2023 5G Challenge
Stage Three – End to End Test Plan

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3 Version History

Version	Date	Author(s)	Notes
1.0	March 7, 2023	Omkar Dharmadhikari	Initial Release Draft
1.1	March 20, 2023	Omkar Dharmadhikari	Addressed comments from NTIA, updated pass/fail criteria for TCP throughput testing, updated pass/fail criteria for web browsing and added a detailed test case table with scoring details in the Annex.

4 Acronyms

3GPP	3rd Generation Partnership Project
5GC	5G Core
APN	Access Point Name
BLER	Block Error Rate
CA	Carrier Aggregation
CC	Component Carrier
COTS	Commercial Off-the-Shelf
CP	Control Plane
CQI	Channel Quality Indicator
CU	Central Unit
DL	Downlink
DLM	Delay Management
DNN	Data Network Name
DRB	Data Radio Bearer
DU	Distributed Unit
E2E	End-to-End
eCPRI	Enhanced Common Public Radio Interface
EMS	Element Management System
FDD	Frequency Division Duplex
FR1	Frequency Range 1 in 3GPP
FTP	File Transfer Protocol
gNB	gNodeB
IE	Information Elements
ICMP	Internet Control Message Protocol
IOT	Interoperability Testing
IP	Internet Protocol
KPI	Key Performance Indicators
M-Plane	Management Plane of the O-RAN Fronthaul interface
MAC	Media Access Control
MCC	Mobile Country Code
MCS	Modulation Coding Scheme
MIB	Master Information Block
MIMO	Multiple Input Multiple Output
MNC	Mobile Network Code
MO	Mobile Originating
MTU	Maximum Transmission Unit
NAS	Non-Access Stratum
NGAP	NG Application Protocol
NR	New Radio
OAM	Operation and Management
ORAN	Open Radio Access Network
OTA	Over-the-Air
PCI	Physical Cell ID
PDU	Packet Data Unit
PLMN ID	Public Land Mobile Network Identity
PTP	Precision Time Protocol
RA	Resource Allocation
RAN	Radio Access Network
RB	Resource Block
RF	Radio Frequency
RLF	Radio Link Failure

RoE	Radio Over Ethernet
RRC	Radio Resource Control
RSRP	Reference Signal Received Power
RTP	Real-time Transport Protocol
RU	Radio Unit
S-Plane	Synchronization Plane of the O-RAN Fronthaul interface
SA	Standalone Architecture
SCTP	Stream Control Transmission Protocol
SFP	Small form-factor pluggable
SIB	System Information Block
SINR	Signal to Interference plus Noise Ratio
SMA	Sub Miniature version A
SSB	Synchronization Signal Block
SUT	System Under Test
TAI	Tracking Area Identifier
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TNL	Transport Network Layer
UC-Plane	User and Control Plane of the O-RAN Fronthaul interface
UDP	User Datagram Protocol
UE	User Equipment
UL	Uplink
UP	User Plane
vRAN	Virtualized Radio Access Network

5 Introduction

Today, mobile wireless networks are assembled by mobile network operators and composed of many proprietary solutions. Each discrete element typically has custom, closed-source software, and hardware. Changes to any single element require complex and meticulous verification of the entire network. This industry dynamic increases costs, slows innovation, and reduces competition. Security issues are often difficult to detect and fix.

In response, the National Telecommunications and Information Administration's Institute for Telecommunication Sciences (NTIA/ITS), in collaboration with Department of Defense's Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) is carrying out the 5G Challenge to accelerate the adoption of:

- Open interfaces
- Interoperable subsystems
- Secure networks
- Modular, multi-vendor solutions

In the envisioned future 5G market, open interfaces reflect clear-cut requirements, enabling true plug-and-play operation. Modular 5G elements let network operators quickly and easily reconfigure, update, or replace subsystems as needed. External scrutiny of open interfaces allows vulnerabilities to be identified and patched. Attracted by this open, modular, interoperable environment, new suppliers can more easily emerge. A diversified marketplace delivers targeted innovation and drives down costs. International allies and partners can establish secure, trusted supply chains. Beneficiaries of this future 5G market include DoD, international allies and partners, network operators, businesses, and consumers.

To realize this vision, the 5G Challenge will:

- Utilize existing open interface standards
- Leverage industry trends toward virtualization, softwarization, and cloud systems
- Encourage modular product development
- Demonstrate multi-vendor interoperability
- Reduce barriers of entry for new solutions providers

This public prize challenge approach will support the growth of a large, vibrant community working on 5G multi-vendor interoperability. This approach is a powerful catalyst for creating diverse solutions, attracting non-traditional performers, and sparking new innovations. The 5G Challenge envisions a world where flexible 5G technologies create new supplier opportunities and enhance network security. Streamlining integration enables continuous development, integration, and testing.

6 Summary

The 2023 5G Challenge focuses on basic functionality of 5G RAN components utilizing open interfaces and interoperable subsystems. The Event will be conducted at CableLabs (acting as a host lab in Louisville, CO). In this Event, participating contestants will have the opportunity to integrate and test their subsystems with the host lab leading up to the prize challenge.

The 2023 5G Challenge Event consists of four stages:

- Stage One: Application
- Stage Two: Emulated Integration
- Stage Three: E2E Integration
- Stage Four: Mobility

The diagram below shows the 5G Challenge reference architecture and the specific interfaces that would be tested for the contestant sub-system under test.

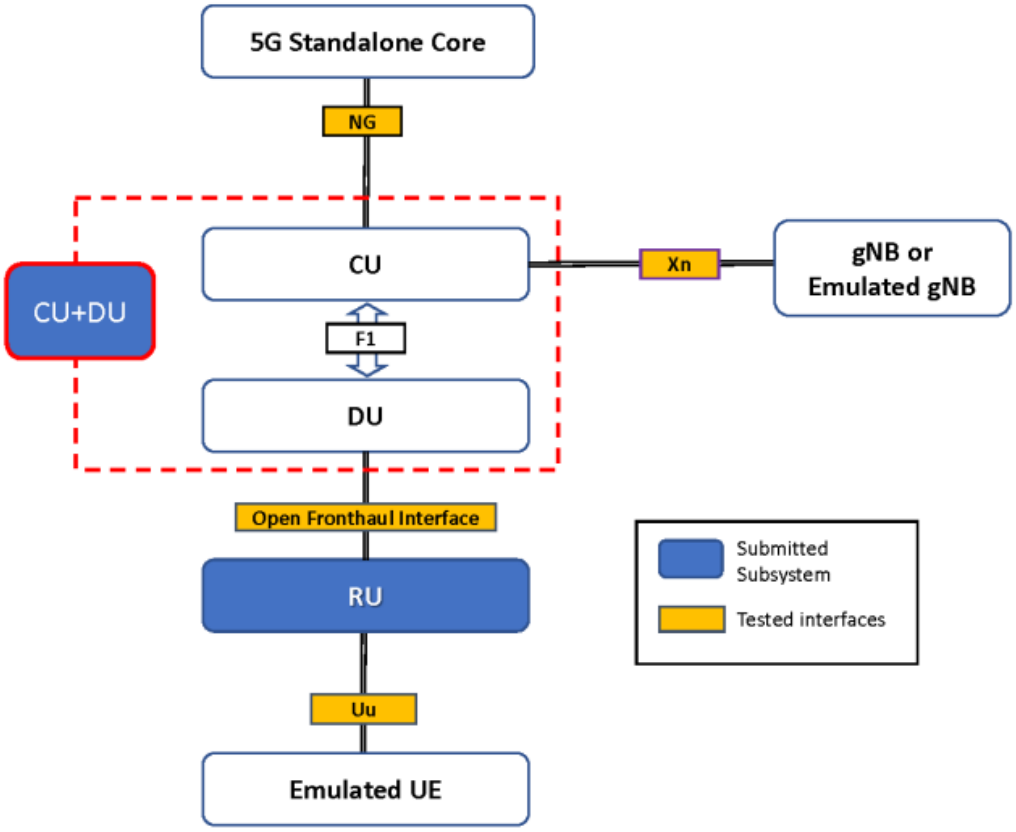

Figure 1 - 5G Challenge Reference Architecture

This document is a compendium of end-to-end test procedures within Stage Three, which include the following levels:

- **Level 0: Operations** - These test cases verify the basic connectivity of the end-to-end setup which are pre-requisite for running any further functional, performance and stress test cases. The test cases validate the ability of the contestants' O-RAN sub-systems to successfully integrate with the E2E setup which consists of a UE emulator and non-emulated 5G SA core. The test cases include Interface Management Procedures (e.g., M-Plane, S-Plane, UC-Plane, etc.)

