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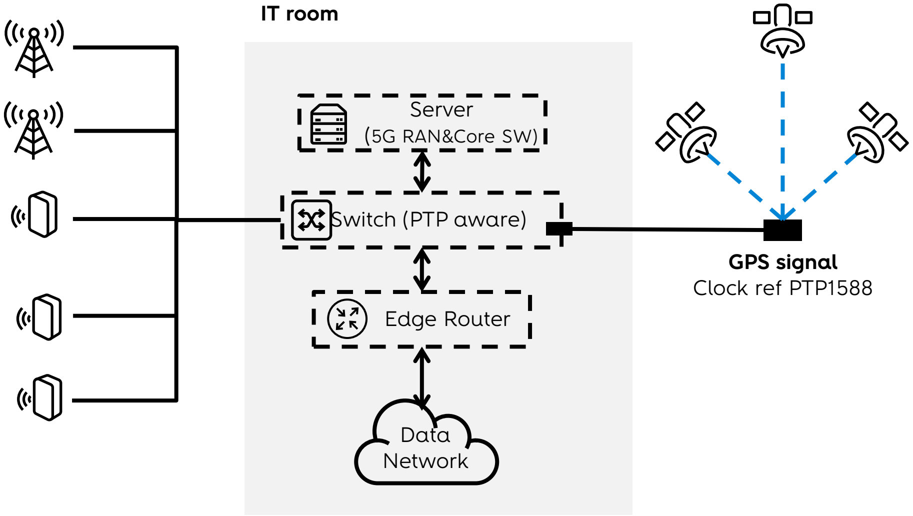
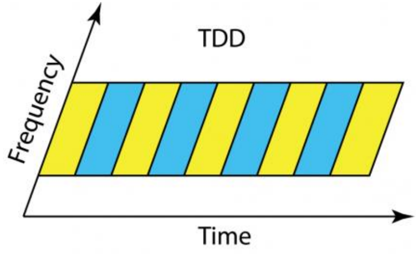
# NEXUS 5G Connected Port

## Planning a 5G network - Porto de Sines

# Private 5G Building Blocks

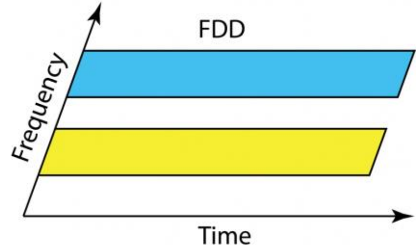


# TDD vs FDD



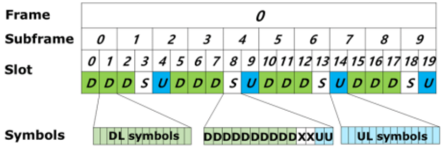

## Advantages:

- Higher spectral efficiency
- Cost effective
- Better for high-frequency bands
- Lower latency in short distances




- Stable  performance in high mobility scenarios
- Lower interference potential
- Wide coverage
- Better Uplink performance

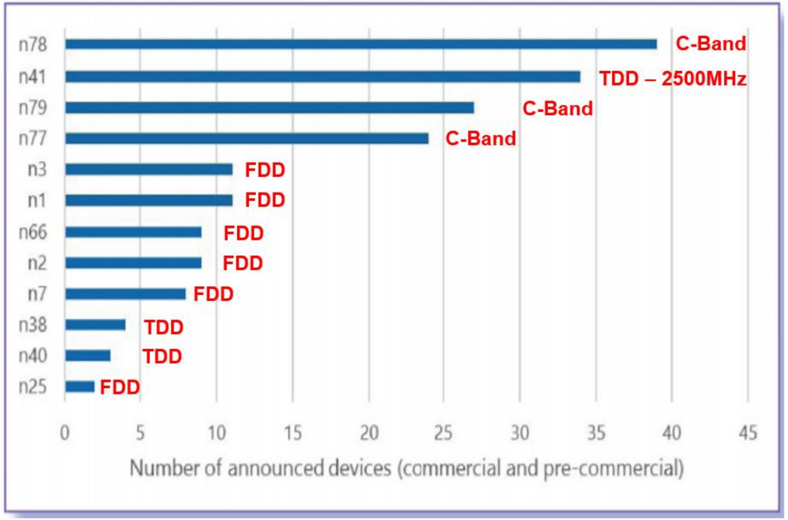
## TDD Frame structure




TDD Pattern:3-1-1
SCS=30KHz
Special slot=32(10-2-2)

