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Macro Site to Small Cell Transitions: Next Generation Strategies in Wireless

Overview

- Macro towers have existed since the inception of cellular theories. They play an integral role in supporting all generations of cellular technologies.
- While small cells have also existed for quite a while, they are now being implemented on a large scale. With the launch of 5G networks, small cells have become the primary focus of modern network expansion.
- This talk will look at the state of Macro tower presence and Macro towers' current design and planning. We will also look at the differences in between Macro cell and small cell implementation as we move forward into the 5G era.
- We will include a look at current advancements such as Remote Radio Heads (RRH), Centralized RAN (C-RAN), and millimeter wave (MMW) equipment which will be crucial for both macro sites and small cells to implement 5G as well as future generation of technologies

Top Tower Companies in the U.S.

Top Tower Companies

Source:
WirelessEstimator.com

Date:
08/30/2022

Rank ▲	Company ▲▼	Tower Count ▲▼
1	American Tower	42,965
2	Crown Castle	40,567
3	SBA Communications	17,395
4	Vertical Bridge	5,089
5	United States Cellular Co.	4,367
6	Diamond Communications	2,960
7	Harmoni Towers	2,012
8	Peppertree Capital	1,023
9	Tillman Infrastructure LLC	995
10	BNSF Railroad	941
11	Time Warner	653
12	Phoenix Tower International	620
13	TowerCo	620
14	Tower Ventures	561

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Source: http://wirelessestimator.com/top-100-us-tower-companies-list/

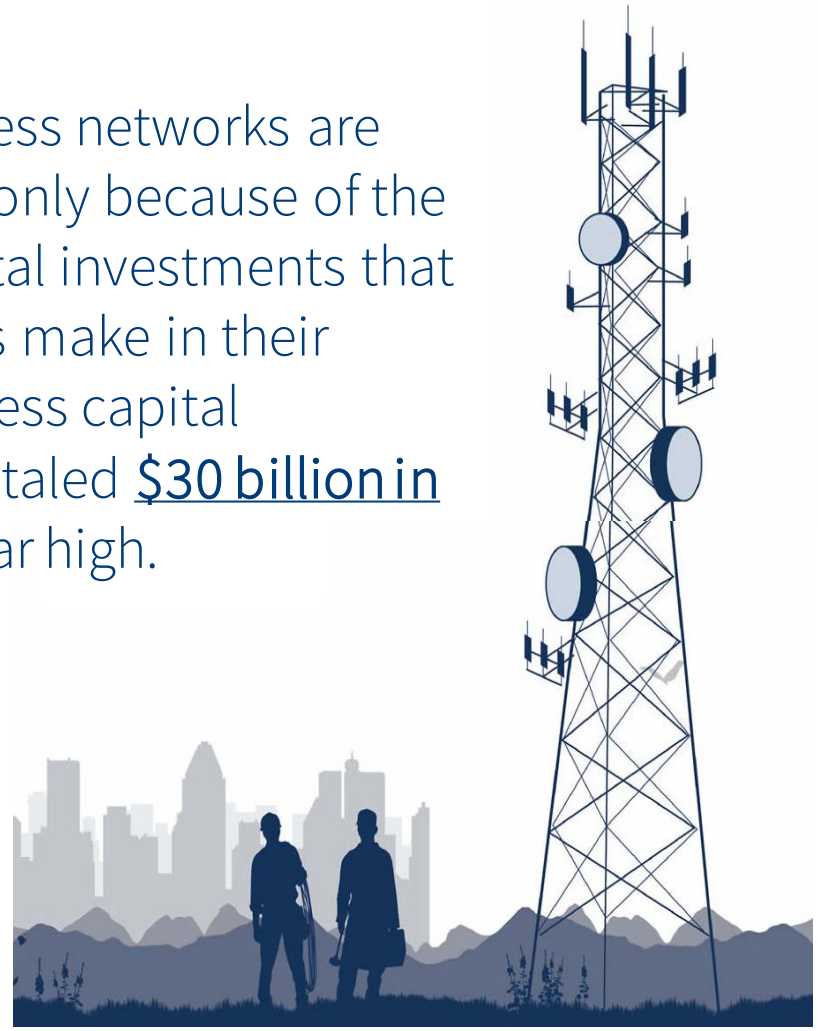
Cell Site Infrastructure: Very Important

$601 BILLION

total U.S. wireless investment

Since 2016, wireless providers have invested nearly $140 billion, and over the life of the wireless industry, capital investment now totals over $601 billion.

America's wireless networks are made possible only because of the significant capital investments that wireless carriers make in their networks. Wireless capital expenditures totaled $30 billion in 2020—a five-year high.



