NextGEN 5G
Broadcast / Broadband Convergence

Mark A. Aitken

Sinclair Broadcast Group/ONE Media

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- Sinclair Broadcast Group (SBG) is one of the largest and most diversified television broadcasting companies in the country.
- SBG owns, operates and/or provides services to 191 TV stations in 89 markets, broadcasting 601 channels and having affiliations with all the major networks.
- Produces approximately 2,400 hours of news per week.
- SBG owns Tennis Channel, Ring of Honor, COMET TV and others.

33
States Nationwide

89
US Markets

39%
Percent of Sinclair's television group reach of US households

191
Stations Managed and Operated

FOX abc NBC CBS

MyTV ROH COMET

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What is NextGEN? (ATSC 3.0)

Cover designed by Jon MONTALBAN and Yiyan WU

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NextGen/5G Alignment Attributes

ATSC 3.0 ("NEXTGEN")		5G
OFDM (Orthogonal Frequency Division Multiplexing)	→	OFDM
IP based (e.g. HTTP Streaming)	→	IP based
LDPC (Low-Density Parity-Check)	→	LDPC
LDM (Layer Division Multiplex)	→	NOMA (Non Orthogonal Multiple Access)
W-CDMA aligned Symbol Rates	→	W-CDMA aligned Symbol Rates
Time aligned frames (5msec increment)	→	Time aligned frames/subframes (10/1msec increment)
Carrier Aggregation / Channel Bonding	→	Carrier Aggregation / Channel Bonding
Cloud based virtualized functions	→	Cloud based virtualized functions
Cognitive RAN (Radio Access Network) *bootstrap	→	Cognitive RAN
OTT (Over-The-Top) Compatible	→	OTT Compatible

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Why NextGEN?

- Broadcasters are looking for opportunities to best leverage ALL core assets and to remain relevant
  - Spectrum
  - Content
  - Reach

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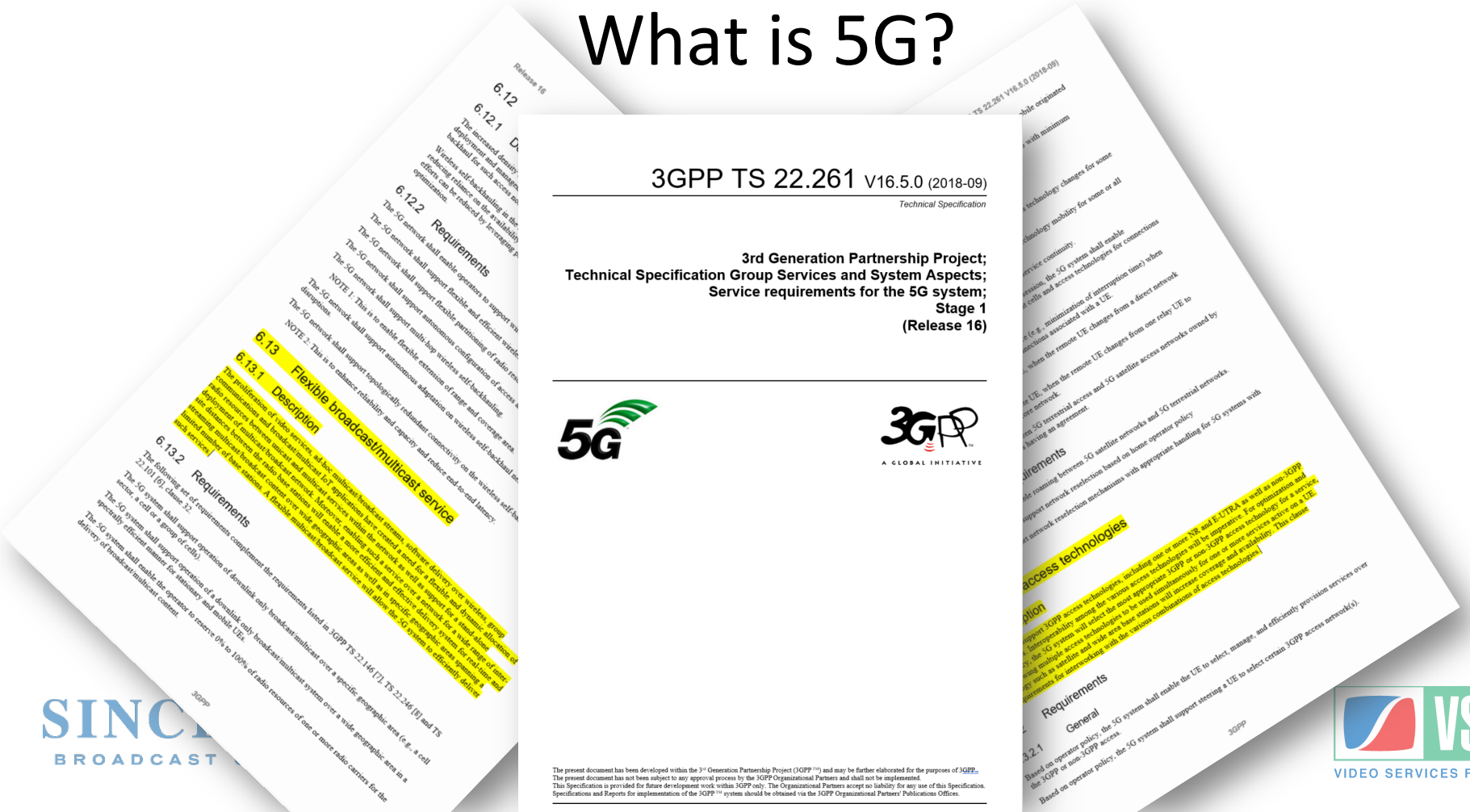
What is 5G?



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The 5G system shall support service continuity between 5G terrestrial access and 5G satellite access networks owned by the same operator or owned by 2 different operators having an agreement.

6.2.4 Roaming related requirements

A 5G system with satellite access shall enable roaming between 5G satellite networks and 5G terrestrial networks.

A 5G system with satellite access shall support network reselection based on home operator policy

UEs with satellite access shall support network reselection mechanisms with appropriate handling for 5G systems with satellite access.

6.3 Multiple access technologies

6.3.1 Description

The 5G system will support 3GPP access technologies, including one or more NR and E-UTRA as well as non-3GPP access technologies. Interoperability among the various access technologies will be imperative. For optimization and resource efficiency, the 5G system will select the most appropriate 3GPP or non-3GPP access technology for a service, potentially allowing multiple access technologies to be used simultaneously for one or more services active on a UE. New technology such as satellite and wide area base stations will increase coverage and availability. This clause provides requirements for interworking with the various combinations of access technologies.

6.3.2 Requirements

6.3.2.1 General

Based on operator policy, the 5G system shall enable the UE to select, manage, and efficiently provision services over the 3GPP or non-3GPP access.

The 5G network shall support autonomous configuration of access and wireless self-backhaul functions.

The 5G network shall support multi-hop wireless self-backhauling.

NOTE 1: This is to enable flexible extension of range and coverage area.

