ATSC Planning Team 5 Report: Automotive/Vehicular Use Cases

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Advanced Television Systems Committee
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1. EXECUTIVE SUMMARY

Today's automobiles consume large amounts of data, from map updates to SW/FW updates to emergency messages to entertainment. ATSC 3.0 is a wireless, high capacity, nationwide, IP data pipe that can cost-effectively deliver large data files and live media to an unlimited number of vehicles simultaneously. Additionally, ATSC 3.0 carries precision time and GPS information, offering network redundancy for this vital information.

As a one-to-many downlink distribution system, ATSC 3.0 can operate independently, as a robust downlink-only data feed, or in concert with a separate two-way network, such as LTE/5G, Bluetooth, Wi-Fi or similar. It is optimally suited for use cases in which a downlink data payload size is large, and an uplink payload size is either small or not needed. Offloading data downlink traffic from a two-way network to ATSC 3.0 can be a compelling use case due to the efficiency of broadcast and the highly resilient broadcast infrastructure, offering a cost-effective solution with a high level of service quality.

This paper explores several such uses cases of relevance to the automotive industry. It further addresses questions about implementation, serving as a FAQ resource for the broadcast and automotive industries.

1.1 Organization

This document is organized as follows:

- Section 1 – Outlines the scope of this document and provides a general introduction.
- Section 2 – Lists references and applicable documents.
- Section 3 – Provides a definition of terms, acronyms, and abbreviations for this document.
- Section 4 – Examination of use cases and capabilities.

2. REFERENCES

All referenced documents are subject to revision. Users of this Planning Team Report are cautioned that newer editions might or might not be compatible.

2.1 Informative References

The following documents contain information that may be helpful in understanding this report.

[1] IEEE: "Use of the International Systems of Units (SI): The Modern Metric System," Doc. SI 10, Institute of Electrical and Electronics Engineers, New York, N.Y.

[2] NextGenTV-Host-Station-Manual-V4, https://1u0n985e0z8o21202f17hkdm-wpengine.netdna-ssl.com/wp-content/uploads/2021/01/NextGenTV-Host-Station-Manual-Version-10-.pdf

[3] Luplow, W: 'First Field Testing of ATSC 3.0 Physical Layer ICs', *Broadcast Technology*, 2nd quarter, pp. 54–60, 2018.

3. DEFINITION OF TERMS

With respect to definition of terms, abbreviations, and units, the practice of the Institute of Electrical and Electronics Engineers (IEEE) as outlined in the Institute's published standards [1].

shall be used. Where an abbreviation is not covered by IEEE practice or industry practice differs from IEEE practice, the abbreviation in question will be described in Section 3.3 of this document.

3.1 Treatment of Syntactic Elements

This document contains symbolic references to syntactic elements used in the audio, video, and transport coding subsystems. These references are typographically distinguished by the use of a different font (e.g., restricted), may contain the underscore character (e.g., sequence_end_code) and may consist of character strings that are not English words (e.g., dynrng).

3.2 Acronyms and Abbreviations

The following acronyms and abbreviations are used within this document.

ATSC – Advanced Television Systems Committee
LDPC – low density parity check
QPSK – quadrature phase shift keying
HEVC – high efficiency video coding
AWGN – additive white Gaussian noise
SNR – signal-to-noise ration
VHF TV – channels 2 through 13
UHF TV – channels 14 and above

4. USE CASES AND CAPABILITIES

4.1 Infotainment

Delivery of audio / video streams to vehicles requires a robust physical layer configuration to account for the highly dynamic nature of the channel. The RF channel is very noisy and can cause a multitude of factors for receiving devices to overcome. It requires a certain amount of received energy to combat these interference factors, so a robust Physical Layer Pipe (PLP) that protects the information payload is required.

How robust does the physical layer need to be?

