TECHNICAL REPORT

2nd mWT Plugtests
Remote
7 - 9 July 2020

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ETSI

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1 Executive Summary

The second Millimetre Wave Transmission (mWT) Plugtests™ event sets a new milestone in a programme of interoperability events for mWT SDN. ETSI, in coordination with the pariticipating organizations, has organized the event in a remote fashion, due to the worldwide restrictions imposed by the COVID-19 pandemic. This event was coordinated and hosted by ETSI, from 07 to 09 of July 2020.

Building on the successful results of the first event, held in March 2019, the aim of this second Plugtests event was to expand the trial of SDN solutions for Microwave and Millimetre-wave applications in transport networks. The main goal of the testing activities was to demonstrate the compliance to the Northbound Interface (NBI) of the SDN Domain Controllers of each participant, connected individually to their respective devices under test. Validation of the service definition was performed with a data traffic generator.

The participation was enabled for completely remote solutions, interconnected via HIVE (Hub for Interoperability and Validation at ETSI).

As for the first mWT SDN Plugtests, a key aspect of the tested scenarios was the adoption of a Standard NBI definition based on Restconf and IETF Data Models, including both general network and service level models, and the recently published Microwave Topology Model, to manage service activation and deactivation for mWT domains.

The main highlights of this event are:

1. 100% compliance was demonstrated, i.e. each participant succefully tested the full set of scenarios in scope;
2. Seven Manufacturers participated, representing 90% of the market solutions providers from around the world, including Asia and Europe;
3. Four Global Telecommunications Operators registered to the event, one operator attending the event as observer;
4. Suitability of this architecture to reduce to zero interoperability testing required among Domains at integration time for real deployments. The Test Cases executed where preparatory to an easier integration process and interoperability levels;
5. Ease and efficiency of converging through active collaboration to a unified and powerful NBI definition;
6. A fully functional (and publicly available) test plan and test suite is produced, as a byproduct of the adopted test architecture, available on the ETSI Forge [i.8].

The results of the Plugtests, and especially the commonly agreed models, will be contributed to ETSI ISG mWT to create a profile of SDN for Microwave and Millimetre-wave transport applications.

2 References

[i.1] I2RS Topology Model: https://tools.ietf.org/html/rfc8345

[i.2] TE Topology Model: https://tools.ietf.org/html/draft-ietf-teas-yang-te-topo

[i.3] MW Topology Model: https://tools.ietf.org/html/draft-ye-ccamp-mw-topo-yang

[i.4] Ethernet Topology Model: https://tools.ietf.org/html/draft-zheng-ccamp-client-topo-yang

[i.5] Ethernet Service Model: https://tools.ietf.org/html/draft-zheng-ccamp-otn-client-signal-yang

[i.6] Restconf protocol: https://tools.ietf.org/html/rfc8040

[i.7] YANG Module Library: https://tools.ietf.org/html/rfc7895

[i.8] FORGE Repository for 2nd mWT SDN Plugtests: https://forge.etsi.org/rep/sdn/mwt/plugtests-2

[i.9] Test Plan: https://portal.etsi.org/Portals/0/TBpages/CTI/Docs/mWT_Plugtests2-3_TestPlan_v1_0.pdf

[i.10] Postman website: https://www.getpostman.com/

[i.11] FORGE Repository for 1st mWT SDN Plugtests: https://forge.etsi.org/rep/sdn/mwt/plugtests-1

3 Abbreviations

DC	Domain Controller
DUT	Device Under Test
GE	Gigabit Ethernet
IFS	Interoperability Feature Statement
mmW	Millimetre wave
MW	Microwave
NBI	Northbound Interface
NE	Network Element
NMS	Network Management System
SBI	Southbound Interface
SDN	Software Defined Network
TD	Test Description

4 Participants

The teams which executed tests during the Plugtest are listed in the table below.

