ATSC Planning Team Report: ATSC 3.0 and Global Convergence

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ATSC 3.0 and Global Convergence

1. SCOPE

Much has been said of the current threats to broadcasting. There is pressure on RF spectrum worldwide and the amount of spectrum allocated to broadcast has been reduced in many countries. As well, data networks capable of delivering video and video-related services are deployed widely. However, broadcasting has many strengths, some of which are unique.

The purpose of this paper is to encourage an exploration of broadcasting strengths and of ways in which those strengths can be harnessed to advance the broadcast industry. In particular, this paper presents the case that the broadcast industry, building on its unique strengths, exploiting its new and advanced technologies, and advancing global convergence can counter threats and advance as an industry globally.

From there, the paper describes ATSC 3.0. This is done to provide a starting point for discussions on convergence. One of the newest technologies in the broadcasting space, it has many features that can provide a basis and opportunity for beneficial convergence.

2. EXECUTIVE SUMMARY

The broadcast environment has changed dramatically in recent years. There are a number of challenges facing the broadcast ecosystem, including but not limited to spectrum reduction, the emergence of global data networks capable of carrying video services, and the emergence of a heterogeneous data delivery network ecosystem.

Historically, broadcasting technologies have advanced intermittently, sometimes at long intervals. This no longer is the case. In recent years, broadcast technologies have been advancing at a pace comparable to that in industries commonly thought to be at the forefront of technological advances, such as wireless and broadband. What is missing is the efficiencies of the global convergence in wireless and broadband technologies.

Decisions in past World Radiocommunications Conference (WRC) meetings have resulted in spectrum reduction for broadcasting. WRC 2023 (WRC23) may yield similar results in some regions. The worldwide adoption of Internet Protocol (IP) services and the resulting proliferation of video streaming has made practically any “data” service into a “video” service. There is also evidence of the increasing importance of a heterogeneous network of inter-working data delivery systems, in which the best network is dynamically selected for a given data session at a given time, such as the seamless use of Wi-Fi and cellular systems in smartphones.

Amid these changes, broadcasters worldwide share a common underlying dynamic. The use of the “public airwaves” must provide some demonstrable public benefit in exchange for licensed access to spectrum. Broadcasters have historically been a central member of local communities. Relationships with government, education, enterprise, and other community organizations puts them in a special place regarding how local communities learn about, discuss, and resolve issues impacting their communities.

In addition, broadcasters share a common infrastructure design, largely anchored by high power, high tower (HPHT) transmission facilities. This infrastructure is often among the most resilient, designed to withstand natural disasters so that information can be transmitted when it is most needed. During a disaster, both power and connectivity need to be maintained. Compared to a cellular network of densely packed, lower towers, HPHT networks have fewer towers, making it more practical to harden the towers against disaster. Typical HPHT sites have back-up power generation, and microwave links are often the data connection source. With back-up power and essentially a fully wireless transmission system from studio to tower to home receiver, the HPHT structures are built for resiliency.

This HPHT design, and indeed broadcasting in general, is also a highly sustainable way to deliver large amounts of data to many receivers. With the ever-increasing need for data in our digital world, broadcasting can play an important role as people seek to reduce energy consumption in all aspects of industry. To illustrate this point, a recent study showed that "…(T)he energy consumption and associated emissions of DTT (Digital Terrestrial TV) are an order of magnitude lower than estimates for OTT and managed IPTV."[1]

Recognizing the importance of energy conservation, DVB has announced the launch of a new study mission focused on "Energy-aware service delivery and consumption."[2] The study mission will initially examine the potential for energy saving in delivery networks and home networks, later looking at potential savings in the receiver devices.

Despite these commonalities of purpose, there are multiple incompatible regional Digital Terrestrial Television (DTT) systems. This fragmentation hinders broadcasters' ability to address the changing environment as a unified group. Meanwhile, global (non-regional) data delivery standards have proven to be very successful (Wi-Fi, LTE/5G, Bluetooth, etc.).

Regional broadcast systems face meaningful challenges in the global landscape. ATSC believes that global DTT convergence is a valuable and attainable goal and will seek and respond to opportunities for convergence. We encourage broadcasters worldwide to look for areas to work together, converge technologies where feasible, and support one another.