Each market is different, some are urban canyons, some are rural settings, others include a variety of factors to overcome. ATSC 3.0 offers a wide selection of options to accommodate the most demanding channel conditions. For automotive, 8K and 16K FFT sizes along with QPSK or 16QAM modulation is recommended. Within those modulations, high protection of bits is offered with low code rates of Type A LDPC encoding, which range from 2/15 to 7/15 for codelength of 64800 bits. How much capacity is available depends on the physical layer configuration.

An example of 7/15 code rate with 16QAM can provide around 10 Mbit/sec, if the entire channel is dedicated to that one Quality of Service (QoS) configuration. If simulcasting of stationary service is desired, then a Multiple PLP (MPLP) configuration is needed and an example configuration of that is provided below which shows around 3 Mbit/sec capacity for the robust PLP. Broadcasters are likely looking to add automotive support to their lineup, not dedicate their entire channel to automotive.

How efficient have HEVC video encoders become?

Video encoders have become more efficient over time. What looks like good video is entirely subjective. Currently a 1080p resolution at 60 frames/sec can be HEVC encoded at around 3.5 to 4 Mbit/sec without too many complaints. Statmuxing and system optimization can improve results. However, for automotive, perhaps 540p video at 60 frame/sec is good enough for small screens. That stream would only need around 750 kbit/sec capacity. At that rate, 3 dedicated automotive channels can be delivered robustly.

Broadcasters already deliver diginets, or multiple video stream services per RF channel. Adding a dedicated robust channel with a high QoS for automotive is very easy in NEXTGEN TV.

Can existing vehicle networks be used?

New vehicles can have the option for a USB interface into a head unit (radio). Also, many vehicles use a Controller Area Network (CAN) bus to route a variety of high priority signals with security from one module to another. The protocol used on the CAN bus will vary across manufacturers. Access to these interfaces / network protocols could be difficult as they are likely protected and secure, not allowing any 3rd party to access critical vehicle information.

Instead, infotainment interfaces can be described with the IP protocol interface. It is well known to many software developers and, if there is interest in infotainment, a bridge to IP packets can be built by manufacturers.

There is also a variety of data casting protocols that can interface with a headend unit. Examples are Bluetooth, Android Auto, Weblink, HiveMQ (IoT data), etc. There are also a series of downloadable APPs like CarConnect, Ring Car Connect (Tesla), etc. that can plug into a vehicle OBD-II port and send messages to a phone. Some of these technologies might be useful for infotainment or data in general, but the bottom line is the auto manufacturer must allow (enable) any data in the vehicle. It is best to work with the automotive OEMs (e.g., Visteon, AC Delco, Johnson Controls) directly to find applicable interfaces.

4.1.1 Content Security

Infotainment content may be protected by existing DRM mechanisms. Content may be encrypted in a way that prohibits decryption by unauthorized receivers, and receivers may be authorized either *a priori*, via one-way broadcast, or via two-way internet connection. These mechanisms are built upon existing, well-proven and widely deployed DRM systems like Widevine.

4.2 Robust Reception

There are physical layer configuration profiles from Pearl (a broadcaster consortium) that can be a great example for automotive service support. Those profiles are listed in their NextGenTV-Host-Station-Manual-V4 [2]. In the Operations Section, there is table of Advanced Setups on page 38 depicting the physical layer parameters for four configurations. The configuration labeled ‘Middle’ applies to automotive use-cases. It depicts a configuration setting for multiple PLPs, one of which (PLP0) is dedicated to a robust service.

That configuration is repeated below in Table 4.1.