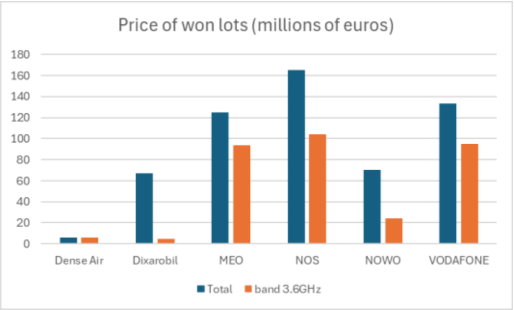
# The most common Sub 6GHz 5G Commercial Bands

n78 (3300–3800 MHz)
n41 (24960–2690 MHz)
n79 (4400–5  00 MHz)
n77 (3300–4200 MHz)
n3 (1800 MHz)
n1 (2100 MHz)
n66 (1700 MHz)
n2 (1900 MHz)
n7 (2600 MHz)
n38 (2600 MHz)
n40 (2300 MHz)
n25 (1900 MHz)




## In Portugual from the auction@2021:

- 3,6GHz (TDD 100MHz)
- 700MHz (FDD 2x10MHz)
- technology neutrality > refarm spectrum used for legacy networks (2G, 3G and 4G)



# Porto de Sines Spectrum

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- Spectrum in the 3.3 GHz to 3.8 GHz range is ideal: Belongs to the FR1
- In Portugal, ANACOM did not put for auction any spectrum for 5G SA private networks
- In Porto de Sines, Altice Labs will implement 5G SA system in 20 MHz of public MEO spectrum
- MEO reduced their spectrum in the surrounding area 5G cells

| | MEO<br>National Wide | MEO<br>Surrounding Sites | NEXUS<br>Porto de Sines |
|---|---|---|---|
| Spectrum (GHz) | 3.71 – 3.8 | 3.71 – 3.78 | 3.78 – 3.8 |

Central Frequency used in Porto de Sines
3.79 GHz

NO!!
Why?!

| NR Frequency | |
|---|---|
| FR1- sub6 | FR2 - mmW |
| <7 GHz | 24 – 52 GHz |

# ARFCN

- ARFCN – Absolute Radio Frequency Channel Number
  - Unique numerical identifiers assigned to radio frequency channels
  - Standardized way to identify and facilitate the efficiency of spectrum resources
  - Each ARFCN corresponds to a specific central frequency

$$F_{REF} = F_{REF-Offs} + \Delta F_{Global}(N_{REF} - N_{REF-Offs})$$

| $F_{REF}$ (MHz) | $\Delta F_{Global}$ (KHz) | $F_{REF-Offs}$ (MHz) | $N_{REF-Offs}$ | Range of $N_{REF}$ |
|---|---|---|---|---|
| 0 – 3000 | 5 | 0 | 0 | 0 – 599999 |
| 3000 - 24250 | 15 | 3000 | 600000 | 600000 – 2016666 |
| 24250 - 100000 | 60 | 24250.08 | 2016667 | 2016667 – 3279165 |

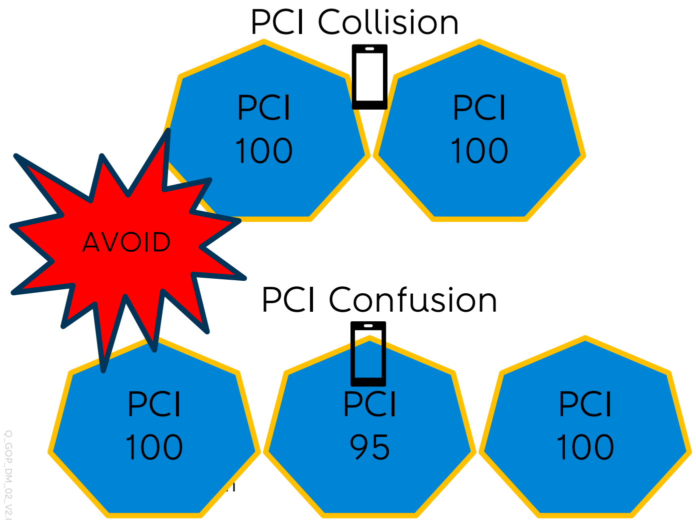
Using the formula above, for 3790 MHz, the corresponding ARFCN is not integer → 652666.6666(..)

