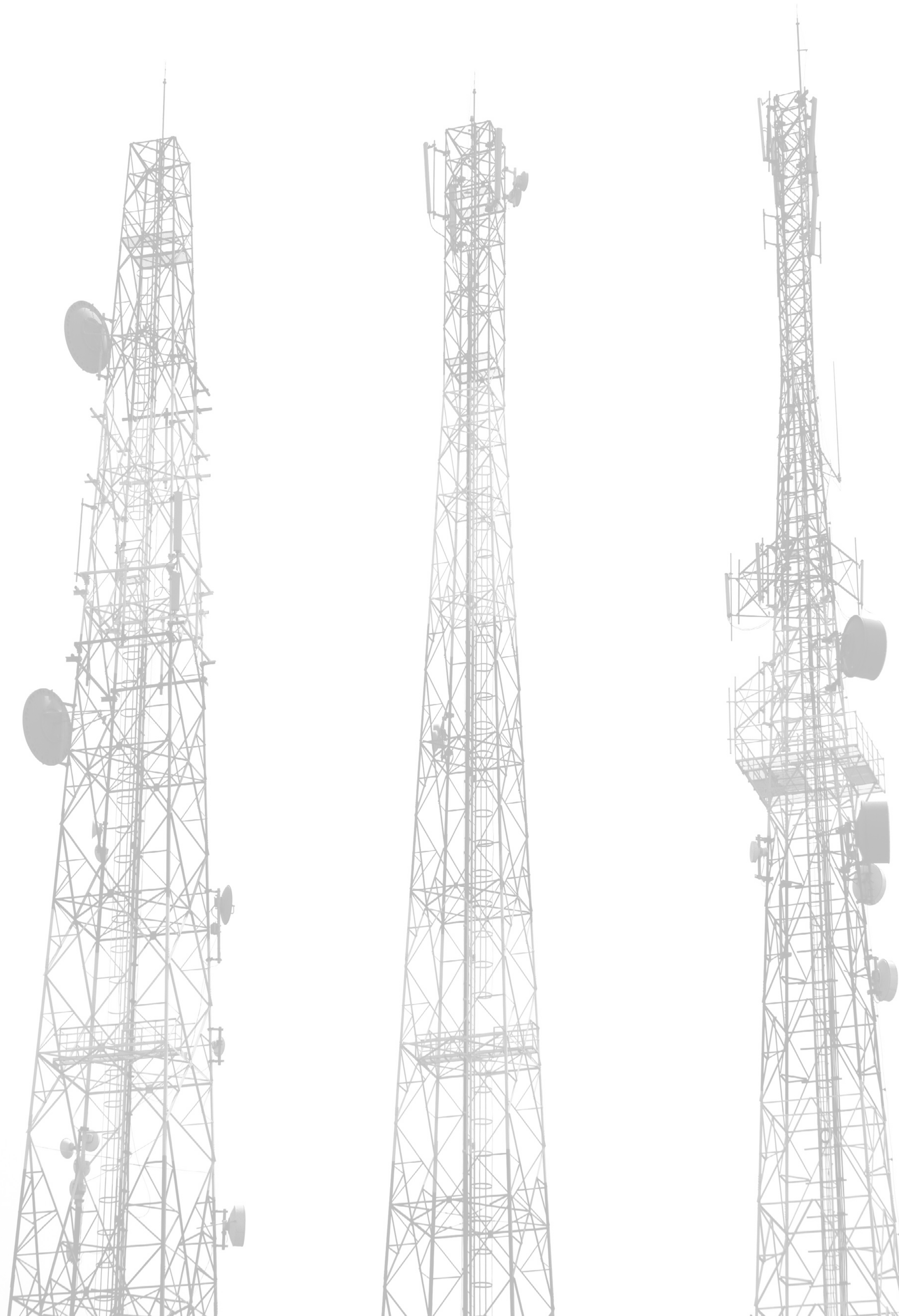
NEXT GENERATION TELEVISION (ATSC 3.0) STATION TRANSITION GUIDE

April 2019



INTRODUCTION

The National Association of Broadcasters (NAB) is pleased to present this manual to assist broadcast stations in transitioning to Next Generation TV, also known as Advanced Television Systems Committee (ATSC) 3.0.

The purpose of this guide is to provide relevant information for implementing a coordinated transition from the current ATSC-1 broadcast standard to the Next Gen TV platform.

The intended audience includes broadcast executives and engineers who want to learn more about how to make ATSC 3.0 part of their business.

This guide includes the basic principles for how to successfully transition to Next Gen TV. How-to information and checklists are provided to assist in the decision making and implementation processes. It should answer many of the questions you might have and provide the basis for taking advantage of the next great television broadcasting opportunity.

NAB thanks Osborn Engineering for its help in developing this document. The overall project was led by the NAB Technology department with strong participation by the NAB ATSC 3.0 Transition Task Force (a sub-group of the NAB TV Technology Committee). Valuable input was also provided by the NAB Legal and Marketing departments.

We hope you find these guidelines useful and informative and that they serve as a mechanism to assist your transition to Next Gen TV.

BACKGROUND

The National Television System Committee (NTSC) standard for broadcast television was developed in 1941. In 1953, a second, compatible standard for color television was introduced. Fast-forward to 1998, when U.S. broadcasters began their first commercial transmission of digital television (digital TV), ATSC-1. It was transmitted alongside analog television using an additional channel made available to all full-power broadcasters. This arrangement provided a simple means to transition from one system to the other without losing audience. The full transition to 100% digital TV successfully occurred in June, 2009.

ATSC-1, the digital TV system currently used in the U.S., is not very flexible in light of the latest advances in technology and viewer preferences. Most of the critical elements of encoding, transmission and receiver decoding are set in standardized technical constraints that are not extensible.

Our current legacy standard cannot adapt to newer and more efficient methodologies because much of the infrastructure in transmission and in-home receivers is set in legacy hardware. This prevents the industry from adding new and enhanced features within the current standard and it is not possible to remain backwards compatible while providing the technology needed to thrive in today's wireless world.

The industry is responding with an aggressive schedule to produce the ATSC's Next Gen TV standard, ATSC 3.0. Through this massive 5-plus-year effort, the future of broadcast television is bright.

This new system addresses viewers' desire for content to be delivered on the go, beyond the home and available on tablets, laptops and smartphones. This can be done with the current state of digital communications, advanced digital content compression and smart (adaptable) software-based receivers.

