

# 5G testing done right

## CPRI

The CPRI is the mainstream communication protocol in current fronthaul networks that transports the digital RF signal on the optical link between the BBU and the RRH. The BBUs main function is to convert the IP/Ethernet data coming from the mobile backhaul into digitalized RF signals (I-Q data). Today, CPRI rates are designed to support up to 24.3 Gbit/s of RF data capacity. CPRI operates at data rates from 614 Mbit/s at the low end to more than 10 Gbit/s at the high end but only up to 500 Mbit/s are available for customers. The delta between the link rate and the customer speed is due to heavy processing in the CPRI protocol (i.e., the conversion from digital to analog RF).

The main features of CPRI include a user plane that transports the IQ data, a C&M plane that provides control signaling to and from the RRH, and a synchronization plane that transfers synchronization and timing information between nodes.

CPRI line bit rate option	CPRI bit rate (Mbit/s)	Line coding	Protocol version (scrambling)
1	614		
2	1228.8		
3	2457.6		
4	3072.0	8b/10b	Version 1: No scrambling
5	4915.2		
6	6144.0		Version 1: No scrambling Version 2: Scrambling Scrambling recommended
7	9830.4		
7A	8110.08		
8	10137.6		
9	12165.12	64b/66b	Version 2: Scrambling
10	24330.24		

Source: Netmanias

## 5G C-band

5G C-band offers a balance between coverage and capacity, providing faster data speeds and improved network reliability compared to lower frequency bands. It enables efficient data transfer and supports a wide range of applications, driving mobile connectivity and IoT advancements.

### Key considerations

- Integrated RU eliminates the need for coax and sweep testing
- Transmission is achieved entirely via fiber-to-the-antenna (FTTA) connectivity
- Time division duplexing (TDD) technology is predominantly used
- mMIMO antennas enable beamforming. When used with C-band frequencies, they deliver faster data speeds, improved network capacity, and consistent overall user experience.

## 5G technical requirements

Reliability/reactive	Mobile broadband	Massive IoT
URLLC	eMBB	mMTC
<1 ms Ultra-low latency	1.4x Mobility [500 km/h]	1000x Connection density [106 devices/km2]
20 Gbit/s Peak throughput	100 Mbit/s User throughput	100x Network energy efficiency

This can be achieved through:

- New spectrum bands and NR antennas
- Centralization and RAN functional split
- Network slicing (E2E virtualization)
- Ultra-low latency < 1 ms 99.9999% reliability

Requiring highly reliable RAN (5G-NR) based on Cloud-RAN

## eCPRI

As the industry migrates to LTE-A Pro and 5G, requirements including latency, power loss and CPRI BER will become concerns, given the need for faster fronthaul and backhaul speeds. Fronthaul networks will be required to support speeds of up to 25 Gbit/s, 50 Gbit/s, even 100 Gbit/s with the higher traffic loads and more demanding services. New specifications such as eCPRI are being released to support new 5G services and massive MIMO deployments. This new fronthaul packet-based protocol is dedicated to transporting radio data over Ethernet or IP networks between the DU and the RU in 5G networks.