Table 1: List of teams

#	Team
1	Ceragon Networks
2	Ericsson
3	Huawei
4	Intracom Telecom
5	NEC
6	Nokia
7	SIAE

Table 2: List of observers

#	Observer
1	BT
2	Deutsche Telekom
3	Orange
4	Vodafone

5 Architecture

5.1 Reference SDN Architecture

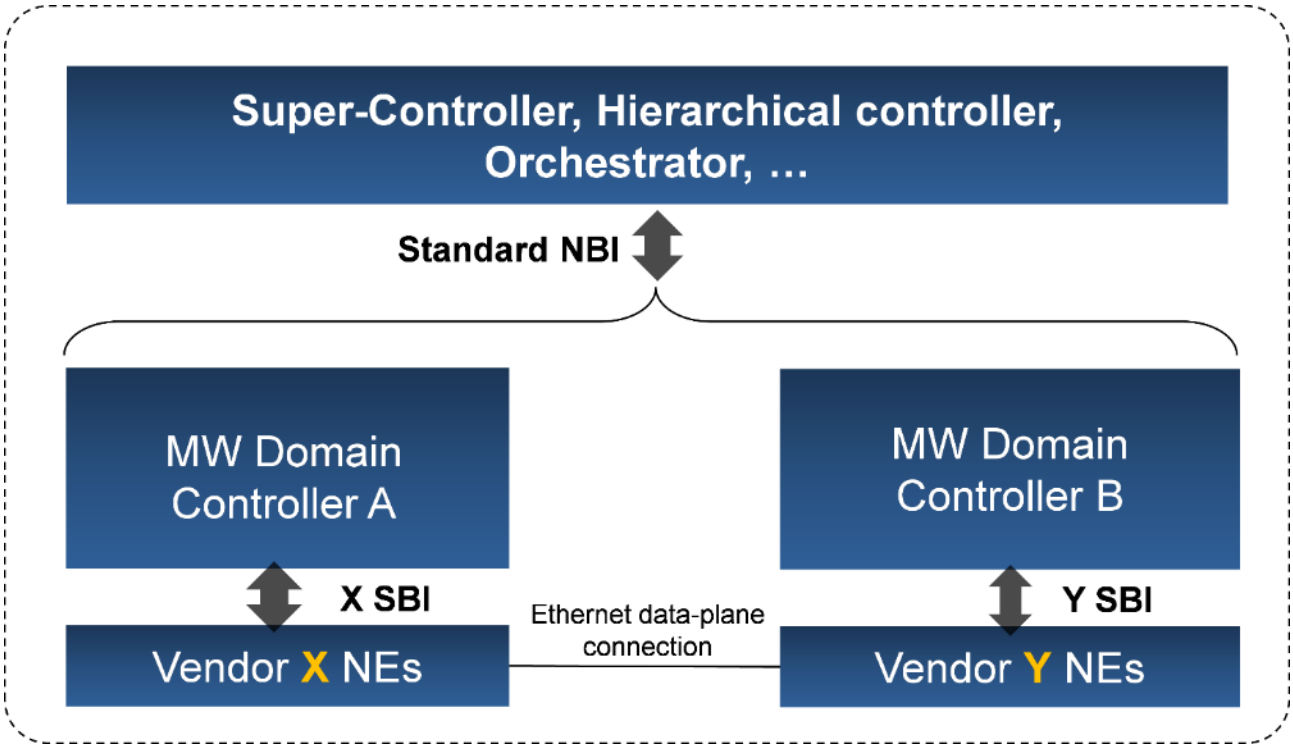


Figure 1 Generic Multi-Domain, Multi-Vendor SDN Architecture

With reference to Figure 1, this Plugtests event kept the focus on the NBI of Domain Controllers (DC), regardless of the specific overall architecture choices made in layers above the Domain Controller itself.

Also, as an explicit choice, nothing was specified or required regarding the DC's SBI (i.e. the interface between a DC and its managed NEs), regarding protocols, data models, etc.

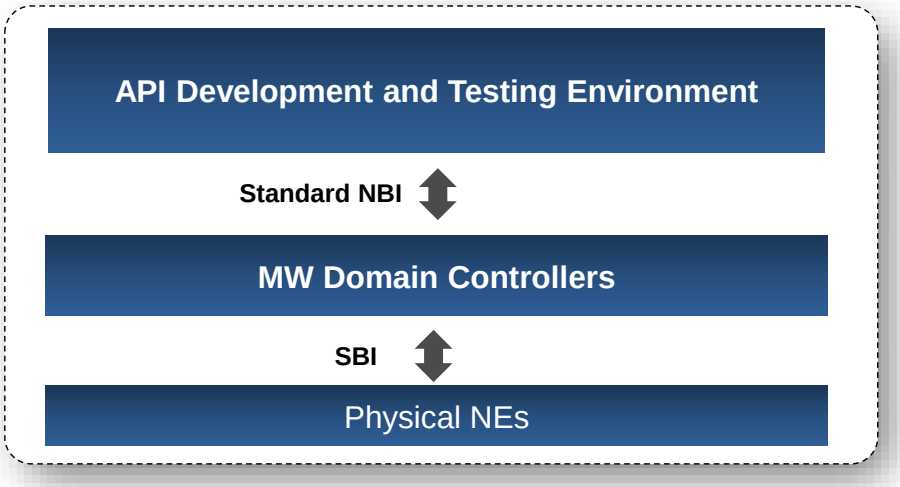
The basis for the definition of the NBI whose compliance was tested by this Plugtests event was the use of the Restconf protocol (RFC 8040 [i.6]) and the YANG Data Model (DM) library provided by IETF (RFCs and relevant drafts [i.7]).

As depicted in Figure 2, in order to simplify the test specification and implementation, the interoperability testing was by unanimous agreement of the participants performed by using an API Development and Testing environment, namely the Postman [i.10] system and its CLI interface, newman.

Tests were performed by exploiting the automation (scripting) capability of *newman*, with a single set of scripts being jointly developed specifically for these Plugtests by the Participants and stored in the ETSI Forge code repository, on the basis of the scripts developed for the 1st mWT Plugtests [i.11].

Specifying a single set of scripts and the expected format and content of the related responses by the DCs, it was possible to univocally determine the compliance of DCs provided by participants to the relevant standards and confirm the single-domain compliance of the systems under test and the specified NBI.

Figure 2 Plugtest SDN Architecture



5.2 Test Network Architecture

The Test Cases were executed against the benches set up on the local lab premises of each participant in a completely remote manner. Remote internetworking was enabled by the HIVE and allowed signaling messages to be exchanged among the ETSI premises (where the test system was deployed) and the remote labs of Plugtests participants. Figure 3 shows a selection of the Test Benches used during the test sessions.

Figure 3 A selection of the Test Benches utilized in the Plugtestsasdfsdf

Figure 3: Pictures of a selection of setup in the remote labs.

5.2.1 Logical Topology

Error! Reference source not found. shows the logical topology of the Plugtests network.

- Each Domain contains exactly one MW (mmW) link. The physical connection between the two RF units of the radio link within one domain shall be realized with coaxial cable or waveguide plus attenuators, no antenna and no free space radiation is allowed;
- The connection between the Domain controller and its MW link is internal to the domain and completely taken care for by the respective Participant;
- All naming of attributes is indexed to the Domain “number” (1 to N for a total of N Domains) in order to simplify the script execution;

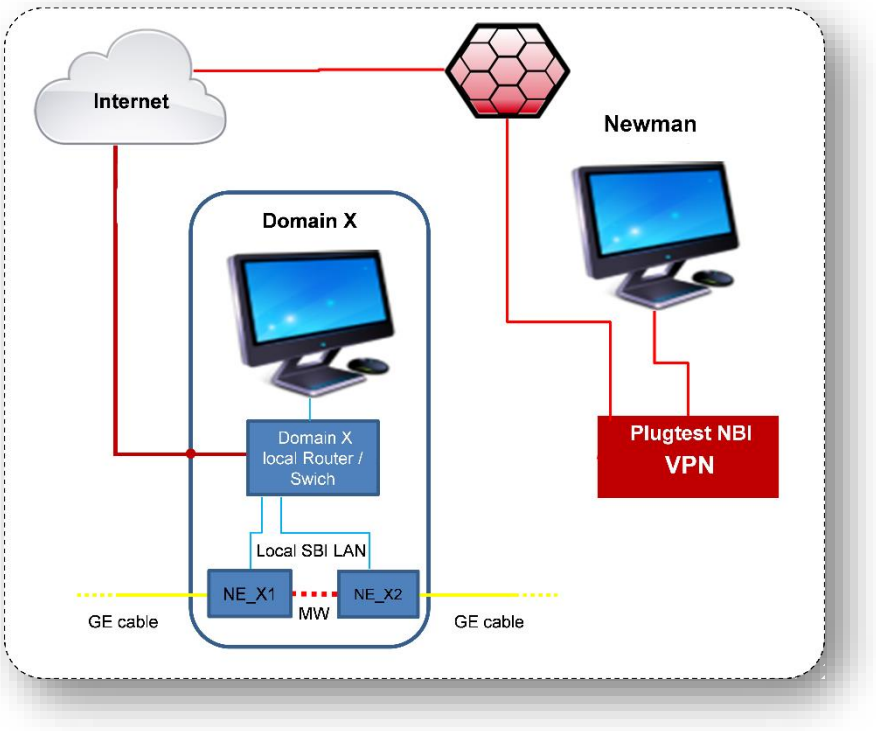


Figure 4 Physical Structure of the Test Network (Detail of one Domain)

