



Futureproofing and Streamlining Deployment

SCWS 2024, London UK

- At >\$12B in annual revenue, Battelle is the world's largest nonprofit research & development organization
- Business pillars: Contract Research, Laboratory Management, STEM Education
- Serving Health & Consumer; Environment & Infrastructure; Global & National Security, and Laboratory Management
- Our Mission: to translate scientific discovery and technology advances into societal benefits
- 501(c)3 charitable trust formed in 1923 by the will of Gordon Battelle to conduct R&D for the benefit of humankind
- Percentage of profit reinvested in science, technology, education, philanthropy



Decades of innovation having an impact today



1929
Battelle Established



1929
Aluminum Foil



1939
Armor Plating



1949
Nautilus



1959
Xerography



1965
Universal Product Code



1974
Compact Discs



1987
PIRI



1991
Battelle Technologies
in Desert Storm



2001
RareCyt



2006
STEM Education



2008
Bio-Based Plasticizer



2011
Battelle HeatCoat™



2012
Battelle LS10™ Liquid
Bottle Scanner



2013
Resource Effective Bio-
Identification System
(REBS)



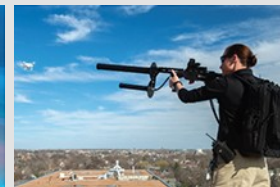
2014
Battelle NeuroLife®



2014
Battelle
DeviceSecure®



Battelle Exact ID®



2015
Battelle
DroneDefender™



Battelle CANProtect™



Battelle RAICS™



2020
COVID-19 Diagnostics
and Vaccines; CCDS™



2021
Biosecurity & Pandemic
Preparedness



2023
RavenStar™

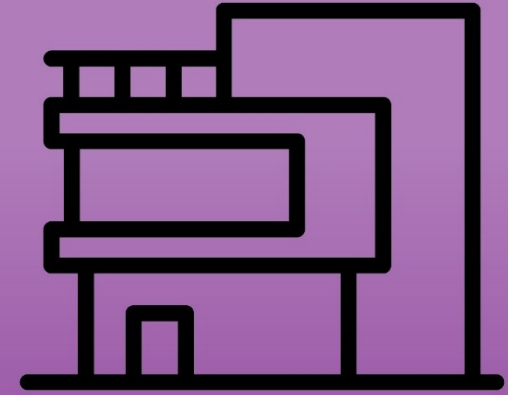
Battelle's approach to commercialization



**Mature Tech in House
To Reduce Science
and Product Risk**



**Explore Industry
Interest**



**Create Free
Standing Commercial
Company**

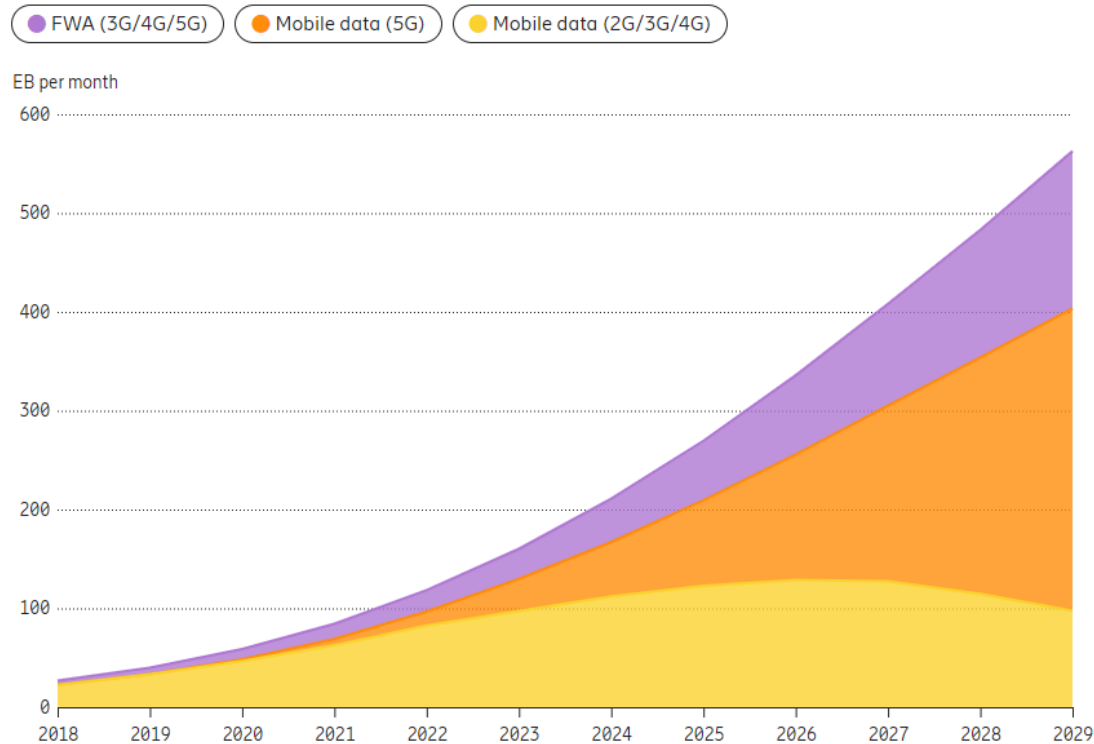
Problems operators want to solve ...