- **Level 1: Functional** – These test cases verify the contestant subsystem's compliance to O-RAN ALLIANCE and 3GPP specifications with regards to protocol conformance and baseline functionality to build a working setup of E2E 5G network for establishing a successful data call. The test cases include System Procedures (e.g., Registration, Deregistration, Service Request, Paging, etc.), Session Management Procedures (e.g., PDU Session Establishment, PDU Session Modification, PDU Session Release, etc.) and RRC Procedures (e.g., RRC Reestablishment, etc.)

- **Level 2: Performance** - These test cases verify the contestant subsystem's performance with regards to peak performance, link budget, capacity, etc., across different KPIs with regards to latency and throughput for varying RF conditions, different traffic types, for stationary and mobility of single UE. The test cases include single UE performance at varying RF conditions for different traffic types (e.g., TCP, UDP, FTP, RTP, ICMP).

- **Level 3: Stress, Load and Stability** - These test cases verify the contestant subsystem's functional and performance aspects across different KPIs for loading conditions with multiple UEs. The test cases include multiple UE performance at varying RF conditions for loading scenarios (e.g., multiple RRC connected UEs, multiple UE state transition) and stability test cases (e.g., traffic load testing, long hours stability testing, etc.).

The test procedures follow pass/fail criteria and are intended to be standalone procedures, not dependent upon any other test cases.

The focus of this document is to harmonize the end-to-end test specification, conditions, methodologies, and procedures. The test configuration (parameters) recorded in the test report enable the tests to be performed in stable and repeatable conditions on stable and consistent test setups.

For each of the above test categories, the test scope, setup, procedures and expected results have been defined together with their associated success criteria.

The test cases to be executed for Stage Three end to end testing are listed below:

Stage 3: E2E Testing (High-Level View)					
Test Case Level	**Test Case Category**	**Test Case Sub-Category**	**Test Case Number**	**Test Case Name**	**Mandatory/ Conditional Mandatory**
Level 0	**Integration**	**FH M-Plane**	E2E-TC-WG4.IOT.2.2.1.1	Start-up in hierarchical mode	CM
			E2E-TC-WG4.IOT.2.2.1.2	Start-up in hybrid mode	CM
		FH S-Plane	E2E-TC-WG4.IOT.2.2.2.1/2/3	Functional test of O-DU + bridged network + O-RU using ITU-T G.8275.1 profile (LLS-C1/C2/C3)	M
		FH UC-Plane	E2E-TC-WG4.IOT.2.2.3.1	Radio Layer 3 C-Plane establishment and Initial Radio U-Plane data transfer	M
			E2E-TC-WG4.IOT.2.2.3.2	Radio U-Plane downlink data transfer	M
			E2E-TC-WG4.IOT.2.2.3.3	Radio U-Plane uplink data transfer	M
Level 1	**Functionality / Protocol Conformance**	**System Procedures**	E2E-TC-TIFG.E2E-4.3	5G SA Registration and deregistration of single UE	M
			E2E-TC-1.1	Integrity Protection and Ciphering Verification	M
			E2E-TC-1.2	Service Request (UE Requested)	M
			E2E-TC-1.3	Service Request (Network Triggered - Paging)	M
		Session Management Procedures	E2E-TC-1.4	PDU Session Modification (UE Requested)	M
			E2E-TC-1.5	RRC Connection Reestablishment (post RLF)	M
Level 2	**Performance (Single UE)**	**Single UE performance**	E2E-TC-TIFG.E2E-5.2	Downlink Peak Throughput	M
			E2E-TC-TIFG.E2E-5.3	Uplink Peak Throughput	M

		(Throughput) (Stationary)	E2E-TC-TIFG.E2E-5.4	Downlink Throughput in different radio conditions (TCP and UDP; Good, Fair and Poor [Cell Edge])	M
			E2E-TC-TIFG.E2E-5.5	Uplink Throughput in different radio conditions (TCP and UDP; Good, Fair and Poor [Cell Edge])	M
			E2E-TC-TIFG.E2E-5.6	Bidirectional throughput in different radio conditions (TCP and UDP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	M
		Single UE performance (Throughput) (Mobility)	E2E-TC-TIFG.E2E-5.7	Downlink coverage throughput (link budget) (Mobility [Cell Center to Cell Edge]; TCP and UDP)	M
			E2E-TC-TIFG.E2E-5.8	Uplink coverage throughput (link budget) (Mobility [Cell Center to Cell Edge]; TCP and UDP)	M
		Single UE performance (Other Traffic Types) (Stationary)	E2E-TC-TIFG.E2E-6.1.1	Web Browsing (HTTP/TLS/TCP or HTTP/QUIC/UDP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	M
			E2E-TC-TIFG.E2E-6.1.2	File upload/download (FTP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	M
			E2E-TC-TIFG.E2E-6.2.1	Video Streaming	CM
			E2E-TC-2.1	Bi-directional RTP Traffic (RTP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	M
			E2E-TC-2.2	ICMP Traffic (ICMP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	M
		Fronthaul	E2E-TC-WG4.IOT.2.2.4	C/U-Plane Delay Management IOT Test	CM

Level 3	**Stress, Load and Stability**	**Stress**	E2E-TC-TIFG.E2E-5.9	Downlink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; TCP and UDP)	CM
			E2E-TC-TIFG.E2E-5.10	Uplink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; TCP and UDP)	CM
		Loading / Reliability	E2E-TC-TIFG.E2E-8.1	Simultaneous RRC_CONNECTED (100 UEs)	CM
			E2E-TC-TIFG.E2E-8.2	Benchmark of UE State Transition (100 UEs)	CM
			E2E-TC-TIFG.E2E-8.3	Traffic Load Testing (100 UEs)	CM
			E2E-TC-TIFG.E2E-8.4	Traffic Model Testing	CM
		Stability	E2E-TC-TIFG.E2E-8.5	Stability Testing	CM

Table 1- Stage Three End to End Test Cases

Level 0 test cases will be a pre-requisite for other levels. Contestants will need to pass all the Mandatory (M) test cases to move on to Stage Four. Both Mandatory (M) and Conditional Mandatory (CM) test cases will be scored for Stage 3. Contestants are encouraged to pass as many Conditional Mandatory test cases as possible, post completion of mandatory test cases to maximize Stage 3 scoring.

The radio conditions for UE (Excellent [Cell Center], Good, Fair and Poor [Cell Edge]) will be as defined in table below as per section 3.6 in O-RAN.TIFG.E2E-Test.0-v04.00.

Radio Conditions	RSRP (dBm)	DL SINR (dB)
Excellent (cell center)	> -75	> 25
Good	-75 to -90 (Typical value = -85)	15 to 20 (Typical value = 17)
Fair	-90 to -105 (Typical value = -95)	5 to 10 (Typical value = 7)

Poor (Cell Edge)	< -105 (Typical value = -110)	< 5 (Typical value = 3)

Table 2- Radio conditions

7 SUT Requirements

7.1 Laptop

The contestants shall provide a laptop for facilitating local and/or remote connection to the SUT (CU+DU and RU).

7.2 Hardware

For contestants providing their own hardware for testing, the hardware shall support:

- 3GPP Rel.15 FR1 and O-RAN ALLIANCE technical specifications mandatory for the Open Fronthaul 7-2x split interface (please see section 13 for references to relevant 3GPP and ORAN ALLIANCE technical specifications)
- An RF antenna port used to transmit/receive NR RF signal (RU only)
- An Ethernet port used for local or remote access to the hardware.
- Hardware must use AC power OR DC -48V. If DC power other than -48V is needed, the contestant will need to provide their own rectifier.
- Power cables should have North American plugs (or adaptors to North American outlets)
- RF Ports need to be adapted to SMA.
- RU vendor shall provide the necessary SFP(s) for connecting its RU to the test setup.