Source: CTIA Wireless Snapshot 2019

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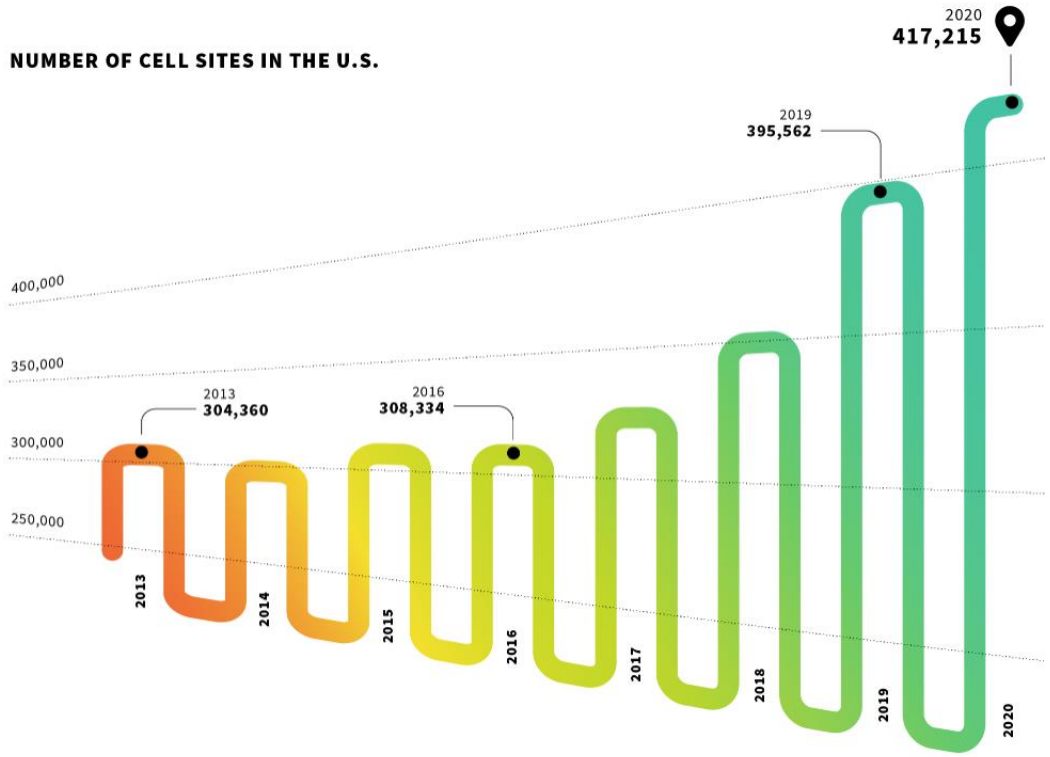
Cell Sites Growth

CTIA 2021 Survey Data:

- More than 98 percent of the U.S. population is covered by three or more providers of mobile wireless service, and more than 95 percent of the population is covered by three or more LTE-based service providers.



By the end of 2020, over 417,000 cell sites were built and operational, an increase of 35% since 2016.

https://www.ctia.org/news/2021-annual-survey-highlights

Estimated Cost to Build a Macro Cell Tower

$264,778

Source: Crown Castle. Note: These numbers can vary +/-v 20% or more depending on the situation, and excludes the land and lease costs.

Site Acquisition: **$22,943**
Telco/Elec/Mtrbrd/Grounding: **$27,705**
Legal: **$4,206**
Access Road: **$16,904**
Civil + General Engineering: **$19,499**
Fence/Gate/General Groundwork: **$19,583**
Tower Foundations: **$54,433**
Tower Erection: **$26,323**
Tower Cost: **$61,122**
Project Manager Time: **$12,060**

Note: This does NOT include the cost of equipment (radios, antennas, cables, etc)!

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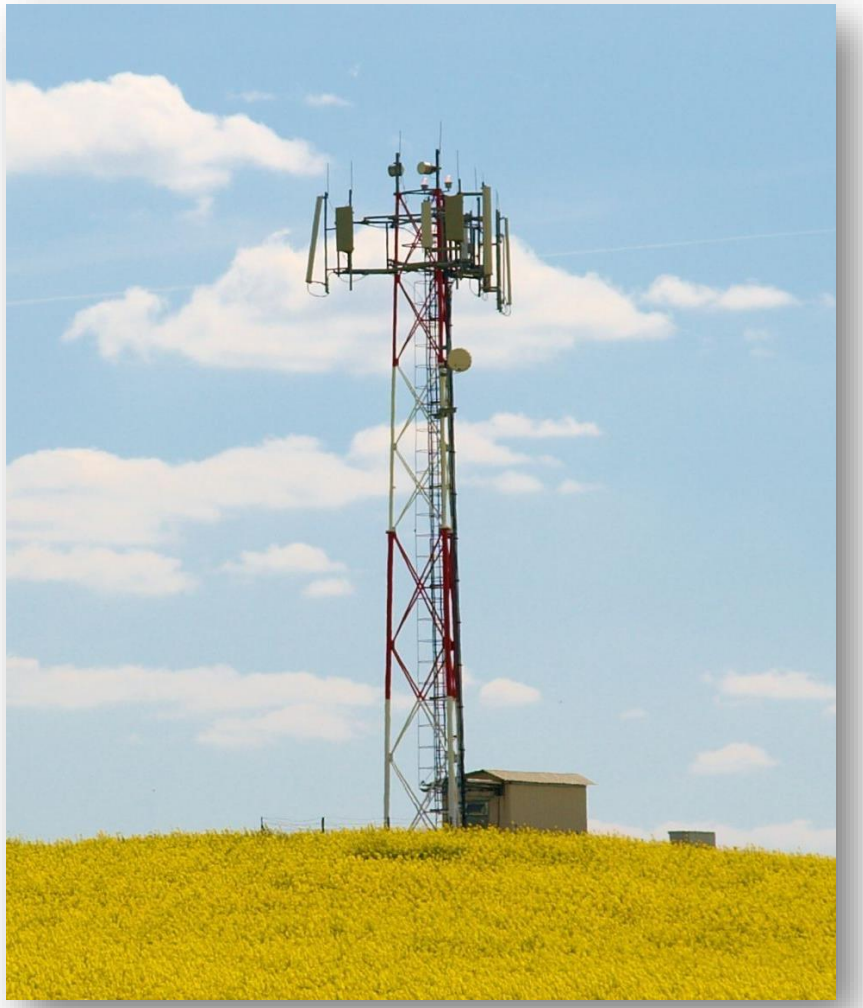
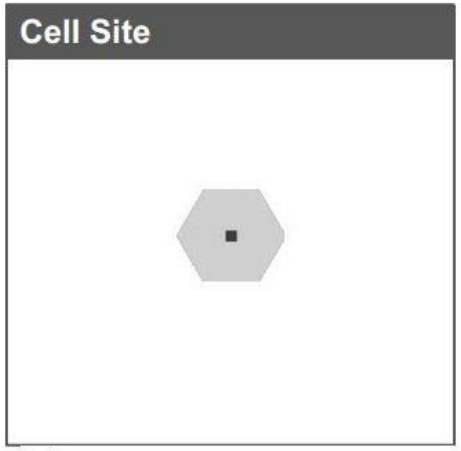
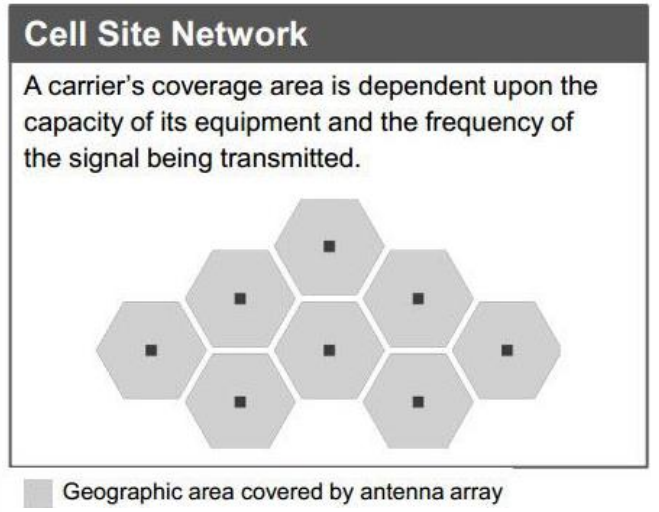
What is a Cell Site?

