5G Technology Basics

Supplier Excellence Program

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Declaration
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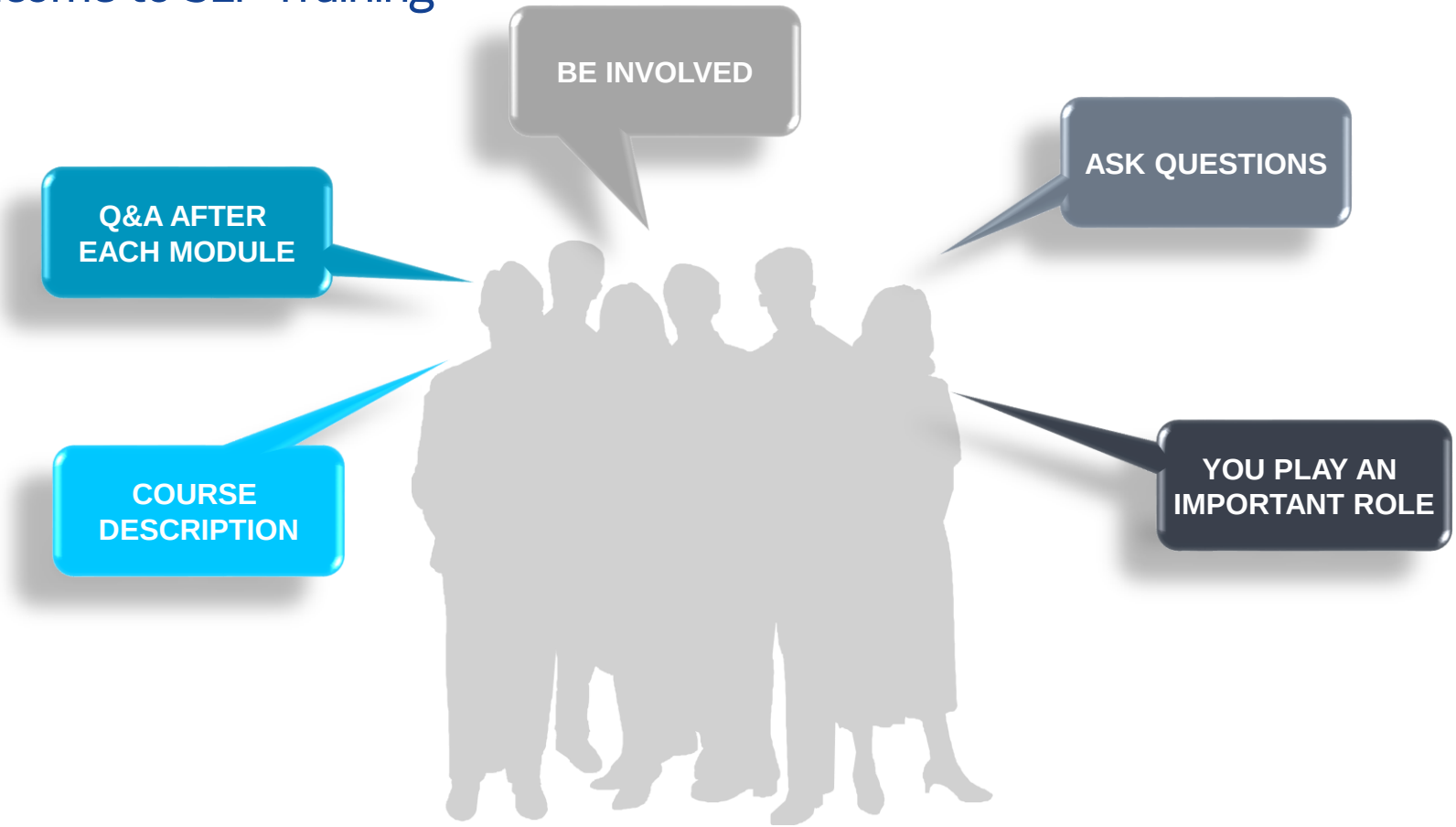
Welcome to SEP Training



Why Are You Here?

- **YOU** play an important role in this project.
- **YOU** can choose to be great at what you do.
- **YOU** have a leadership role.
- **YOU** can make a difference.

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WebEx Environment Reminders

- **MUTE** your phone lines.
- **PARTICIPATE** by asking questions.
- **ENSURE** you are qualified to be here.
- **ASK** questions if you don't understand.
- **WE ARE HERE FOR YOU!**

Training Modules

- Introduction to 5G
- Evolution from 1G to 5G
- Comparison of 1G to 5G Technologies
- Key Concepts & Features
- Architecture & Hardware & Software of 5G (Radio Units)
- Airscale Evolution
- 5G Commissioning & Integration Evolution and Options
- Review and Q&A

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Course Description

Course Name	5G Technology Basics
Level	Information Session. Level 0
Target Group	Personnel wanting to attend an additional Nokia5G project-specific training course
Objectives:	After the training, the participant will be able to: • Understand 5G Technology Basics • Understand Wireless Evolution • Describe the Nokia Hardware and Software • Understand Airscale Evolution
Duration	0.5 day
Delivery Method	Theory/WebEx
Max. Number of Participants	20
Prerequisite Courses	N/A
Underpinning Knowledge & Skills	Telecommunications knowledge. Basic personal computer skills
What to Bring with You	• Proof of valid PTID number and/or PTID badge
Training Modules	• Introduction to 5G • Evolution from 1G to 5G • Key Concepts & Features • Architecture & Hardware & Software of 5G (5G Radio Units, Radio Units <>6Ghz) • Airscale Evolution • 5G Commissioning/ Integration Evolution and Options • Review and Q&A
Output	Upon successful completion participant should be prepared for a Nokia project-specific technical 5G course

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INTRODUCTION TO 5G

5G End-to-end Strategy

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What is 5G?

- 5G Wireless: 5th generation wireless technology
- Complete wireless communication with almost no limitations
- Can be called REAL wireless world
- Has incredible transmission speed
- Still in trials

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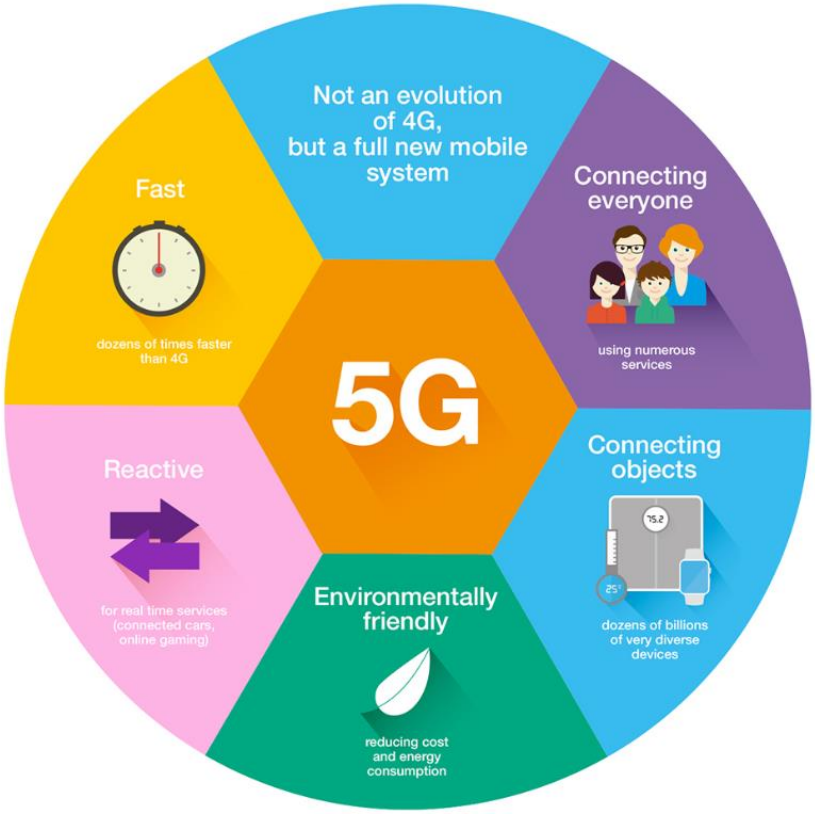
What Does it Offer?

- Worldwide cellular phones
- Extraordinary data capabilities
- High connectivity
- More power & features in hand held phones
- Large phone memory
- More dialing speed
- More clarity in audio & video
- Expected speed up to 1 Gbps



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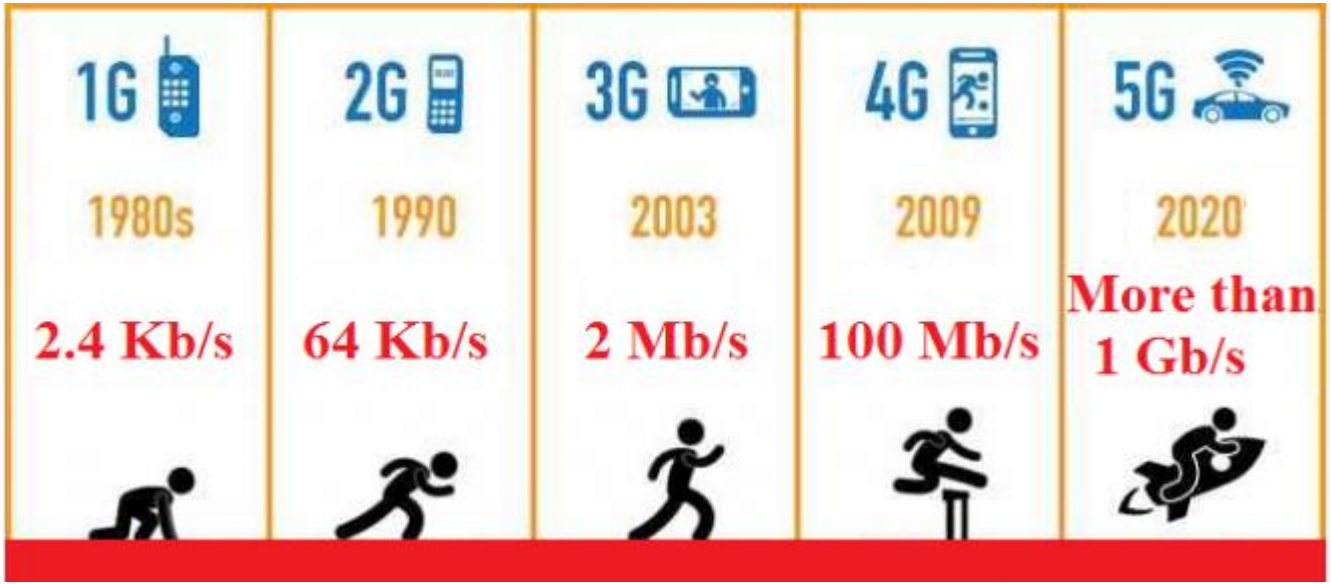
THE EVOLUTION OF 1G TO 5G TECHNOLOGIES

Evolution of 1G to 5G Speeds



1G to 5G Comparison

Technology	1G	2G/2.5G	3G	4G	5G
Deployment	1970/1984	1980/1999	1990/2002	2000/2010	2014/2015
Bandwidth	2kbps	14-64kbps	2mbps	200mbps	>1gbps
Technology	Analog cellular	Digital cellular	Broadband width/CDMA /IP technology	Unified IP & seamless combo of LAN/WAN/WLAN/PAN	4G+WWWW
Service	Mobile telephony	Digital voice, short messaging	Integrated high quality audio, video & data	Dynamic information access, variable devices	Dynamic information access, variable devices with AI capabilities
Multiplexing	FDMA	TDMA/CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit/circuit for access network, air interface	Packet except for air interface	All packet	All packet
Core network	PSTN	PSTN	Packet network	Internet	Internet
Handoff	Horizontal	Horizontal	Horizontal	Horizontal & Vertical	Horizontal & Vertical

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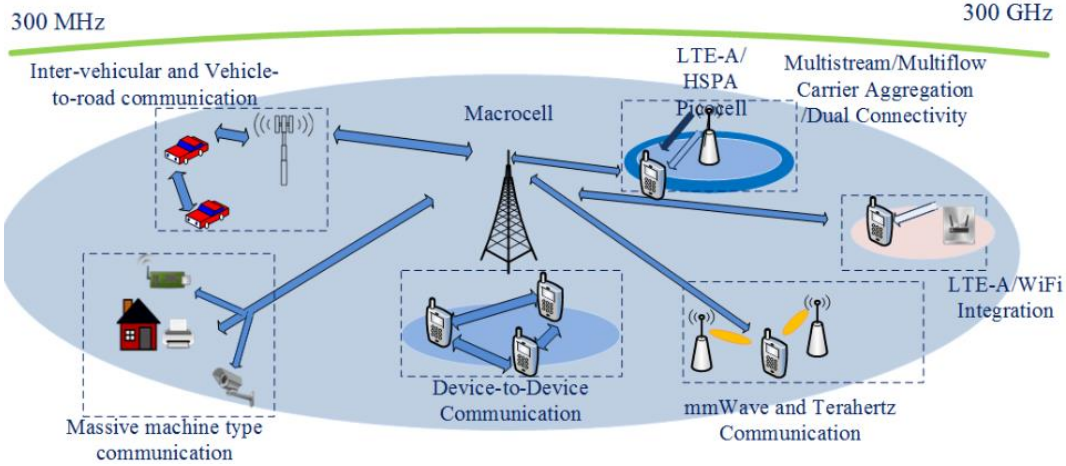
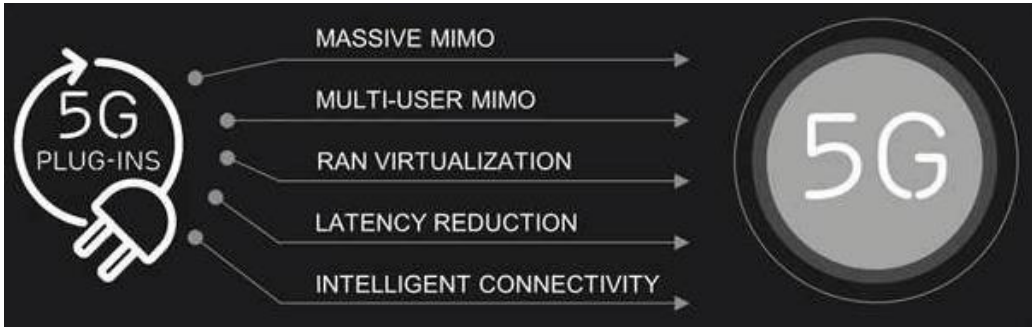
5G KEY CONCEPTS & FEATURES

5G Key Concepts & Features

- Real wireless world with no more limitations with access & zone issues
- Wearable devices
- IPv6, where a visiting care of mobile IP address is assigned according to location & connected network
- One unified global standard
- Smart radio
- The user can simultaneously be connected with several wireless access technology
- Multiple concurrent data transfer path



5G Key Concepts & Features



- High resolution for crazy cell phone users
- Bi-directional large BW
- Less traffic
- >1Gbps connectivity speed
- Enhanced & available connectivity just about the world
- Uploading & Downloading speed of 5G touching the peak (up to 1 Gbps)
- Better & fast solution
- High quality service based on policy to avoid error
- Support virtual private networks
- More attractive & effective
- Provides subscriber supervision tools for fast action

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Advantages of 5G

- Data BW of 1 Gbps or higher
- Globally accessible
- Dynamic information access
- Available at low cost

Application of 5G

- Wearable devices with AI (Artificial Intelligence) capabilities
- Pervasive (Global) networks
- Media independent handover
- Radio resource management
- VoIP (Voice over IP) enabled devices
- With 6th sense technology

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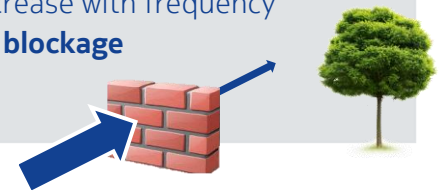
5G Performance Aspects

mmWave and cmWave propagation characteristics

Higher bands bring propagation challenges in 5G

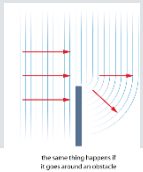
Higher losses

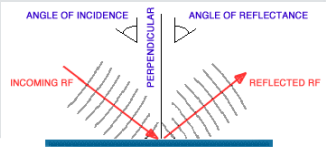
- Atmospheric lossess (Free space loss)
- **Additional losses** to be considered (rain, vegetation)
- **Penetration loss** (material dependent) tends to increase with frequency
- **Body/head blockage**



Diffraction and diffuse scattering

- Diffraction and reflection loss increases with frequency
- Diffuse scattering will be more pronounced at higher frequencies





Consistency across frequency and space

- Huge differences in propagation and fading characteristics owing to width of any single carrier (100 MHz)
- MU-MIMO/massive MIMO needs to capture spatial correlation of channel

- Larger antenna arrays - Massive MIMO
- RF based beamforming
- Directional antennas on UE side
- Dedicated indoor installations

New channel models are developed for 5G needs:

- 3GPP Urban Micro (UMi), Urban Macro (Uma), Indoor Hotspot (InH)
- ITU-R M.2135

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5G Features

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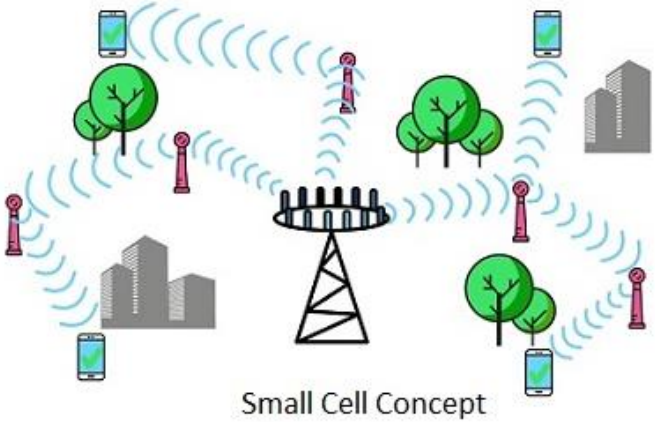
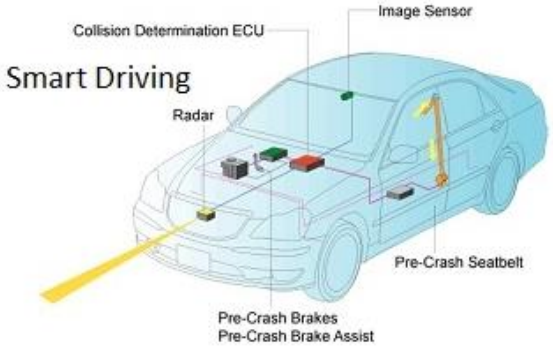
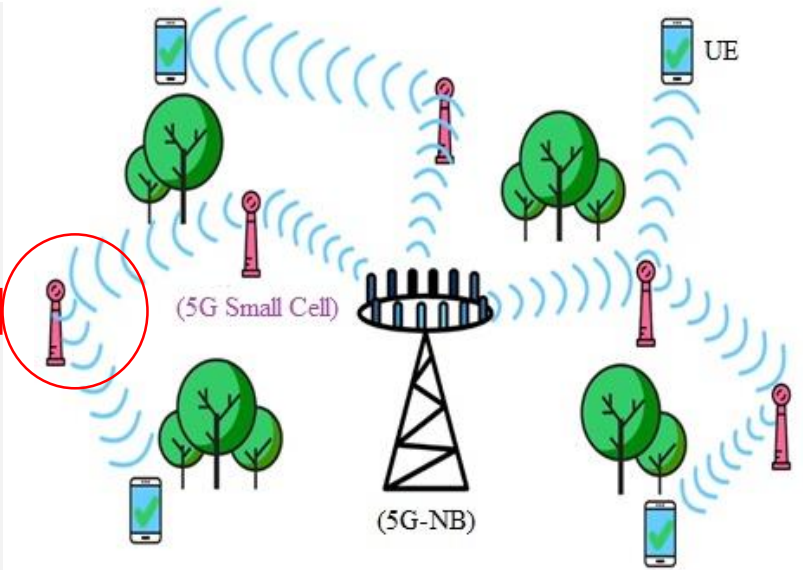
Millimeter Wave Radio





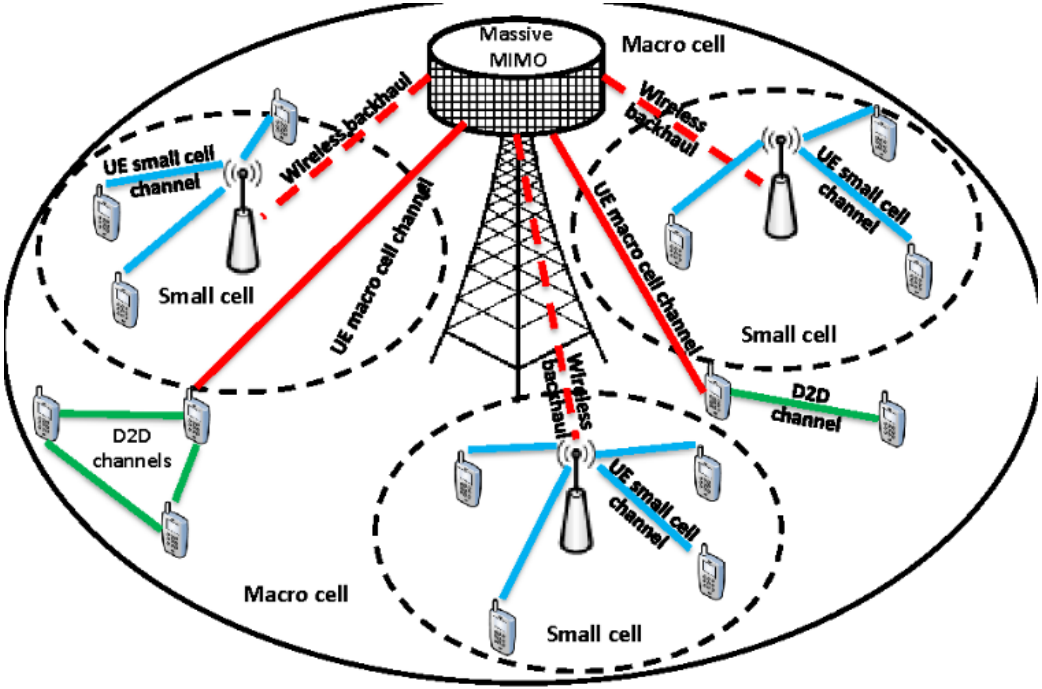
Small Cells

Small cells can be used to provide in-building and outdoor wireless service. Mobile operators use them to extend their service coverage and/or increase **network** capacity.



Massive MIMO

Massive multiple-input, multiple-output, or **massive MIMO**, is an extension of **MIMO**, which essentially groups together antennas at the transmitter and receiver to provide better throughput and better spectrum efficiency.