The 5G network shall support autonomous adaptation on wireless self-backhaul network topologies to minimize service disruptions.

The 5G network shall support topologically redundant connectivity on the wireless self-backhaul.

NOTE 2: This is to enhance reliability and capacity and reduce end-to-end latency.

6.13 Flexible broadcast/multicast service

6.13.1 Description

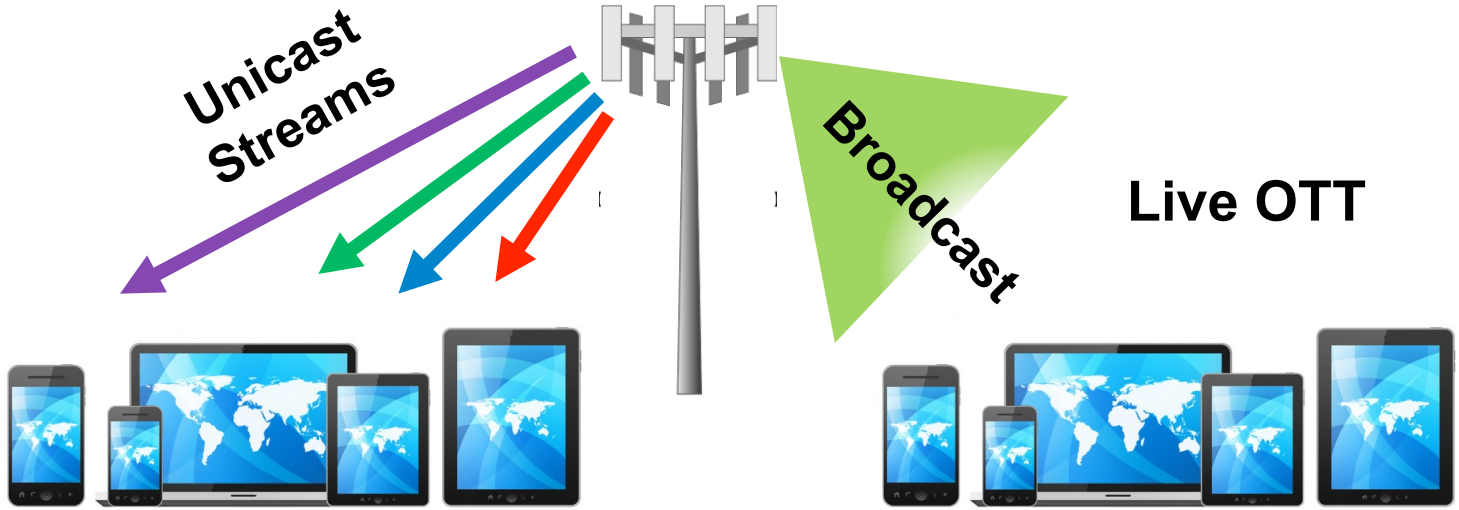
The proliferation of video services, ad-hoc multicast/broadcast streams, software delivery over wireless, group communications and broadcast/multicast IoT applications have created a need for a flexible and dynamic allocation of radio resources between unicast and multicast services within the network as well as support for a stand-alone deployment of multicast/broadcast network. Moreover, enabling such a service over a network for a wide range of inter-site distances between the radio base stations will enable a more efficient and effective delivery system for real-time and streaming multicast/broadcast content over wide geographic areas as well as in specific geographic areas spanning a limited number of base stations. A flexible multicast/broadcast service will allow the 5G system to efficiently deliver such services.

6.13.2 Requirements

The following set of requirements complement the requirements listed in 3GPP TS 22.146 [7], TS 22.246 [8] and TS 22.101 [6], clause 32.

5G Broadcast is a Multicast Supplement to Unicast

- Broadcast offloads live content (news, sports, popular entertainment), downloads, etc.
- Unlimited number of users access same content in broadcast footprint
- No pixilation, buffering or freezing – improves user experience
- Broadcast/broadband convergence



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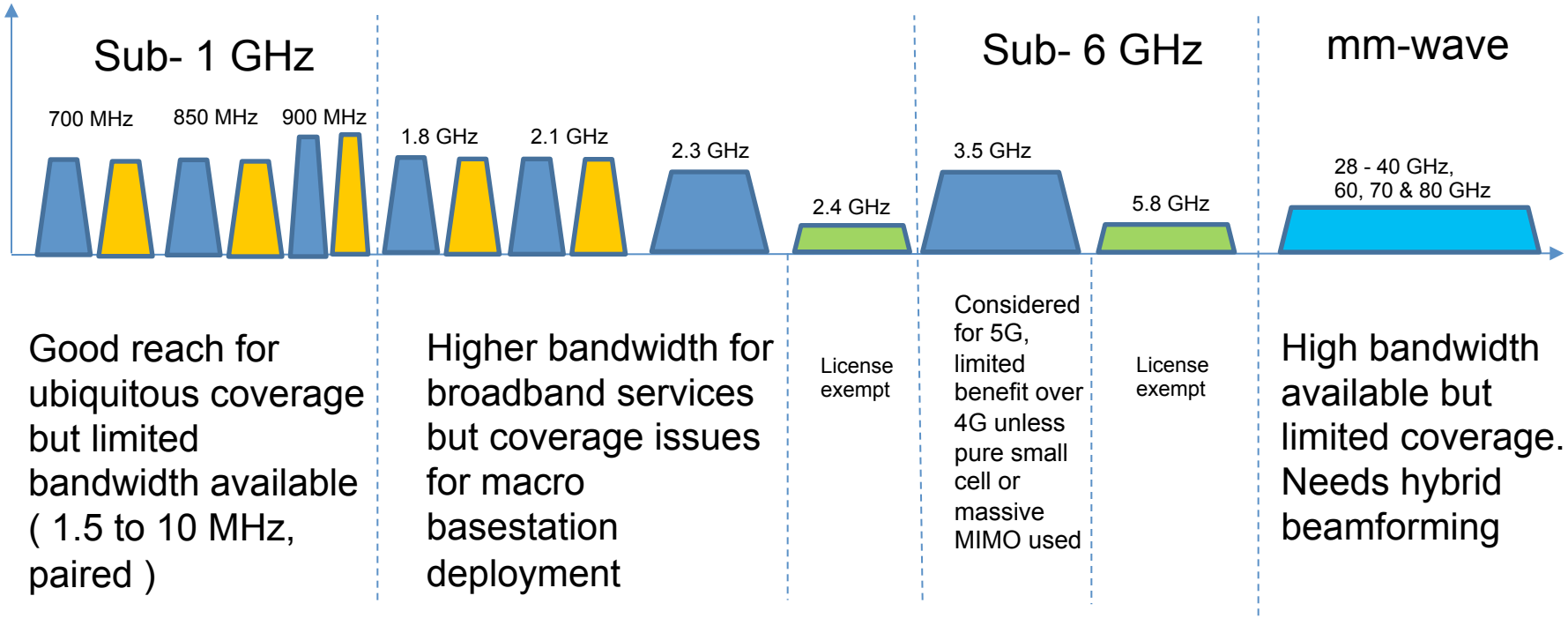
5G is also about Spectrum for Services



