

5G Challenge 2023

Stage Two – CU+DU Test Plan

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1 Version History

Version	Date	Author(s)	Notes
1.0	March 07, 2023	Spiros Kapoulas, Sundar Sriram	Initial Release
1.1	March 16, 2023	Spiros Kapoulas, Sundar Sriram	Minor changes to clarify test set-up a procedures, general references throughout the document (e.g. O-DU → DU) and clarification of Mandatory vs. Conditional Mandatory tests in Annex C.

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3 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
SUT	Device Under Test
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	SubMiniature 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
UUT	Unit Under Test
vRAN	Virtualized Radio Access Network

4 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
- 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.

5 Summary

The 5G Challenge consists of a Preliminary Event in 2022 and the 2023 5G Challenge. The Preliminary Event focused on basic functionality for individual supplier 5G RAN components utilizing open interfaces and interoperable subsystems. The Preliminary Event was conducted at the CableLabs host lab in Louisville, CO.

In the 2023 5G Challenge, also conducted at the CableLabs host lab in Louisville, CO, participating contestants will have the opportunity to integrate and test their subsystems in the host lab leading up to the prize challenge. The 2023 5G Challenge will focus on CU+DU and RU subsystem integration with an emphasis on end-to-end performance and mobility testing.

The 5G Challenge Preliminary Event consists of four stages:

- Stage One: Application
- Stage Two: Emulated Integration
- Stage Three: End-to-End (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.

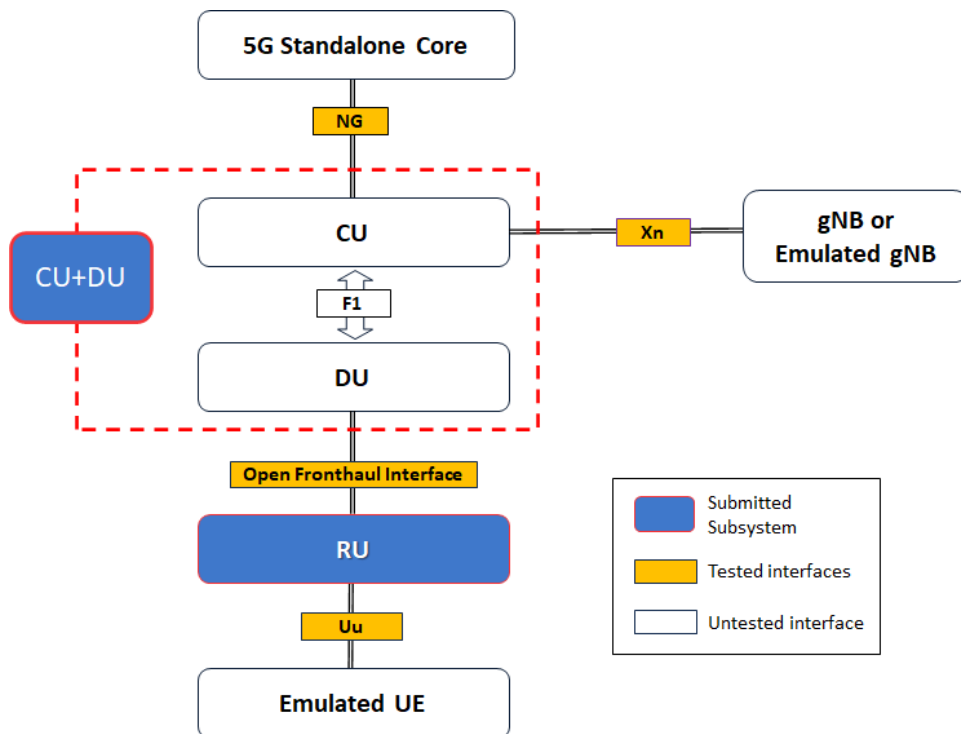


Figure 1 - 5G Challenge Reference Architecture

This document is a compendium of combined Central Unit (CU) + Distributed Unit (DU) test procedures within Stage Two, which include the following levels:

- **Level 0 - Integration** – The CU+DU combo system under test (SUT) shall demonstrate successful integration into the test environment.
- **Level 1 –Conformance, Functional** – The CU+DU combo system under test (SUT) shall demonstrate interface conformance and functionality.

For each of the above test categories, test environment, equipment, lab setup and test procedures have been defined together with their associated success criteria.

The test cases to be executed for Stage Two, CU+DU testing are listed in the table below. In the “Mandatory / Optional” column, M refers to Mandatory test cases and CM refers to Conditional Mandatory test cases (see Annex C).

Level	Test Category	Sub-Category	Test Case ID	Test Case	Test Requirement
0	Integration	CU Integration	CU-TC-INT.1	CU integration	M
		DU Integration	DU-TC-INT.1	DU Fronthaul S-Plane integration	M
			DU-TC-INT.2	DU Fronthaul M-Plane integration	CM
			DU-TC-INT.3	DU Fronthaul UC-Plane integration	M
1	Conformance, Functional	UC-Plane DU Scenario Class NR testing Generic	DU-TC-WG4.CONF.3.4.4.1.1	UC-Plane DU Scenario Class Base CAT-A RU	M
		UC-Plane DU Scenario Class Compression (CMP)	DU-TC-WG4.CONF.3.4.4.3.1	Static Format Fixed-Point (FP) Uncompressed	M
			DU-TC-WG4.CONF.3.4.4.3.2	UC-Plane DU Scenario Class Compression (CMP) Static Format Block Floating Point	CM
		UC-Plane DU Scenario Class Delay Management (DLM)	DU-TC-WG4.CONF.3.4.4.4.1	Delay Management On-time arrival	M
			DU-TC-WG4.CONF.3.4.4.4.2	Delay Management Early Arrival and Late Arrival	CM
		UE Context Management	CU-TC-WG5.IOT.2.3.1.20	UE CONTEXT SETUP (UE Initial Registration)	M
			CU-TC-WG5.IOT.2.3.1.19	UE CONTEXT SETUP (UE Service Request)	M
			CU-TC-WG5.IOT.2.3.1.21	UE CONTEXT RELEASE (UE De-Registration)	M
			CU-TC-WG5.IOT.2.3.1.23	UE CONTEXT MODIFICATION (add DRB)	CM
			CU-TC-WG5.IOT.2.3.1.24	UE CONTEXT MODIFICATION (release DRB)	CM
		gNB Reset	CU-TC-WG5.IOT.2.3.1.29	Reset CU Initiated	M