Table 4.1 Example Mobile Configuration

Parameter	PLP0 (Mobile)	PLP1 (Stationary)
FFT Size	subframe 0: 8K	subframe 1: 16K
Pilot Pattern	subframe 0: 6_4	subframe 1: 12_4
Pilot boost	4	
Guard Interval	G5_1024	
Preamble Mode	(Basic: 3, Detail: 3) Pattern Dx = 3	
Frame Length	~155 msec	
# of Symbols	41	39
Time Interleaver	Hybrid 16 FEC Blocks 1 TI Block	Hybrid 63 FEC Blocks 2 TI Block
Modulation	subframe 0: 16 QAM	subframe 1: 256 QAM
Code Rate	subframe 0: 7/15	subframe 1: 10/15
Code Length	64K	
Bit Rate (Mbps)	subframe 0: 3.093	subframe 1: 18.166
Required C/N (dB)	sub 0: 5.2 (est. AWGN)	sub 1: 17.1 (est. AWGN)

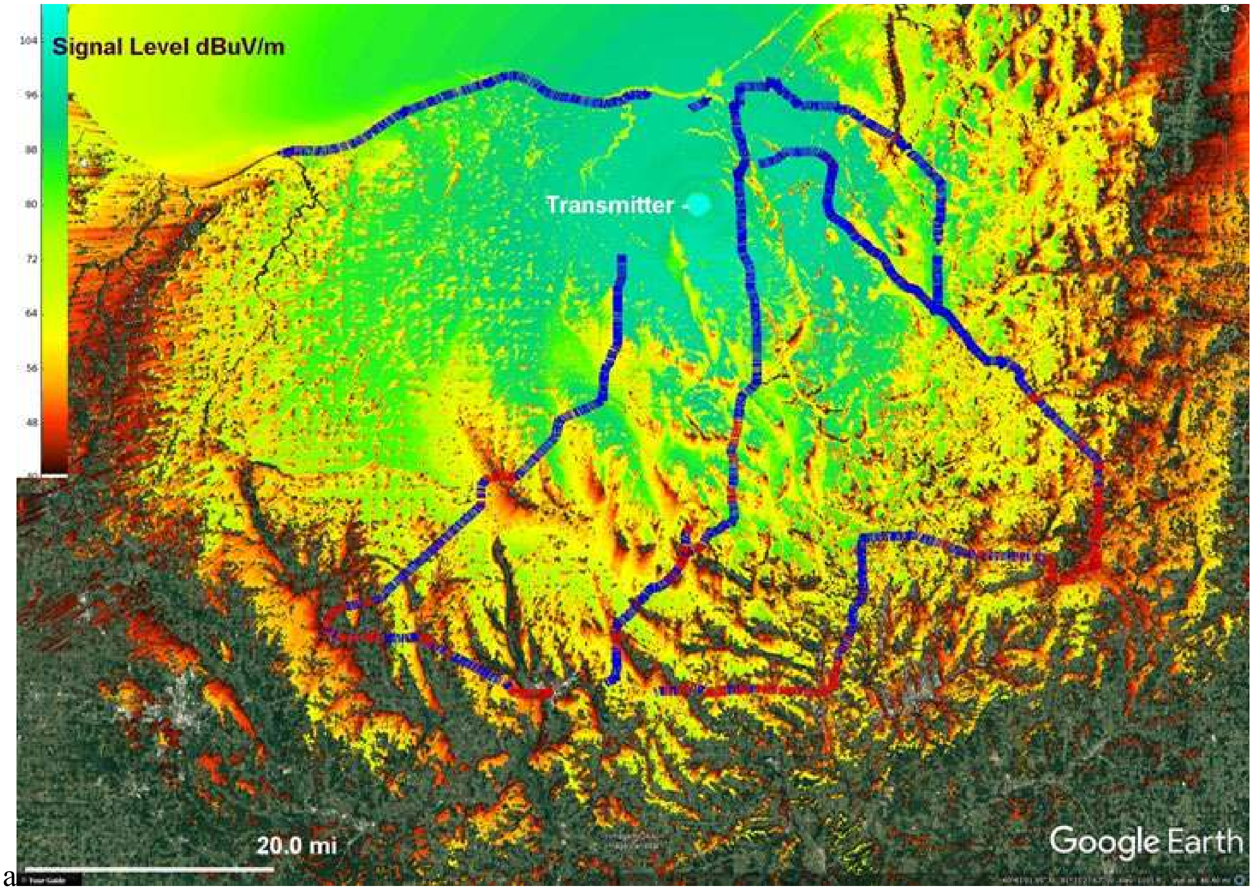
This configuration offers over 3 Mbps payloads for mobile service and operates around 5dB SNR in the AWGN channel. If more energy is received, then receivers have that extra energy to mitigate channel effects.

