TELECOM INFRA PROJECT®

Neutral Host Vertical Analysis Playbook

U.S. Sports Sector

NH Indoor Market Segment Playbook Professional Sports Venues

Purpose and Audience

This playbook provides vertical-specific context to the benefits of dedicated in-building neutral-host (NH) networks in the context of Sports & Entertainment venues for the major league sports in the United States. It is intended for solution providers, equipment vendors, and system integrators who desire context for applying in-building networks to industry pain points. The focus is on the unique requirements of professional sports venues and the opportunities presented by high-capacity, high-traffic environments where mobile broadband connectivity is crucial for fan engagement, operational efficiency, and public safety.

Vertical Definition

This study involves High Capacity Sports Stadiums and Arenas covering Professional Football, Basketball, Hockey and Baseball. These venues typically also host a multitude of music and other entertainment events during the year and are unique given wireless carrier interest to provide mobile connectivity in these venues. For the purpose of this study, NCAA stadiums and arenas are not included as the carrier interest to provide and pay for connectivity in these high capacity venues is distinctly less than venues hosting professional sports teams with some exceptions as Big 10 and SEC stadiums.

Venue Types – 4 Major League Sports, High Capacity Venues

For the 2023-2024 season, there are 112 venues hosting teams from the NFL, NBA, NHL, and MLB, with the Intuit Dome the latest to be added in 2024. These venues are a critical market for mobile carriers, presenting unique challenges and opportunities due to their high traffic and demands for advanced connectivity technologies, such as C-Band and mmWave. Current breakdown of the 112 venues is listed below:

	Total Number of Venues	Total Number of Teams	Seating Capacity
NFL	30 NFL Venues (2 venues are shared)	32 NFL Teams	**61.5K - 82.5K Seating** capacity typically expandable by 8-10K for Music Events
NBA NHL	52 NBA and NHL Arenas (10 venues are shared)	30 NBA Teams and 32 NHL Teams	**16.5K - 22K Seating** capacity expandable by 5-8K for Music Events
MLB	30 MLB Stadiums	30 MLB Teams	**25K - 56K Seating** capacity

A few distinct market dynamics of this strategic vertical (Professional Sports Venues) that define the overall market potential while keeping in mind that these high-traffic venues are typically marquee networks for the mobile carriers, and they continue to invest selectively while introducing new technologies (eg. C-Band, mmWave) into these mega networks.

1. **High Traffic:** These high profile "Sports & Entertainment" venues host a large number of people typically - both inside the stadiums/arenas AND tailgaters - who all have an increased need for high-speed, high-capacity, and low latency mobile connectivity; serves as an ideal use case for 5G deployments; with NFL/MLB stadiums ranging from 25K to 82.5K seating capacity and NBA/NHL arenas ranging from 16.5K to 22K seating capacity, there is no bigger stage for people congregating with their devices ready to connect at all times than stadiums and arenas.
2. **Upload Capacity:** Games and music events are unique in that fans and patrons attending like to capture their venue experience real-time and share with families and friends. This requires a highly robust, resilient, and future-proof network architecture that accommodates high upload speed and capacity; this requirement is distinct from any other vertical given the need to share live feeds and the influence of social media and videos at all times. Network speed, capacity

and latency are prioritized in the stadiums and arenas with high sectorization of essence to maximize spectrum utilization.