A cell site is an area within a service providers' network that is serviced by, and includes, the following:

- Tower
  - Various types
- Base Station Antennas
  - (usually near top but not always)
- Dish Antenna
  - Or fiber connection to rest of the network
- Cables (feeder cables)
- Cabinet/Shelter
  - Contains radio equipment, jumper cables, amplifiers, etc.







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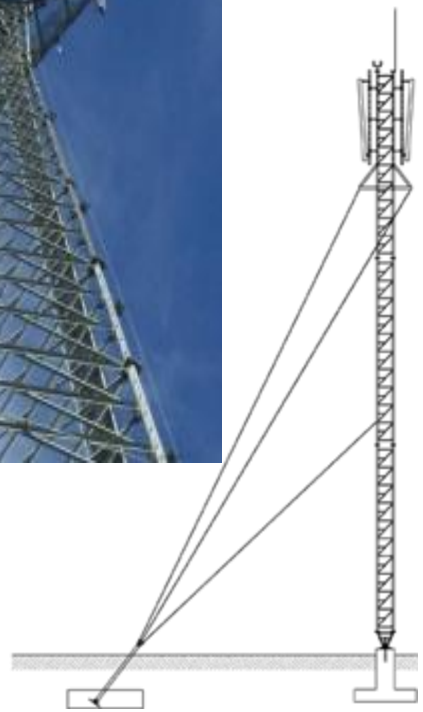
Macro Site Examples

Monopole

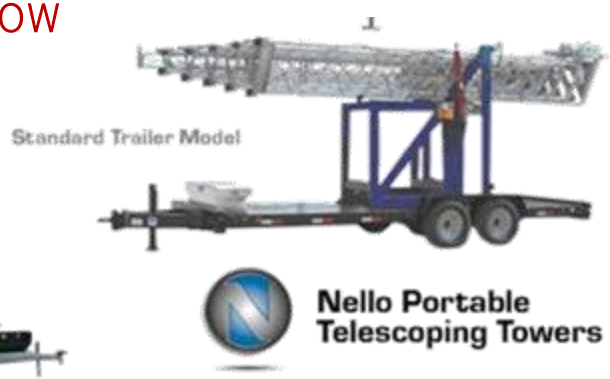
Lattice Tower



Guyed Tower

Rooftop

COW



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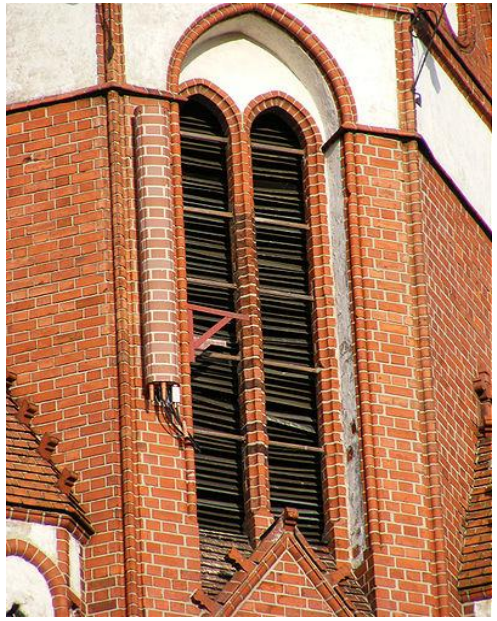
Macro Site Examples: Concealed



http://twistedsifter.com/2012/08/examples-of-cell-phone-tower-disguises/

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Cell Site Examples

Roof-top Site

Cell On Wheels (COW)