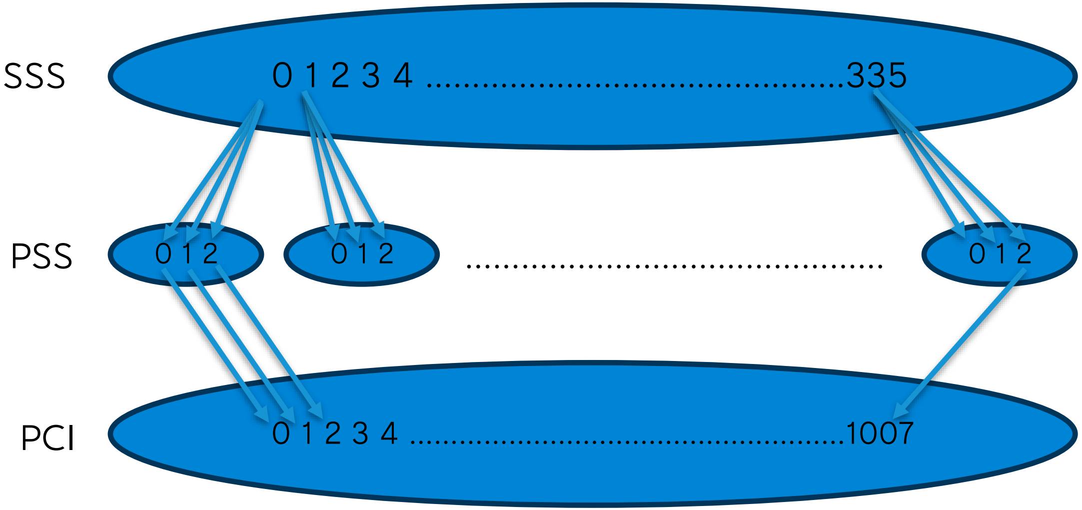
For an ARFCN of **652666** the Central Frequency is **3789.99 MHz** → Central Frequency used in Porto de Sines

$F_{REF}$ → Central Frequency in MHz
$\Delta F_{Global}$ → Granularity of the global frequency raster
$F_{REF-Offs}$ → Reference frequency offset based on frequency range
$N_{REF-Offs}$ → ARFCN offset (the starting ARFCN) for the frequency range
$N_{REF}$ → ARFCN value

# Cell Planning: PCI

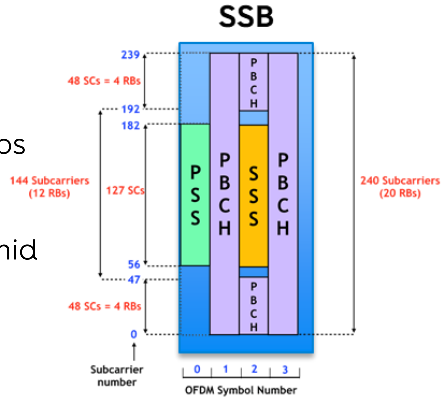
- **PCI – Physical Cell ID**
  - How to distinguish cells on the radio side
  - There are 1008 unique PCIs
  - $N_{ID}^{cell} = 3N_{ID}^{1} + N_{ID}^{2}$
  - $N_{ID}^{1}$ → Secondary Synchronization Signal (SSS) {0,1 …335}
  - $N_{ID}^{2}$ → Primary Synchronization Signal (PSS) {0,1,2}



# Cell Planning: SSB

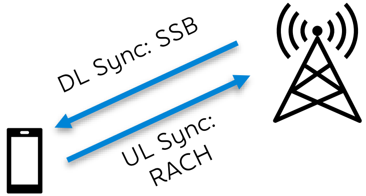

- **SSB – Synchronization Signal Block**
  - Transmitted periodically by cell and carries information to establish DL synchronization
  - It can be located anywhere across the carrier bandwidth:
    - ❖ near the centre frequency can reduce the risk of edge effects and frequency overlaps with neighbour cells (option followed in Porto de Sines)
    - ❖ In the initial part of the bandwidth, cell search time would be shorter compared to mid band SSB



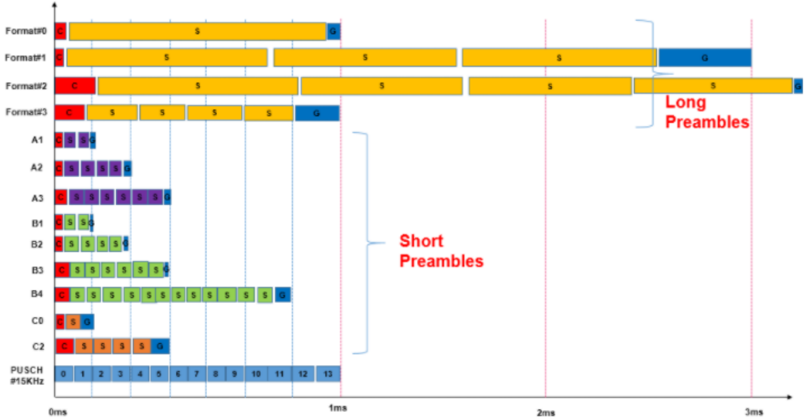

**SSB Scanning**

1. UE starts scanning from the beginning of the band to try to find SSB to sync with cell
2. UE finds SSB and then decode PSS and SSS to acquire PCI from cell

# Cell Planning: RACH




- **RACH – Random Access Channel**
  - After detecting SSB and decoding some channels, the device will try to gain UL synchronization with the cell
  - UE selects a random-access preamble from a set of predefined preambles
  - For the RACH transmission, it is used the following information
    - RSI configuration
    - Preamble format
    - SCS index