3. **Design and Architecture**: Stadium roofs can be open, semi-open, retractable and closed while arenas are all closed and compact. This leads to the importance of network design especially as it relates to radios and antenna placement and fiber to the edge architecture.
4. **Premium Seating:** Venue owners are constantly increasing premium seating and suites options to increase revenue while delivering improved venue experience. From a connectivity perspective, these suites and fan zones are prime for high capacity connectivity including C-Band, mmWave and WiFi.
5. **Technology Leadership**: These high traffic venues are a big focus for the mobile carriers and the Top 3 carriers have shown an inclination to invest in the networks in these venues; despite the ongoing capital crunch, mobile carriers have continued to allocate modest investments in these venues and the trend is expected to continue as mid-band spectrum (C-Band for VZ and AT&T and 2.5GHz for T-Mobile) and mmWave continues to be deployed.
6. **Network Scalability to Accommodate Music Events**: A typical stadium can extend seating by 10K for music events with patrons packing the field. Similarly, arenas expand seating by about 5K by accommodating fans and patrons on the floor. This leads to the need for antennas and sectors in the field and floor for stadiums and arenas respectively.
7. **Concessions & Merchandise Ordering**: Monetization and fan engagement is key for venue and team owners and ordering from the stands requires network connectivity everywhere. Carrier owned public cellular networks and venue owned private networks are both utilized to enable ordering from anywhere, everywhere in the stadium and arena.
8. **Facial Recognition & Ticketless Entry**: Easing the entry process is of critical importance for venue and team owners. A typical entry process can take fans 15-30 minutes to reach their assigned seating. With facial recognition, this process can be shortened dramatically and venues are looking at ways to increase fan satisfaction.

Customer Pain Points

Delivering Ultra-Fast & High Capacity Connectivity in a Capital Constrained Environment

Sports Venue vertical has varied network owners with unique pain points and requirements. Listed below are the primary pain points (and requirements) for each customer type pertaining to cellular and wireless connectivity:

A) Venue/Team Ownership

- Improve venue experience for the fans and patrons by ensuring a "fully connected venue"
- Ensure a multi-carrier mobile network delivering high capacity 5G to ensure that the biggest network bottleneck - live video uploads and social media - can be supported from the venue
- Increase revenue stream by:
  - Ensuring easier merch, food & beverage, and paraphernalia sales via private cellular or Wi-Fi networks
  - Owning and operating the 4G/5G network with carriers paying a monthly recurring fee to provide their service (akin to a neutral-host operator model)
- Provide guaranteed public safety/first responder access for any emergency situation from every location in the venue via a highly reliable mobile network

B) Mobile Network Operator (MNO)

- Sports venues have become "connectivity showcases" for the MNOs with the carriers investing heavily to deliver 5G connectivity for their subs attending games and events in the venue
- With spectrum being limited, MNOs biggest pain point is to deliver the fastest and highest capacity mobile connectivity with the maximum spectral efficiency in the lowest possible CapEx and OpEx model
- MNOs want to typically minimize the use of the venue's Wi-Fi network and keep their subs on their own cellular network as much as possible

C) Neutral-Host (NH) Operators

- Typically, NH operators, or 3POs as they are also commonly referred to, focus on bringing all 3 MNOs on their network

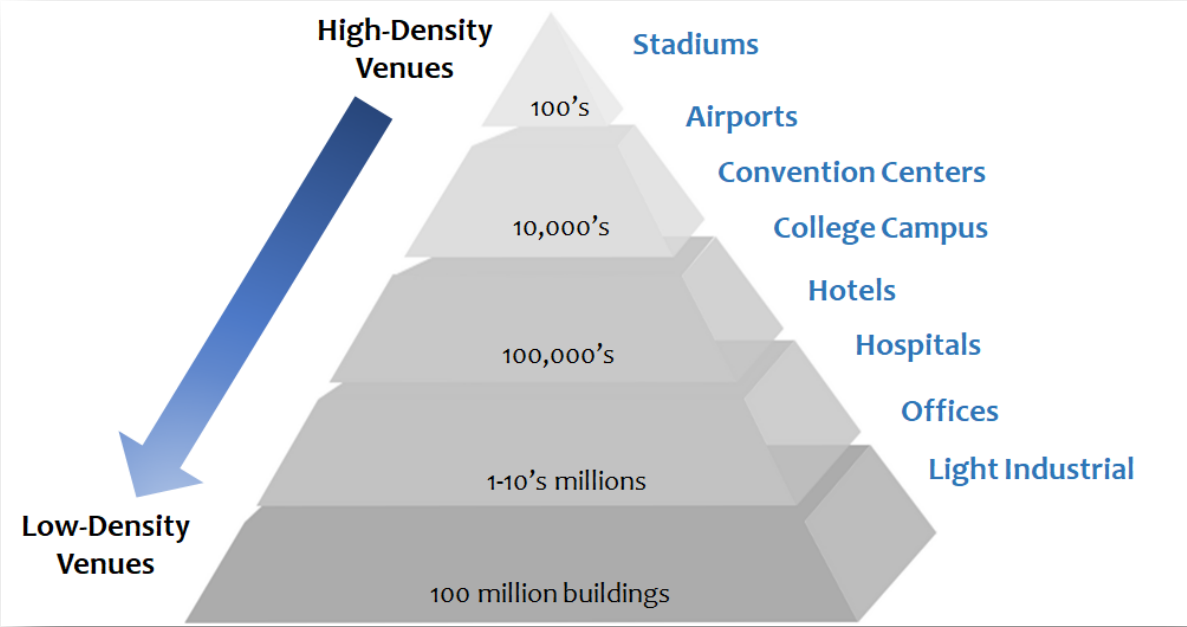
- NH operators are focused on lowering the total cost of network ownership (TCO) as they are responsible for the maintenance and upgrades to the network for a 10-15 year period
- As they may share the revenue with either the venue or anchor carriers, the business model is the biggest requirement for the NH operator – in some instances, the MNO may be the NH operator