In addition, the SUT hardware serial number and SUT photo(s) shall be submitted to the 5G Lab before testing begins and after testing concludes.

7.3 Software

7.3.1 Inventory

The SUT software inventory details shall be submitted to the 5G Lab personnel in three occasions during the testing period, i.e.:

1. Prior entering the 5G Challenge Lab,
2. Prior final scoring testing begins, and
3. After final scoring testing ends.

7.3.2 Installation

- Contestants bringing their own SUT HW along with their SUT SW to the 5G Lab, are responsible for installing and integrating both their HW and SW into the test environment.

- Contestants bringing to the 5G Lab only their SUT SW are responsible for SW installation and integration into the test environment.

7.3.3 Configuration

- SUT software configuration (i.e., parameter changes) that is required for executing and/or troubleshooting a test case, shall be performed by the SUT vendor.
- SUT software and/or parameter changes during integration, preliminary/initial testing, and troubleshooting are allowed.
- SUT software changes and/or parameter changes during final scoring testing are not allowed.
- Any SUT software and/or hardware changes during Level 1 testing shall require a rerun of previously passed Level 1 test case(s); to validate that the compliance demonstrated before has been maintained after software and/or hardware changes applied.
- After SUT exits Level 1 testing, any software change during Level 2, 3 and 4 testing will require a rerun of Level 1 testing to validate the compliance demonstrated in Level 1 has been maintained.
- All testing (including re-runs) needs to be completed in the testing window allocated to the contestant.

8 Test Environment

The System Under Test (SUT), i.e., CU+DU+RU, is connected via its NG interface towards the baseline 5G SA Core and its NR air-interface towards a UE Emulator (or actual UE), as shown in the figure below.

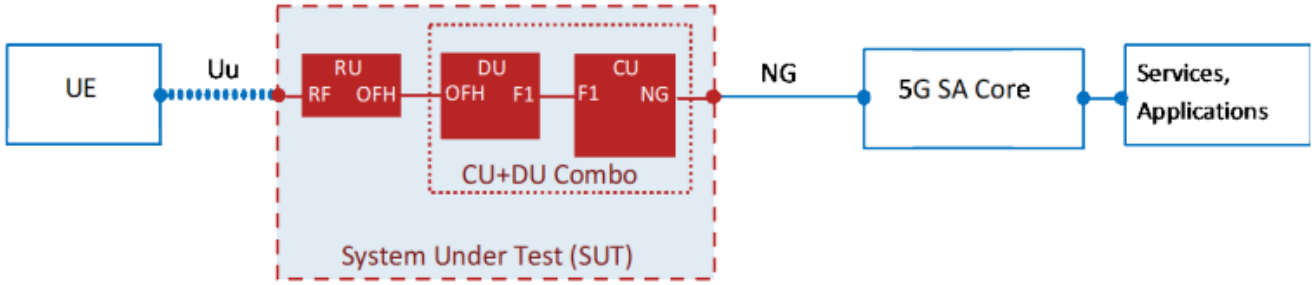

Figure 2. Stage 3 End-to-end test environment

8.1 Test Equipment

Vendor	Model	SW	Use
UE Emulator	Viavi TK5000/E500	NLA 5.13.1	Emulates up to 100 UEs and used to initiate all test cases and campaigns for Stage 3 testing
	Keysight UeSIM	v23.2.1	
Core	Mavenir Core	21.4.1	Non-Emulated Rel-15 compliant 5G SA Core
Traffic Generator	Viavi RDA	15.9	Emulates network and application layer traffic for the Quality of service (QoS) and Quality of Experience (QoE) analysis. Tests and analyzes networks and network equipment by sending various forms of traffic over that network.
	Keysight Ix Load	9.30.0.331	
PTP GM	Viavi MTS5800		Timing Grand Master (T-GM)
Fronthaul switch	Fibrolan Falcon-RX	Falcon_RX812G_8-0-17-4	Fronthaul transport and timing switch compatible with ORAN architecture. It has high-capacity low latency and supports extensive sync and timing options like SyncE and PTP (PTRC/GM, BC, TC).

Fronthaul Analyzer	Wireshark	4.0.3	A protocol analyzer that parses and decodes O-RAN fronthaul interface packets. It provides visibility into the fronthaul protocol messages.

Table 3. Stage 3 Equipment List

8.2 Test Setup

The test setup is illustrated in the diagram below.

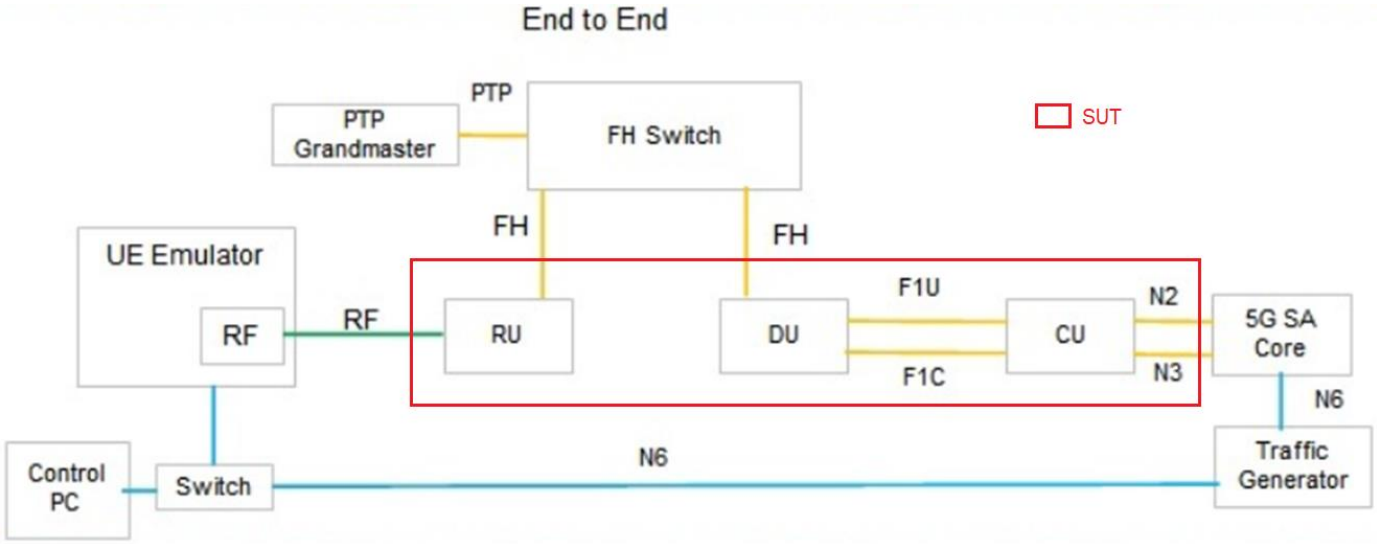

Figure 3. Stage 3End-to-end test setup

9 Test Cases - Level 0: Network Sanity/Connectivity Test Cases

These test cases verify the basic connectivity of the end-to-end setup which is pre-requisite for running any further functional, performance and stress test cases. The test cases validate the ability of the contestants' O-RAN sub-systems to successfully integrate with the E2E setup which consists of a UE emulator and non-emulated 5G SA core.

Level 0 test cases will be pre-requisite for the further levels of testing – functional, performance and stress.

9.1 E2E-TC-WG4.IOT.2.2.1.1 Start-up in hierarchical mode

The test case demonstrates RU support for NETCONF sessions to the DU.

9.1.1 Scope

The purpose of this test case is to validate the startup sequence of RU and the interface to DHCP server and NETCONF client in DU for the start-up scenario.

9.1.2 Procedure

The testing procedure will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.1.1.6.

9.1.3 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.1.1.7 and 2.2.1.1.8.

The pass/fail criteria will be the validation of the correct transmission of parameters such as downlink carrier frequency, cell ID, system information, etc., within the synchronization and broadcast channels that match up with the configured values.

