# वर्गीय आवश्यकताओं के लिए मानक

# टीईसी २१११०:२०२४

# STANDARD FOR GENERIC REQUIREMENTS

# TEC 21110:2024

## ओपन-रेडियो एक्सेस नेटवर्क (ओ-रैन)

## Open-Radio Access Network (O-RAN)

ISO 9001:2015


दूरसंचार अभियांत्रिकी केंद्र

खुर्शीदलाल भवन, जनपथ, नई दिल्ली-११०००१, भारत

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# FOREWORD

Telecommunication Engineering Centre (TEC) is the technical arm of Department of Telecommunications (DOT), Government of India. Its activities include:

- Framing of TEC Standards for Generic Requirements for a Product/Equipment, Standards for Interface Requirements for a Product/Equipment, Standards for Service Requirements & Standard document of TEC for Telecom Products and Services
- Formulation of Essential Requirements (ERs) under Mandatory Testing and Certification of Telecom Equipment (MTCTE)
- Field evaluation of Telecom Products and Systems
- Designation of Conformity Assessment Bodies (CABs)/Testing facilities
- Testing & Certification of Telecom products
- Adoption of Standards
- Support to DoT on technical/technology issues

For the purpose of testing, four Regional Telecom Engineering Centre's (RTECs) have been established which are located at New Delhi, Bangalore, Mumbai, and Kolkata.

# ABSTRACT

This document contains the Standard for Generic Requirements (GR) of RU, CU & DU and other network elements commonly referred to as 'O-RAN' for deployment in the Indian mobile communication network. Open Radio Access Network (O-RAN) defines an architecture for radio access network (RAN) that allows to split the RAN functions primarily into CU, DU and RU with well-defined interfaces between them. O-RAN aims to transform the traditional monolithic hardware-centric RAN design into one that uses separate building blocks with open and standardized interfaces.

The document specifies Technical Requirements, General Requirements, Features and Functionality of the O-RAN for mobile communication system.

# CONVENTIONS

In this document, requirements are classified as follows:

- The keywords "shall" or “is/are required to” indicate a requirement or requirements, which must be mandatorily complied and from which no deviation is permitted, if conformance to this document is to be claimed; and
- The keywords “Optional” or “may” indicate an optional requirement, which is permissible for exclusion from mandatory compliance, unless the said requirement is claimed to be complied by the vendor. These terms are not intended to imply that the vendor's implementation must provide the option; it means the vendor may optionally provide the feature and still claim conformance with this document.

# CONTENTS

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# HISTORY SHEET

| *Sl. No.* | Standard / document *No.* | *Title* | *Remarks* |
|---|---|---|---|
| 1. | TEC 21110:2024 | Standards for Generic Requirements (GR) of Open-Radio Access Network (O-RAN) | Release 1 |

## REFERENCES

| S. No | Document No. | Title/Document Name |
|---|---|---|
| 1. | 3GPP TR 21.905 | Vocabulary for 3GPP Specifications |
| 2. | 3GPP TS 23.501 | System Architecture for the 5G System (5GS); Stage 2" |
| 3. | 3GPP TS 36.401 | Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture Description |
| 4. | 3GPP TS 36.420 | Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 general aspects and principles |
| 5. | 3GPP TS 36.211 | Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation |
| 6. | 3GPP TS 38.401 | NG-RAN; Architecture description |
| 7. | 3GPP TS 38.460 | NG-RAN; E1 general aspects and principles |
| 8. | 3GPP TS 38.470 | NG-RAN; F1 general aspects and principles |
| 9. | 3GPP TS 38.322 | NR; Radio Link Control (RLC) protocol specification |
| 10. | 3GPP TS 38.323 | NR; Packet Data Convergence Protocol (PDCP) specification |
| 11. | 3GPP TS 38.331 | NR; Radio Resource Control (RRC) protocol specification |
| 12. | 3GPP TS 38.321 | NR; Medium Access Control (MAC) protocol specification |
| 13. | O-RAN.WG2.A1GAP-v03.02 | A1 interface: General Aspects and Principles |
| 14. | O-RAN.WG6.CADS-v06.00 | Cloud Architecture and Deployment Scenarios for O-RAN Virtualized RAN |

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|---|---|---|
| 15. | O-RAN.WG4.CUS.0-R003-v14.00 | Control, User and Synchronization Plane Specification |
| 16. | O-RAN.WG4.CTI-TCP.0-R003-v04.00 | Cooperative Transport Interface; Transport Control Plane Specification |
| 17. | O-RAN.WG2.Non-RT-RIC-ARCH-R003-v05.00 | Non-RT RIC Architecture |
| 18. | O-RAN.WG4.CTI-TMP.0-R003-v04.00 | Cooperative Transport Interface; Transport Management Plane Specification |
| 19. | O-RAN.WG4.MP.0-R003-v14.00 | Management Plane Specification |
| 20. | O-RAN.WG3.E2GAP-R003-v05.00 | E2 General Aspects and Principles |
| 21. | O-RAN.WG3.E2SM-RC-R003-v05.00 | O-RAN E2 Service Model (E2SM), RAN Control 5.0 |
| 22. | O-RAN.WG6.O-Cloud Notification API-v03.00 | O-Cloud Notification API Specification for Event Consumers |
| 23. | O-RAN.WG10.OAM-Architecture-R003-v11.00 | Operations and Maintenance Architecture |
| 24. | O-RAN.WG10.O1-Interface.0-R003-v12.00 | O-RAN Operations and Maintenance Interface Specification |
| 25. | TEC 11016:2016 | Electromagnetic Compatibility Standard for Telecommunication Equipment |
| 26. | QM-333 | Standard For Environmental Testing of Telecommunication Equipment |
| 27. | IP 65 | Ingress Protection |
| 28. | IS 13252 Part 1:2010 | Information Technology Equipment -- Safety, Part 1: General Requirements |

| | | |
|---|---|---|
| 29. | IEC 62368-I | Audio/video, information and communication technology equipment - Part 1: Safety requirements |
| 30. | CISPR 32 | Limits and methods of measurement of radio disturbance characteristics of information technology equipment |
| 31. | IEC-61000-4-2 | Electrostatic discharge immunity test |
| 32. | IEC-61000-4-3 | Radiated, radio-frequency, electromagnetic field immunity test |
| 33. | IEC-61000-4-4 | Electrical fast transient / burst immunity test |
| 34. | IEC-61000-4-5 | Surge immunity test |
| 35. | IEC-61000-4-6 | Immunity to conducted disturbances, induced by radio-frequency fields |
| 36. | IEC-61000-4-11 | AC Power Supply Voltage dips, shot interruptions and voltage variations immunity tests |
| 37. | IEC-61000-4-29 | DC Power Supply Voltage dips, shot interruptions and voltage variations immunity tests |
| 38. | ITU-T Q.513 | Digital exchange interfaces for operations, administration and maintenance |
| 39. | ITU-T T.50 | International Reference Alphabet (IRA) (Formerly International Alphabet No. 5 or IA5) - Information technology - 7-bit coded character set for information interchange |
| 40. | ETSI EN 301 489-17 | Electro Magnetic Compatibility (EMC) standard for radio equipment and services |
| 41. | ETSI ES 202 706-1 | Environmental Engineering (EE); Metrics and measurement method for energy efficiency of wireless access network equipment |

***Note** – The latest revisions of the above mentioned standards shall apply as and when revised.

# CHAPTER 1

## 1.1 Scope

This document contains the Standard for Generic Requirements (GR) of 'Open Radio Access Network (O-RAN)' for deployment in the Indian mobile communication network. O-RAN defines an architecture for radio access network (RAN) that allows to split the RAN functions primarily into CU, DU and RU with well-defined interfaces between them. O-RAN aims to transform the traditional monolithic hardware-centric RAN design into one that uses separate building blocks with open and standardized interfaces. O-RAN focuses on below objectives: -

i. Leading the industry towards open, interoperable interfaces, RAN virtualization, and big data and AI enabled RAN intelligence.
ii. Maximizing the use of common-off-the-shelf hardware and merchant silicon and minimizing proprietary hardware.
iii. Specifying APIs and interfaces, driving standards to adopt them as appropriate, and exploring open source where appropriate.
iv. The O-RAN Architecture identifies the key functions and interfaces adopted in O-RAN.

The document specifies Technical Requirements, General Requirements, Features and Functionality of the O-RAN for mobile communication system.

## 1.2 O-RAN

### 1.2.1 Overview

O-RAN (Open Radio Access Network) offers an open, interoperable, and virtualized architecture that is consistent with 3GPP architecture, enabling network operators to break free from vendor lock-in, reduce costs, and promote innovation. It defines standardized interfaces, supports virtualization, and encourages competition among vendors, fostering flexibility and scalability while ensuring security and readiness for

4G/5G and beyond. O-RAN's global standardization efforts and ecosystem development aim to transform the mobile network landscape, making it more accessible, efficient, and adaptable to evolving telecommunications needs.

### 1.2.2 Architecture

The Key Component of O-RAN are mentioned below:

(a) O-RU (Radio Unit): O-RU is a logical node hosting Low-PHY layer and RF processing based on a lower layer functional split. This is similar to 3GPP's "TRP" or "RRH" but more specific in including the Low-PHY layer (FFT/iFFT, PRACH extraction).

(b) O-CU (Control Unit): O-CU (O-Centralized Unit) is split into two parts i.e., O-CU CP and O-CU UP. Both functions support Non-real time functionalities covered in PDCP, RRC and SDAP protocol. OCU can be part of ODU as per deployment.

(c) O-DU (Distributed Unit): O-DU (Distributed Unit): A logical node hosting RLC/MAC/High-PHY layers based on a lower layer functional split.

