of the Capacity Building Workshop on Testing Methods for Internet of Things (IoT) Products (SCSC 05 2021A) introduced the overview of the project to the seminar participants. The presentation on the project overview contains the project background, objectives, output, and outcomes as well as the workplan, the beneficiaries, linkages, and relevant stakeholders like the co-sponsoring economies. The presentation also includes the overall timeline of the project and the agenda for each of the activities to be conducted later in this project and what areas are to be addressed in the upcoming activities to inform the participants accordingly.

After the participation in the project, the participants are expected to improve APEC participating laboratories' competency as they will be equipped with the right knowledge and skills on testing IoT products and a more thorough understanding on the round robin test which will be a helpful basis in expanding their testing skills. Moreover, the activities in this project should be a starting point for further technical

skills transfer especially across APEC economies.

The project aims to get the testing laboratories upskilled and eventually improve the standard within the economies and that would, in turn, have an impact on a wider circle such as the policy makers, relevant decision-making parties, accreditation bodies as well as the IoT product manufacturers.

### *6.1.2 The Importance of PT in Accreditation*

Proficiency Testing or PT is defined as an evaluation of participant performance against pre-established criteria by means of inter-laboratory comparison. The evaluation in the context of the Proficiency Testing is not just some kind of comparison, but it is a certain form of analysis that can be conducted on the PT results, and it is statistics based. Furthermore, the evaluation comes with ISO standards that can be used in assisting such an evaluation. The current ISO for PT is ISO/IEC 17043:2023. These criteria make the Proficiency Testing different from the Inter-Laboratory Comparisons or ILC in general.

The Proficiency Testing also includes pre-determined criteria which are set ahead of time; mostly when creating the testing schemes and these criteria are usually set and evaluated by a third party which is different from the usual ILC. However, the inter-laboratory comparison is also another important component for a PT. Most PT would use multiple labs to ensure the quality of the end data. Many providers also set the evaluation based on the number of the participating labs since the more it is, the better the data comparison can be conducted.

The Proficiency Testing plays a vital role in accreditations. Most of the standards and accreditation will require some kind of Proficiency Testing since they are important in terms of standard maintenance. The Proficiency Testing has become very important to keep track of how certain laboratories have been doing between different cycles; especially if there have been certain major changes in between those maintenance cycles. These PT results will provide different information to let the relevant parties know about the laboratory before running any other PT or to basically maintain certain standards.

PT can, on the other hand, imply the competence of the organization and how it can be maintained or improved. With the parameter set by another party, the laboratories using PT would be able to know where exactly they stand compared to other laboratories based on certain targets set out by the third parties. The results

could also provide a guideline on how things are to be managed, which areas to focus on for future training, etc. In a situation where certain changes happen to a laboratory; this can be a change in equipment or staff turnover, running a PT would be a great way to ensure that the laboratories are still on track in different aspects. Moreover, for certain standards, several PT results are required in order to get a related accreditation.

Additionally, the PT result can also be used to boost the credibility and the confidence of the laboratories themselves and a kind of a verification from the outsiders' perspectives. It can also be used as a guideline for further development and maintenance as it can be implemented in future training to improve overall performance for instance.

## 6.2 Summary of Workshop & Trainings

### *6.2.1 The 1st Workshop & Training:*

#### a. Introduction to Training on ISO/IEC 17025 and IoT Testing Laboratory

ISO/IEC 17025: 2017 has become an international reference for testing and calibration of laboratories. The standard focuses mainly on the competence of the laboratories themselves, and it has certain key changes from 2005 to 2017.

One of the main changes is the new structure which is adjusted to align with the existing standards such as ISO/CASCO. Mr. Chen Di also stated that one of the most important elements in these changes is the risk-based thinking and risk to impartiality. Apart from that, there are also some new terms and definitions in the version of 2017 and another significant change is the Laboratory Information Management System or LIMS.