9.2 E2E-TC-WG4.IOT.2.2.1.2 Start-up in hybrid mode

The test case demonstrates that RU is able to support simultaneous NETCONF sessions to the DU and NMS.

9.2.1 Scope

The purpose of this test case is to validate the startup sequence of RU and the interface to DHCP server and NETCONF client in DU and NMS for the start-up scenario.

9.2.2 Procedure

The testing procedure will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.1.2.6.

9.2.3 Expected Result (Pass/Fail Criteria)

The expected result and pass/fail criteria will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.1.2.8 and 2.2.1.2.9.

9.3 E2E-TC-WG4.IOT.2.2.2.1/2/3 Functional test of DU + bridged network + RU using ITU-T G.8275.1 profile (LLS-C1/C2/C3)

The test case demonstrates RU synchronization from an DU using either:

- LLS-C1 - a PTP grand master and SyncE Master with ITU-T G.8275.1 profile and is traceable to a PRTC or
- LLS-C2 - Chain of T-BC using ITU-T G.8275.1 profile
- LLS-C3 – Common PRTC via chain of T-BCs using ITU-T G.8275.1 profile

9.3.1 Scope

The purpose of this test case is to validate the correct synchronization status of the RU and/or DU.

9.3.2 Procedure

The testing procedure will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.2.1.5.

9.3.3 Expected Result (Pass/Fail Criteria)

The expected result and pass/fail criteria will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.2.1.6.

9.4 E2E-TC-WG4.IOT.2.2.3.1 Radio Layer 3 C-Plane establishment and Initial Radio U-Plane data transfer

The test case demonstrates the radio system functionalities, performance and multi-vendor interoperability of the DU and RU from different vendors connected using the O-RAN WG4 specified FH interface.

9.4.1 Scope

The purpose of this test case is to validate key radio operation after M-Plane startup, i.e., Radio Layer 3 C-Plane establishment and initial Radio U-Plane data transfer on system level with integration of DU and RU from different vendors.

9.4.2 Procedure

The testing procedure will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.3.1.5.

9.4.3 Expected Result (Pass/Fail Criteria)

The expected result and pass/fail criteria will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.3.1.6.

9.5 E2E-TC-WG4.IOT.2.2.3.2 Radio U-Plane downlink data transfer

The test case demonstrates performance of U-Plane data transfer in downlink (from network to UE) via DU and RU.

9.5.1 Scope
The purpose of this test case is to validate downlink U-Plane data transfer after Layer 3 C-Plane establishment including throughput performance on system level with integration of DU and RU from different vendors.

9.5.2 Procedure
The testing procedure will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.3.2.5.

9.5.3 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.3.2.6.

The pass/fail criteria will be that the recorder Radio U-Plane data rate in downlink is within 90% of the expected value as per 3GPP TS 38.211 and TS 38.214 and O-RAN.WG4.IOT.0-v05.00 section 2.2.3.2.6.

9.6 E2E-TC-WG4.IOT.2.2.3.3 Radio U-Plane uplink data transfer
The test case demonstrates performance of U-Plane data transfer in uplink (from UE to network) via RU and DU.

9.6.1 Scope
The purpose of this test case is to validate uplink U-Plane data transfer after Layer 3 C-Plane establishment including throughput performance on system level with integration of DU and RU from different vendors.

9.6.2 Procedure
The testing procedure will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.3.3.5.

9.6.3 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.3.3.6.

The pass/fail criteria will be that the recorder Radio U-Plane data rate in uplink is within 90% of the expected value as per 3GPP TS 38.211 and TS 38.214 and O-RAN.WG4.IOT.0-v05.00 section 2.2.3.3.6.

10 Level 1: Functional Test Cases

These test cases verify the contestant subsystem's compliance to O-RAN ALLIANCE and 3GPP specifications regarding protocol conformance and baseline functionality to build a working setup of E2E 5G network for establishing a successful data call.

10.1 E2E-TC-TIFG.E2E-4.3 5G SA Registration and De-registration of single UE

This test case validates successful Registration and De-registration with a single UE.

10.1.1 Scope

The purpose of this test case is to verify a UE can successfully perform Registration and De-registration procedures as per 3GPP specified signaling. The test also validates the PDU Session Establishment and PDU Session Release Procedures as per 3GPP specified signaling.

10.1.2 Call Flow

As defined by the 3GPP TS 23.502 Figure 4.2.2.2.2-1 for Registration.
As defined by the 3GPP TS 23.502 Figure 4.2.2.3.2-1 for UE-initiated de-registration.
As defined by the 3GPP TS 23.502 Figure 4.3.2.2.1-1 for UE Requested PDU Session Establishment.
As defined by the 3GPP TS 23.502 Figure 4.3.4.2-1 for UE Requested PDU Session Release.

10.1.3 Procedure

The test focuses on the procedure of:

- 'Initial registration' as defined in 3GPP TS 23.502 Section 4.2.2.2.2.
- 'UE-initiated de-registration' as defined in 3GPP TS 23.502 Section 4.2.2.3.2.
- 'UE Requested PDU Session Establishment' as defined in 3GPP TS 23.502 Section 4.3.2.2.
- 'UE Requested PDU Session Release' as defined in 3GPP TS 23.502 Section 4.3.4.2.

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 4.3.3.

10.1.4 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 4.3.4.

The pass/fail criteria will be Registration/De-registration/PDU Session Establishment/ PDU Session Release request (attempt) and accept (success) counts are equal and reject (failure) count is zero.

10.2 1.1 E2E-TC-1.1 Ciphering and Integrity Protection

This test case validates the ciphering and integrity protection of RRC signaling and user data between UE and gNB.

10.2.1 1.1.1 Scope

The purpose of this test case is to verify that any RRC signaling, and user data packets exchanged over the NG RAN air interface are ciphered and integrity protected.

10.2.2 1.1.2 Procedure

The actual testing procedure will be as per 3GPP TS 33.511 section 4.2.2.1.1, 4.2.2.1.2, 4.2.2.1.6 and 4.2.2.1.7.

10.2.3 1.1.3 Expected Result (Pass/Fail Criteria)

The pass/fail criteria will be validating the ciphering and integrity protection as per the algorithms used and supported by the UE and the network for both RRC signaling and user data packets.

10.3 E2E-TC-1.2 Service Request (UE-triggered)

This test case validates the UE triggered service request procedure as per 3GPP specified signaling.

10.3.1 Scope

The purpose of this test case is to verify that a UE can successfully trigger a service request via the 5G network.

10.3.2 Call Flow

As defined by 3GPP TS 23.502 Figure 4.2.3.2-1 for UE triggered Service Request.

10.3.3 Procedure

Step #	Step Description			
1.1	Ensure the physical connection from the RF ports on UE emulator to Antenna ports on RU.			
1.2	Ensure the UE emulator configuration aligns with the configuration on the 5GC and RAN nodes.			
1.3	Run the UE initiated service request test case from the UE emulator.			
1.4	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.5	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.5.1	NAS Service Request MO Request Count	1		

Step #	Step Description			
1.5.2	NAS Service Request MO Success Count	1		

10.3.4 Expected Result (Pass/Fail Criteria)

The pass/fail criteria will be Service Request MO requests(attempt) and accept (success) counts are equal and reject (failure) count is zero.

10.4 E2E-TC-1.3 Service Request (Network-triggered) (Paging)

This test case validates the network-triggered service request procedure as per 3GPP specified signaling.

10.4.1 Scope

The purpose of this test case is to verify that a UE can be successfully paged via a service request by the 5G network.

10.4.2 Call Flow

As defined by 3GPP TS 23.502 Figure 4.2.3.2-1 for Network triggered Service Request.

10.4.3 Procedure

Step #	Step Description			
1.1	Ensure the physical connection from the RF ports on UE emulator to Antenna ports on RU.			
1.2	Ensure the UE emulator configuration aligns with the configuration on the 5GC and RAN nodes.			
1.3	Run the UE initiated service request test case from the UE emulator.			
1.4	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.5	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.5.1	NAS Service Request MT Request Count	1		
1.5.2	NAS Service Request MT Success Count	1		

10.4.4 Expected Result (Pass/Fail Criteria)

The pass/fail criteria will be Service Request MT request (attempt) and accept (success) counts are equal and reject (failure) count is zero.