(d) O-Cloud: It is a cloud computing platform comprising a collection of physical & virtual infrastructure nodes that meet O-RAN requirements to host the relevant O-RAN functions. O-Cloud platform can be part of the OCU and ODU unit. Cloud platform can be virtual or container or other platform to meet RAN requirements to host O-RAN functions.

(e) Near RT RIC Platform: An O-RAN Network Function (NF) that enables near-real-time control and optimization of RAN elements and resources via fine-grained data collection and actions over E2 interface. It may include AI/ML (Artificial Intelligence / Machine Learning) workflow including model training, inference, and updates.

(f) Near RT RIC Platform APIs: A set of service-based interfaces that can be produced and consumed by the Near RT RIC Platform Platform and xApps.

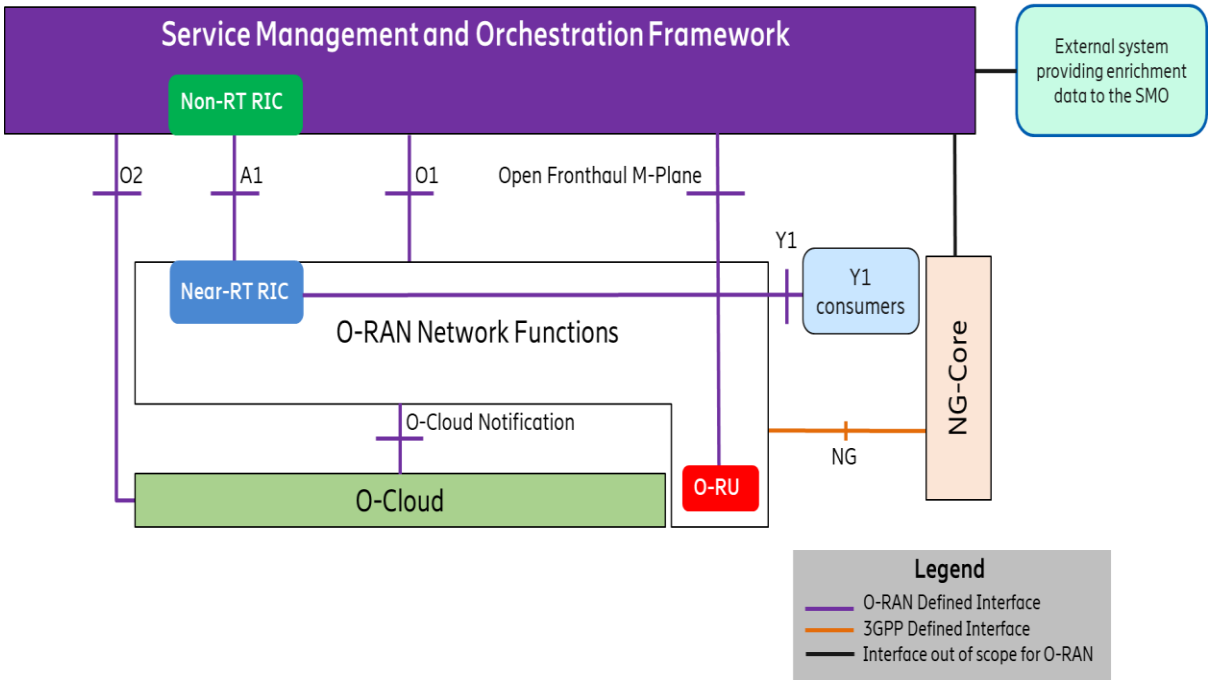
(g) Non-Real-Time RAN Intelligent Controller: A functionality within SMO that drives the content carried across the A1 interface. It is comprised of the Non-RT RIC Framework and the Non-RT RIC Applications (rApps)

(h) Non-RT RIC Applications (rApps): Modular applications that leverage the functionality exposed via the Non-RT RIC Framework's R1 interface to provide added value services relative to RAN operation. The rApp functionality within the Non-RT RIC enables non-real-time control and optimization of RAN elements and resources and policy-based guidance to the applications/features in Near RT RIC Platform

(i) Non-RT RIC Framework: That functionality internal to the SMO that logically terminates the A1 interface to the Near RT RIC Platform and exposes to rApps, via its R1 interface, the set of internal SMO services needed for their runtime processing.

(j) SMO: SMO is responsible for RAN domain management & orchestration.

The high-level view of the O-RAN architecture is as mentioned below. It shows that there are four key interfaces – namely, A1, O1, Open Fronthaul M-plane and O2. These interfaces connect SMO (Service Management and Orchestration) framework to O-RAN network functions and O-Cloud. As depicted in this figure, the O-Cloud includes the O-Cloud Notification interface which is available for the relevant O-RAN network functions (e.g., Near RT RIC Platform, O-CU-CP, O-CU-UP and O-DU) to receive O-Cloud related notifications.



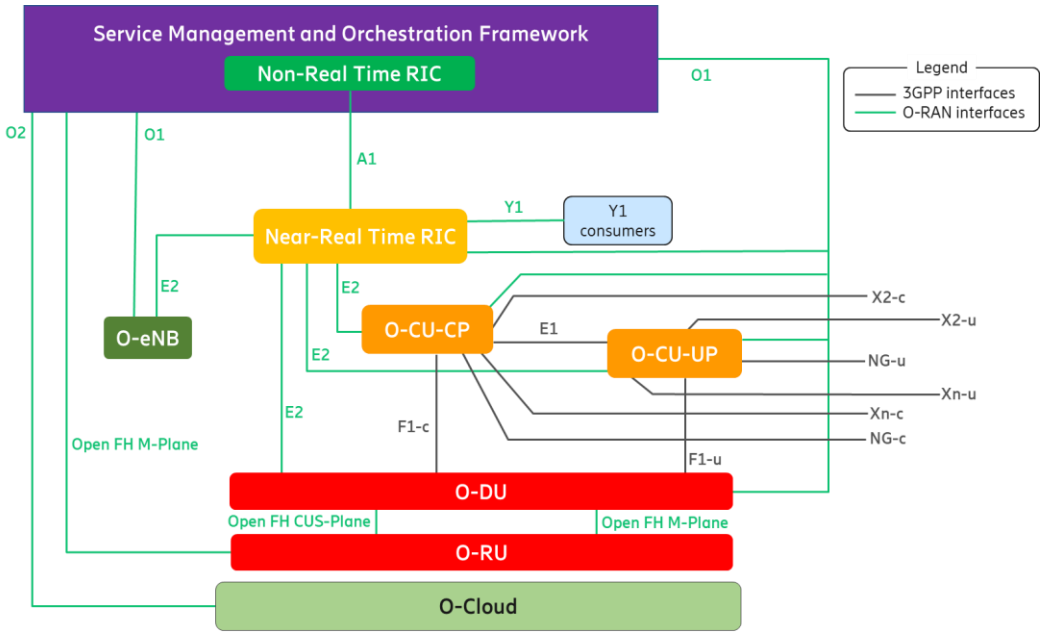

Source: O-RAN.WG1.OAD-R003-v11.00

The O-RAN network functions can be VNFs (Virtualized Network Function), i.e., hosted in VMs or Containers, sitting above the O-Cloud and/or PNFs (Physical Network Function) utilizing customized hardware/general purpose off the shelf hardware. All O-RAN network functions, except O-RU, are expected to support the O1 interface when interfacing the SMO framework. The Open Fronthaul M-plane interface, between SMO and O-RU, is to support the O-RU management in Hybrid or between O-DU and O-RU in hierarchical mode.

The Near RT RIC Platform provides RAN analytics information services via the Y1 service interface. These services can be consumed by Y1 consumers after mutual authentication and authorization by subscribing to or requesting the RAN analytics information via the Y1 service interface. Y1 consumers role can be played by entities which are within an PLMN trusted domain. Y1 consumers outside the PLMN trusted domain may use Y1 services in a secure manner via an exposure function, e.g., as in 3GPP TS 23.501, Clause 5.20. The framework for mutual authentication and

authorization between Y1 consumers and the Near RT RIC Platform is not supported in the present document.

In the logical architecture of O-RAN, as shown in figure below, the RAN and its Management side includes Near RT RIC Platform, O-CU-CP, O-CU-UP, O-DU, and O-RU functions. The E2 interface connects O-eNB, O-DU & O-CU to Near RT RIC Platform. Although not shown in this figure, the O-eNB does support O-DU and O-RU functions with an Open Fronthaul interface between them. The Near RT RIC Platform, in the figure below, supports the Y1 service interface towards Y1 consumers. Y1 consumers, unlike the other network elements shown in this figure, does not denote a logical O-RAN function.




Source: O-RAN.WG1.OAD-R003-v11.00

The O-Cloud, on the other hand, is a cloud computing platform comprising a collection of physical infrastructure nodes that meet O-RAN requirements to host the relevant O-RAN functions (such as Near RT RIC Platform, O-CU-CP, O-CU-UP and O-DU etc.), the supporting software components (such as Operating System, Virtual Machine Monitor, Container Runtime, etc.) and the appropriate management and orchestration functions. The virtualization of O-RU is not supported in the present document.

### 1.2.3 Interfaces

1.2.3.1 A1 Interface: A1 is the interface between the Non-RT RIC function in SMO and the Near RT RIC Platform function. A1 interface supports three types of services:

(i) Policy Management Service

(ii) Enrichment Information Service

(iii) ML Model Training Service

1.2.3.2 O1 Interface: The O1 interface is between the SMO and the Near RT RIC Platform, the O-CU and O-DU

1.2.3.3 O2 Interface: The O2 interface is between the SMO and O-Cloud

1.2.3.4 E2 Interface: E2 is a logical interface connecting the Near RT RIC Platform with an E2 Node.

1.2.3.5 An E2 Node (O-eNB, O-DU & O-CU) is connected to only one Near RT RIC Platform.

1.2.3.6 A Near RT RIC Platform can be connected to multiple E2 Nodes.

1.2.3.7 The protocols over E2 interface are based exclusively on Control Plane protocols

1.2.3.8 O-Cloud Notification Interface: The O-Cloud Notification interface allows event consumer such as an O-DU deployed on O-Cloud to subscribe to events/status from the O-Cloud. The cloud infrastructure will provide event producer to enable cloud workloads to receive events/status that might be known only to the infrastructure.