3. HISTORICAL CONTEXT

The practice of separate silos of broadcast standards leads to fragmentation of the broadcast story and its importance in the global economy.

3.1 Existing DTT Systems

Broadcast systems have been evolving to more advanced technology, as shown in Figure 1. However, this is evolution has not resulted in a converged broadcast system. There has been subsystem-level convergence through deliberate design and through natural evolution to better technologies, e.g., in video and channel coding, but system-level convergence has been elusive due to differences in established technology and infrastructure, as well as in timeframe for transition.

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[1] Quantitative Study of the GHG Emissions of Delivering TV Content, Carnstone/The LoCAT Project, Final Report, v1.1, September 2021, https://thelocatproject.org/wp-content/uploads/2021/11/LoCaT-Final_Report-v1.2-Annex-B.pdf

[2] https://dvb.org/news/dvb-to-investigate-three-new-potential-work-areas/

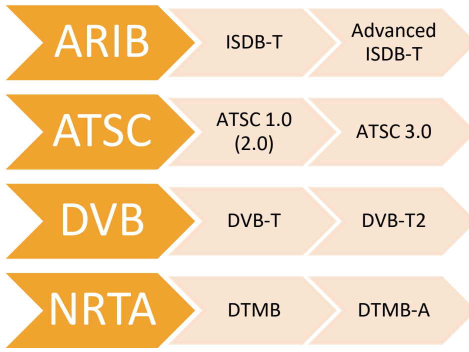

Figure 1 The evolution of digital broadcast standards.

In addition to the four systems illustrated above, enTV (feMBMS) is being proposed as a fifth DTT system designed by the Third Generation Partnership Project (3GPP). While enTV is an LTE-based technology 5G broadcast technology will no doubt continue to evolve in future releases and play a role in the evolving broadcast infrastructure associated with telco standards.

The essence of broadcasting is a one-to-many value proposition—the broadcast signal is transmitted once and consumed by many. There is no need for the additional infrastructure or bandwidth needed to support unicast service delivery. In consequence, the broadcast model supports the lowest cost per unit of information per viewer. When combined with Internet delivery in a hybrid scenario, as is the case in modern systems, it can offer the best of the broadcast and unicast worlds.

3.2 Efforts Towards Convergence

The effort to forge a next-generation broadcast standard that encompasses all the major standards development organizations (SDOs) dates back over 10 years. The initial *Future of Broadcast Television* (*FOBTV*) *Summit* was held on November 10 and 11, 2011, in Shanghai, China. Hosted by the National Engineering Research Center of Digital Television (NERCDTV), the event brought together representatives from around the globe to discuss emerging broadcast technologies. The initial goal of FOBTV to foster work on a best-of-the-best next-generation television system has not been realized to date, but since its formation the group has served as a forum for communication and exploration of new technologies and ongoing efforts underway within the various SDOs.

International convergence is being explored across the globe in the context of several projects, a selection of which is summarized below.

- Canada
  - 2019 Humber College initiated standing up a front-facing industry ATSC 3.0 research lab
  - 2021 Humber College awarded a federal government grant to develop Canada's first Broadcast-Broadband Convergence B2C Lab to explore multisectoral applications of the ATSC 3.0 standard including research into ATSC 3.0 / 5G convergence
- Europe
  - 2017-2019 European Union conducted the 5G PPP X-Cast project
  - 2019 Demonstrations of FeMBMS

- China
  - 2019 National Broadcaster granted a 5G carrier license using 700 MHz band to deploy 5G while maintaining broadcast TV services
- United States
  - 2020 ATSC initiated work on a Broadcast Core Network that could interface with a 5G Core Network
  - 2021 ATSC initiated a report describing various ATSC 3.0 / 5G convergence technical architectures
- India
  - 2018 TSDSI published a white paper on broadcast traffic offload (from a cellular network to a broadcast network)
- South Korea
  - Demonstrated seamless switching between 4G/LTE and ATSC 3.0 in a field trial
  - Engaged in ATSC 3.0 / 5G convergence project

Brazil has launched a project to implement a new next-generation television system called "TV3.0". The Brazil SBTVD Forum has selected system elements for TV3.0 from among a group of proposed systems, and it appears that Brazil will select elements of various systems, essentially creating a new converged DTT system that could inform global convergence efforts going forward.