After giving a general outline, the speaker discussed about the different aspects of the standards based on the standard structure consisting of scope, normative references, terms and definitions, general requirements, structural requirements, resource requirements, process requirements and management requirements as well as the other 2 annexes: metrological traceability and management system.

Speakers also went into details of each aspect, and he started with risk management first as it seems to be one of the significant key changes between 2005 and 2017. Generally, risk management even in the context of laboratories concerns

those of the business operations. This could be anything posted by the company itself, but in order to achieve the standards in this aspect, it is essential for the laboratories in question to identify and address the risks that could have an impact on the lab results

For the scope of the standard, it can be said that it applies for the general requirement for competence, impartiality and consistent operation of laboratories and with this new standard, it does not matter how many personnel are running the laboratory in question. All the organizations with laboratory activities should conform to these standards.

In summary, the ISO/IEC 17025 is like a general requirement requested by the regulator. The laboratories which are in the process of getting international standards will need to try to really meet all these requirements. However, it is also important to really know your laboratories' strength based on the field the laboratories have worked on, the resources the laboratories have. This can also be kicked off by using a domestic accreditation body to ensure certain standards are met before becoming an even more competent laboratory.

### *6.2.2 The 2nd Workshop & Training:*

**a. Introduction on ISO/IEC 17043:2023 Conformity assessment - General requirements for proficiency testing providers**

The presentation started off with an introduction on what ISO/IEC 17043 is and who it is actually for. They are like a foundation of PT scheme required by regulator and specification bodies. The standard is also usually used by accreditation bodies to support the accreditation for ISO/IEC 17025, ISO/IEC 17020 and ISO 15189. However, after the new versions of ISO 17011:2017, 17025:2017 and ISO 17034:2016 are published, there was a huge change since the accreditation bodies can no longer run the PT by themselves.

The session has also included detailed changes of the updated ISO/IEC 17043:2023; with a thorough explanation for the audience to consider if they are planning to get accredited or having anything relevant to the standard coming up very soon. From the session, we can see that most of the changes are in the wording and consistency of the overall standard. As for the resource requirements, they are simplified with direct references to ISO/IEC 17025 and ISO 17034. Another relevant requirement can be clarified through a note in this version.

Apart from the wordings, the other significant changes are in clause 7; the new structure has been introduced and there are also some new contents which are the dealing of control of data and information management as well as the surveillance of the process. This is probably due to the current situation where things have been changing all the time. The other elements that have been changed and altered are also explained to the participants such as homogeneity, complaint handling and the measurement uncertainty.

When it comes to management system requirements, the speaker stated that the clause is now aligned with the most recent version of the PROC33 and ISO/IEC 17025 wordings but there is no more option A and Option B, but the quality management system is what they have made such changes for. Additionally, Annexes A and B were updated, and Annex C is not taken of the standard.

After addressing the different changes in the standard, the speaker has also given brief information on the Keys of Proficiency Testing Scheme. The presentation in this part includes the definition of related terms such as interlaboratory comparison, proficiency testing, PT round and PT scheme. This is to provide an explanation of the differences between these terms. Moreover, the presentation also includes different purposes of ILC which has a boarder definition compared to the PT itself.

The features of the PT itself are also explained briefly along with the flowchart for a PT and flowchart of an RM project to give the participants an overview of how they should proceed if they are planning to do any of this.

The speaker has also presented the PT within the Asia-Pacific region and emphasized that the IoT still need much more PT and survey in the context of Asia-Pacific. The PT in Asia Pacific can be supported by APMP-APAC if assistance is needed. The organization can be reached out to support such an action.

**b. Experience Sharing PT/PTP in China**

The speaker started off with the definition of PT which is the evaluation of participant performance against pre-established criteria by means of interlaboratory comparisons before explaining about the general PT process. She also explained briefly how the PT provider normally proceeds when a PT request is brought into action.