10.5 E2E-TC-1.4 PDU Session Modification (UE Requested)

This test case validates the PDU Session Modification procedure as compliant with 3GPP specification.

10.5.1 Scope
The purpose of this test case is to verify that a UE can successfully request a modification to an already established PDU session.

10.5.2 Call-Flow
As defined by 3GPP TS 23.502 Figure 4.3.3.2-1 for PDU Session Modification.

10.5.3 Procedure

Step #	Step Description			
1.1	Ensure the physical connection from the RF ports on UE emulator to Antenna ports on RU.			
1.2	Ensure the UE emulator configuration aligns with the configuration on the 5GC and RAN nodes.			
1.3	Run the PDU Session Modification test case from the UE emulator.			
1.4	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.5	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.5.1	PDU Session Modification Request Count	1		
1.5.2	PDU Session Modification Success Count	1		

10.5.4 Expected Result (Pass/Fail Criteria)
The pass/fail criteria will be PDU Session Modification request (attempt) and accept (success) counts are equal and reject (failure) count is zero.

10.6 E2E-TC-1.5 RRC Connection Reestablishment (post RLF)
This test case validates the RRC connection re-establishment procedure as compliant with 3GPP specification.

10.6.1 Scope
The purpose of this test case is to verify that a UE can successfully re-establish RRC connection following a radio link failure.

10.6.2 Call-Flow
As defined by 3GPP TS 38.401 Figure 8.7-1 for RRC connection reestablishment.

10.6.3 Procedure

Step #	Step Description			
1.1	Ensure the physical connection from the RF ports on UE emulator to Antenna ports on RU.			
1.2	Ensure the UE emulator configuration aligns with the configuration on the 5GC and RAN nodes.			
1.3	Run the RRC Connection Reestablishment test case from the UE emulator.			
1.4	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.5	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.5.1	RRC Reestablishment Request Count	1		
1.5.2	RRC Reestablishment Success Count	1		

10.6.4 Expected Result (Pass/Fail Criteria)

The pass/fail criteria will be RRC Reestablishment request (attempt) and accept (success) counts are equal and reject (failure) count is zero.

11 Level 2: Performance Test Cases

These test cases verify the contestant subsystems for peak performance, link budget, cell capacity across different KPIs with regards to latency and throughput for different traffic types and RF conditions.

11.1 E2E-TC-TIFG.E2E-5.2 Downlink peak throughput

This test case assesses the performance for a single stationary UE at Cell Center for downlink TCP and UDP traffic.

11.1.1 Scope

The purpose of the test is to measure the peak (i.e., maximum achievable) user data throughput for TCP and UDP in the downlink direction (i.e., data transmitted from application (traffic) server to UE) for a stationary UE under excellent radio conditions inside an isolated cell.

11.1.2 Setup

The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.2.2.

11.1.3 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.2.3.

11.1.4 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.2.4.

The pass/fail criteria will be for the recorded L1 DL Throughput [Mbps] values to be equal to or greater than 90% for UDP and 70% for TCP of the expected theoretical throughput values calculated as per 3GPP TS 38.306 clause 4.1.2 and O-RAN.TIFG.E2E-Test.0-v04.00 section 5.1.2.

11.2 E2E-TC-TIFG.E2E-5.3 Uplink Peak Throughput

This test case assesses the performance for a single stationary UE at Cell Center for uplink TCP and UDP traffic.

11.2.1 Scope

The purpose of the test is to measure the peak (i.e., maximum achievable) user data throughput for TCP and UDP in the uplink direction (i.e., data transmitted from UE to application (traffic) server) for a stationary UE under excellent radio conditions inside an isolated cell.

11.2.2 Setup
The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.3.2.

11.2.3 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.3.3.

11.2.4 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.3.4.

The pass/fail criteria will be for the recorded L1 DL Throughput [Mbps] values to be equal to or greater than 90% for UDP and 70% for TCP of the expected theoretical throughput values calculated as per 3GPP TS 38.306 clause 4.1.2 and O-RAN.TIFG.E2E-Test.0-v04.00 section 5.1.2.

11.3 E2E-TC-TIFG.E2E-5.4 Downlink Throughput in different radio conditions
This test case assesses the performance for a single stationary UE in different radio conditions for downlink TCP and UDP traffic.

11.3.1 Scope
The purpose of the test is to measure the user experienced data throughput in the downlink direction for TCP and UDP traffic while varying (from excellent to poor) received radio signal quality (strength) with regards to RSRP and SINR for a stationary UE inside the isolated cell.

11.3.2 Setup
The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.4.2.

11.3.3 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.4.3.

11.3.4 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.4.4.

The pass/fail criteria will be for the recorded L1 DL Throughput [Mbps] values to be equal to or greater than 90% for UDP and 70% for TCP of the expected theoretical throughput values calculated as per 3GPP TS 38.306 clause 4.1.2 and O-RAN.TIFG.E2E-Test.0-v04.00 section 5.1.2.

11.4 E2E-TC-TIFG.E2E-5.5 Uplink Throughput in different radio conditions

This test case assesses the performance for a single stationary UE in different radio conditions for uplink TCP and UDP traffic.

11.4.1 Scope

The purpose of the test is to measure the user experienced data throughput in the uplink direction for TCP and UDP traffic while varying (from excellent to poor) received radio signal quality (strength) with regards to RSRP and SINR for a stationary UE inside the isolated cell.

11.4.2 Setup

The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.5.2.

11.4.3 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.5.3.

11.4.4 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.5.4.

The pass/fail criteria will be for the recorded L1 DL Throughput [Mbps] values to be equal to or greater than 90% for UDP and 70% for TCP of the expected theoretical throughput values calculated as per 3GPP TS 38.306 clause 4.1.2 and O-RAN.TIFG.E2E-Test.0-v04.00 section 5.1.2.

11.5 E2E-TC-TIFG.E2E-5.6 Bidirectional throughput in different radio conditions

This test case assesses the performance in both downlink and uplink in parallel for a single stationary UE in different radio conditions for TCP and UDP traffic.

11.5.1 Scope
The purpose of the test is to measure the user experienced data throughput in both downlink and uplink in parallel for TCP and UDP traffic while varying (from excellent to poor) received radio signal quality (strength) with regards to RSRP and SINR for a stationary UE inside the isolated cell.

11.5.2 Setup
The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.6.2.

11.5.3 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.6.3.

11.5.4 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.6.4.

The pass/fail criteria will be for the recorded L1 DL Throughput [Mbps] and L1 UL Throughput [Mbps] values to be equal to or greater than 90% for UDP and 70% for TCP of the expected theoretical throughput values calculated as per 3GPP TS 38.306 clause 4.1.2 and O-RAN.TIFG.E2E-Test.0-v04.00 section 5.1.2.

11.6 E2E-TC-TIFG.E2E-5.7 Downlink coverage throughput (link budget)
This test case assesses the network performance in downlink during the movement of a for a single stationary UE from excellent radio conditions to poor radio conditions for UDP (and optionally TCP) traffic.

11.6.1 Scope
The purpose of the test is to measure the downlink user data throughput (i.e., data transmitted from application (traffic) server to UE) when radio conditions of UE change gradually. Test is verified by moving UE from cell center to cell edge of the until UE loses the coverage (call drop).

11.6.2 Setup
The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.7.2.

11.6.3 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.7.3.

11.6.4 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.7.4.

The pass/fail criteria will be validating the recorded DL Throughput [Mbps] values to be in accordance with the change in MCS values and path loss as the UE moves within the cell.

11.7 E2E-TC-TIFG.E2E-5.8 Uplink coverage throughput (link budget)

This test case assesses the network performance in uplink during the movement of a for a single stationary UE from excellent radio conditions to poor radio conditions for UDP (and optionally TCP) traffic.

11.7.1 Scope

The purpose of the test is to measure the uplink user data throughput (i.e., data transmitted from UE to application (traffic) server) when radio conditions of UE change gradually. Test is verified by moving UE from cell center to cell edge of the until UE loses the coverage (call drop).

11.7.2 Setup

The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.8.2.

11.7.3 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.8.3.

11.7.4 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.8.4.