<u>Preamble Formats & Sequences</u>

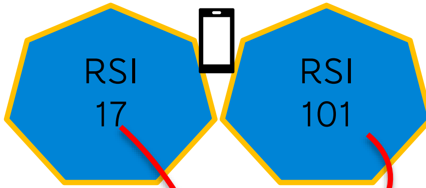
The preambles that UE selects can be of two categories:

- Long Preambles based on a sequence of 839 values
  - ❖ Only for FR1 frequencies and for long range cells
- Short Preambles based on a sequence of 139 values
  - ❖ For normal and small cells

# Cell Planning: RACH RSI

- **RSI – Root Sequence Index**
  - As said in the previous slide, UE selects a random-access preamble from a set of predefined preambles
  - If two UEs send the same "signature" at same time, both signals can act as interference and network may not be able to decode neither of them . To avoid this:
    - Cells that use the same RSI should be separated by a sufficient distance (should not overlap)
    - Each RSI corresponds to a sequence with good autocorrelation properties: **Zadoff-Chu sequence**

$$x_u(i) = e^{-j\frac{\pi u i(i+1)}{L_{RA}}}, i = 0,1,\dots,L_{RA}-1$$




RSI that is configurate d in the cell

RSI = 0 RSI = 1 RSI = 2 ...

| $i$ = RSI | $u$ = Numerical RSI | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-19 | 1 | 138 | 2 | 137 | 3 | 136 | 4 | 135 | 5 | 134 | 6 | 133 | 7 | 132 | 8 | 131 | 9 | 130 | 10 | 129 |
| 20-39 | 11 | 128 | 12 | 127 | 13 | 126 | 14 | 125 | 15 | 124 | 16 | 123 | 17 | 122 | 18 | 121 | 19 | 120 | 20 | 119 |
| ... | - | | | | | | | | | | | | | | | | | | | |
| 100-119 | 51 | 88 | 52 | 87 | 53 | 86 | 54 | 85 | 55 | 84 | 56 | 83 | 57 | 82 | 58 | 81 | 59 | 80 | 60 | 79 |
| 120-137 | 61 | 78 | 62 | 77 | 63 | 76 | 64 | 75 | 65 | 74 | 66 | 73 | 67 | 73 | 68 | 71 | 69 | 70 | - | - |

# Cell Planning: SCS

- **SCS – Sub Carrier Spacing**
  - Frequency interval between adjacent carriers
  - Different numerologies to cover a wide range of frequencies available for 5G (15kHz, 30kHz, 60kHz, 120kHz)
  - The more sub carrier can be packed into a bandwidth, more data can be transmitted

Dense Urban Areas

- Higher SCS values which improves data rates

Rural and Macro Deployments

- Lower SCS values with lower frequencies, which provides better range and penetration

| μ | SCS (KHz) |
|---|---|
| 0 | 15 |
| 1 | 30 |
| 2 | 60 |
| 3 | 120 |
| 4 | 240 |
| 5 | 480 |

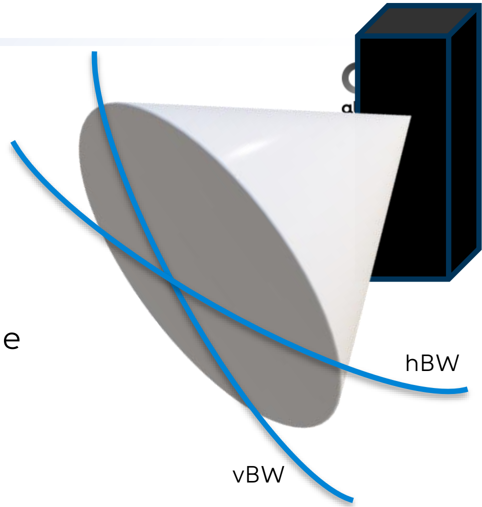
# Cell Planning: Cell Radius

| Sequence | RACH Format | Max Cell Radius | | | | | |
|---|---|---|---|---|---|---|---|
| | | SCS 1.25 KHz | SCS 5 KHz | SCS 15 KHz | SCS 30 KHz | SCS 60 KHz | SCS 120 KHz |
| Short | A1 | - | - | 0.9 Km | 0.5 Km | 0.2 Km | 0.1 Km |
| | A2 | - | - | 2.1 Km | 0.8 Km | 0.4 Km | 0.2 Km |
| | A3 | - | - | 3.5 Km | 1.3 Km | 0.6 Km | 0.3 Km |
| | B1 | - | - | 0.5 Km | 0.2 Km | 0.1 Km | 0.06 Km |
| | B2 | - | - | 1 Km | 0.4 Km | 0.2 Km | 0.1 Km |
| | B3 | - | - | 1.7 Km | 0.8 Km | 0.4 Km | 0.2 Km |
| | B4 | - | - | 3.8 Km | 1.3 Km | 0.6 Km | 0.3 Km |
| Long | 0 | 12 Km | - | - | - | - | - |
| | 1 | 57 Km | - | - | - | - | - |
| | 2 | 22 Km | - | - | - | - | - |
| | 3 | - | 14 Km | - | - | - | - |