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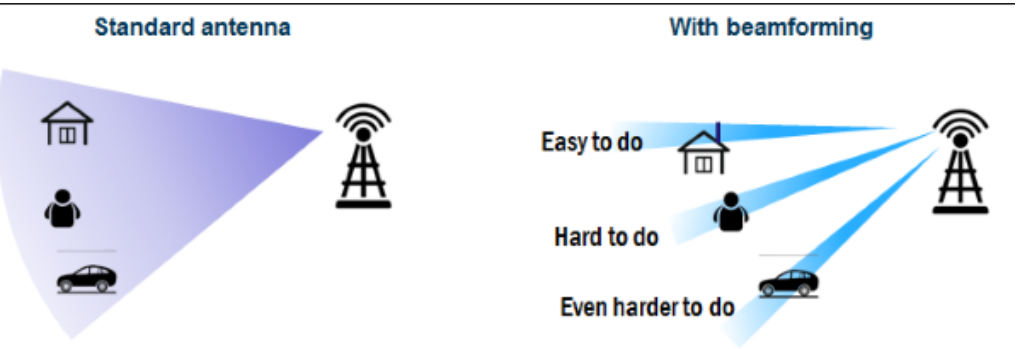
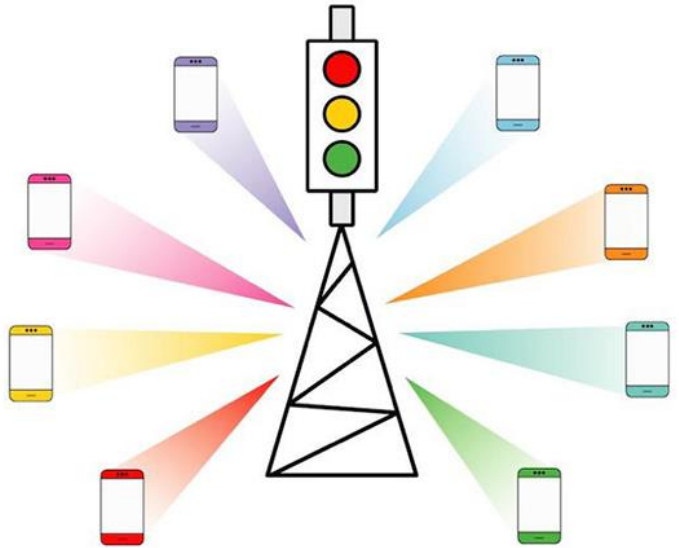
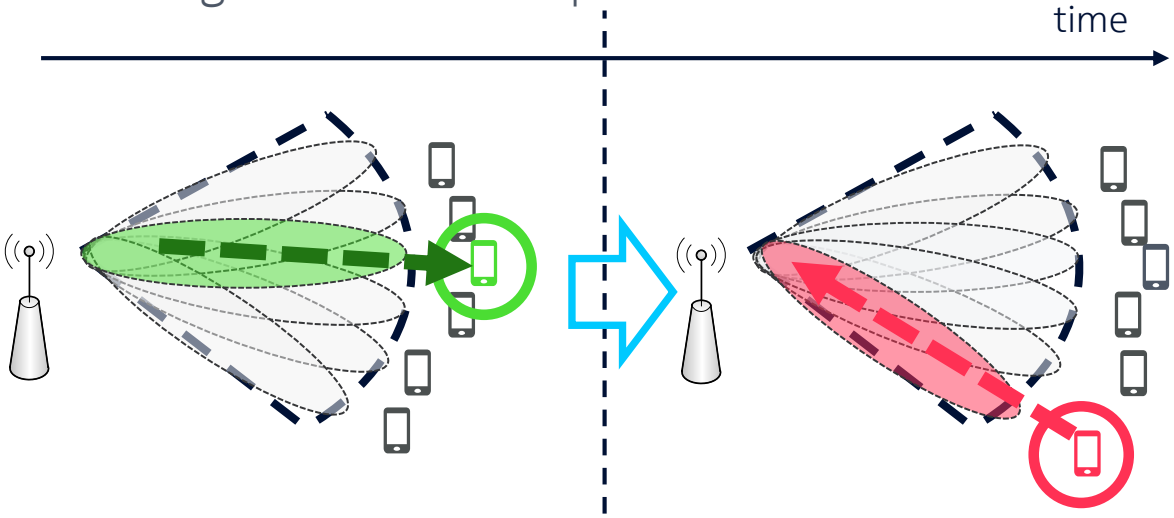
Beamforming

To improve performance, we deploy a **5G** system at 15GHz with 100MHz TDD, using massive **beamforming** with an antenna with 200 elements. … The system is designed to enable very flexible UE **beamforming**, and implements an ultra-lean design of its control





Beamforming – Downlink and uplink



Downlink transmisson, followed by uplink transmission. The switching can be done on slot basis, or on symbol basis

The TDD transmission mode means that there could be DL or UL frames at the same carrier frequency. The DL and, respectively, UL scheduler will choose the beam direction that will be used during the incoming TTI, according to the frame type (direction)

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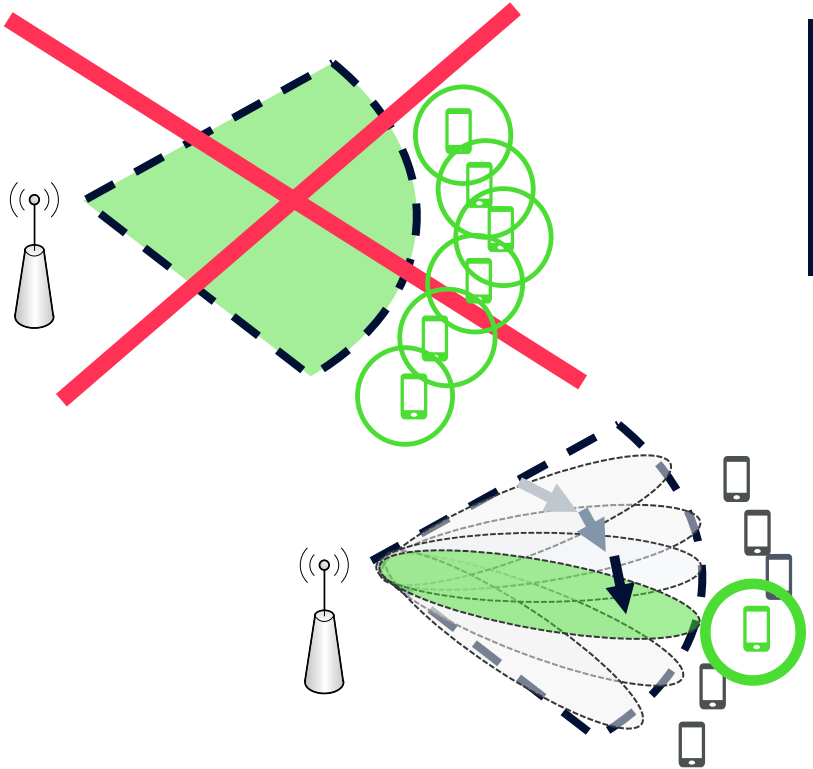
5G New Radio

Beamforming - common channels coverage

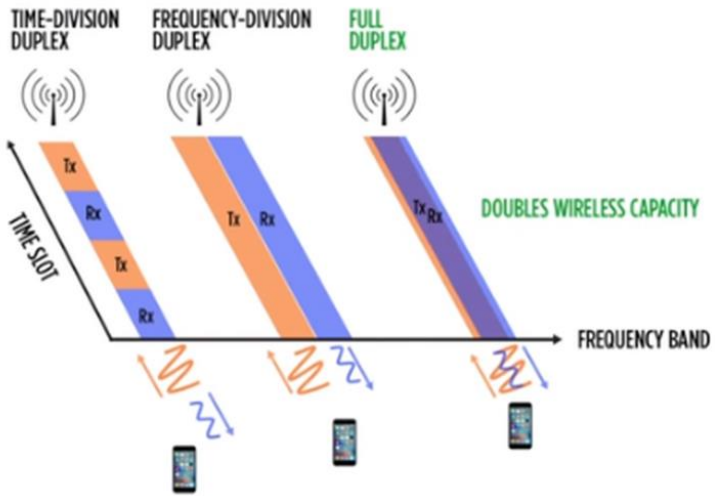


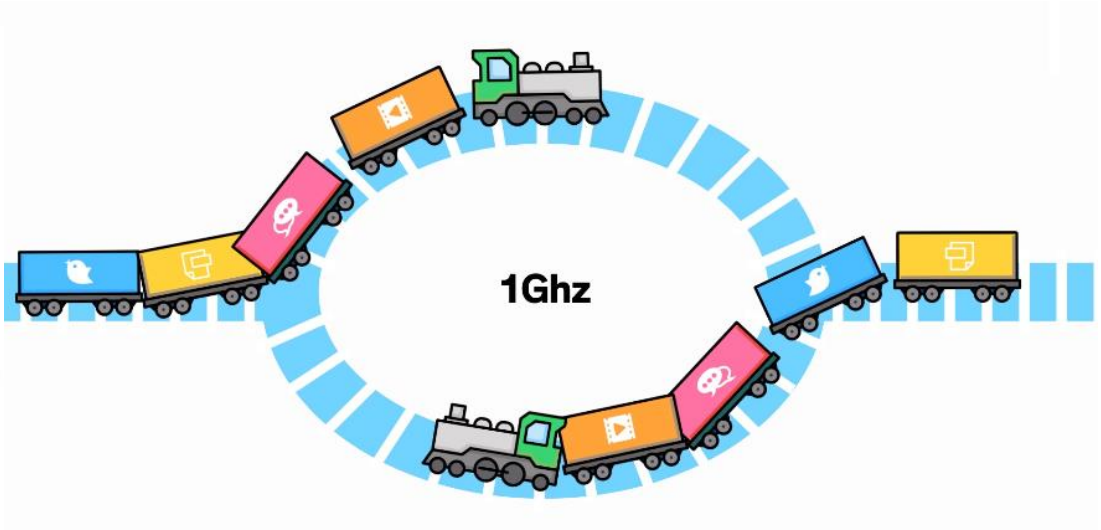
The continuous coverage of the cell area is not there any more. The problem is: how to provide common control channels. These channels need to be heard by all UEs in the coverage area of the given cell.

The answer is: **sweeping**. At predefined amounts of time, the same information is being sent sequentially across al beams (e.g. MIB) – think about a lighthouse for a real-world reference.

Full Duplex

Full-**duplex** data transmission means that data can be transmitted in both directions on a signal carrier at the same time. For example, on a local area network with a technology that has **full**-**duplex** transmission, one workstation can be sending data on the line while another workstation is receiving data.
For **example**, a telephone is a **full**-**duplex** device because both parties can talk at once. In contrast, a walkie-talkie is a **half**-**duplex** device because only one party can transmit at a time.





Video

Let’s watch a short video on the 5G features

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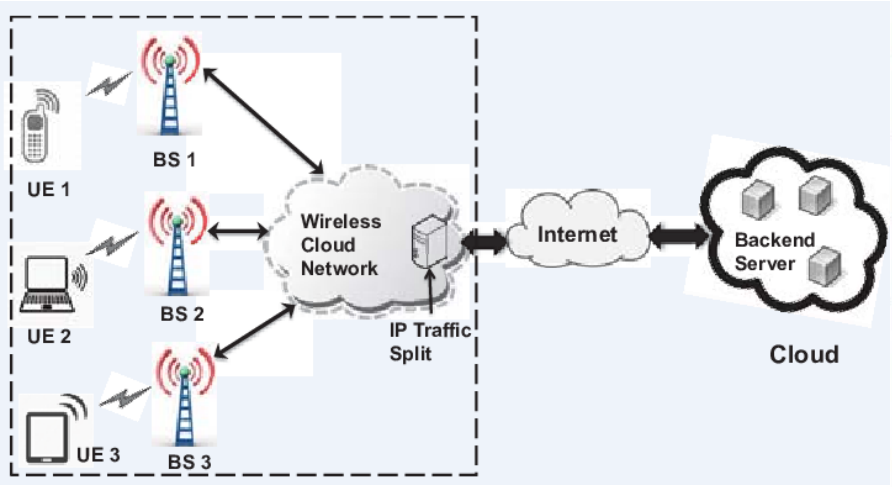
5G NB Architecture and Hardware Components

5G Basic Architecture



Application Layer	Application(Service)
Presentation layer	
Session Layer	Open Transport Protocol
Transport Layer	
Network Layer	Upper network layer
	Lower network layer
Datalink Layer	Open Wireless Architecture
Physical Layer	

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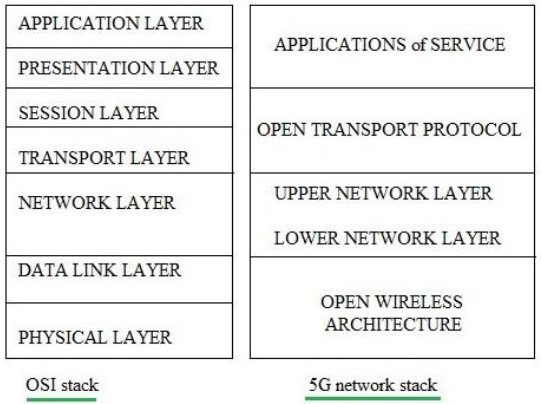
Open Wireless Architecture (OWA)

- OSI layer 1 & OSI layer 2 define the wireless technology
- For these two layers the 5G mobile network is likely to be based on Open Wireless Architecture (OWA)
- Physical layer + Data link layer = OWA

Network Layer

- All mobile networks will use mobile IP
- Each mobile terminal will be FA (Foreign Agent)
- A gNB can be attached to several mobiles or wireless networks at the same time
- The fixed IPv6 will be implemented in the mobile phones
- Separation of network layer into two sub-layers:
  (i) Lower network layer (for each interface)
  (ii) Upper network layer (for the mobile terminal)



Open Transport Protocol (OTP)

- Wireless network differs from wired network regarding the transport layer
- In all TCP versions the assumption is that lost segments are due to network congestion
- In wireless, the loss is due to higher bit error ratio in the radio interface
- 5G mobile terminals have transport layer that is able to be downloaded & installed – Open Transport Protocol (OTP)
- Transport layer + Session layer = OTP

Application (Service) Layer

- Provides intelligent QoS (Quality of Service) management over variety of networks
- Provides possibility for service quality testing & storage of measurement information in information database in the mobile terminal
- Select the best wireless connection for given services
- QoS parameters, such as, delay, losses, BW, reliability, will be stored in DB of 5G mobile
- Presentation layer + Application layer = Application

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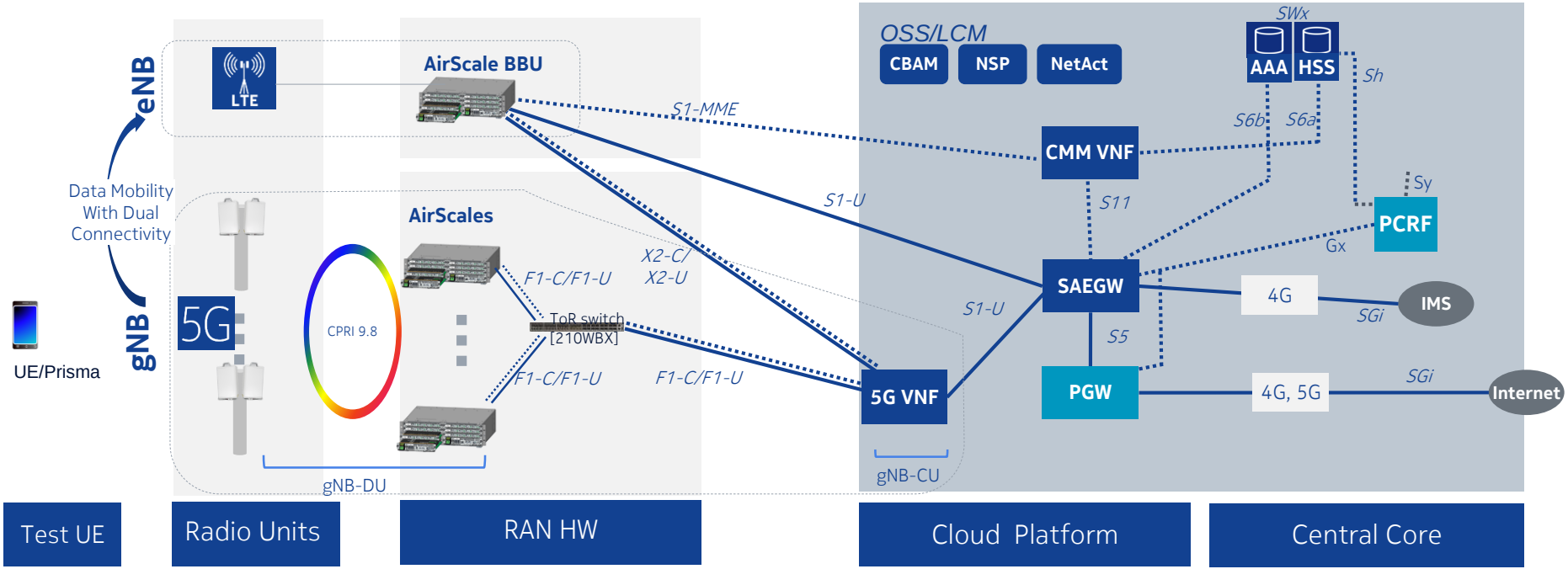
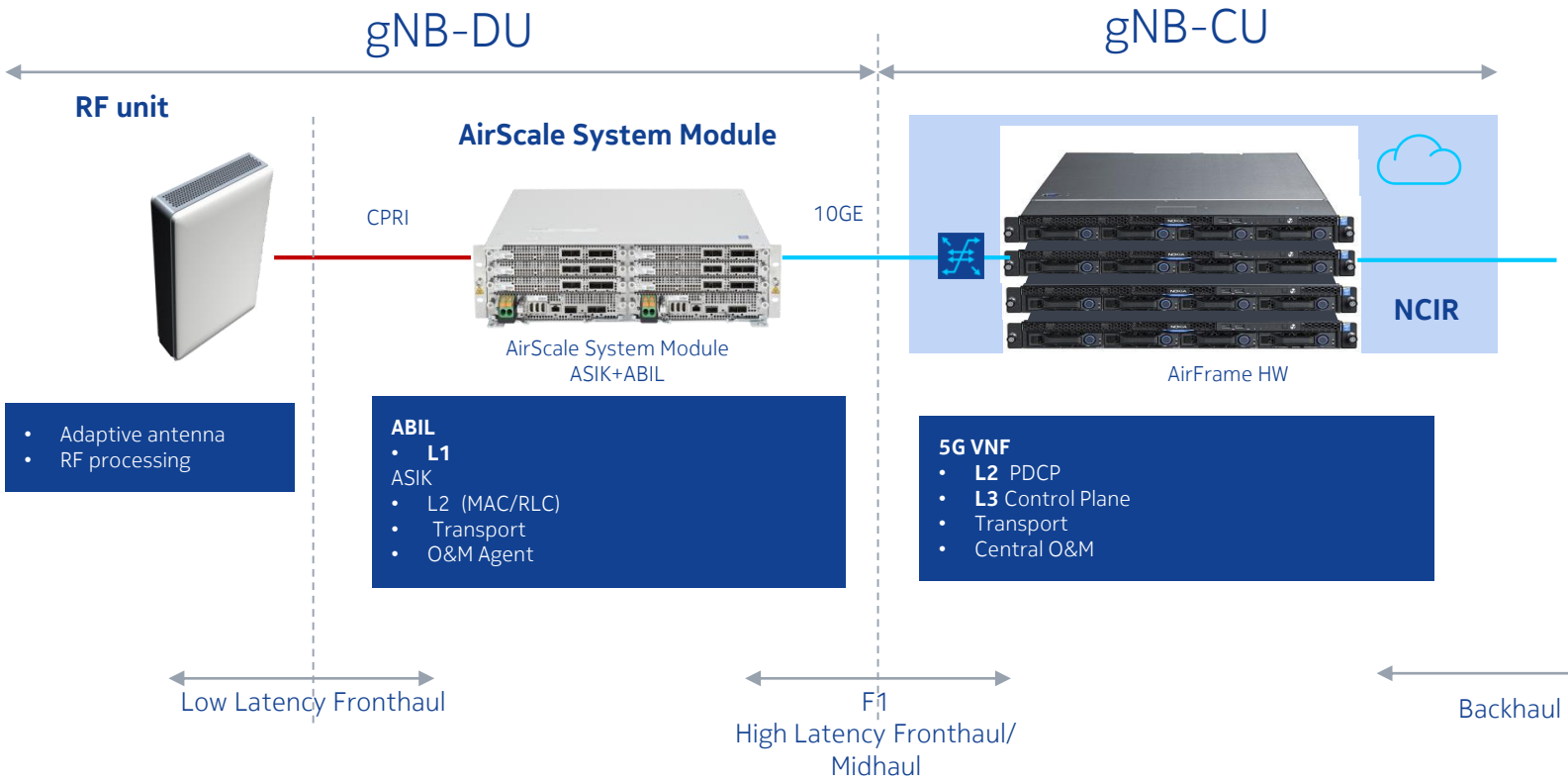
5G18A End to End Network Architecture

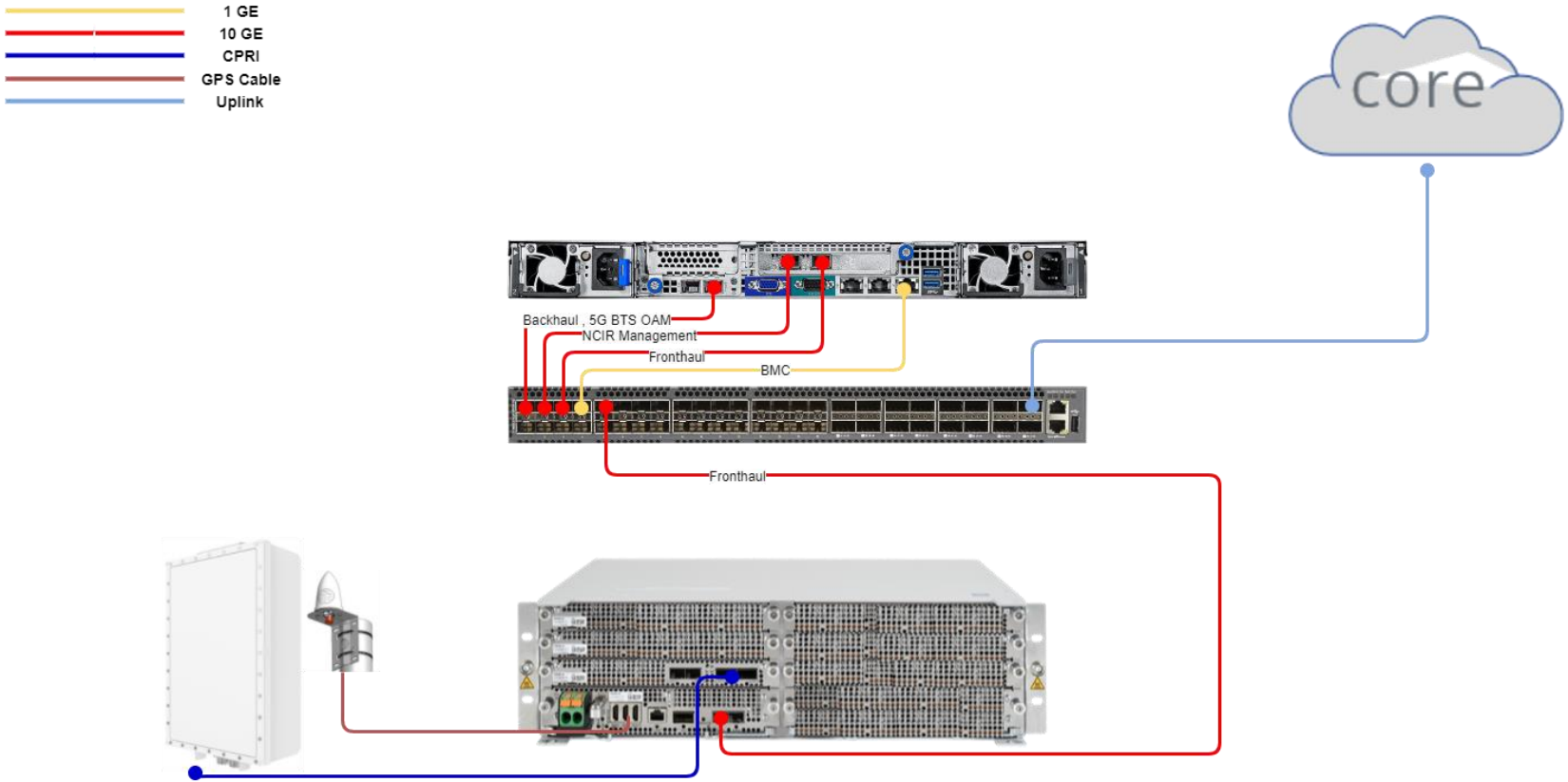


HW Products Realizing Physical Entities of 5G gNB

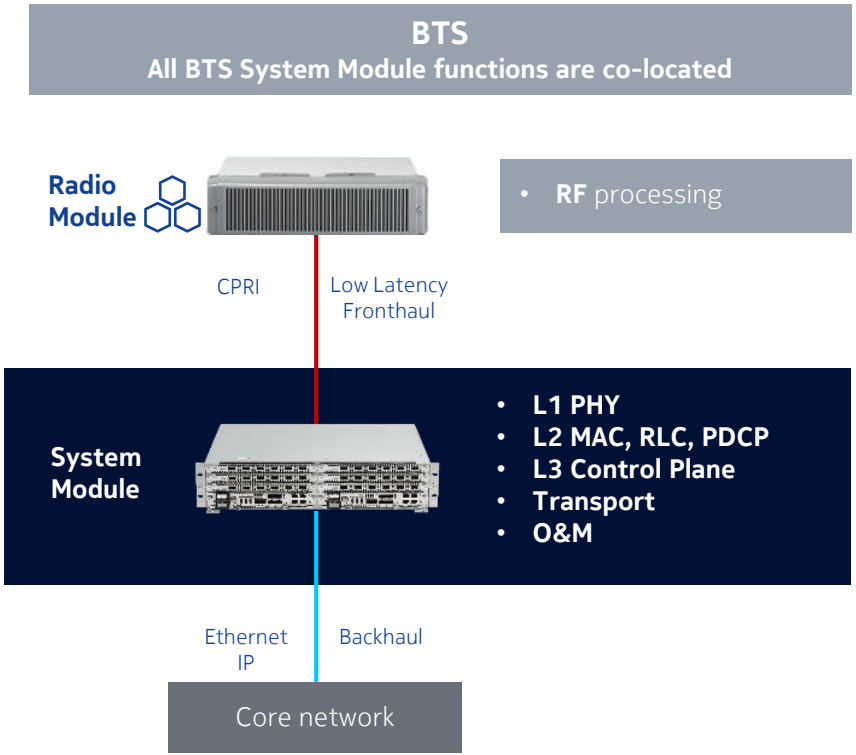
NCIR - Nokia Cloud Infrastructure for Real Time applications