4.2.1 Mobile Reception Tests

Field tests have been conducted on the reception of ATSC 3.0 signals. A paper published in Broadcast Technology “First Field Testing of ATSC 3.0 Physical Layer ICs” [3] shows that the capabilities of mobile reception extend throughout the coverage area of the broadcaster.

Tribune Broadcasting donated the use of their transmitter in Parma, Ohio. The signal was on channel 31 with 460 kW ERP coming from the antenna mounted 236 meters above average terrain.

The primary limitation to reception is field strength. Reception data was collected during travel on several highways in the broadcast market in Cleveland. This can be seen in Figure 4.1.



a

Figure 4.1 Signal strength and error reception:
= error-free reception, = errors.

Using just a 6-inch magmount antenna, reception is solid in cities and at highway speeds. The signal strength necessary for two low threshold modes is summarized in Figure 4.2.

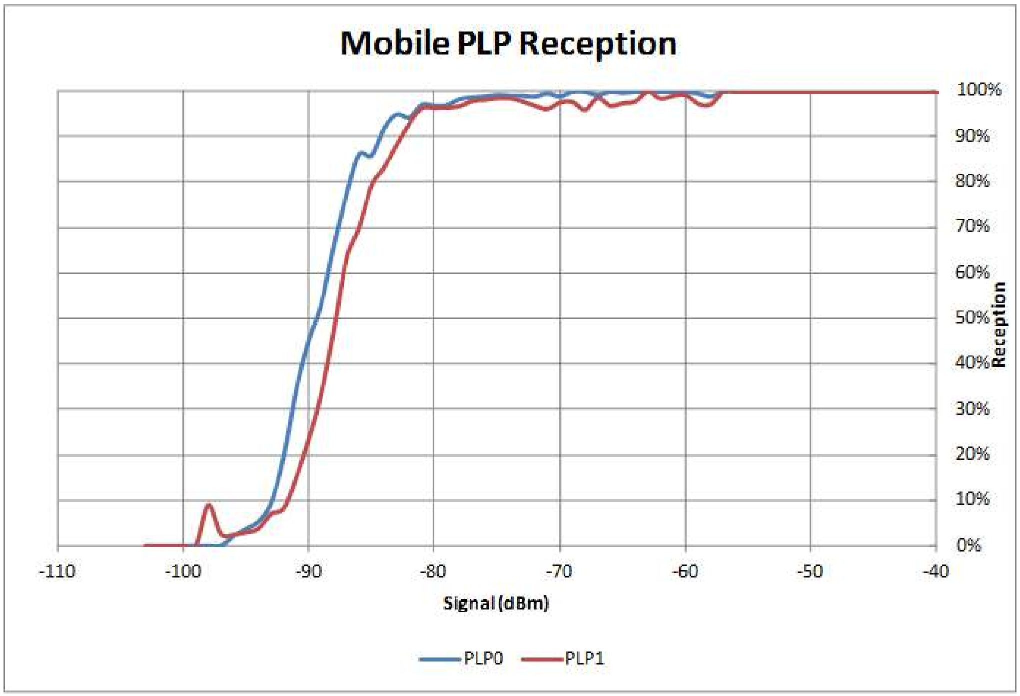


Figure 4.2 Robust reception threshold.

PLP0 has a white noise threshold of –1 dB and PLP1 has a white noise threshold of 3 dB.

To give an indication of the relative robustness of various ATSC 3.0 modes, Figure 4.3 shows the percentage of clean reception points during the mobile tests. The tests were conducted to a distance sufficiently far from the transmitter to guarantee loss of all reception. This was intentional to show the limits of each part of the transmission.