- The LAN used to connect the Domain Controllers to the Newman is a Virtual Private Network, enabled via the HIVE;
- Within a test session, the NBI IP addressing plan is static, based on private IP;
- The Domain's own Router / Switch is complete responsibility of the Domain's owner;
- The single Newman instance used for all testing is running on a virtual machine in the HIVE data center, connected via VPN to the NBI LAN;

5.2.2 Data Plane Network

The test cases that create and delete a L2 service required the use of a Test Instrument to generate the traffic, and to confirm that it is flowing correctly withing the indivual Domain. Each participanting organization individually provided such a Test Instrument in its own lab, connected to the respective NEs.

Data Plane network was therefore contained in the remote lab of its organization, and traffic generation and validation was performed on site by the participants, under review of the Plugtests Team and the rest of the participants.

5.3 Data Model Architecture

Figure , Figure 6 and Figure depict a simplified DM topology overview as it was used in this Plugtest.

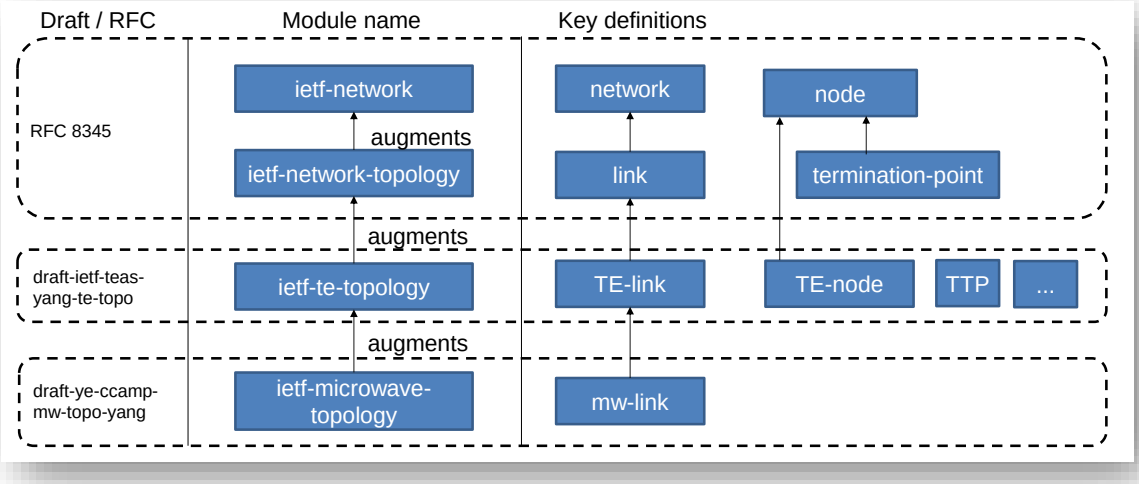


Figure 5 IETF Microwave Topology Models

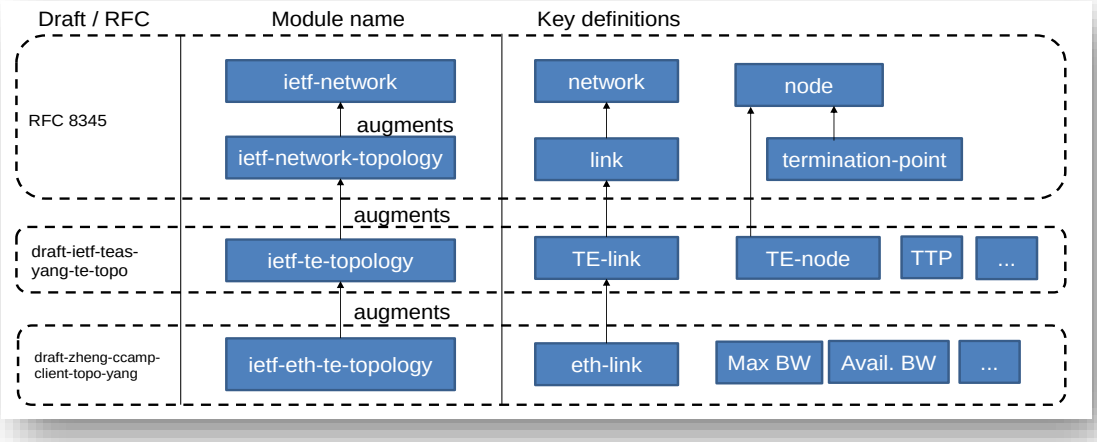


Figure 6 IETF Ethernet Topology Models

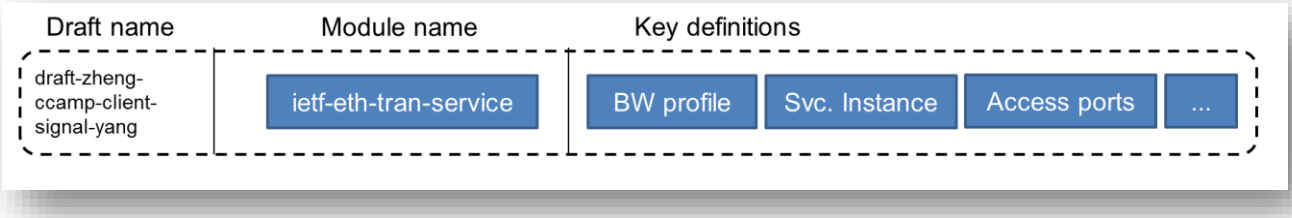


Figure 7 IETF Ethernet Service Model

5.4 Reference Topology Models

5.4.1 Single Domain Topology Exposed on NBI

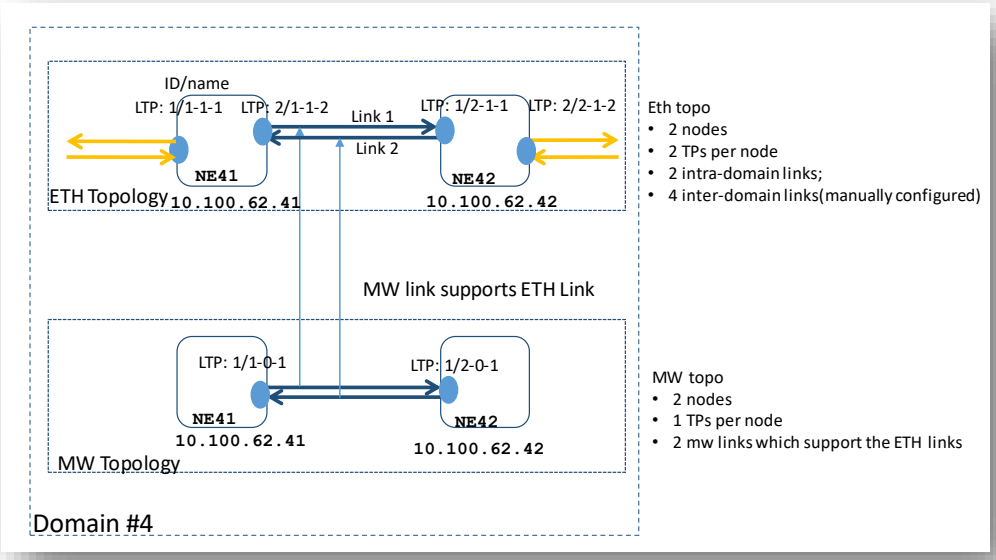


Figure 8 Single Domain Topology Exposed on NBI

Note 1: The inter-domain links' information is not requested to be published across the NBI for this Plugtests.

6 Achieved Compliance Results

For the full description of the Test Plan document that can be found at [i.9].

The Postman scripts that were used can be found on the ETSI Forge at [i.8]. The scripts are publically available and may be re-used for future testing activities.

```
1  {
2    "info": {
3      "_postman_id": "10a2aaa5-bc89-40bb-9eb5-06051f517078",
4      "name": "TD_SSP_01",
5      "schema": "https://schema.getpostman.com/json/collection/v2.1.0/collection.json"
6    },
7    "item": [
8      {
9        "name": "TD_SSP_01-Step-1",
10       "event": [
11         {
12           "listen": "test",
13           "script": {
14             "id": "950caa88-75b1-429b-8337-4a138ea4fc66",
15             "exec": [
16               "pm.environment.unset('TD_SDN_RESTCONF_PATH');",
17               "var settings = pm.environment.get('TD_SDN_SETTINGS');",
18               "var companyName = pm.environment.get('TD_SDN_COMPANY');",
19               "var companySettings = settings.companies[companyName];",
```

Figure 9: An example of a scripted test for the NBI, executable with Newman.

Below are the seven screenshots proving the successful result of each individual TD_SSP_01 test, targeting the actual provisioning of the L2 services. The screenshots report the remote participant traffic generators showing traffic related to the L2 services activated by the central Newman-based script. Huawei performed the tests in a completely remote fashion, including the Newman-based script client.