			CU-TC- WG5.IOT.2.3.1.30	Reset DU Initiated	M
		Paging	CU-TC- WG5.IOT.2.3.1.18	Paging (CN-Initiated)	CM
		Xn Setup	CU-TC- WG5.IOT.2.4.1.1	Xn Setup	CM

Table 1- Stage Two CU Test Cases

The test procedures will evaluate basic pass/fail criteria for the CU+DU system under test (SUT).

These test procedures are subject to change during the contest as additional information and criteria are identified.

6 Lab entry requirements

6.1 Laptop

The contestant shall provide a laptop for facilitating local and/or remote connection to the CU+DU combo.

6.2 CU+DU Hardware

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

- An Ethernet port used for local or remote access to the CU.
- Devices must use AC power OR DC -48V. If DC power other than -48V is needed, the contestant will need to provide their rectifier.
- Power cables should have North American plugs (or adaptors to North American outlets)
- Required and spare SFPs for connecting to the test environment.

In addition, the CU+DU hardware serial number and CU+DU photo shall be submitted to the 5G Lab before testing begins and after testing concludes.

6.3 CU+DU Software

3GPP TS 38.413 V15.6, 3GPP TS 38.423 V15.6

O-RAN-WG4.CUS.0-v05.00, O-RAN.WG4.MP.0-v05.00, O-RAN.WG4.CONF.0-v05.00, O-RAN.WG4.IOT.0-v04.00

6.3.1 Inventory

The CU+DU software inventory details as requested in the Software Bill of Materials (SBOM) 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.

6.3.2 Installation

The CU+DU software installation shall be performed by the SUT vendor.

6.3.3 Configuration

- CU+DU software configuration (i.e. parameter changes) that is required for executing and/or troubleshooting a test case, shall be performed by the SUT vendor.
- CU+DU software and/or parameter changes during integration, preliminary/initial testing, and troubleshooting are allowed.
- CU+DU software changes and/or parameter changes during final scoring testing are not allowed.

- Any CU+DU software and/or hardware change 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 have been applied.
- All testing (including re-runs) needs to be completed in the testing window allocated to the contestant.

7 Level-0: Integration

7.1 Objective

The CU+DU system under test (SUT) shall demonstrate successful integration into the test environment. SUT shall adequately interoperate with the test environment before proceeding to further testing.

7.2 Prerequisites

None

7.3 Preparation

None

7.4 Test Environment

In this test configuration, the CU+DU wraparound tester (OCUDUWT) surrounds the CU+DU system under test (SUT) via its NG interface towards the 5G SA Core, the Xn interface towards the CU Emulator, and the Fronthaul interface towards the RU Emulator, as illustrated in Figure 2.

Note: while an O1 or EMS interface isn't included in the scope of the testing, it is necessary for configuring the CU+DU system.

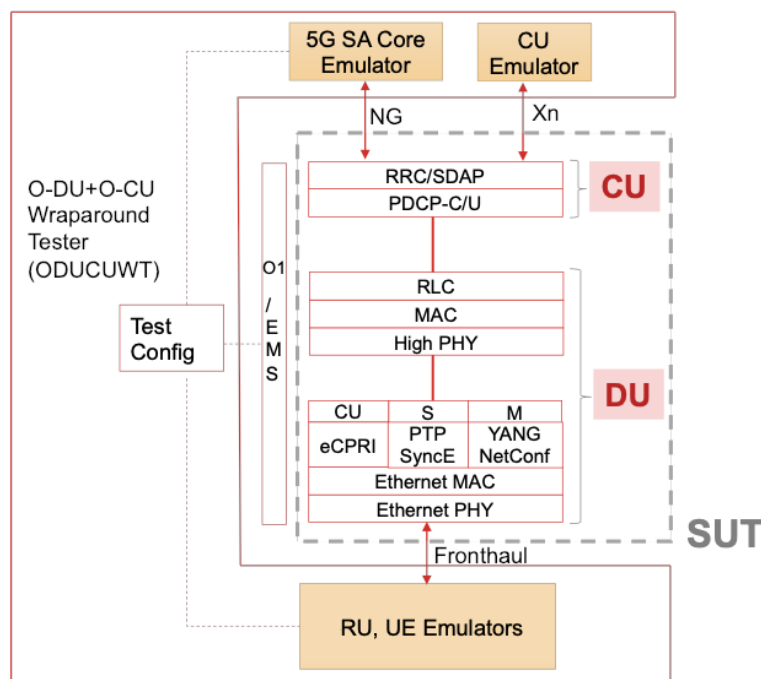


Figure 2 - Logical Test Set-up for CU+DU System under Test (SUT)

Testing of a CU+DU in a 5G environment, i.e. Standalone Architecture (SA) mode involves testing the following interfaces: Fronthaul, NG (N2, N3, N1), and Xn.

The O1/ EMS (Element Management System) interface is not included in the scope of the testing. The Vendor shall provide either an O1 interface or an EMS interface to configure the CU+DU combo.

The SA NAS and RRC messages/procedures are also tested for functional compliance.