The pass/fail criteria will be validating the recorded UL Throughput [Mbps] values to be in accordance with the change in MCS values and path loss as the UE moves within the cell.

11.8 E2E-TC-TIFG.E2E-6.1.1 Web Browsing

This test case assesses the network performance for a single stationary UE in different radio conditions using HTTP/TLS/TCP or HTTP/QUIC/UDP or both these protocols.

11.8.1 Scope
The purpose of the test is to validate that the end user device is able to browse the web with no packet drops or out of sequence packets which could impact the user experience.

11.8.2 Setup
The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.1.1.2.

11.8.3 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.1.1.3.

11.8.4 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.1.1.4.

The pass/fail criteria will be for the Time To First Byte (TTFB) to be less than 3 seconds and Page Load Time to be less than 12 seconds.

11.9 E2E-TC-TIFG.E2E-6.1.2 File upload/download
This test case assesses the network performance for a single stationary UE in different radio conditions for FTP.

11.9.1 Scope
The purpose of the test is to validate the end user device can upload/download the complete file to/from the FTP server without interruption.

11.9.2 Setup
The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.1.2.2.

11.9.3 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.1.2.3.

11.9.4 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.1.2.4.

The pass/fail criteria will be for the recorded L1 DL Throughput [Mbps] and L1 UL Throughput [Mbps] values to be equal to or greater than 90% of the expected theoretical throughput values calculated as per 3GPP TS 38.306 clause 4.1.2 and O-RAN.TIFG.E2E-Test.0-v04.00 section 5.1.2 and for the Time taken to upload/download to be equal or less than the expected time calculated as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.1.2.4.

11.10 E2E-TC-TIFG.E2E-6.2.1 Video Streaming – Stationary Test

This test case assesses the network performance for a single stationary UE in different radio conditions for video streaming using HTTP protocol over TCP/TLS or UDP/QUIC.

11.10.1 Scope

The test's purpose is to validate the end user can stream and watch the video content without delays or intermittent buffering and with no packet drop or out of sequence packets which could impact user experience.

11.10.2 Setup

The test setup will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.2.1.2.

11.10.3 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.2.1.3.

11.10.4 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 6.2.1.4.

The pass/fail criteria will be for the recorded Video Start time or Time to load first video frame to be less than 1.5 seconds, Number of video stalls/buffering to be less than 1, Duration of stalls in the video to be less than 5 seconds and Video MOS Score to be more than 3.5.

11.11 E2E-TC-2.1 Performance with bi-directional RTP Traffic

This test case assesses the network performance for a single stationary UE in different radio conditions for bi-directional traffic using RTP protocol.

11.11.1 Scope

The purpose of the test is to validate the end user is able to successfully send RTP traffic (over UDP) via the E2E network with any performance impacting issues.

11.11.2 Procedure:

Step #	Step Description			
1.1	Run the test case for bi-directional RTP traffic for a single stationary UE at excellent (cell center) radio conditions from the UE emulator.			
1.2	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.3	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.3.1	Jitter			
1.4	Run the test case for bi-directional RTP traffic for a single stationary UE at good radio conditions from the UE emulator.			
1.5	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.6	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.6.1	Jitter			
1.7	Run the test case for bi-directional RTP traffic for a single stationary UE at fair radio conditions from the UE emulator.			
1.8	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.9	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.9.1	Jitter			
1.10	Run the test case for bi-directional RTP traffic for a single stationary UE at poor radio conditions from the UE emulator.			
1.11	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.12	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.12.1	Jitter			

11.11.3 Expected Result (Pass/Fail Criteria)

The pass/fail criteria will be for the recorded Jitter to be less than 100 microseconds.

11.12 E2E-TC-2.2 Performance with bi-directional ICMP Traffic

This test case assesses the network performance with ICMP (PING) traffic with MTU size of 32 bytes for a single stationary UE in different radio conditions.

11.12.1 Scope

The purpose of the test is to validate the performance of the network for packet loss and round-trip time with ICMP (PING) traffic with MTU size of 32 bytes for a single stationary UE.

11.12.2 Procedure:

Step #	Step Description			
1.1	Run the test case for ICMP traffic with MTU size of 32 bytes for a single stationary UE at excellent (cell center) radio conditions from the UE emulator.			
1.2	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.3	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.3.1	Average round-trip time (msec)			
1.4	Run the test case for ICMP traffic with MTU size of 32 bytes for a single stationary UE at good radio conditions from the UE emulator.			
1.5	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.6	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.6.1	Average round-trip time (msec)			
1.7	Run the test case for ICMP traffic with MTU size of 32 bytes for a single stationary UE at fair radio conditions from the UE emulator.			
1.8	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.9	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.9.1	Average round-trip time (msec)			
1.10	Run the test case for ICMP traffic with MTU size of 32 bytes for a single stationary UE at poor (cell edge) radio conditions from the UE emulator.			

1.11	Click on generate reports after the successful test run completion and rename the folder with test results with the test case name			
1.12	Verify the below mentioned KPIs from the UE emulator after successful test run completion.			
	Element Tested	**Expected Value**	**Recorded Value**	**Pass/Fail**
1.12.1	Average round-trip time (msec)			

11.12.3 Expected Result (Pass/Fail Criteria)

The pass/fail criteria will be for the recorded Average round-trip time to be less than 15 milli seconds.

11.13 E2E-TC-WG4.IOT.2.2.4 C/U-Plane Delay Management IOT Test

This test case validates that the transmitted Control and User packets sent from the DU are received within the reception windows at the O-RU by checking the frame timing on the air interface is correct.

11.13.1 Scope

The purpose of the test is to validate that the RU will transmit the user data at the correct point in time and with correct content on the air interface regardless of the RU processing time and fronthaul latency between the DU and RU.

11.13.2 Procedure:

The actual testing procedure will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.4.3.5, section 2.2.4.4.5, section 2.2.4.5.5, and section 2.2.4.6.5.

11.13.3 Expected Result (Pass/Fail Criteria)

The expected result and the pass/fail criteria will be as per O-RAN.WG4.IOT.0-v05.00 section 2.2.4.3.6, section 2.2.4.4.6, section 2.2.4.5.6, and section 2.2.4.6.6.

12 Level 3: Stress Test Cases

The level 3 test cases verify the contestant subsystem's performance across different KPIs with regards to latency, jitter, and throughput for different RF and loading conditions with multiple UEs.

12.1 E2E-TC-TIFG.E2E-5.9 Downlink aggregated cell throughput (cell capacity)

This test case assesses the network performance in downlink for multiple UEs at varying radio conditions for UDP (and optionally TCP) traffic.

12.1.1 Scope

The purpose of the test is to validate the downlink aggregated cell throughput (downlink cell capacity) when the UEs are distributed in a uniform or non-uniform way inside a cell.

12.1.2 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.9.3.

12.1.3 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.9.4.

The pass/fail criteria will be for the recorded DL Cell Throughput [Mbps] values for each set of UE in specific radio conditions to be in accordance with the measured MCS and path loss.

12.2 E2E-TC-TIFG.E2E-5.10 Uplink aggregated cell throughput (cell capacity)

This test case assesses the network performance in uplink for multiple UEs at varying radio conditions for UDP (and optionally TCP) traffic.

12.2.1 Scope

The purpose of the test is to validate the uplink aggregated cell throughput (uplink cell capacity) when the UEs are distributed in a uniform or non-uniform way inside a cell.

12.2.2 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.10.3.

12.2.3 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 5.10.4.

The pass/fail criteria will be for the recorded UL Cell Throughput [Mbps] values for each set of UE in specific radio conditions to be in accordance with the measured MCS and path loss.

12.3 E2E-TC-TIFG.E2E-8.1 Simultaneous RRC_CONNECTED UEs

This test case validates multiple UEs can be simultaneously maintained in RRC_CONNECTED state at excellent (cell center) radio conditions loading the cell and testing the capacity of SUT.

12.3.1 Scope

The purpose of this test case is to assess the performance of the network with multiple UEs in RRC_CONNECTED state at excellent (cell center) radio conditions.

12.3.2 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.1.3.

12.3.3 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.1.4.