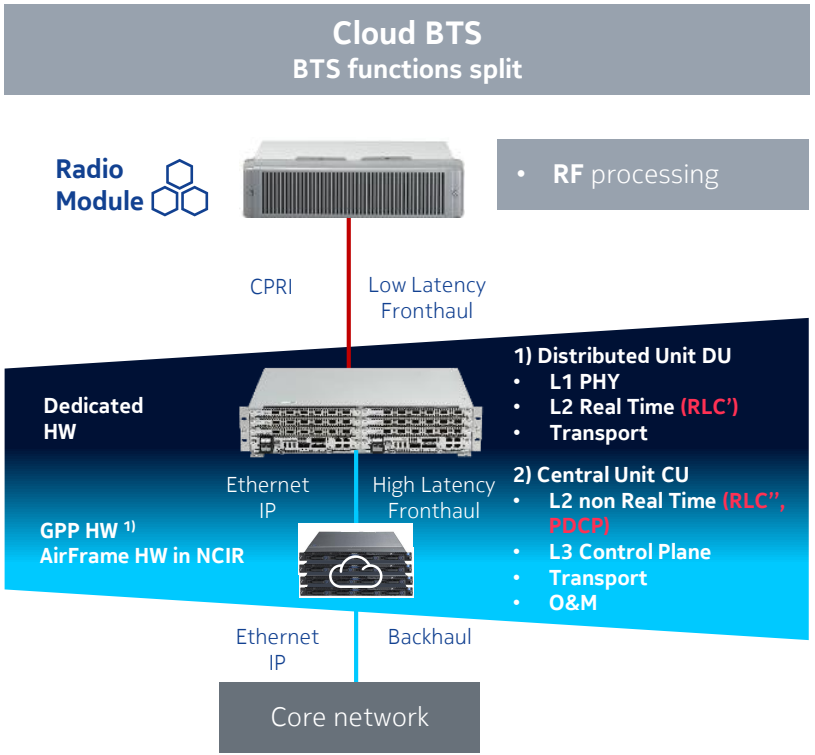


5G18A All in One Cloud BTS Cabling



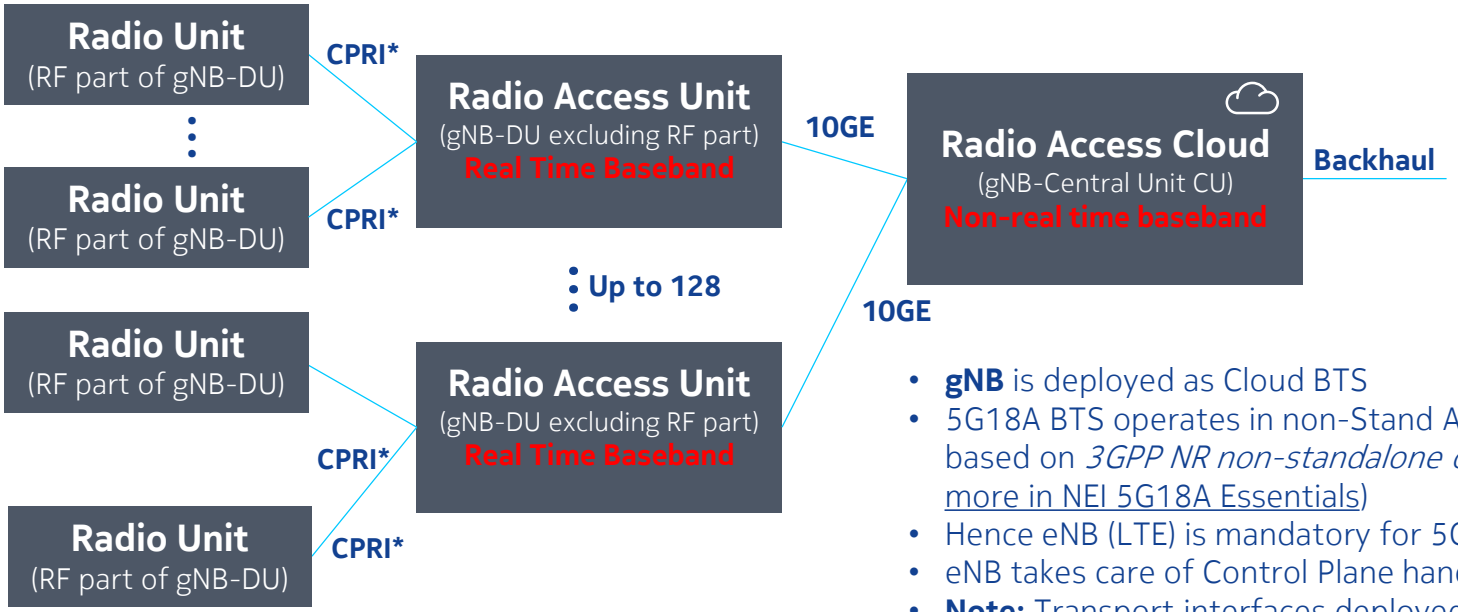
BTS Architecture Evolution From Traditional to Cloud BTS in LTE





1) GPP – General Purpose Hardware

Physical Entities Used to Deploy gNB Functionality in 5G18A



- **gNB** is deployed as Cloud BTS
- 5G18A BTS operates in non-Stand Alone (NSA) mode based on *3GPP NR non-standalone option 3X* (see more in NEI 5G18A Essentials)
- Hence eNB (LTE) is mandatory for 5G18A BTS
- eNB takes care of Control Plane handling
- **Note:** Transport interfaces deployed between physical entities are described in dedicated NEI materials

(*) Ethernet CPRI planned for 5G19 release for connecting ethernet radios to AirScale

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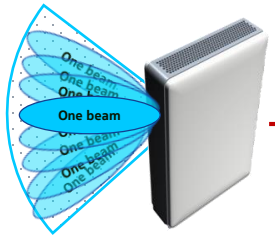
HW Products Realizing Physical Entities of 5G BTS in 5G18A

(*) Ethernet CPRI planned for 5G19 release for connecting ethernet radios to AirScale
NCIR - Nokia Cloud Infrastructure for Real Time applications
MAA – Massive MIMO Adaptive Antenna

	AirSCale MAA (RU) (RF part of gNB-DU)	**AirScale System Module (RAU)** (gNB-DU excl. RF part)	**NCIR (RAC)** (gNB-CU)
Product Name	Sector horizontal coverage		
Function	• Adaptive antenna • RF processing	**Real Time Baseband** • **L1** • L2 RLC • L3 Control Plane Real Time (see Notes) • Transport • O&M Agent	**Non-Real Time Baseband** • **L2** PDCP • **L3** Control Plane • Transport • Central O&M
Scales primarily with	• Number of cells • Cell TX/RX antennas • SU/MU-MIMO • gNB-DU Peak L1 Throughput		• Average cell throughput • Number of cells • Number of Active Users • Number of Control Plane events per second



CPRI*

AirScale System Module
ASIK+ABIL

10GE

ToR switch

AirFrame HW

Low Latency Fronthaul

F1
High Latency Fronthaul

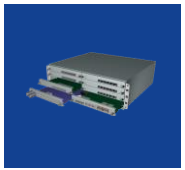
Backhaul

F1- 3GPP based interface for gNB-DU<->gNB-CU connection

Multiple BTS Product Variants With Common SW and Supporting New Interfaces

Cloud BTS

Non-Real Time Baseband



Real Time Baseband

RF Adaptive antenna

Scalability for high performance HetNets

5G Classical BTS

Alternative Future Solution

Non-Real Time Baseband

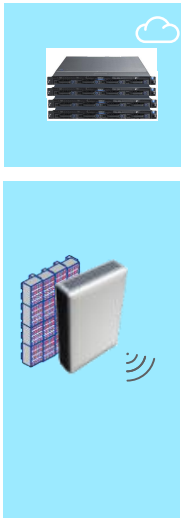
Real Time Baseband

RF Adaptive antenna

Cost efficient standalone solution for 5G

Cloud optimized BTS with Ethernet Radio

Alternative Future Solution



Non-Real Time Baseband

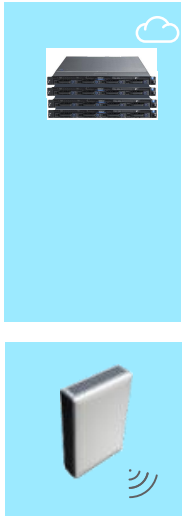
Real Time Baseband

RF Adaptive antenna

Radios connected directly to radio cloud. Capacity layer under LTE and indoor solution

Full Cloud BTS

Alternative Future Solution



Real Time enabled Edge Cloud

RF Adaptive antenna

Small Cell BTS for 5G

NSA – Non StandAlone mode, **SA** – StandAlone mode

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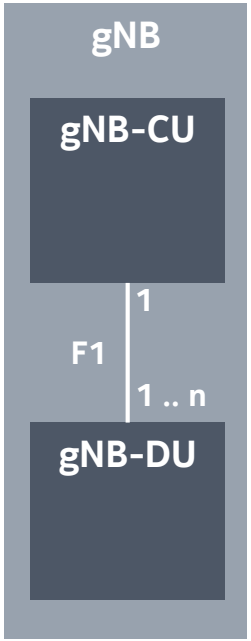
Next Generation NodeB (gNB)

- 3GPP defines gNB functionality:
  - **gNB →**
    - A logical NG-RAN node providing NR user plane and control plane protocol terminations towards the UE (source 3GPP TS 38.300), gNB is divided into following logical entities:
  - **gNB-CU (CU – Central Unit) →**
    - A logical node hosting RRC, SDAP and PDCP protocols, and which controls the operation of one or more gNB-DUs
    - The gNB-CU also terminates F1 interface connected with the gNB-DU (source 3GPP TS 38.401)
  - **gNB-DU (DU – Distributed Unit) →**
    - A logical node hosting RLC, MAC and PHY layers, and its operation, that is partly controlled by gNB-CU
    - One gNB-DU supports one or multiple cells. One cell is supported by only one gNB-DU
    - The gNB-DU terminates F1 interface connected with the gNB-CU (source 3GPP TS 38.401)



F1→ 3GPP based interface for gNB-DU<->gNB-CU connection
NG-RAN → Next Generation Radio Access Network
NR → New Radio

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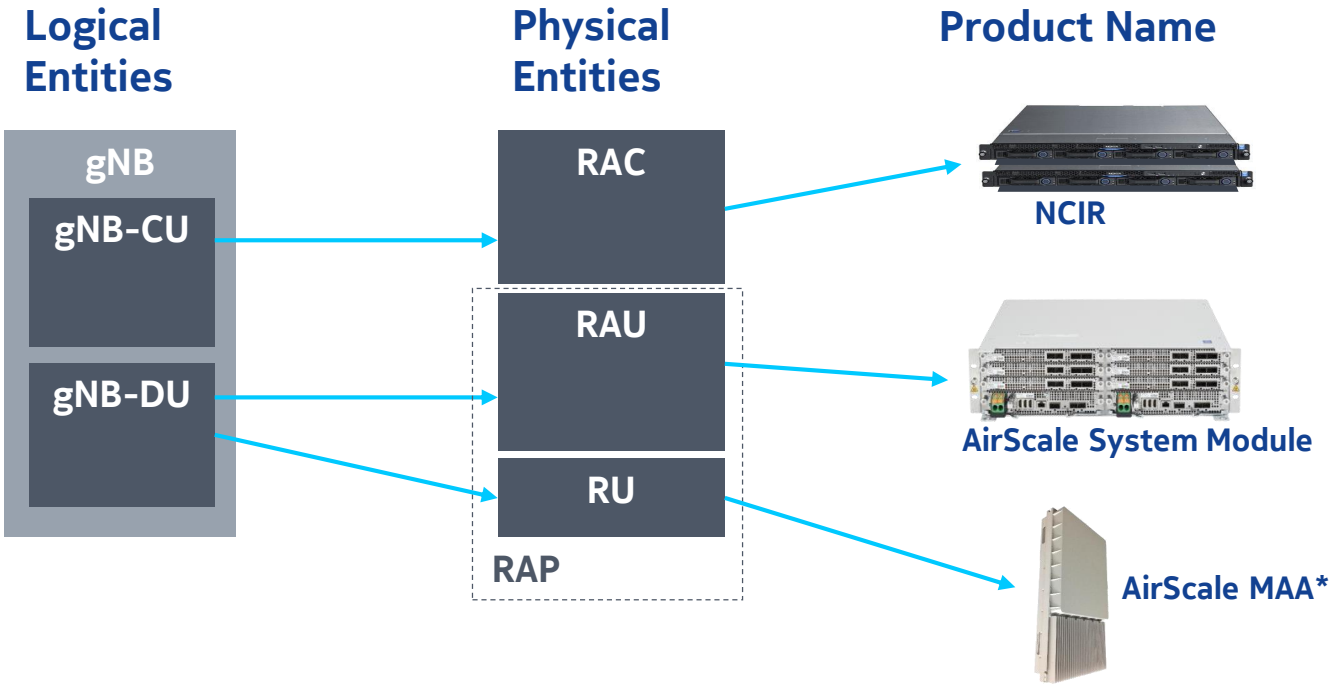
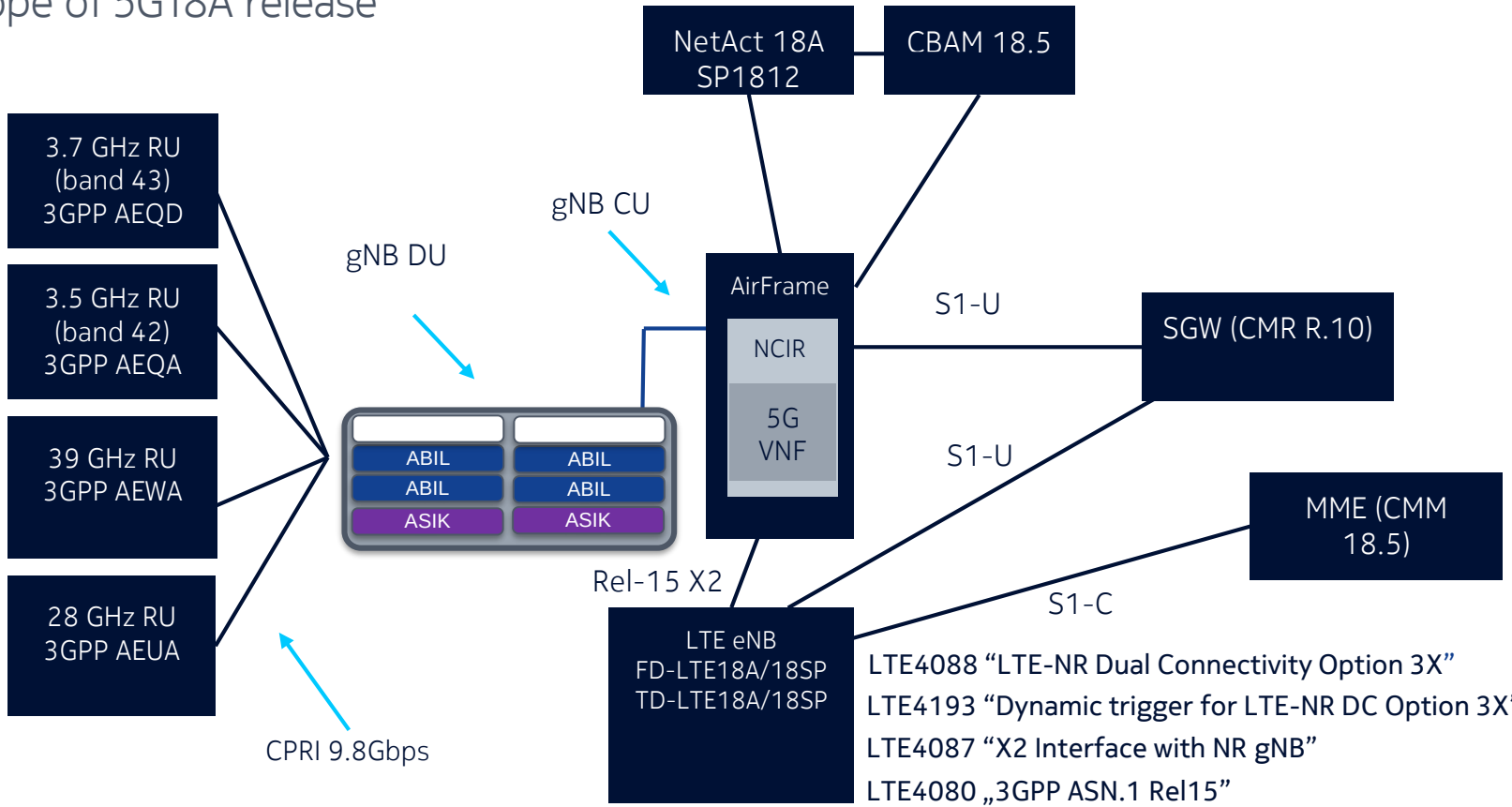
Nokia HW Building Blocks



(*) AirScale MAA → AirScale Massive MIMO Adaptive Antenna

Nokia 5G18A Release

Scope of 5G18A release

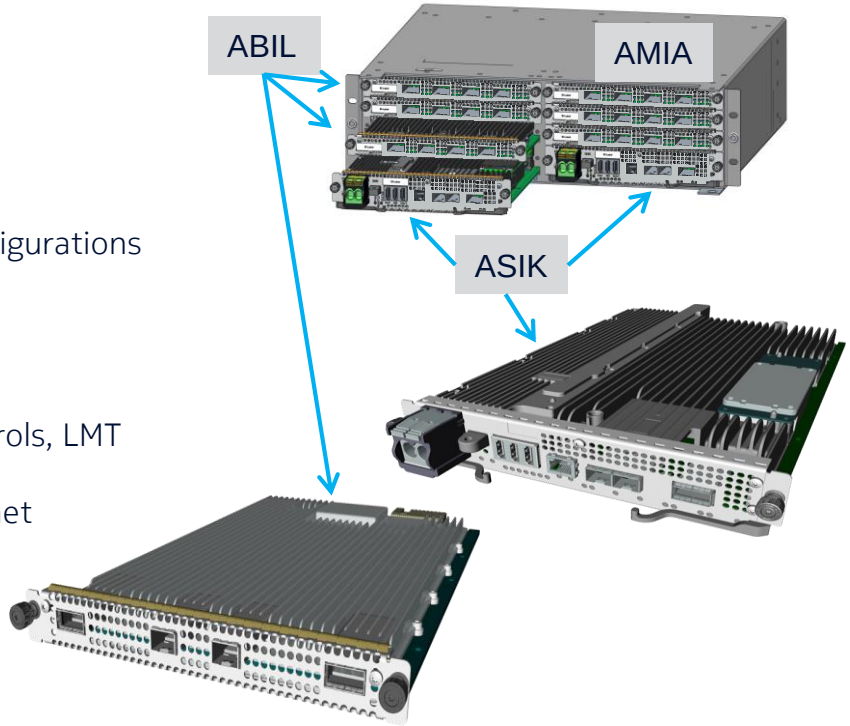


LTE4088 “LTE-NR Dual Connectivity Option 3X”
LTE4193 “Dynamic trigger for LTE-NR DC Option 3X”
LTE4087 “X2 Interface with NR gNB”
LTE4080 „3GPP ASN.1 Rel15”

Nokia 5G18A Release

AirScale 5G modules in 5G18A

- AirScale SM Indoor consist of
  - 1 AirScale Subrack **AMIA**
    - Common with 2G/3G/4G
    - 8 Slots
  - 1…4 AirScale Capacity **ABIL**
    - Capacity Unit
    - 8x 100MHz MIMO layers depending on configurations
    - 2x QSFP+: 8x9.8 Gbps for CPRI fronthaul
  - 1…2 AirScale Common **ASIK**
    - Common Unit
    - 2x SFP10: for Backhaul interface
    - Sync IN and OUT, External Alarms and Controls, LMT
    - DC 48 V input
- Installation options: 19 inch, pole and wall, outdoor cabinet
- Dimensions 19” 3 U : H 128 x W 447 x D 400 [mm]
- Weight: 10.1 kg minimum 23.5 kg maximum



Technical Details

5G18A Radio Units

DIGITAL Beamforming

5GC000562
AEQA 3.5GHz Radio Unit

5GC000664
AEQD 3.7GHz Radio Unit

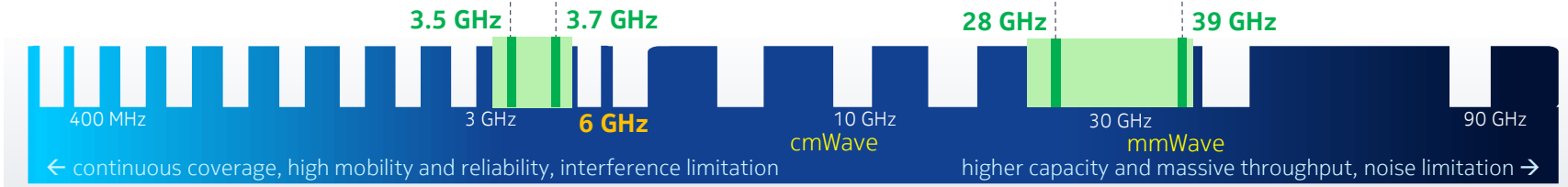
- UL/DL 2x2 SU-MIMO
- DL: 4x4 SU-MIMO / UL: 2x2 SU-MIMO
- 16DL MU-MIMO

ANALOG Beamforming

5GC000515
AEUA 28GHz Radio Unit

5GC000514
AEWA 39GHz Radio Unit

- UL/DL 2x2 SU-MIMO



Carrier BW	n * 20MHz	n * 100 MHz	1-2GHz
Duplexing	FDD*		TDD
Cell size	Macro	Small	Ultra small

* - not supported in 5G18A

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Nokia 5G18A Release

RAP configuration and capacity figures - FR1

- **gNB configuration and capacity highlights:**
  - One sector
  - Up to 2x 100MHz cells per sector
  - Up to 1 UE 2x2 MIMO (DL) is scheduled per slot per cell (1_beam/2_polarizations_per_beam UE), or
  - Up to 1 UE 4x4 *) MIMO (DL) is scheduled per slot per cell (2_beams/2_polarizations_per_beam per every UE)
  - 1 CA UE with 2CC can be scheduled per slot

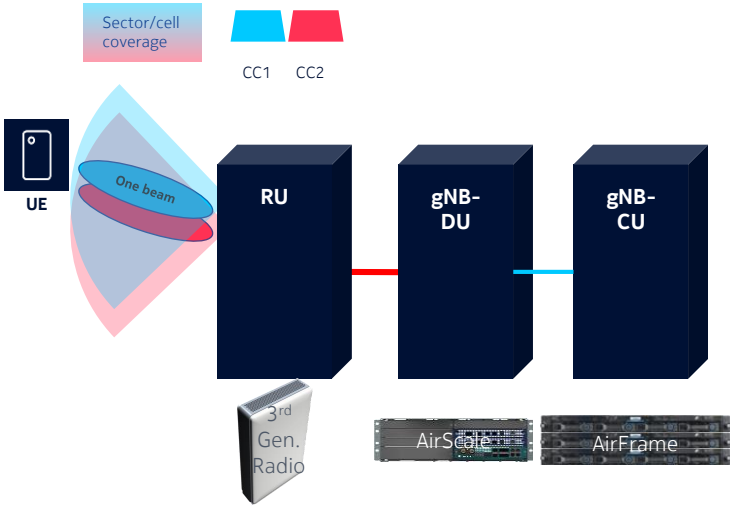


Figure: gNB max configuration: 1 sector/2 cells/2 frequency layers

Nokia 5G18A Release

RAP configuration and capacity - FR2

- **gNB configuration and capacity highlights:**
  - One sector
  - Up to 8x 100MHz cells per sector
  - Up to 8 CC CA
  - Up to one UE 2x2 MIMO is scheduled per slot per cell (1 beam/2 polarizations per UE)
  - Up to 8 UEs 2x2 MIMO is scheduled per slot, each user in separate cell
  - 1 CA UE with 8CC can be scheduled per slot

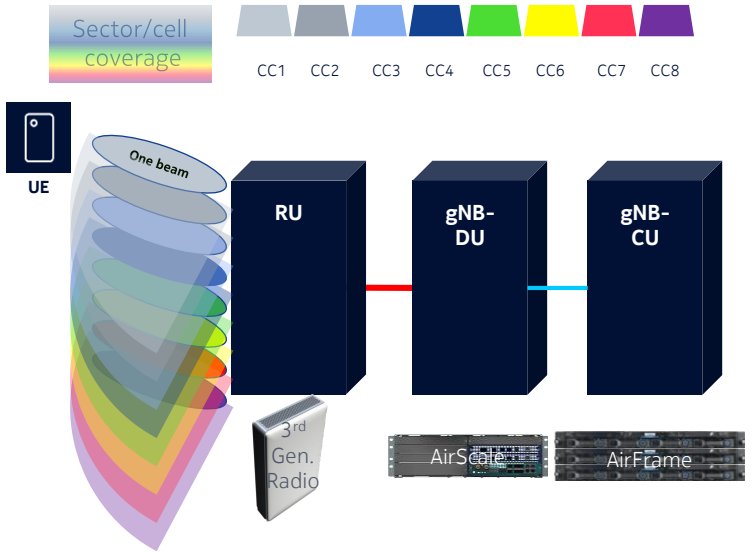


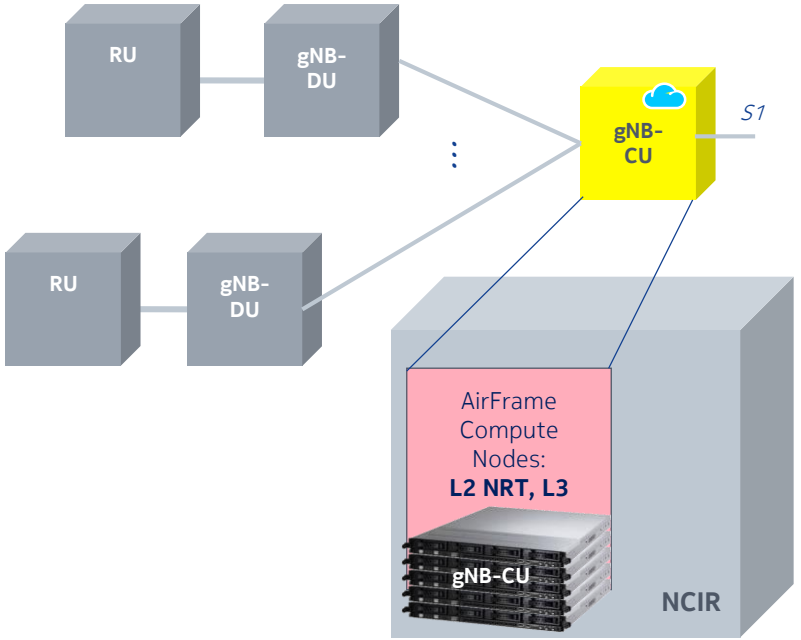
Figure: gNB max configuration: 1 sector/8 cells/8 frequency layers