Approximated values from *On the design details of SS/PBCH, Signal Generation and PRACH in 5G-NR*, Arvind Chakrapani

# Cell Planning: Tilt and Azimuth

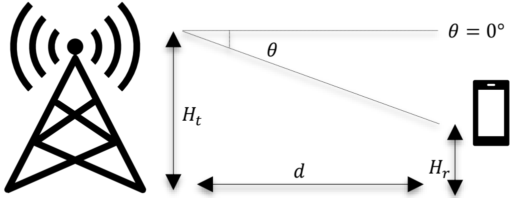



- **Antenna**
  - **vBW** – Angular width of the antenna's radiation pattern in the vertical plane
  - **hBW** – Angular width of the antenna's radiation pattern in the horizontal plane
  - In Porto de Sines was installed an antenna with 63º hBW and 27.5º vBW to extend the coverage area

- **Tilt**
  - Vertical angle of antenna's main lobe relative to the horizon
  - It can be adjusted mechanically or electrically

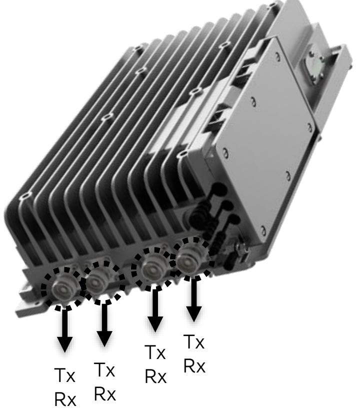
$$\theta° = \arctan\left(\frac{H_t - H_r}{d}\right)$$

- **Azimuth**
  - Horizontal orientation of the antenna's main lobe relative to a fixed reference direction
  - 0° represents north, 180º represents south and so on

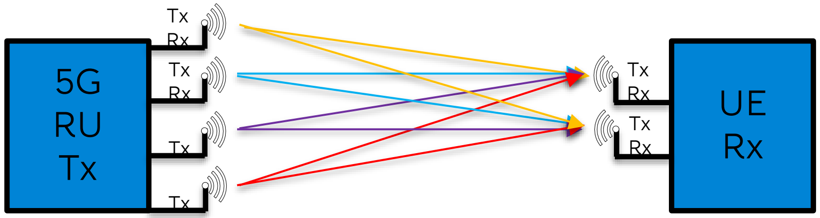



$\theta$ → Down tilt angle in degrees
$H_t$ → Transmission Height (Antenna Height)
$H_r$ → Receiver height
$d$ → Distance between transmission tower and receiver

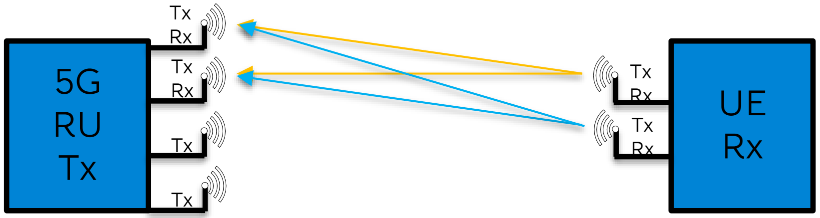
# 5G Radio Unit: MIMO




- MIMO – Multiple Input Multiple Output
  - RU has the capability to up four antennas to transmit and to receive: 4Tx 4Rx
    - Data streams transmitted in parallel , multiplying the data rate
    - Used to increase diversity to combat channel fading
- In Porto de Sines, a configuration of MIMO 4x2 is used:
  - 4Tx 2Rx : MIMO 4x2
  - Even though HW's RU is capable of 4x4 MIMO, currently, the DU and CU deployed entities don't support the full 4 ways of receiving