1.2.3.9 Open Fronthaul Interface: The Open FH (Fronthaul) Interface is between O-DU and O-RU functions The Open FH Interface includes the CUS (Control User Synchronization) Plane and M (Management) Plane. In hybrid mode, the Open FH M-Plane interface connects the O-RU to the SMO for FCAPS functionality. In hierarchical mode, the Open FH M-Plane interface connects the O-RU to the O-DU for FCAPS functionality.

1.2.3.10 E1 Interface: The E1 interface, as defined by 3GPP, is between the gNB-CU-CP and gNB-CU-UP logical nodes. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted between the O-CU-CP and the O-CU-UP functions.

1.2.3.11 F1-c Interface: The F1-c interface, as defined by 3GPP, is between the gNB-CU-CP and gNB-DU logical nodes. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted between the O-CU-CP and the O-DU functions, as well as for the definition of interoperability profile specification.

1.2.3.12 F1-u Interface: The F1-u interface, as defined by 3GPP, is between the gNB-CU-UP and gNB-DU logical nodes. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted between the O-CU-UP and the O-DU functions, as well as for the definition of interoperability profile specifications.

1.2.3.13 NG-c (N2) interface: The NG-c interface, as defined by 3GPP, is between the gNB-CU-CP and the AMF in the 5GC. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted between the O-CU-CP and the 5GC

1.2.3.14 NG-u (N3) Interface: The NG-u interface, as defined by 3GPP, is between the gNB-CU-UP and the UPF in the 5GC. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted between the O-CU-UP and the 5GC.

1.2.3.15 X2-c Interface: The X2-c interface is defined in 3GPP for transmitting control plane information between eNBs or between eNB and en-gNB in EN-DC. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted for the definition of interoperability profile specifications.

1.2.3.16 X2-u Interface: The X2-u interface is defined in 3GPP for transmitting user plane information between eNBs or between eNB and en-gNB in EN-DC. In

O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted for the definition of interoperability profile specifications.

1.2.3.17 Xn-c Interface: The Xn-c interface is defined in 3GPP for transmitting control plane information between gNBs, ng-eNBs or between ng-eNB and gNB. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted for the definition of interoperability profile specifications.

1.2.3.18 Xn-u Interface: The Xn-u interface is defined in 3GPP for transmitting user plane information between gNBs, ng-eNBs or between ng-eNB and gNB. In O-RAN, it reuses the principles and protocol stack defined by 3GPP but is adopted for the definition of interoperability profile specifications

1.2.3.19 Uu Interface: The UE to e/gNB interface in 3GPP is denoted as the Uu interface. The Uu is a complete protocol stack from L1 to L3 and as such, seen as a whole, it terminates in the NG-RAN. If the NG-RAN is decomposed, different protocols terminate at different reference points and none of them has been defined by O-RAN. Since the Uu messages still flow from the UE to the intended e/gNB managed function, it is not shown in the O-RAN architecture as a separate interface to a specific managed function.

1.2.3.20 CTI (Cooperative Transport Interface): Interface between the O-DU and TN to dynamically control bandwidth allocations to TUs when using a shared point-to-multipoint transport network.

1.2.3.21 Y1 Interface: Y1 service interface allows the authorized authenticated consumers to subscribe or request the RAN analytics information provided by Near RT RIC Platform.

### 1.2.4 Functional Requirements:

#### 1.2.4.1 O-RU Functionality

1.2.4.1.1 The O-RU shall terminate the Open Fronthaul interface CUS plane (also known as LLS interface) towards O-DU as well as Low-PHY functions of the radio interface towards the UE. This is a physical node.

1.2.4.1.2 The O-RU shall terminate the Open Fronthaul M-Plane interface towards the O-DU or SMO. O-RU/AAU shall support Open FH interface (including CUS and M Plane) as per O-RAN Alliance specifications.

1.2.4.1.3 Each O-RU shall manage at least one carrier in LTE/NR (or combination of LTE+NR or DSS) typically in macro outdoor or indoor small cell solutions or as specified by procurer requirements. As per 3GPP specification, O-RU shall support all three modes of IoT (inband, guard band and Standalone).

1.2.4.1.4 The O-RU shall support Energy Efficiency & Power Savings:

i. Power saving functionality and shall be power efficient.
ii. Micro Sleep Transmission, which reduces energy consumption by turning off certain radio hardware components when there is no traffic.
iii. Low energy scheduler solution (LESS) uses a large amount of resource blocks in the frequency domain to free up space in the time domain. It can help to increase energy efficiency while maintaining the same network performance.
iv. Discontinuous transmission (DTX) on downlink to save energy during low traffic.
v. Long cycle Discontinuous Reception (C-DRX).
vi. Decrease of UE battery consumption by typical traffic patterns and reduces the risk of overheating.

vii. Automatic enablement/ disablement of the main power amplifier (PA) in the radio-unit. The PA may be turned off in the following cases:

1. When no PDSCH traffic is scheduled on a subframe; and
2. During symbols that do not carry mandatory information.

1.2.4.1.5 In 5G, the O-RU shall support the adaptation of the UL waveform (between CP-OFDM and DFT-s-OFDM) depending on the coverage, doppler effect, scheduling with multiple users and peak rate maximization.

1.2.4.1.6 In 5G, the O-RU shall support at least 4:1 TDD slot pattern configuration: DDDSU and 8:2 TDD slot pattern configuration: DDDSUUDDDD.

1.2.4.1.7 The O-RU shall, when operating in 4G TDD mode, support TDD frame structures frame format 1 and 2 and special subframe 6 and 7, according to 3GPP 36.211.

1.2.4.1.8 The O-RU shall support a Cyclic Prefix (CP) between OFDM symbols.

1.2.4.1.9 The O-RU may support below MIMO options:-

i. SISO, 2X2 MIMO option
ii. up to 4 DL MIMO layers in Low Band
iii. Downlink Single-User MIMO in Mid Band.
iv. Downlink Multi-User MIMO in Mid Band to support minimum 8 layers
v. Uplink Multi-User MIMO in Mid Band to support minimum 4-layer UL MU-MIMO for PUSCH transmission

1.2.4.1.10 The O-RU shall support modulation mode as under :-

| | |
|---|---|
| **Downlink modulation Mode** | QPSK,16QAM,64QAM supported in all bands |
| | 256QAM in sub-6GHz bands |
| | 256QAM in mmWave |
| | 1024QAM supported in sub 6GHz bands (Optional) |

| | |
|---|---|
| **Uplink modulation Mode** | π/2BPSK (Optional) ,QPSK,16QAM,64QAM supported in all bands |
| | 256QAM supported in sub-6Ghz bands |
| | 256QAM supported in mmWave |

1.2.4.1.11 O-RU shall support parameter measurement and telemetry including O-RU Alarms Indicators, Status LEDs, support of various counters as defined in ORAN.WG4.MP including transceiver-stat, rx-window-stats, tx-measurement-objects and epe-stats and support for measuring and reporting of EE metrics (power, current voltage, temperature, etc.).

1.2.4.1.12 O-RU receiver Uplink Noise Figure shall be as per 3GPP requirements and O-RU shall support PIM cancellation methods.

1.2.4.1.13 O-RU shall support AAU Beam-steering capability (user data beam), AAU Front-to-back ratio, AAU Antenna Elements and AAU Number of simultaneous TX user beams/layers per carrier as per capacity requirements.

1.2.4.1.14 Sub carrier spacing (SCS) of 15 KHz, 30 KHz and/or 60 KHz and/or 120 KHz shall be supported as per valid combinations of SCS, Cell Carrier Bandwidth and cyclic prefix as specified by 3GPP.

1.2.4.1.15 O-RU shall support Physical layer functions as under:-

i. Synchronization Signal Block (SSB).
ii. Uplink (UL) and downlink (DL) demodulation reference signal.
iii. UL and DL Link Adaptation.
iv. UL and DL Power Allocation for data channels.
v. DL Power setting for data channels.
vi. DL Power setting for signalling and control channels.
vii. Normal & Extended Cyclic Prefix for OFDM symbols.
viii. At least one Static TDD Mode with single Bandwidth Part.

ix. Communication of timing advance value to UE.

1.2.4.1.16 Operating Frequency & Channel bandwidth

- Operating frequency and Channel bandwidth shall be as per the applicable National Frequency Allocation Plan.
- The system shall be capable of operating in at least one of the frequency bands as per the applicable National Frequency Allocation Plan.

1.2.4.1.17 In case of 5G O-RU, the Transmitter and Receiver Specification for conducted and radiated mode shall be as per clause 3.24, 3.25, 3.26 and 3.27 respectively of TEC Standard No. 21060:2022 of gNodeB.

1.2.4.1.18 In case of 4G O-RU, the Transmitter and Receiver Specification shall be as per clause 2.3.38.2 and 2.3.38.3 respectively of TEC Standard No. 21050:2019 of eNodeB.

### 1.2.4.2 O-DU Functionality

1.2.4.2.1 The O-DU is a logical network function in the O-RAN Architecture. An O-DU, combined with one or more O-RU(s) connected to it, supports and is fully compatible with the functions of a gNB-DU as defined by 3GPP TS 38.401.