The presentation also provided the participants with information on different

types of PT such as quantitative, qualitative and interpretative and how they are different from one another in terms of the result. PT can also be divided by how the test items are to be tested; they can be simultaneous or sequential. While the former is usually with singular samples, the other one is suitable for samples that are difficult to obtain but the PT will have a longer running cycle. The other types of PT are the ones that are divided based on the participants' awareness. This can be an open PT or a blind PT. For an open PT, the participants understand they are at certain moment being part of the test and they are likely to employ the best equipment and put more effort into their work on the TP testing. However, the blind PT is the kind of PT that happens without any other party knowing about it. It usually happens when the test items cannot be separated from the working people or the staff themselves. If the blind PT is to be conducted, it would require a lot of preparation.

The speaker has also included the benefits and the reason for participating in PT in the presentation. The participating laboratories will be able to identify the differences between laboratories and see what they are capable of and what are their strengths compared with the other laboratories. They can also compare the methods or procedures they are using with the other laboratories using PT. Apart from that, PT can also be used as a training tool for the laboratory's personnel. For a bigger picture, PT also allows the laboratories to identify the risk and problem they might be facing in time and eventually develop a solution to such problem and a tool to keep the laboratories improve themselves from time to time. Lastly, the PT is required for accreditation activities.

Later in the presentation, the speaker has also given a brief overview about PT work in China; when the accreditation was established and how there have been a lot of PT and accreditation activities happening in the economy. However, when it comes to the telecommunication field, there was only a little of PTP accreditation.

With the ceaseless growth in the number of IoT devices, the speaker has also emphasized that the testing objects for IoT include mobile, wireless LAN equipment, antenna, rail transit and much more needed to be tested for their quality. However, there is only a limited number of PT providers in China. Moreover, the speaker has also given a brief explanation about the 3 main types of communication testing; the conducted emission, radiated emission and electro-magnetic compatibility or EMC.

The speaker has also included some of the examples for those testing including the important details such as the testing parameter, the test standard used in such

test, the PT Items or the samples selection and preparation to give an overview to the participants on how things have been working in China. When it comes to PT in the communication field, the person in charge of such testing should consider homogeneity and stability test of the samples. As for the performance evaluation; the assigned value should be the consensus value from the testing participant, z scores, differences and D should be considered as the performance statistics and the statistical technique along with the expert consensus should be the evaluation criteria.

### *6.2.3 The 3rd Workshop & Training session:*

**a. Unleashing the IoT Revolution**

The speaker has pointed out the importance of how the very first steps in designing IoT products or connectivity can play a vital role in the use of these technologies in mission critical situations. Such a connectivity, in the future, would be among the very top priorities as it might have a direct impact on people's lives, especially when such an application is in the health care sector.

For such a reason, it would be best to prevent these kinds of errors during the very first stages of the relevant project. The speaker has highlighted '5Cs' for the user to easily follow which are connectivity, continuity, compliance, coexistence and cybersecurity. The other things that should also be considered as challenges are radio, sensors and energy.

The speaker also mentioned the main challenges in IoT Devices as follow, radio, sensors and energy. The first one, which is radio's challenges, are the regulatory compliance tests that need to be caught up even when it seems to be changing all the time. The sensors which deal with the accuracy of measurements, reliability and cost concerns. The energy since the power consumption of IoT devices are different and can be varied in different use cases. This might also require a signal and power integrity analysis to really address the challenge.

As for this kind of application, the speaker has also included an introduction to LoRa and its test solution. What should be addressed here is LoRaWan which can offer multi-year battery lifetime and is designed for sensors and applications that need to send small amounts of data over long distances a few times per hour from every environment. For LoRa, the test requirement, can be tested on the receiver test with the sensitivity test, transmitter test in terms of the general power measurement; total power, spectrum and OBW for instance. The speaker has also provided some

examples of his company's testing solution as a reference for the participants to get an overview of what they are like at the end of the presentation.