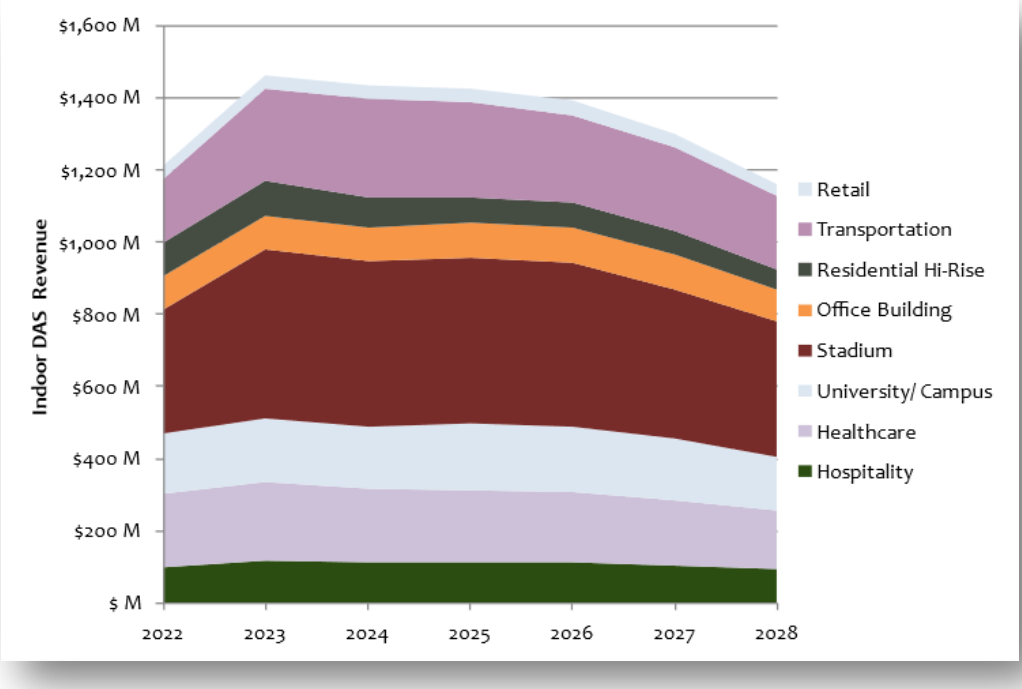
Price Sensitivity – Lower When Compared to Other Verticals

While lower TCO is always the focus and requirement, Professional Sports Venues are "typically less sensitive" to pricing as it pertains to the varied network elements from OEMs and vendors. The current capital crunch environment though offers pricing pressure even in this vertical as MNOs and other network owners are all pushing for the lowest possible CapEx and OpEx. However, it is a fair assumption that the pricing for DAS, fiber, antennas, and other elements are the highest in the Professional Sports vertical than any other vertical.