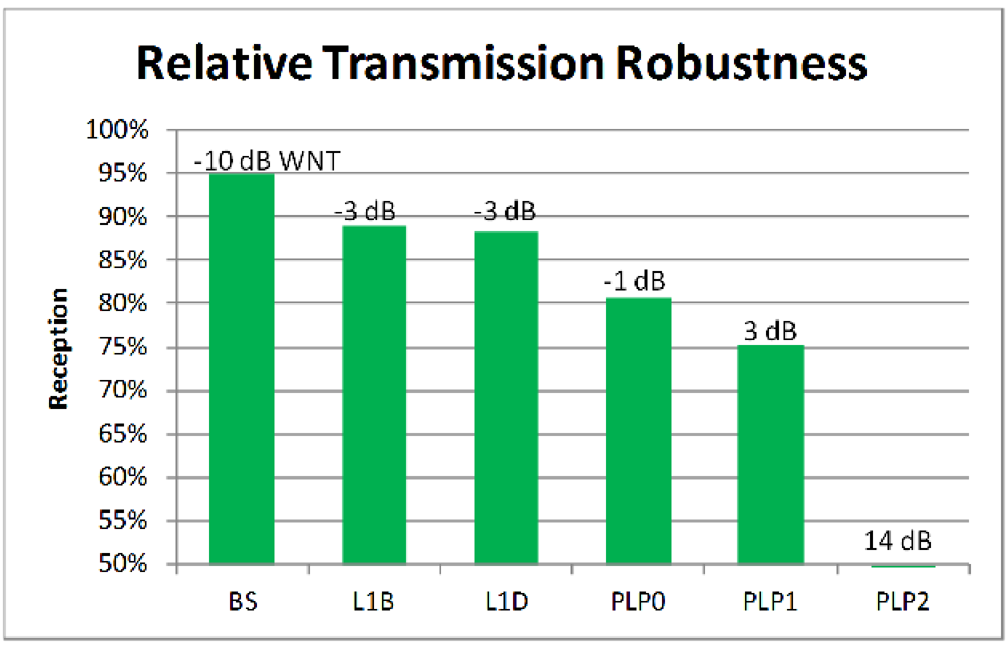


Figure 4.3 Signal robustness.

As expected, the bootstrap (BS) is the most robust. L1 data must be received to indicate the characteristics of the PLP transmission. The two mobile modes, PLP0 and PLP1, show decreasing coverage as robustness decreases. Finally, PLP2, which is set to reflect the typical home reception mode, shows expected poor mobile reception.

The previous tests were all conducted using a single layer modulation scheme. An additional test was conducted using Layered Division Multiplexing (LDM). Figure 4.4 shows that LDM affords the same coverage as single layer modulation when set to the same robustness characteristics. There may be a slight bandwidth efficiency with LDM, but it comes at a receiver cost. LDM reception requires the RF receiver hardware to be on longer and to perform many more demodulation steps on the signal. This results in reduced battery life for portable products.