**b. Accelerating New Wave of IoT Application with Cellular IoT**

Within the IoT ecosystem, there are various M2M devices connected through different wireless connectivity technology, but there is no single IoT technology for all application since the best adoption depends on many factors such as types of data, coverage area, mobility, life cycle as well as cost consideration.

Some comparisons among popular wide area IoT Technologies like Cat-M1, NB-IoT, Lora and Sigfox have been shown in several aspects such as network's frequency range, bandwidth, module cost and mobility. This is also to emphasize that there is no single technology that would be best for every kind of application. Moreover, he has also talked about the different operation mods of NB-IoT with different deployment. With these differences, some design and test challenges are necessary to make sure it can work across different modes.

The speaker has also included how to test the device in a different way with a focus on how some technologies might be tested in a different way if they are deployed in different modes. Therefore, when conducting certain testing, there are some common KPI to be evaluated. Things that should be considered are the quantity to be deployed, operating lifetime and service/maintenance time. These will become the requirements that need to be translated into the product specification such as the coverage range and the battery operating time for instance. After such KPI considerations, it is also important to include all other integration into consideration; this could be the battery, antenna, casing, sensors, etc. to really get the full requirement.

5G IoT was first deployed on the phone's ecosystem, but it could be expanded beyond that and into several applications such as education experience, smart factory, smart farming, smart city, intelligent retail, remote construction, and connected healthcare through wearables.

**c. 5G Private Networks – The Key to Unlocking Industry 4.0**

The speaker started off with an introduction on the 5G networks and how they are affecting every industry, manufacturing, warehouse, mining, ports, critical infrastructure, and oil or gas. The common things as a requirement for 5G technology

applications is the superior performance level in terms of the data rate and latency.

The main example on the use case in this session is the smart factory and how the speaker has deployed 5G technologies within this context. This can be remote maintenance and training in virtual reality, process automation, workplace monitoring and safety monitoring for large machines. These examples have different numbers of packets and technical requirements even though they are all happening within the same workplace or factory. The challenge here is how to monitor and ensure that all the necessary requirements are met at all times to achieve a seamless operation.

Hence, the speakers then mentioned a couple of her company's testing methods available as an example and how the factory has been through different testing phases to ensure network performance within the factory as follows. The first test phase is the rollout preparation which includes spectrum clearance, interferers locating to eventually eliminate them for a clean RF environment within the factory. This test should be done before any kind of deployment and regularly during the operations. The second test phase is the site acceptance testing to get the network infrastructure installed correctly. During this test phase, there should be a functional testing; measure download, upload and round-trip time performance from end user's perspective, OTA RF signal verification; visualize the transmitted signal to verify the correct 5G transmission, and signal decoding to ensure the PCI, SSB and SIB information for 5G and LTE anchor signals. The electro-magnetic field strength should also be checked in this phase. The 2nd test phase should be done after deployment as well as after there are any changes made to the deployment.

The next phase would be the coverage and performance testing, the result of which is to have verified coverage and performance. In this phase, the 5G connectivity should be tested to ensure there are enough redundancies. The data should be collected using portable HW platform and analyzed with data analytics SW in control room. The network should also be optimized in this phase and the data collection should also be done in three dimensions. This kind of test should be done right after the factory is completed and after certain modifications are made and, ideally, regularly. The last test phase is a 24/7 real-time service quality monitoring to achieve continuous performance monitoring and awareness of issues. This means there should be continuous data collection with multiple RF probes installed within the factory and on automated guided vehicles to report the network quality on a real-time basis. Once the data is collected, it will be analyzed through machine learning algorithms to

identify trends and detect anomalies. This kind of test should be done on a real-time basis and continuously.

After the 4 testing phases, there should also be a performance testing after deployment such as the antenna verification to ensure it is ready for service as well as other devices functional tests for the network availability, latency and data test and interactivity test to ensure they are ready for the customers

### 6.3 Summary of 2nd Seminar

#### a. Introduction to Round Robin Test

The project aims to develop a round robin test in order to make a comparison between different participating laboratories. The seminar session will address in detail the round robin test through discussion with the participants.