- Capacity
- Tower Space
- Multiple Radios
- Spectrum Holdings
- New Spectrum



Problems operators want to solve ... *Capacity*

Global Mobile Network Data Traffic

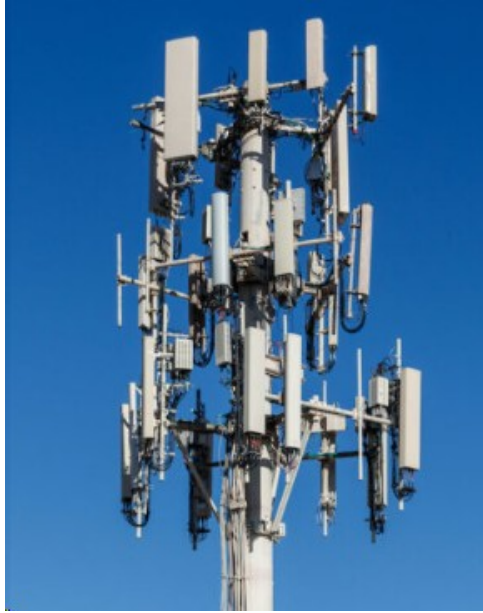


56 GB

Globally, average monthly mobile data usage per smartphone is expected to reach 56 GB, rising from 21 GB at the end of 2023.