The pass/fail criteria will be for 98% of the UEs to maintain simultaneous connections by being in RRC_CONNECTED state without an occurrence of call loss.

12.4 E2E-TC-TIFG.E2E-8.2 Benchmark of UE State Transition

This test case validates multiple UEs at excellent (cell center) radio conditions performing repeated state transitions loading the cell and testing the processing capacity of SUT.

12.4.1 Scope

The purpose of this test case is to verify the benchmark value of the number of UE state transitions that can be processed per unit time by connecting multiple UEs to SUT.

12.4.2 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.2.3.

12.4.3 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.2.4.

The pass/fail criteria will be for 98% of the UEs to successfully perform RRC state transitions without an occurrence of call loss.

12.5 E2E-TC-TIFG.E2E-8.3 Traffic Load Testing
This test case validates multiple UEs at excellent (cell center) radio conditions performing simultaneous data sessions loading the cell and testing the processing capacity and stability of SUT.

12.5.1 Scope
The purpose of this test case is to validate the stability of the system under load with a large number of UEs sending and receiving user data.

12.5.2 Procedure:
The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.3.3.

12.5.3 Expected Result (Pass/Fail Criteria)
The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.3.4.

The pass/fail criteria will be for the RRC Access Success rate to be greater than 98%.

12.6 E2E-TC-TIFG.E2E-8.4 Traffic Model Testing
This test case validates multiple UEs at excellent (cell center) radio conditions performing different activities simultaneously based on traffic model loading the cell and testing the processing capacity and stability of SUT.

12.6.1 Scope
The purpose of this test case is to assess the performance of the network under varying load for the SUT by generating various UE behavior such as Registration/Deregistration, Data upload/download, and Mobility based on the traffic model to load the SUT.

12.6.2 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.4.3.

12.6.3 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.4.4.

The pass/fail criteria will be for the Registration Success rate to be greater than 98%, average UL and DL Cell Throughput [Mbps] values to be equal to or greater than 90% for UDP and 70% for TCP of the expected theoretical throughput values calculated as per 3GPP TS 38.306 clause 4.1.2 and O-RAN.TIFG.E2E-Test.0-v04.00 section 5.1.2.

12.7 E2E-TC-TIFG.E2E-8.5 Long hours stability Testing

This test case validates multiple UEs at excellent (cell center) radio conditions performing different activities simultaneously based on traffic model loading the cell and testing the processing capacity and stability of SUT over an extended period.

12.7.1 Scope

The purpose of this test is to conduct a load test using the traffic model for an extended time period to validate the stability of the system over a long period of time.

12.7.2 Procedure:

The actual testing procedure will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.5.3.

12.7.3 Expected Result (Pass/Fail Criteria)

The expected result will be as per O-RAN.TIFG.E2E-Test.0-v04.00 section 8.5.4.

The pass/fail criteria will be for the call drop percentage to less than 2%.

13 References

- O-RAN.TIFG.E2E-Test.0-v04.00
- O-RAN.WG4.IOT.0-v05.00
- 3GPP TS 23.501 - System architecture for the 5G System (5GS)
- 3GPP TS 23.502 - Procedures for the 5G System (5GS)
- 3GPP TS 33.501 - Security architecture and procedures for 5G System
- 3GPP TS 33.551- Security Assurance Specification (SCAS)
- 3GPP TS 38.133 - 5G; NR; Requirements for support of radio resource management
- 3GPP TS 38.211 - 5G; NR; Physical channels and modulation
- 3GPP TS 38.214 - 5G; NR; Physical layer procedures for data
- 3GPP TS 38 300 - 5G NR Overall description Stage-2
- 3GPP TS 38.304 – 5G; NR; User Equipment (UE) procedures in idle mode and in RRC Inactive state
- 3GPP TS 38.306 – NR; User Equipment (UE) radio access capabilities
- 3GPP TS 38.401 - NG-RAN; Architecture description
- 3GPP TS 38.410 NG-RAN; NG general aspects and principles
- 3GPP TS 38.411 NG-RAN; NG layer 1
- 3GPP TS 38.412 NG-RAN; NG signaling transport
- 3GPP TS 38.413 NG-RAN; NG Application Protocol (NGAP)
- 3GPP TS 38.414 NG-RAN; NG data transport
- 3GPP TS 38.425 NG-RAN; NR user plane protocol

14 Annex A – Test Cases and Scoring

Stage 3: E2E Testing (Total Test Cases = 67; Mandatory Test Cases = 54; Optional Test Cases = 13)								
Test Case Level	**Test Case Category**	**Test Case Sub-Category**	**Test Case Number (Mapping to the ORAN E2E spec)**	**Test Case Name (Mapping to the ORAN E2E spec)**	**Sub-Test Case Number**	**Sub-Test Case Name**	**Mandatory/ Conditional Mandatory**	**Scoring**
Level 0	**Integration (6 Test Cases) (Mandatory = 4; Conditional Mandatory = 2)**	**FH M-Plane**	E2E-TC-WG4.IOT.2.2.1.1	Start-up in hierarchical mode	E2E.TC-1	Start-up in hierarchical mode	CM	1
			E2E-TC-WG4.IOT.2.2.1.2	Start-up in hybrid mode	E2E.TC-2	Start-up in hybrid mode	CM	1
		FH S-Plane	E2E-TC-WG4.IOT.2.2.2.1/2/3	Functional test of O-DU + bridged network + O-RU using ITU-T G.8275.1 profile (LLS-C1/C2/C3)	E2E.TC-3	Functional test of O-DU + bridged network + O-RU using ITU-T G.8275.1 profile (LLS-C1/C2/C3)	M	1
		FH UC-Plane	E2E-TC-WG4.IOT.2.2.3.1	Radio Layer 3 C-Plane establishment and Initial Radio U-Plane data transfer	E2E.TC-4	Radio Layer 3 C-Plane establishment and Initial Radio U-Plane data transfer	M	1

			E2E-TC-WG4.IOT.2.2.3.2	Radio U-Plane downlink data transfer	E2E.TC-5	Radio U-Plane downlink data transfer	M	1
			E2E-TC-WG4.IOT.2.2.3.3	Radio U-Plane uplink data transfer	E2E.TC-6	Radio U-Plane uplink data transfer	M	1
Level 1	**Functionality / Protocol Conformance (6 Test Cases) (Mandatory = 6)**	**System Procedures**	E2E-TC-TIFG.E2E-4.3	5G SA Registration and deregistration of single UE	E2E.TC-7	5G SA Registration and deregistration of single UE	M	1
					E2E.TC-8	Integrity Protection and Ciphering Verification	M	1
					E2E.TC-9	Service Request (UE Requested)	M	1
					E2E.TC-10	Service Request (Network Triggered - Paging)	M	1
		Session Management Procedures			E2E.TC-11	PDU Session Modification (UE Requested)	M	1
					E2E.TC-12	RRC Connection	M	1

						Reestablishment (post RLF)		
Level 2	**Performance (Single UE) (46 Test Cases) (Mandatory = 44; Conditional Mandatory = 2)**	**Single UE performance (Throughput) (Stationary)**	E2E-TC-TIFG.E2E-5.2	Downlink Peak Throughput (Single UE; Stationary; TCP and UDP; Excellent [Cell Center])	E2E.TC-13	Downlink Peak Throughput (Single UE; Stationary; UDP; Excellent [Cell Center])	M	1
					E2E.TC-14	Downlink Peak Throughput (Single UE; Stationary; TCP; Excellent [Cell Center])	M	1
			E2E-TC-TIFG.E2E-5.3	Uplink Peak Throughput (Single UE; Stationary; TCP and UDP; Excellent [Cell Center])	E2E.TC-15	Uplink Peak Throughput (Single UE; Stationary; UDP; Excellent [Cell Center])	M	1
					E2E.TC-16	Uplink Peak Throughput (Single UE; Stationary; TCP; Excellent [Cell Center])	M	1