As there might be different testing methods, standards and criteria used among APEC members, there should be an agreement on the common methods to be applied in the round robin test activity. This also includes the statistical approach to be used in the evaluation of the test result. The information is also aligned with the project objectives to develop and improve the testing quality and standard for APEC members to be of the global standard.

The seminar addressed different elements to be included and applied in the round robin test which is the next activity of the project such as the assigned value, stability testing, evaluation method or statistical method, packaging, labeling and distribution for instance. This is mainly to provide a more detailed guideline for the round robin test and on the protocol to be sent to the interested participants.

The speaker also led a discussion on the testing parameters; which ones should be selected to get the closest value and what to be considered when choosing these items. The expert also emphasized that the chosen items should not be so different from each other to ensure consistency between different economies. The PT items are also exemplified with each of the items unique characteristics and how they can be a right choice for the testing. The session provided information on the different types of PT; sequential and simultaneous and how the project's limitation made it more likely to be simultaneous one.

The session also went into the detail of how to evaluate and choose the

statistical method to ensure the comparison between different laboratories are properly evaluated; this can be the Standard Deviation or SD or Z-score along with the acceptable evaluation criteria.

The speaker also provided the information for the interested participants who want to be part of the Round Robin tests on how they can proceed for the next step and how the PT protocol with all the answers to several questions discussed about in the session today will be provided.

### 6.4 Summary of 3rd Seminar

The speaker has provided a detail on how the Round Robin Test had been conducted with different elements set up among the participating laboratories. He has also included how different parameters are set up for the test such as maximum power emission, duty cycle, spurious emission and occupied bandwidth.

Different elements of the Round Robin test such as IoT sample composition, testing methodology, analysis methodology and evaluation criteria are also discussed in detail to ensure that the participants are provided with the accurate information on how the test would be conducted as well as a clear understanding of how the test can be conducted for the interlaboratory comparison.

The speaker started with how the project has been conducted from the very start with the handling of the IoT sample. He also explained how the samples have been put through for homogeneity test based on ISO/IEC 17043:2023 followed by the determination of the assigned value both before and after distribution of the sample including the stability test on these samples. The speaker also explained different methods of analysis in detail including how the measurement should be made in order to provide the most accurate information for the Round Robin test.

The measurement and the result of the round robin test are interrelated, and the speaker had also provided information on how the calculation could be done for the evaluation of all the measurements and result. These calculations methods are z-score, the use of median and the MAD, Least Squares Estimates and Key Comparison Reference Value (KCRV). These different methods are explained in detail including each method’s advantages and shortcomings.

### 6.5 Summary of Round Robin Test Report

For the Round Robin Test conducted for the project of Capacity Building

Workshop on Testing Methods for Internet of Thing (IoT) Products (SCSC 05 2021A), the Internet of Things samples were used as travelling samples. The homogeneity of these samples from participants were tested statistically using sampling variation method (Ss) and the stability of the samples also was measured statically with t-Test and F-Test. The t-Test and F-Test can be analysed as the p-value of less than 0.05 (regarded as statistically significant). Then, the results with uncertainty of all laboratories were reported and compared with data analysis for KCRV, Z-Score, Difference, D and En ratio. The results from the comparison provided the evidence that most of the participating laboratories were able to conduct the measurement within their claimed uncertainties.

## 7. SUMMARY OF DISCUSSION & KEY RESULTS

The project of Capacity Building Workshop on Testing Methods for Internet of Things (IoT) Products (SCSC 05 2021A) has been initiated and designed to provide relevant information, knowledge as well as training for the participants in APEC economies which are still in a very early stage when it comes to the aspect of the Testing Methods for the Internet of Things (IoT). Even though most of the APEC economies within the region have a very high volume of usage in IoT technologies, there seems to be only a limited number of laboratories which can provide a standardized verification of these technologies within the region. The project aims to provide and build on the capacity of the participants in terms of the testing method they should be aware of in the international context.