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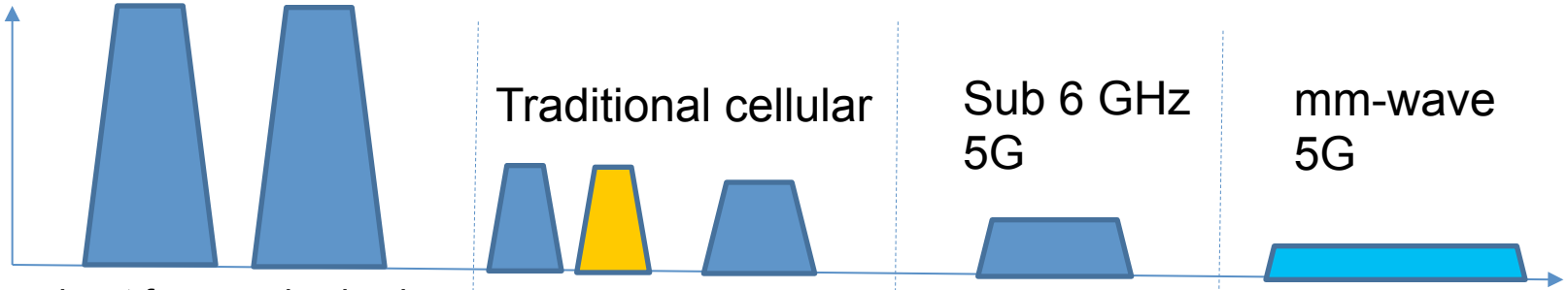
Additional Spectrum available in Broadcast frequencies



UHF broadcast frequencies having excellent coverage and moderately high bandwidth. Can be a good complementary network for both traditional cellular and upcoming 5G frequency bands. Different network engineering can be done as it is not limited by uplink

Good coverage
lower bandwidth

intermediate

High bandwidth
poor coverage

Coverage limited by uplink power, which is limited by human safety levels (~ 200 mW)

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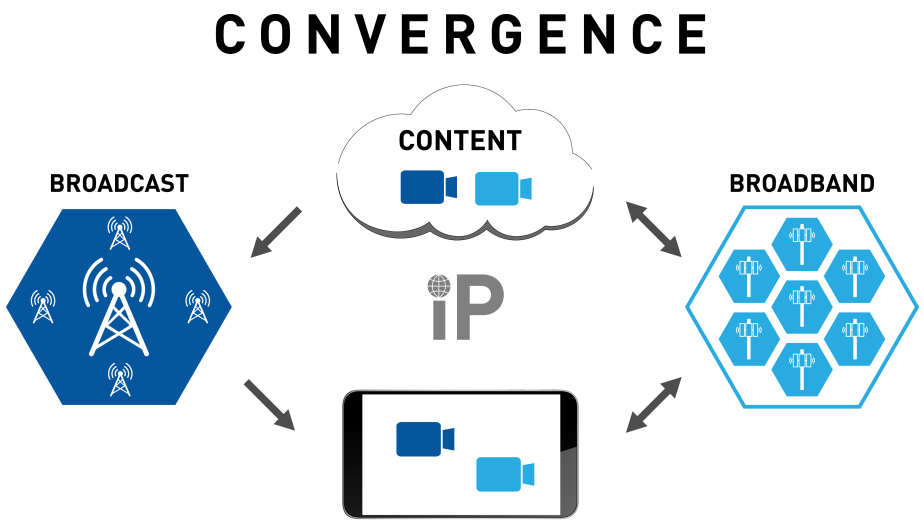
It is most Importantly about…



- 5G Broadcast PHY must be integrated into mobile devices
- The Broadcast and Broadband Networks **must be converged**
- The topology must be cellularized (“Low power, low tower”)
- The user must not care how the content is received

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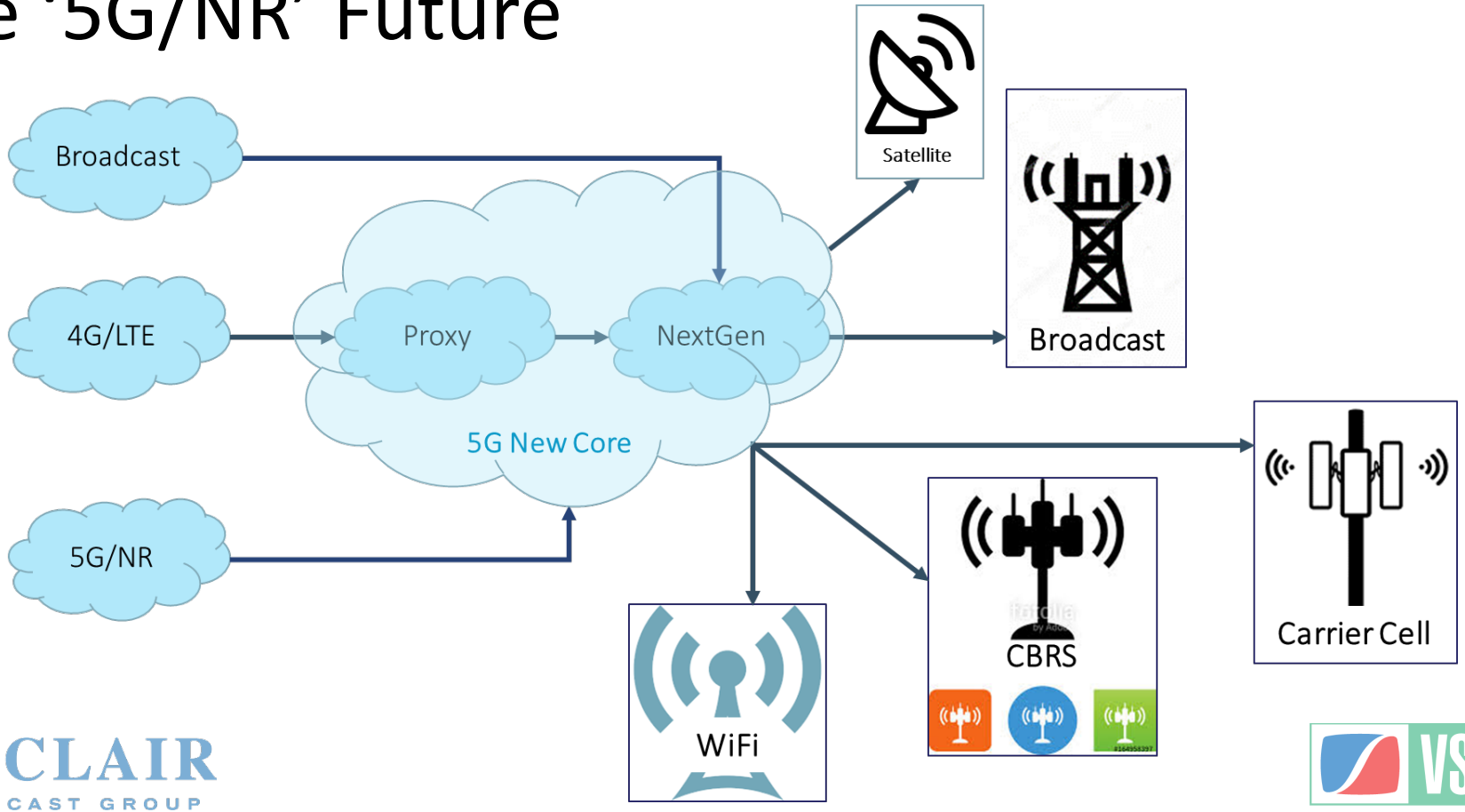
The ‘5G/NR’ Future