1.2.4.2.2 The O-DU shall be implemented either by virtualized or non-virtualized methods.

1.2.4.2.3 The O-DU shall terminate the Open Fronthaul interface CUS plane (also known as LLS interface) towards O-RU as well as the RLC, MAC and High-PHY functions of the radio interface towards the UE.

1.2.4.2.4 The O-DU may terminate the F1 interface towards O-CU (only if O-CU & O-DU are deployed as split configuration).

1.2.4.2.5 The O-DU may terminate the O1 interface towards the SMO and E2 interface towards Near RT RIC Platform.

1.2.4.2.6 The O-DU may terminate the Open Fronthaul M-Plane interface, towards the O-RU, to support O-RU management if hybrid mode is not supported.

1.2.4.2.7 The O-DU shall support CTI to a TN to control UL bandwidth allocation to TUs for UL LLS traffic on shared point-to-multipoint transport network (TN is a PON OLT or DOCSIS CMTS, TU is a PON ONU or DOCSIS Cable Modem).

1.2.4.2.8 The number of Front Haul ports shall be according to capacity scenarios.

1.2.4.2.9 For Layer 1 acceleration, look-aside or inline configuration shall be supported.

1.2.4.2.10 O-DU shall support inter gNB-O-DU mobility, i.e. when UE moves from one gNB-O-DU to another gNB-O-DU within the same gNB-O-CU.

1.2.4.2.11 In a centralized scenario where O-DU supports multiple cells on different cell sites, support of intra gNB-O-DU mobility shall be there when UE moves from one cell site to other

1.2.4.2.12 O-DU shall support of inter gNB-O-DU mobility for EN-DC, i.e. when UE moves from one gNB-O-DU to another gNB-O-DU within the same gNB-O-CU in case of EN-DC

1.2.4.2.13 O-DU may support intra gNB-O-DU Carrier Aggregation: CA between 2 cells belonging to 2 different O-DUs on the same gNB.

1.2.4.2.14 O-DU may have routing capabilities to support in-site connection to other/legacy equipment.

1.2.4.2.15 O-DU shall support DHCP server to allow O-RU bring-up and IP configuration in a more secure way.

1.2.4.2.16 In order to enhance URLLC capabilities, 5G NR O-DUs shall support the existence of non-slot scheduling.

1.2.4.2.17 O-DUs may be able to support connectivity to multiple O-CUs for resilience.

1.2.4.2.18 O-DU shall support at least one of the following synchronization options: -

1. GNSS (GPS or NAVIC) (to be specified by vendor)
2. IEEE 1588 V2

3. Sync E

Frequency and Phase Synchronization shall be supported with at least 1 hr hold over mode in case of frequency and phase synchronization loss.

1.2.4.2.19O-DU shall perform the below RLC and MAC functions as under –

1.2.4.2.19.1 Radio Link Control (RLC)

a) RLC shall be responsible for segmentation and retransmission handling. The RLC shall provide services to the PDCP in the form of RLC channels. There shall be one RLC entity per RLC channel (and hence per radio bearer) configured for a device.
b) Segmentation/ Concatenation: RLC layer shall support segmentation and concatenation to adapt the payload to the transport block size.

1.2.4.2.19.2 Medium Access Control (MAC)

a) The MAC shall handle multiplexing and de-multiplexing of logical channels, hybrid-ARQ retransmissions, and dynamic resource allocation (scheduling) and scheduling-related functions.
b) The MAC shall provide services to the RLC in the form of logical channels.
c) From the physical layer, the MAC layer shall use the services in the form of transport channels.
d) Short Buffer Status Report (BSR) and Long BSR
e) Discontinuous Reception (DRX) to enable reasonable UE battery consumption
f) The system shall support:
    i. Link adaptation and power control; and
    ii. Contention based Random Access (RA) procedure.

1.2.4.2.20 O-DU may support artificial traffic generation to fill a percentage of Physical Resource Block according to ETSI ES 202 706-1 in order to measure power consumption for different traffic load levels

- Operator shall set the percentage of PRB to be filled
- Operator shall choose between below two options:
  - PDSCH is equally distributed over time within the 10ms radio frame
  - PDSCH load is concentrated in time, but use the full bandwidth.

### 1.2.4.3 Open Fronthaul Interface

1.2.4.3.1 The Open FH (Fronthaul) Interface is between O-DU and O-RU functions. It shall support (as specified in O-RAN alliance from time to time)

- CUS (Control User Synchronization) Plane related functions
- M (Management) Plane functions

1.2.4.3.2 The Open FH M-Plane interface connects the O-RU to the O-DU in hierarchical mode and the O-RU to the SMO in hybrid mode for FCAPS functionality.

### 1.2.4.4 O-CU Functionality

#### 1.2.4.4.1 O-CU-CP

1.2.4.4.1.1 The O-CU-CP may terminate the E1 interface towards O-CU-UP (only if O-CU-CP & O-CU-UP are deployed in split configuration).

1.2.4.4.1.2 The O-CU-CP may terminate F1-c interfaces towards O-DU (only if O-DU & O-CU are deployed in split configuration)

1.2.4.4.1.3 The O-CU-CP shall terminate the RRC and PDCP (for SRB) protocols towards the UE.

1.2.4.4.1.4 The O-CU-CP may terminate E2 interface to Near RT RIC Platform.

1.2.4.4.1.5 The O-CU-CP may terminate O1 interface towards the SMO.

1.2.4.4.1.6 The O-CU-CP shall terminate NG-c interface to 5GC.

1.2.4.4.1.7 The O-CU-CP shall terminate X2-c interface to eNB or to en-gNB in EN-DC.

1.2.4.4.1.8 The O-CU-CP shall terminate Xn-c to gNB or ng-eNB.

1.2.4.4.2 **O-CU-UP**

1.2.4.4.2.1 The O-CU-UP may terminate the E1 interface towards O-CU-CP (only if O-CU-CP & O-CU-UP are deployed in split configuration).

1.2.4.4.2.2 The O-CU-UP may terminate F1-u interfaces towards O-DU (only if O-DU & O-CU are deployed in split configuration)

1.2.4.4.2.3 The O-CU-Up shall terminate the PDCP and SDAP protocols towards the UE.

1.2.4.4.2.4 The O-CU-UP may terminate E2 interface to Near RT RIC Platform.

1.2.4.4.2.5 The O-CU-UP may terminate O1 interface towards the SMO.

1.2.4.4.2.6 The O-CU-UP shall terminate NG-u interface to 5GC.

1.2.4.4.2.7 The O-CU-UP shall terminate X2-u interface to eNB or to en-gNB in EN-DC.

1.2.4.4.2.8 The O-CU-UP shall terminate Xn-u to gNB or ng-eNB.

1.2.4.4.3 The O-CU may support O-CU-CP and O-CU-UP nodes only if its Control and User part is deployed in split configuration.

1.2.4.4.4 gNB O-CU and O-vCU may support geo-redundancy mechanism in case of centralized deployment.

1.2.4.4.5 O-CU-CPs shall be able to support connectivity to multiple O-CU-UPs

1.2.4.4.6 O-CU shall provide L3 functions (RRC/RRM, PDCP, SDAP, QoS and VoNR) as under:-

1.2.4.4.6.1 QoS requirements as under:

- 5QI (5G QoS Identifiers) for NR-Standalone mode as per 3GPP TS 23.501 Table 5.7.4-1.
- Multiple data radio bearers (DRBs).
- Dynamic addition and deletion of dedicated bearers.

- Both UE initiated as well as Network Initiated dedicated bearer creation.
- Prioritization of traffic in downlink as per the QCI/ 5QI priority value.

1.2.4.4.6.2 Voice over NR (VoNR) support as under:-The O-CU shall support Voice over NR (VoNR) functionality, including:

- Basic Voice over NR, which provides traffic functions and protocol procedures for establishing, maintaining, and releasing a voice call in NR;
- Voice over NR calls, which allow the handling of voice traffic directly;
- Intra frequency handover for voice services; and
- IP header compression.
- Need to include EPS fall-back mechanism since VoNR may not be supported by all the UEs

1.2.4.4.6.3 Radio Resource Control/ Radio Resource Management (RRC/ RRM)

a) Cell control and AMF support: NG-RAN owns and controls the radio resources of its own cell or cells. Cell resources as requested by and granted to AMF shall be provided in an ordered fashion.
b) RRC messages shall be transmitted to the device using signalling radio bearers (SRBs) including SRB0, SRB1and SRB2.
c) The O-RAN shall support:
    i. Event-triggered measurement reporting;
    ii. System Information Broadcast (SIB); and
    iii. RRC_IDLE, RRC_CONNECTED, and RRC_INACTIVE states.

1.2.4.4.6.4 Service Data Adaptation Protocol (SDAP)

SDAP shall be responsible for mapping Quality-of-Service (QoS) bearers to radio bearers according to their QoS requirements.

1.2.4.4.6.5 Packet Data Convergence Protocol (PDCP)

a) The O-CU shall support;

i. integrity protection and ciphering of RRC signalling;
ii. RoHC;
iii. data recovery; and
iv. ciphering of DRBs

b) PDCP shall also handle retransmissions, in-sequence delivery, and duplicate removal in the case of handover.

1.2.4.5 **O-CU/O-DU Common features**

1.2.4.5.1 Shall have support of

1.2.4.5.1.1 IPv6 protocol

1.2.4.5.1.2 IPv4 (Optional)

1.2.4.5.2 O-CU/O-DU shall allow SFP ports from 3rd party.

1.2.4.5.3 O-DU/O-CU shall support containerization and containers deployment need to make an efficient use of IP addresses avoiding multiple IP addresses per single CNF with preference only 1 IP address per CNF.