4. BENEFITS OF CONVERGENCE

Global DTT convergence can inspire broadcasters worldwide to develop a common voice on international issues affecting the community. Convergence can also be a catalyst for broadcasting to become among the technologies utilized in a heterogeneous data network ecosystem. Commonalities can also foster economies of scale in developing both professional and consumer devices and solutions.

To avoid losing additional spectrum, broadcasters must work together to increase and demonstrate the economic value and global importance of broadcasting. WRC23 is certain to be a forum for continued discussions around reallocating broadcast spectrum to other services. Involvement in this process is critical for the future of broadcasting. A global approach to modernizing broadcast technologies and capabilities can galvanize broadcasters into developing a single voice on the world stage.

Digital terrestrial television (DTT) broadcasters are operating in a global ecosystem of data delivery networks. Data session steering, switching, and sharing across heterogeneous networks can improve spectrum usage efficiency by using the most appropriate network(s) for each given data session in a dynamic fashion. Indeed, 3GPP envisions a 5G ecosystem of heterogeneous global data networks. Next-generation DTT systems are the most efficient physical layers for one-to-many data delivery in the world—for TV and non-TV uses, and for fixed and mobile uses. This technology edge can be leveraged for convergence with other data delivery networks, e.g., the Internet and LTE/5G, but fragmentation creates a fundamental barrier to including DTT in this heterogeneous ecosystem. As a means of more than just survival, the more exciting potential for this segment is to integrate the next generation digital transmission technologies into the generalized convergence. Convergence among the major DTT technologies would facilitate convergence with other networks (and may be necessary for long-term success).

Broadcasting offers specific technical and operational capabilities combined with a special community positioning. This represents a unique opportunity to refresh and reinvent local relationships to better understand, collaborate, and initiate local change via the development of a new community centric framework of objectives, relationships, capabilities, policies, and best practices that could foster a shared, local-centric, digital commons.

5. ATSC 3.0 – AN OVERVIEW

ATSC 3.0 was conceived as an international broadcast standard that can be easily adopted by many countries/regions and designed to converge with international data transmission systems such as the Internet and 4G/5G, enabling the free flow of content and applications across platforms. It was architected not only to evolve, but also to have maximum commonality and potential for convergence with other media and data delivery platforms.

In order to provide context for suggested specific recommendations for convergence initiatives, ATSC offers the following overview of ATSC 3.0 technologies, and Table 1 below lists the standards in the ATSC 3.0 suite.

- Physical Layer – The physical layer is flexible, configurable, and highly efficient.
- Transport – The decision to build ATSC 3.0 around an IP core opened the door to many new applications and use cases. The IP-based protocol can be delivered via MMTP and ROUTE/DASH.
- Video – HEVC H.265 codec, coupled with HDR, Wide Color Gamut (WCG), High Frame Rate (HFR), and Scalable HEVC Video Coding (SHVC). (ATSC is currently specifying Versatile Video Coding (VVC) for inclusion in the ATSC 3.0 suite of standards.)
- Audio – Immersive audio and personalization are available through the use of the Dolby AC-4 and MPEG-H Audio systems.
- Apps – Web-based interactivity is based on HTML5, CSS, JavaScript, and Websocket APIs. ATSC made a choice early on to align whenever possible with existing standards that are widely deployed and extensible.
- Accessibility – New capabilities for visually and hearing-impaired are an integral component of ATSC 3.0.
- Advanced Emergency Messaging – ATSC 3.0 offers a rich set of media capabilities for emergency messaging and information, including a receiver “wake-up” function.
- Datacasting – The IP foundation enables broadcasters to deliver data to Internet-of-Things (IoT) devices, including cars, agriculture, signage, smart cities, etc.