Voluntary migration to Next Gen TV will require broadcaster investment, time and some disruption to our industry, as well as to the general viewing public. This disruption is necessary if the industry is to meet the ever-increasing demands of our viewers. **How to minimize this disruption is the overall goal of this guide.**

To accomplish a seamless implementation of Next Gen TV without disenfranchising viewers, the industry must deploy this new technology in parallel with its existing digital TV services in a voluntary, market-based manner. Today, television is only broadcast in ATSC-1. Like the analog to digital transition, there will be a multi-year period where both ATSC-1 and ATSC 3.0 will be on the air and eventually only ATSC 3.0 will be used.

The Next Gen TV standard must operate within the existing 6-MHz television channel and be subject to the same radio frequency (RF) interference constraints and requirements that apply to the current standard. In other words, this transition must be accomplished without additional spectrum being provided.

The good news is that it is possible for Next Gen TV services to be deployed within stations' existing coverage contours without causing interference to current digital TV services. Parallel implementation will mean that broadcasters in each market will voluntarily deploy Next Gen TV, while continuing to transmit using the current legacy digital standard.

Using the strategies put forth in this guide, broadcasters in each market can share the available spectrum to simulcast their respective legacy and Next Gen TV signals, so that all viewers can receive programming from their local stations with the choice of viewing the current ATSC-1 or ATSC 3.0 television formats, all free and over the air.

As new devices and compelling programming become available, the long-term goal is to sunset our current standard once Next Gen TV is sufficiently adopted in each market.

In a channel-sharing (Lighthouse) scenario, the current Federal Communications Commission (FCC) rules regarding simultaneous carriage during the transition require that the programming carried over both our current standard and ATSC 3.0 must be substantially the same. However, the ATSC 3.0 content can make use of many of the enhancements found in the new standard such as ultra high definition (UHD) video, immersive audio and broadcaster smart device applications, while still meeting regulatory requirements.

For signal coverage in a Lighthouse scenario, the FCC Report and Order mandates that a shared ATSC-1 coverage contour must remain substantially the same as a station's existing contour. The Report and Order is less restrictive for a shared ATSC 3.0 coverage contour. Chapter 2 of this guide examines the Report and Order in depth.

Note about this document: If you are viewing this in portable digital format (.pdf), the document is interactive. The Document Map on the next page contains links to sections and chapters, and there are links to external references within. Arrows at the bottom of each page navigate to the next or previous pages, and the "Back to Main Doc Map" button at the top of each page returns the reader to the Document Map. The page numbers in the Table of Contents link to the corresponding page.

DOCUMENT MAP

Doc Map

TABLE OF CONTENTS

SECTION 1: EXPLORING THE ATSC 3.0 TELEVISION STANDARD

CHAPTER 1: DESCRIPTION OF ATSC 3.0

Overview
ATSC 3.0 is a major upgrade and expansion of our existing over-the-air broadcast platform.

Unlike the move to digital TV, adoption of ATSC 3.0 is voluntary. It is also not backwards compatible with our existing ATSC-1 standard.

Opportunities
Broadcasters' focus on covering, attracting and keeping an audience are accounted for in the transition to Next Gen TV. The technology behind Next Gen TV will better reach viewers through a more robust signal and by delivering to hard-to-reach indoor over-the-air televisions and mobile receivers in smartphones, tablets and even the rear seats of automobiles.

The features offered by Next Gen TV mean that marquee events such as the Olympics, Super Bowl, World Cup or The Masters can provide enhanced viewer experience opportunities, including UHD, immersive audio and second screen features, that can draw and keep larger audiences. This can provide enhanced revenue and an opportunity for stations to gain and keep a larger viewership.

There will be new sales opportunities before and after the transition. Along with core programming, broadcasters can choose to provide enhanced advertising as well as many of the same features now commonplace in other forms of advanced television content delivery.

Research tells us that 50% of television viewing does not involve over-the-air content. Viewers are moving quickly to platforms that provide a richer and more fulfilling experience. The industry can adapt to meet this challenge and remain the best source of local news, information and entertainment.

With the increasing expectations for all media, Next Gen TV will rise to the challenge of retaining viewers with the following business improvements and viewer benefits.

Robust Untethered Reception
The new standard provides a level of robustness to the over-the-air signal that allows for excellent reception by non-traditional receiving devices such as smart phones and tablets, and will even allow for reception inside moving vehicles.

UHD TV
Next Gen TV provides for 4K resolution with high dynamic range, wide color gamut and high frame rate. These capabilities provide immersive, photo-realistic images with smooth motion, which will enhance all types of content.

Immersive Audio
The features provided by the new audio capabilities of Next Gen TV provide immersive theater-like sound. There are capabilities for multiple languages and enhanced dialogue that will widen audiences.

Advanced Emergency Information
Next Gen TV provides the capability to "wake" a receiver from an off-state in order to provide the viewer with important emergency information. This could be critical in weather-endangered areas where minutes are often critical in saving lives. More advanced, vitally important and time-sensitive content can be geo-targeted and delivered over the air, or supplemented via broadband, seamlessly to the viewer.

Second Screen
Next Gen TV includes the ability to deliver program-related second-screen interactive content by either over the air or via hybrid (broadband) distribution. Research shows that over 75% of viewers of over-the-air television watch with a second screen in their hand.

Targeted Content and Advertising
Next Gen TV provides for viewer-driven choice of content that can provide geographical or user-choice targeting capabilities, some of which require optional single frequency network (SFN) and/or low data rate backhaul. With the addition of a hybrid-broadband connected receiver, Next Gen TV also has the capability to directly measure audience activity.

Multiple Streams
The incredible improvement in video and audio compression technology make more streams available to broadcasters, both for our current ATSC-1 standard and for ATSC 3.0. These improvements help provide the means for a market transition to the new service, and ultimately more choice to the viewers.

Audience Measurement
Next Gen TV makes possible enhanced audience measurement capabilities through its internet protocol (IP)-based architecture and support of a return pathway. In addition, ratings data from the ATSC-1 standard can be compared against Next Gen TV data, and used to gauge the rate of adoption of Next Gen TV devices.

Challenges
As with most efforts to advance the state of the art, challenges must be faced and met. The road to Next Gen TV is no different. Significant business and technology considerations are involved, and they vary by market size and geography, duopoly and shared services agreement (SSA) scenarios, repack status and operating band. Some specific challenges include:

The Spectrum Shortage
Allotted spectrum for broadcasting has been significantly impacted over the years, with the most recent reduction resulting from the broadcast spectrum incentive auction.

Unlike the transition from analog to digital, the FCC is not providing a second channel for the purpose of transitioning to Next Gen TV.

Incompatible with ATSC-1
In order to merge with today's wireless environment and remain within the allotted 6-MHz bandwidth assigned to each station, the ATSC 3.0 standard could not be made compatible with our existing ATSC-1 standard. Differences in modulation schemes and other factors prohibit mixing the two standards on the same transmitter.