Base Station Inside the Shelter

- Tx Radios
- Rx Panel
- Amplifiers
- Filter Panel
- many other components

- Note: feeder cables going up the tower are attached to jumper cables to go into the shelter

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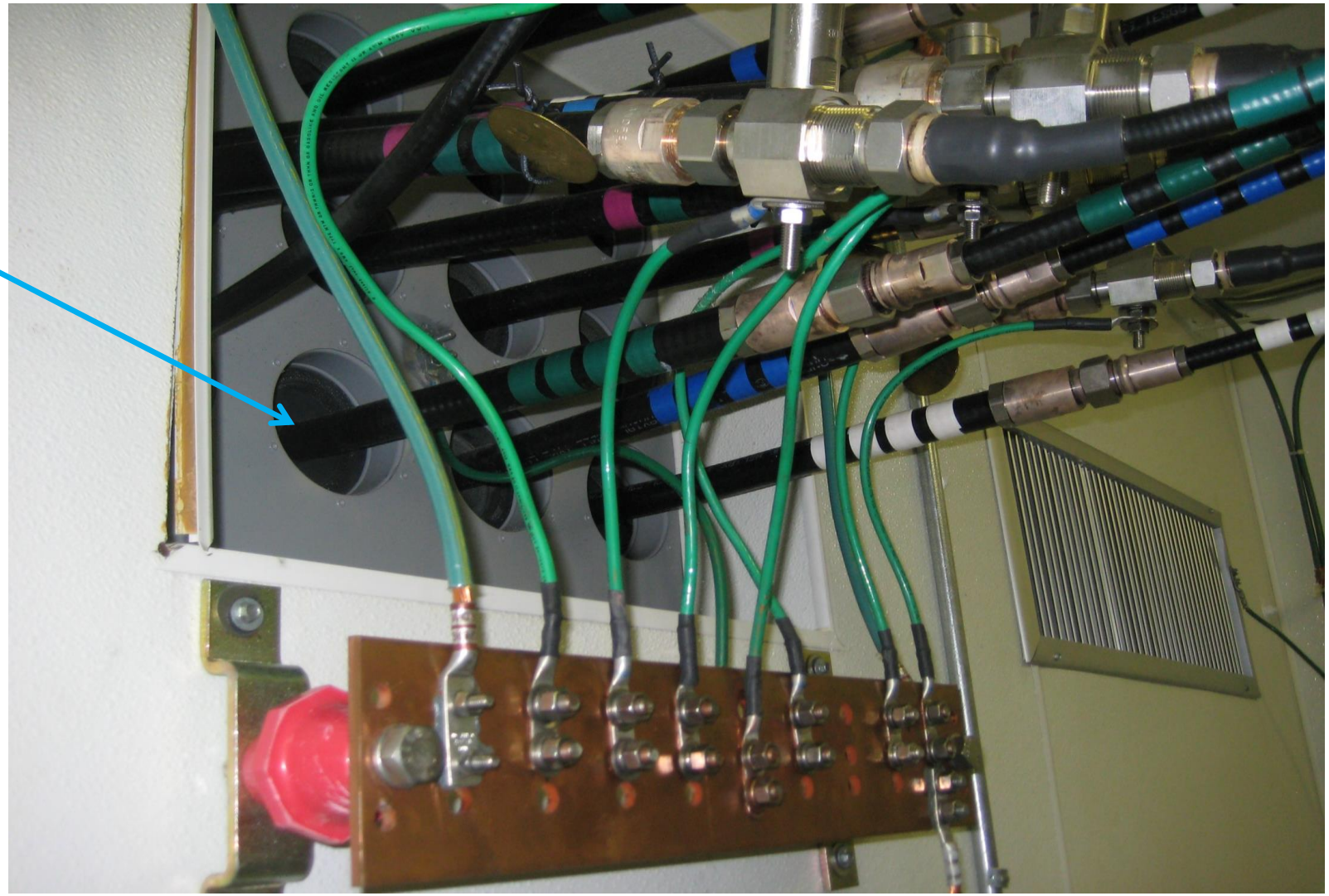
Inside the Shelter

Hatch Plate

The hatch plate marks a separation of equipment inside the shelter from the feeder lines and antennas on the tower itself



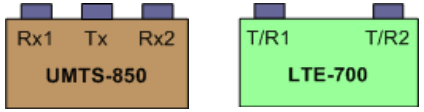
Macro Cell Site Components

- BTS / NodeB / eNodeB / gNodeB Peripheral Components (Vendor Neutral)
- Power Amplifiers – in Tx Line
- Tower Mounted Amplifiers (TMAs) – in Rx Line
- Antennas and Tilt Controlling Components
- Filters and Combiners
- Multicouplers
- Diplexers and Duplexers
- Power Sources, Bias Tees
- Cables and Connectors
- RF and Power Measurements at Cell Site
- Alarming Scheme, Lightning Protectors, Grounding Material