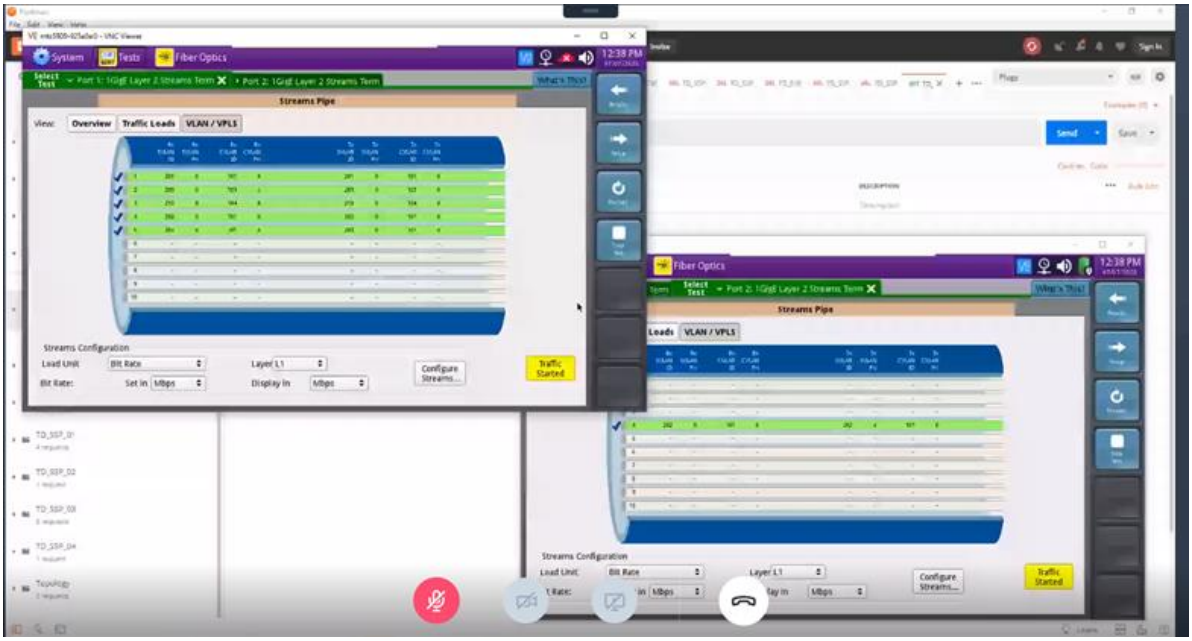


Figure 9 Ceragon TD_SSP_01 test

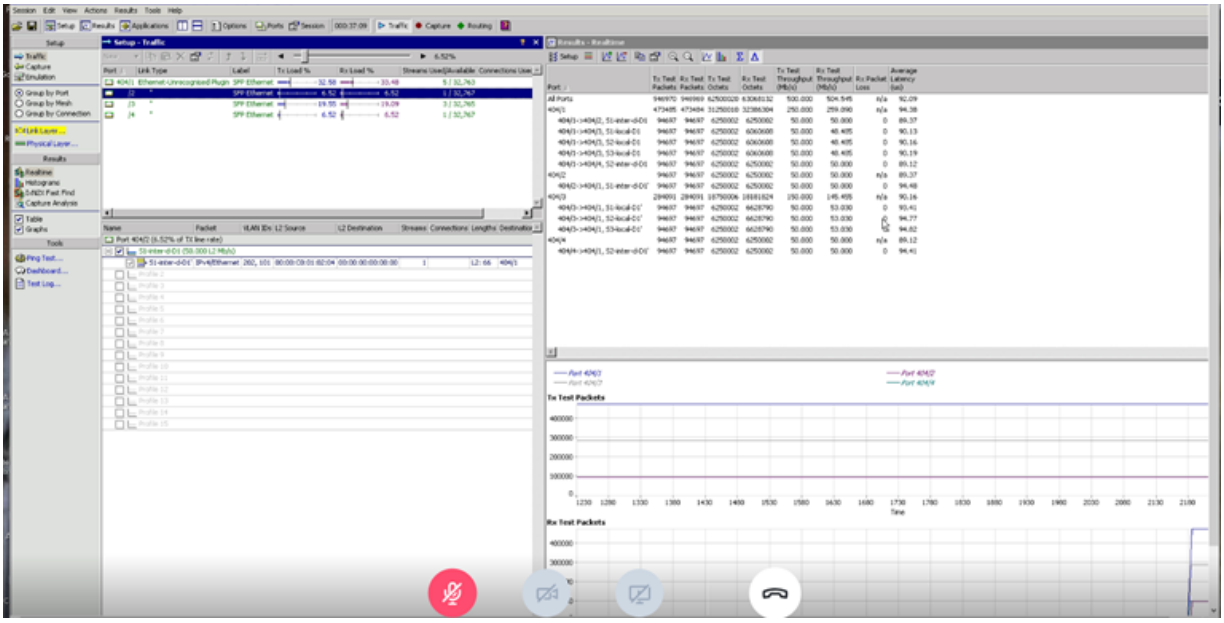


Figure 10 Ericsson TD_SSP_01 test

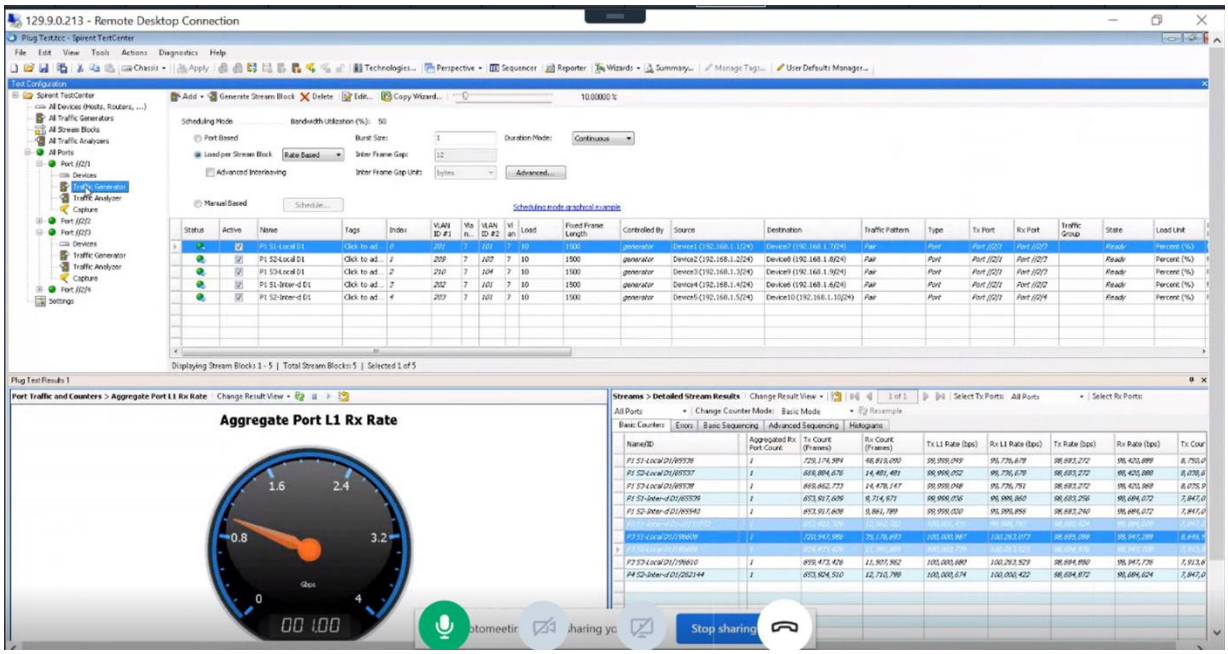


Figure 11 Huawei TD_SSP_01 test

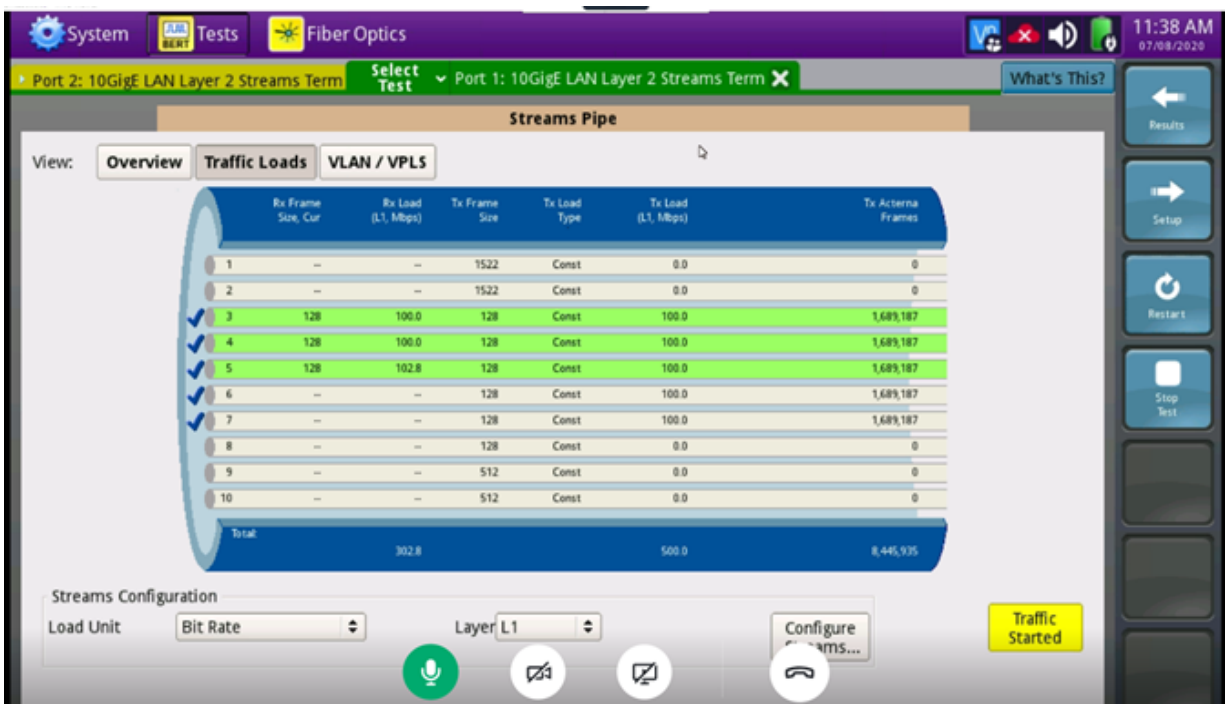


Figure 12 Intracom TD_SSP_01 test

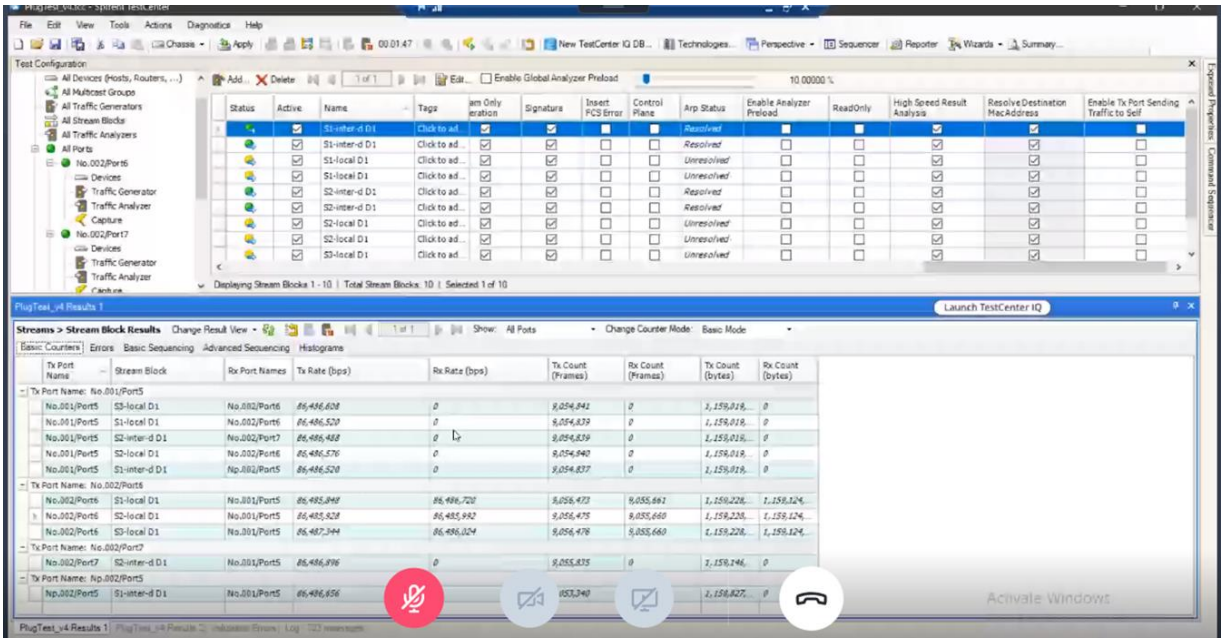


Figure 13 NEC TD_SSP_01 test

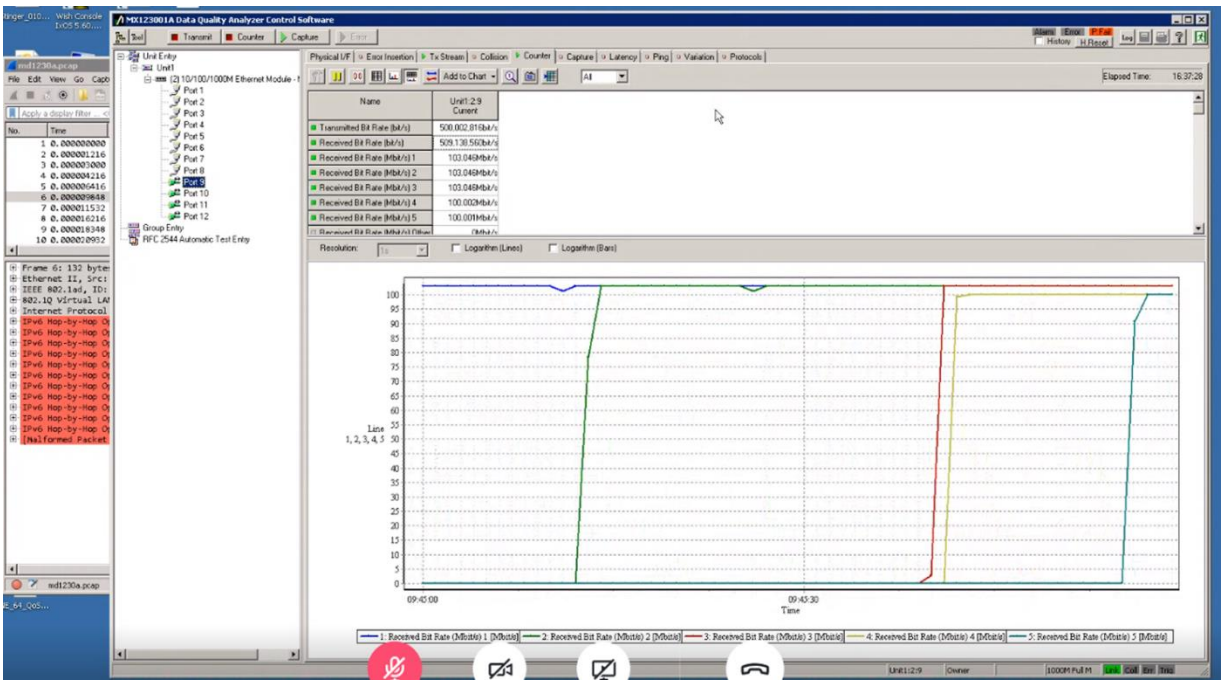


Figure 14 Nokia TD_SSP_01 test