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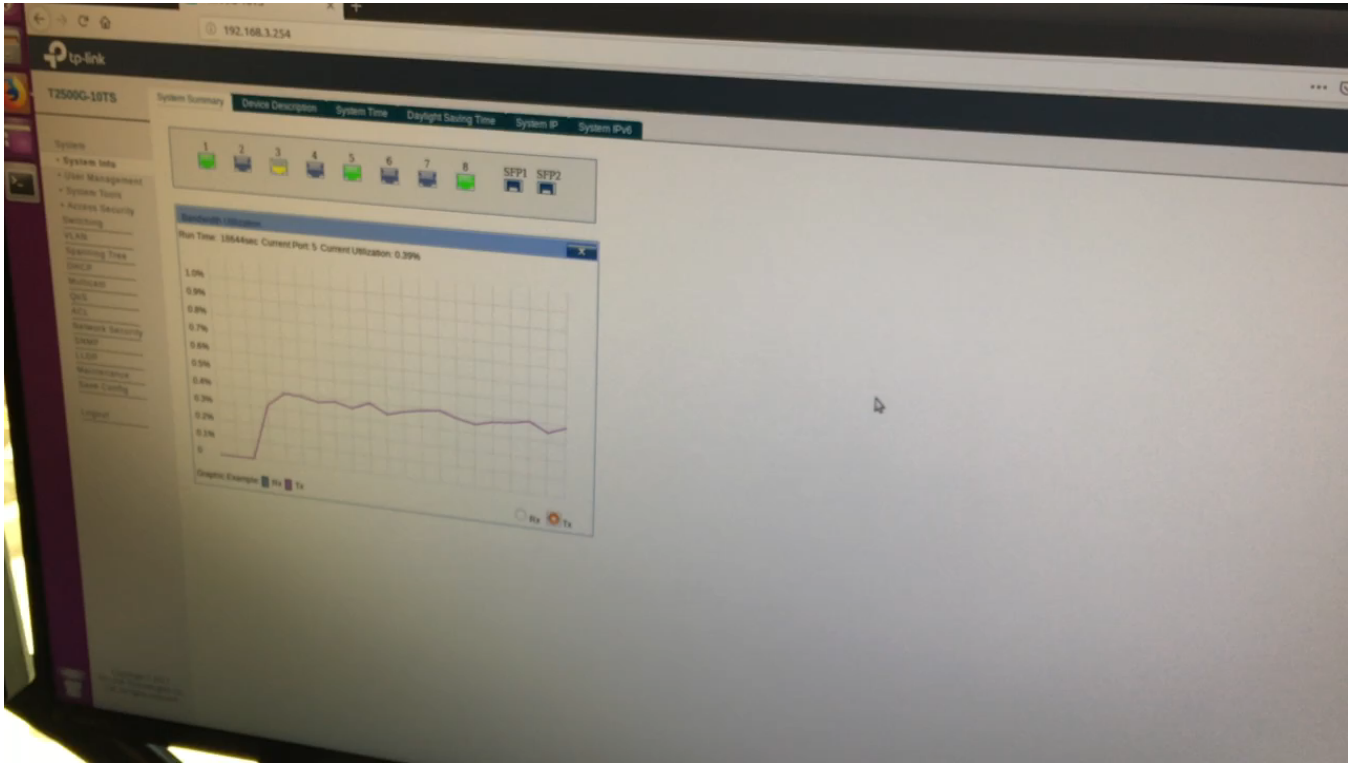

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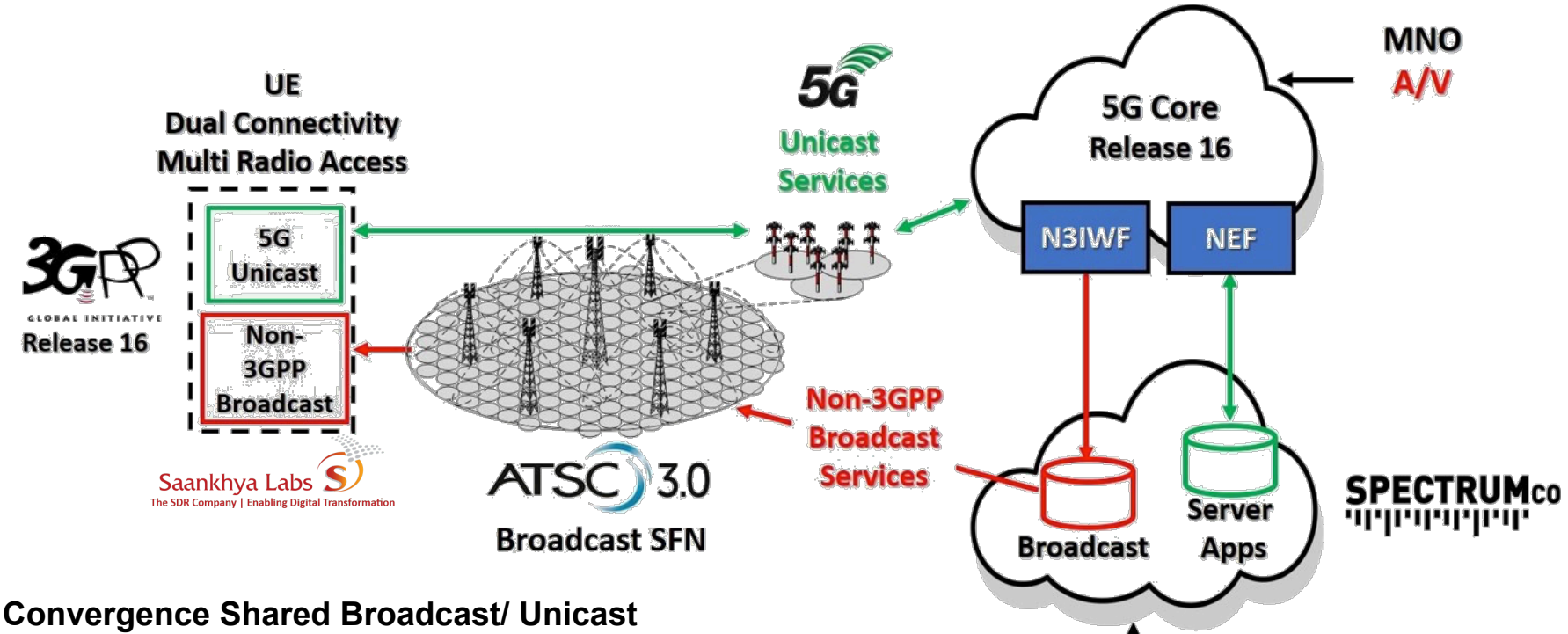
Broadcast 5G Convergence