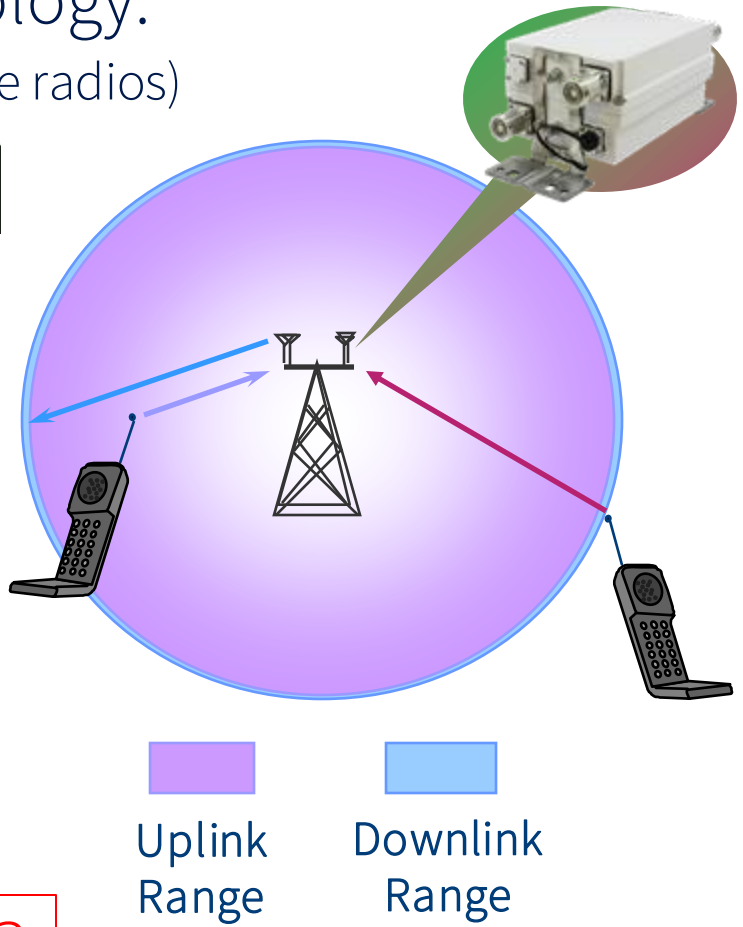
Why so complex?

Equipment Breakdown (part 1)

- Some of the equipment is required for the technology:
  - BTS / NodeB / eNodeB / gNodeB : Vendor Neutral. (These are the radios)
  - Power Amplifiers – in transmitter Line
  - Antennas and Tilt Controlling Components
  - Cables and Connectors



- Some is required to improve performance:
  - Tower Mounted Amplifiers (TMAs) – in Receiver Line
    - The Basestation makes a louder signal than the phone.
      TMA acts like a hearing aid for the basestation.
  - Power Sources (Bias Tees) supply power for the TMA.
- Some is required for safety:
  - Alarming Scheme, Lightning Protectors, Grounding Material



What about the rest?

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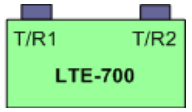
Equipment Breakdown (part 2)

- How can we implement co-siting?
- Answer: same band combining and multiband combining
- We will need the rest of the equipment:
  - Filters and Combiners
  - Multicouplers (to split signals)
  - Diplexers and Duplexers *(what are these?)*
  - RF and Power Measurements at Cell Site



Built-in Duplexer: Transmit and receive on the same port

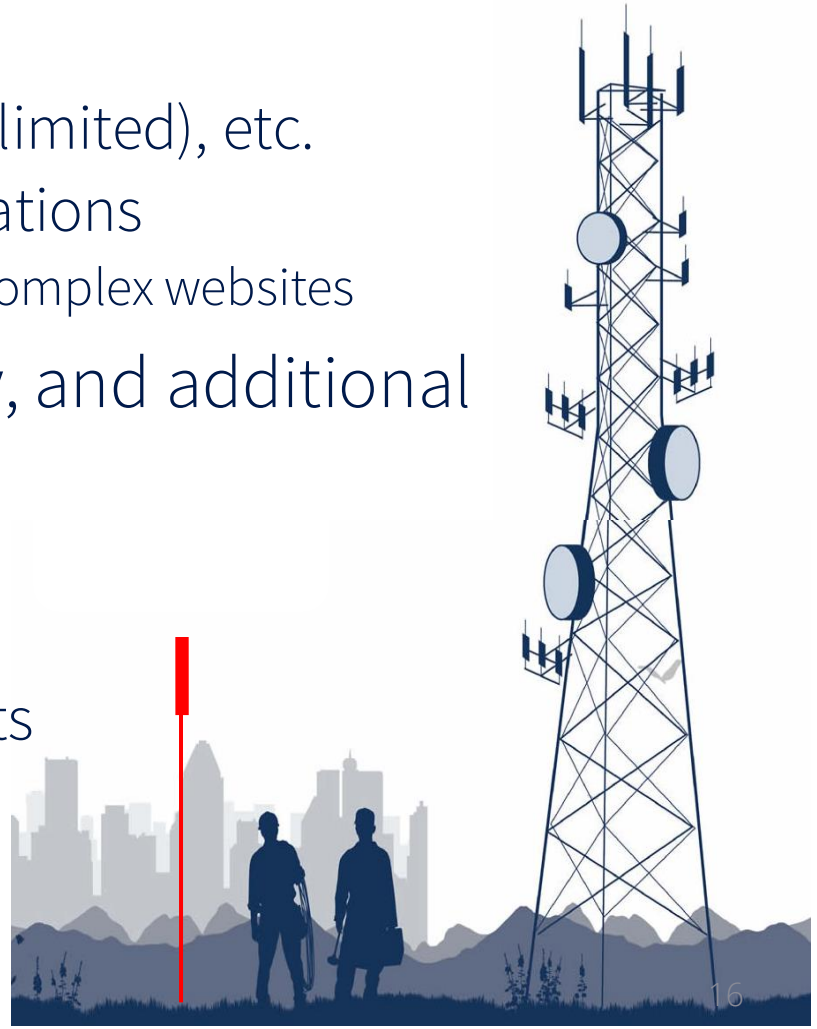
- Duplexers: combine the uplink and downlink signal so it can be carried on the same feeder cable
  - Often built into modern radio equipment
- Diplexers: combine multiple bands on the same feeder cable (also: triplexers…)

Diplexer

Source: commscope

What changes when going to small cells?