5G Radio Access Cloud
gNB-CU

- **In 5G18A RAC (physical entity) maps 1:1 to 3GPP defined logical entity *gNB-CU***

- **gNB-CU** is a Virtual Network Function (VNF) of gNB
- VNF is implemented in cloud environment in Data Center Solution with *Nokia Cloud Infrastructure for Real-Time application* (NCIR)
- One **gNB-CU** is processing traffic from multiple **gNB-DU**

- **gNB-CU** is processing **N**on-**R**eal **T**ime (**NRT**) part of traffic and **Control Plane L3** in AirFrame Compute Nodes
- Number of AirFrame Compute Nodes needed per gNB-CU depends on gNB traffic requirement and on NCIR capacity

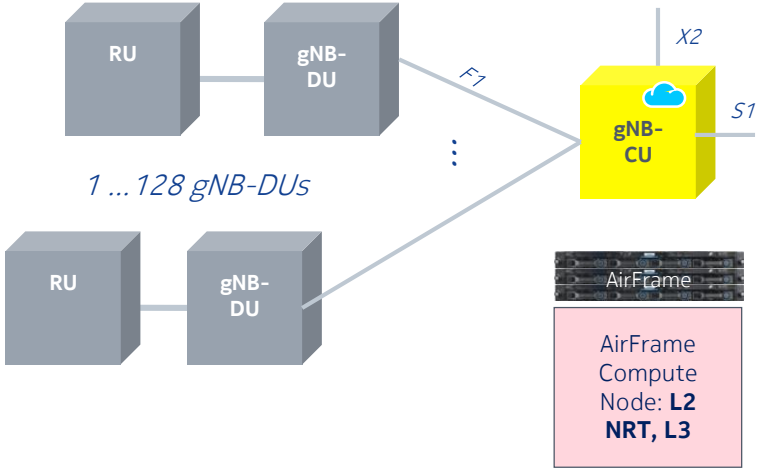


5G Radio Access Cloud
gNB-CU Capacity Highlights in 5G18A

- gNB-CU VNF capacity and connectivity limits are as follows:

gNB-CU VNF capacity [1]	
# Active UEs [2]	50000
# DRBs [3]	50000
# C-Plane events/sec [4]	1573
Throughput DL + UL [5]	150 Gbps

gNB-CU connectivity [1]	
# gNB-DU	128
# cells	1024
# X2 interfaces	128
# S1 interfaces	1
# OAM/NetAct interfaces	1
# F1 interfaces	128

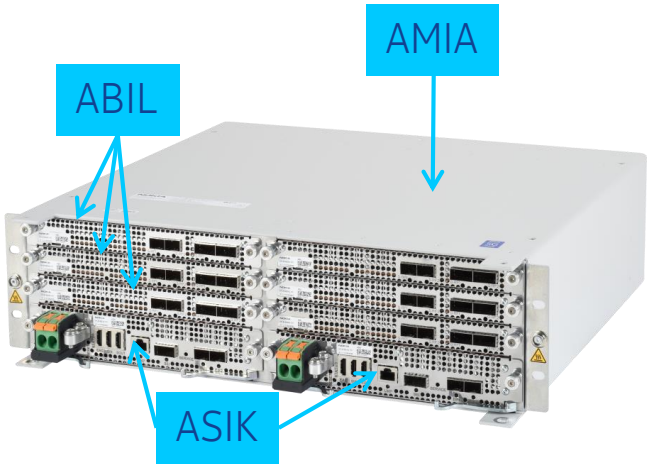


F1 – 3GPP specified High Latency Fronthaul

[1] Design targets for 5G18A
[2] Assuming 500 Active UEs per gNB-DU, 128 gNB-DUs and accounting for multiplexing gain
[3] One DRB per Active UE is supported
[4] eMBB traffic profile requirement
[5] Maximal throughput DL + UL depends on RU/gNB-DU configuration. 150Gbps is assumed for satisfying 128 gNB-DUs with MU-MIMO and accounting for multiplexing gain

5G Radio Access Unit
AirScale System Module in 5G18A

- In 5G18A **gNB-DU** is deployed using **AirScale System Module**



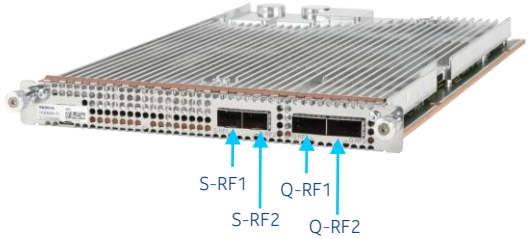
- 5GC000623 AirScale Subrack AMIA. prodCode: 473098A
- 5GC000275 AirScale Common ASIK. prodCode: 474021A
- 5GC000276 AirScale Capacity ABIL. prodCode: 474020A

- See AirScale SM HW items compatibility matrix in Deployment Aspects chapter

- **AirScale SM** Indoor consist of
  - 1x AirScale Subrack **AMIA** (the same AMIA as in 2G/3G/4G)
    - Casing
    - 8 slots for plug-in units (**5G18A**: max 6 slots are used)
    - Backplane for high bandwidth inter-connect between AirScale Common and AirScale Capacity plug-in units
    - Fans with changeable airflow direction
  - AirScale Common **ASIK** (1…2 per AMIA)
  - AirScale Capacity **ABIL** (in 5G18A: 1…2 per ASIK)
- Multiple installation options:
  - 19 inch rack, pole and wall, inside Outdoor Enclosure
- Dimensions:
  - 19” 3U: H 128 x W 447 x D 400 [mm]
- Weight:
  - 10.1 kg minimum 23.5 kg maximum
- Ingress protection
  - IP20
- Operational temperature range
  - -5 °C to 55 °C

gNB-DU in 5G18A:
- Minimal configuration: 1x ASIK + 1 ABIL
- Maximal configuration: 1x ASIK + 2 ABIL

5G Radio Access Unit
ABIL - Capacity Indoor Plug in Unit



ABIL functions:

- **L1 + L2 RT** processing in gNB-DU
- RF interfaces to RU. Up to 2x 3rd generation radios

Port	#	Physical I/F	Usage
Q-RF	2	QSFP+/QSFP28	Low Latency Fronthaul connection to Radio Unit. Remark: Only QSFP+ (4x CPRI 9.8 Gbps per each port) available in **5G18A**
S-RF	2	SFP+/SFP28	Low Latency Fronthaul connection to Radio Unit. Remark: eCPRI 10/25 GE per each port available in **5G19**
LEDs	5	-	Visual indication of status

- 5G18A ABIL capacity vs. frequency band and MIMO mode:

>6GHz 2x2 Single User (SU) -MIMO

#cells 2x2 MIMO	#ABIL per gNB-DU	Peak L1 t-put
1-4	1	2.5 Gbps
5-8	2	5 Gbps

<6GHz 2x2 or 4xN*) DL SU-MIMO

#cells 4xN DL MIMO 2x2 UL MIMO	#ABIL per gNB-DU	Peak L1 t-put
1-2	1	2.5 Gbps

*) *5GC000605 DL SU adaptive 4x4 MIMO*

<6GHz Multi User (MU)-MIMO 16DL 2UL. Up to 4 simultaneous UEs 4xN DL MIMO or 8 simultaneous UEs 2x2 DL MIMO

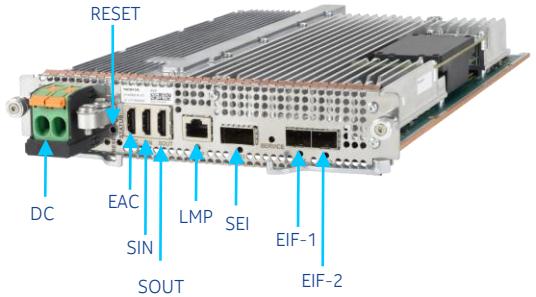
#cells 4xN DL MIMO 2x2 UL MIMO	#ABIL per gNB-DU	Peak L1 t-put
1	2	5.1 Gbps *

* 4 or 8 parallel UEs in DL

ABIL ProdCode: 474020A

5G Radio Access Unit

ASIK - Common Indoor Plug in Unit



Port	#	Physical I/F	Usage
EIF	2	SFP28	Supports 1GE, 10GE and 25GE per port. Support for SyncE and IEEE15888 **5G18A:** 10GE per port. High Latency Fronthaul interface to gNB-CU (F1) **5G19:** 25GE per port. Also as backhaul Interface in Classical gNB
SEI	1	QSFP+	System Extension Interface 4x10 GE (for System Module chaining, planned in future)
DC-IN	1	DC terminal	48V DC Input
EAC	1	HDMI	External alarm & control, 6 alarms, 6 alarms/ctrls (available in **5G19**)
SIN	1	HDMI	Synchronization input, GNSS interface
SOUT	1	HDMI	Synchronization output
LMP	1	RJ-45	Local management port, 1G Ethernet
LEDs	7		Visual indication of status
RESET	1		Plug-in unit RESET

ASIK functions:

- **L2 non-Real Time** processing**, L3**
- Transport interfacing (Ethernet)
- Local O&M
- Synchronization
- Power feed

ASIK ProdCode: 474021A

5G Radio Access Unit

5G18A Deployment Cases

5G18A release supports three deployment cases:

1) Above 6 GHz 2x2 MIMO (analog beamforming)*
2) Below 6 GHz Single User MIMO (digital beamforming)*
3) Below 6 GHz Multi User MIMO (digital beamforming)*

On following slides **gNB-DU capacity** is discussed separately for those 3 deployment cases

(*) Note:

- Within 5G18A release there are strictly defined RAP configuration families to support each of the deployment cases mentioned above (5g_pid11, 5g_pid12, 5g_pid13)
- RAP configuration families are distinguished with RAP profiles: (details are provided in Supported RAP configurations chapter)

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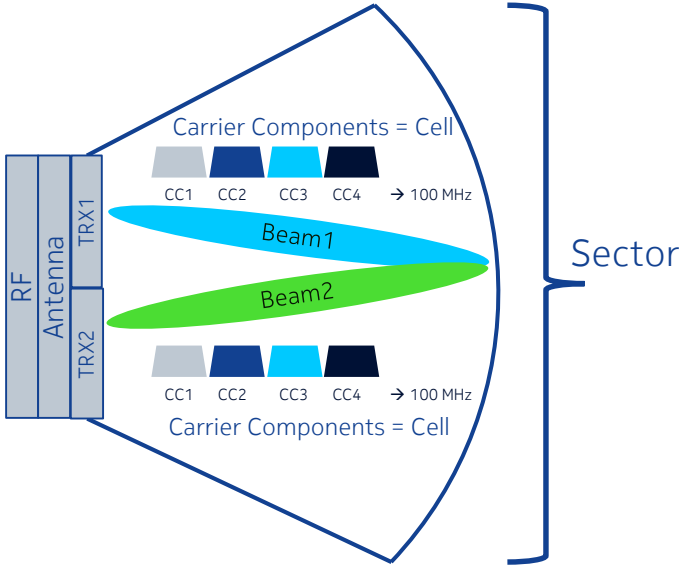
5G Radio Access Unit
RAP Configurations → Carrier / Sector Definitions

Example with analog beamforming configuration:
- 2TRX RF HW,
- 4 Carrier Components (100 MHz BW) → 4 Cells



Sector
- The set of cells on different carrier frequencies using the same physical antennas and the same beam forming hardware.

Cell = Component Carrier
- The cell has a single physical-layer cell identity and a single global cell ID
- The cell is mapped to one component carrier
- Each Cell belongs to a sector

Beam
- Single Entity of a directed Signal from Beamforming capable Antenna
- In Analog Beamforming Single Beam is Generated per antenna array for each polarization, in Digital Beamforming the Antenna Array can be split to smaller entities resulting in multiple Beams (Directed TRX signals)

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5G Radio Units

5G Radio Units Introduction

5G18A Radio Units

DIGITAL Beamforming

5GC000562
AEQA 3.5GHz Radio Unit

5GC000664
AEQD 3.7GHz Radio Unit

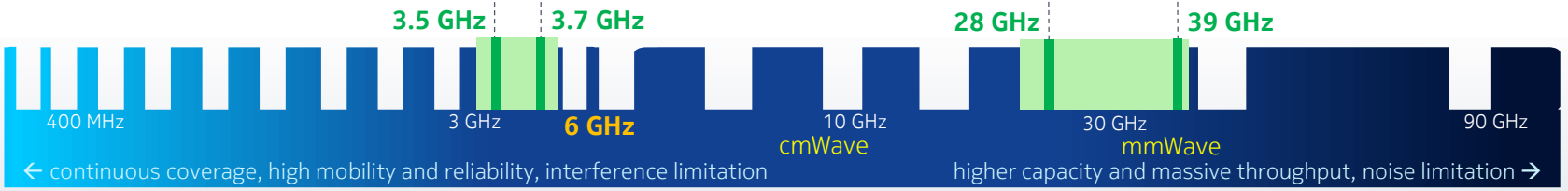
- UL/DL 2x2 SU-MIMO
- DL: 4x4 SU-MIMO / UL: 2x2 SU-MIMO
- 16UL/16DL MU-MIMO

ANALOG Beamforming

5GC000515
AEUA 28GHz Radio Unit

5GC000514
AEWA 39GHz Radio Unit

- UL/DL 2x2 SU-MIMO



Carrier BW	n * 20MHz	n * 100 MHz	1-2GHz
Duplexing	FDD*		TDD
Cell size	Macro	Small	Ultra small

* - not supported in 5G18A

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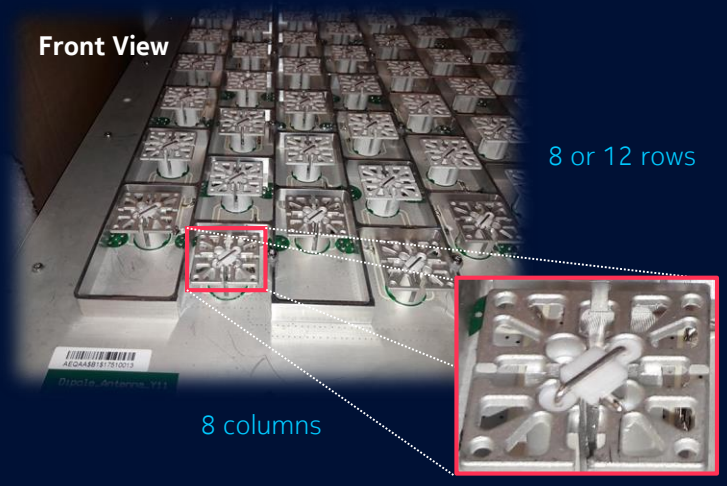
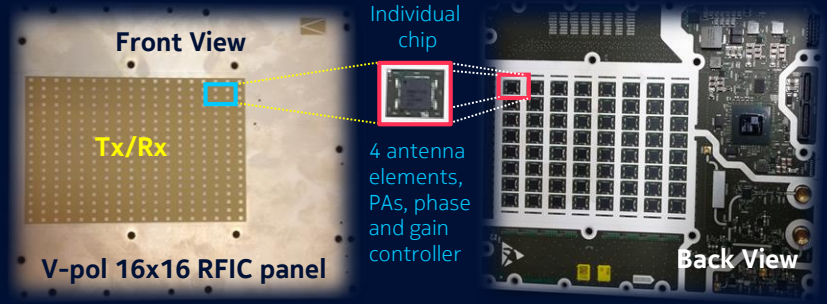
5G Radio Units

5G18A Antenna System Solution

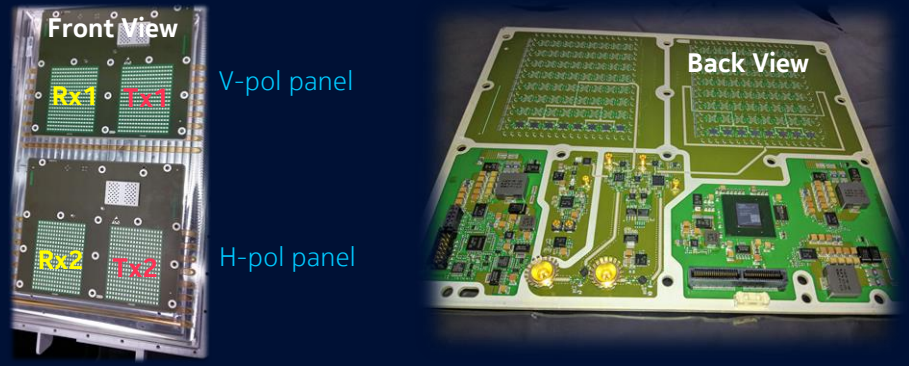
AEQA 3.5GHz — 8x12 phased array panel (AEQD 3.7GHz 8x8 array panel)



AEUA 28GHz — 2 x (16x16) RFIC phased array antenna panel (1xH-pol and 1xV-pol)



AEWA 39GHz — 4 x (16x16) RFIC phased array antenna panel (2xH-pol & 2xV-pol)



cmWave ● antenna size ⇗ ● TRX separated

Classic X-Pol Phased Array Antenna Panel

Digital Beamforming

MU-MIMO, SU-MIMO

mmWave ● antenna size ⇘ ● TRX integrated in chip

RFIC (**R**adio **F**requency **I**ntegrated **C**ircut) H&V-Pol Antenna Panels

Analog Beamforming

2x2 MIMO

5G Radio Units

Illustrative Pictures

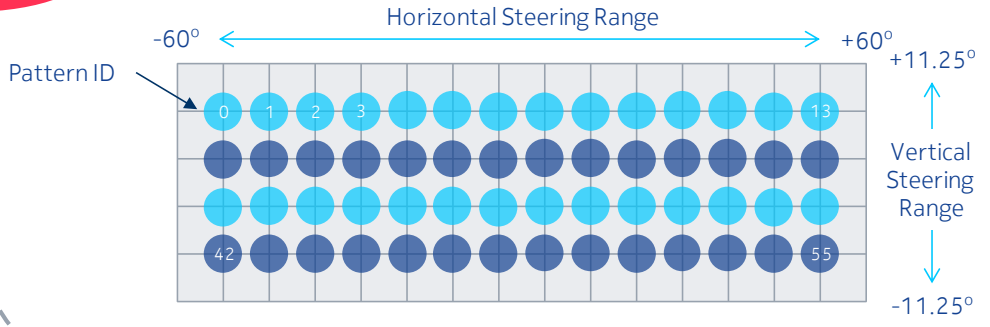
Radiation characteristic overview

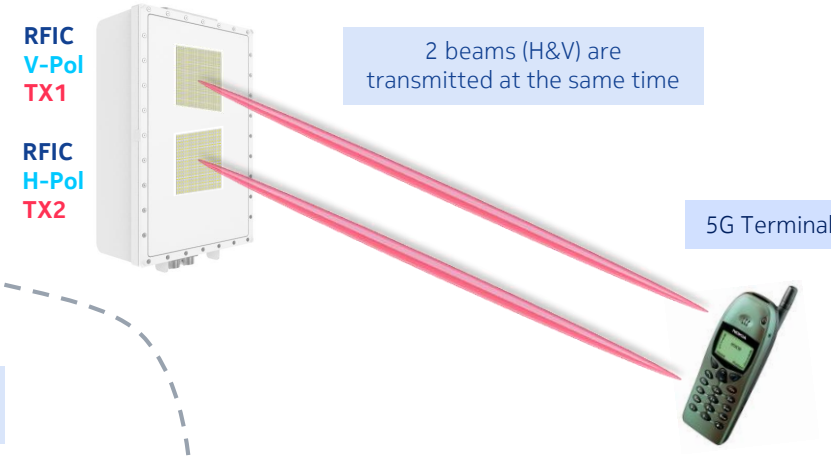
1Cell = 100MHz
8x100MHz = 8 Cells

Sector Width **120°**
(**8dB** Power Beam Width)*

* - Sector Width 90° for 3dB HPBW

Example Beam Pattern (H-pol/V-pol)





2x2 MIMO

Analog Beamforming

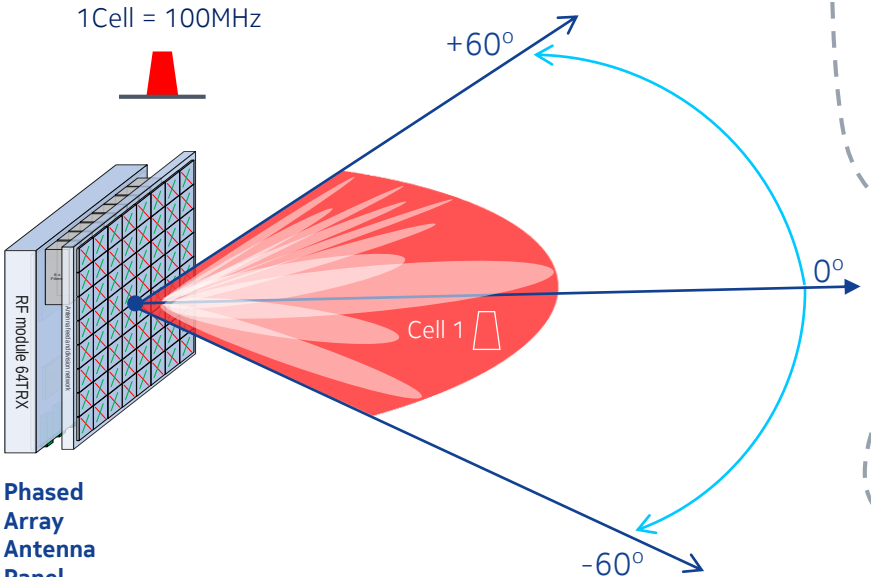
NOKIA

5G Radio Units

Illustrative Pictures

Radiation characteristic overview

1Cell = 100MHz

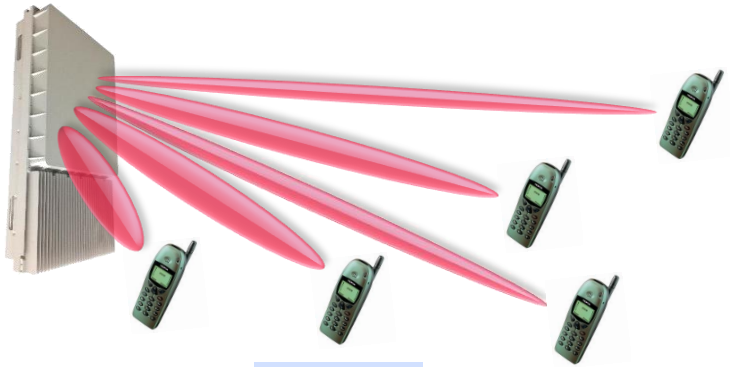


Phased Array Antenna Panel
X-Pol
64TRX

Sector Width **120°**
(**8dB** Power Beam Width)*

Multiple beams (↖- 45° ↗+45°) are transmitted at the same time

Phased Array
X-Pol
64TRX



5G Terminal

SU-MIMO, MU-MIMO
Digital Beamforming

* - Sector Width 90° for 3dB HPBW

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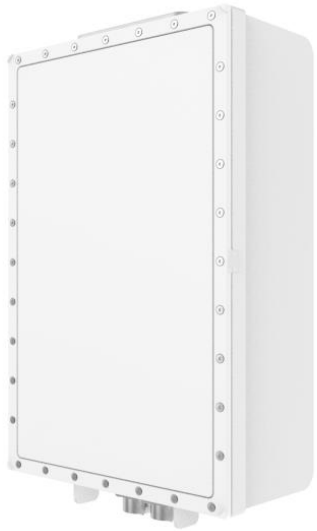
Radio Units >6GHz

5G Radio Units
General Description
5GC000515 AEUA AirScale MAA 2T2R 512AE 28 GHz 8 W
5GC000514 AEWA AirScale MAA 2T2R 512AE 39 GHz 8 W