1.2.4.5.4 O-DU/O-CU shall support Mid Haul or Back Haul ports as per capacity scenarios.

1.2.4.5.5 O-DU/O-CU shall support platform management through IPMI v2.0 Compliant (or later) or RedFish v1.6.0 Compliant (or later).

1.2.4.5.6 O-CU/O-DU may support stateless implementation.

1.2.4.5.7 In a centralized scenario, where O-DU instances are deployed in a pool of servers, O-RUs may spread load across those multiple O-DU servers such as pooling the processing of many cells in a pool of servers located in the Cloud (edge/regional).

1.2.4.5.8 O-DU/O-CU shall support of centralized retransmission in intra gNB-O-CU/DU scenarios, i.e. the gNB-O-CU/DU can switch transmission of data traffic, as well as perform retransmission of undelivered PDCP PDUs, from a gNB-O-DU/CU affected by an outage to other available gNB-O-DUs/CUs.

1.2.4.6 **Midhaul (F1) Interface**

1.2.4.6.1 The F1 interface shall support:

- procedures to establish, maintain and release UE contexts, including handling of the radio bearers for the NG-RAN part of PDU sessions and for EUTRAN Radio Access Bearers;
- procedures to establish, maintain and release BH RLC channels; (Optional)
- the separation of each UE on the protocol level for user specific signalling management;
- the separation of each IAB-MT on the protocol level for IAB-MT-specific signalling management; (Optional).
- transfer of RRC signalling messages between the UE and the gNB-CU.
- Synchronization (S-Plane) Requirements of O-RAN

1.2.4.7 **Service Management and Orchestration (SMO) Functionality**

1.2.4.7.1 The key services of the SMO that provide support in O-RAN are:

a. OAM interface to O-RAN Network Functions
b. Non- RT RIC for RAN optimization
c. O-Cloud Management, Orchestration and Workflow Management.

1.2.4.7.2 The SMO shall perform above services through four key interfaces to the O- RAN Elements

a. A1 Interface between the Non-RT RIC in the SMO and the Near RT RIC Platform for RAN Optimization
b. O1 Interface between the SMO and the O-RAN Network Functions for FCAPS support
c. In the hybrid model, Open Fronthaul M-plane interface between SMO and O-RU for FCAPS support

d. O2 Interface between the SMO and the O-Cloud to provide platform resources and workload management

1.2.4.7.3 SMO shall support FCAPS to O-RAN Network Functions

a. The SMO shall provide support for O-RAN network function FCAPS via the O1 Interface

b. The following FCAPS functions defined in the O1 Specification shall be provided across the O1 interface :-

i. Performance Management (PM)

ii. Configuration Management (CM)

iii. Fault Management (FM)

iv. File Management

v. Communication Surveillance (Heartbeat)

vi. Trace

vii. Physical Network Function (PNF) Discovery

viii. PNF Software Management

1.2.4.7.4 SMO shall provide the capability of managing the O-Clouds as well as providing support for the orchestration of platform and application elements and workflow management.

1.2.4.7.5 The SMO shall be able to correlate ME telemetry to Infrastructure and Deployment telemetry to aggregate problems to a root cause and thus correlate a Managed Element to its deployment components.

1.2.4.7.6 The O2 interface supports the management of the O-cloud infrastructure and the use of the O-cloud resources allocated to the RAN.

1.2.4.7.7 SMO shall provide the following functionalities: -

a. Discovery and administration of O-Cloud Resources

b. Scale-In, Scale-Out for O-Cloud

c. FCAPS (PM, CM, FM, Communication Surveillance) of O-Cloud

d. Software Management of Cloud Platform

e. Create, Delete Deployments and Associated Allocated O-Cloud Resources
f. Scale-In, Scale-Out Deployments and Allocated O-Cloud Resources
g. FCAPS (PM, FM) of Deployments and Allocated O-Cloud Resources
h. Software Management of Deployments

1.2.4.8 **Non-RT RIC (Non-real time RAN Intelligent Controller) and A1 Interface**

1.2.4.8.1 Non-Real Time RAN Intelligent Controller (Non-RT RIC) is the functionality internal to the SMO in O-RAN architecture that provides the A1 interface to the Near-Real Time RIC.

1.2.4.8.2 The Non-RT RIC is comprised of two sub-functions:

a. Non-RT RIC Framework – Functionality internal to the SMO Framework that logically terminates the A1 interface and exposes the required services to rApps through its R1 interface.
b. Non-RT RIC Applications (rApps) – Modular applications that leverage the functionality exposed by the Non-RT RIC Framework to perform RAN optimization and other functions. Services exposed to rApps via the R1 interface enable rApps to obtain information and trigger actions (e.g., policies, re-configuration) through the A1, O1, O2 and Open FH M-Plane related services.

1.2.4.8.3 Non-RT RIC shall support intelligent RAN optimization by providing policy based guidance, ML model management and enrichment information to the Near RT RIC Platform function so that the RAN can optimize.

1.2.4.8.4 The Non-RT RIC framework shall support functionality to register services along with their service producers and Data Producers (including rApps) to register their DME types production capabilities, if such functionality is not supported in the SMO framework.

1.2.4.8.5 The Non-RT RIC framework shall support functionality to allow service consumers to discover services and data Consumers (including rApps) to

discover and register available DME types they consume, if such functionality is not supported in the SMO framework.

1.2.4.8.6 The Non-RT RIC framework shall support functionality to allow service consumers to subscribe/unsubscribe notifications about newly registered/updated/deregistered services and Data Consumers (including rApps) to subscribe/request instances of registered DME types for consumption if such functionality is not supported in SMO.

1.2.4.8.7 The Non-RT RIC framework shall support functionality to notify subscribed service consumers about newly registered/updated/deregistered services.

1.2.4.8.8 The Non-RT RIC framework shall support functionality to authenticate and authorize service consumers to access services.

1.2.4.8.9 The Non-RT RIC framework shall support functionality to send messages to and receive messages from the Near RT RIC Platform via the A1 interface.

1.2.4.8.10 The Non-RT RIC framework shall support functionality to allow Data Producers (including rApps) to offer instances of registered DME types for collection and storage, if such functionality is not supported in the SMO framework.

1.2.4.8.11 The Non-RT RIC framework shall support functionality to train AI/ML models and allow service consumers to store and retrieve these trained AI/ML models, if such functionality is not supported in the SMO framework.

1.2.4.8.12 The Non-RT RIC framework shall support functionality to monitor the performance for deployed AI/ML models in runtime, if such functionality is not supported in the SMO framework.

1.2.4.8.13 The Non-RT RIC framework shall support functionality to collect external enrichment information from external enrichment information sources.

1.2.4.8.14 The Non-RT RIC framework shall support functionality to retrieve trained ML models (and metadata) from external AI/ML service providers also.

1.2.4.8.15 The Non-RT RIC framework shall support functionality to allow external sources to inject RAN intents, suspend/resume/check rApps, and configure/check/initiate/suspend/resume/terminate AI/ML training processes.

1.2.4.8.16 The Non-RT RIC framework shall support functionality to consolidate the alarm information from multiple managed entities, if such functionality is not supported in the SMO framework.

1.2.4.8.17 The Non-RT RIC framework may have the capability to identify the potentially applicable Near RT RIC Platform(s) for A1 policy creation if the Near RT RIC Platform identifier is absent in the create A1 policy request received from the rApp.

1.2.4.8.18 The Non-RT RIC framework shall support the functionality to collect trace data, from multiple managed entities and analytical data from the Near RT RIC Platform, if such functionality is not supported in the SMO framework

1.2.4.8.19 The Non-RT RIC framework shall support functionality to allow Data Consumers (including rApps) to consume Deployment and Infrastructure Telemetry metrics collected by the O2- related functions.

1.2.4.8.20 The Non-RT RIC framework shall support functionality that allows managing the configuration, if such functionality is not supported in the SMO framework. Similarly, Non-RT RIC framework shall support functionality that allows obtaining, from an rApp, information about that rApp's performance, fault information related to that rApp, logging information reported by the rApp and to store log information received from rApps, if such functionality is not supported in the SMO framework.

### 1.2.4.9 Near RT RIC Platform

1.2.4.9.1 Near RT RIC Platform platform shall provide a database that stores an up-to-date RAN information, history of time-varying network state, as well as configurations related to E2 Nodes, Cells, Bearers, Flows, UEs, etc.

1.2.4.9.2 Near RT RIC architecture shall also support WG3.RICARCH functional requirements from 5.1.2 (xApp requirements) and 5.1.3 (near-RT RIC API requirements).

1.2.4.9.3 Near RT RIC Platform shall provide AI/ML tools that support for data pipelining, training.

1.2.4.9.4 Near RT RIC Platform shall provide a messaging infrastructure.

1.2.4.9.5 Near RT RIC Platform shall provide logging, tracing and metrics collected from Near RT RIC Platform platform and xApps toward SMO.

1.2.4.9.6 Near RT RIC Platform shall provide security functions.

1.2.4.9.7 Near RT RIC Platform shall support resolution of potential conflicts or overlaps of controls from xApps toward an E2 node.

1.2.4.9.8 Near RT RIC Platform shall communicate with xApp(s) via Near RT RIC Platform APIs.

1.2.4.9.9 Near RT RIC Platform shall register the Near RT RIC Platform APIs it produces.

1.2.4.9.10 Near RT RIC Platform shall be capable of discovering the Near RT RIC Platform APIs it consumes.

1.2.4.9.11 Near RT RIC Platform shall provide means to resolve compatibility clashes between xApps and the Near RT RIC Platform services they access.

1.2.4.9.12 Near RT RIC Platform shall support subscription merging from multiple xApps to avoid unnecessary network load.