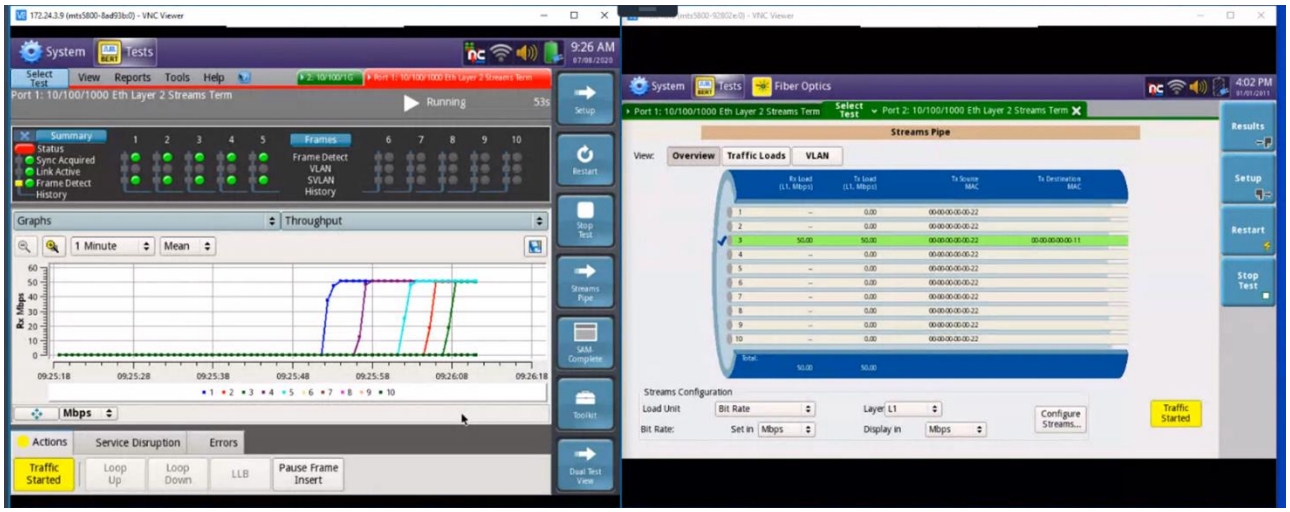


Figure 16 SIAE TD_SSP_01 test

The plots of Figure and Figure report the outcome of each Test Case.

Figure shows the outcome statistics collected for each Test Case of the test collection. The figure shows that all the tests were successful (each test includes 7 passed trials, one for each participant), however three test attempts failed. In particular, the TD_SSD_02 test failed twice due to