Preliminary Data



Radio Unit without optional fan unit

Operating bandwidth:	26.50÷29.5 GHz (**AEUA**) 38.60÷40.0 GHz (**AEWA**)
Number of TX/RX paths:	2Tx/2Rx (2x2 MIMO)
Carrier configuration:	800 MHz (1÷8 x 50 MHz / 100 MHz)
Max supported modulation schemes:	64 QAM
Antenna type:	16x16 Phased array (RFIC)
Optical ports:	2 x QSFP+ CPRI 9.8 Gbps rate
Supply Voltage / Connector type:	AC (100-250 V) / BTS Amphe OBTSAC
Power consumption (maximum):	<380 W, <550 W (with active cooling)
Operational temperature range:	-40°C to 55°C
Natural convection cooling or active cooling with AFMA AirScale Fan MAA unit	

Analog Beamforming

NOKIA

5G Radio Units
RF Specification
5GC000515 AEUA AirScale MAA 2T2R 512AE 28 GHz 8 W

Preliminary Data

Radio Unit without optional fan unit

	without fan	with optional fan
Frequency band:	26.5÷29.5 GHz	26.5÷29.5 GHz
Instantaneous bandwidth:	800 MHz	800 MHz
Nominal total output Tx RF power:	28 dBm	31 dBm
Antenna type:	16x16 Phased array	16x16 Phased array
Nominal antenna gain in boresight:	26 dBi	29 dBi
Total/Peak EIRP:	54 dBm / 64 dBm	60 dBm / 70 dBm
Horizontal beam width:	6.5° (boresight)	6.5° (boresight)
Vertical beam width:	8.6° (boresight)	4.3° (boresight)
Horizontal steering angle:	±45° (3 dB) ±60° (6 dB)	±45° (3 dB) ±60° (6 dB)
Vertical steering angle:	±25° (3 dB)	±25° (3 dB)
Vertical/Horizontal plane orientation:	H and V polarization	H and V polarization

Analog Beamforming

NOKIA

5G Radio Units
RF Specification
5GC000514 AEWA AirScale MAA 2T2R 512AE 39 GHz 8 W

Preliminary Data

Radio Unit without optional fan unit

	without fan	with optional fan
Frequency band:	38.6÷40.0 GHz	38.6÷40.0 GHz
Instantaneous bandwidth:	800 MHz	800 MHz
Nominal total output Tx RF power:	25 dBm	28 dBm
Antenna type:	16x16 Phased array	16x16 Phased array
Nominal antenna gain in boresight:	26 dBi	29 dBi
Total/Peak EIRP:	51 dBm / 61 dBm	57 dBm / 67 dBm
Horizontal beam width:	6.5° (boresight)	6.5° (boresight)
Vertical beam width:	8.6° (boresight)	4.3° (boresight)
Horizontal steering angle:	±45° (3 dB) ±60° (6 dB)	±45° (3 dB) ±60° (6 dB)
Vertical steering angle:	±30° (3 dB)	±30° (3 dB)
Vertical/Horizontal plane orientation:	H and V polarization	H and V polarization

Analog Beamforming

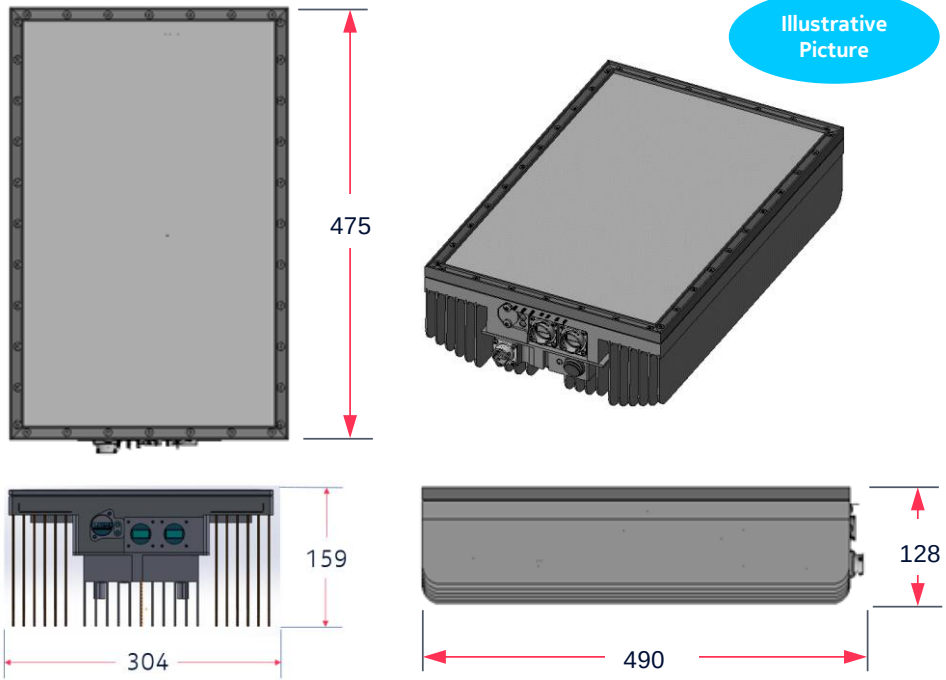
NOKIA

5G Radio Units

Technical Details

Installation and mechanical specification

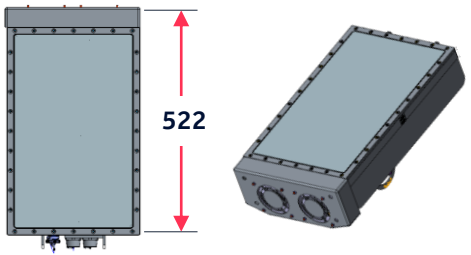
Preliminary Data



Radio Unit **without** optional fan unit

5GC000515 AEUA AirScale MAA 2T2R 512AE **28 GHz** 8 W
5GC000514 AEWA AirScale MAA 2T2R 512AE **39 GHz** 8 W

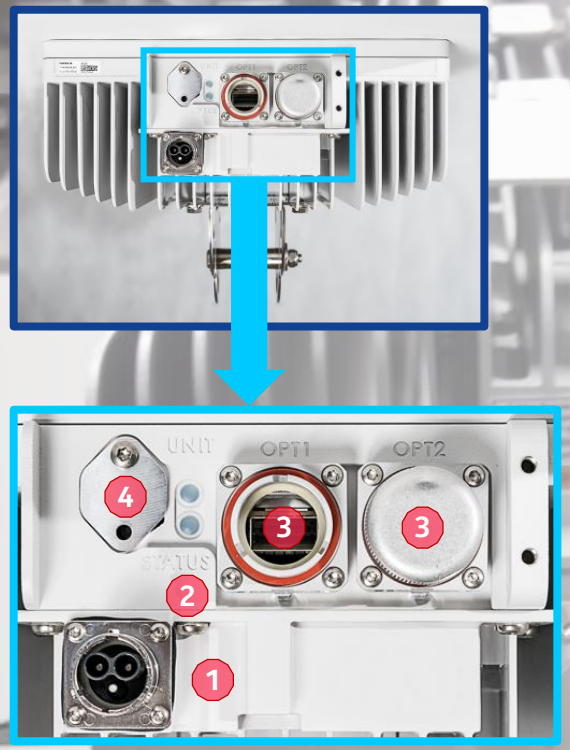
Mounting	Pole, Wall
Mechanical Tilt/Azimuth Range	±15° / ±30°
Powering	100÷250 V AC
Dimensions (HxWxD)	475mm x 304mm x 159mm (without fan) 522mm x 304mm x 161mm (with optional fan)
Weight (without monuting brackets)	22kg (without fan) 24kg (with optional fan)



Radio Unit **with** optional fan unit

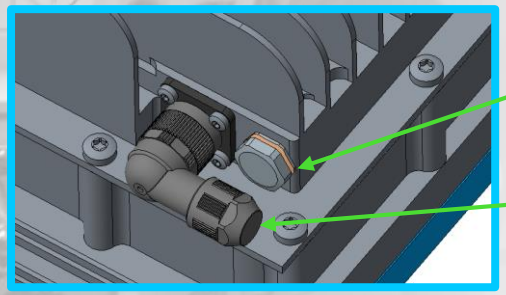
NOKIA

5G Radio Units
Technical Details
External interfaces



5GC000515 AEUA AirScale MAA 2T2R 512AE **28 GHz** 8 W
5GC000514 AEWA AirScale MAA 2T2R 512AE **39 GHz** 8 W

	Interface	Initials	Purpose	Connector Type	Note
1	**Power supply**	AC	AC power input	AC 3-pole connector	
2	**2xLED**	UNIT led STAT led	Visual indicator, three color LEDs	-	
3	**2 x system interface**	OPT 1-2	Data and control interface	QSFP+	Data in time domain
4	**LMI**	LMI	Local Management Interface	HDMI	1G Ethernet



NOKIA

NOKIA

Radio Units <6GHz

5G Radio Units

General Description

5GC000562 AEQA AirScale MAA 64T64R 192AE B42 200W

5GC000564 AEQD AirScale MAA 64T64R 128AE B43 200W

Preliminary Data

Operating bandwidth:	3.4÷3.6 GHz (**AEQA**) 3.6÷3.8 GHz (**AEQD**)
Number of TX/RX paths:	64Tx/64Rx
Carrier configuration:	100 MHz
Max supported modulation schemes:	256 QAM
Antenna type:	8x12 phased array (**AEQA**) 8x8 phased array (**AEQD**)
Optical ports:	2 x QSFP+ CPRI 9.8 Gbps rate
Supply Voltage / Connector type:	DC -40.5V...-57 V / Screw terminal
Power consumption (maximum):	≤1400 W (75% duty cycle)
Operational temperature range:	-40°C to 55°C
Natural convection cooling	

Digital Beamforming

5G Radio Units

RF Specification

5GC000562 AEQA AirScale MAA 64T64R 192AE B42 200W

Preliminary Data

Frequency band:	3.4÷3.6 GHz
Instantaneous bandwidth:	100 MHz
Antenna type:	8x12 Phased array
Antenna gain:	25.5 dBi
Total average EIRP:	≥77.5 dBm
Horizontal beam width:	15° (boresight)
Vertical beam width:	6° (boresight)
Horizontal steering angle:	±45° (3 dB), ±60° (8 dB)
Vertical steering angle:	±6°
Polarization:	±45° X-polarized

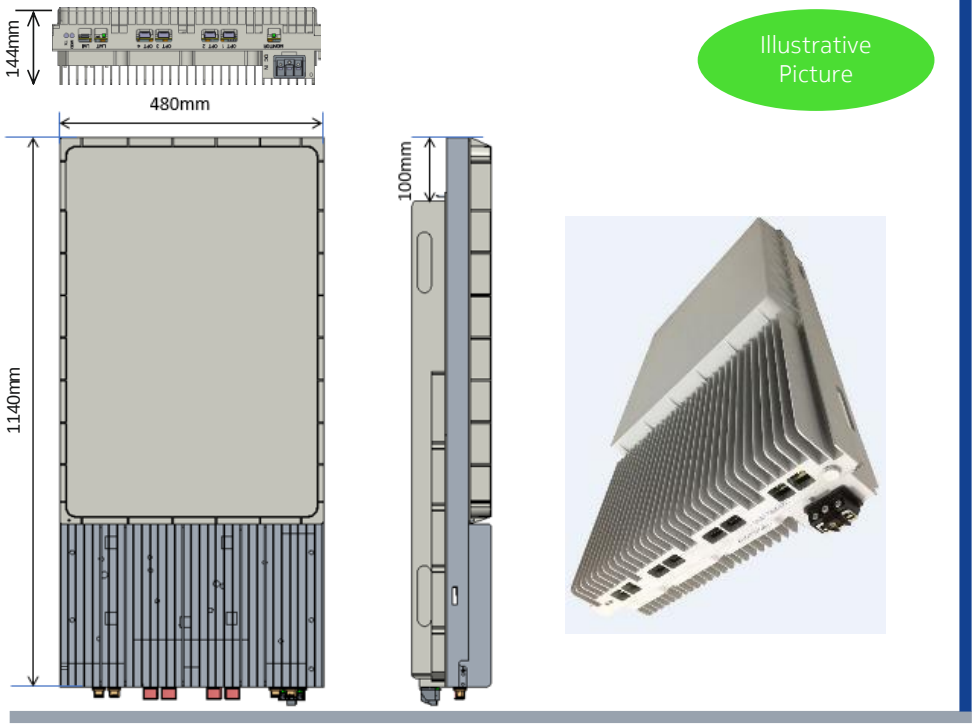
Digital Beamforming

5G Radio Units

Technical Details

Installation and mechanical specification

Preliminary Data



5GC000562 AEQA AirScale MAA 64T64R 192AE B42 200	
Mounting	Pole, Wall
Mechanical Tilt/Azimuth Range	±15° / ±30°
Powering	DC -40.5V ... -57 V
Dimensions (HxWxD)	1140mm x 480mm x 136mm
Weight	47kg (without mounting brackets)

5G Radio Units

RF Specification

5GC000564 AEQD AirScale MAA 64T64R 128AE B43 200W

Preliminary Data

Frequency band:	3.6÷3.8 GHz
Instantaneous bandwidth:	100 MHz
Antenna type:	8x8 Phased array
Antenna gain:	24 dBi
Total average EIRP:	≥76 dBm
Horizontal beam width:	15° (boresight)
Vertical beam width:	9° (boresight)
Horizontal steering angle:	±45° (3 dB), ±60° (8 dB)
Vertical steering angle:	±11.25°
Polarization:	±45° X-polarized

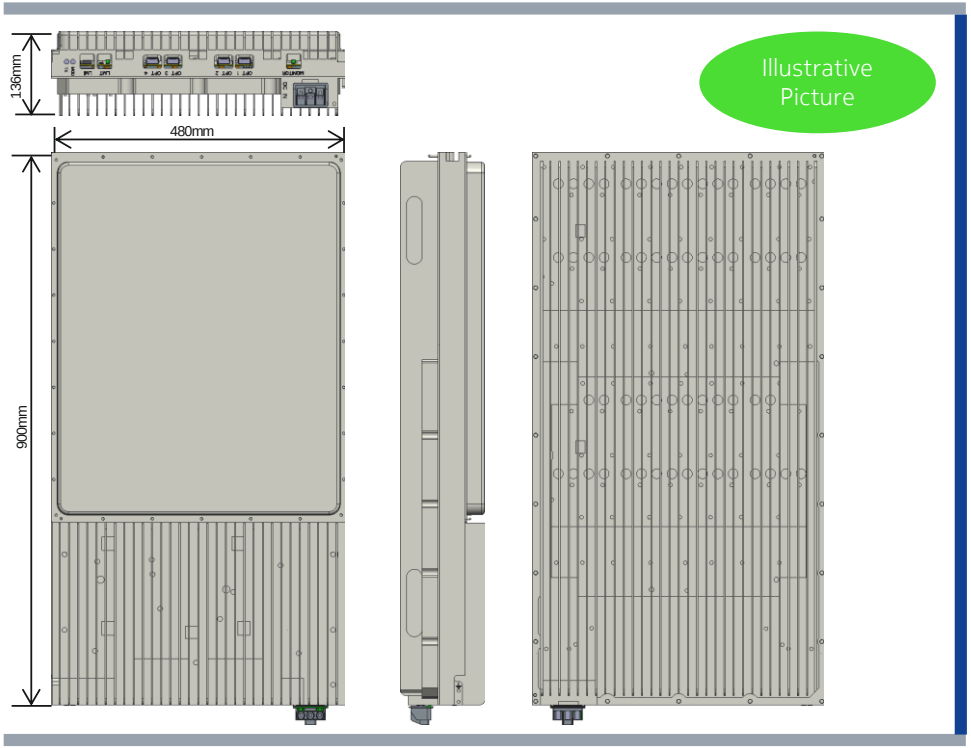
Digital Beamforming

5G Radio Units

Technical Details

Installation and mechanical specification

Preliminary Data



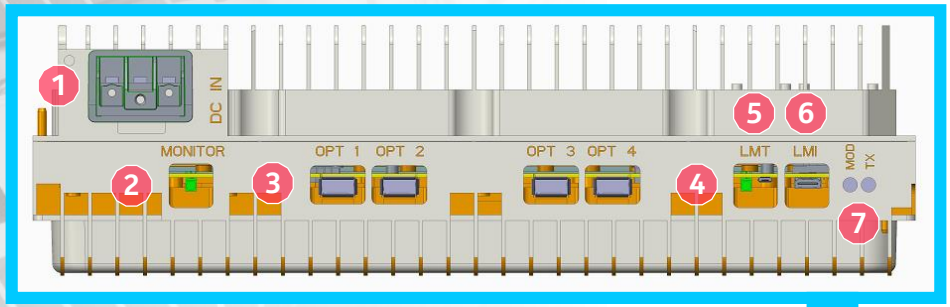
5GC000562 AEQD AirScale MAA 64T64R 128AE B43 200	
Mounting	Pole, Wall
Mechanical Tilt/Azimuth Range	±15° / ±30°
Powering	DC -40.5V ... -57 V
Dimensions (HxWxD)	900mm x 480mm x 136mm
Weight	40kg (without mounting brackets)

5G Radio Units

Technical Details

External interfaces

Illustrative Picture



5GC000562 AEQA AirScale MAA 64T64R 192AE B42 200
5GC000564 AEQD AirScale MAA 64T64R 128AE B43 200

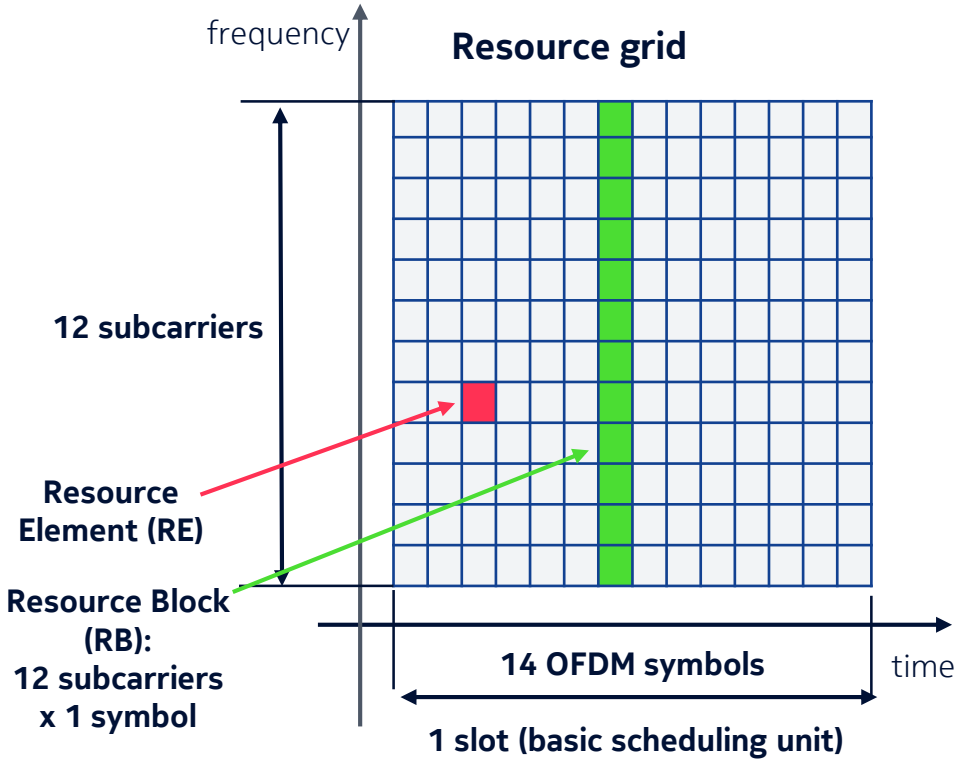
	Interface	Initials	Purpose	Connector Type	Note
1	**Power supply**	DC	DC power input	AC 3-pole connector	
2	**RF monitor port**	MONITOR	For regulatory monitoring and R&D use	QMA	
3 4	**2 x system interface**	OPT 1-2	Data and control interface	QSFP+	
5	**LMT**	LMT	Local Management Terminal	HDMI	
6	**LMI**	LMI	Local Management Interface	HDMI	
7	**2xLED**	MOD led TX led	Visual indicator, three color LEDs	-	

NOKIA

5G New Radio
Overview

Duplex scheme: TDD

Large areas of unpaired spectrum easier to be found	**Every subframe can be dynamically selected to carry UL or DL data. Flexible adaptation to DL/UL throughput requirements**
Both uplink and downlink use OFDM • Simplified RF design • Eases self-backhauling and device-to-device communication	**Possibility to have control signals in every subframe for low latency scheduling. Support for self-contained slots**



5G New Radio

Multiple numerologies – PRBs and carrier frequency span

3GPP specifies the minimum and maximum bandwidth (limit: 400 MHz carrier)

Numerology | min #PRBs | max #PRBs | subc. spacing | min system BW | max system BW

u	min RB	Max RB	sub carrier spacing (kHz)	Freq BW min (MHz)	Freq BW max (MHz)
0	24	275	15	4.32	49.5
1	24	275	30	8.64	99
2	24	275	60	17.28	198
3	24	275	120	34.56	396
4	24	138	240	69.12	397.44
5	24	69	480	138.24	397.44

Nokia: 273 PRBs (100 MHz). **FR1**

Nokia: 66 PRBs (100 MHz). **FR2**

5G New Radio
Physical channels

The physical channels defined in the **downlink** are:

- Physical Downlink Shared Channel (**PDSCH**)
- Physical Downlink Control Channel (**PDCCH**)
- Physical Broadcast Channel (**PBCH**)

The physical channels defined in the **uplink** are:

- Physical Random Access Channel (**PRACH**)
- Physical Uplink Shared Channel (**PUSCH**)
- Physical Uplink Control Channel (**PUCCH**)

The supported modulation schemes:

- Downlink: **QPSK, 16QAM, 64QAM**
- Uplink: **QPSK, 16QAM, 64QAM**

The following downlink physical signals are defined:

- Demodulation reference signals, **DM-RS**, for PDSCH and PBCH
- Phase-tracking reference signals, **PTRS**
- Channel-state information reference signal, **CSI-RS**
- Primary synchronization signal, **PSS**
- Secondary synchronization signal, **SSS**

The following uplink physical signals are defined:

- Demodulation reference signals, **DM-RS**
- Phase-tracking reference signals, **PTRS**
- Sounding reference signal**, SRS**

NOKIA

AIRSCALE EVOLUTION

Abbreviations

General policy for Abbreviations:

1st letter: A for AirScale or F for Flexi

2nd letter:

- A for Antenna Equipment and Same Band Combiner
- D for Diplexers
- R for Radio Modules
- S for System Modules
- B for Baseband Extension Modules
- T for Transport Modules, Sub modules and Cables
- P for Power Supply Modules and Sub modules
- M for Mounting Kits
- C for Cabinet and Cabinet Accessories
- L for low noise Mast Head Amplifier
- X for Cross Technology Radio Modules

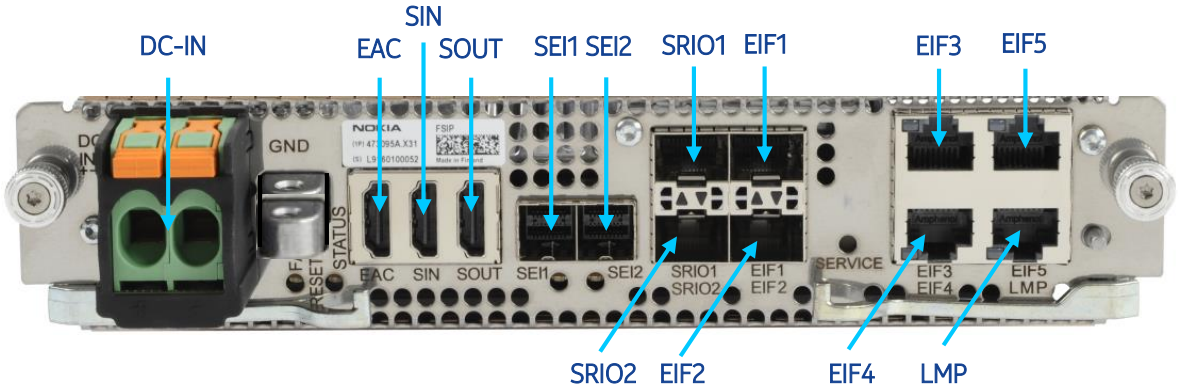
3rd letter: Application or usage or frequency band (RF and Mast Head Amplifiers)

4th letter: The Hardware revision: Version A is the first one, future B, C…

Example Abbreviations

ASIK	AirScale System Module Indoor Version K
ABIL	AirScale Baseband Extension Sub-Module
AMIA	AirScale Subrack Indoor Version A
AMOB	AirScale Subrack Outdoor Version A
AHLOA	AirScale RRH 700/600MHz (Band 12/71) 240W
AH__	Flexi RF Module codes: A = 400 MHz L = 700 MHz C = 850 MHz O = 600 MHz D = 900 MHz F = 1900 MHz G = 2100 MHz H = 2500 MHz I = 1700/2100 MHz J = 2000MHz
AHFIB	AirScale RRH 1900/2100 MHz (Band 25/66) 320W
AAFIA	AirScale mMIMO 1900/2100 MHz (Band 25/66)
AEUF	AirScale millimeterWave RRH 28GHz
AMFG/H	AMOB FCOA Install Kit/ AMOB Pole Install Kit
FPKA	Flexi Pole Kit version A
FCOA	Flexi Cabinet Outdoor version A
FYGA/B	Flexi GPS Antenna