- Macro towers provide coverage for users
  - Users can make phone calls, send texts, use broadband (limited), etc.
  - Macrocells can't provide all the capabilities for 5G applications
    - E.g. streaming videos, low latency apps, massive connectivity, complex websites
- Small cells can provide extra capacity, lower latency, and additional connectivity
  - Usually only serving 5G technology
  - Usually only one band
  - Usually higher frequency → smaller hardware components



Changes when building small cells

Macro Tower (4G)
(monopole)

- What's changed?
  - Shorter height
  - Less obtrusive
  - Smaller antennas
  - No shelter
  - Less cost: < 1/10 of a Macrocell

Small Cell (5G)

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Small Cell Properties

- Since the desired coverage area is so much smaller, things become easier:
  - It's not necessary to build very high towers (outdoor)
    - Can also put them indoors (no tower)
  - Small coverage area means we can use higher frequencies:
    - Antennas can be smaller and less obtrusive.
    - High frequency equipment is generally smaller as well
  - We can implement a distributed basestation concept to eliminate shelter (and much of the equipment)

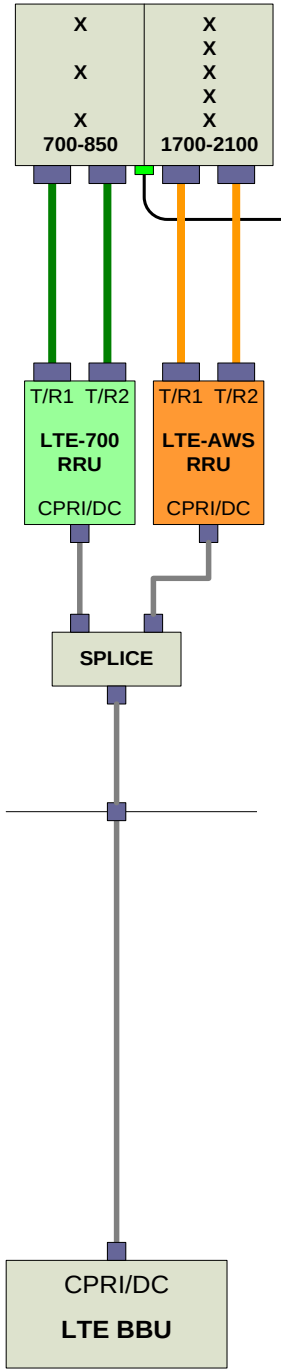
How is this possible?

Distributed Base Station:

“Distributed Base Station” concept

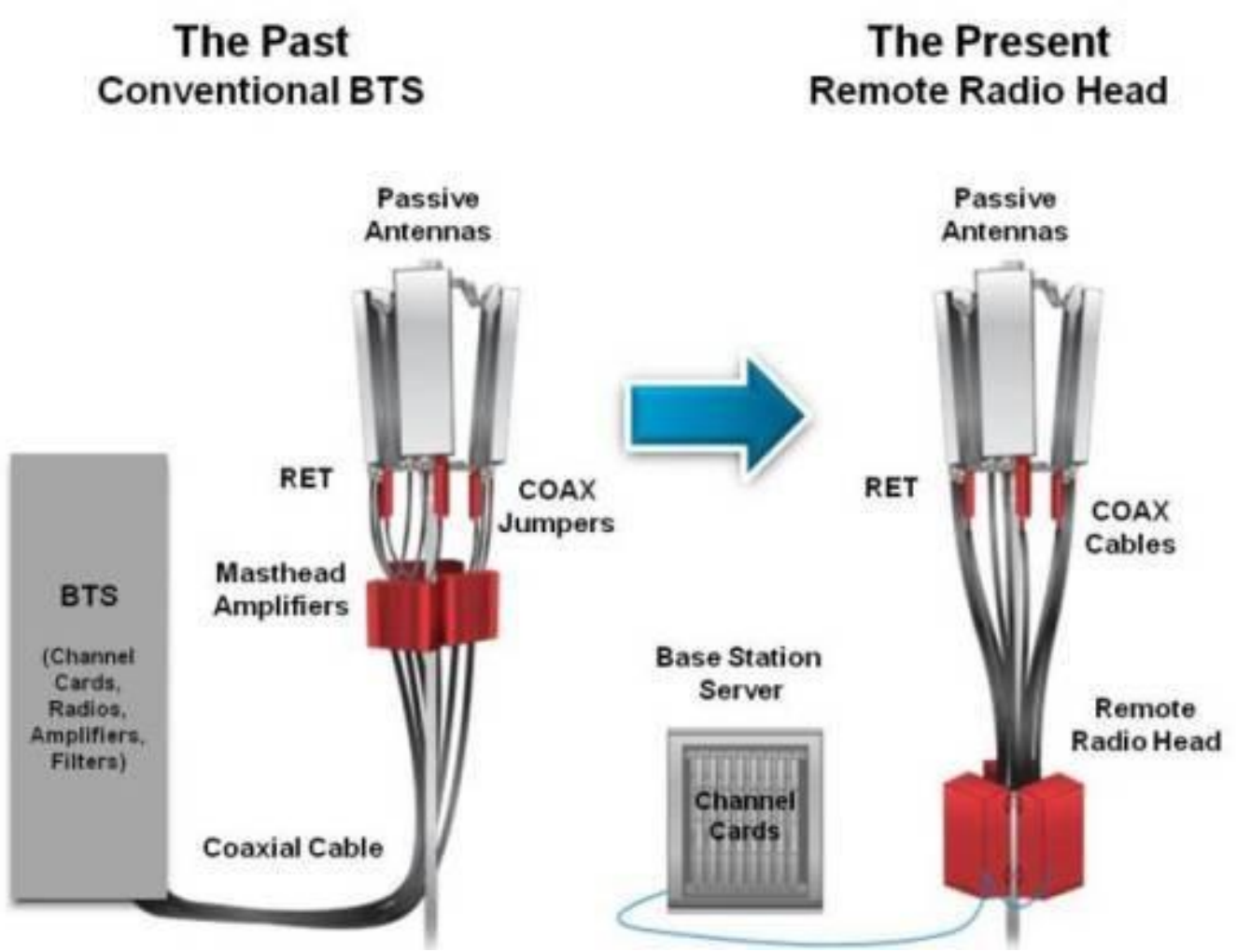
Architecture where a separate RF portion of the radio can be located closely to the antenna.