Ericsson Mobility Report – November 2023

Problems operators want to solve ... *Tower space*



Problems operators want to solve ... *Multiple radios*

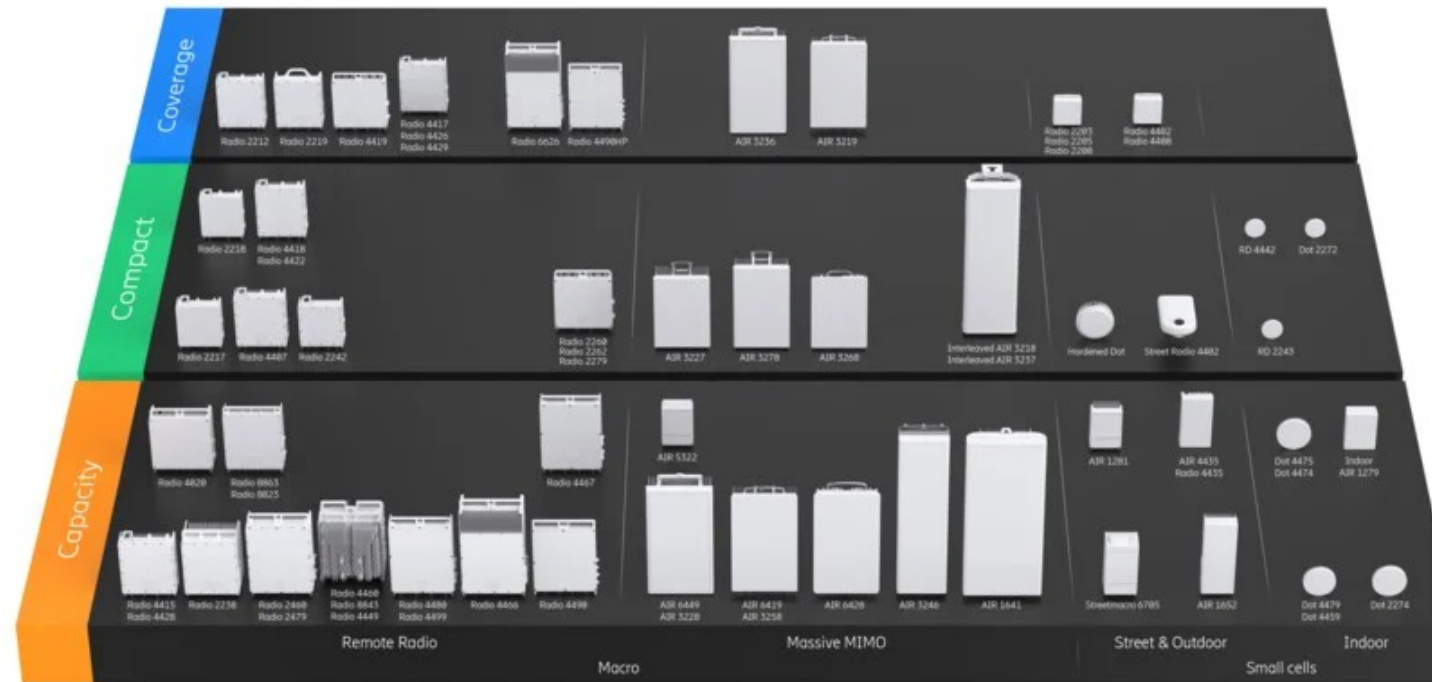
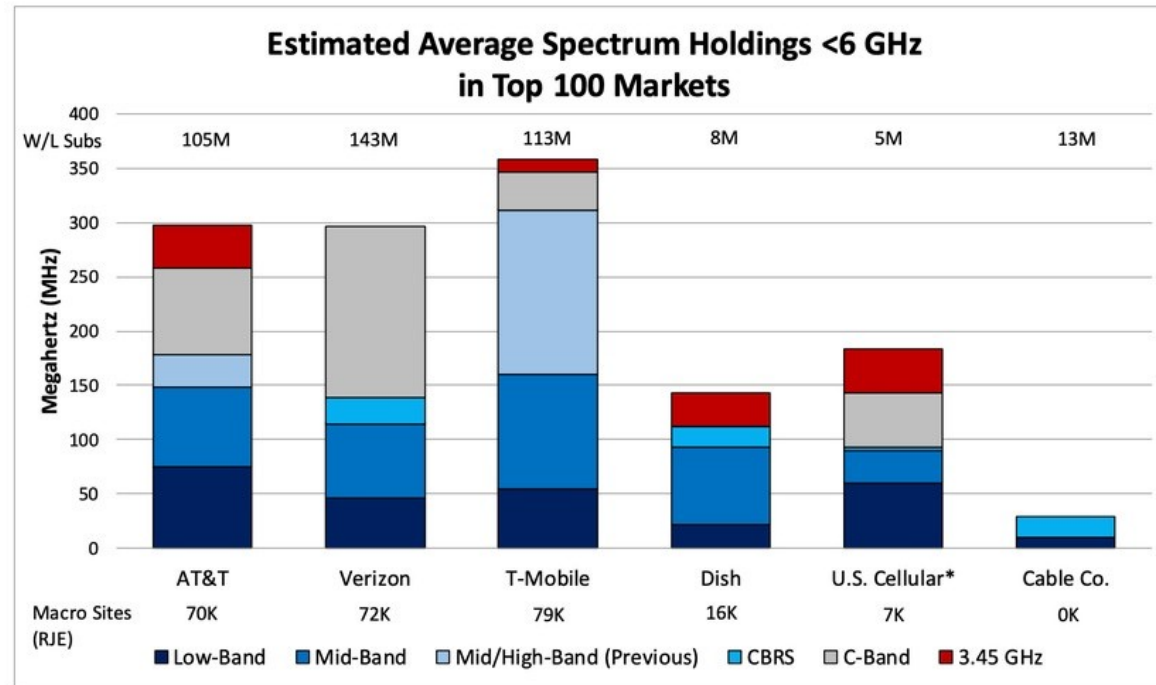