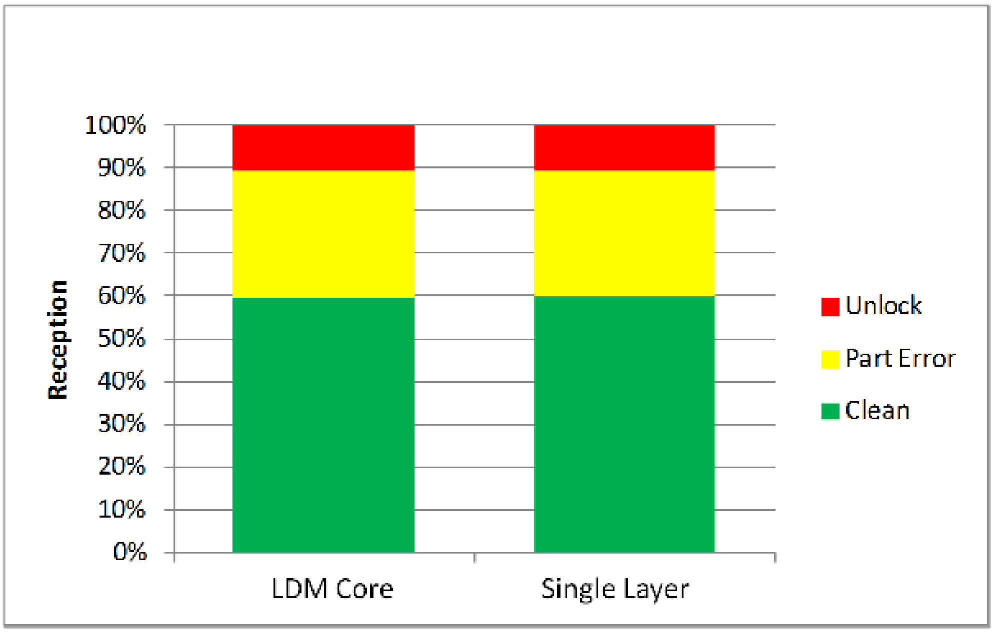


Figure 4.4 LDM vs. single layer.

4.3 Software / Firmware Updates

Can firmware updates be delivered to all vehicles in a market?

The size of firmware updates to vehicles will vary, but an example case of 1 GByte file size is used here. Instead of OEM's having the complexity of delivering to each car one by one, they could broadcast software updates to all vehicles in a market at once.

In a 6 MHz channel that is used for stationary and automotive services, there is always room for a little bit more data. That is where Non-Real Time (NRT) file downloads can be delivered. It operates as described in FLUTE (RFC 3926). Pieces of the file are delivered in around 1 Mbit chunks until the entire file is delivered. Then the file is delivered again at a carousel rate. The number of times the file is delivered, and how often, can be configured by the broadcaster.

For example, for a 1 GByte file, there are 8 Gbits = 8000 Mbits. If the physical layer is configured with the Pearl configuration depicted above and there are 3 services at 750 kbits, there is an extra 843 kbit/sec capacity in the 3.093 Mbit/sec PLP. Rounding to 800 kbit/sec capacity for this NRT file, that puts the number of pieces to deliver at 8000/0.8 = 10,000 pieces. Each piece is delivered on a per second basis, so there are 10,000 seconds required to deliver the entire 1 GByte file. = 2.78 hours (almost 3 hours).

Those 3 hours can be at any time of day, and if the broadcaster is motivated to deliver large files a larger PLP can be used, or less A/V services supplied to increase the payload size for those large files. In one day, that file could be delivered 8 times for redundancy, that is the carousel rate.

Vehicles are typically parked at night and a robust PLP might not be required for this stationary receiver case, enabling higher payload capabilities at night for file downloads. The above example could also be improved if a broadcaster limits an AV service during late night hours giving more bandwidth for data services. File downloads could go on for a period of time depending on the OEM and broadcaster agreements.

For vehicles to be notified of pending software updates, a ping could arrive via WiFi or cellular connection telling the vehicle which channel to tune to at what time to receive the update. Verification of download could be sent by that same WiFi or cellular connection.

4.4 Security

Although there is no ATSC-standardized trust or security mechanisms for firmware updates, such mechanisms can be defined uniquely (proprietarily) by each manufacturer. Alternately, if it is desired, a mechanism can be defined that is common to a set of manufacturers.

To date, thinking has been that this would be entirely within the province of the manufacturer (e.g., there is no need for Sony and LG firmware updates to have similar security mechanisms). Of course, it would be sensible to describe broadcast firmware updates using existing data broadcast mechanisms.

This could be described as requiring two-way communication but should probably be either one-way or two-way.

If the requirements are that the software/firmware updates have both confidentiality and integrity protection, the existing app download mechanisms could be leveraged to provide confidentiality (in addition to integrity). The existing mechanisms are based on secure email standards, S/MIME. The existing mechanisms use email signature methods only (providing integrity and trust); however, S/MIME has defined mechanisms to encrypt the email contents which could be applied to software download as well to provide confidentiality. Of course, depending on the actual requirements (yet to be defined), other mechanisms may be more appropriate.