AT&T/Sprint/TMO AirScale Common ASIA Plug in Unit

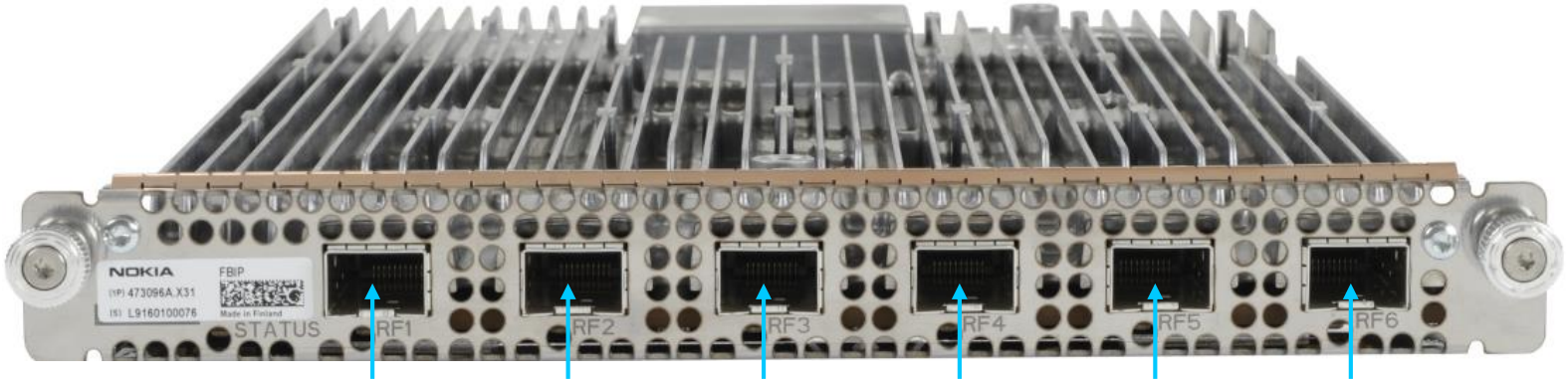


Port	#	Physical I/F	Usage
EIF1…2	2	SFP+	1/10GE optical or 1GE electrical transport
EIF3…5	3	RJ45	1GE electrical transport
SEI	2	MiniSAS-HD	Subrack extension, 2x 10GE
SRIO	2	SFP+	Rapid IO connection for Flexi Multi Radio 10
DC-IN	1	DC terminal	-48V DC Input
EAC	1	HDMI	External alarm & control, 6 alarms, 6 alarms/ctrls
SIN	1	HDMI	Synchronization input, GPS interface
SOUT	1	HDMI	Synchronization output

Port	#	Physical I/F	Usage
LMP	1	RJ-45	Local management port, 1G Ethernet
LEDs	14		Visual indication of status
RESET	2		Plug-in unit RESET, with several scenarios

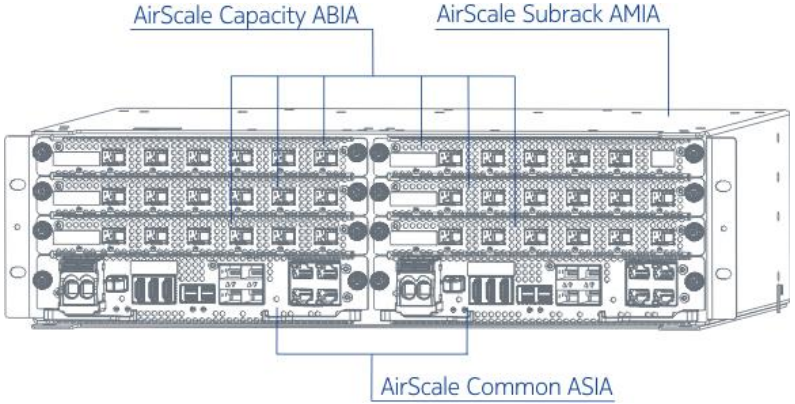
VZW AirScale Common ASIAA Plug in Unit

AirScale Capacity ABIA Plug in Unit



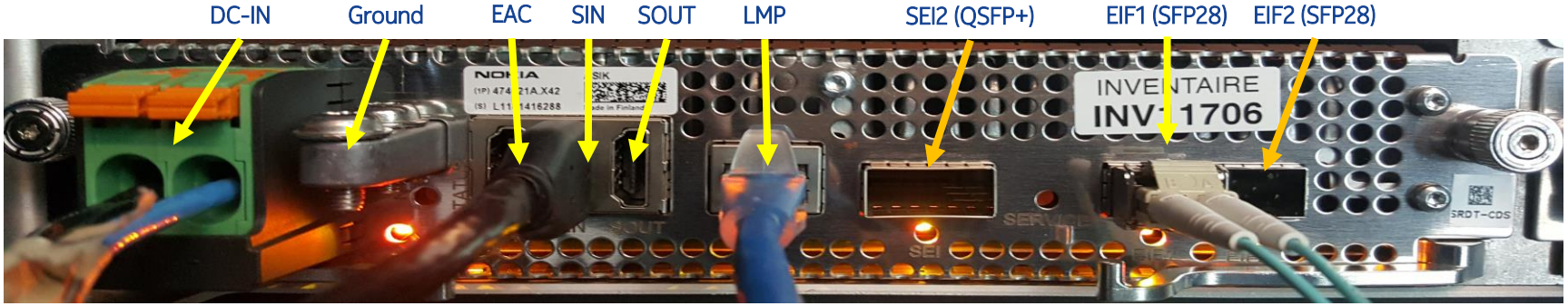
Capacity plug in unit:

- Cell specific baseband processing
- Up to 6 PIU in Subrack for flexible expansion of BTS baseband capacity
- RF Module connectivity
  - 6 x OBSAI/CPRI up to 9.8 Gbps
    - 3 out of 6 CPRI interfaces support IQ compression



AirScale Common ASIK Plug in Unit (System Module)

Note : Do Not Install any software below version FL17



Port	#	Physical I/F	Usage
DC-IN	1	DC terminal	48V DC Input
GND	1	GND	Grounding of unit
RESET	1	Button	Plug-in unit RESET, with 2 scenarios (<5sec; >5sec pressed)
EAC	1	HDMI	External alarm & control, 6 alarms, 6 alarms/ctrls, CAN/RS485
SIN	1	HDMI	Synchronization input, GPS interface
SOUT	1	HDMI	Synchronization output
SEI	1	QSFP+	Extension towards second subrack, 4x 10GE
EIF1…2	2	SFP28	New back-/midhaul interface. Up to 25GE per port.
LMP	1	RJ-45	Local management port, 1G Ethernet
Service	1	Button	Plug-in unit Service Reset
LEDs	6	LED	Visual indication of status

Common plug-in unit:

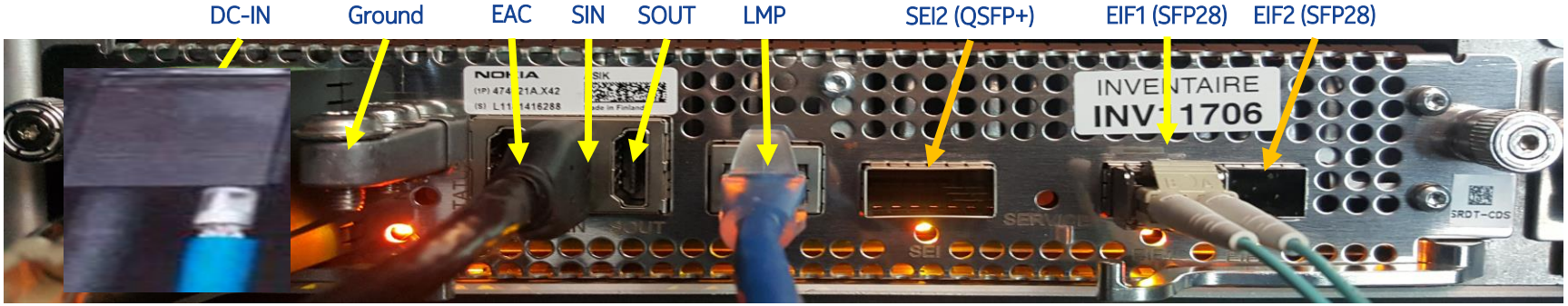
- Centralized control processing
- Up to 2 units in one Subrack for independent Base Stations or high capacity configurations
- Integrated Ethernet transport termination per subrack side

Connectivity to:

- Transport *(EIF)*
- External System Module Extension
  - AirScale SM Subrack *(SEI)*
  - Flexi Multi Radio 10 SM *(SRIO)*

VZW AirScale Common ASIKA Plug in Unit (System Module)

Note : Do Not Install any software below version FL17



Port	#	Physical I/F	Usage
DC-IN	1	DC terminal	48V DC Input
GND	1	GND	Grounding of unit
RESET	1	Button	Plug-in unit RESET, with 2 scenarios (<5sec; >5sec pressed)
EAC	1	HDMI	External alarm & control, 6 alarms, 6 alarms/ctrls, CAN/RS485
SIN	1	HDMI	Synchronization input, GPS interface
SOUT	1	HDMI	Synchronization output
SEI	1	QSFP+	Extension towards second subrack, 4x 10GE
EIF1…2	2	SFP28	New back-/midhaul interface. Up to 25GE per port.
LMP	1	RJ-45	Local management port, 1G Ethernet
Service	1	Button	Plug-in unit Service Reset
LEDs	6	LED	Visual indication of status

Common plug-in unit:

- Centralized control processing
- Up to 2 units in one Subrack for independent Base Stations or high capacity configurations
- Integrated Ethernet transport termination per subrack side

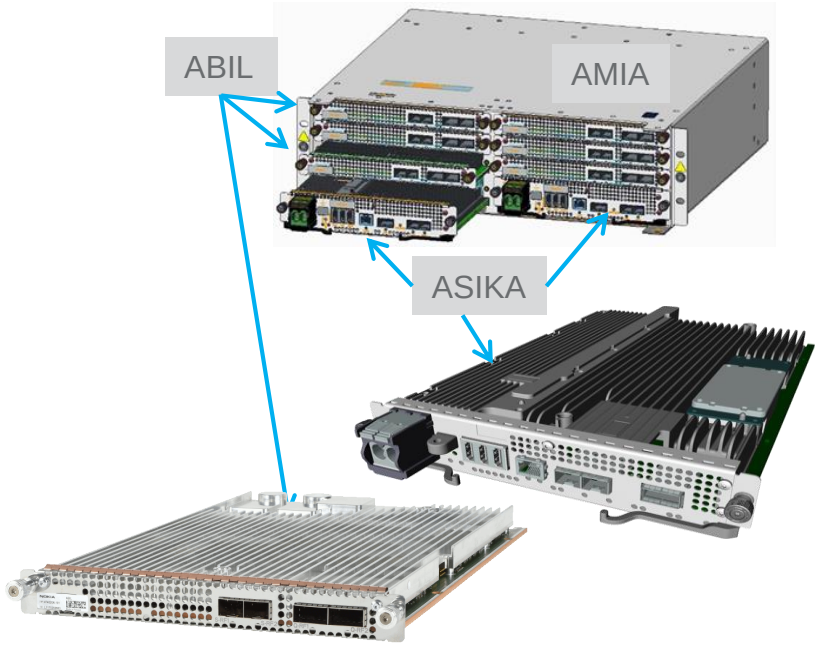
Connectivity to:

- Transport *(EIF)*
- External System Module Extension
  - AirScale SM Subrack *(SEI)*
  - Flexi Multi Radio 10 SM *(SRIO)*

AirScale System Module Indoor

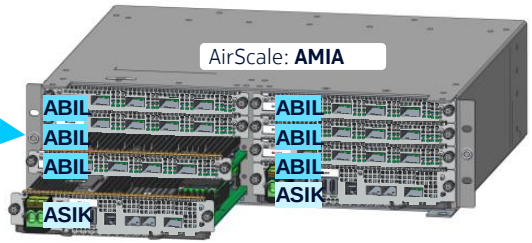
ASIK & ABIL for 5G high capacity

- AirScale SM Indoor consist of
  - 1 AirScale Subrack **AMIA**
    - Subrack for 2G/3G/4G/5G
    - 8 Slots: 2 common, 6 capacity
  - 1…6 AirScale Capacity **ABIL**
    - Supports either L1 or L1H
    - Supports L2RT
    - 2x QSFP+: 8x9.8 Gbps for CPRI fronthaul
    - 2x SFP28: 2x25 GE for eCPRI [5G19]
  - 1…2 AirScale Common **ASIKA**
    - Local OAM, sync, transport and L2NRT
    - L3 for Classical
    - 2x SFP28: for 25/10 GE Backhaul interface
    - Sync IN and OUT, External Alarms and Controls, LMT
    - DC 48 V input
- Installation options: 19 inch, pole and wall, outdoor cabinet
- Dimensions 19” 3 U : H 128 x W 447 x D 400 [mm]
- Weight: 10.1 kg minimum 23.6 kg maximum
- Ingress protection IP20
- Temperature range = -5…60°C
- Airflow direction front to back (default) or back to front. Back to front with relaxed ambient temp (-5…+55°C)



AirScale Hardware Configuration

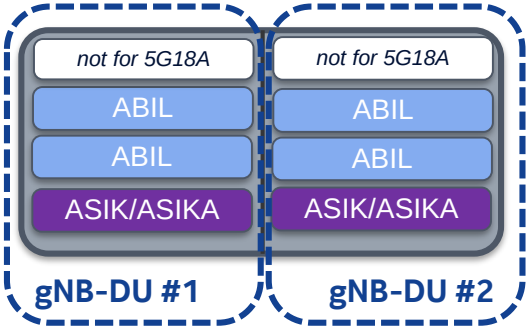
ABIL



ASIK

ABIL is 5G baseband capacity card supporting **L1 processing.**

ASIK/ASIKA is used for common processing functions: O&M, transport, synchronization. Also supports 5G L2 real-time processing (MAC/RLC') + the DU portion of L2 non-real time processing (RLC").



AirScale card capacity (HW):
- 1-2 ASIK/ASIKA
- 1-6 ABIL

Supported 5G18A gNB-DU configurations contain:
- 1 ASIK/ASIKA
- 1-2 ABIL

- Installation options: 19 inch, pole and wall, outdoor cabinet
- Dimensions 19" 3 U : H 128 x W 447 x D 400 [mm]
- Weight: 10.1 kg minimum 23.6 kg maximum
- Ingress protection IP20
- Temperature range = -5...60°C
- Airflow direction front to back (default) or back to front. Back to front with relaxed ambient temp (-5...+55°C)

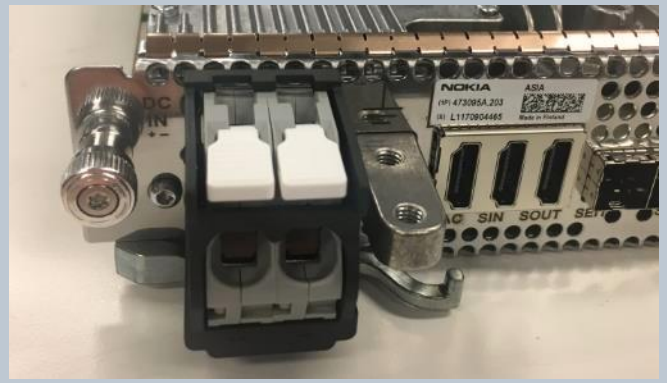
ASIKA

The ASIKA is a new variant of ASIK designed to meet Verizon Wireless requirements.

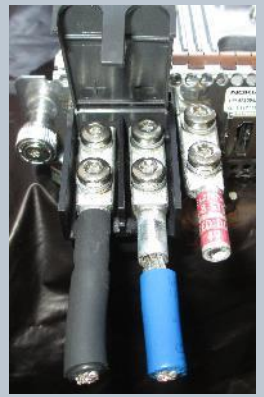
It is identical to THE ASIK with the following exceptions:

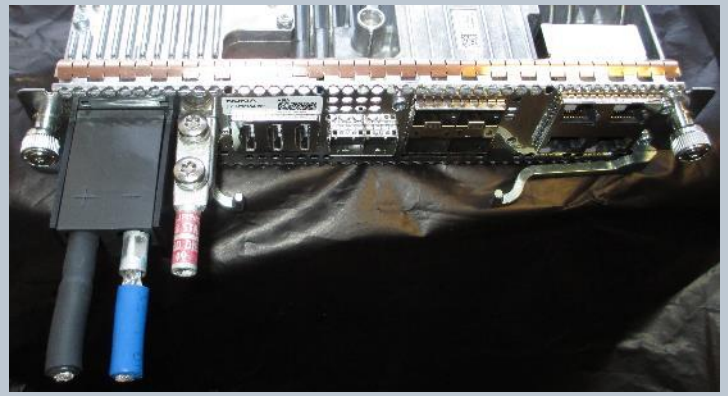
1. New power connector (lug connector vs. current clamped connector)
2. New information in flash (new product code)

ASIK
474021A

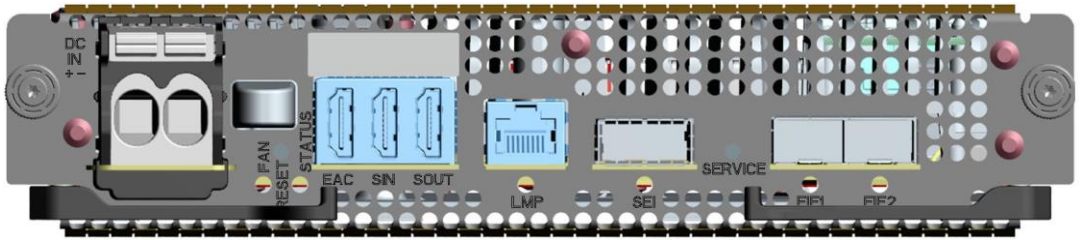


ASIKA
474424A



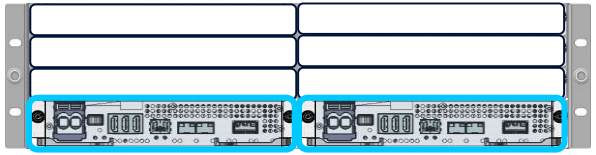


*Above pictures are from ASIA/ASIAA units



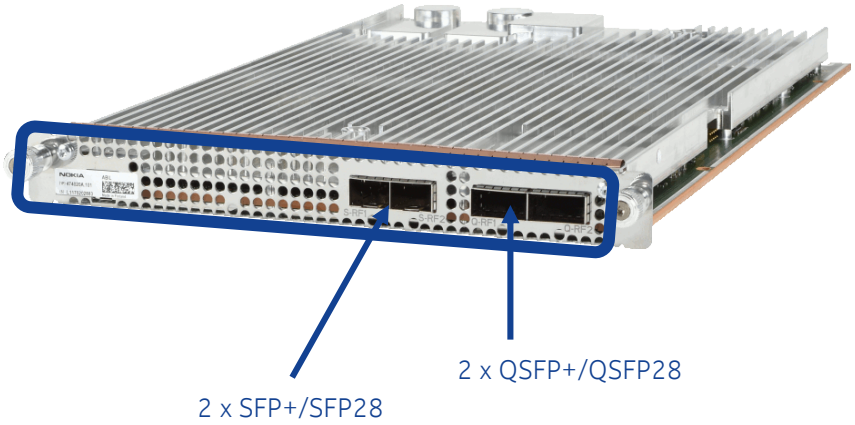
- ASIK/ASIKA is mechanically compatible with the ASIA.
  - ❑ **ASIK** power connector is a DC clamp connector
  - ❑ **ASIKA** power connector uses lug connector (screw) for DC power connector. **ASIKA meets Verizon requirements.**

Port	#	Physical I/F	Usage
DC-IN	1	DC terminal	48V DC Input
GND	1	GND	Grounding of unit
RESET	1	Button	Plug-in unit RESET, with 2 scenarios (<5sec; >5sec pressed)
EAC	1	HDMI	External alarm & control, 6 alarms, 6 alarms/ctrls, CAN/RS485
SIN	1	HDMI	Synchronization input, GPS interface
SOUT	1	HDMI	Synchronization output
SEI	1	QSFP+	Extension towards second subrack, 4x 10GE
EIF1…2	2	SFP28	New back-/midhaul interface. Up to 25GE per port.
LMP	1	RJ-45	Local management port, 1G Ethernet
Service	1	Button	Plug-in unit Service Reset
LEDs	6	LED	Visual indication of status



ABIL Plug-In Unit Interfaces

A single ABIL in 5G18A supports maximum of 8DL/8UL @ 100MHz or 50MHz cell bandwidth (i.e., max of 4x100MHz 2x2 MIMO)

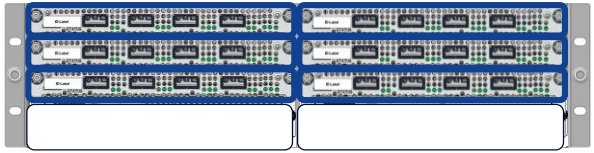


Front panel interfaces

- 2xQSFP+/QSFP28: 8 x 9.8 Gbps for CPRI fronthaul
- 2xSFP+/SFP28: 2 x 25 GE for eCPRI

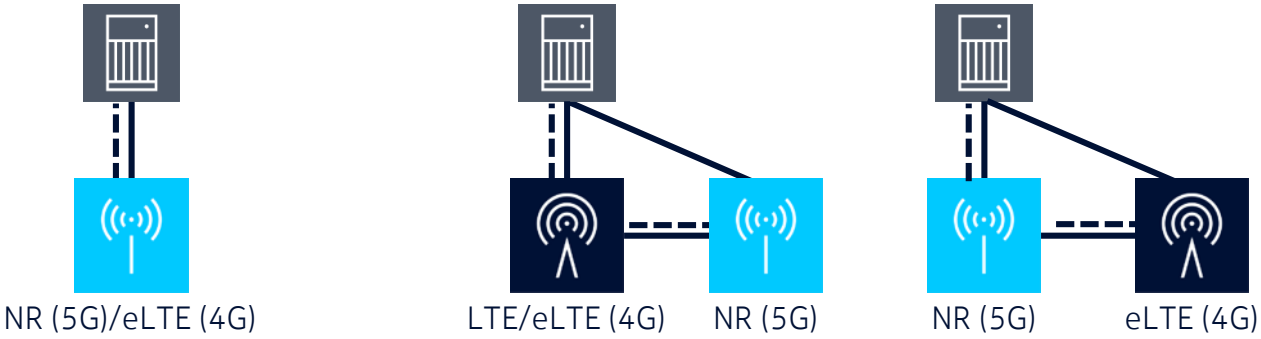
Depending on use case:

- Used for RF interfaces or inter ABIx data
- CPRI or eCPRI (Ethernet) for Lower Layer Fronthaul
  - NOTE: eCPRI support is targeted beginning in 5G19



Standalone (SA) and Non-standalone (NSA) 5G Deployments

3GPP background: New Radio (NR) functionality



Feature	Standalone (SA)	Non-standalone (NSA)	
NR radio cells	Standalone control and user planes	Secondary user plane	Master control and user
Core choice	5G NGC	4G EPC or 5G NGC	
CSP perspective	Simple, high-performance overlay	Leverages existing 4G deployments	
Vendor perspective	Independent RAN product	Requires tight interworking with LTE	
End-user experience	Peak bitrate per bearer set by NR Dedicated low-latency transport	Peak bitrate per bearer could be sum of LTE and NR Latency impacted if routed via LTE master	