Voluntary Transition
Although the FCC has adopted rules to guide the transition to Next Gen TV, the broadcast industry requested adoption be voluntary. Accordingly, broadcasters and consumer electronics manufacturers must determine the best path for their specific business strategies.

Market-specific spectrum coordination among broadcasters, content production and the integration of Next Gen TV chipsets in TV sets, home routers and untethered smart devices are all significant considerations.

If a voluntary transition does not yield acceptable progress in migrating to Next Gen TV, other measures might potentially be considered, such as broadcasters or others providing Next Gen TV-compliant devices to viewers at a reduced or no cost.

The Technology Behind ATSC 3.0

Internet Protocol (IP)

The underlying data in the ATSC 3.0 standard uses IP. This aligns the new transmission system with the current over-the-top (OTT) and broadband web-delivered world, which opens the possibility of hybrid broadband delivery (to supplement the broadcaster's bandwidth) of enhanced guides, broadcaster applications, deep-linking to enhanced content and in-program purchasing.

ATSC 3.0 offers a wide array of improvements and enables many new capabilities. However, a core element of any broadcast system is its capability and capacity for getting audio and video to the receiver.

A broadcast gateway, located on the studio side of the transmission system, produces the appropriate IP transport stream for sending to the transmitter, multi-channel video programming distributor (MVPD) operators and to optional SFN transmitters.

ATSC 3.0 Transport Features

Broadly stated, capacity for a wireless delivery system is determined by two factors:

- **Modulation/coding** determines how receivers can successfully receive the signal and the total data capacity of the signal
- **Encoding** determines how much data capacity is needed to pass video and audio of a given quality

In ATSC-1, stations know that the data capacity of our modulation scheme (8-level vestigial side-band [8-VSB]) is 19.39 megabits per second (Mbps). Stations have learned, over time, about what mix of audio and video channels they can encode using the Moving Picture Experts Group version 2 (MPEG-2) video and Dolby Digital Audio Coding Version 3 (AC-3) audio encoding schemes that are part of the standard, to fit into that 19.39 Mbps at a quality they find acceptable.

Initially, many stations reserved the entire capacity for a single high definition (HD) stream. Over time, improved business opportunities, the availability of revenue-generating multicast channels or diginets, and improved encoding technologies (eg, updated MPEG-2 video encoders) allowed multiple streams to fit in that capacity at high quality. Today, some stations carry one HD channel and as many as four standard definition (SD) channels. Others carry two HD channels or as many as nine or 10 SD channels.

Using ATSC 3.0, both modulation/coding and encoding take significant leaps forward. By enabling more sharing partners per transmitter during the transition, this advancement will help the transition create new business opportunities and flexibility. However, it also creates decision-making challenges for business and technical management, because so many possibilities are enabled.

If one looks at a direct translation of ATSC-1 approaches to ATSC 3.0, the following is true:

- The modulation scheme (orthogonal frequency division multiplexing [OFDM]), when configured to achieve similar results to ATSC-1, allows approximately 25 Mbps vs. 19.39 Mbps.
- The improved video (high efficiency video coding [HEVC] is two generations better than MPEG-2) and audio (Dolby Digital Audio Coding Version 4 [AC-4]), are considerably more efficient than the existing digital TV standard, offering the opportunity for more flexible use of the assigned 6-MHz channel bandwidth, with an HD channel requiring on the order of 10 to 12 Mbps in ATSC-1 vs 3 to 6 Mbps in ATSC 3.0, contractual obligations notwithstanding.

ATSC 3.0 will enable better quality video and more channels to the home as well as significant new opportunities and flexibility.

A given modulation scheme is designed to balance the needs for robustness (strength and density of signal) and payload capacity (amount of data) needed for a given distribution scenario. ATSC-1 has just one modulation scheme, where ATSC 3.0 enables a wide range of modulation schemes and allows more than one to be used at the same time. These multiple distribution scenarios are enabled using an approach called physical layer pipes (PLPs). The standard allows for up to 64 PLPs to be used on a single RF broadcast channel. Each program service can be assigned one to four PLPs at a given time. Each PLP can be defined to have the level of robustness and capacity needed for a specific task. To replicate today's scheme, an ATSC-1 equivalent PLP could be configured to provide capacity for multiple video and audio channels, even including UHD to the home (*Figure 1*). For ATSC 3.0, a different PLP could be configured to have the additional robustness needed to reach mobile devices, but recognizing that mobile displays are smaller, would be configured for a lower-resolution image. Another PLP could be configured to have maximum robustness to reach moving vehicles.

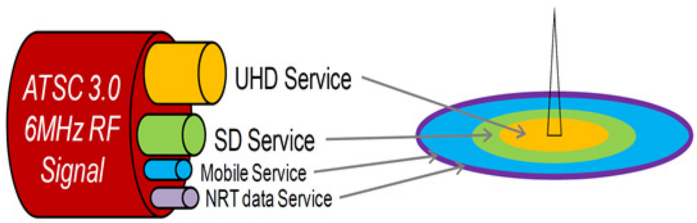


Figure 1. (Source: Comark Communications)

Example of Multiple PLPs

With each PLP configuration, stations are trading off robustness for capacity. That is, a PLP that is more robust has less data capacity. While there are a multitude of configurations possible, a simple example is enlightening:

- Designating the entire 6-MHz channel as a single PLP designed for home consumption would yield approximately 25 Mbps of capacity, enough for one UHD and multiple HD streams.
- However, splitting the channel in half would yield a home consumption PLP with capacity of approximately 12.5 Mbps, providing enough capacity for one UHD or multiple HD streams, while a mobile PLP with only 3 Mbps would be enough for a single HD stream, but not enough for UHD.

Table 1 demonstrates the trade-off between PLP data capacity and robustness. Other factors, including guard interval and forward error correction values must also be considered because they will also affect an ATSC 3.0 channel's capacity.

Table 1

Description	Content	3D or UHD	HD	2nd Scrn	SD	Mobile	Data	Nbr of PLPs	PLP NBR	Data Rate	Robust	Mod
Main Program	A	PLP 4	PLP 3	PLP 2	PLP 2	PLP 1	PLP 1	4	1	Very Low	Very High	LDM
All About Cars	B		PLP 3		PLP 2	PLP 1	PLP 1	3	2	Low	High	LDM
24 Hour News	C				PLP 6	PLP 5	PLP 5	2	3	Medium	Medium	
Cooking Channel	D				PLP 6	PLP 5	PLP 5	2	4	High	Low	
Lucy Channel	E					PLP 5	PLP 5	1	5	Low	High	
Meditation Channel	F					PLP 5	PLP 5	1	6	Medium	High	

CHAPTER 2: REGULATORY AND LEGAL ISSUES

On November 20, 2017, the FCC authorized voluntary use of the Next Gen TV transmission standard. The FCC envisions a voluntary, market-driven transition to Next Gen TV that does not rely on mandates or a nationwide transition. Under this framework, television broadcasters are permitted, but not required, to transmit using the Next Gen TV standard subject to certain regulatory requirements. The following is a brief summary of the important rules; any station seeking to transition should consult with legal counsel regarding additional detailed requirements.