Total Addressable and Serviceable Market (TAM & SAM) – Highest Investment in Single Venue Across All Verticals

Mobile Experts, a leading research firm, provides a top-down view of the DAS market where Stadiums represents the single largest vertical for DAS investment despite having the fewest absolute number of Large Stadiums. In terms of TAM, Stadiums are expected to be a $450M+ market in North America in 2024.





Indoor DAS Revenue by Vertical Market							
	2023	2024	2025	2026	2027	2028	CAGR ('23-'28)
Stadium	$467 M	$459 M	$456 M	$453 M	$416 M	$372 M	-4%

Here are some important points related to the TAM and SAM:

- Networks are expected to have a 10-year lifespan with periodic technology upgrades during that time period
- NH operators and other network owners get additional tranche of 5-year renewals of the contract
- Digital DAS have demonstrated reduced capital and operating expenditures vs. Analog DAS that have historically dominated the Professional Sports venue vertical – the impact of Digital DAS investment is evident in the reduced market size
- The market size will differ based on the network ownership (i.e., OEM vendors care about the network equipment sales and associated service revenue while MNOs and NH operators evaluate the overall cost of ownership/TCO)

Commercial Models & Network Ownership – Multiple Ownership Models of "Shared Networks"

All venues have shared networks where multiple carriers are expected to participate. There are 3 primary types of network ownership in high-traffic venues with different CapEx and OpEx implications:

- Scenario 1: Mobile Network Operator (MNO) Owned Model
- Scenario 2: Neutral-Host (NH) Operator Owned Model
- Scenario 3: Venue Owned Model

We discuss each scenario briefly as the TAM impact is different in each case given the breakdown of the CapEx and OpEx is influenced by the network ownership.

A) **MNO-Owned Model**: In this scenario:
   a. Anchor carrier (anchor MNO) has "won" the business with the Venue
   b. Functioning as a Neutral-Host, the anchor is the network owner and typically leverages a systems integrator to build the network
   c. The anchor carrier is responsible for the shared network and brings on other carriers as additional carriers
   d. Anchor collects revenue from other carriers and is responsible financially for the lifetime OpEx and any overlays/upgrades (CapEx) made to the network
   e. The anchor carrier may have a revenue-share agreement with the venue

B) **Neutral-Host Operator Owned Network**: In this scenario:

a. 3PO owns and operates the neutral-host network
b. While the 3PO typically leverages multiple subcontractors to build the network, the design and ongoing operations are generally conducted via in-house resources by the 3PO
c. 3PO owns the entire network - all maintenance expenses are on the 3PO - while monetizing from carriers
d. While the onus of the equipment vendor selection rests on the 3PO, the anchor carrier is a major influencer
e. 3POs may have a revenue-share agreement with the venue

C) **Venue Owned Network**: In this scenario:

a. Venue owns the cellular network
b. A system integrator, or another third party, leads the network design and build
c. Typically, they work in conjunction with the anchor carrier and OEM vendor selection decisions are a collective decision with the venue owner involved
d. Venues monetize from the carriers either directly or via the integrator involved
e. Venue management companies and, in some cases even, construction companies are influencers