			E2E-TC-TIFG.E2E-5.4	Downlink Throughput in different radio conditions (Single UE; Stationary; TCP and UDP; Good, Fair and Poor [Cell Edge])	E2E.TC-17	Downlink Throughput in different radio conditions (Single UE; Stationary; UDP; Good)	M	1
					E2E.TC-18	Downlink Throughput in different radio conditions (Single UE; Stationary; UDP; Fair)	M	1
					E2E.TC-19	Downlink Throughput in different radio conditions (Single UE; Stationary; UDP; Poor [Cell Edge])	M	1
					E2E.TC-20	Downlink Throughput in different radio conditions (Single UE;	M	1

						Stationary; TCP; Good)		
					E2E.TC-21	Downlink Throughput in different radio conditions (Single UE; Stationary; TCP; Fair)	M	1
					E2E.TC-22	Downlink Throughput in different radio conditions (Single UE; Stationary; TCP; Poor [Cell Edge])	M	1
			E2E-TC-TIFG.E2E-5.5	Uplink Throughput in different radio conditions (Single UE; Stationary; TCP and UDP; Good, Fair and Poor [Cell Edge])	E2E.TC-23	Uplink Throughput in different radio conditions (Single UE; Stationary; UDP; Good)	M	1
					E2E.TC-24	Uplink Throughput in	M	1

						different radio conditions (Single UE; Stationary; UDP; Fair)		
					E2E.TC-25	Uplink Throughput in different radio conditions (Single UE; Stationary; UDP; Poor [Cell Edge])	M	1
					E2E.TC-26	Uplink Throughput in different radio conditions (Single UE; Stationary; TCP; Good)	M	1
					E2E.TC-27	Uplink Throughput in different radio conditions (Single UE; Stationary; TCP; Fair)	M	1
					E2E.TC-28	Uplink Throughput in different radio	M	1

						conditions (Single UE; Stationary; TCP; Poor [Cell Edge])		
			E2E-TC-TIFG.E2E-5.6	Bidirectional throughput in different radio conditions (Single UE; Stationary; TCP and UDP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	E2E.TC-29	Bidirectional throughput in different radio conditions (Single UE; Stationary; UDP; Excellent)	M	1
					E2E.TC-30	Bidirectional throughput in different radio conditions (Single UE; Stationary; UDP; Good)	M	1
					E2E.TC-31	Bidirectional throughput in different radio conditions (Single UE; Stationary; UDP; Fair)	M	1
					E2E.TC-32	Bidirectional throughput in different radio conditions	M	1

						(Single UE; Stationary; UDP; Poor [Cell Edge])		
					E2E.TC-33	Bidirectional throughput in different radio conditions (Single UE; Stationary; TCP; Excellent)	M	1
					E2E.TC-34	Bidirectional throughput in different radio conditions (Single UE; Stationary; TCP; Good)	M	1
					E2E.TC-35	Bidirectional throughput in different radio conditions (Single UE; Stationary; TCP; Fair)	M	1
					E2E.TC-36	Bidirectional throughput in different radio conditions (Single UE;	M	1

						Stationary; TCP; Poor [Cell Edge])		
		Single UE performance (Throughput) (Mobility)	E2E-TC-TIFG.E2E-5.7	Downlink coverage throughput (link budget) (Single UE; Mobility [from Cell Center to Cell Edge]; TCP and UDP)	E2E.TC-37	Downlink coverage throughput (link budget) (Single UE; Mobility [from Cell Center to Cell Edge]; UDP)	M	1
					E2E.TC-38	Downlink coverage throughput (link budget) (Single UE; Mobility [from Cell Center to Cell Edge]; TCP)	M	1
			E2E-TC-TIFG.E2E-5.8	Uplink coverage throughput (link budget) (Single UE; Mobility [from Cell Center to Cell Edge]; TCP and UDP)	E2E.TC-39	Uplink coverage throughput (link budget) (Single UE; Mobility [from Cell Center to Cell Edge]; UDP)	M	1

					E2E.TC-40	Uplink coverage throughput (link budget) (Single UE; Mobility [from Cell Center to Cell Edge]; TCP)	M	1
		Single UE performance (Other Traffic Types)	E2E-TC-TIFG.E2E-6.1.1	Web Browsing (Single UE; Stationary; HTTP/TLS/TCP or HTTP/QUIC/UDP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	E2E.TC-41	Web Browsing (Single UE; Stationary; HTTP/TLS/TCP or HTTP/QUIC/UDP; Excellent [Cell Center)	M	1
					E2E.TC-42	Web Browsing (Single UE; Stationary; HTTP/TLS/TCP or HTTP/QUIC/UDP; Good)	M	1
					E2E.TC-43	Web Browsing (Single UE; Stationary; HTTP/TLS/TCP or HTTP/QUIC/UDP; Fair)	M	1

					E2E.TC-44	Web Browsing (Single UE; Stationary; HTTP/TLS/TCP or HTTP/QUIC/UDP; Poor [Cell Edge])	M	1
			E2E-TC-TIFG.E2E-6.1.2	File upload/download (Single UE; Stationary; FTP; Excellent [Cell Center], Good, Fair and Poor [Cell Edge])	E2E.TC-45	File upload/download (Single UE; Stationary; FTP; Excellent [Cell Center])	M	1
					E2E.TC-46	File upload/download (Single UE; Stationary; FTP; Good)	M	1
					E2E.TC-47	File upload/download (Single UE; Stationary; FTP; Fair)	M	1
					E2E.TC-48	File upload/download	M	1

						(Single UE; Stationary; FTP; Poor [Cell Edge])		
			E2E-TC-TIFG.E2E-6.2.1	Video Streaming	E2E.TC-49	Video Streaming	CM	1
					E2E.TC-50	Bi-directional RTP Traffic (Single UE; Stationary; RTP; Excellent [Cell Center])	M	1
					E2E.TC-51	Bi-directional RTP Traffic (Single UE; Stationary; RTP; Good)	M	1
					E2E.TC-52	Bi-directional RTP Traffic (Single UE; Stationary; RTP; Fair)	M	1
					E2E.TC-53	Bi-directional RTP Traffic (Single UE; Stationary; RTP; Poor [Cell Edge])	M	1

					E2E.TC-54	ICMP Traffic (Single UE; Stationary; ICMP; Excellent [Cell Center])	M	1
					E2E.TC-55	ICMP Traffic (Single UE; Stationary; ICMP; Good)	M	1
					E2E.TC-56	ICMP Traffic (Single UE; Stationary; ICMP; Fair)	M	1
					E2E.TC-57	ICMP Traffic (Single UE; Stationary; ICMP; Poor [Cell Edge])	M	1
		Fronthaul	E2E-TC-WG4.IOT.2.2.4	C/U-Plane Delay Management IOT Test	E2E.TC-58	C/U-Plane Delay Management IOT Test	CM	1

Level 3	**Stress, Load and Stability (Multiple UEs - 100) (9 Test Cases) (Mandatory = 0; Conditional Mandatory = 9)**	**Stress**	E2E-TC-TIFG.E2E-5.9	Downlink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; TCP and UDP)	E2E.TC-59	Downlink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; UDP)	CM	1
					E2E.TC-60	Downlink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; TCP)	CM	1
			E2E-TC-TIFG.E2E-5.10	Uplink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; TCP and UDP)	E2E.TC-61	Uplink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; TCP and UDP)	CM	1

					E2E.TC-62	Uplink aggregated cell throughput (cell capacity) (Multiple UEs; Uniformly distributed [from Cell Center to Cell Edge]; TCP and UDP)	CM	1
		Loading/Reliability	E2E-TC-TIFG.E2E-8.1	Simultaneous RRC_CONNECTED (100 UEs)	E2E.TC-63	Simultaneous RRC_CONNECTED (100 UEs)	CM	1
			E2E-TC-TIFG.E2E-8.2	Benchmark of UE State Transition (100 UEs)	E2E.TC-64	Benchmark of UE State Transition (100 UEs)	CM	1
			E2E-TC-TIFG.E2E-8.3	Traffic Load Testing (100 UEs)	E2E.TC-65	Traffic Load Testing (100 UEs)	CM	1
			E2E-TC-TIFG.E2E-8.4	Traffic Model Testing	E2E.TC-66	Traffic Model Testing	CM	1
		Stability	E2E-TC-TIFG.E2E-8.5	Stability Testing	E2E.TC-67	Stability Testing	CM	1