7.4.1 Test Equipment

Test Equipment	Model	SW	Use
UE Simulator	VIAVI TK5000/E500	NLA 5.13.1	UE simulator capable of generating traffic equivalent to 100 eMBB UE, in a realistic mobile environment
	Keysight UeSIM	v23.2.1	
RU Emulator	Viavi TeraVM CU Test	V2.47i	It emulates the RU portions of the gNB functions, as defined by O-RAN ALLIANCE split option 7-2x.
	Keysight RuSIM	v23.1	
Core Emulator	Viavi TeraVM CU Test	V2.47i	3GPP Compliant SA Core Emulator supporting the N2, N3 interface towards the CU and implicitly supporting the N1 Interface from the emulated UE.
	Keysight CoreSIM	4.0	
CU Emulator	VIAVI TVM6000	v2.49	It emulates the CU-CP of the gNB for Xn.
	Keysight CuSIM	-	
Backhaul Switch	Cisco Nexus 9K	-	48x10/25G SFP28, 6x40/100G QSFP28
Fronthaul switch	Fibrolan Falcon-RX	Falcon_RX812G_8-0-17-4	Fronthaul transport and timing switch compatible with ORAN architecture. It has high capacity and low latency and supports extensive sync and timing options like SyncE and PTP (PTRC/GM, BC, TC).
PTP GM	Viavi MTS5800	-	Timing Grand Master (T-GM)
Protocol Analyzer	Wireshark Application	3.6.3	PC based software, used to analyze the messages on the Fronthaul, N2, N3, and Xn interfaces.

Table 2 - Test Equipment for CU as SUT

7.4.2 Lab Setup & Configuration

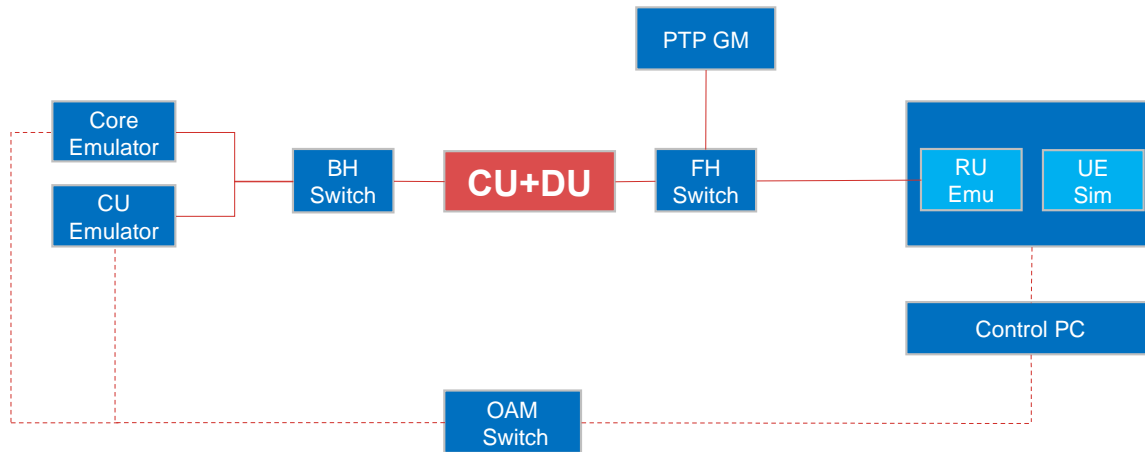


Figure 3 - Lab Set-up for CU+DU system under test

7.5 Test Cases

7.5.1.1 CU-TC-INT.1: CU Integration

Test Procedure

1. Power up SUT and verify access to it.
2. Verify that SUT is physically and logically connected to the Viavi CU+DU Tester.
3. Configure the Network parameters (PLMN, TAC, PCI, Emulated elements configuration – Core, UE Information).
4. A protocol analyzer is physically connected to the Xn and NG links.
5. NG Setup procedure specified in [6] has been completed with the 5G SA Core Emulator.
6. Collect results and verify connectivity.

Success Criteria

- The NG Interface between the Core Emulator and SUT is successfully established AND
- The SCTP association between the SUT and Core Emulator is successfully established shall indicate a Pass.
- Logs recorded in the Protocol Analyzer are checked.

7.5.1.2 DU-TC-INT.1: DU Fronthaul S-Plane integration

The purpose of this test is to validate the integration of DU Fronthaul S-Plane to the CU+DU wraparound test environment by demonstrating *PTP lock* state.

Test procedure

1. MTS5800 has been configured as PTP/SyncE master using the ITU-T G.8275.1 profile and connected to the Fronthaul switch.

2. Log onto RU Emulator and adjust the configuration for LLS-C3
3. Verify that RU Emulator has achieved *PTP Lock* state
4. Verify that DU is in *PTP Lock* state

Collect and store logs, pcap files providing evidence of successful execution of this test case.

Success criteria

The SUT has been able to establish S-Plane connectivity and achieve time synchronization successfully.

7.5.1.3 DU-TC-INT.2: DU Fronthaul M-Plane integration

The purpose of this test is to validate the integration of DU Fronthaul M-Plane to the CU+DU wraparound test environment by demonstrating a successful Call Home M-Plane procedure.

Test procedure

1. Configure a mirror port at the Fronthaul switch where Wireshark is connected to.
2. RU Emulator has been configured per M-Plane IOT profile in Annex A.
3. RU Emulator shall attempt to call home.
4. Wireshark should show bidirectional TCP traffic between the DU and RU IP addresses.
5. The payload content of these packets is NETCONF over SSH
6. The details of the NETCONF exchange are encrypted; therefore the establishment of the session with the DU shall be confirmed in the RU Emulator.
7. In the RU Emulator verify the Call Home procedure per section 6.3 in [9].

Collect and store relevant logs, pcap files providing evidence of successful execution of this test case.

Success criteria

The RU emulator has completed a NETCONF Call Home procedure to the DU per section 6.3 in [9].