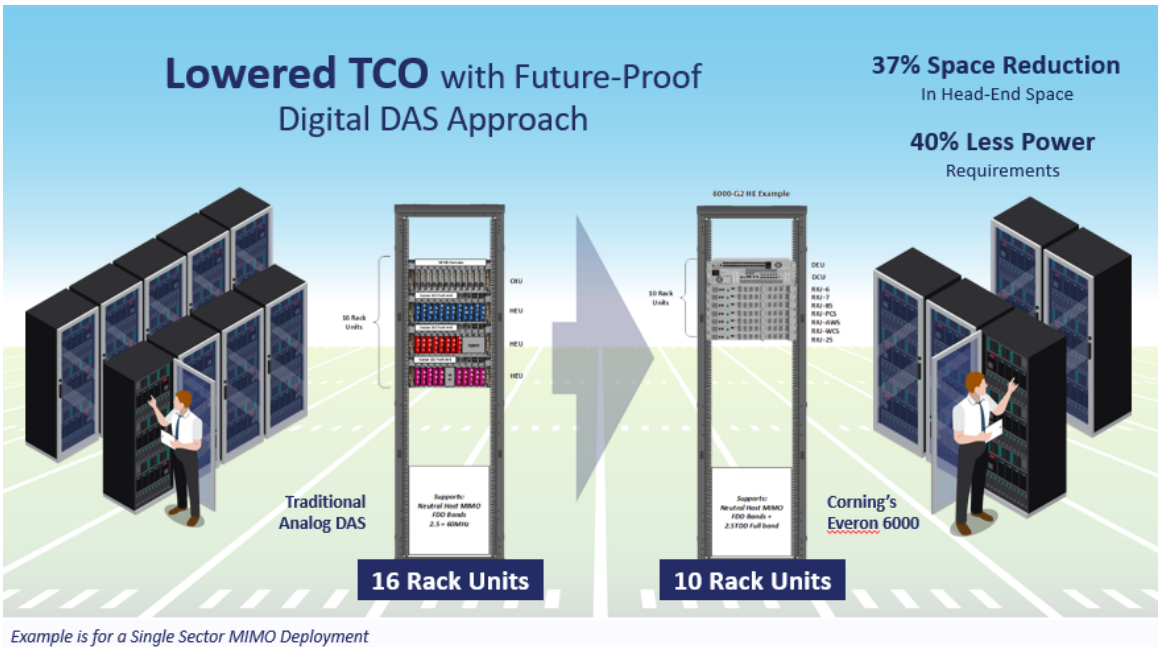
High Level Radio Network & Fiber Components

Focus on MIMO, DAS, Fiber-to-the-Edge & Line-of-Sight Antennas for High Sectorization

The high capacity sports venues have extensive IT infrastructure requiring an integrated solution for MIMO (multiple input/multiple output) DAS. Here are some technologies leveraged in this vertical:

- **Analog DAS**
  - Traditional approach
  - Massive hub room
  - Higher CapEx and OpEx

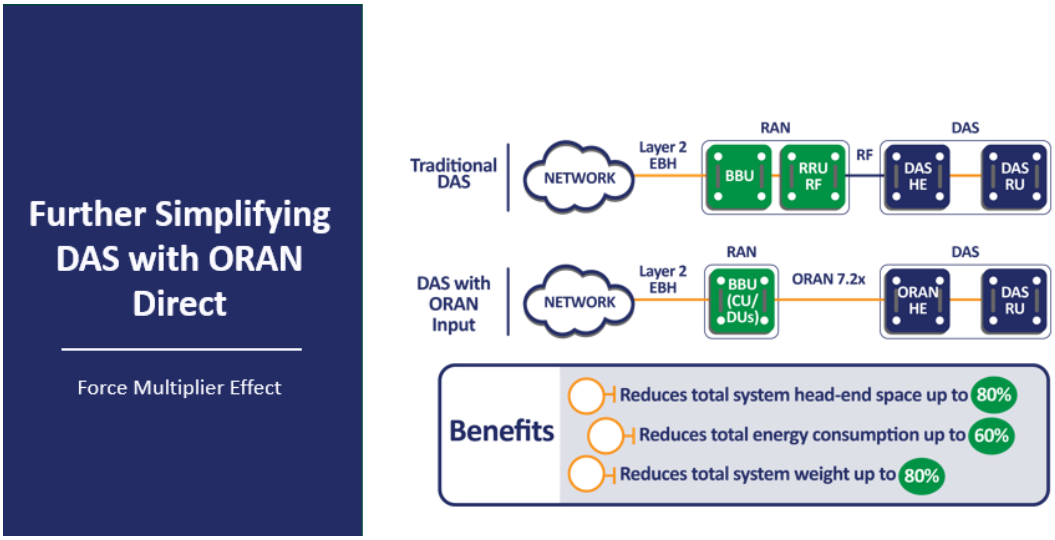
- **Digital DAS**
  - New approach
  - No signal conversion required
  - Require smaller hub room
  - Significantly lower CapEx and OpEx compared to Analog DAS