- Fewer power stages required in a given base station.
- More efficient network operation.
- BBU (base band unit) at the bottom
- RRU (remote radio unit) at the top near antenna
- FTTA (Fiber to the Antenna)



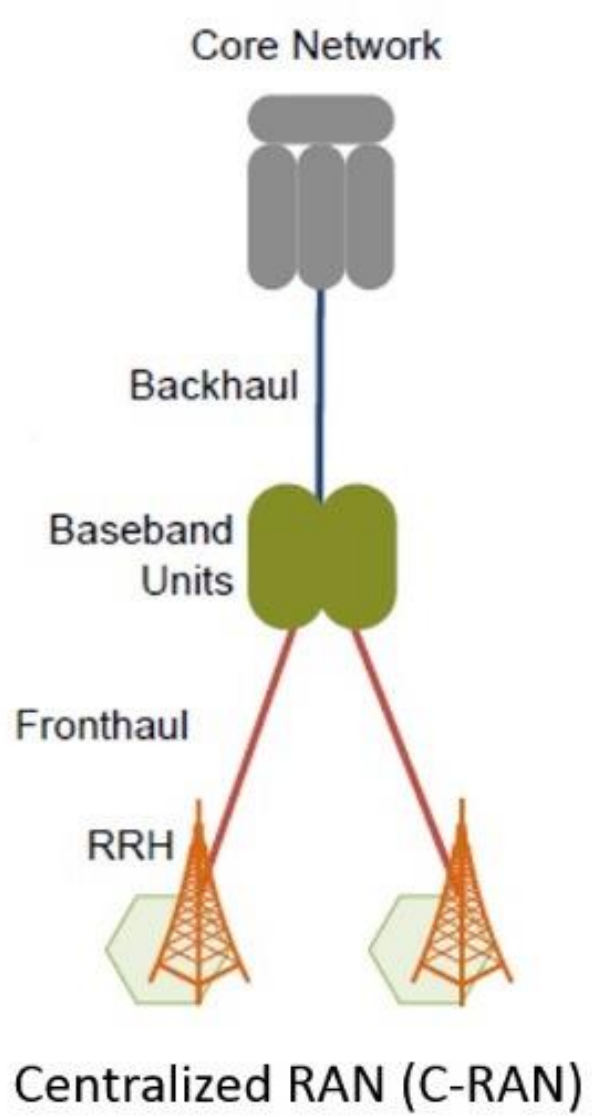
Remote Radio Unit (RRU):

- Cell site architectures have been evolving from the legacy cell site architecture where large radios are located remote from the antennas, to an architecture wherein a separate RF portion of the radio is operating near the antenna.
- Separation of the digital radio, BBU, from the analog radio, RRH.
- Allows for a reduction of the equipment foot print at the site and for a more efficient operation of the network.



Centralized RAN (C-RAN):