Local Simulcasting Requirement

The FCC's order requires Next Gen TV broadcasters to air a local simulcast of the primary video programming stream of their Next Gen signal in ATSC-1 format so that viewers can continue to receive ATSC-1 service. Next Gen TV broadcasters must partner with another television station to air an ATSC-1 signal. Broadcasters have discretion to determine what constitutes their primary stream, though the order states that the FCC believes broadcasters will simulcast the stream that viewers expect to be able to receive, such as network programming or the stream that has the highest viewership for non-network stations. The FCC intends for this simulcasting requirement to be temporary and will determine in a subsequent proceeding when it would be appropriate to permit broadcasters to cease providing an ATSC-1 signal.

Further, a station's ATSC-1 simulcast channel must be in the same designated market area (DMA) and must continue to cover the station's community of license. The FCC will consider any losses in signal coverage in evaluating simulcasting applications and will consider more favorably simulcasting arrangements that result in service losses of no more than five percent of the population a station serves.

Substantially Similar Programming

To comply with the FCC's simulcasting requirement, the programming a broadcaster airs on its ATSC-1 simulcast channel must be "substantially similar" to the programming on the primary video stream the broadcaster airs on its Next Gen TV channel. This means the programming must be the same except for: (1) features that are only available due to the enhanced capabilities of the Next Gen TV standard; (2) advertisements; and (3) promotions for upcoming programming. This requirement will end in 5 years unless the Commission conducts a further proceeding to extend it.

Carriage

A Next Gen broadcaster's ATSC-1 simulcast channel will retain mandatory carriage rights, but its Next Gen channel will not have mandatory carriage rights. As a practical matter this means that a Next Gen broadcaster may continue to choose must-carry or retransmission consent for its ATSC-1 signal but may only seek carriage of its Next Gen signal via retransmission consent.

Public Interest Obligations

Next Gen TV broadcasters must comply with all FCC broadcast rules including, for example, foreign ownership, political broadcasting, children's programming, equal employment opportunities, public inspection file, indecency, sponsorship identification, contests and accessibility.

Intellectual Property and Licensing

The ATSC 3.0 standard contains intellectual property covered in some 13,068 patents. Some technology, such as HEVC compression, has multiple patent pools (3) for licensing, and some IP patent holders are not part of member's patent pools. It should be noted that all equipment purchase agreements language should include indemnification of the purchaser from patent infringement, since affiliation and network agreements may require similar indemnification.

Content Protection (CP) and Digital Rights Management (DRM)

Since ATSC 3.0 is based on IP, the broadcast over-the-air content can be easily streamed over the internet, violating redistribution agreements with copyright holders. As such, content owners seek to prevent unauthorized reproduction and redistribution of copyrighted works by developing CP requirements to protect against these unauthorized practices. These requirements will be included in their contractual relationships with their distribution partners.

<u>DRM Goals</u>

1. Protect against unauthorized reproduction of broadcast content intended to be transmitted over the air using the ATSC 3.0 standard both inside and outside a station's DMA. This will be done by incorporating CP technology and workflows that will provide both technical protection and a basis for legal enforcement.
2. Provide a mechanism of content control that will enable new business models for broadcasters, including services such as premium channels and pay per view, which could be offered on either a free or paid subscription basis.
3. Find a mechanism so that receiving devices that are not connected to the internet, or unable to be connected to the internet, can be included in the first two goals.
4. Provide certainty to the distribution partners and to consumer electronics manufacturers about broadcasters' operational needs and timelines for the launch of ATSC 3.0 using the CP technology and commercial DRM solutions that it supports.

CHAPTER 3: ADDRESSING THE SPECTRUM CONUNDRUM

Given that no new spectrum is available for the transition, any plan must meet the challenge of managing the industry's overall spectrum capacity. The specific number of channels available in a given market, and the physical propagation characteristics of those channels, are major considerations.

Physical Considerations

All practical transition models for ATSC 3.0 must consider the RF spectrum allocated to broadcasting. Since TV spectrum extends from low-band very-high frequency (VHF) to ultra-high frequency (UHF), which involves more than a ten-fold difference in frequency between the high and low channels, the characteristics of the specific TV channel assigned to your station and its usefulness for different services is relevant.

Fixed and Mobile Service Choices

ATSC 3.0 has the flexibility and choices to allow mobile and portable/handheld service as well as traditional fixed reception. UHF spectrum is suitable for all services. However, mobile devices use very short antennas that are inefficient for the lower VHF channels, making mobile service in the VHF band a challenge. High-band VHF has been shown to be viable for a vehicular mobile service but may be challenged for personal portable device reception where longer antennas are not practical.

To offset this disadvantage, consumer gateway devices that receive over-the-air ATSC 3.0 signals and merge them into home or local WiFi routers are being developed (*Figure 2*).

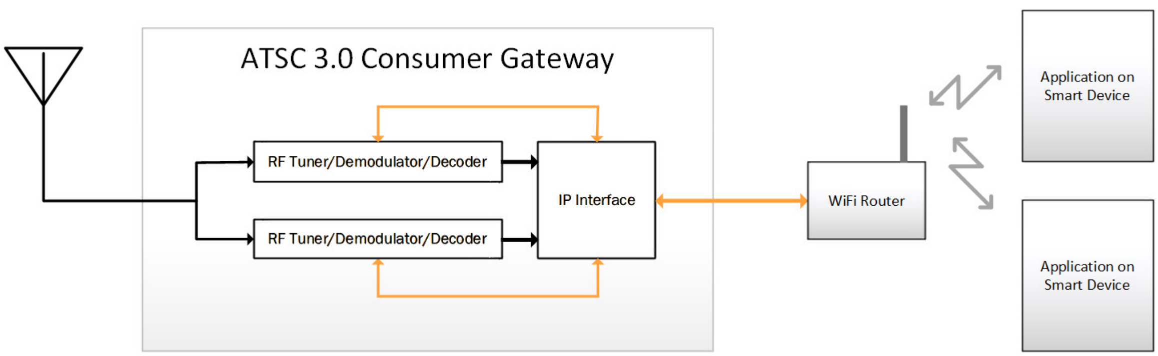


Figure 2. Example of Consumer Gateway with 2 receivers, supporting 2 smart devices

Robustness vs. Coverage Area

The ATSC 3.0 standard is highly flexible, with combinations of modulation and coding trading off robustness for data rate. Highly robust signals traveling long distances can be configured at lower data rates suitable for low definition programs or small mobile screens. Less robust signals with high data rates for services such as UHD TV are also possible with lesser coverage. For service planning and coverage and interference analysis, different robustness/data rate trade-offs will yield different results.