Table 1 Documents Comprising the ATSC 3.0 Standard

Document	Name
A/300:2022-04	ATSC 3.0 System
A/321:2022-03	System Discovery and Signaling
A/322:2022-11	Physical Layer Protocol
A/323:2022-03	Dedicated Return Channel for ATSC 3.0
A/324:2022-06	Scheduler / Studio to Transmitter Link
A/330:2022-03	Link-Layer Protocol
A/331:2022-11	Signaling, Delivery, Synchronization and Error Protection
A/332:2022-03	Service Announcement
A/333:2022-03	Service Usage Reporting
A/334:2022-03	Audio Watermark Emission
A/335:2022-03	Video Watermark Emission

A/336:2022-03	Content Recovery in Redistribution Scenarios
A/337:2022-03	Application Event Delivery
A/338:2022-03	Companion Device
A/341:2022-09	Video – HEVC
A/342:2022-03 Part 1	Audio Common Elements
A/342:2022-03 Part 2	AC-4 System
A/342:2022-03 Part 3	MPEG-H System
A/343:2022-03	Captions and Subtitles
A/344:2022-03	ATSC 3.0 Interactive Content
A/360:2022-011	ATSC 3.0 Security and Service Protection

5.1 ATSC 3.0 – New Work Items

In addition to the existing, published standards ATSC has a structured process for beginning new work in order to manage the evolution of standards. New work items underway in various DTT SDOs can present good opportunities for convergence.

5.1.1 Broadcast Core Network

After considerable study within ATSC Planning Team 8 (PT-8), "Core Network Technologies for Broadcast," ATSC launched a project to specify a Broadcast Core Network (BCN) that is agnostic to the DTT system. BCN is being designed for standalone, broadcast-only operation and/or for converged operation with other data delivery networks, e.g., 802.11, 5G, LTE, 3G, SMPTE 2110, CBRS, Satellite (LEO-MEO-GEO), LoRA, IoT, etc. BCN will accommodate cases where an uplink is always available, never available, or sometimes available. The goal of the BCN is to enable broadcasters to offer regional data delivery services, such as software updates to game consoles, recall updates to managed automobile fleets, and more. Among these use cases is redundant or enhanced GPS signaling (eGPS). Demonstrations of this capability indicated that GPS accuracy could improve from +/– one meter to +/– 2–3 centimeters.[3]

Work is underway at this writing in the Specialist Group on ATSC 3.0 Broadcast Core Network (TG3/S43) to define a system that will enable current and future use cases (e.g., datacasting) efficiently at scale across a collection of broadcast facilities. This work is focused on submissions in response to a Request for Proposals issued by ATSC in November 2021.

Figure 2 illustrates the concept of a Broadcast Data Network in the U.S. covering all significant markets with defined coverage and quality-of-service (QoS) according to wireless industry norms. This system has an evolvable virtual network core, and uses the same protocols, APIs, devices, and device stacks everywhere. In this illustration, it is envisioned that all major arteries would be serviced (blue dots) as well as traditional television broadcast areas (green dots) in order to facilitate data services to vehicles.

[3] https://www.atsc.org/news/nextgen-tv-bitpath-cast-era-and-one-media-demo-enhanced-gps/