NOKIA

RAN-Core 5G Scenarios: Options 1, 2, 3, 4, 5 and 7

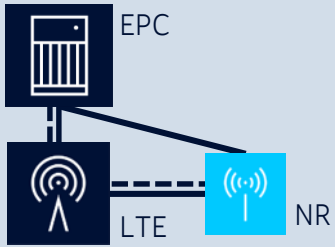
3GPP background

Option 1 | SA LTE with EPC

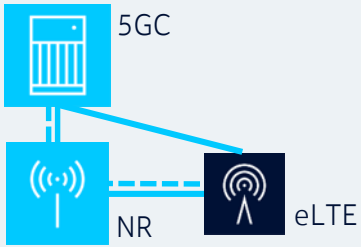
Option 2 | SA NR with 5GC

Option 5 | SA LTE with 5GC

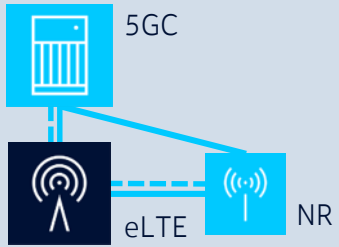
Option 3 | NSA LTE+NR with EPC



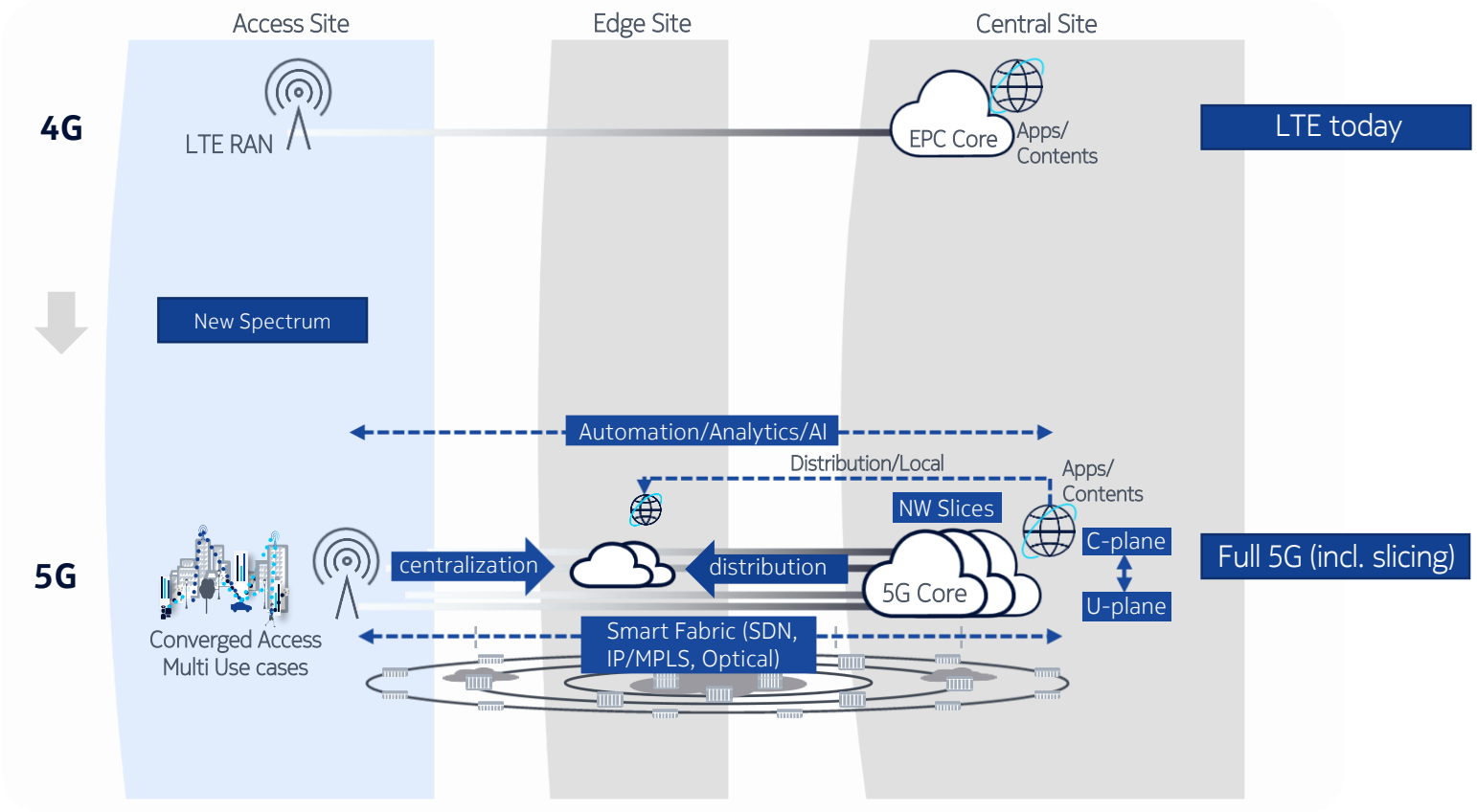
Option 4 | NSA NR+LTE with 5GC



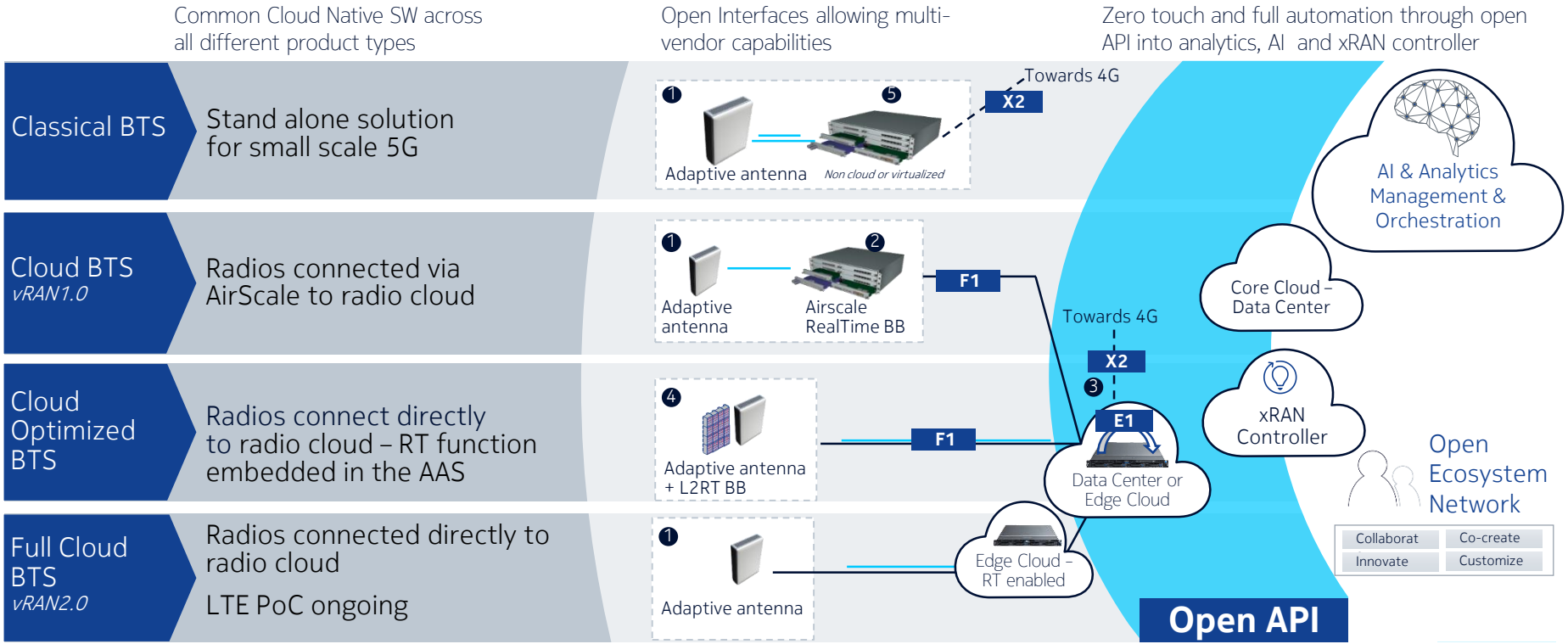
Option 7 | NSA LTE+NR with 5GC



SA: Standalone; NSA: Non-standalone

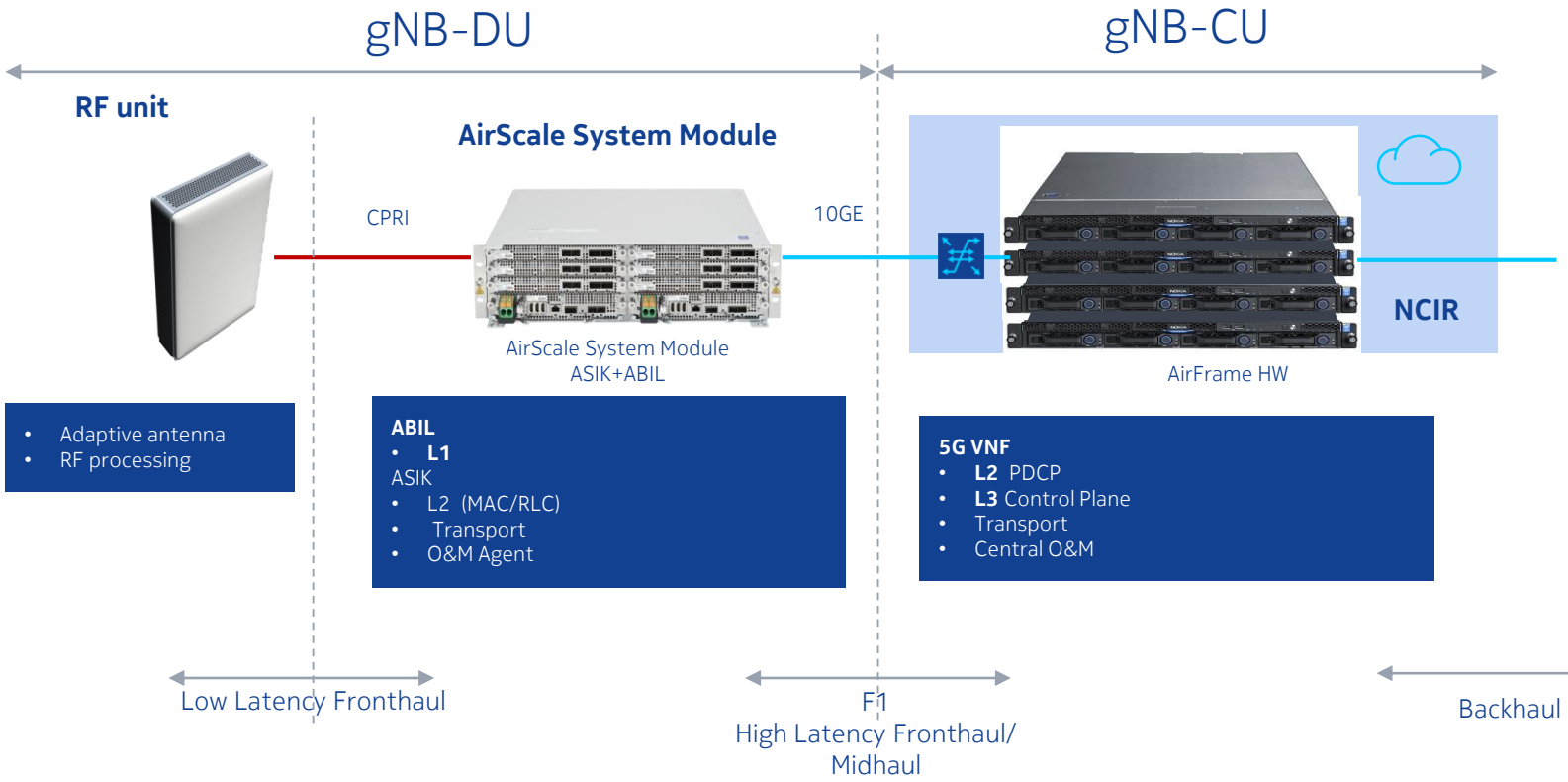

Access Site
Edge Site
Central Site
4G
LTE RAN
EPC Core
Apps/
Contents
LTE today
New Spectrum
Automation/Analytics/AI
Distribution/Local
Apps/
Contents
NW Slices
5G
centralization
distribution
5G Core
C-plane
U-plane
Full 5G (incl. slicing)
Converged Access
Multi Use cases
Smart Fabric (SDN,
IP/MPLS, Optical)

Flexible, Innovative and Open Massive Scale Access



HW Products Realizing Physical Entities of 5G gNB

NCIR - Nokia Cloud Infrastructure for Real Time applications

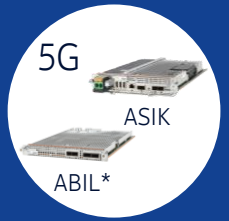


AirScale SM Evolution Plan

AirScale Baseband

Multi-RAT HW: 2G, 3G, 4G, 4.5G, 4.5G Pro, 4.9G

- Common PIU (ASIA)
- Capacity PIU (ABIA)
- High capacity indoor subrack (AMIA)
- High capacity outdoor subrack (AMOB)
- Basic capacity outdoor subrack (AMOC)
- Throughput 10 Gbps

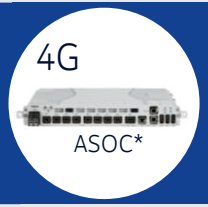


5G BB

- ASIK Common PIU
- ABIL* Capacity PIU
- Throughput 28 Gbps

3-fold 4G Capacity – sub3GHz 5G

- ASIB Common PIU (ASIB) with 2G/3G/4G/5G capability
- ABIC* Capacity PIU with 2G/4G/5G capability
- Throughput 15 Gbps



Compact all-in-one 4G BB

- ASOC* Outdoor Core Unit with 2G/4G capability
- Tower or rack mount

4G, 5G

3-fold 5G Capacity

- Common PIU*
- Capacity PIU*
- Throughput 84 Gbps

6 Tbps connectivity: AirScale System Module backplane

*) ReefShark technology based product; PIU = Plug-In Unit

3Q/2018 - 2Q/2019

4Q/2019 →

BTS BB Summary

- Installed base HW can be fully utilized at multi-RAT sites evolving to 5G

- Nokia's new AirScale High Performance 4G plug-ins with 5G capability: **ASIB, ABIC**
  - Wide, fast 5G coverage at < 3 GHz frequency bands with <60 MHz bandwidth
  - Legacy RAT spectrum refarming to 5G or new narrowband 5G spectrum allocations

- Nokia's High Performance 5G plug-ins: **ASIK, ABIL**
  - 5G roll-outs at any band
  - Typically >3 GHz frequency bands with 100-200 MHz bandwidth
  - AirScale System Module subracks delivered since 2016 are used to house the 5G plug-in units. System Module is thus 5 RAT capable, with 5G and multi-RAT plug-in units installed.

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AirScale RF Evolution Plan

AirScale RF

Multi-RAT HW: 2G, 3G, 4G, 4.5G, 4.5G Pro, 4.9G, 5G

- Remote RF Head (RRH)
- RF Module
- Single-, dual-, triple-band
- 2T2R, 2T4R, 4T4R, 8T8R
- mMIMO 64T64R

2G, 3G, 4G,5G

RRH

- DFE: 2-fold bandwidth, 4-fold TRX amount
- ETAdvanced: 30% lower RF line-up power consumption

4G, 5G

Ultra deployable MAA sub6GHz

- DFE and RFIC: 50% size and weight reduction
- DFE: 2-fold bandwidth, 4-fold TRX amount
- Beamforming in RF
- E.g. AEQJ

4G, 5G

MAA sub6GHz

- DFE: 2-fold bandwidth, 4-fold TRX amount
- Beamforming in RF
- E.g. AEQB, AEQE

MAA = mMIMO Adaptive Antenna

3Q/2018 – 4Q/2019

Note: this page is not showing maximum performance capabilities, but a typical use case

BTS use case example, tri-sectored site

Band	2G	3G	4G
A	2+2+2	1+1+1	
B	2+2+2		1+1+1@15 MHz 2x2 MIMO
C		1+1+1	

3 RF Modules
- Band A (2G, 3G)
- Band B (2G, 4G)
- Band C (3G)

n x OBSAI, CPRI

ABIA
ABIA
ASIA

AirScale System Module

Band	2G	3G	4G	5G
A	2+2+2	1+1+1		
B	2+2+2		1+1+1@15 MHz 2x2 MIMO	
C		2+2+2	1+1+1@10 MHz 2x2 MIMO	
D			1+1+1@10 MHz 2x2 MIMO	1+1+1@10 MHz 2x2 MIMO
E			1+1+1@20 MHz 4x4 MIMO	
F				1+1+1@100MHz, mMIMO, 16 DL layers, 8 UL layers

4 RF Modules
- Band A (2G, 3G)
- Band B (2G, 4G)
- Band C (3G, 4G)
- Band D (4G, 5G)

3 mMIMO
- Band F (5G)

n x CPRI, eCPRI

n x OBSAI, CPRI

Fronthaul Switch

n x CPRI

3 RRH
- Band E (4G)

ABIC | ABIL
ABIA | ABIL
ABIA | ABIL
ASIB | ASIK

AirScale System Module

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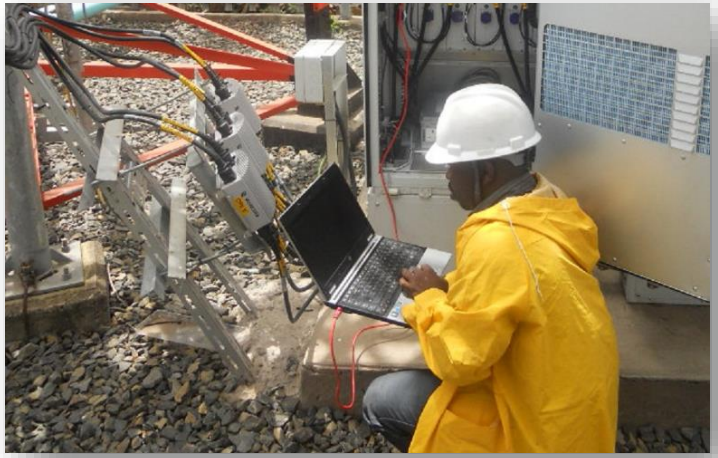
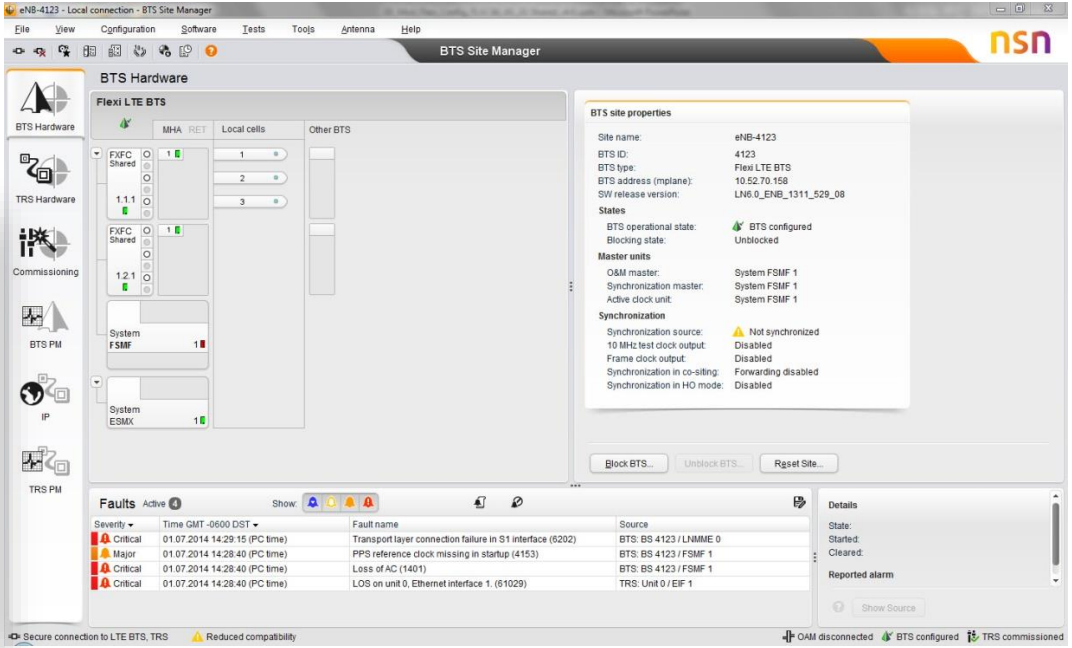
5G COMMISIONING & INTEGRATION

4G Software Upgrade & SCF Load Through BTS Site Manager

Using a laptop with the installed BTS Manager, begin the software update and commissioning of the Flexi BTS. The next slides will step you through the process.





4G Software Upgrade & SCF Load Through BTS Site Manager

- **Before you start…**
  - Make sure the following conditions are fulfilled:
  - If the PC is connected to the System Module LMP port, specify your PC's network settings to match the following settings:
    - IP address: 192.168.255.130 (Can be used for 4G, 3G, or 2G)
    - Subnet mask: 255.255.255.0

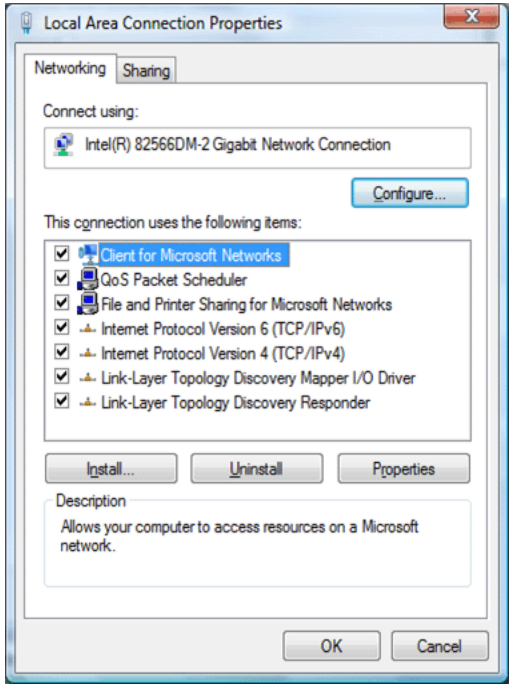
Use this IP set up for the commissioning of the BTS

  - If you want to establish a connection to the BTS site locally, connect the PC to the LMP port on the System Module (FSMx/ Airscale) using an Ethernet cable with an RJ-45 connector.

4G Software Upgrade & SCF Load Through BTS Site Manager

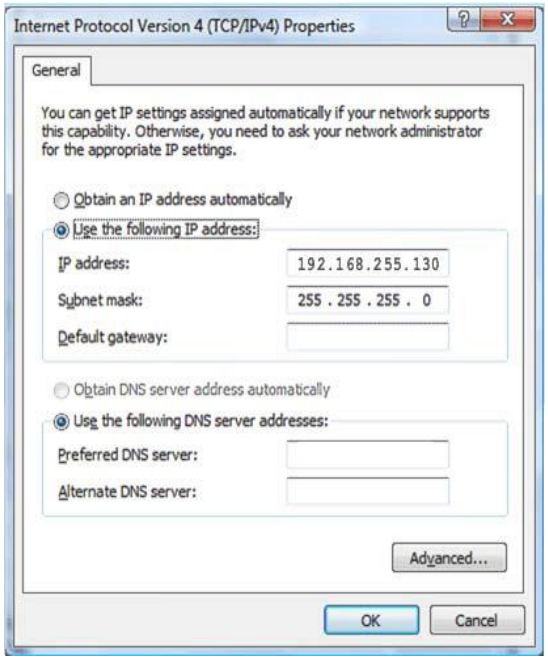
Changing IP address settings with Windows Vista/7

- **Select Internet Protocol Version 4(TCP/IPv4) → View Internet Protocol Version 4(TCP/IPv4) Properties**



Double click Internet Protocol Version 4(TCP/IPv4).

Ensure that the 'Use the following IP address' button is selected, and enter the IP Address, Subnet mask and Default gateway according to the following figure.