Convergence Shared Broadcast/ Unicast

- **5G Offload Broadcast (N3IWF)**
- **Broadcaster Unicast Services (NEF)**

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Note: Broadcast Core Network and SFN Shared by Broadcasters/Spectrum Co

Motivations for 5G Broadcast Convergence

- Enable Flexibility at PHY (A/321 and A/322) by extending baseline
  - Extended OFDM Numerology, L1 signaling, Frame structure
  - Improve Mobility, Larger BW and Higher Frequency band Options
  - Support for Convergence Broadcast 5G Release 16 in Core Network Layers and UE
- Emergence of Programmable SDR Chip (Multi-RAT)
  - Saankhya/ ONE Media 3.0 SDR Chip (1st shown CES 2019)
  - A/321 Bootstrap Multi (Root + Seed) capability new waveforms beyond 3.0

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“Mobile First” Chipset

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Motivations for 5G Broadcast Convergence

- ATSC 3.0 Layers above IP replaced to support Mobile 5G Convergence
  - Transport protocols must support new IP Core Network and UE
  - ATSC 3.0 assumed only Smart TV, we also need intelligent Core Network
- 3GPP Release 16 is the right time with new 5G Core Network Paradigm
  - New 5G Core Service Based Architecture (SBA) Agnostic to Access Network
  - Support for Network Slicing (SDN/NFV)
  - Control Plane / User Plane split
  - Support Non-3GPP Access Networks and Dual Conn UE (See TR 23.793)
  - Broadcast ATSC 3.0 (L1/L2 extend) is positioned as a Non-3GPP Access Network

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5G Core Network Release 16
Two Types of Non-3GPP Access Networks Defined

1. **Trusted** Non-3GPP Access (Broadcast) tightly integrated into 5G Core (MNO benefits without any support broadcaster) MNO has spectrum

2. **Un-Trusted** Non-3GPP Access (Broadcast) Broadcaster + MNO cooperative convergence Spectrum Co. Model
   a. Evolved ATSC 3.0 / NextGEN

5G Core is **Agnostic** to access network

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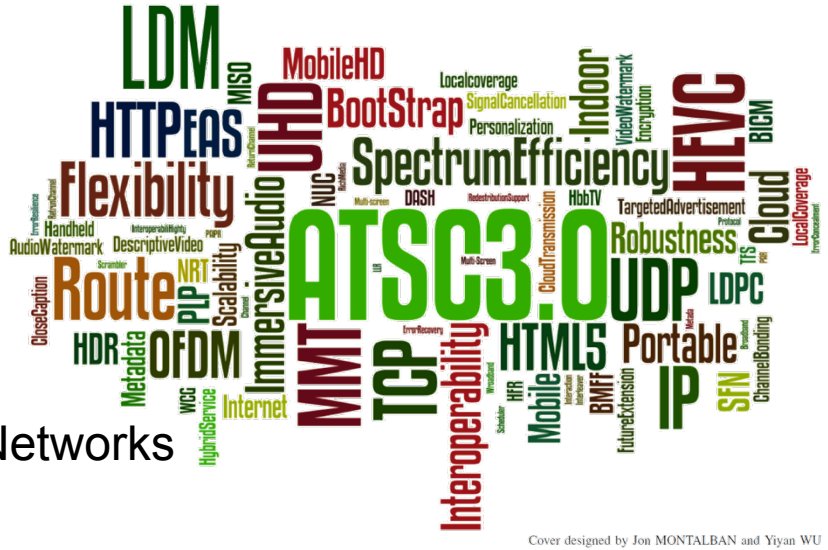
What are the Opportunities?

- Enhance the existing business of Broadcasting
  - A “Mobile First” Strategy
  - IP Transport
  - Targeted Advertising
  - Convergent Services
  - Better Video (e.g. UHD)
  - Immersive “3D” Audio
- Offload video traffic from Unicast Wireless Networks with Broadcast-Broadband convergence
  - In 2020, 75% of mobile traffic will be video
  - Broadcast offload pays off with 3 to 4 users per cell



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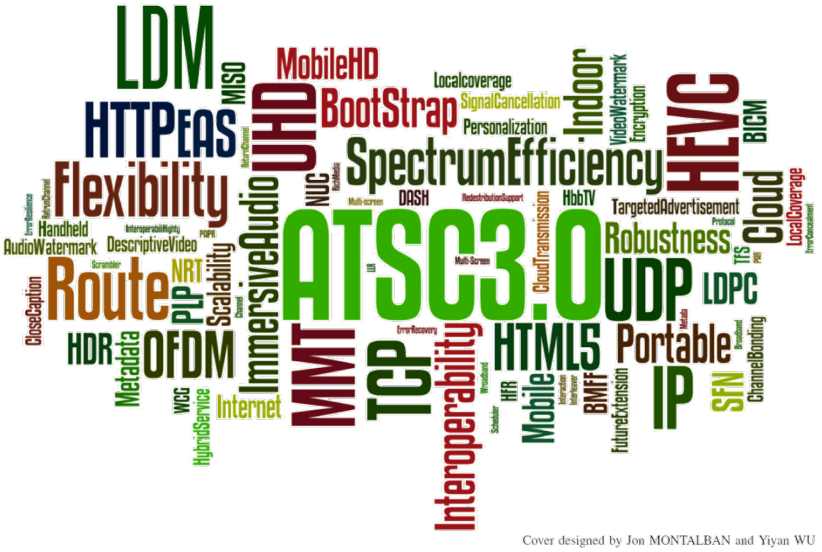
What are the Advantages?

- Native one-to-many broadcast / multicast delivery
- Licensed spectrum
- Ubiquitous coverage
- Transmission infrastructure already built-out and operating
- Resiliency including generators, engineers, backup systems are in place to support the broadcast television business model
- Backhaul, vertical real estate and other supporting systems also in place to support broadcast business model



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How do we get there?

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What Business Objectives, and How?

- Aggregate a broadcast spectrum, build a Nation Platform
- 3 Priority Business Models
  - Mobile TV
  - Hybrid Television
  - Automotive CDN
- All 3 demand a high level of automation, coordination and sophistication
- We envision and are bringing together the broadcast entities and assets that can drive the multi-Billion dollar spend to build a new business (SpectrumCo)
  - Beyond broadcast spectrum, two other primary alignments are being organized
    - NetworkCo and InfrastructureCo

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Sinclair Broadcast Consortium

- NetworkCo and InfrastructureCo
- These two entities and its participants are being developed
- They will bring together the final base for the capitalization required
  - NetworkCo - The architecting, design, development and deployment of the Network infrastructure
    - The “smarts” that drives optimum value from spectrum resources
    - Distribution of content and control
  - InfrastructureCo – The ‘big equipment’ needs of a national Build
    - The towers, antennae, transmitters and siting of the enabling RF infrastructure
    - Essential element that enables mobility, in-home reception, QoS delivery of bits

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Sinclair Broadcast Consortium (SpectrumCo)

- Industry consolidation brings extensive reach nationally for the purpose of exploiting the opportunities of ATSC 3.0
- 3 Priority Business Opportunities
  - Mobile TV
  - Hybrid Television
  - Automotive CDN
- Sinclair and Nexstar, represent 350 stations and 60+% U.S. (soon to be more) national reach
- We have recently announced the "… *establishment of a consortium that will promote spectrum aggregation, innovation and monetization and enhance their abilities to compete in the wireless data transmission sector*."
- Expect future "Big Player" additions

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Nexstar
MEDIA GROUP, INC.