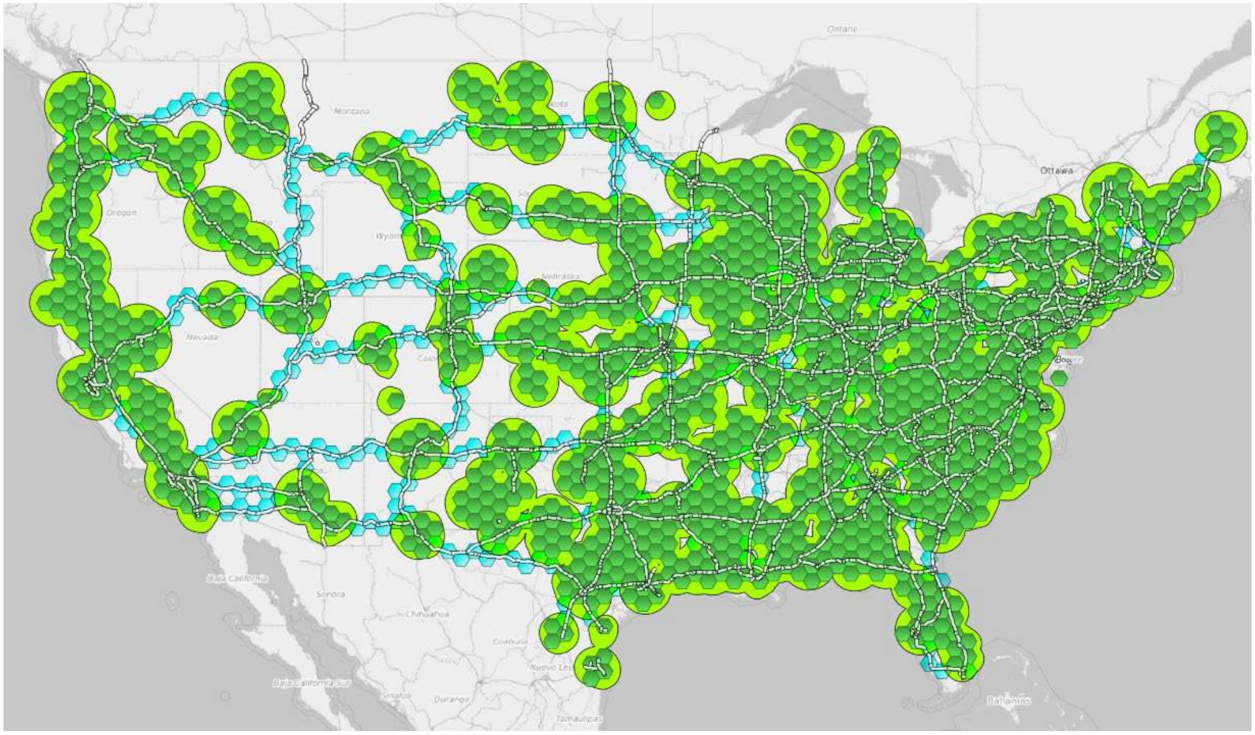

Figure 2 Concept of a Broadcast Core Network.

5.1.2 Inter-Tower Communications Network

A unique method of communications between and among broadcast facilities provides another potential opportunity for convergence across DTT systems. The ATSC IT-5, "Tower Network Implementation Team," has embarked on a project to design an inter-tower communications network (ITCN) that would enable both one-way and two-way communications among broadcast towers. Recently introduced into ITU-R, there is growing international interest in adopting ITCN technology to various DTT systems.

The goal of IT-5 is to design, implement, test, validate, and demonstrate the Inter-Tower Communications Network (ITCN) and In-band Distribution Link (IDL). IDL is a one-way distribution system that will provide the program feed to SFN towers similar to Studio to Transmitter Link (STL) systems. It is a special case (unidirectional) within ITCN for SFN signal distribution. The ITCN may additionally distribute Broadcast Internet data. In-band full-duplex technology may be used on a portion of the broadcast spectrum to distribute TV programs and data, potentially unrelated to video content, where the transmission and reception occur simultaneously on the same RF band. ITCN is designed to link all broadcast towers to form a Tower Communications Network (cluster) for control, monitoring, data communication, and localized datacast and broadcast services. The systems developed may utilize Artificial Intelligence (AI) to monitor, configure, and direct process flow, bandwidth requirements, and diversity schemes for ITCN and IDL along with other available technologies to enhance the overall capabilities and to allow for future growth. Channel sharing and bonding may be considered as well.

Figure 3 illustrates in-band two-way communications between towers. Broadcast service to fixed/handheld/mobile receivers is characterized by low receive antenna height and corresponding limited coverage area due to terrain and structure blockage. This use case can be addressed effectively by an SFN. With the typically high elevation of broadcast towers, direct tower-to-tower communication is possible. Such line-of-sight paths and professional grade transmitters and receivers will optimize efficiency and minimize bandwidth needed for inter-tower data transmission.

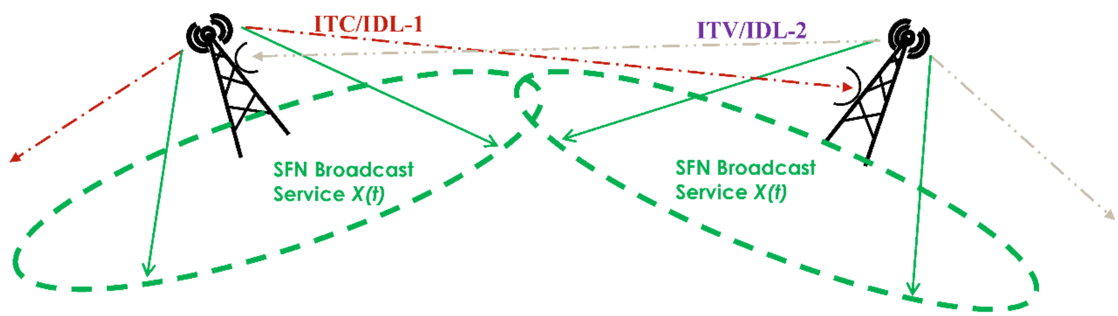

Figure 3 In-band two-way communications between towers.