The project has featured 3 seminar sessions, 3 workshops and training sessions and the round robin test. The project overview was introduced in the first seminar sessions to give an idea of how the participants would be enhanced with the knowledge and skills through different project activities and followed by the session on the importance of PT in Accreditation. The session provided information on how the accreditation works and why Proficiency Testing (PT) plays a vital role in such an accreditation and standard maintenance.

After the first seminar, the participants got to participate in different workshops and training sessions which have included different knowledge and information on different standards of the testing laboratory such as ISO/IEC 17025, ISO/IEC 17043 and the round robin test. These sessions were designed to provide information that participants should know to move on to the round robin test which is the project's final milestone in which each of the participant will get to participate in to eventually get the

final result for further discussion in the 3rd seminar session.

The Round Robin test results and comparison most of 20 participated laboratories were able to carry out the measurement within their claimed uncertainties and they would be able to get the result with the assigned value which would only be revealed to the participating members along with the unique laboratory code to ensure confidentiality. As the participating laboratory has played their parts in submitting the analysis and result with honesty, they would also be to get the result and work on it to further develop their laboratory's competency which is also part of the project's objectives.

## 8. CONCLUSION & RECOMMENDATION

### 8.1 Conclusion

The project of Capacity Building Workshop on Testing Methods for Internet of Thing (IoT) Products (SCSC 05 2021A) consists of different activities designed to provide knowledge and information as well as training by the experts from the more advanced economies to equip the participants to build on and enhance the capacity on the Testing Methods for Internet of Things (IoT) Products of the participants from the developing economies in which IoT products are still in quite an early stage. This is to respond to the global trends where IoT products are expected to be tripled in number in the very near future. These IoT products will need to be verified in terms of quality to an acceptable global standard which is why the participating members should be equipped with the knowledge and training in this.

Throughout the project, participants get to learn about different global standards, Proficiency Testing or PT and its importance in getting global accreditation as well as different standards for the testing laboratories, and this information is important for the participants to get an overview of the globally recognized standards they should ensure their facility should meet to be able to verify the quality of IoT products. Moreover, with the participation in the Round Robin test in this project, the participants would be able to make use of the result to eventually improve and maintain their facility to meet international standards.

Hopefully, these project activities will help promote even more cross-border trade in IoT products within the participating economies. Apart from providing knowledge and training to the participants, the project would be like a steppingstone for the participants to encourage future knowledge and skill transfers within the

economies to eventually improve the overall standard within the region and among the relevant parties in an even wider circle such as the policy makers, relevant decision-making parties, accreditation bodies as well as the IoT product manufacturers.

## 8.2 Recommendation

As the project consist of different activities and last for an extended period of time, it might be more beneficial if the project participants can be more engaged during the gap of each activity; especially the one that have quite an extensive break in between. This is to ensure that the knowledge and training they have obtained from previous sessions is still relatable after such a break.

As for the seminar sessions, it might be more useful if the participants can also join in some kind of activity and stay engaged throughout the session, as some of the sessions are very detailed and extensive which might be difficult for the participants to follow up and go through all the information provided in the session. Moreover, the experts or speakers might need to send out some of the materials such as handout before the session begins so they can have a review and expectation of what the session is about to ensure even more effectiveness and better outcome.

## ANNEX A – SPEAKERS' BIO

### 1. Dr. Prawate Kluaypa, TISTR

Dr. Prawate Kluaypa currently works as the Director of the Electrical and Electronic Laboratory (EEL), the Industrial Metrology and Testing Service Centre (MTC), and the Thailand Institute of Scientific and Technological Research (TISTR). He graduated with a bachelor's degree in electrical engineering from Khon Kaen University, Thailand; a master's degree in information technology from EAU Thailand; a master's degree in management of competitive manufacturing from the University of Strathclyde, Scotland; and a PhD in Quality Management from the University of Portsmouth, England.