a transient down issue of internal connectivity. In addition, one TD_SSP_01 test trial failed due to timeout issues (default 30s timeout raised test failure, update timeout to 120s achieved full test pass). Both temporary issues where resolved and overcome, though reporting the experience may be helpful for future work.

The aggregate test outcome results are reported in Figure , showing that the aggregate test pass rate is 94,23% and the fail rate is 5,77% (including test repetitions).

All the tests programmed in the full remote setup were performed successfully.

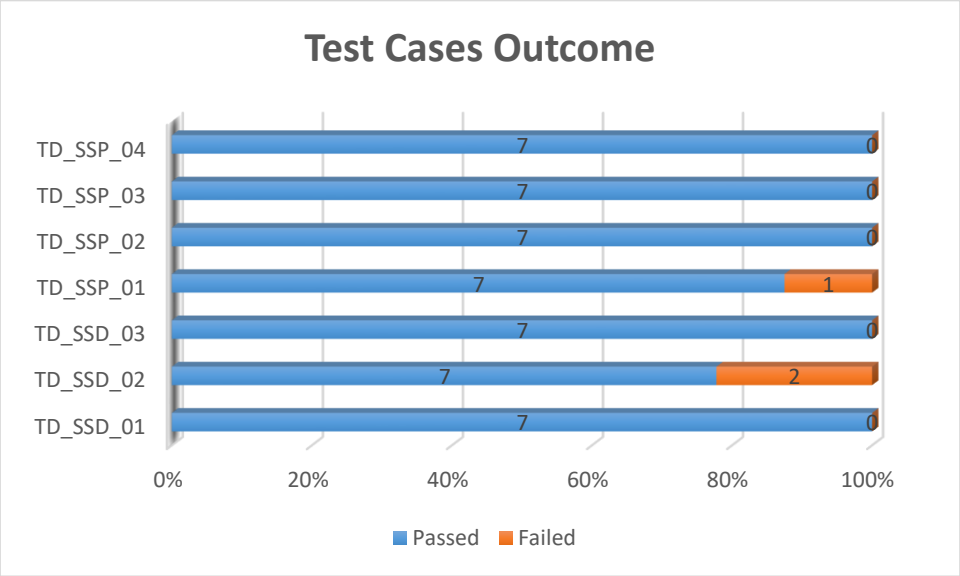


Figure 17 Individual Test Case Outcome results.

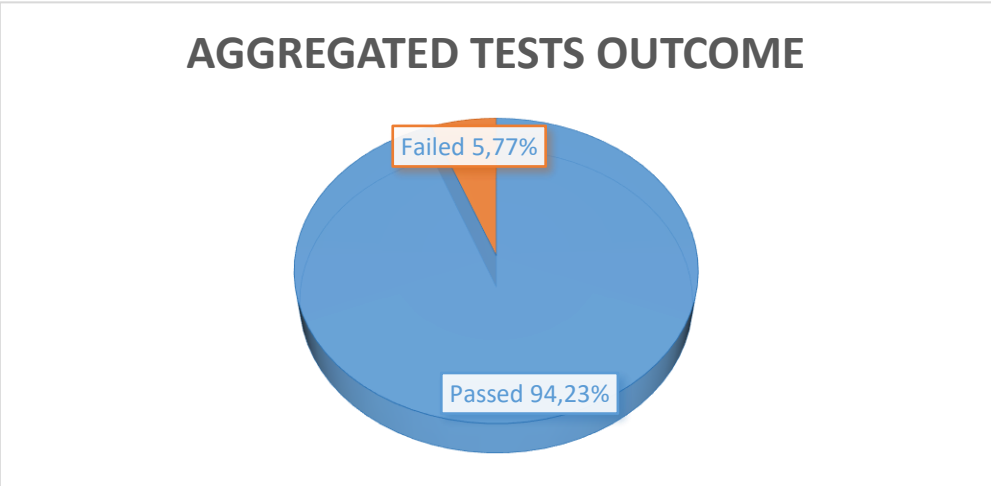


Figure 18 Aggregate Tests Outcome results

6.1 Single Domain Discovery Tests

The results can be found in the accompanying document "2nd_mWT_SDN_Plugtests_Report-Network_Discovery.pdf".