For Immediate Release

NEWS ANNOUNCEMENT

NEXSTAR MEDIA GROUP AND SINCLAIR BROADCAST GROUP ESTABLISH CONSORTIUM TO PROMOTE BROADCAST SPECTRUM AGGREGATION, INNOVATION AND MONETIZATION

IRVING, Texas and BALTIMORE, Maryland – March 15, 2017 – Nexstar Media Group, Inc. (NASDAQ: NXST) ("Nexstar") and Sinclair Broadcast Group, Inc. (Nasdaq: SBGI) ("Sinclair"), (together referred to as "the Parties") announced today that they have entered into a memorandum of understanding regarding the establishment of a consortium that will promote spectrum aggregation, innovation and monetization and enhance their abilities to compete in the wireless data transmission sector. The consortium, which will be jointly owned and controlled equally by the founding Parties, has agreed to collaborate on a non-exclusive basis and the consortium is intent on exploring the inclusion of other television broadcasting entities. Nexstar and Sinclair are two of the largest and most diversified television broadcasting companies in the nation and collectively own and operate television stations reaching approximately 60% of the country.

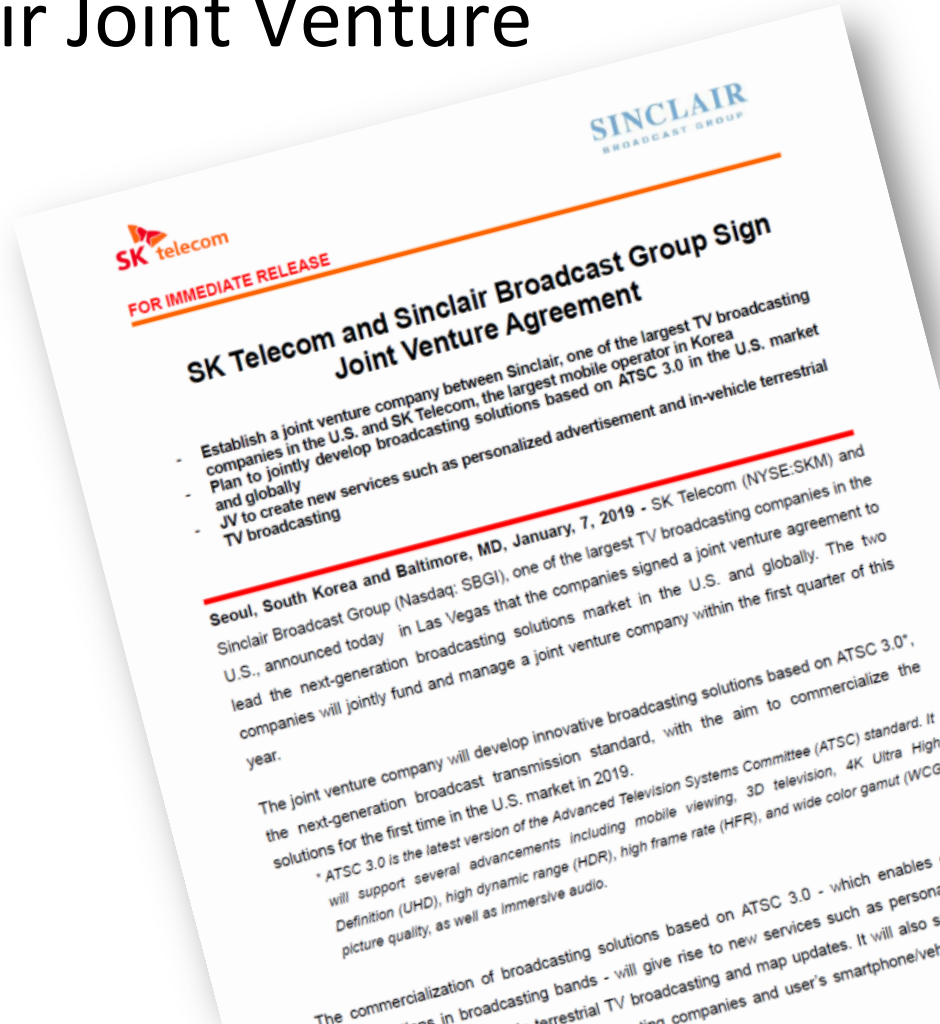
Unlike prior industry efforts which were based on flawed technology, this consortium has be established in anticipation of the adoption of the ATSC 3.0 "Next Generation" broadcast transmis standard and its proven capabilities. The consortium will promote innovation and develop and e products and services associated with ATSC 3.0 and monetization opportunities such as sp utilization, virtual MVPD platforms, multicast channels, automotive applications, single fr networks and wireless data applications, among others.

Upon adoption of ATSC 3.0, consumers will be able to integrate video content and data acro "smart" devices, to more effectively and efficiently address their information and entertai With the proper technology and data gathering methodologies, Nexstar and Sinclair ex significant and meaningful information relating to consumers' actual viewing and consum As a result, broadcasters will no longer have to rely on expensive third party measuren small sample sizes and unverified results. The value of this captured data across all and their users can be monetized several ways. For advertisers, it will provi with elevated addressability, personalization and accountability. encies in reaching and monetizing a significantly larger ad

Chief Executive Officer of Nexstar Medi has led the industry in advan laborative effort to 3.0, we can

SK Telecom Sinclair Joint Venture

- JV between Sinclair, one of the largest TV broadcasting companies in the U.S. and SK Telecom, the largest mobile operator in Korea
  - Jointly develop broadcasting solutions based on ATSC 3.0 in the U.S. market and globally
- JV to create new services such as personalized advertisement and in-vehicle terrestrial TV broadcasting
- Commercialization of broadcasting solutions
  - new services such as personalized advertisement
  - in-vehicle terrestrial TV broadcasting
  - map updates
- Develop two-way communication between Broadcasters and user's smartphone/vehicle/ TV



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SK telecom

FOR IMMEDIATE RELEASE

SK Telecom and Sinclair Broadcast Group Sign Joint Venture Agreement

- Establish a joint venture company between Sinclair, one of the largest TV broadcasting companies in the U.S. and SK Telecom, the largest mobile operator in Korea
- Plan to jointly develop broadcasting solutions based on ATSC 3.0 in the U.S. market and globally
- JV to create new services such as personalized advertisement and in-vehicle terrestrial TV broadcasting

Seoul, South Korea and Baltimore, MD, January. 7, 2019 - SK Telecom (NYSE:SKM) and Sinclair Broadcast Group (Nasdaq: SBGI), one of the largest TV broadcasting companies in the U.S., announced today in Las Vegas that the companies signed a joint venture agreement to lead the next-generation broadcasting solutions market in the U.S. and globally. The two companies will jointly fund and manage a joint venture company within the first quarter of this year.