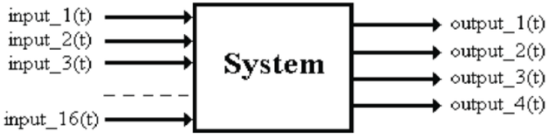


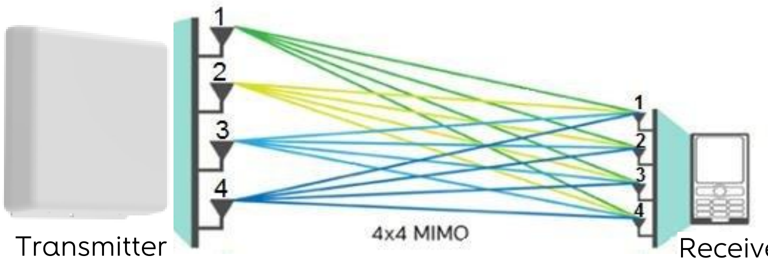

Downlink Streams




Uplink Streams

# MIMO – Multi Input Multi Output



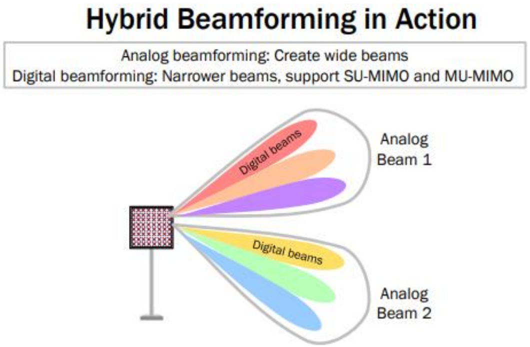




Transmitter

Receiver

SU-MIMO

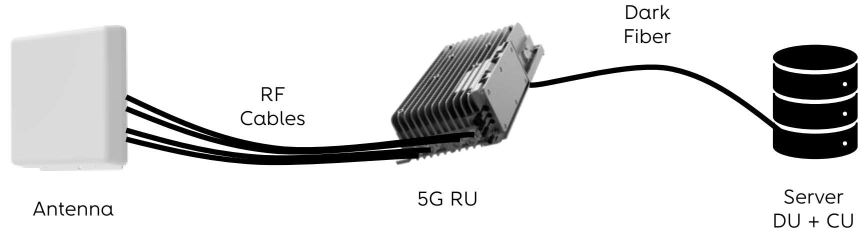
MU-MIMO and beamforming concepts very useful in Macro-cells
(not applied in 5G small cells)




Benefits:

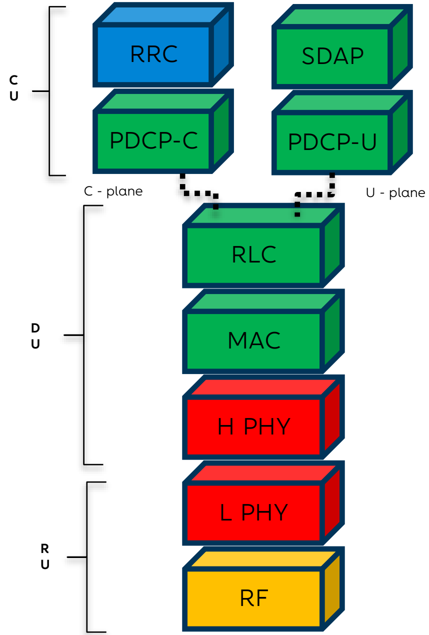
- Spectral efficiency
- Higher throughput
- Lower interference
- Extended range

# 5G RAN - Stack




- <u>RU – Radio Unit</u>
  - ❖ Hosts the lower-PHY and RF layer
- <u>DU – Distributed Unit</u>
  - ❖ Hosts RAN RLC, MAC and high-PHY layer
- <u>CU – Centralized Unit</u>
  - ❖ Hosts the RAN RRC and PDCP capabilities