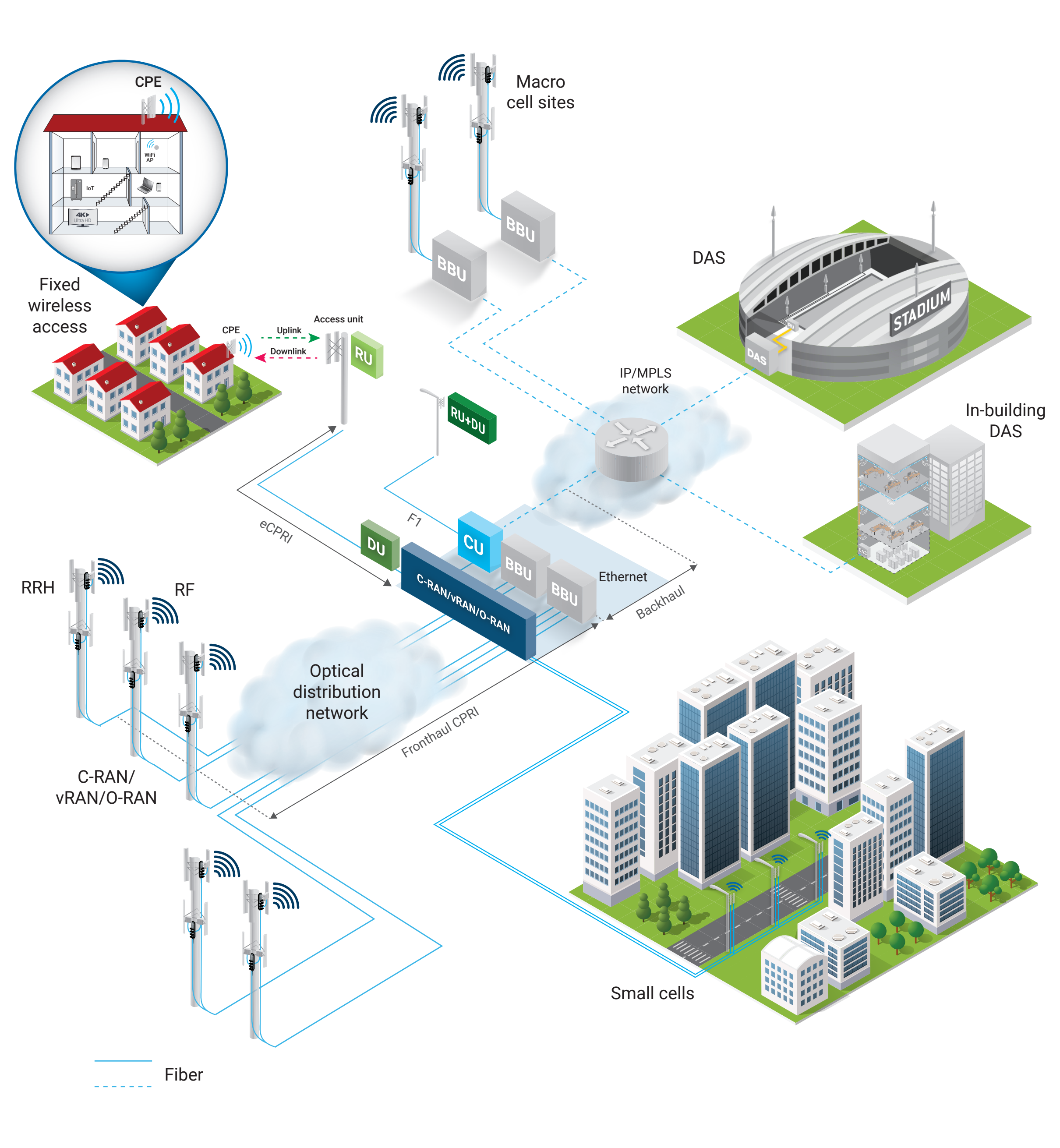
## 5G-NR functional split options

### eNB/gNB functional split

- CPRI
- New split option 7 (eCPRI)
- New split option 2

## Three spectrum bands: low, mid, and high

Low band (FR1) 450 MHz - 1 GHz  
Mid band (FR1) 1 GHz - 7.125 GHz  
High band/mmWave (FR2) 24 GHz - 71 GHz



## Boost your network's performance

### CPRI, eCPRI and F1 interface

#### Link validation - RRH/RU testing

**Objectives (deployment & troubleshooting)**

- Validate CPRI transport link
- Validate RRH operation
- Identify source of RF interference
- Complete FTFA infrastructure validation
- Validate antenna and coax cable system using VSWR and RSSI levels
- Validate RF transmission using OTA spectrum analyzer

**Benefits**

- Eliminate unnecessary tower climbs by testing RRH health from the bottom of the tower via BBU emulation

#### RF spectrum analysis over CPRI

**Objectives (deployment & troubleshooting)**

- Access RF signals at the BBU location either at the bottom of the tower or at the C-RAN hub via the CPRI link
- Analyze the standard RF metrics such as DTE, VSWR and RF power
- Validate CPRI RF spectrum by accessing the digital uplink, where the CPRI protocol carries the RF signal in a digital format (IQ data)
- Identify and troubleshoot RF signal quality in cell sites

**Benefits**

- Fast diagnosis of issues such as external RF interference, internal and external PIM
- Quickly eliminate RF interference sources
- Simplify and speed up cell site deployment
- Reduce maintenance and troubleshooting expenses by eliminating unnecessary truck rolls and tower climbs
- Optimize network reliability and service quality at fiber-based cell sites

#### Timing and synchronization

**Objectives (deployment & troubleshooting)**

- Confirm if SyncE and IEEE 1588 PTP services are active and validating the synchronization services
- Validate clock quality level, PDV and SyncE frequency across the network
- Confirm timing accuracy by measuring time error between base station and grandmaster
- Pinpoint synchronization issues in the grandmaster or across the network using grandmaster emulation
- Analyze intercell interference or slot overlap with the gated sweep feature in the spectrum analyzer