The joint venture company will develop innovative broadcasting solutions based on ATSC 3.0*, the next-generation broadcast transmission standard, with the aim to commercialize the solutions for the first time in the U.S. market in 2019.

* *ATSC 3.0 is the latest version of the Advanced Television Systems Committee (ATSC) standard. It will support several advancements including mobile viewing, 3D television, 4K Ultra High Definition (UHD), high dynamic range (HDR), high frame rate (HFR), and wide color gamut (WCG) picture quality, as well as immersive audio.*

The commercialization of broadcasting solutions based on ATSC 3.0 - which enables
in broadcasting bands - will give rise to new services such as personal
terrestrial TV broadcasting and map updates. It will also
companies and user's smartphone/veh

SK Telecom, Harman, Sinclair MOU

- SK Telecom, Harman and Sinclair sign MoU
  - Develop and commercialize broadcasting network-based automotive platform in the U.S. and globally
- Advanced automotive platform with ATSC 3.0-based broadcasting solutions
  - Provide terrestrial TV broadcasting, HD map updates, V2X, etc.
- The three companies will seek business opportunities in the global market for connected cars
  - In-vehicle HD terrestrial TV broadcasting
  - Secure firmware updates
  - HD map updates
  - V2X certificate management via terrestrial digital broadcasting facilities

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SK telecom

SK Telecom, Harman and Sinclair Broadcast Group Sign MOU

- SK Telecom, Harman and Sinclair sign an MoU to jointly develop and commercialize broadcasting network-based automotive platform in the U.S. and globally
- The advanced automotive platform will be applied with ATSC 3.0-based broadcasting solutions to provide terrestrial TV broadcasting, HD map updates, V2X, etc.
- The three companies will seek business opportunities in the global market for connected cars

Las Vegas, NV - January 9, 2019 - SK Telecom (NYSE:SKM) and Sinclair Broadcast Group (Nasdaq: SBGI) today announced that they signed a Memorandum of Understanding (MoU) with Harman at the '2019 CES' in Las Vegas to jointly develop and commercialize digital broadcasting network-based automotive electronics technology for global markets.

Under the MOU, the companies will collaborate to build an advanced automotive platform based on ATSC 3.0, the next-generation broadcasting technology standard, to enable drivers to experience in-vehicle HD terrestrial TV broadcasting, secure firmware updates, HD map updates and V2X certificate management via terrestrial digital broadcasting facilities operated by Sinclair Broadcast Group throughout the United States. The technology will also b deployed in other geographies as local broadcast facilities become available.

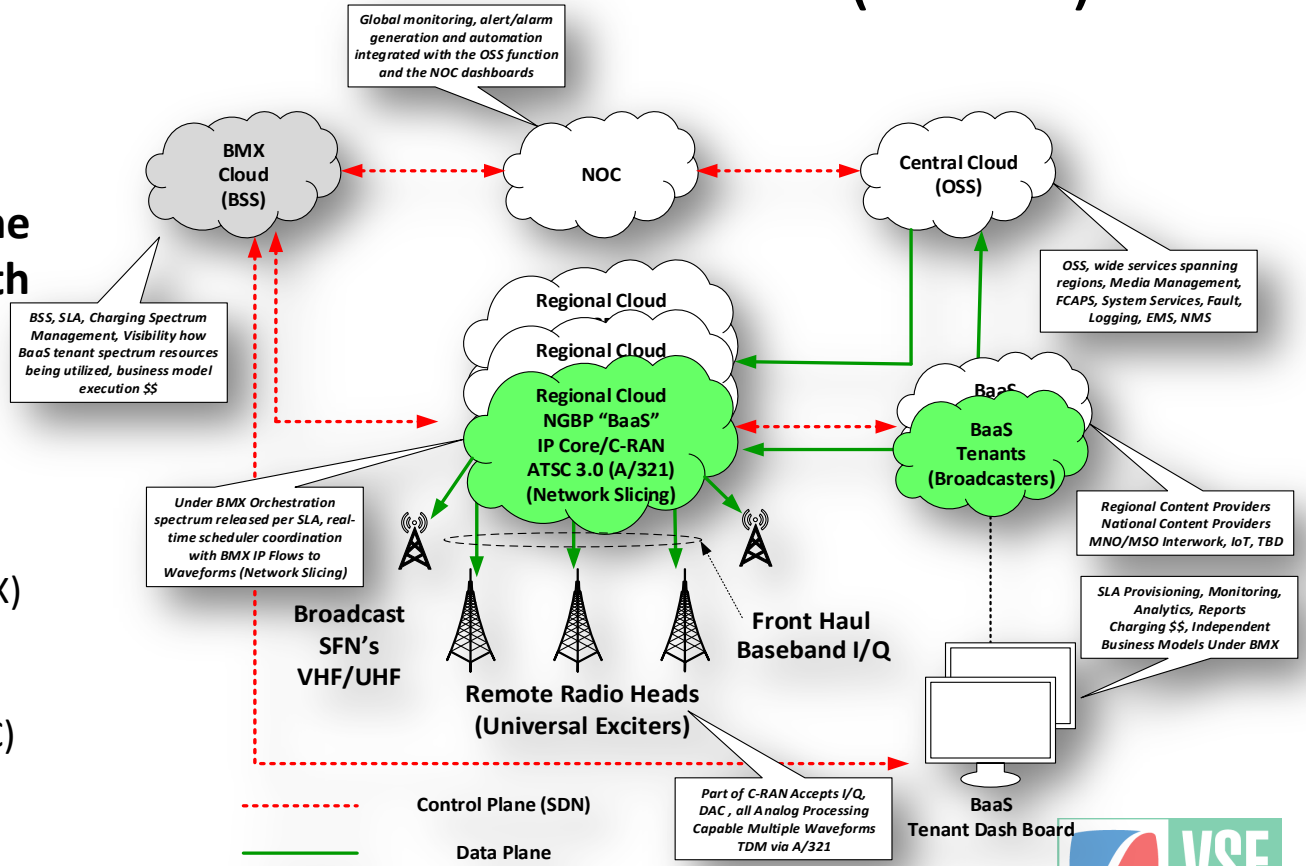
The three companies will work together to provide market leading technology and grow ma share in U.S. Market. The companies also plan to seek joint business opportunities in global automotive market.

panies intend to unveil their automotive platform and related equipment and 2019 National Association of Broadcasters Show (NAB Sh ibition hosted in Las Vegas in April 2019.