Technology limitations for receiving noise-free UHF signals are significant. On the other hand, low-band VHF stations must deal with impulse noise generated by power lines, electric motors and appliances. These issues had put analog high-band VHF in a more desirable position for many years.

By the time the transition to digital TV came along, the UHF noise problem was countered by digital error correcting techniques. These techniques work well for the predictable noise inherent in UHF, but do not counter the unpredictable impulse noise most prevalent in low-band VHF.

Suitability for Service by Band

All stations can enjoy the benefits of ATSC 3.0. The decision for each station on whether to move to ATSC 3.0 and how to implement depends on several factors. A significant factor for smart device and mobile reception is channel allocation. Operating channel wavelength and resulting propagation characteristics present a major consideration when developing ATSC 3.0 technical planning and performance predictions.

According to the post-auction FCC database, a total of 11 full service UHF stations were repacked to high-band VHF and 15 were repacked to low-band VHF. Once the repack is complete, there will be approximately 1215 UHF full service stations, 419 high-band VHF and 39 low-band VHF stations, for a total of 1673 full service stations (73% UHF, 25% high-band VHF and 2% low-band VHF).

Low-band VHF

Propagation characteristics of channels 2 through 6 are not well suited for mobile or portable operation. Random impulse noise, lower power density, and interference from man-made and natural noise gives this band a distinct disadvantage in comparison to UHF. Effective radiated power from channels 2 through 6 is limited due to interference concerns between markets. While low-band VHF is challenged for mobile and portable ATSC 3.0 services, fixed reception with an appropriate rooftop antenna should be reliable as an operational system mode.

High-band VHF

Performance of VHF channels 7 through 13 is better than low-band VHF, but the longer wavelength of VHF reduces the chances of successful reception for many portable use cases, due to utilization of built-in antennas in these devices. In many markets, transmitted VHF power will be more limited. High-band VHF has been tested and found suitable for many ATSC 3.0 applications. It could be effective in diversity mobile use cases utilizing diversity receive technology but will not perform as well as UHF when received with a handheld device.

Utilization of optional SFNs has not been tested on VHF, so additional work will be needed to gain a full assessment of use in the VHF band.

UHF

Due to the short wavelengths and resulting reception advantages in this part of the TV spectrum, UHF is suitable for all anticipated ATSC 3.0 service models.

Managing Available Spectrum

It is not possible to combine the current ATSC-1 service and the new ATSC 3.0 service in the same transmitter, and additional spectrum to aid in the transition is not available. Therefore, several coordinated transition scenarios have been studied in order to maintain existing digital TV service while transitioning to ATSC 3.0.

Scenario 1. Flash-cut from ATSC-1 to ATSC 3.0

Definition: Flash-cutting is the transition technique where a broadcaster simply switches (ie, flash-cuts) from one transmission standard to another on their assigned operating channel. Most broadcasters would be unwilling to flash-cut from ATSC-1 to ATSC 3.0 unless there is a large penetration of ATSC 3.0 receivers in place in the marketplace. This might be the case in the latter stages of the transition for smaller non-network affiliate broadcasters or low power television (LPTV) stations. It's generally accepted that a critical catalyst for ATSC 3.0 receiver sales will be network programming availability. Thus, in the early part of the transition, assuming that few receivers are deployed in the marketplace, flash-cutting to ATSC 3.0, if approved by the FCC, could possibly disenfranchise a large number of viewers.

Benefit: Minimum transition time. A flash-cut scenario would considerably reduce the complexity of the transition for broadcasters. All stations would continue to have full use of their 6-MHz channel for their program and service offerings, resulting in maximizing the ATSC 3.0 service with no degradation to the ATSC-1 service during a transition phase. Complex collaboration between competitive broadcasters in a market to use common facilities or sharing channels would be avoided. The transition time could be minimized in this scenario.

Disadvantage: Requires receiver "seeding." Flash-cutting on a large scale would be practical as a general transition scenario only if the ATSC 3.0 receiver population is large, in order to avoid mass viewer disenfranchisement. As ATSC 3.0 receivers are likely to cost more than ATSC-1 receivers (at least initially), and manufacturers compete vigorously with each other on price, manufacturers are unlikely to manufacture ATSC 3.0 receivers without such signals already in the marketplace. The relatively low level of broadcast antenna use among viewers also influences manufacturers' decisions to introduce new products solely for broadcast service.

<u>Scenario 2. Full simulcasting of ATSC-1 and ATSC 3.0</u>
Definition: This is the transition scenario that was followed in the digital TV transition, whereby a second 6-MHz channel is used to transmit the new signal and both ATSC-1 and ATSC 3.0 channels would co-exist simultaneously. Once ATSC 3.0 receiver penetration reaches some acceptable threshold, the ATSC-1 transmissions would stop. This is the transition adopted in the Republic of Korea (South Korea) for UHD TV service that was introduced, starting in 2017 based on ATSC 3.0 standards, where five new 6-MHz channels were allocated nationwide by the Korean government for UHD TV transmissions by broadcasters.

Benefit: Maximum certainty of smooth transition. With each broadcaster able to provide simultaneous transmissions of both standards on separate channels, consumers would always have access to broadcast programming, yielding a smooth transition. During the ATSC-1 transition, a government subsidization program allowed viewers who had not updated to the new system to obtain low-cost converter boxes. There is no such government program envisioned for the transition to ATSC 3.0.

Disadvantage: Requires adequate spectrum resources for simulcasting. The amount of spectrum allocated for broadcasting was reduced as a result of the conclusion of the incentive auction, making this transition scenario largely impractical. In almost all areas, there will not be enough available unused spectrum to allow each broadcaster to use an extra channel for ATSC 3.0. However, in some rural and geographically isolated areas with a small number of broadcast stations, simulcasting may be possible.