**Benefits**

- Built-in high precision GNSS receiver for accuracy down to the nanosecond (± 5 ns)
- High-accuracy GNSS receiver slashes set-up time to under 20 minutes
- Easy-to-configure test application for measuring one-way latency, time error and wander
- Absolute time error results from multiple PCs at a glance, helping to resolve C-band degradation issues quickly, easily and accurately

## Fiber

### Fiber inspection

**Objectives (deployment & troubleshooting)**

Inspect and clean:

- Active equipment (BBU and RRH)
- CPRI panel
- Junction box
- Test jumper
- Cable connectors
- MUX/DEMUX

**Benefits**

- Assess connector quality which is an essential step during fiber commissioning and installation
- Ensure a problem-free network by avoiding issues that stem from dirty or bad connectors
- Maintain connector certification records which can be important for future reference

### Fiber characterization

**Objectives (deployment & troubleshooting)**

Validate:

- Total fiber length
- ORL: the ratio of the forward optical power to the reflected optical power
- Splice loss: loss of optical power at every (fusion) splice point
- Connector loss: the loss of light at a mated pair of connectors
- Connector reflection: the percentage of power reflected back from a mated pair of connector

**Benefits**

- Ensure proper transmission by controlling the power loss in the network against the link loss budget specifications from the network design requirements
- Complete fiber characterization to document the fronthaul fiber

### Fiber verification

**Objectives (deployment & troubleshooting)**

Validate:

- Total fiber length
- Total link loss (attenuation)
- ORL: the ratio of the forward optical power to the reflected optical power
- Identify and locate elements causing excess loss or excess reflection

**Benefits**

- Health check to identify and eliminate common issues on the fronthaul fiber

### OSA

**Objectives (deployment & troubleshooting)**

Validate:

- Signal wavelength
- Signal power
- Signal power is higher than the receiver sensitivity

**Benefits**

- Ensure that there will be transmission on the link
- Eliminate BER on the link

## EXFO's fronthaul and backhaul network test solutions

### FIP-500

**Fiber inspection probe**

Fastest and first inspection in the industry for single, duplex and multi-fiber connectors, with the most reliable results. Self-contained, fully automated tool to test all day without needing to recharge batteries or offload results.

### Optical Explorer

**Industry's first optical fiber multimeter**

Optical Explorer is a 5-star fiber testing solution made simple for frontline technicians. It performs fiber link verification and automated fault tracking in seconds, empowering technicians to explore further and troubleshoot potential issues. Optical Explorer displays fiber length, loss and optical return loss (ORL) in under 3 seconds, includes built-in power checker and light source and on-the-spot detection and location of common causes of failures.

### iOLM/OTDR

**Intelligent Optical Link Mapper/OTDR**

This innovative OTDR-based application uses multipulse acquisitions and advanced algorithms to deliver information on every element in the link by providing a one-touch, automatic analysis and clear link view display. iOLM minimizes training and avoids misconfiguration via automatic parameter settings and clear go/no-go results, turning complex OTDR information into simple and accurate analysis via Link-Aware™ technology. It also provides the ability to test two fibers simultaneously with the loopback testing method.

### FTB 5GPro

**Ultra-portable multiservice test solution**

The FTB 5GPro is an intelligent, automated and modular test solution that delivers unmatched operational efficiency when validating 4G and 5G networks. It combines connector inspection, fiber characterization, CPRI link validation up to option 8 and CPRI option 10, 10/25G eCPRI protocol testing, RF spectrum analysis over CPRI, OTA interference hunting, timing and synchronization, grandmaster emulation, support for FR1 & FR2 bands, Ethernet testing up to 400G and optical transceiver validation. This solution integrates all the testing functionalities required to effectively install, activate and troubleshoot fronthaul, midhaul and backhaul networks.

### Intelligent OpticalRF (IORF)

**Intelligent RF spectrum analyzer over CPRI**

The IORF application provides the industry's most powerful real-time high-resolution RF spectrum analysis over CPRI. Integrated into EXFO's portable FTB 5GPro test solution, IORF features a one-button, fully automated testing approach that provides complete analysis of the RF spectrum with an easy-to-understand, pass-or-fail verdict. It requires no configuration, saving over 45 minutes in set-up time. IORF quickly and easily identifies internal and external passive intermodulation (PIM) issues in less than 5 minutes, providing cell techs with the speed, granularity and clarity to get the job done right, the first time.