Next Generation Broadcast Platform (NGBP)

High level view of a new broadcast system architecture representing the Sinclair vision of a NGBP with six major 'high-level' entities:

- Regional Data-Centers (IP Flows / Baseband Waveforms)
- Remote Radio Heads (RRH)
- Broadcast Market Exchange (BMX) Cloud w/BSS
- Central Private Cloud (w/OSS)
- Network Operations Center (NOC)
- BaaS Tenant Dash Board



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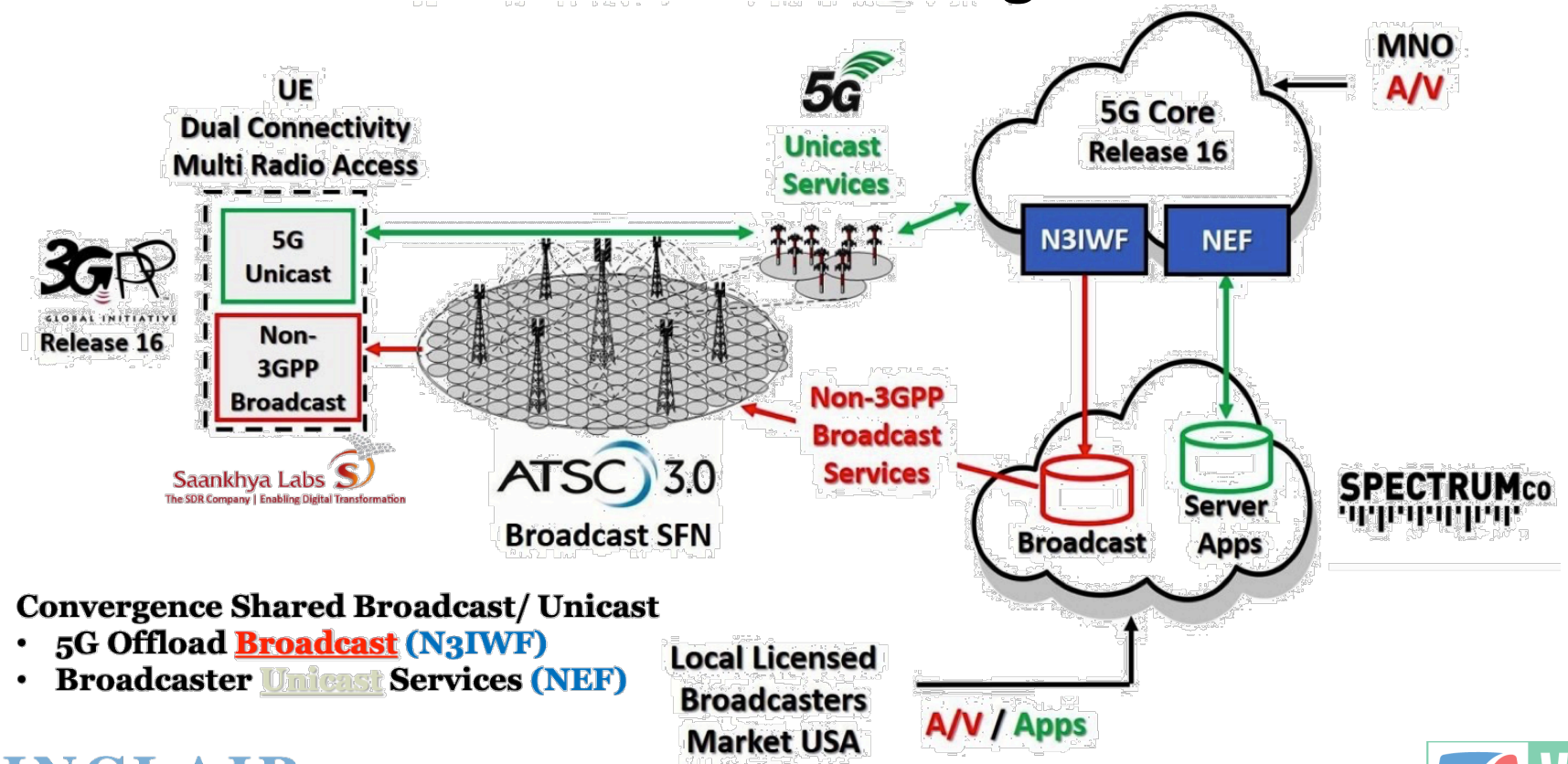
5G Broadcast Convergence



Convergence Shared Broadcast/ Unicast

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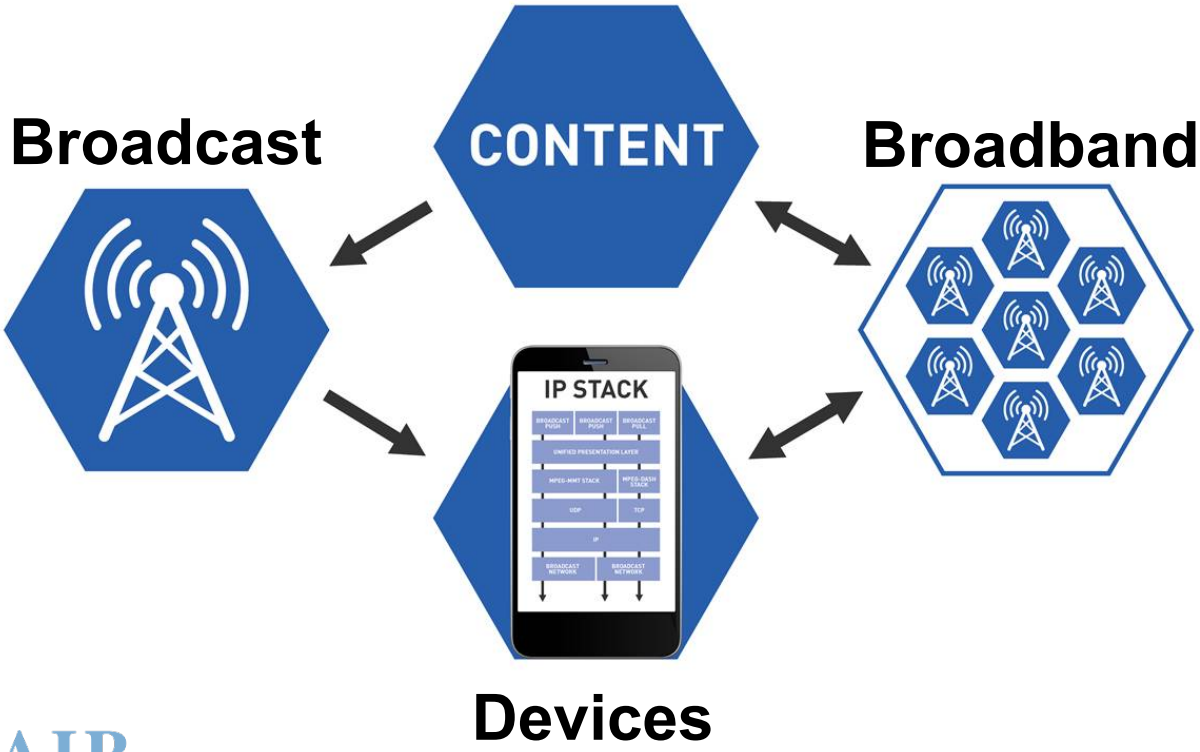
Convergence



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