Image Source: Radio Portfolio - Ericsson

Problems operators want to solve ... *Spectrum holdings*



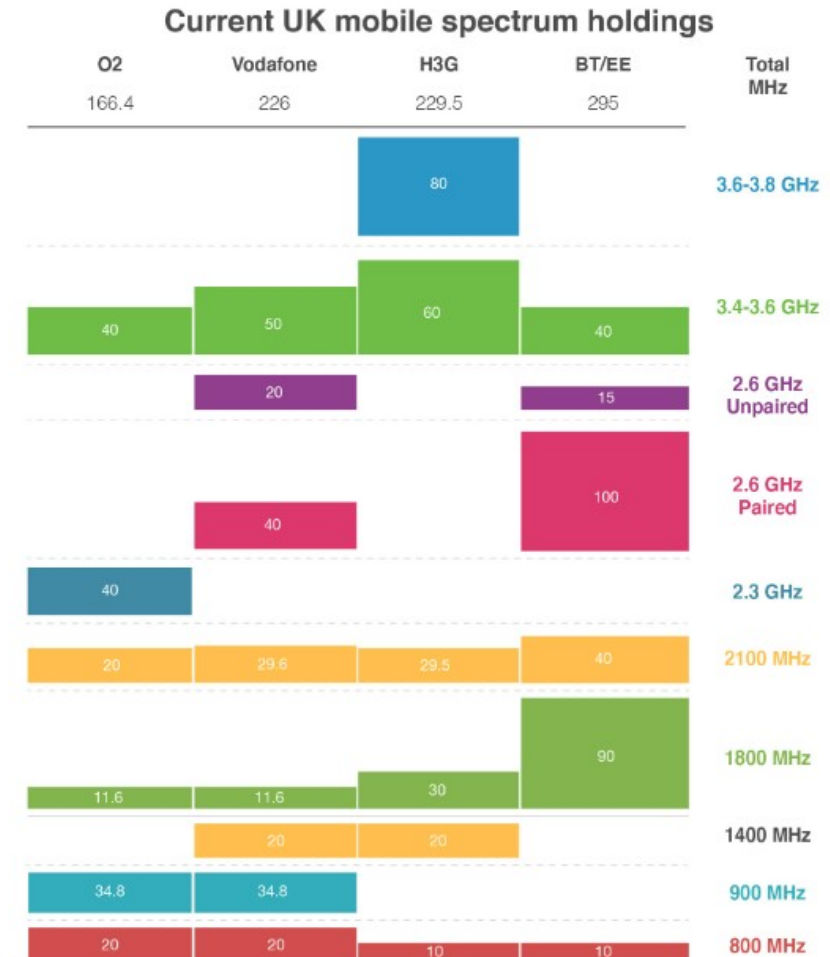
*USM holdings in Covered Markets (~32M Pops)

W/L Subs: Retail branded postpaid + prepaid. AT&T excludes connected devices. TMUS/USM/VZ exclude fixed wireless Low Band <1 GHz, Mid-Band 1-2 GHz, Mid/High-Band 2-6 GHz

Cable Co. includes CMCSA, CHTR, ATUS, Cox, Mediacom, and CMCSA-Midcontinent Joint Venture.

Assumes DISH does not exercise option to purchase 13.5 MHz of 800 MHz spectrum from TMUS.

Source: Raymond James, FCC, AllNet Labs, Company documents



Problems operators want to solve ... *New spectrum*

Nov. 21st, 2023 – US National Spectrum Strategy

- 2,786 MHz of airwaves to study for new users
- More study of lower 3 GHz (3.1 – 3.45 GHz) – possible sharing with DoD
- 5030-5091 MHz: The FCC, in coordination with NTIA and the Federal Aviation Administration, will facilitate limited deployment of unmanned aircraft systems (UAS) in this 61 MHz of spectrum.
- 7125-8400 MHz: This 1,275 MHz of spectrum will be studied for wireless broadband use on a licensed and/or unlicensed basis, and some sub-bands eventually may be studied for other uses.
- 18.1-18.6 GHz: This 500 MHz of spectrum will be studied for expanded federal and non-federal satellite operations
- 37.0-37.6 GHz: Building on prior collaborative efforts of NTIA, DoD and the FCC, this 600 MHz of spectrum will be further studied to implement a co-equal, shared-use framework allowing federal and non-federal users to deploy operations in the band

Problems operators want to solve ... *New spectrum*

Sweden completes spectrum auction

POSTED ON SEPTEMBER 27TH, 2023

IN: 5G AUCTIONS 5G SPECTRUM

NEWS IN THE EU, SWEDEN

TAGS: #5G AUCTION, #5G COVERAGE, #5G SPECTRUM

Three operators won frequencies in 900 MHz, 2.1 GHz and 2.6 GHz bands.

India will make 10,523.15MHz of spectrum available to telcos

Spectrum in several frequency bands, including 800MHz, 900MHz, 1800MHz, 2100MHz, 2300MHz, 2500MHz, 3300MHz and 26GHz, will be available for service providers to purchase.