### 5GPro Spectrum Analyzer

**Over-the-air (OTA) spectrum analyzer**

Combined with IORF on the same compact FTB 5GPro platform, the 5GPro Spectrum Analyzer with audible tone is designed for safe and effective RF interference and PIM hunting. Powered by automated, field-specific features instead of confusing or unnecessary apps, it provides visibility into 4G LTE and 5G RF propagation in FR1 (450 MHz to 6 GHz) or FR2 (24.25 GHz to 40 GHz) frequency bands with the same device for extreme upgradability and flexibility. It's smart, UX-optimized GUI design simplifies RF testing with 5G SSB blind scanner and TDD gated sweep.

### Timing and synchronization

**1588 PTP, SyncE and OTA time error test solution**

Available on the FTB 5GPro test solution, this simple-to-use, highly accurate test methodology for timing and synchronization validation over fiber (1588-PTP, SyncE and wander/time error) and OTA measurements provides the fastest set-up time in the industry. Integrating a high-accuracy GNSS receiver slashes test-set-up time from 3 hours to under 20 minutes, delivers accuracy down to the nanosecond and ensures reliable measurements every time. Time error results from multiple PCs can also be taken simultaneously and are available at a glance, without the need to connect to network equipment.

### FTB-5235

**OSA**

The FTB-5235 entry-level OSA is an easy-to-use instrument perfectly tailored for C-RAN analysis, thanks to its support of DWDM and CWDM technology. This compact, easy-to-use OSA addresses various applications with a single product, and provides accurate channel power and channel wavelength measurements.

### EX10

**Multigigabit and WiFi test solution**

EX10 is a purpose-built, app-enabled multigigabit and WiFi test solution designed to qualify broadband connections delivered to both residential and business Ethernet customers. The EX10 validates the delivery of full line rate 10 Gigabit Ethernet speeds using Speedtest® by Ookla™ to provide latency and download and upload measurements, as well as complete WiFi 6E testing with channel stats analysis.

## Ethernet

### Fixed wireless access and backhaul testing

Backhaul/packet-based fronthaul

**Objectives (deployment & troubleshooting)**

- Test and validate transmission performance of backhaul links to ensure that BER, throughput, latency, jitter and frame loss rates are met
- Troubleshoot issues by segmenting the investigation and identifying the root cause from the backhaul perspective
- Full line rate 10 Gigabit capability for wired electrical RJ45 interface, optical SFP and WiFi 6E up to 1.8 Gbit/s, providing latency and download and upload measurements
- Validate residential network performance from the wired to the wireless connection

**Benefits**

- Fast and efficient deployment of the backhaul network with easy validation of optical power budgets and KPIs at the installation phase
- Lower OPEX by dispatching the right teams to quickly resolve network issues in the backhaul and fronthaul (in most cases, the technical skills of both backhaul and fronthaul teams include different technologies)
- Guarantee speeds delivered match subscriber SLAs
- Improve subscriber quality of experience and reduce churn

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## Acronyms

4G/5G	4 <sup>th</sup> /5 <sup>th</sup> generation mobile network	FTTA	fiber-to-the-antenna	OSA	optical spectrum analyzer
BER	bit error rate	FTTP	fiber-to-the-premises	OTA	over-the-air
BBU	baseband unit	GNSS	global navigation satellite system	PCI	physical cell ID
CPE	customer premise equipment	HDLC	high-level data link control	PDCP	packet data convergence protocol
CPRI	common public radio interface	IoT	internet of things	PDV	packet delay variation
C&M	control and management	LTE	3GPP long-term evolution (4G)	PON	passive optical network
C-RAN	centralized radio access network	LTE-A	LTE-advanced	RAN	radio access network
CU	central unit	MAC	media access control	RF	radio frequency
CWDM	coarse wavelength division multiplexing	MIMO	multiple input multiple output	RLC	radio link control
DAS	distributed antenna system	mMIMO	massive multiple input multiple output	RRH	remote radio head
DU	distribution unit	mMTC	massive machine type communication	RU	radio unit
DWDM	dense wavelength division multiplexing	NFV	network function virtualization	SA	standalone
EAD	Ethernet access device	NR	new radio	TDD	time division duplexing
eCPRI	enhanced common public radio interface	NSA	non standalone	URLLC	ultra-reliable low latency communication
eMBB	enhanced mobile broadband	OADM	optical add-drop multiplexer	vCU	virtualized central unit
eNodeB	evolved node B	OBSAI	open base station architecture initiative	WDM	wavelength-division multiplexing