<u>Scenario 3. Channel-Sharing ATSC-1 and ATSC 3.0 Scenarios</u>
Definition: This transition scenario has a high degree of consensus support from broadcasters and has been described in a number of forums. The original April 2016 Joint Petition for Rulemaking submitted to the FCC by broadcasters, consumer electronics and others presents it this way: "Stations electing to deploy Next Generation TV will enter into market-by-market deployment plans that will rely on local simulcasting agreements to ensure the ongoing availability of programming in the current digital TV format. Specifically, a temporary "host" broadcaster would agree to carry on its digital TV sub-channels the programming of those stations broadcasting with the Next Generation TV format. The "host" station's programming would be carried reciprocally as a programming stream on one of the stations deploying the Next Generation TV standard. Local simulcasting will permit uninterrupted service to continue as the American public embraces Next Generation TV reception equipment and will permit this innovative new standard to be implemented without necessitating new simulcast channels from the Commission." A form of channel sharing within the current standard has already been utilized in order for some stations to continue programming after relinquishing their spectrum during the auction.

The balance of how much data rate and how many channels to allocate for ATSC-1 vs. ATSC 3.0 is a variable in this transition scenario. The following concept of using a Lighthouse channel has been developed:

- *ATSC-1 Lighthouse.* A station that carries lower data rate versions of ATSC-1 signals maximizes the data capacity available for ATSC 3.0 while maintaining ATSC-1 service continuity.
- *ATSC 3.0 Lighthouse.* A similar case can be made for the Lighthouse concept to be applied by transitioning one or two channels to ATSC 3.0, while maintaining most of the market's payload capacity for the existing ATSC-1 service, in the amount and quality level experienced by consumers prior to the transition. The ATSC 3.0 Lighthouse station(s) would provide main programming from each of the participating stations in the new standard, perhaps with enhanced quality and new features afforded by ATSC 3.0.

Finding the right balance to provide enough capacity for the enhanced services ATSC 3.0 provides and offering enough capacity to maintain continuity of service via ATSC-1 is the key challenge. Without enough ATSC 3.0 programming, users will have little reason to migrate, which could prolong or stagnate the transition.

Benefit: Maximum practicality. This scenario takes into account the lack of additional spectrum available for broadcasters after the completion of the incentive auction and divides the existing spectrum resource for simultaneous provision of ATSC-1 and ATSC 3.0 services.

Disadvantage: Possible service degradation or reduction. In order to fit both ATSC-1 and ATSC 3.0 services into the existing spectrum now occupied solely by ATSC-1, several techniques are available:

- Employ the latest modern compression and statistical multiplexing equipment
- Use extra data capacity not currently being used in some ATSC-1 channels
- Reduce the ATSC-1 bit rate for some or all services
- Eliminate some ATSC-1 services
- Reduce the optimum bit rate new ATSC 3.0 services

Apart from the first and second bullets, the result will be some compromises on the number or the quality of the services provided. Carefully balancing these compromises to avoid consumer disappointment will be a priority.

<u>Scenario 4. Other Models</u>

It has become common to find Moving Picture Experts Group version 4 (MPEG-4) advanced video coding video decoders in newer TV sets. While the ATSC-1 standard as adopted by the FCC is based solely on MPEG-2 video encoding, it appears that many, if not all, manufacturers that have MPEG-4 decoders in their television sets will function if the over-the-air ATSC-1 signal is encoded with MPEG-4. No comprehensive survey has been done to quantify the actual percentage. It is possible to extrapolate that as older legacy sets are replaced with new TVs that include MPEG-4 decoders, MPEG-2 signals could be entirely replaced with MPEG-4 signals. Since the efficiency of MPEG-4 is on the order of twice the efficiency of MPEG-2, the recovered data capacity could provide significant additional data rate for ATSC 3.0 services in the channel-sharing model. This scenario is further challenged by consumer electronics companies stating they do not have MPEG-4 decoders in their broadcast receiver test scenarios, so while the TV may have an MPEG-4 decoder, they are unwilling to guarantee it will work in broadcast mode. Also, digital converter boxes from the ATSC-1 transition era generally do not have MPEG-4 capabilities. Additionally, this would require a rule change by the FCC since MPEG-4 is not part of ATSC-1.

Comparisons and Rationale

The full simulcast transition scenario would seem to be the most desirable transition scenario, but will not be a universally practical alternative due to a lack of availability of spectrum for the ATSC 3.0 simulcast channels. Simulcasting may be viable for a subset of situations where ample spectrum is available.

Similarly, flash-cutting from ATSC-1 to ATSC 3.0 will not be practical in a voluntary transition, due to inescapable mass viewer disenfranchisement. Flash-cutting may be possible for some stations toward the end of the transition if and when ATSC 3.0 receivers are highly dominant in the marketplace.

Channel sharing emerges as the most practical transition method among stakeholders. However, a cautionary note is that broadcasters, manufacturers and consumers could be caught in a dual ATSC-1/3.0 scenario for an extended period of time as the pace of this marketplace approach to the transition is somewhat unpredictable and may need to be reassessed as the transition continues. In addition, this scenario assumes a great deal of collaboration within and across industries.

Broadcasters need ATSC 3.0 receivers to be available in the marketplace in order to justify transmitting ATSC 3.0 programming. Manufacturers need compelling ATSC 3.0 programming available in order to justify the investment of manufacturing ATSC 3.0 receivers. Both receivers and transmission of enhanced programming need to be present in sufficient quantities for consumers to justify the increased cost of buying an ATSC 3.0 receiver. If these cross-industry needs are not met, the channel-sharing transition scenario may stagnate.

CHAPTER 4: CHANNEL SHARING IN DEPTH

Overview

The FCC Report and Order and Further Notice of Proposed Rulemaking 17-158, adopted on November 16, 2017 ("Authorizing Permissive Use of the Next Generation Broadcast Television Standard Television Service") does require some obligations by the parties that will share bandwidth to make this transition possible.

Since the Report and Order did not provide for additional bandwidth (channels) in each market to aid in the transition, each market must find a means to transmit the ATSC 3.0 standard, while retaining its legacy ATSC-1 digital service.

There is no single method that can be used in all markets, but the channel-sharing approach is applicable in most markets. This will require extraordinary coordination with the stations involved that likely have been fierce competitors. However, the ultimate goal is the improved service provided to all viewers as well the continued health of television broadcasting as a business.

The channel-sharing scenario addresses the realities that existing ATSC-1 service shall be maintained during the transition, no additional spectrum is available for the transition, and combining our existing standard with the new ATSC 3.0 standard is not possible within the same transmitter.

Channel sharing requires significant cooperation and properly structured business relationships among stations in a given market, but it is not very challenging technically.