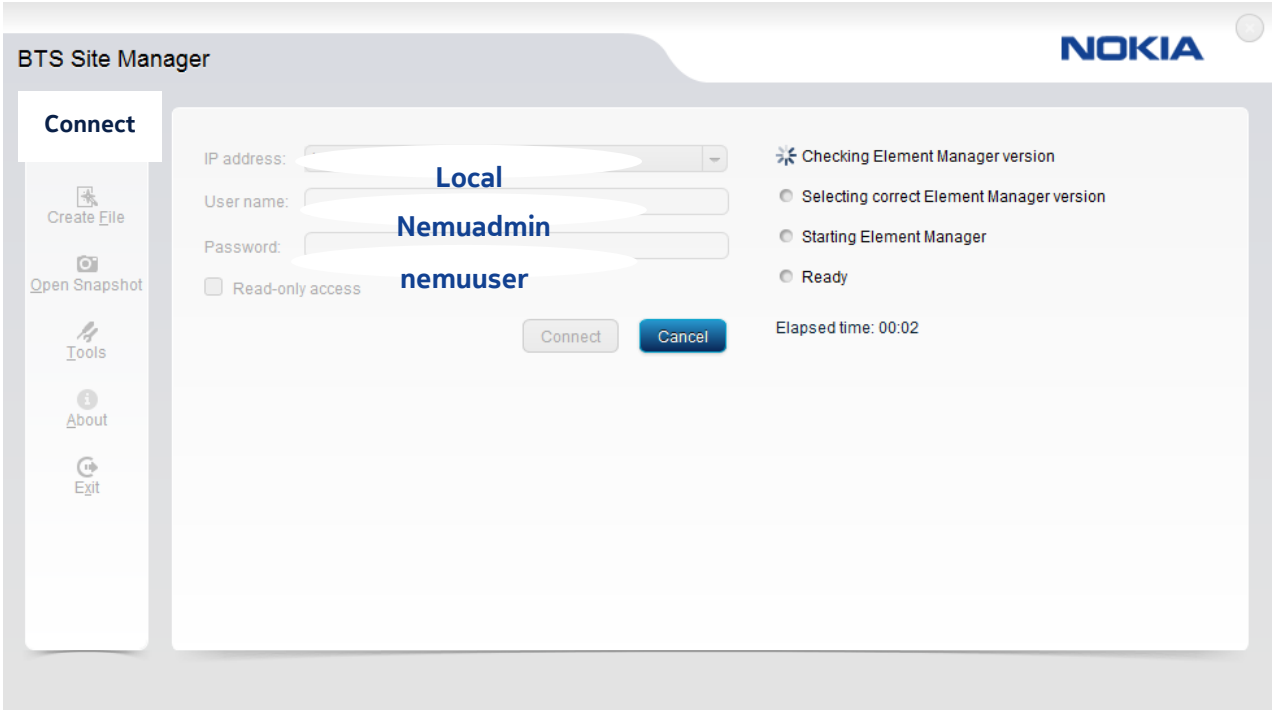
Entering the IP Address, Subnet mask and Default gateway

4G Software Upgrade & SCF Load Through BTS Site Manager

Launching BTS Site Manager

- **Steps:**

1. **Start BTS Site Manager by clicking the icon on your desktop.**
2. **Establish connection: , select the “Local” option from the IP Address list.**
3. **If you want to establish a remote connection, define the IP address of the remote BTS.**
4. **Username: “Nemuadmin” Password: “nemuuser”**
5. **Click: “Connect”**



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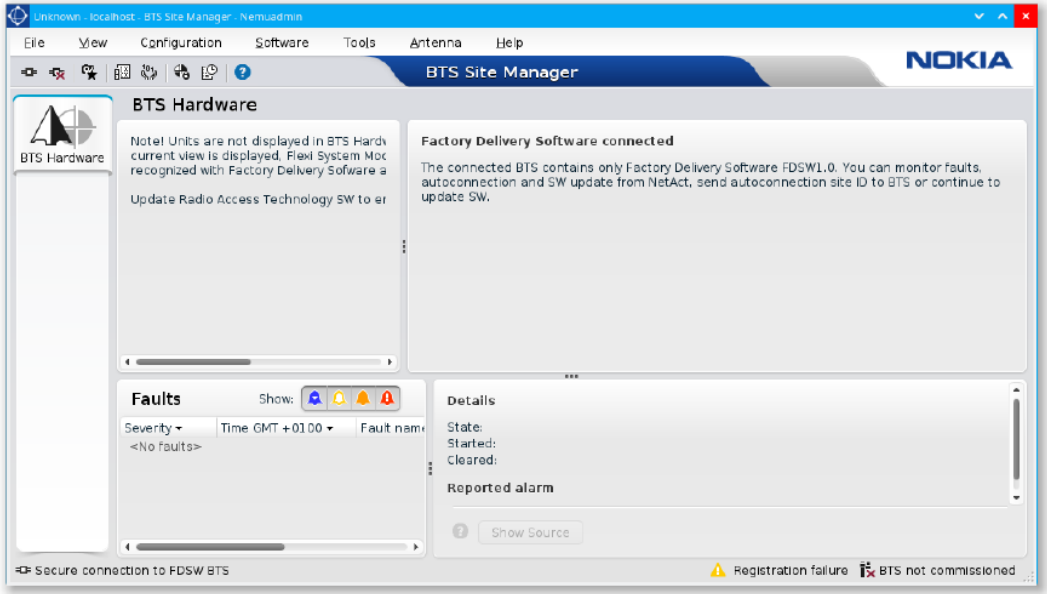
4G Software Upgrade & SCF Load Through BTS Site Manager

FDSW message displayed in BTS Site Manager

The eNode B may come with a FDSW version, in this case you need to perform a SW update to detect all the units in the configuration.

Once the radios are connected to the BBU then a second SW update is required to update the radios.



FDSW does not detect any connected modules before SW upgrade to RAT - specific BTS SW. **BTS Hardware** displays **Incompatible View** when BTS Site Manager does not display HW modules in **BTS Hardware** view and no licensing information identification is available. An example of the message can be seen in Figure 5: BTS Hardware view in FDSW Site Manager

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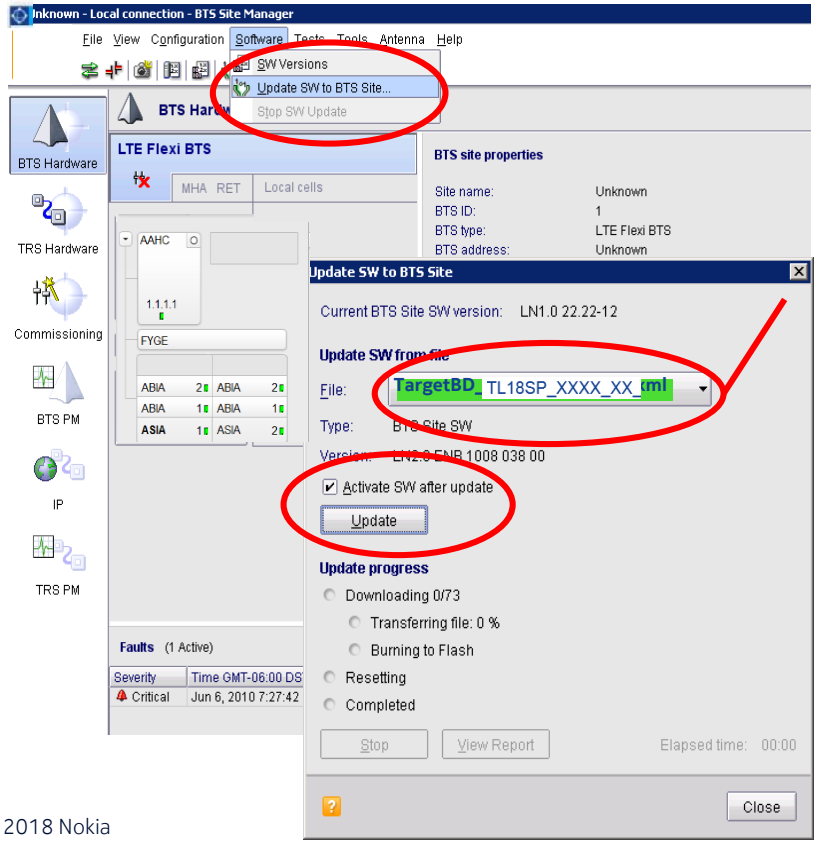
4G Software Upgrade & SCF Load Through BTS Site Manager

Software Update for TD-LTE via BTS Site Manager



FL XXX SW is for FDD-LTE.
TL XXX SW is used for TDD-LTE.

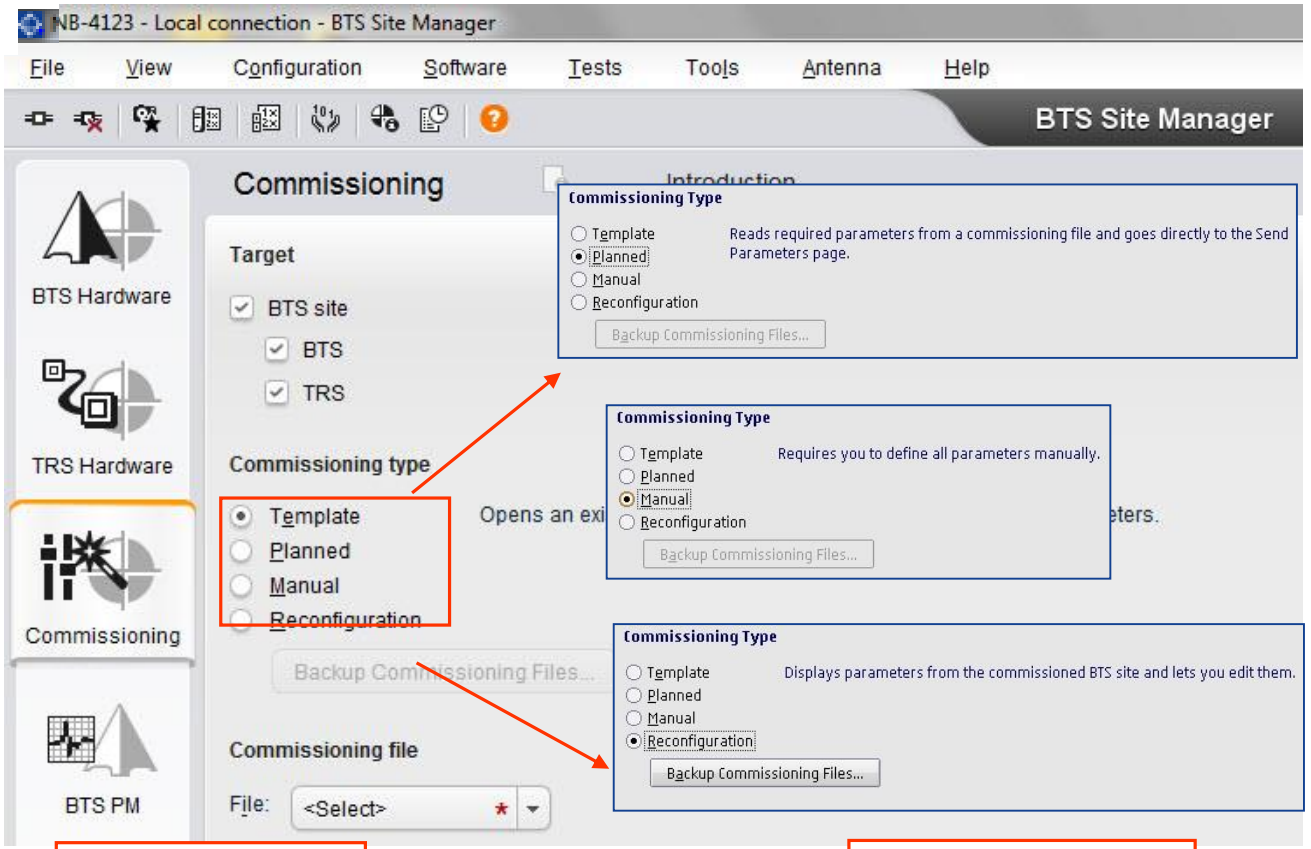
File selected will be TL18SP_XXXX_XX_release_BTSSM_downloadable.zip according to the project software version. BTSSM decompresses and selects the TargetBD file which points to necessary binaries for this release.

SW update takes approximately 15-35 minutes, depending on the number of files updated.

4G Software Upgrade & SCF Load Through BTS Site Manager

Commissioning Type

Make sure you select TEMPLATE option as you may need to complete RET, TMA, or External Alarms pages based on the project requirements.

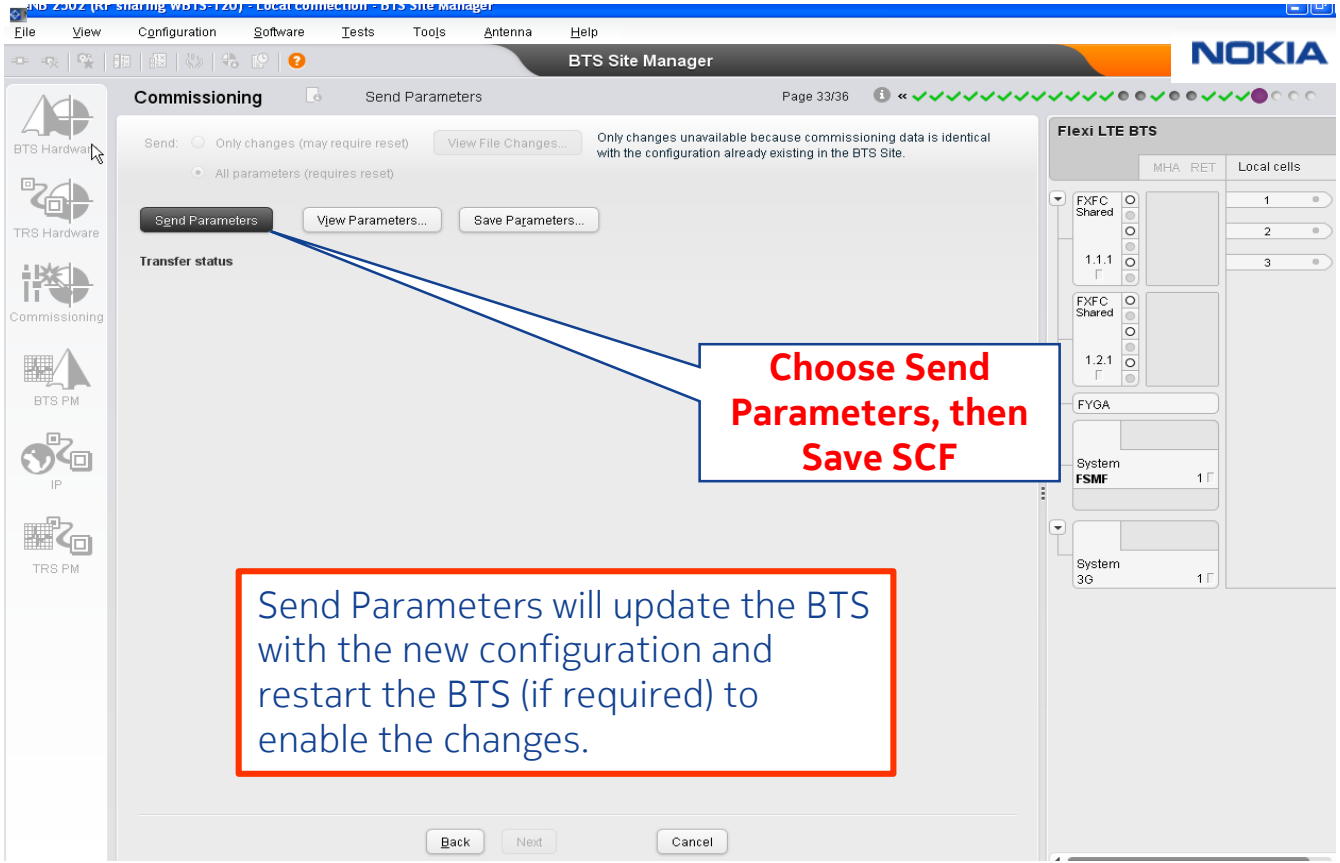


Select Commissioning file for Template or Planned commissioning

Reconfiguration option is only available in on-line mode

4G Software Upgrade & SCF Load through BTS Site Manager

Send Parameters



5G Software Upgrade Through BTS Rescue Console

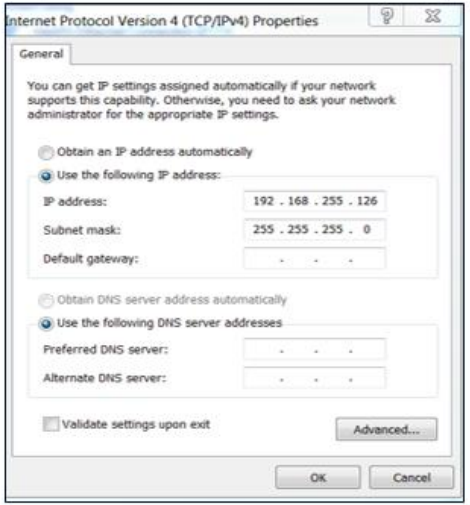
SETTING UP TEST PC AND ASIK

Set your PC IP to 192.168.255.126 netmask 255.255.255.0

IP address = 192.168.255.126

netmask = 255.255.255.0

gateway = none



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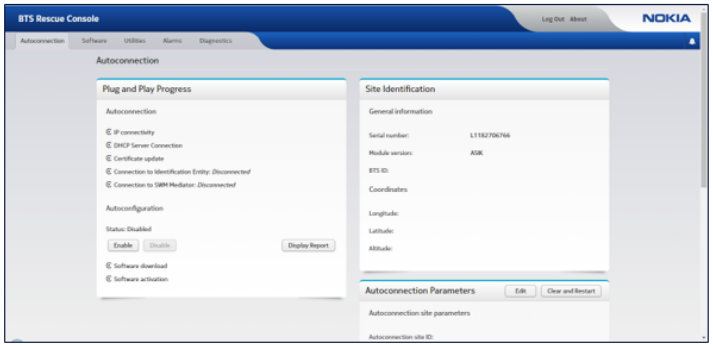
5G Software Upgrade Through BTS Rescue Console

Log in to BTS Rescue Console entering provided credentials

Username : Nemuadmin

Password : nemuuser

BTS Rescue Console frontpage



ASIK FDSW UPGRADE

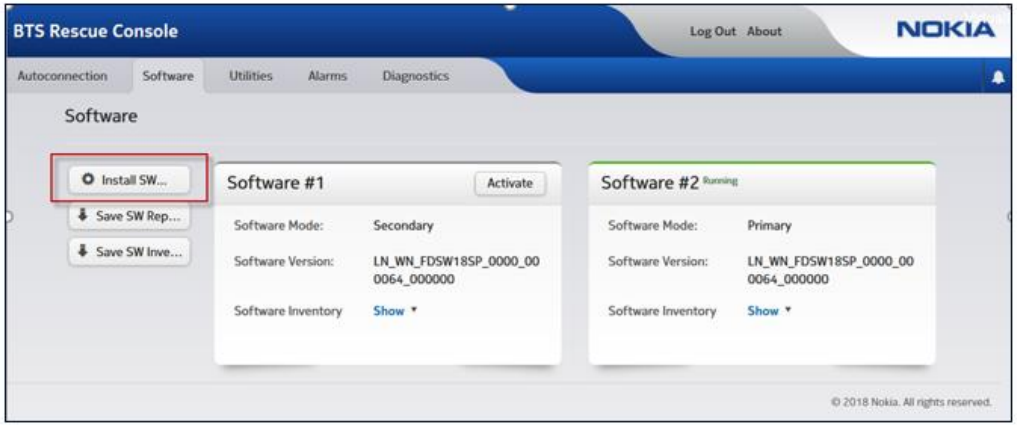
Make sure there is **NO ABIL** boards are plugged in nor the backhaul transmission.

Log in to BTS Rescue Console entering provided credentials

Username : Nemuadmin

Password : nemuuser

Go to "Software" tab in BTS Rescue Console and select "Install SW.." Button.



Install FDSW on the ASIK first and then upgrade it to the 5G software

The SCF needs to be loaded remotely through the cloud.

5G Software Upgrade & SCF load Through Cloud

Commissioning Overview: Prerequisites for the successful commissioning according to these instructions are that:

- the gNB has passed the factory acceptance tests
- the installation has to be accepted
- in a two-cabinet configuration, the cabling has been done during the installation phase

All software that belongs to the gNB must be prepared on the hard disks of the system before starting the commissioning tests. If there is a newer SW available that what is installed on the gNB disk, the gNB must be commissioned with the same SW that is installed on the disks. The newer SW is installed before the integration of the gNB.

There is an overview of the gNB site commissioning. There are three different commissioning types:
In actual release there is only one method to perform a commissioning gNB. Planned commissioning provides an option to commission network elements by loading a commissioning file (SCF), specifically made for the gNB site. The commissioning file can be prepared with the Offline Configuration Tool.

5G Software Upgrade & SCF Load through Cloud

Commissioning via 5G BTS Element Manager, using a default SCF file (provided by OAM)

Equipment preconditions

- Control nodes and compute nodes are pre-installed.
- Network environment is properly connected and configured with proper VLANs (network switches configuration).
- Stacks were successfully created.
- OAM IP is known.

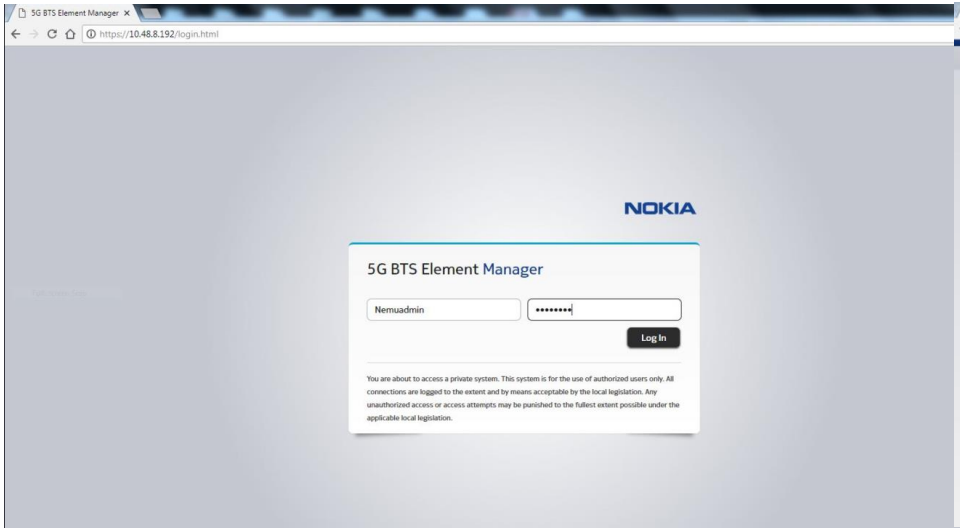
Procedure

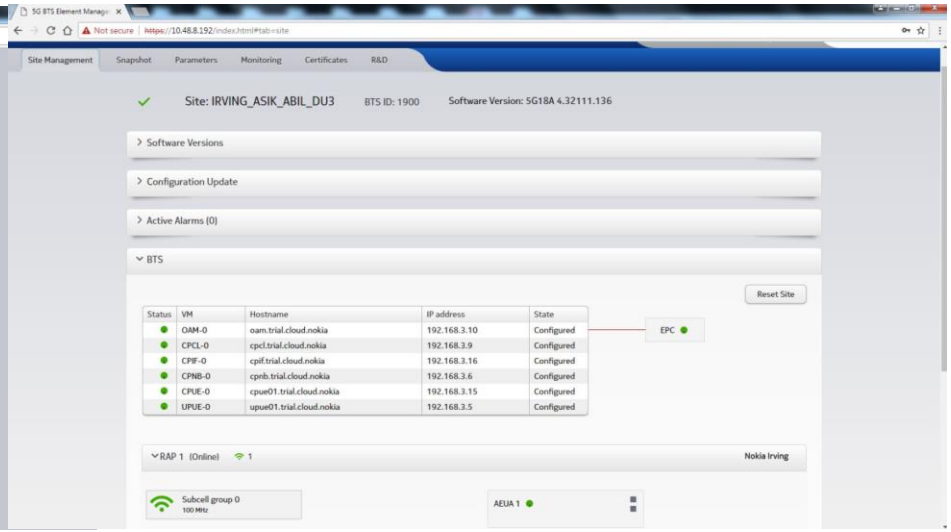
Log in to 5G BTS Element Manager (Web UI).
Click the **Browse** button in Configuration update section
Select matching Commissioning file and click **Update**.
Use matching Commissioning file based on network planning for the current VNF to commission the freshly deployed CU.

Step result

5G Software Upgrade & SCF Load Through Cloud

Connect to the BTS IP address through the cloud by using Google Chrome.





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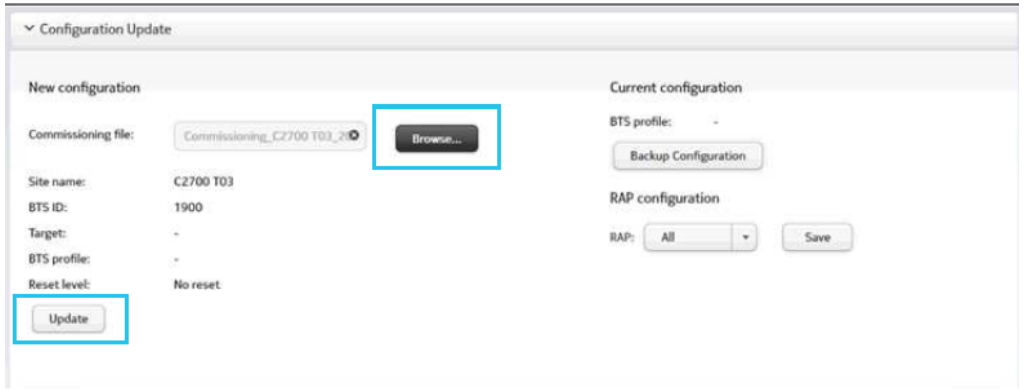
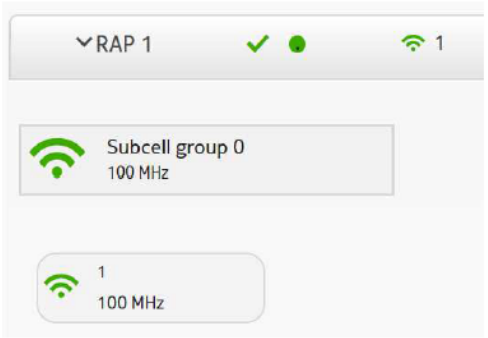
5G Software Upgrade & SCF Load Through Cloud



Note: The gNB restarts automatically after performing the configuration and needs to re-login.



Result

After commissioning 5G CU VNF is fully prepared and ready to integrate with remote DU sites.

Review and Questions & Answers

- ✓ Do you have any questions? Ask!
- ✓ What are some of the main things you learned from this course?
- ✓ Did this session give you a better understanding of 5G Basics?
- ✓ Do you think you will be better prepared for an in-depth 5G technical course?
- ✓ Was it helpful?

Thank you for attending.
Please submit your student evaluation before leaving class today.
We look forward to your feedback on ways we can improve this training.

https://tinyurl.com/sepfeedbackeval

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Revision history and metadata

Please delete this slide if document is uncontrolled

Document ID: DXXXXXXXXX
Document Location:
Organization:

Version	Description of changes	Date	Author	Owner	Status	Reviewed by	Reviewed date	Approver	Approval date
First Version		04-10-2018					DD-MM-YYYY		DD-MM-YYYY