1.2.4.9.13 Near RT RIC Platform shall provide an O1 interface.

1.2.4.9.14 Near RT RIC Platform shall be able to route A1 policy management messages to the registered xApps based on A1 policy type and operator policies.

1.2.4.9.15 Near RT RIC Platform shall control access of A1-EI types for xApps based on operator policies.

1.2.4.9.16 Near RT RIC Platform shall provide APIs enabling the hosting of 3rd party xApps and xApps from the Near RT RIC Platform platform vendor.

1.2.4.9.17 Near RT RIC Platform APIs shall support the Near RT RIC Platform control loop of execution time from 10 milliseconds to 1 second.

1.2.4.9.18 Near RT RIC Platform shall provide APIs decoupled from specific implementation solutions, including a Shared Data Layer (SDL) that works as an overlay for underlying databases and enables simplified data access.

1.2.4.9.19 Near RT RIC Platform shall provide an API repository/registry for the services provided by the Near RT RIC Platform platform and/or xApps.

1.2.4.9.20 Near RT RIC Platform APIs shall provide means for xApps to discover the published APIs based on the xApps' needs;

1.2.4.9.21 Near RT RIC Platform APIs shall provide means to restrict xApps from discovering some published APIs based on configured policies.

1.2.4.9.22 Near RT RIC Platform shall provide APIs enabling all xApps to directly use the information elements of E2SMs with which they are associated.

1.2.4.9.23 Near RT RIC Platform shall provide APIs aiming to simplify the development of xApps and enable rapid innovation.

1.2.4.9.24 Near RT RIC Platform shall provide Near RT RIC Platform APIs supporting xApp development in multiple programming languages (e.g. C, C++, Python, Go).

1.2.4.9.25 Near RT RIC Platform APIs shall support xApp subscription management based on operators' policies. An xApp may be restricted to interface with only a subset of E2 Nodes by such policies. Near RT RIC Platform shall be responsible for routing messages between this xApp and the subset of E2 Nodes.

### 1.2.4.10 Cloudification and Orchestration

1.2.4.10.1 The O-Cloud services shall provide the ability to discover what event types the cloud instance supports. The minimal list of supported event types shall be:

a. Inventory Change

b. Configuration Change

c. Fault Events

d. Performance Reporting

e. Heartbeat

f. Shall support O2 interface.

1.2.4.10.2 The O-Cloud shall support O2 interface towards SMO.

1.2.4.10.3 The O-Cloud shall be able to make all Configuration Data and any external changes to it available to the SMO.

1.2.4.10.4 O-Cloud telemetry shall minimally consist of Fault, Performance, and Configuration Data.

1.2.4.10.5 The O-Cloud shall be able to report telemetry of NF deployment relative to those identified in the deployment descriptor.

1.2.4.10.6 The O-Cloud shall be able to report Cloud Infrastructure Resource telemetry and is a major functionality of the O-Cloud represented by the DMS. NF function will have it's own requirement.

1.2.4.10.7 O-Cloud shall provide the collection and reporting of performance information of O-Cloud resources and notify this information.

1.2.4.10.8 O-Cloud shall expose the type of performance information that can be collected for the allocated O-Cloud resource(s) and type of O-Cloud resource, for which the performance information can be collected.

1.2.4.10.9 O-Cloud shall provide the collection and notification of fault information for O-Cloud resources.

1.2.4.10.10 To support the deployments, O-Cloud Provisioning will need to provide several functionalities. There shall be initial support for the following:

a. Affinity, Anti-Affinity, Quorum Diversity Rules

b. Capacity Query

c. Availability Query

d. Managed O-Cloud Noe Clusters and Logical Clouds

1.2.4.10.11 O-Cloud shall provide Add, Delete, Update and Query Software Images of O-RAN Cloudified Network Function to O-Cloud repository

1.2.4.10.12 O-Cloud shall provide Software Image properties information of O-RAN Cloudified Network Function.

1.2.4.10.13 In O-RAN the O-Cloud Life Cycle Management shall provide the following capabilities:

a. Deploy
b. Registration
c. Scale

1.2.4.11 **Operations and Maintenance (OAM) for O-RAN**

1.2.4.11.1 O-RAN OAM Architecture shall support the interaction between the Service Management and Orchestration Framework and the O-Cloud through O2 interface to perform virtualized resource orchestration.

1.2.4.11.2 O-RAN OAM Architecture shall support the capability for the Service Management and Orchestration Framework to consume the provisioning management service exposed by the MnF of each O-RAN NF, regardless of whether the NF is implemented as PNF or VNF, through the O1 interface except O-RU.

1.2.4.11.3 O-RAN OAM Architecture shall support creation, modification and termination of VNFs in an O-RAN network by the Service Management and Orchestration Framework

1.2.4.11.4 O-RAN OAM Architecture shall support registration and inventory of newly activated VNFs and PNFs by the Service Management and Orchestration Framework.

1.2.4.11.5 O-RAN OAM Architecture shall support collection of status change and other indications from VNFs and PNFs by the Service Management and Orchestration Framework

1.2.4.11.6 O-RAN OAM Architecture shall support configuration of VNFs and PNFs by the Service Management and Orchestration Framework, including, for example, addressing information needed to allow them to connect to each other

1.2.4.11.7 O-RAN OAM Architecture shall support management of PM jobs/PM data collection/storage/query/statistical reports from MnFs of O-RAN NFs.

1.2.4.11.8 O-RAN OAM Architecture shall support operation logging, operation authority and management of O-RAN NFs

1.2.4.11.9 O-RAN OAM Architecture shall support management of O-DU, O-CU, O-RU and other hardware components.

1.2.4.11.10 O-RAN OAM Architecture and interfaces shall support network slicing, where an instance of O-RAN NF may be associated with one or more slices.

1.2.4.11.11 O-RAN OAM Architecture may support O1 interface to the MnF of each O-RAN NF (with the exception of the RU) even if the MnF is deployed behind a NAT.

1.2.4.11.12 The O-RAN OAM architecture shall support the capability of the Service Management and Orchestration (SMO) framework to discover the RAN FCAPS-related management capabilities of the O-RAN MnF that terminates the O1 interface or NF that terminates the Open fronthaul M-plane interface.

1.2.4.12 **Operations and Maintenance (OAM) for O-RAN Non-Functional Requirements**

1.2.4.12.1 O-RAN OAM Architecture shall support the introduction of new and more cost-effective technologies into the RAN through open, standard interfaces.

1.2.4.12.2 O-RAN OAM Architecture shall support virtualization of RAN components, allowing operators use of common, off-the-shelf hardware implementations

1.2.4.12.3 O-RAN OAM Architecture shall support use of Analytics and Artificial Intelligence/Machine Learning to improve network efficiency and performance and reduce operations costs.

1.2.4.12.4 O-RAN entities emitting alarms to the SMO shall provide an Alarm Dictionary with the product delivery that is delivered to the SMO at onboarding for O-RAN NFs, xApps and rApps or at registration for OCloud entities and the same shall be updated when the entity emitting the alarm supports a new alarm definition, the information associated with the alarm definition changes or the entity no longer supports an alarm definition.

1.2.4.12.5 The SMO shall maintain the association between an entity version onboarded from a product delivery and its alarm dictionary.

1.2.4.12.6 The Alarm Dictionary shall be delivered following the schema to be defined in the IM/DM specification.

1.2.4.12.7 O-RAN OAM Architecture shall support security of interactions between the components of an O-RAN network.

### 1.2.5 Quality Requirements

1.2.5.1 The supplier/manufacturer shall conform to ISO 9001:2015 certifications. A quality plan describing the quality assurance system followed by the manufacturer shall be required to be submitted.

1.2.5.2 For O-RAN, the failure of any component/ sub-system in the system may not result in the failure of complete system.

### 1.2.6 EMI/EMC Requirements

These requirements are applicable for purposely built hardware or a physical entity only. The equipment shall conform to the following EMC requirements as per TEC Standard No. TEC11016:2016 as modified/ amended from time to time:-

| Clause | Parameter | Standard |
|---|---|---|

| | | |
|---|---|---|
| 1. | Conducted and Radiated Emission | CISPR 32<br>Class-A |
| 2. | Immunity to Electrostatic discharge: Contact discharge level 2 {± 4 kV} | IEC-61000-4-2<br>Performance Criteria-B, Clause 9 |
| 3. | Immunity to Electrostatic discharge: Air discharge level 3 {± 8 kV} | IEC-61000-4-2<br>Performance Criteria-B, Clause 9 |
| 4. | Immunity to radiated RF:<br>a) Radio Frequency: 80 MHz to 1 GHz, Electromagnetic field: 3V/m<br>b) Radio Frequency: 800 MHz to 960 MHz, Electromagnetic field: 10V/m<br>c) Radio Frequency: 1.4 GHz to 6 GHz, Electromagnetic field: 10V/m | IEC 61000-4-3 (2010);<br>Performance Criteria-A, Clause 9<br>***Note** - In the case of O-RAN with Wi-Fi interface, the exclusion bands for Immunity to radiated RF testing needs to be considered as per clauses (4.3.2) and (4.3.3 & 4.3.4) of ETSI EN 301 489-17 standard for WLAN operation in 2.4 GHz band 5 GHz bands respectively with exception that exclusion bands will not be applicable for testing of transmitters in standby mode or receivers or receiver part of transceivers.* |
| 5. | Immunity to fast transients (burst): Test Level 2:<br>a) 1 kV for AC/DC power port<br>b) 0. 5 kV for signal / control / data / telecom lines. | IEC 61000- 4- 4 {2012); Performance Criteria-B, Clause 9 |