7.5.1.4 DU-TC-INT.3: DU Fronthaul UC-Plane integration

The purpose of this test is to validate the integration of DU Fronthaul UC-Plane to the DU+CU wraparound test environment.

Test procedure

1. Configure a mirror port at the Fronthaul switch where Wireshark is connected to.
2. RU Emulator has been configured per UC-Plane IOT profile in Annex B.
3. RU Emulator is connected to the UE Simulator.
4. Verify that UE Simulator can successfully detect and decode the MIB and SIBs.

Collect and store relevant logs, pcap files providing evidence of successful execution of this test case.

Success criteria

Verify that MIB and SIBs carry the network parameters (e.g. PLMN, TAC, PCI, etc.) configured in section 7.5.1.1.

8 Level-1: Conformance, Functional

8.1 Objective

The CU+DU system under test (SUT) shall adequately demonstrate conformance and functionality that would enable it to perform further testing in Stage-3 and Stage-4.

The NR C-Plane profile specification [12] Section 4.2.3.1 will be used where applicable.

8.2 Prerequisites

An SCTP association is successfully established between the two SCTP endpoints.

8.3 Preparation

As outlined in section 7.5.

8.4 Test Environment

Same as in Level-0.

8.4.1 Test Equipment

Same as in Level-0.

8.4.2 Lab Setup & Configuration

Same as in Level-0.

8.5 Test Cases

8.5.1 Fronthaul UC-Plane

8.5.1.1 UC-Plane DU Scenario Class NR testing Generic

The purpose of the tests in this section is to ensure that the CU+DU SUT supports the mandatory open fronthaul features of the specification as defined in Table 8-2 in [8].

8.5.1.1.1 DU-TC-WG4.CONF.3.4.4.1.1 UC-Plane DU Scenario Class Base CAT-A RU

This test case validates the capability of the DU to meet the basic requirements of the O-RAN fronthaul to support connecting with a CAT-A RU with no beamforming and 16-bit fixed-point IQ format; using either a TDD IOT profile (i.e. A.2.1.1 NR TDD IOT Profile 1 - NR-TDD-FR1-CAT-A-NoBF in [11]), or an FDD IOT profile (i.e. A.2.2.3 NR FDD IOT Profile 3 - NR-FDD-FR1-CAT-A-NoBF).

Test preparation

- The DU SUT has been provisioned to connect to a CAT-A RU for 5G NR and be able to synchronize with the RU emulator.

- The RU Emulator has been configured to emulate a CAT-A RU with no beamforming and 16-bit fixed-point IQ format.
- UE Emulator is connected to the RU Emulator.

Test procedure

1. UE Emulator (through the RU Emulator) initiates a connection towards the DU SUT.
2. UE Emulator initiates bi-directional (UL, DL) data transmission towards an application server (i.e. FTP) connected to the 5GC & CU Emulator.
3. Log and analyze the open front haul data stream between the DU SUT and RU Emulator, including used section types and section extensions.

Success criteria

Obverse non-zero data throughput in both uplink and downlink.

8.5.1.2 UC-Plane DU Scenario Class Compression (CMP)

8.5.1.2.1 DU-TC-WG4.CONF.3.4.4.3.1 Static Format Fixed-Point (FP) Uncompressed

The objective is to verify that DU supports Static Fixed-Point Uncompressed 16-bit IQ signals over the Fronthaul interface.

This test case validates the capability of the DU to meet the basic requirements of the O-RAN fronthaul to support connecting with a CAT-A RU with no beamforming and 16-bit fixed-point IQ format; using either the TDD IOT profile (A.2.1.1 NR TDD IOT Profile 1 - NR-TDD-FR1-CAT-A-NoBF in [11]) or the FDD IOT profile (A.2.2.3 NR FDD IOT Profile 3 - NR-FDD-FR1-CAT-A-NoBF in [11]).

Test preparation

- The DU SUT has been provisioned to connect with a 5G NR CAT-A RU and has been able to synchronize with the RU emulator.
- The RU Emulator has been configured to emulate a CAT-A RU with no beamforming and 16-bit fixed-point IQ format.
- UE Emulator is connected to the RU Emulator.

Test procedure

The test procedure is described in section 3.4.4.3.1 C in [10].

Success criteria

Per section 3.4.4.3.1 D in [10], all conditions below shall be met:

4. The C-Plane Section Header has `udCompHdr` set to 0x0.
5. The C-Plane Downlink Data Section Header has `udCompHdr`, “reserved” and `udCompParam` fields are absent.
6. Non-zero data throughput in both uplink and downlink.

8.5.1.2.2 DU-TC-WG4.CONF.3.4.4.3.2 UC-Plane DU Scenario Class Compression (CMP) Static Format Block Floating Point

The objective is to verify that DU supports IQ Static Block floating-point compression for 3 supported bit widths: 9, 12 or 14 bits.

This test case validates the correct encoding/decoding of UL/DL IQ data (9, 12 or 14 bits) by the RU using either the TDD IOT profile (A.2.1.1 NR TDD IOT Profile 1 - NR-TDD-FR1-CAT-A-NoBF in [11]) or the FDD IOT profile (A.2.2.3 NR FDD IOT Profile 3 - NR-FDD-FR1-CAT-A-NoBF in [11]).

Test preparation

- The DU SUT has been provisioned to connect with a 5G NR CAT-A RU and has been able to synchronize with the RU emulator.
- The RU Emulator has been configured to emulate a CAT-A RU with no beamforming and Static Format BFP Compression IQ format.
- UE Emulator is connected to the RU Emulator.

Test procedure

The test procedure is described in section 3.4.4.3.2 C in [10].

Validate correct encoding/decoding of IQ data for 9bits, and/or 14bits, and/or 12bits mantissa, for all vendor supported compression mantissa value(s).

Success criteria:

1. Per section 3.4.4.3.2 D in [10].
2. Validate correct encoding/decoding of IQ data for 9bits, and/or 14bits, and/or 12bits mantissa, for all vendor supported compression mantissa value(s).