He is also the Project Overseer of the Project of Capacity Building Workshop on Testing Methods for Internet of Thing (IoT) Products (SCSC 05 2021A)

### 2. Mr. Nick Slawson, PTP/RMP Program Manager, A2LA, United States

Nicholas Slawson is a Program Manager at the American Association for Laboratory Accreditation (A2LA). He supports the day-to-day operations of accreditation by assisting clients in obtaining and maintaining accreditation for labs in the Reference Material and Proficiency Testing Programs. Nick also has experience working with the Environmental Program including work with the DoD/DOE accreditation programs, the TNI standard, and on the Calibration team. He also ensures that the assessor reports, responses from laboratories, and the status of deficiencies with laboratories are reviewed and evaluated. He has been employed as an Accreditation Officer for A2LA since June 2015.

Nick is certified as a lead assessor and Assessor Evaluator for A2LA. He is trained in ISO standards 17025, 17034, 17043, 17065, 17020, 20387, and 15189. He also serves on the board of directors for TNI and is a member of the Quality System and the TNI PTP Committee.

### 3. CHEN Di, Senior Manager, China National Accreditation Service for Conformity Assessment (CNAS), People's Republic of China

He graduated from Beijing University of Posts and Telecommunications with a major in electromagnetic and microwave technology. He also has the Master degree of Engineering and is a visiting scholar of City University of Hong Kong— Hong Kong, China.

He currently is a Senior manager of CNAS, a member and a secretary of electrical technical committee of CNAS, a Lead assessor of laboratory accreditation, a member of ILAC AIC and a member of metrological traceability working Group as well as an APAC peer

evaluator. He has 15 years of Electrical laboratory accreditation experience.

**4. Roger SHENG, Deputy Director, Taiwan Accreditation Foundation (TAF), Chinese Taipei**

Roger Sheng is the Deputy Director of Taiwan Accreditation Foundation or TAF. The organization has been leading and managing the accreditation activities of testing laboratories, inspection bodies, and proficiency testing providers in electrical and optical sectors. He is also ISO/IEC 17025 and ISO/IEC 17043 Lead Assessor with 12 years of expertise in EMC, RF, and Telecommunication technologies. He has also participated in building and setting up TAF E&E accreditation programs and collaborated with international or regional forums such as Bluetooth SIG, CTIA, IECEE, IECRE, and ISA Secure, etc.
He also has a lengthy of more than 10 years' working experience in government and private laboratories/CBs including testing method development, verification, validation, standardization and product certification.

Roger Sheng is also a representative of TAF in international forums such as APEC, APAC, and ILAC. Moreover, he is also recognized as APAC ISO/IEC 17011 Evaluator and has been serving as the APAC Liaison at APEC TEL WG since 2017. He formerly was the APEC TEL MRA Task Force chair from 2013 to 2015.

**5. Mr. Ping He, Senior Manager, China National Accreditation Service for Conformity Assessment (CNAS), People's Republic Of China**

Mr. Ping, HE graduated with a master's degree in chemistry and a bachelor's degree in chemical biology. He has been a senior manager in CNAS on RMPs accreditation with a lengthy experience in PTPs accreditation as well as in commissioning PT schemes. He is also an expert in ISOREMCO & TC334. He has been working in the accreditation and standard fields for more than 10 years and has also worked as an evaluator, a member and a convener of standard revision in many leading organizations and working groups. He has also chaired the APLAC/PTC & APAC/TC1/PTSC and co-chaired APMP-AP(L)AC Joint PTWG. Apart from that, he has been a frequented invited speaker at different events on PTPs & RMPs accreditation in Brazil; Malaysia; Uzbekistan; Chinese Taipei etc.