4.5 Advanced Emergency Information

ATSC 3.0 is uniquely ahead of all other alerting mechanisms by including the capability to add relevant information along with the alert. For example, a weather alert can be accompanied with maps, web pages and videos describing the timeframe and path of the event.

This mechanism can also be used to carry news alerts such as school and road closings. The alerts can be geo-targeted by county or GPS area.

The television broadcast infrastructure is much more resilient than other data distribution systems. Time and again, the broadcaster has been the sole news distribution source during natural disasters. When cellular or landline systems become compromised, the redundant backup systems of the broadcasters allow them to remain functional. This resilience is particularly important in the Emergency Information arena.

4.6 Signaling Security

Currently, the ATSC 3.0 standard requires that all signaling tables include a signing certificate (using email-like S/MIME mechanisms) to allow the receiver to verify the validity of the information. This prevents pirates from being able to spoof the ATSC 3.0 signal.

The mechanism in place works entirely within the broadcast signal and does not require a return channel for verification.

4.7 Broadcast Data

There is no current description of Confidentiality as applied to broadcast data, but it should be reasonably easy to apply existing S/MIME mechanisms which do provide Confidentiality in one-way implementations. (For two-way implementations, see Packet Security below.)

4.8 Market Coverage

Using a threshold similar to today's standard digital television, a broadcaster has a range of about a 50-mile radius. The population in this coverage area defines the market for that broadcaster. In many cases, adjacent large metropolitan areas will have overlapping market coverage ensuring reception of a particular network signal.

Is it possible to maintain service among vehicles travelling between markets?

The ATSC system allows the possibility to signal the proper station to tune to when traveling between adjacent markets. Clean handoff is theoretically possible with multiple tuners.

There is an extension to the ATSC system in the works to enable core networks that can distribute data nationwide. These core networks will be a cooperative effort of various traditional program network providers. This cooperation enables distribution of services over the complete 210 Designated Market Area national footprint.

Is there a service in all markets?

ATSC 3.0 is intended to become ubiquitous and extend in all markets in the U.S.

For the first few years of deployment, having one station in a market means it is an ATSC 3.0 market. Transitioning to ATSC 3.0 requires starting with one ATSC 3.0 signal and adding more as the receiver population grows. Mesh networks provide larger coverage area. For redundancy, signals are sent in many networks (broadcast towers). Such a service might not start unless three stations in a market were available. Most stations in a market have similar coverage.

4.9 Return Path

Broadcast television is optimum for large file one-to-many distribution. Return acknowledgement can easily be economically supported by cellular or WiFi systems.

4.9.1 Packet Security

ATSC 3.0 requires the use of TLS 1.2 or TLS 1.3 for internet communication, which provides both confidentiality and integrity, as well as DNSSEC to enable secure bidirectional communications.

4.10 Antenna Interface

A typical 50- or 75-ohm antenna is needed broadcast television reception. Multiple antennas could be used with diversity receivers for improved performance. Consumer television receivers use the industry standard "F" connector, but other options can be supported.

While traditionally, television has been horizontally polarized, the recognition of the need to reach mobile receivers has driven broadcasters to implement transmissions with an additional vertical component.

VHF channels require a larger antenna but has some benefits over UHF channels. Coverage with UHF tends to be very line-of-sight while VHF signals tend to do better at following terrain features. Also, VHF coverage comes at a lower power requirement for the same performance.

4.11 Broadcaster Motivation

Should a broadcaster entertain this opportunity?

A variable rate, pass-through data stream can be used to fill the PLP to maximum capacity especially in the presence of video, which can have a highly variable bit rate. This becomes very economical for the broadcaster and for the data client. Special opportunities may exist during late night hours when typical viewership is down.

A centralized organization would be optimum for broadcasters to aggregate deals with auto OEMs. Education is the key to this opportunity.

– End of Document –