8.5.1.3 UC-Plane DU Scenario Class Delay Management (DLM)

8.5.1.3.1 DU-TC-WG4.CONF.3.4.4.4.1 Delay Management On-time arrival

The objective is to verify that DU supports configured delay management parameters for the C-Plane and U-Plane of the O-RAN fronthaul interface.

DU shall use either the TDD IOT profile (A.2.1.1 NR TDD IOT Profile 1 - NR-TDD-FR1-CAT-A-NoBF in [11]), or the FDD IOT profile (A.2.2.3 NR FDD IOT Profile 3 - NR-FDD-FR1-CAT-A-NoBF in [11]).

Test preparation

The DU SUT has been provisioned to connect with a 5G NR CAT-A RU and has been able to synchronize with the RU emulator.

The RU Emulator has been configured to emulate a CAT-A RU with no beamforming and Static Format BFP Compression IQ format. UE Emulator is connected to the RU Emulator.

Test procedure

The test procedure is described in section 3.4.4.4.1 C in [10].

Success criteria:

Per section 3.4.4.4.1 D in [10], all conditions below shall be met:

1. DU receive (uplink) counters (RX_ON_TIME, RX_EARLY, RX_LATE) for each configured eAxC for the U-Plane are observed. Only RX_ON_TIME should show non-zero values or changed values if the counters cannot be cleared.
2. RU emulator (downlink) RX counters report that only on-time PDUs are received. No early or late PDUs are received.

8.5.1.3.2 DU-TC-WG4.CONF.3.4.4.2 Delay Management Early Arrival and Late Arrival

The objective is to verify that DU supports delay management receive counters for the C-Plane and U-Plane of the O-RAN fronthaul interface.

DU shall use either the TDD IOT profile (A.2.1.1 NR TDD IOT Profile 1 - NR-TDD-FR1-CAT-A-NoBF in [11]), or the FDD IOT profile (A.2.2.3 NR FDD IOT Profile 3 - NR-FDD-FR1-CAT-A-NoBF in [11]).

Test preparation

The DU SUT has been provisioned to connect with a 5G NR CAT-A RU and has been able to synchronize with the RU emulator.

The RU Emulator has been configured to emulate a CAT-A RU with no beamforming and Static Format BFP Compression IQ format.

UE Emulator is connected to the RU Emulator.

The counters in table 7-1 of the CUS Fronthaul protocol specification [6] for on-time reception on the DU shall be accessible.

Test procedure

The test procedure is described in section 3.4.4.4.2 C in [12].

Success criteria:

Per section 3.4.4.4.2 D in [12], observe the DU counters (RX_TOTAL, RX_ON_TIME, RX_EARLY, RX_LATE) incrementing for each configured eAxC.

8.5.2 UE Context Management

8.5.2.1 CU-TC-WG5.IOT.2.3.1.20 - UE Context Creation (Registration Request)

The purpose of this test case is to verify that the UE initiated Initial Registration Request procedure can be performed successfully with CU and DU, conforming to the NR C-Plane profile specification [12] Section 6.1.2.

DUT: CU + DU

- DUT shall apply the parameter condition specified in 4.2.1 of the NR C-Plane profile specification [12]

Testing tools which are required for this test scenario:

- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe NG procedural flows and content

Test Procedures

1. Initiate the Initial Registration Request procedure from the UE emulator. O&M command/trigger in the UE emulator CU tester to trigger the Initial Registration Request procedure.
2. Observe the Protocol Analyzer NG logs and UE emulator logs.

Success Criteria:

- The Initial registration procedure is successfully completed, and a new UE context is created in NG-RAN for signaling only connection.
- The NG interface logs recorded in the Protocol Analyzer are aligned with the message flow specified in the NR C-Plane profile specification [12] Sections 6.1.1.2/6.1.1.3.

8.5.2.2 CU-TC-WG5.IOT.2.3.1.19 - UE Context Creation (Service Request)

The purpose of this test case is to verify that the UE initiated Service Request procedure can be performed successfully with the CU and DU, conforming to the NR C-Plane profile specification [12] Section 6.1.1

DUT: CU + DU

- DUT shall apply the parameter condition specified in 4.2.1 of the NR C-Plane profile specification [12]

Testing tools which are required for this test scenario:

- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe NG procedural flows and content

Test Procedures

1. Initiate the Initial Service Request procedures from the UE emulator. O&M command/trigger in the UE emulator to trigger the Initial Service request procedure.
2. Observe the Protocol Analyzer NG logs and UE emulator logs.

Success Criteria:

-
- The service request procedure is successfully performed, a PDU session and DRB are established and data transfer from the Application Test Server to the Test UE or UE emulator and vice versa is possible.
- NG logs recorded in the Protocol Analyzer are aligned with the message flow specified in the NR C-Plane profile specification [12] Sections 6.1.1.2/6.1.1.3. -Logs recorded in the Protocol Analyzer and Test UE or UE emulator logs show that:
- All U-Plane data NG logs is correctly received by the emulated UE

8.5.2.3 CU-TC-WG5.IOT.2.3.1.21 - UE Context Release

The purpose of this test case is to verify that the UE Context Release Procedure is successfully performed between CU and DU, conforming to the NR C-Plane profile specification [12] Section 6.2.1

DUT: CU + DU

- DUT shall apply the parameter condition specified in 4.2.1 of the NR C-Plane profile specification [12]

Testing tools which are required for this test scenario:

- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe NG procedural flows and content

Initial Conditions

The following list of initial conditions are applicable for this specific test case:

- Test UE on the UE emulator has registered to the network and a PDU session has been established, ie, Registration procedure specified in NR C-Plane profile specification [12] section 6.1.2 has been successfully completed

Test Procedures

1. Initiate the UE Context Release procedure from the UE emulator. O&M command/trigger in the UE emulator to trigger the UE Context Release procedure.
2. Observe the Protocol Analyzer NG and UE emulator logs.