Croatian 5G auction concluded

POSTED ON MARCH 12TH, 2023

IN: 5G AUCTIONS

CROATIA, NEWS IN THE EU

TAGS: #5G AUCTION, #5G COVERAGE, #5G SPECTRUM

Croatia's regular HAKOM has awarded 5G spectrum at national level in the 800, 900, 1800, 2100 and 2600 MHz bands, and at regional level in the 3600 MHz band.

Problems operators want to solve ...

- Capacity
- Tower Space
- Multiple Radios
- Spectrum Holdings
- New Spectrum

... Our Solution?



Increasing capacity while simplifying deployment

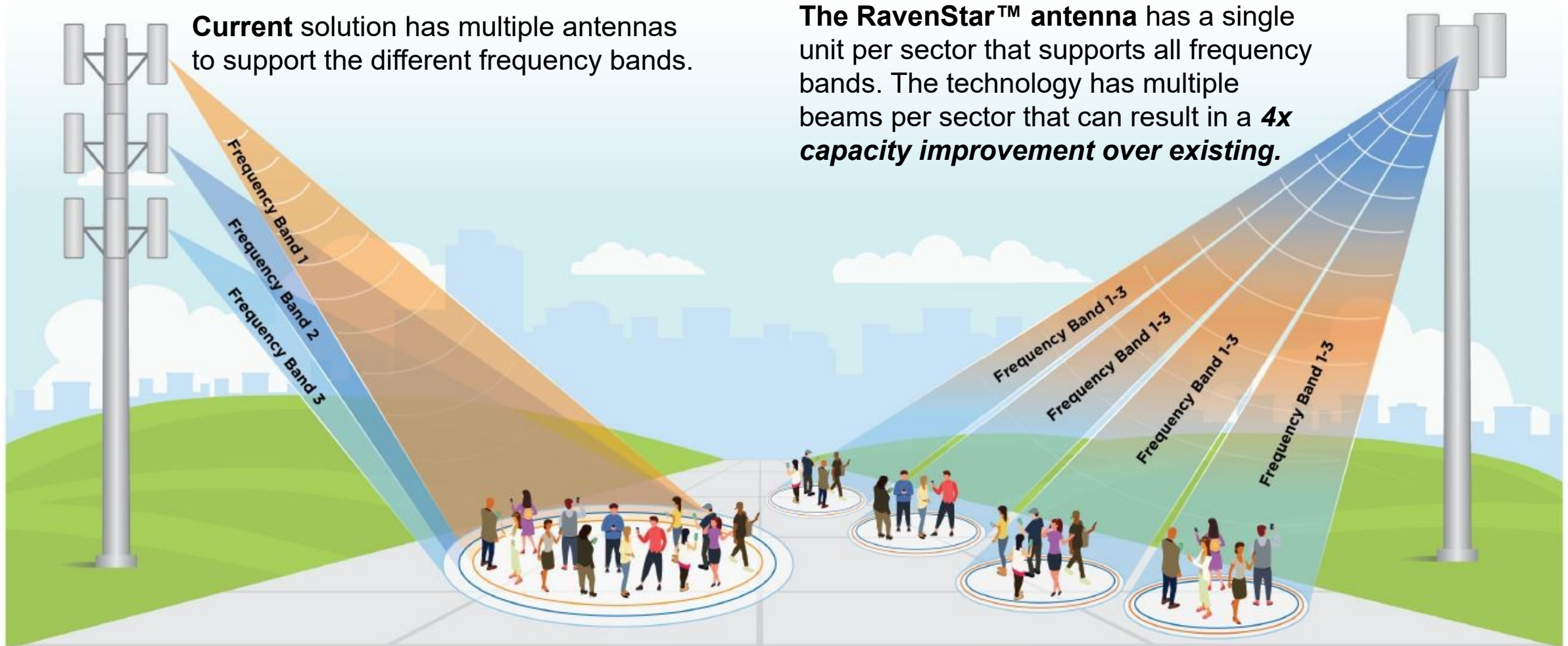
RavenStar™ antenna technology is an adaptable, compact, massive MIMO RU that operates from 600 MHz to 7 GHz - optimizing radio signals for the best throughput, with minimal energy radiated.