| | | |
|---|---|---|
| 6. | Immunity to surges: AC/DC ports<br>a) 2 kV peak open circuit voltage for line to ground<br>b) 1kV peak open circuit voltage for line to line | IEC 61000-4-5 (2014)<br>Performance Criteria-B, Clause 9 |
| 7. | Immunity to surges: Telecom ports<br>a) 2 kV peak open circuit voltage for line to ground coupling.<br>b) 2 kV peak open circuit voltage for line-to-line coupling. | IEC 61000-4-5 (2014)<br>Performance Criteria-C, Clause 9 |
| 8. | Immunity to conducted disturbance induced by Radio frequency fields:<br>Under the test level 2 {3 V r.m.s.} in the frequency range 150 kHz-80 MHz for AC / DC lines and Signal /Control/telecom lines. | IEC 61000-4-6 (2013)<br>Performance Criteria-A, Clause 9 |
| 9. | Immunity to voltage dips & short interruptions (applicable to only ac mains power input ports, if any):<br>Limits: - | IEC 61000-4-11 (2004):<br>a) Performance Criteria B for Reduction of Supply 30% for 500ms or Dip to reduction of 60% for 100ms<br>b) Performance Criteria C for Reduction of 60% for 200ms |

| | | |
|---|---|---|
| | a) a voltage dip corresponding to a reduction of the supply voltage of 30% for 500ms (i.e., 70% supply voltage for 500ms)<br>b) a voltage dip corresponding to a reduction of the supply voltage of 60% for 200ms; (i.e.,40% supply voltage for 200ms)<br>c) a voltage interruption corresponding to a reduction of supply voltage of > 95% for 5s.<br>d) a voltage interruption corresponding to a reduction of supply voltage of >95% for 10ms. | c) Performance criteria C for Voltage Interruption>95% for 5 s<br>(Note: In case of Battery back-up performance criteria A is applicable).<br>d) Performance Criteria B for Voltage Interruption >95% duration :10ms<br>(Note: In case of Battery back-up Performance Criteria A is applicable for above conditions.) |
| 10. | Immunity to voltage dips & short interruptions (applicable to only DC power input ports, if any):<br>a) Voltage Interruption with 0% of supply for 10ms.<br>b) Voltage Interruption with 0% of supply for 30ms, | IEC 61000-4-29(2000)<br>a) Applicable Performance Criteria shall be B.<br>b) Applicable Performance Criteria shall be C.<br>c) Applicable Performance Criteria shall be B. |

| | | |
|---|---|---|
| | 100ms, 300ms and 1000ms.<br>c) Voltage dip corresponding to 40% & 70% of supply for 10ms, 30 ms.<br>d) Voltage dip corresponding to 40% & 70% of supply for 100ms, 300 ms and 1000 ms.<br>e) Voltage variations corresponding to 80% and 120%of supply for 100 ms to 10s as per Table 1c of IEC 61000-4-29. | d) Applicable Performance Criteria shall be C.<br>e) Applicable Performance Criteria shall be B. |

### 1.2.7 Safety Requirements

The equipment shall conform to relevant safety requirements as per (IS/IEC 62368-1:2018 or Latest & IS 10437: 2019/IEC 60215: 2016) as prescribed under Table no. 1 of the TEC document 'SAFETY REQUIREMENTS OF TELECOMMUNICATION EQUIPMENT": TEC10009: 2024. These requirements are applicable for purposely built hardware or a physical entity only.

### 1.2.8 System Radio Operating Environments

#### 1.2.8.1 System supervision

a. Provision shall be made for continuous testing of the system to allow both system qualities check and fault indication as a fault arises.

b. In case a fault is detected requiring reloading of the program, this shall be carried out automatically. In case of manual re-loading, it shall be possible to stop and start at any particular point in the program.

#### 1.2.8.2 Relative UE Speed

The targeted relative speed between the O-RU and the mobile stations shall be chosen from the following categories: (Applicable for Low/Mid band)

a. Stationary (0 km/h)
b. Pedestrian (up to 10 km/h)
c. Vehicular: 10 km/h to 120 km/h
d. High speed vehicular: 120 km/h to 500 km/h

For High band, the targeted relative speed between the O-RAN and the mobile station shall be up to 100 km/h.

### 1.2.9 Operational Requirements

#### 1.2.9.1 Availability

a. The facility shall be available for introduction of centralized Operation and Maintenance Control (OMC).
b. The maintenance spares supplies shall take in to account the MTBF and MTTR.

#### 1.2.9.2 Diagnostic Capability

a. The diagnostic capability of the system shall be such as to minimize the human efforts required. The diagnostic programs which are normally resident in the on-line program shall be indicated. Details of the off-line diagnostic programs shall be given. The procedure for invoking such programs shall be described. The procedure for consulting fault dictionary for diagnostic programs shall be made available.

b. The system shall provide facility for automatic restart under severe fault conditions. Where automatic restart fails to restore system sanity, facility shall be provided for manual restart of the system.

#### 1.2.9.3 Environmental Test Conditions:

a. Indoor entity (such as CU, DU, RIC, SMO): Category A SD: QM-333
b. Outdoor entity (such as O-RU): Category D SD: QM-333 and IP65
c. Antenna & Feeders: Category E as per SD: QM-333

### 1.2.10 General Requirements

#### 1.2.10.1 General

1.2.10.1.1 The operation of the equipment shall be in the frequency band allotted.

1.2.10.1.2 Support of Multiple Equipment Vendors as per tender requirement

1.2.10.1.3 The system shall support the possibility of using equipment and sub-systems of different vendors as per defined industry standards, wherever relevant.

#### 1.2.10.2 Hardware

1.2.10.2.1 The system hardware shall be modular in design and shall permit growth in steps. The arrangement shall be such that failure/ deterioration of service shall not occur when implementing the growth.

1.2.10.2.2 Design precautions shall be taken to minimize the possibility of equipment damage arising from the insertion of an electronic package into the wrong connector or the removal of any package from any connector.

1.2.10.2.3 The system hardware shall not pose any problem, due to changes in date and time caused by events such as changeover of leap year etc., in the normal functioning of the system.

1.2.10.3 **Processors**

1.2.10.3.1 Provision shall be made to prevent the loss/alteration of memory contents due to power failures, improper operating procedures and the procedure for restoring the system to its normal state, etc.

1.2.10.4 **Input-Output Devices**

1.2.10.4.1 The communication facilities provided for exchange of information between the elements of O-RAN and the maintenance and operating personnel shall include facilities for a system test, control and alarm indication at OMC.

1.2.10.4.2 Input / output terminals shall be capable of transmitting/ receiving characters of a subset of the ITU-T T.50 alphabet. The printing/display device shall print/display different graphic symbols for the digit zero and the capital letter O. The input/output terminal shall have the English Keyboard.

1.2.10.4.3 Adequate number of man-machine interfaces shall be available.

1.2.10.4.4 If provision is made for monitoring from a remote terminal, it shall be ensured that the data links conform to the ITU-T Recommendation Q.513. Care shall be taken that the reliability of the data links towards remote terminal does not, in any way, affect the reliability of the O-RAN. Special provision shall also be made for storage of failure event even when the system is unable to transmit an output message.

1.2.10.4.5 A suitable alarm and display system at OMC shall be provided for a continuous indication of the system status.

1.2.10.5 **Equipment Practice**

1.2.10.5.1 For indoor O-RAN components like O-CU, O-DU, SMO, RIC etc., suitable test access points and displays shall be provided for facilitating maintenance. Test access points shall be located on the front side of the bay. All visual display devices shall be located in a position attracting immediate attention of the operation and maintenance personnel.

1.2.10.5.2 For O-RAN components like O-RU, O-CU, O-DU, SMO, RIC etc, it shall be indicated whether printed board connectors are of edge-type or plug-and-socket type. They shall not be easily damaged during replacements and removals. The contact particulars as well as life test performance on contact resistance for each type of connector shall be supplied.

1.2.10.5.3 All components and material used in the equipment shall be non-inflammable or in absence of it, self-extinguishable. They shall be fully tropicalised.

1.2.10.5.4 For O-RAN components like O-RU, O-CU, O-DU, SMO, RIC etc, the method used for connection of permanent wiring outside the printed cards shall be indicated.

1.2.10.5.5 The buses, if any, shall be suitably protected against electrical and magnetic interference from neighbouring systems (like electromechanical systems, fluorescent tubes, motors, etc.).

1.2.10.5.6 For O-RAN components like O-RU, O-CU, O-DU, SMO, RIC etc, the different plug-in cards shall have suitable mechanical safeguards to prevent damage due to accidental interchange of cards.

1.2.10.5.7 The requirement at the external interface against induced voltages and currents due to lightning, high power system, etc. shall be indicated.

1.2.10.5.8 The system shall provide for human isolation and protection from accidental high voltage power contact.

1.2.10.6 **Quality Requirements**

1.2.10.6.1 The components used shall be available from multiple sources with adequate qualification. Number of proprietary components used shall be minimum. List of such components shall be indicated.

1.2.10.6.2 All the equipment shall have a tropical finish and coated to protect against saline atmosphere.

1.2.10.7 **Software**

1.2.10.7.1 The software shall be written in a High-Level Language. The software shall be modular and structured.

1.2.10.7.2 The software shall include the following characteristics:

a. The design of the software shall be such that the system is easy to handle both during installation and normal operations as well as during extensions.
b. The functional modularity of the software shall permit introduction of changes wherever necessary with least impact on other modules.
c. It shall be open-ended to allow addition of new features.
d. Adequate flexibility shall be available to easily adopt changes in service features & facilities and technological evolution in hardware.
e. The design shall be such that propagation of software faults is contained.
f. Test programs shall include fault tracing for detection and localization of system faults.