Success Criteria:

-
- The NGAP UE Context Release procedure is successfully completed, NG-AP signaling connection and associated User Plane connections are released
- NG logs recorded in the Protocol Analyzer are aligned with the message flow specified in the NR C-Plane profile specification [12] Sections 6.2.1.1/6.2.1.2

8.5.2.4 CU-TC-WG5.IOT.2.3.1.23 - UE Context Modification (DRB to be setup)

The purpose of this test case is to verify that the UE Context Modification procedure to setup a DRB for a UE can be performed successfully between CU and DU, conforming to the NR C-Plane profile specification [12] Section 6.3.1

DUT: CU + DU

- DUT shall apply the parameter condition specified in 4.2.1 of the NR C-Plane profile specification [12]

Testing tools which are required for this test scenario:

- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe NG procedural flows and content

Initial Conditions

The following list of initial conditions are applicable for this specific test case:

-
- Test UE on the UE emulator has registered to the network, ie, Registration procedure specified in NR C-Plane profile specification [12] section 6.1.2 has been successfully completed
- Test UE on the UE emulator is within the coverage area of the PCell
- The service request procedure, as specified in NR C-Plane profile specification [12] section 6.1.1, is successfully performed, a DRB is established and data transfer from the Application Test Server to the Test UE or UE emulator and vice versa is possible

Test Procedures

1. Initiate the UE Context Modification procedure for DRB setup from the UE emulator. O&M command/trigger in the UE emulator to trigger the UE Context Modification procedure.
2. Observe the Protocol Analyzer NG and UE emulator logs.
3. Perform data transfer in both directions from the Application Test Server on Core/Core Emulator and the UE Emulator.

Success Criteria:

- The UE Context Modification procedure for DRB setup to UE is performed successfully.

- Data transfer is possible using the newly established DRB.
- NG logs recorded in the Protocol Analyzer are aligned with the message flow specified in the NR C-Plane profile specification [12] Sections 6.3.1.2/6.3.1.2.1.
- NG logs recorded in the Protocol Analyzer and Test UE or UE emulator logs show that the new DRB has been successfully setup.

8.5.2.5 CU-TC-WG5.IOT.2.3.1.24 - UE Context Modification (DRB to be released)

The purpose of this test case is to verify that the UE Context Modification procedure to release a DRB for a UE can be performed successfully between CU and DU, conforming to the NR C-Plane profile specification [12] Section 6.3.1

DUT: CU + DU

- DUT shall apply the parameter condition specified in 4.2.1 of the NR C-Plane profile specification [12]

Testing tools which are required for this test scenario:

- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe NG procedural flows and content

Initial Conditions

The following list of initial conditions is applicable for this specific test case:

- Test UE on the UE emulator has registered to the network, ie, Registration procedure specified in NR C-Plane profile specification [12] section 6.1.2 has been successfully completed
- Test UE or UE emulator is within the coverage area of the PCell
- The service request procedure, as specified in NR C-Plane profile specification [12] section 6.1.1, is successfully performed, a DRB is established and data transfer from the Application Test Server to the Test UE or UE emulator and vice versa is possible

Test Procedures

1. Initiate the UE Context Modification procedure for DRB setup from the UE emulator. O&M command/trigger in the UE emulator to trigger the UE Context Release procedure.
2. Observe the Protocol Analyzer NG logs.
3. Perform data transfer in both directions from the Application Test Server on Core/Core Emulator and the UE Emulator.

Success Criteria:

- The UE Context Modification procedure for DRB setup to UE is performed successfully.
-

- NG logs recorded in the Protocol Analyzer are aligned with the message flow specified in the NR C-Plane profile specification [3] Sections 6.3.1.2/6.3.1.2.1.
- NG logs recorded in the Protocol Analyzer and Test UE or UE emulator logs show that DRB has been successfully released.

8.5.3 gNB Reset

8.5.3.1 CU-TC-3.1 Reset gNB – CU Initiated

8.5.3.1.1 Test Purpose

The purpose of this test case is to verify that the CU initiated Reset procedure with CU and DU from different vendors can be successfully completed; conforming to the NR C-Plane profile specification [12] Section 4.2.2.3.

8.5.3.1.2 Minimum Requirements

DUTs: Single CU and single DU.

Testing tools which are required for this test scenario:

- Test UE or UE emulator which is capable of supporting NR: used to terminate NAS/AS protocol and data transmission/reception
- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe NG procedural flows and content

8.5.3.1.3 Initial Conditions

The following list of initial conditions are applicable for this specific test case:

- NG Setup procedure has been successfully completed between the CU and DU according to the NR C-Plane profile specification [12]
- Multiple Test UEs or emulated UEs have registered to the network, ie, Registration procedure and Service Request procedure specified in the NR C-plane profile specification [12] has been successfully completed
- Data transfer between the Application Test Server and Test UE or UE emulator is possible

8.5.3.1.4 Procedure

1. Perform the CU initiated Reset procedure to indicate the release of all allocated UE contexts.

An example of how this procedure can be performed (or triggered) is listed below. The exact method to perform (or trigger) this procedure is out of scope of this specification and is left up to the implementation of the DUT.

- a. Stimulate cell deactivation. One of the possible methods can be to make use of O&M command in the CU in order to deactivate all cells serving UEs.

2. Perform the CU initiated Reset procedure to indicate the release of a part of allocated UE contexts.

An example of how this procedure can be performed (or triggered) is listed below. The exact method to perform (or trigger) this procedure is out of scope of this specification and is left up to the implementation of the DUT.

- a. Stimulate cell deactivation. One of the possible methods can be to make use of O&M command in the CU in order to deactivate few cells serving UEs.
3. Observe the Protocol Analyzer NG link logs.