The ITCN data paths can be extremely efficient, taking advantage of line-of-sight pathways between towers. Additionally, professional grade transmitters and receivers can be deployed that utilize technologies such as multiple-input multiple-output (MIMO), which may not be feasible in consumer receivers yet, but can be incorporated into professional-grade solutions.

5.1.3 Commonalities in Application Layers

Many DTT systems already have several technologies in common, e.g., audio, video, captions, and interactivity, and as newer systems are developed, DTT SDOs engage in parallel efforts. For example, MPEG systems such as video and audio codecs, can be found in many DTT standards. ATSC is currently specifying VVC for ATSC 3.0, while the DVB Project has already completed work on VVC for DVB-T2. Similarly, the DASH Industry Forum completed work on Common Media Application Format (CMAF). ATSC and other SDOs are working to incorporate it into the upper layers of their respective systems. The ATSC 3.0 watermarking standards for audio and video enable discovery, launch, and synchronization of advanced TV features for services distributed across heterogeneous video distribution paths. These standards have been adopted by DVB for the HbbTV interactivity platform[4] and targeted advertising[5] and have been placed on the 2023 roadmap of the Internet Advertising Bureau (IAB) for potential inclusion in future digital video advertising standards[6].

6. RECOMMENDATIONS

The possibility of a fully, globally converged next-generation broadcast system may not be feasible, as installed infrastructure and consumer receivers cannot easily be replaced wholesale. However, there exists the chance to converge and cooperate where various standards intersect or overlap. This section offers suggestions for technical convergence opportunities and describes arenas that can foster discussion among broadcasters worldwide.

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[4] https://www.etsi.org/deliver/etsi_ts/103400_103499/103464/01.02.01_60/ts_103464v010201p.pdf

[5] https://dvb.org/wp-content/uploads/2020/12/A178-1r1_Dynamic-substitution-of-content-in-linear-broadcast_Part1_Signalling_Draft-TS-103-752-1v121_Feb-2021.pdf

[6] https://iabtechlab.com/press-releases/iab-tech-lab-unveils-advanced-tv-roadmap/

6.1 Develop a Common Foundation

One of the challenges is that many (maybe most) nations or regions require a specific set of capabilities, which necessitates differing standards—although perhaps just *slightly* different. International cooperation could build a framework that countries and/or regions can independently build upon. Multiple versions of the standard could all be included under a singular label.

Examples of adapting a basic standard can be seen with DVB-T2, ISDB-T, and ATSC 3.0 implementations in which each country or region may deploy slightly different versions of the core standard. These templates illustrate an effective way to address regional differences, while at the same time maintaining a common technology foundation. Regional differences can effectively be handled by local organizations, which can survey and discuss the current and future technology landscape from various perspectives relevant to the local region.

6.2 Develop Common Abstraction Layers between DTT and Other Systems

While certain areas of DTT standards may necessarily differ, DTT technologies could present a common face to other data delivery systems in a heterogeneous ecosystem. One or more "abstraction layers" could be developed that lie between a global data delivery network (e.g., Wi-Fi) and the major DTT data delivery networks. In this way, developers of the global data delivery network need only concern themselves with the abstraction layer technologies, which would then interface with the DTT networks. The Broadcast Core Network and DVB-I may be good candidates for this concept.

6.3 IP Data Delivery as a Common Point

The concept of IP-based broadcasting as a "platform" is powerful, and it accurately describes the capabilities of these next generation broadcasting systems. The Internet Protocol (IP) foundation of Advanced ISDB-T, DVB-NIP, DVB-I, ATSC 3.0, and DTMB-A provides an opportunity to work toward a unified global broadcast approach that shares common ground among regional systems.

6.4 Improving Energy Efficiency

The importance of reducing the energy footprint of all industries is well known. DTT SDOs could work together to develop methods of measuring and improving sustainable DTT operations. Due to the broad scope of industries that comprise the DTT system, from production to transmission to receivers, participation among all affected SDO is critical to success.