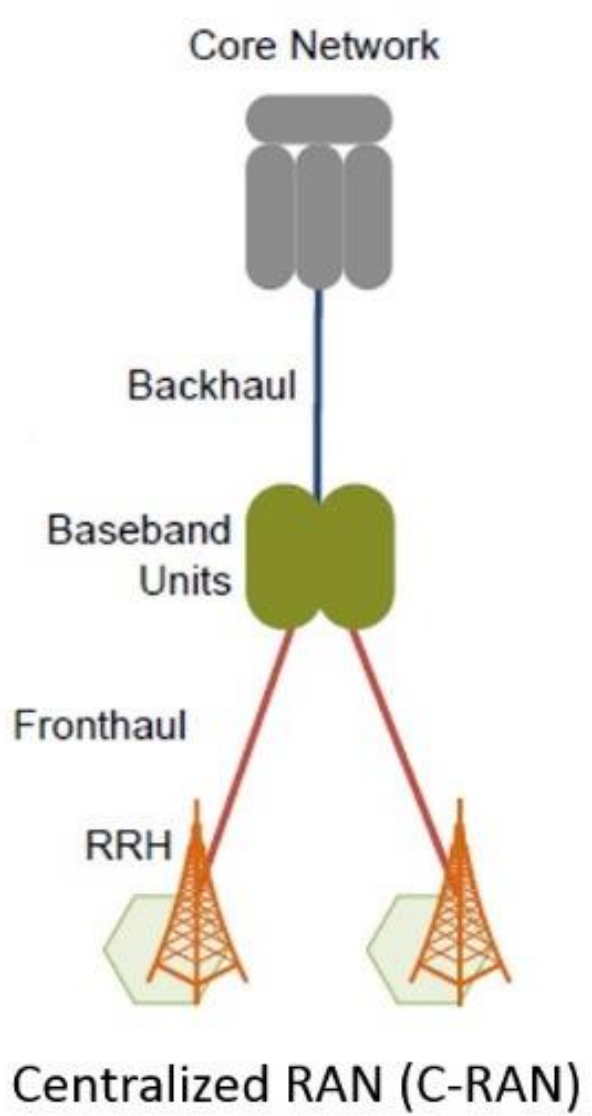
- The trend toward C-RAN is **still fairly new,** having started just a few years ago in Asia.
- In a traditional distributed cellular network, the RAN is the part of the network that we think of as a cell site, with equipment at the top and bottom of a cell tower (BBU and RRU).
- **Until recently**, the BBU was almost always located on-site near the bottom of the tower in some type of shelter or enclosure.



Centralized RAN (C-RAN)

Centralized RAN (C-RAN):

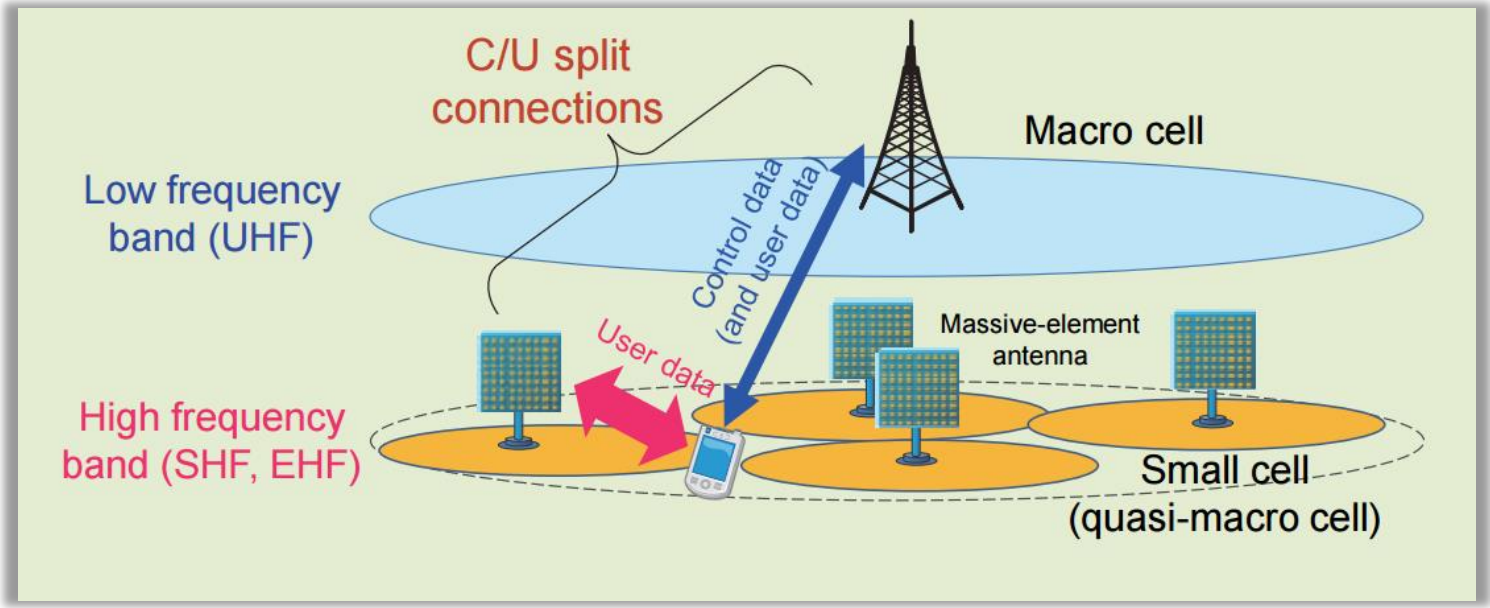
- By leveraging fiber's huge signal-carrying capacity for fronthaul, operators can centralize multiple BBUs in one location, either at a cell site or at a centralized BBU pool location. Centralizing multiple BBUs simplifies the amount of equipment needed at each individual cell site and presents a host of other key advantages, such as lower latency.



Centralized RAN (C-RAN)

Role of Macro Cells and Small Cells in 5G

- One of the Myths of 5G:
  - 5G is possible with Small Cells only; Macro will not play any role in 5G (NOT TRUE)
- Macro are important for C/U Split
  - A connection link for the Control Plane (C-Plane) that handles control signal via the macro cell.
  - A link for the User Plane (U-Plane) that handles use data via overlaid cells.
- Macro cells use lower frequency spectrum
  - 700MHz up to 2GHz
- Small cells use higher bands
  - up to millimeter wave
- In-between: Metro Cells:
  - 2GHz to ~4GHz



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Thank You

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