8.5.3.1.5 Expected Results

The reset is successfully completed by Reset (CU initiated) procedure in step1. All of the UE contexts affected by the CU initiated Reset procedure is successfully released in the CU and data transfer between the Application Test Server and the Test UE or UE emulator has ended.

The partial reset is successfully completed by Reset (CU initiated) procedure in step2. The part of the UE contexts affected by the CU initiated Reset procedure is successfully released in the CU and data transfer between the Application Test Server and the Test UE or UE emulator has ended.

8.5.3.1.6 Log Observation

NG logs recorded in the Protocol Analyzer are aligned with the message flows specified in the NR C-Plane profile specification [12] Sections 4.2.2.3.1/4.2.2.3.2.1/4.2.2.3.2.2.

NG interface should be successfully established and UE emulator should be able to successfully execute the UE Context Creation (Registration Request) procedure outline in CU-TC-WG5.IOT.2.3.1.20.

8.5.3.2 CU-TC-3.2 Reset gNB - DU Initiated

8.5.3.2.1 Test Purpose

The purpose of this test case is to verify that the DU initiated Reset procedure with CU and DU from different vendors can be successfully completed; conforming to the NR C-Plane profile specification [12] Section 4.2.2.4.

8.5.3.2.2 Minimum Requirements

DUTs: Single CU and single DU.

Testing tools which are required for this test scenario:

- Test UE or UE emulator which is capable of supporting NR: used to terminate NAS/AS protocol and data transmission/reception
- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe F1 procedural flows and content

8.5.3.2.3 Initial Conditions

The following list of initial conditions are applicable for this specific test case:

- NG Setup procedure has been successfully completed between the CU and DU according to the NR C-Plane profile specification [12]
- Multiple Test UEs or emulated UEs have registered to the network, ie, Registration procedure and Service Request procedure specified in the NR C-plane profile specification [12] has been successfully completed
- Data transfer between the Application Test Server and Test UE or UE emulator is possible

8.5.3.2.4 Procedure

1. Perform the DU initiated Reset procedure over F1 to indicate the release of all allocated UE contexts.

An example of how this procedure can be performed (or triggered) is listed below. The exact method to perform (or trigger) this procedure is out of scope of this specification and is left up to the implementation of the DUT.

- a. Stimulate cell deactivation. One of the possible methods can be to make use of O&M command in the DU in order to deactivate all cells serving UEs.
4. Perform the DU initiated Reset procedure over F1 to indicate the release of a part of allocated UE contexts.

An example of how this procedure can be performed (or triggered) is listed below. The exact method to perform (or trigger) this procedure is out of scope of this specification and is left up to the implementation of the DUT.

- a. Stimulate cell deactivation. One of the possible methods can be to make use of O&M command in the DU in order to deactivate few cells serving UEs.
5. Observe the Protocol Analyzer NG link logs.

8.5.3.2.5 Expected Results

The reset is successfully completed by Reset (DU initiated) procedure in step1. All of the UE contexts affected by the DU initiated Reset procedure is successfully released in the CU and data transfer between the Application Test Server and the Test UE or UE emulator has ended.

The partial reset is successfully completed by Reset (DU initiated) procedure in step2. The part of the UE contexts affected by the DU initiated Reset procedure is successfully released in the CU and data transfer between the Application Test Server and the Test UE or UE emulator has ended.

8.5.3.2.6 Log Observation

NG logs recorded in the Protocol Analyzer are aligned with the message flows specified in the NR C-Plane profile specification [12] Sections 4.2.2.4.1/4.2.2.4.2.1/4.2.2.4.2.2.

NG interface should be successfully established and UE emulator should be able to successfully execute the UE Context Creation (Registration Request) procedure outline in CU-TC-WG5.IOT.2.3.1.20.

8.5.4 Paging

8.5.4.1 CU-TC-3.3 Paging (CN-Initiated)

8.5.4.1.1 Test Purpose

The purpose of this test case is to verify that the Paging (CN-initiated) procedure between CU and DU from different vendors can be successfully completed; conforming to the NR C-Plane profile specification [12] Section 4.2.6.1.

8.5.4.1.2 Minimum Requirements

DUT: CU + DU:

- DUTs shall apply the parameter condition specified in 4.2.6.1 of the NR C-Plane profile specification [12]

Testing tools which are required for this test scenario:

- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- Protocol Analyzer: used to record and observe F1 procedural flows and content

8.5.4.1.3 Initial Conditions

Refer to Section 2.3 for the F1 related list of initial conditions. Besides, refer to Section 2.2 for the X2 related list of initial conditions.

The following list of initial conditions are applicable for this specific test case:

- F1 Setup procedure has been successfully completed between the CU and DU according to the NR C-Plane profile specification [12]
- Test UE or UE emulator has registered to the network, ie, Registration procedure specified in NR C-Plane profile specification [12] section 6.1.2 has been successfully completed

8.5.4.1.4 Procedure

2. Initiate Paging procedure from Core or Core emulator (5GC capabilities) to page a UE in RRC-IDLE state.

An example of how this procedure can be performed (or triggered) is listed below. The exact method to perform (or trigger) this procedure is out of scope of this specification and is left up to the implementation of the DUT.

- a. Initiate data transfer from Core or Core emulator (5GC capabilities) to UE in CM-IDLE state.
6. Observe the Protocol Analyzer F1 link logs.

8.5.4.1.5 Expected Results

The Paging procedure is successfully completed.

In step 2, the Paging message is observed to page the UE.

8.5.4.1.6 Log Observation

F1 logs recorded in the Protocol Analyzer are aligned with the message flow specified in the NR C-Plane profile specification [12] Sections 4.2.6.1./4.2.6.2.