6.5 Areas of Potential Cooperation within ATSC 3.0

ATSC 3.0 is designed to easily interoperate with other IP data delivery networks as a fundamental feature. The broad feature set of ATSC 3.0 offers the opportunity for convergence across DTT systems in multiple areas.

Physical Layer – The bootstrap signal enables robust reception and evolvability and also signals fundamental characteristics of the broadcast so that receivers do not need to be pre-coded with this information. With the proper registry for the bootstrap signaling, it is possible for non-ATSC systems to co-exist in the same RF channel. This can be seen almost like an "app store" where the broader community can develop and deploy technology.

Transport Layer– IP-based transport (MMTP, ROUTE/DASH) creates a natural point of convergence with other IP data networks. Features include flexible, extendable signaling structures and security for signaling tables and application files.

Applications/Presentation Layer – Capabilities include HEVC/SHVC, Dolby AC4, MPEG-H Audio, and IMSC1 captions to name just a few. In addition, the system allows new codecs to be added. W3C-based interactivity and common encryption based digital rights management (DRM) leverage the huge developmental efforts of the web. Many of these technologies are common among multiple DTT standards as well as non-DTT data network technologies, and the ATSC 3.0 platform is extendable to incorporate other codecs and security systems. For example, ATSC is currently developing specifications for CMAF and VVC and is constantly adding new APIs for the interactivity system.

Broadcast Core Network – Currently under development, the Broadcast Core Network (BCN) is envisioned as agnostic to radio-access-technology. For example, in a scenario where one-to-many traffic is congesting a unicast network, the BCN could orchestrate broadcast traffic offload to any DTT system capable of delivering the data.

Inter-tower Communications Network – The ITCN holds great promise to, at minimum, reshape the architecture of SFN signal distribution. The concepts embodied by the ITCN potentially apply to any broadcast network.

6.6 Focus on New Work Items

It is often the case that the best time for adaptation is before work is underway. DTT SDOs can share plans for new work items and discuss desired use cases and collective approaches that would result in converged outcomes. For example, if a new video codec is developed, the various DTT SDOs could work together to form a common foundation of specifications.

6.7 Establish a Global Discussion Forum

In order to make progress on any item suggested in this paper, a forum for openly discussing options and next steps will be required.

6.7.1 ATSC Planning Team 6 on Global Recognition of ATSC 3.0 (PT-6)

PT-6, ATSC's Planning Team on Global Recognition of ATSC 3.0, has been working to consider and recommend specific action items for encouraging global recognition of ATSC 3.0 as one of the leading international DTT standards. The focus of this work includes strategic communications with other SDOs, new work item proposals for technical enhancements to the ATSC 3.0 standard suite that support global use cases, and strategic presence at international tradeshows and conferences. In addition, PT-6 considers how to best utilize the resources of ATSC and its members, and how to best leverage other organizations' expertise to promote DTT. This group is a natural forum for discussions about global convergence among DTT systems. ATSC welcomes information about similar groups within other DTT SDOs.

6.7.2 FOBTV

FOBTV has a global membership and has the infrastructure in place to support discussions. Further, FOBTV has proposed forming an Ad-hoc Group of global members to discuss 5G and future 3GPP standards and to start research on a new generation of broadcast and multicast technologies. This project is pending, with comments requested from FOBTV members. The proposal suggests:

- Research on a collaborative improvement plan for existing mobile systems.
- Research on simulcast and "collaborative cast" between mobile networks and terrestrial broadcast, focused on cooperation towards WRC23.

- Explore other options that could extend the current broadcast standards to facilitate the convergence of broadcast and broadband.
- Development of an FOBTV Research Report on new multicast and broadcast technologies.

7. SUMMARY COMMENTS

This paper makes the case for global convergence among next-generation broadcast standards. ATSC believes that the opportunity exists for harmonization of elements of systems already deployed, and those currently under development, and that harmonization will open new opportunities for broadcasting worldwide. With the advent of new broadcasting technologies, erosion of spectrum, and even the complete shut-down of HPHT infrastructure in some regions, we also believe that the window of opportunity is limited. We encourage broadcasters worldwide to take steps forward together to ensure a bright future for our industry and our communities.

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