1.2.10.8 **Software Maintenance**

1.2.10.8.1 All software updates, for a period as specified, shall be supplied on continuing basis. These updates shall include new features and services and other maintenance updates.

1.2.10.8.2 Integration of software updates without posing any problem to the existing functionality shall be possible.

1.2.10.9 **O-RAN Security**

1.2.10.9.1 The O-RAN shall provide the protection against DOS attack. The vendor shall describe how to protect against DOS attack in their system.

1.2.10.9.2 The different O-RAN components such as O-RU, O-CU, O-DU, RIC, SMO etc. shall comply to the security requirements mentioned in the applicable Indian Telecommunication Security Assurance Requirements (ITSAR) as and when notified by National Centre for communication Security (NCCS).

# CHAPTER 2

## 2.1 INFORMATION FOR THE PROCURER/VENDOR OF PRODUCT

In the document, as O-RAN provides flexibility to choose the different network elements of the O-RAN from different vendors so the procurer of the product needs to identify the network element(s) (i.e. O-RU/O-DU/O-CU/SMO/ Near Real Time RIC/Non Real Time RIC/O-Cloud or combination of these) from the O-RAN architecture as per their requirement based on the deployment scenario and suitably specify it in the tender conditions. Accordingly, the technical specification of that network element(s) as mentioned in this document will apply and needs to be conformed by the vendor of that network element(s).

**Note**: Based on the procurer/tenderer requirements, the equipment vendor shall specifically indicate the product specific configuration/features being offered for type approval/ technology approval from following optional requirements as per below table:-

| S. No. | Tendering parameter | Clause |
|---|---|---|
| 1 | To identify network element(s) i.e. O-RU/O-DU/O-CU/SMO/ Near Real Time RIC/Non Real Time RIC/O-Cloud or combination of these offered for type approval/ technology approval | As per Standard |
| 2 | No. of carriers and technology supported by O-RU | 1.2.4.1.3 |
| 3 | Slot pattern configuration supported by O-RU | 1.2.4.1.6 |
| 4 | MIMO and Modulation schemes supported by O-RU | 1.2.4.1.9 & 1.2.4.1.10 |
| 5 | Sub carrier spacing supported by O-RU | 1.2.4.1.14 |

| | | |
|---|---|---|
| 6 | F1, O1, E2 and Open FH M -Plane support in O-DU | 1.2.4.2.4 to 1.2.4.2.6 |
| 7 | Carrier Aggregation support in O-DU | 1.2.4.2.13 |
| 8 | Routing capability in O-DU | 1.2.4.2.14 |
| 9 | O-DU to support connectivity to multiple O-CUs | 1.2.4.2.17 |
| | O-DU to support GPS or NAVIC or both | 1.2.4.2.18 |
| 10 | O-DU to support artificial traffic generation | 1.2.4.2.20 |
| 11 | E1, F1-c, E2 and O1 support in O-CU-CP | 1.2.4.4.1 |
| 12 | E1, F1-u, E2 and O1 support in O-CU-UP | 1.2.4.4.2 |
| 13 | O-CU to support O-CU-CP & O-CU-UP nodes | 1.2.4.4.3 |
| 14 | Geo-redundancy mechanism support in O-CU | 1.2.4.4.4 |
| 15 | IPv4 support in O-DU/O-CU | 1.2.4.5.1.2 |
| 16 | Stateless implementation in O-DU/O-CU | 1.2.4.5.6 |
| 17 | O-RUs to spread load across those multiple O-DU | 1.2.4.5.7 |
| 18 | F1 interface to support BH RLC channels and IAB-MT specific management | 1.2.4.6.1 |
| 19 | Non-RT RIC framework capability to identify the potentially applicable Near RT RIC Platform(s) | 1.2.4.8.16 |
| 20 | O-RAN OAM Architecture to support O1 interface to the MnF of each O-RAN NF | 1.2.4.11.11 |
| 21 | The failure of any component/ sub-system in the system to result in the failure of complete system | 1.2.5.2 |
| 22 | EMI/EMC Requirements - applicable for purposely built hardware or a physical entity only | 1.2.6 |
| 23 | Safety Requirements - applicable for purposely built hardware or a physical entity only | 1.2.7 |

# ABBREVIATIONS

| | |
|---|---|
| 3GPP | 3rd Generation Partnership Project |
| 5GC | 5G Core |
| 5GS | 5G System |
| AAL | Accelerator Abstraction Layer |
| AAU | Active Antenna Unit |
| API | Application Programing Interface |
| AI | Artificial Intelligence |
| AMF | Access and Mobility Functions |
| ALM | Application lifecycle management |
| ASIC | Application-Specific Integrated Circuit |
| BBU | Base Band Unit |
| BH | Back Haul |
| CM | Configuration Management |
| CMTS | Cable Modem Termination System |
| COTS | Commercial Off-The-Shelf |
| COMP | Coordinated Multipoint |
| CP-OFDM | Cyclic Prefix – Orthogonal Frequency Division Multiplexing |
| CSP | Communications Service Provider |
| CTI | Cooperative Transport Interface |
| D-TLS | Datagram Transport Layer Security |
| DFE | Digital Frontend |

| | |
|---|---|
| DFT | Discrete Fourier Transform |
| DHCP | Dynamic Host Configuration protocol |
| DME | Data Management and Exposure |
| DOCSIS | Data Over Cable Service Interface Specification |
| DM | Data Model |
| DSS | Dynamic Spectrum Sharing |
| E2SM | E2 Service Model |
| EPS | Evolved Packet System |
| E-UTRA | Evolved Universal Terrestrial Radio Access |
| E-UTRAN | Evolved Universal Terrestrial Radio Access Network |
| EN-DC | E-UTRAN New Radio – Dual Connectivity |
| eNB | evolved Node B |
| FCAPS | Fault, Configuration, Accounting, Performance, Security |
| FFT | Fast Fourier Transform |
| FHGW | Fronthaul Gateway |
| FHM | Fronthaul Multiplexer |
| FM | Fault Management |
| FPGA | Field Programmable Gate Array |
| gNB | next generation Node B |
| gNB-CU | gNB Central Unit |
| gNB-DU | gNB Distributed Unit |
| GPU | Graphics Processing Unit |
| GNSS | Global Navigation Satellite System |

| | |
|---|---|
| HARQ | Hybrid ARQ (Automatic Repeat Request) |
| iFFT | inverse Fast Fourier Transform |
| IAB-MT | Integrated Access and Backhaul Mobile Termination |
| IEC | International Electrotechnical Commission |
| IM | Information Model |
| IPSec | Internet Protocol Security |
| LAN | Local Area Networks |
| LLS | Lower Layer Split |
| LTE | Long Term Evolution |
| MA | Managed Application |
| MAC | Media Access Control |
| ME | Managed Element |
| MF | Managed Function |
| ML | Machine Learning |
| MnF | Mobile Network Function |
| MTBF | Mean Time Between Failures |
| MTTR | Mean Time to Repair |
| NAC | Network Access Control |
| Near RT RIC Platform | Near-Real-Time RAN Intelligent Controller |
| NFV | Network Function Virtualization |
| NG | Next Generation |
| NG-RAN | Next Generation RAN |
| NICs | Network Interface Card |

| | |
|---|---|
| NIST | National Institute of Standards and Technology |
| NMS | Network Management System |
| Non-RT RIC | Non-Real-Time RAN Intelligent Controller |
| NR | 5G New Radio |
| O-Cloud | O-RAN Cloud |
| O-CU-CP | O-RAN Central Unit – Control Plane. |
| O-CU-UP | O-RAN Central Unit – User Plane |
| O-DU | O-RAN Distributed Unit |
| O-eNB | O-RAN eNB |
| O-RAN | Open-RAN |
| O-RU | O-RAN Radio Unit |
| OLT | Optical Line Terminal |
| ONU | Optical Network Unit |
| Open FH | Open Fronthaul |
| PDCP | Packet Data Convergence Protocol |
| PDSCH | Physical Downlink Shared Channel |
| PUSCH | Physical Uplink Shared Channel |
| PHY | Physical layer |
| PIM | Passive Intermodulation |
| PM | Performance Management |
| PNF | Physical Network Function |
| PON | Passive Optical Network |
| PON OLT | Passive Optical Network Optical Line Terminal |

| | |
|---|---|
| PON ONU | Passive Optical Network Optical Network Unit |
| PRACH | Physical Random Access Channel |
| PTP | Precision Time Protocol |
| RAN | Radio Access Network |
| rApp | Non-RT RIC Application |
| RAT | Radio Access Technology |
| RF | Radio Frequency |
| RLC | Radio Link Control |
| RRC | Radio Resource Control |
| RRH | Remote Radio Head |
| RRM | Radio Resource Management |
| RRU | Remote Radio Unit |
| RT | Real Time |
| RU | Radio Unit |
| SBA | Service Based Architecture |
| SFP | Small form-factor pluggable |
| SCS | Sub Carrier Spacing |
| SDAP | Service Data Adaptation Protocol |
| SMO | Service Management and Orchestration |
| SMOF | Service Management and Orchestration Function |
| SMOS | Service Management and Orchestration Service |
| SRB | Signalling Radio Bearer |
| TDD | Time-Division-Duplexing |

| | |
|---|---|
| TLS | Transport Layer Security |
| TN | Transport Node |
| TR | Technical Report |
| TRP | Transmission and Reception Point |
| TS | Technical Specification |
| TU | Transport Unit |
| UE | User Equipment |
| UL | Up Link |
| URLLC | Ultra Reliable Low Latency Communications |
| VNFs | Virtual Network Functions |
| WG | Working Group |
| xApp | Near RT RIC Platform Application |
| xNF | Any Network Function |