Cloud Functionalities that can be embedded in the same server

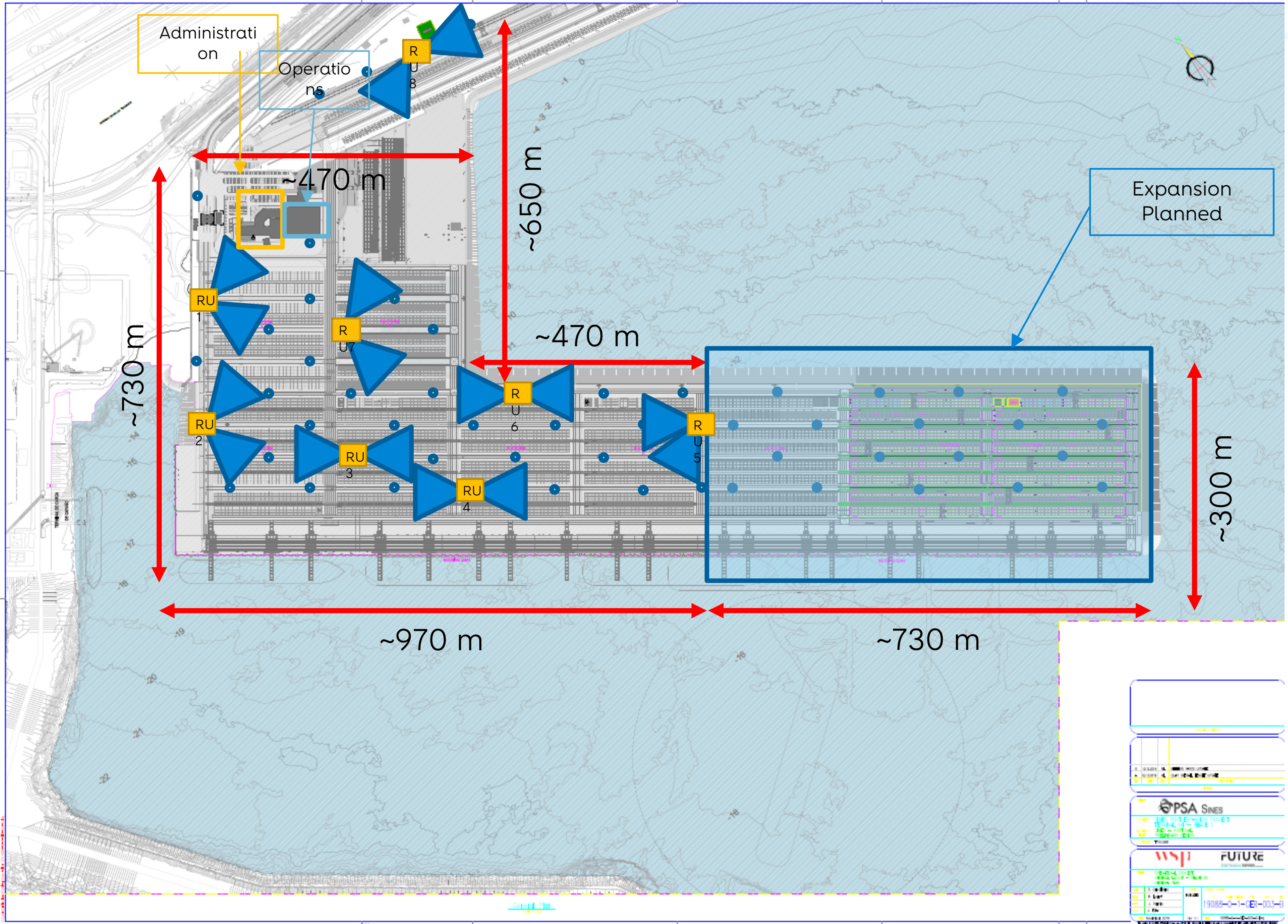



✓ Allows great flexibility according the use case

# Deployment and Technical Constrains

- Dense deployment of small cells
  - 5G high frequency signals can't travel far
  - 5G high frequency signals can't penetrate obstacles effectively
- 5G Radio Unit
  - Can handle high data rates in small areas
  - Buildings and utility poles can be used to install them
  - Power sources need to be available at each RU site
- Antennas
  - Oriented in such ways that LoS areas between containers are equally covered
  - Each RU will connect to 2 antennas to enhance coverage
  - Large vertical angle of the main lobe
- Backhaul
  - Connection between RUs and other elements must be extremely high-capacity: Dark Fibers Optic Cables

# Terminal

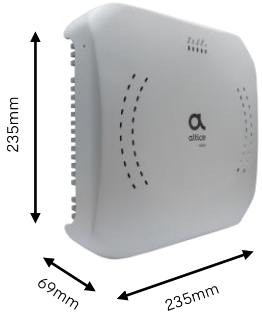


Administration
Operations
RU 8
RU 1
RU 7
RU 2
RU 3
RU 4
RU 6
RU 5
~470 m
~650 m
~470 m
~730 m
~970 m
~730 m
~300 m
Expansion Planned
PSA Sines
WSP
FUTURE