Key benefits include:

- O-RAN 7.2x compliant
- Extended coverage and performance
- Innovations in beamforming and interference reduction
- Small form factor, future proof multi-band radio unit (RU)



4x capacity improvement over what exists today



Current solution has multiple antennas to support the different frequency bands.

The RavenStar™ antenna has a single unit per sector that supports all frequency bands. The technology has multiple beams per sector that can result in a **4x capacity improvement over existing**.

Each band can be 4G or 5G.

Each beam transmits/receives.
Frequency band 1, 2, 3 (4G and/or 5G).

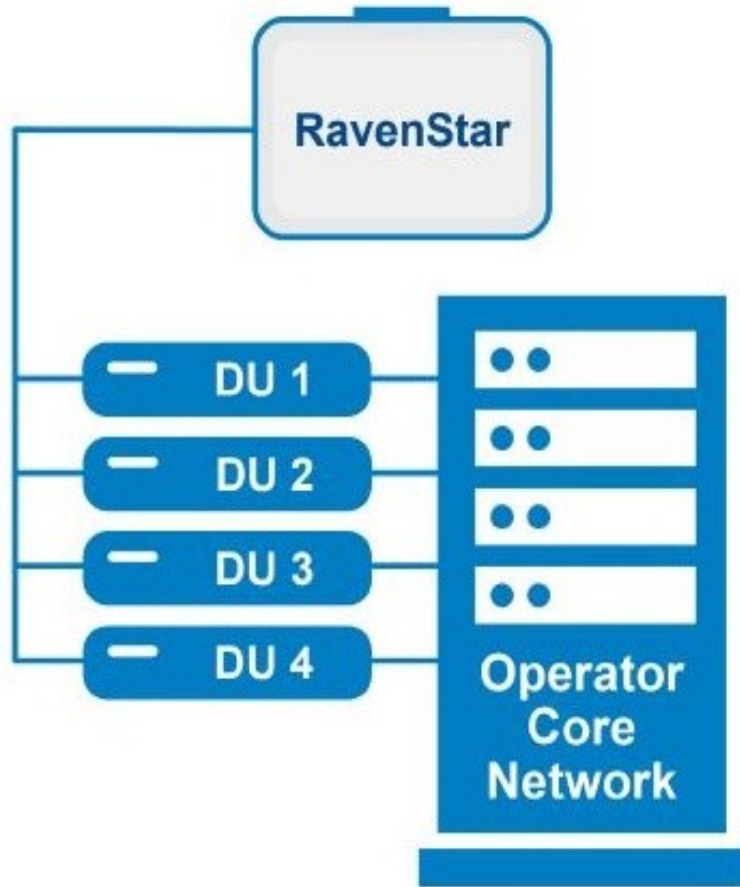
RavenStar™ antenna design

Creates a new performance benchmark

- Mixes characteristics of a flattened dipole and traveling waveguide
- Tiled array enables tailoring antenna pattern and gains
- Maintains strong beam pattern and cross polarization when steered
- Produced at volume using standard electronics assembly techniques



RavenStar™ technology deployment architecture



- **Ultrawide band** Single SKU reduces operational complexity.
- **Software configurable** Configurations are changed through software as new spectrum and technologies are deployed.
- **Form factor** – The RavenStar unit with integrated wideband antenna and radio is significantly smaller and uses less energy than traditional approaches.
- **Four independent RU to DU connections** are available which enables operators to use different DU vendors for different bands/technologies

OTA testing challenges

- Massive MIMO testing geared toward handset testing
- O-RAN support for massive MIMO in process
- Standardized test plans in development