8.5.5 Xn Setup

8.5.5.1 CU-TC-3.3 Xn Setup

8.5.5.1.1 Test Purpose

The purpose of this test case is to verify that the Xn Setup procedure with CU+DU and CU emulator can be successfully completed, conforming to the NR C-Plane profile specification [12] Section 4.2.1.

8.5.5.1.2 Minimum Requirements

DUT: CU + DU

- DUT shall apply the parameter condition specified in 4.2.1 of the NR C-Plane profile specification [12]

Testing tools which are required for this test scenario:

- Core or Core emulator (5GC capabilities): used to terminate UEs (emulator) NAS protocol
- CU emulator to initiate an Xn Setup Request towards the DUT.
- Protocol Analyzer: used to record and observe Xn procedural flows and content

8.5.5.1.3 Initial Conditions

- An SCTP association is successfully established between the two SCTP endpoints (SCTP initiation procedure has taken place before or is taking place with execution of this test case)

8.5.5.1.4 Procedure

3. Initiate the Xn Setup procedure from CU emulator towards the DUT.

An example of how this procedure can be performed (or triggered) is listed below. The exact method to perform (or trigger) this procedure is out of scope of this specification and is left up to the implementation of the DUT.

O&M command on the CU emulator to trigger an Xn Setup Request towards the Cu+DU.

7. Observe the Protocol Analyzer Xn logs.

8.5.5.1.5 Expected Results

The Xn Setup procedure is successfully completed.

8.5.5.1.6 Log Observation

Xn logs recorded in the Protocol Analyzer are aligned with the message flows specified in the NR C-Plane profile specification [12] Sections 4.2.1.1/4.2.1.2.

9 References

- [1] VIAVI O-RAN FrontHaul (FH) Server User Guide.
- [2] VIAVI TM500 and E500 Network Tester Test Mobile Application User Guide
- [4] VIAVI TeraVM CU, Test User Guide
- [3] Keysight RuSIM O-RAN M-Plane – User’s Manual
- [4] Keysight UeSIM/RuSIM AirMosaic - User’s Manual
- [5] 3GPP TS 38.401: “5G; NG-RAN; Architecture description”
- [6] 3GPP TS 38.413: "5G;NG-RAN; NG Application Protocol (NGAP)"
- [7] 3GPP TS 38.423: "5G;NG-RAN; Xn Application Protocol (XnAP)
- [8] O-RAN-WG4.CUS.0-v05.00: “Control, User and Synchronization Plane”
- [9] O-RAN.WG4.MP.0-v05.00: “Management Plane”
- [10] O-RAN.WG4.CONF.0-v05.00
- [11] O-RAN.WG4.IOT.0-v05.00
- [12] O-RAN.WG5 NR C-Plane Profile v05.00, July 2021
- [13] O-RAN WG5.NR U-Plane Profile v04.00, March 2021
- [14] O-RAN WG5.IOT.0-v05.00 Interoperability Test Specification

10 Annex A. Fronthaul M-Plane IOT Profiles



Fronthaul M-Plane
IOT Profiles.xlsx

11 Annex B. Fronthaul UC-Plane IOT Profile



Fronthaul UC-
Plane IOT

12 Annex C. Scoring

CU+DU Stage Two is pass / fail.

Test cases are labeled as MANDATORY (M) and CONDITIONAL MANDATORY (CM).

A CONDITIONAL MANDATORY test case becomes MANDATORY for a contestant who will use the corresponding functionality in Stage Three or Stage Four. Otherwise, the CONDITIONAL MANDATORY test case will be treated as OPTIONAL.

CU+DU shall have successfully completed Stage Two testing once it passes all the MANDATORY test cases and applicable CONDITIONAL MANDATORY test case (see above).

Level	Test Category	Sub-Category	Test Case ID	Test Case	Test Requirement
0	Integration	CU Integration	CU-TC-INT.1	CU integration	M
		DU Integration	DU-TC-INT.1	DU Fronthaul S-Plane integration	M
			DU-TC-INT.2	DU Fronthaul M-Plane integration	CM
			DU-TC-INT.3	DU Fronthaul UC-Plane integration	M
1	Conformance , Functional	UC-Plane DU Scenario Class NR testing Generic	DU-TC-WG4.CONF.3.4.4.1.1	UC-Plane DU Scenario Class Base CAT-A RU	M
		UC-Plane DU Scenario Class Compression (CMP)	DU-TC-WG4.CONF.3.4.4.3.1	Static Format Fixed-Point (FP) Uncompressed	M
			DU-TC-WG4.CONF.3.4.4.3.2	UC-Plane DU Scenario Class Compression (CMP) Static Format Block Floating Point	CM
		UC-Plane DU Scenario Class Delay Management (DLM)	DU-TC-WG4.CONF.3.4.4.4.1	Delay Management On-time arrival	M
			DU-TC-WG4.CONF.3.4.4.4.2	Delay Management Early Arrival and Late Arrival	CM
		UE Context Management	CU-TC-WG5.IOT.2.3.1.20	UE CONTEXT SETUP (UE Initial Registration)	M
			CU-TC-WG5.IOT.2.3.1.19	UE CONTEXT SETUP (UE Service Request)	M
			CU-TC-WG5.IOT.2.3.1.21	UE CONTEXT RELEASE (UE De-Registration)	M
			CU-TC-WG5.IOT.2.3.1.23	UE CONTEXT MODIFICATION(add DRB)	CM
			CU-TC-WG5.IOT.2.3.1.24	UE CONTEXT MODIFICATION(release DRB)	CM
		gNB Reset	CU-TC-WG5.IOT.2.3.1.29	Reset CU Initiated	M
			CU-TC-WG5.IOT.2.3.1.30	Reset DU Initiated	M
		Paging	CU-TC-2.1.3 (WG5.IOT.2.3.1.18)	Paging (CN-Initiated)	CM
		Xn Setup	CU-TC-2.2.1 (WG5.IOT.2.4.1.1)	Xn Setup	CM