Example is for a Single Sector MIMO Deployment

Open RAN

- Implies open systems and interfaces with onus on vendor diversity which allows for carriers to leverage best-of-breed network components with increased interoperability
- Cloud-native architecture and virtualization benefits
- Increased reliance on software for upgrades and increased network uptime
- Higher network availability and superior performance via the distributed architecture
- Energy efficiencies via low-powered radio that automatically shut-off



- Fiber-to-the-Edge (FTTE) architecture
  - Future proof architecture with longer shelf life and support for oncoming technologies and advancements
  - Easy to deploy and maintain with lowered complexity
  - Immediate support for higher bandwidth applications, lower latency, and integrated services
- Line of Sight and Under-the-Seat Antennas
  - Multibeam LOS antennas provide higher bandwidth and lower cost last mile connectivity
  - Maximized spectrum utilization via LOS multibeam antennas
  - Under the seat provide stadium wide coverage and capacity, at a higher cost and

complexity than LOS multibeam antennas

- Multiple technology support
  - C-Band in the Bowl
  - CBRS for Private Networks
  - mmWave for premium suites

Technology – First Adopter Approach

While professional sports venues are known to be first-adopters of new technology in the in-building space, they are also the test bed for future technologies. Facial recognition, ticketless entry, mmWave, C-Band, private networks etc. are all examples of technologies that are trialed and deployed first in the mega venues. Let's expand on a few relevant ones for this study:

A) **C-Band**: FCC's Auction 107 raised over $80M with Verizon and AT&T together spending about $70 million in the 3.7-3.98 GHz spectrum in the US. While Verizon got the first tranche of the spectrum in 2021 itself, soon after the auction, AT&T received their C-Band spectrum recently in 2023. Previously used by satellite operators, this prized spectrum was cleared for mobile use. While the initial push was in the outdoors, the recent push has been in the indoors, primarily in the high-traffic venues. C-Band provides a balance between capacity and coverage and is poised to serve as the ideal spectrum for 5G services. Verizon has been the lead proponent of C-Band in venues recently with a handful venues already capable of C-Band – including Acrisure Stadium and Allegiant Stadium. AT&T is expected to begin deploying C-Band in high-traffic venues soon.

B) **mmWave**: mmWave is the high band spectrum that provides high capacity but has limitations with line of sight and distance. With that said, Verizon has been actively deploying mmWave in NFL venues. Other carriers are also expected to begin deploying mmWave soon. Important to note that mmWave is expected to also cover suites and premium zones in the prominent venues.

C) **Private Networks**: Venues typically own and operate private networks which may operate in the licensed spectrum or in the shared CBRS spectrum. Private networks are being looked upon as eventually replacing WiFi, which has inherent voice, security, mobility and scalability limitations. Private networks are poised to

increase fan engagement while providing venues fan related data and revenue enhancement possibilities.

Use Cases for Private Networks in Stadiums & Arenas:

- **Internal communications**: Secure cellular communications for staff, teams, players, coaches, etc. within managed properties
- **Team Analytics**: Ability for teams to communicate with team members, analyze stats and performance, etc.
- **Fan Analytics**: Ability to capture fan and patron buying behavior and other habits within the venue
- **Location-Based Services (LBS)**: Targeted promotions, proximity-based notifications, public safety
- **Operational Automation**: Task orders, robotic-based cleaning and delivery, etc.
- **Security/Safety**: CCTV surveillance cameras in parking areas or other places where wires don't reach, mobile video monitoring, etc.
- **Building Management**: Monitoring and controlling thermostats, lighting, elevators, power systems, etc.

Professional sports venues represent a unique and lucrative segment within the in-building neutral-host network space. With a focus on cutting-edge technologies and the ability to handle massive traffic, these venues serve as showcases for 5G, private networks, and other innovations that will define the future of connectivity. Addressing the distinct pain points of venue owners, carriers, and neutral-host operators is key to unlocking the full potential of this vertical. This playbook outlines the key considerations for vendors, solution providers, and integrators in tackling the challenges and opportunities presented by high-capacity sports venues. By understanding the unique dynamics of this market, stakeholders can better position themselves to deliver impactful solutions that meet the evolving demands of professional sports and e-entertainment venues.