Conceptually, the term channel sharing refers to one of two strategies, or some combination of both:

1. The ATSC 3.0 Lighthouse
    a. Most stations remain on the current standard, while volunteer station(s) change to the new ATSC 3.0 standard.

b. The stations remaining on the current ATSC-1 standard update their encoders if necessary and/or give up some sub-channel capacity in order to broadcast the ATSC 3.0 Lighthouse station's main programming. This will allow for maintaining the FCC requirement to provide their main content in the current ATSC-1 standard during the transition.

c. The ATSC 3.0 Lighthouse station(s) configure their payload capacity in order to carry the main programming of the other participating stations so that all participants are represented in the market with an ATSC 3.0 version of programming. As adoption of ATSC 3.0 grows, the balance of ATSC 3.0 and ATSC-1 stations can be adjusted, while maintaining FCC requirements for providing a legacy version of content.

2. The ATSC-1 Lighthouse

a. Most stations will switch to the ATSC 3.0 standard early in the transition period. One or two stations in the market remain on the legacy standard of ATSC-1 Lighthouse and make the necessary payload capacity accommodations in order to broadcast the main programming of the other participating stations.

b. As ATSC 3.0 stations come on line, they broadcast the ATSC-1 Lighthouse programming within their ATSC 3.0 payload, thus providing ATSC 3.0 content from each participating station during the transition.

c. As adoption of ATSC 3.0 grows, the balance of ATSC-1 and ATSC 3.0 stations can be adjusted, while maintaining FCC requirements for providing a legacy version of content.

Using either strategy provides both standards, the existing ATSC-1 and ATSC 3.0, to the market during the transition.

It is important to note that regardless of the strategy selected for a given market, over-the-air viewers will need to re-scan their TV receivers. Upon completion, their receivers will tune to the virtual channel of each station, thus channel branding for each station will remain undisturbed.

Specific market conditions, along with duopolies and SSAs will guide which strategy is used in a given market.

Tables 2 and 3 depict a market lineup prior to the transition, and then after adopting an ATSC 3.0 Lighthouse scenario.

Market Coordinator

Each market should consider obtaining the services of a market coordinator to assist in the coordinating and focusing the leadership required to accomplish this task. This position should be used to negotiate and help draft, with the aid of legal counsel, technical and business proposals for channel-sharing partners to find the right transition scenario for the specific market. This agreement must also ensure the partner coverage meets the FCC requirements as well as equally protecting business interests of all the participating stations.

ATSC 3.0 offers many more choices than our existing ATSC-1 standard. At least at the beginning of the ATSC 3.0 rollout, reaching a general agreement on specific ATSC 3.0 configurations across a market can be facilitated by a market coordinator. This should help in providing a more uniform viewer experience.

Coverage Considerations

If the host station's legacy signal is moved to another station, that station must provide coverage that is substantially the same as the original station transmission coverage.

Table 2. Pre-Transition

WAAA	Station A Main Channel	WAAA	ATSC-1
	Station A Sub Channel 1	Fun with Flags	ATSC-1
	Station A Sub Channel 2	Maynard Goes Sailing	ATSC-1
	Station A Sub Channel 3	The Dobie Gillis Channel	ATSC-1
WBBB	Station B Main Channel	WBBB	ATSC-1
	Station B Sub Channel 1	All About Cars	ATSC-1
	Station B Sub Channel 2	The Zelda Channel	ATSC-1
WCCC	Station C Main Channel	WCCC	ATSC-1
	Station C Sub Channel 1	Professor Proton	ATSC-1
	Station C Sub Channel 2	The Sleep Channel	ATSC-1
	Station C Sub Channel 3	Matlock vs the Sheriff	ATSC-1
	Station C Sub Channel 4	Nothing but Cheers	ATSC-1

Table 3. Station C becomes the ATSC 3.0 Lighthouse

WAAA	Station A Main Channel	WAAA	ATSC-1
	Station A Sub Channel 1	Fun with Flags	ATSC-1
	Station A Sub Channel 2	Maynard Goes Sailing	ATSC-1
	Station A Sub Channel 3	The Dobie Gillis Channel	ATSC-1
	Station C Main Channel	WCCC	ATSC-1
	Station C Sub Channel 1	Professor Proton	ATSC-1
WBBB	Station B Main Channel	WBBB	ATSC-1
	Station B Sub Channel 1	All About Cars	ATSC-1
	Station B Sub Channel 2	The Zelda Channel	ATSC-1
	Station C Sub Channel 2	The Sleep Channel	ATSC-1
	Station C Sub Channel 3	Matlock vs the Sheriff	ATSC-1
	Station C Sub Channel 4	Nothing but Cheers	ATSC-1
WCCC	Station C Main Channel	WCCC	ATSC 3.0
	Station C Sub Channel 1	Professor Proton	ATSC 3.0
	Station A Main Channel	WAAA	ATSC 3.0
	Station A Sub Channel 1	Fun with Flags	ATSC 3.0
	Station B Main Channel	WBBB	ATSC 3.0
	Station B Sub Channel 1	All About Cars	ATSC 3.0

As mentioned, the FCC in its Next Generation Television Report and Order imposes two requirements regarding coverage during this transition period:

1. The shared facilities of a legacy ATSC-1 Lighthouse station should replicate 95% of its original coverage and that of the other participating stations in the Lighthouse scenario. This is so market coverage in the current ATSC-1 standard is not significantly impaired. The FCC will likely accept a loss of coverage of up to 5% of the population of the market audience, but would be less likely to entertain waiver requests that have a larger loss in audience.
2. Any station that chooses to operate as an ATSC 3.0 Lighthouse must broadcast substantially the same content of their primary service in the new standard. It is likely that any broadcaster entering into an ATSC 3.0 Lighthouse agreement would want to replicate their legacy coverage area in the new service, although this is not mandated.