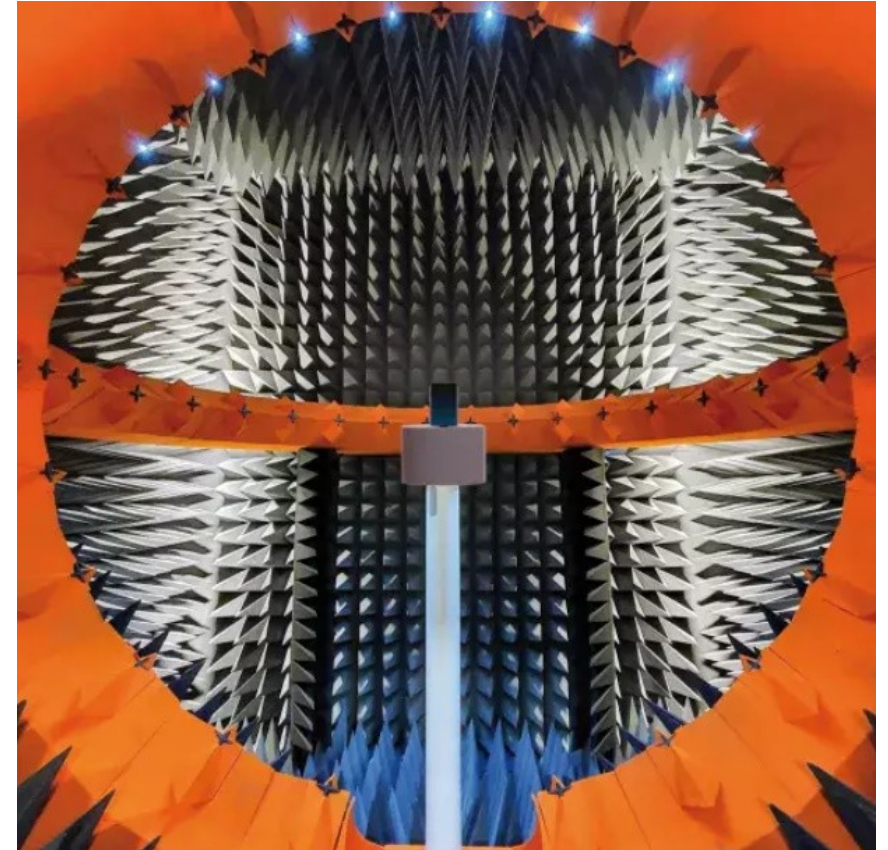
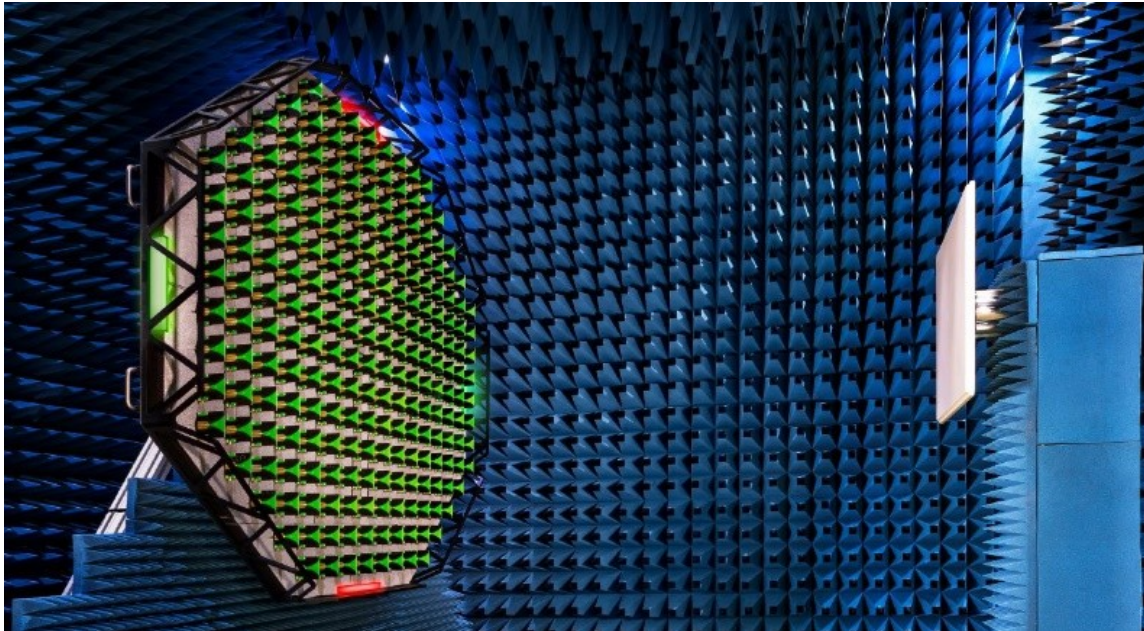


Image Sources: Rohde & Schwarz / mvg

RU integration testing – making progress

- Multiple test and integration centers in various stages of development
- Need standardized test procedures and reports



Summary

- Operators and neutral hosts face many deployment challenges – capacity, spectrum, permitting, tower space
- Wideband massive MIMO active RUs address these issues
- Need to continue working on standardized performance testing on O-RAN massive MIMO integration



BATTELLE

It can be done

800.201.2011 | solutions@battelle.org | www.battelle.org