# 5G RU and Antennas

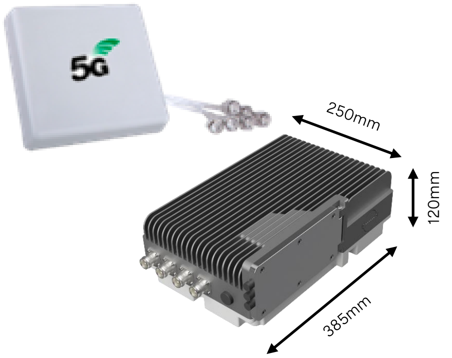
# Altice Labs Radio Units

## Indoor small cell

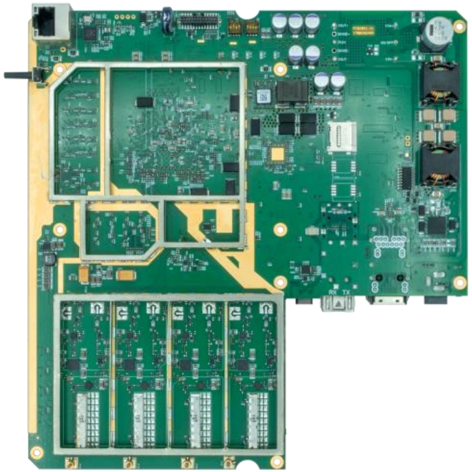


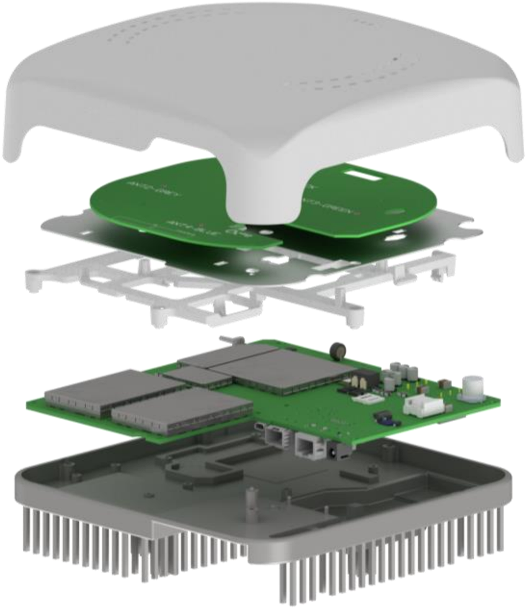

| | Indoor small cell | Outdoor small cell |
|---|---|---|
| **Bands** | Single Band (n78 – 3.5GHz) | |
| **Bandwidth** | Up to 100MHz per Cell | |
| **MIMO** | 4x4 | |
| **Output Power** | 24 dBm per port | 37dBm per port |
| **Interface** | 10GBE / SFP+ | |
| **Protocol** | ORAN-FH (split 7.2) | |
| **Antennas** | Internal | External |
| **Size HxWxD (mm)** | 69x235x235 | 385x250x120 |
| **Mounting options** | Ceiling or wall mount;<br>Desk standing | Rooftop, side of building (wall), pole, under overhang |

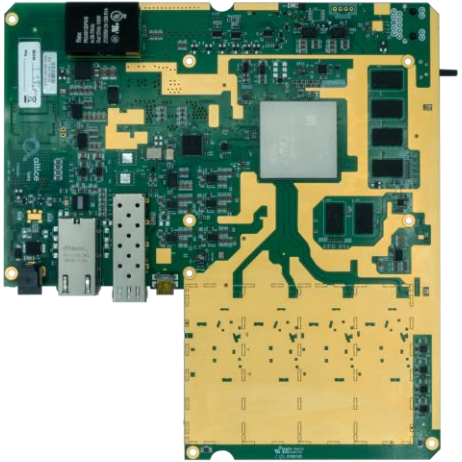
## Outdoor small cell



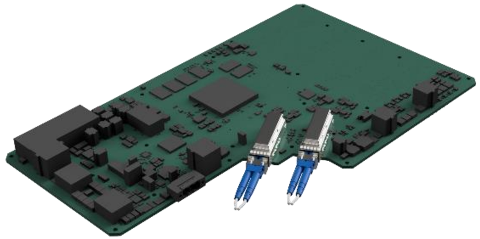
# Indoor RU mechanical details



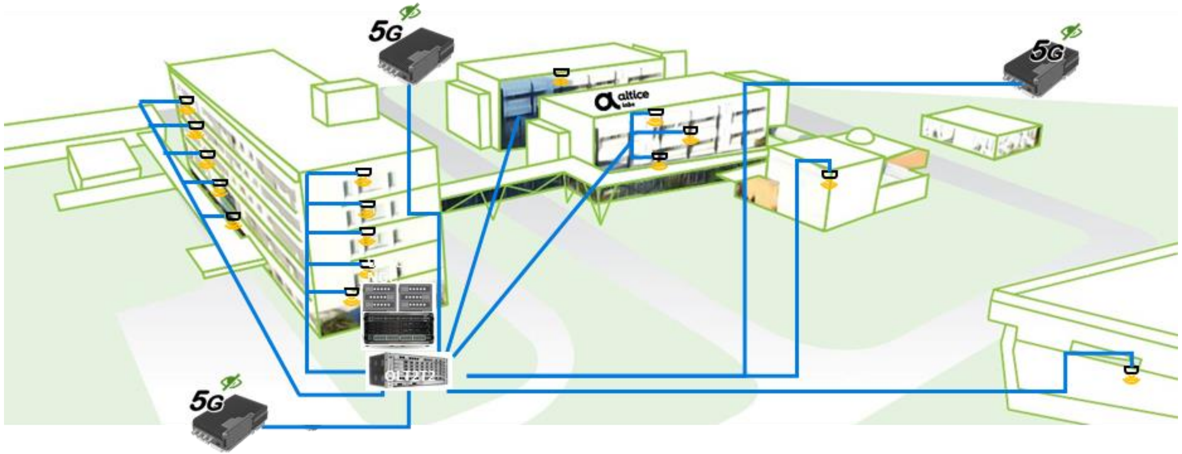




# Outdoor RU mechanical details



# 5G Altice Labs Campus Private Network




## Application scenarios:

- **Independent E2E small/medium-sized 5G network** for government, business, or group of companies;
- For **critical communications** in industrial centers that require availability, reliability, quality of service, security, and interoperability;
- For large companies and facilities that require **secure networks, high throughput, and quality of service**.

## Main goals:

- Streamline various use cases related to 5G, providing a real basis for experimentation.
- Gain relevant knowledge and experience for the next generation of Altice Labs portfolio.
- Be a storefront for future customers.

# Thank you!

Questions?

altice labs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