6.2 Single-Domain Service Provisioning Tests

The results can be found in the accompanying document "2nd_mWT_SDN_Plugtests_Report-Service_Provisioning.pdf"".

The indicated throughput measured by the Spirent TestCenter instruments, and shown as a tachometer graph in the screenshots from the instrument's management software, show a value for "Aggregate Port L1 Rx Rate" around 25.6Mb/s. This is due to the fact that the requested L2 service specified 6.4Mbps CIR and 6.4Mbps EIR, so the theoretical aggregate throughput (both directions) in absence of congestion is 25.6 Mb/s.

7 Lessons Learned

The main novelty introduced in this 2nd event for mWT Interoperability via controller NBI compliance is the definition of common and shared practices to set up L2 services in the realistic deployment types of mWT equipment. This has been resulted in the updataes of the Test Plan[i.9] and consequently in the development of a common set of Postman scripts.

The definition of such services bring the interoperability levels closer to real-life requirements for transport networks.

Other significant lessons learned include:

- The IETF Data Model library provides a very rich set of standards, including micro- / millimetre-wave dedicated models;
- Only a subset of the defined models is needed for the MW/mmW applications;
- It is extremely easy and backward-compatible to extend the standards (now and in the future) to cover specific and new features and applications of MW/mmW;
- Being compliant to common standards, the Domain Controller implementtions are ready for production deployment in real networks;
- Using an API development platform like Postman has many important advantages:
    - It is very easy to quickly converge to a common and compliant implementation of the NBI among different manufacuters by using the very same code and comparing results and behaviours directly. This step took only a few weeks from when the Domain Controllers' implementations were available;
    - There is no ambiguity in describing the expected behaviour for each test case;
    - There is no troubleshooting required in case of behaviour divergence among domains, as there may be by using a third-party "Application";
    - Compliance is determined by the tool itself in a clear Pass/Fail manner;
    - The code developed to be used in the Postman platform turns out to be – as it is – the complete and unified test suite to certify any product for compliance to the NBI definition;
- The ETSI Plugtests™ framework provides a productive, collaborative and fair collaboration environment among different parties across the industry.

8 Conclusions

With respect to initial plans, the Covid-19 Pandemic imposed the remotization of the 2nd mWT Plugtests and required a great organizationional effort for the redefinition of the event and the enablement of remote connectivity among implementations of participating organizations.

In particular, the set of applicable test configurationsahs has been focused on single domain configurations and the focus on the tests was centered on compliance of the NBI implementation for Service Discovery and Provisiong.

This compliance test campaign resulted in a complete success, of great significance given the almost universal participation of the MW/mmW industry, which is building on the successful results of the first Plugtests.

A clear NBI defined, based on the huge amount of IETF Data Models and protocols and frameworks, allows to quickly achieve complete and provable portability, without need of extensive and extremely resource-intensive prior interoperability testing among any combination of Domain Controller implementations.

This allows not only orders of magnitude for cost savings, but also ensures extreme ease and speed of development and convergence, as was demonstrated that the actual time required to complete all the tests took less time than what was initially planned; instead of 4 testing days, the test campaign could be accomplished within two days.

In conclusion, the 2nd mWT SDN Plugtests, thanks to the great efforts of the participating community to overcome logistics and technological difficulties caused by external factors, set a new step towards higher compliance, portability and interoperability of mWT technologies, demonstrated the possibility and soundness of remote set up for testingwhich will enable future events to address new challenges and scenarios.

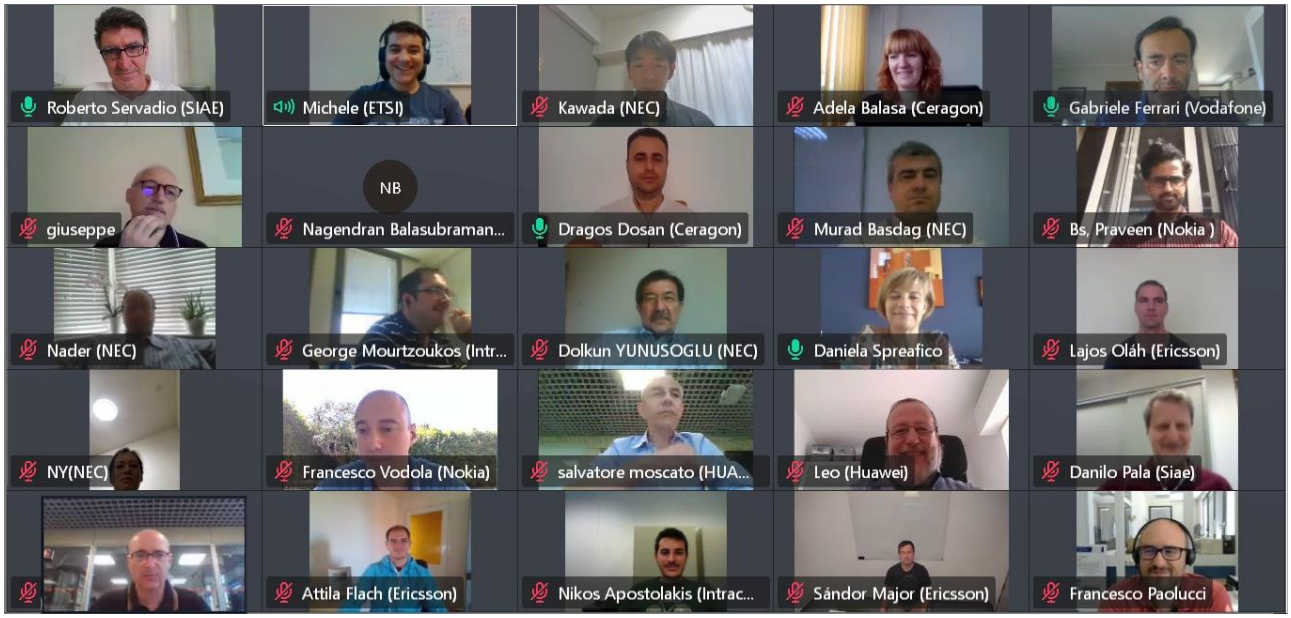


Figure 19: A "virtual" group picture of participants in the Remove mWT Plugtests