**6. Ms. Rujing JIA, Senior Manager, China National Accreditation Service for Conformity Assessment (CNAS), People's Republic of China**

Ms. Rujing Jia graduated with an MSc from Peking University in the Health Science Center. She is the Senior Manager of China National Accreditation Service for Conformity Assessment, responsible for accreditation of Proficiency Testing Providers in China. She has specialization in Proficiency Testing (PT) and accreditation since 2009 and worked extensively on the organization, application and standardization of PT for testing, calibration and inspection in various fields. She is currently a member of ISO/CASCO Technical Expert Group (TEG) and an APAC peer evaluator.

**7. Danny Tan**

He is the Education and Research Business Development Manager for Keysight Technologies. He has been working with Keysight Technologies for about 13 years across different functions from Test and Manufacturing Engineering in the Spectrum Analyzer and Signal Source Division in Malaysia as well as in Sales. Currently, he is working in a Business Development role in Australia and his duty also covers most of Asia Pacific.

**8. Guo Ling**

Guo Ling is a Regional Sales Manager for the Mobile Network Testing Market Segment at Rohde & Schwarz's Singapore headquarters. She has over 16 years of experience in the telecom industry, and she has also spent some of her time at Keysight Technologies and Anite. During the GSM/WCDMA period, she began as a technical support engineer for 7 years and progressively took up a sales position. With the technical education and experience, she understands the customer's difficulty from both a business and industrial perspective, allowing her to deliver the most appropriate solution to the customer and assist them in achieving their goals.

**9. Liew Voon Yen, Field Marketing Manager, Anritsu Pte Ltd**

Mr. Liew has more than 20 years in wireless, spanning RF, chipsets, and devices. Beginning at Agilent, he pioneered FBAR filters components that are now widely used in mobile devices. With Motorola, he shaped compact 2G/3G phones and aided R&D-to-manufacturing. Intel Mobile also saw his work on advanced LTE chipsets. Currently, he has been at Anritsu since 2019, he has been providing advice on various leading wireless technologies like 5G, WIFI, automotive including their requirements, relevant tests, challenges and solutions.

## 10. Dr. Vitawat SIttakul

Dr. Vitawat Sittakul gradated with B.Eng. degree in telecommunication from Chulalongkorn University, Bangkok, Thailand, in 2000 and the M.Sc. degree (with distinction) in optical and communication systems from Northumbria University, Newcastle, U.K., in 2003 with the thesis of Investigation of Microstrip Antennas using U-slot. He was awarded the Ph.D. degree with Thai government's funding and received the Ph.D. degree from the Department of Electrical and Electronic Engineering, University of Bristol, Bristol, U.K., in 2006.
He has been working in the relevant field and for the government for more than 15 years. From 2003 to 2004, he was a Measurement Engineer with Fabinet, where he was a global engineering and manufacturing services provider. From 2004 to 2006, he was a Senior RF Engineer with Advance Information Service Company, Ltd. (AIS), one of Thailand's largest telecommunication service providers. From 2006 to 2009, he worked as a research assistant at the University of Bristol, Bristol, the U.K. where he advised the students and designs the laboratory experiment. From 2009 to 2015, he worked as an RF Metrologist in the National Institute of Metrology (Thailand) where he developed and calibrated industrial electrical equipment in the primary standard levels.

The speaker also has lengthy experience in consultant to many companies such as FPRI advisor company and Telco-Economics company in telecommunication area. He is currently an associated professor in the Department of Electrical and Electronics Engineering Technology and the head of 5G and beyond Wireless Innovation Center, King Mongkut's University of Technology North Bangkok, Thailand. He had also been invited as keynote speakers for more than 10 international conferences and he has published 18 journals and 40 conference proceedings on RF devices & Antenna measurement, optical communication, wireless communication, RF-over-fiber, active integrated antennas, antenna design, IoT: smartplug, wireless sensor network, solar tracking system using ZigBee and fuzzy logic control system.