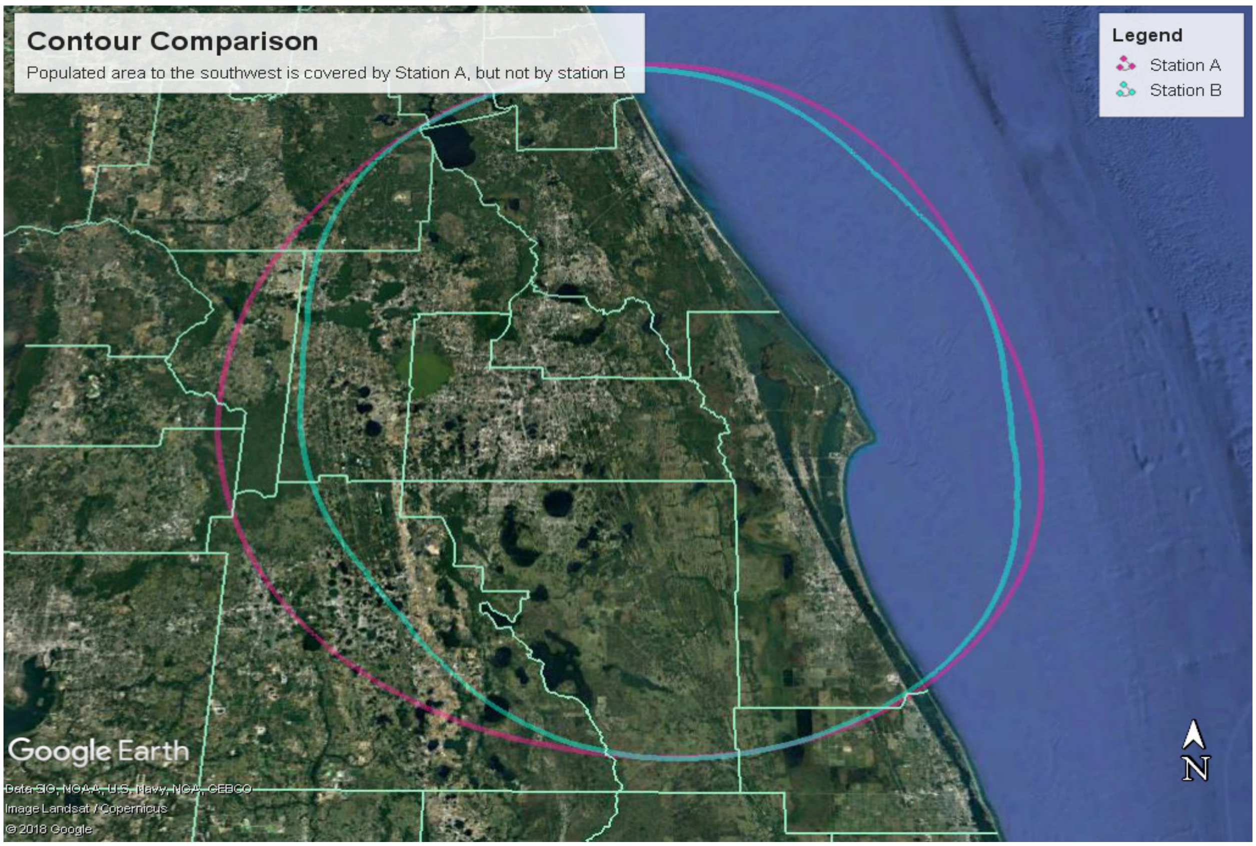


Figure 3. Example of two stations with similar but not duplicative coverage

ATSC 3.0 service is given more leeway in its requirements for duplication of coverage. There is a requirement for the primary ATSC 3.0 service to be a free service using modulation and coding that provides a signal to noise ratio (S/N) approximately equal (15.5 dB) to that of its legacy ATSC-1 signal.

Coverage patterns among full power stations in most markets are roughly equivalent, and finding a suitable host station will be relatively easy. However, other markets have stations with some overlap, but do not replicate each other (see *Figure 3*). In these specific cases, it may be challenging to find a host station that can be served by a legacy signal partner and replicate 95% of their original coverage. In some of these cases, the use of SFNs may provide a solution in an ATSC 3.0 Lighthouse scenario, as covered later in this guide.

The simulcast of ATSC 3.0 services must be substantially the same as the legacy ATSC-1 transmission in terms of program content. Small items such as commercials or promotional messages can be different, but the overall programming must be the same. The resolution and features of the services are also permitted to be different, such as high dynamic range video, possibly additional audio channels, or the addition of interactive applications. However, content should be substantially the same in program content as the station's legacy transmission.

Capacity Needs

As previously mentioned, during the initial years of the ATSC 3.0 transition, in most markets broadcasters will need to share a common channel or channels. If a transmission mode in the ATSC 3.0 standard (called modulation and coding) is used that approximately replicates the current legacy transmission S/N of 15.5 dB, it will constrain the usable digital payload capacity in a single ATSC 3.0 RF channel to approximately 25 or 26 Mbps.

At the same time, it is likely that most initial broadcasts will require ATSC 3.0 content at quality levels at least equal to or greater than their current legacy ATSC-1 content quality. In practice this can be achieved using HEVC, variable bit rate and statistical multiplexing. The rule-of-thumb is that HEVC is about four times more efficient than the MPEG-2 encoding used in ATSC-1.

Using this general rule of thumb, a single standard RF channel can easily accommodate four to five or more HD progressive-scan channels in ATSC 3.0 because of the greatly improved efficiency of its more modern encoding.

Inventory of Streams and Services

One of the most important requirements of the market coordinator will be taking an inventory of the currently available payload capacity of each station in a market. Any potential excess capacity needs to be evaluated. Evaluation should consider efficiencies that may be provided with any improvements in encoding and multiplexing at each of the stations that are part of the common transition planning.

For example, the displaced streams from the host station would be accommodated by the other market transition participants. This might require the displacement of several individual multicasts from the host station as well as the other participants in order to make room for the host station's main legacy HD telecast. Market partners that either own duopolies or share facilities in service agreements will make finding a spectrum clearing solution easier.

Through market-wide planning and the use of Program and System Information Protocol (PSIP), the identities of the individual streams will remain clear, despite being moved to other channels, once a market-wide re-scan of all viewer receivers has been completed.

In all cases, television broadcasting is the best platform to provide notifications to its viewers via its own promotional platform. No other medium provides a better platform to inform the audience about an impending change in a market. If done properly with plenty of advance notice, there should be little, if any, market disruption.

Market-wide coordination and MVPD communication is particularly important. Despite many market stations feeding their signal to cable head-ends via means other than over the air, generally MVPDs still use the over-the-air signal as a backup. Therefore, as these streams are moved, careful coordination with cable and direct broadcast satellite service is critical. It is required under current FCC rules for MVPDs to be notified 120 days in advance of such a move.

Optimizing ATSC-1

Regardless of the agreed upon transition scenario, the first step in enabling a transition to Next Gen TV is to optimize and clear spectrum in order to provide capacity for ATSC 3.0 services, while maintaining the legacy ATSC-1 service. To help make that happen, each station must look at how efficiently they are making use of the current payload capacity being used for their legacy digital service. Any capacity they can clear will help in hosting current services and thus clear the channel(s) required for Next Gen TV.

By updating existing encoding equipment, an ATSC-1 Lighthouse station may gain sufficient capacity to host legacy content for stations transitioning to ATSC 3.0. Similarly, ATSC-1 stations with updated encoding equipment will have more flexibility for carrying legacy program streams displaced by the ATSC 3.0 Lighthouse station.

The use of PSIP that currently resides within the legacy ATSC-1 signal, provides the legacy station's logical identity to all receivers and will be used to ensure that the viewers will be able to find their favorite services by the same virtual channel number, despite the possibility that the service has been moved to a different physical channel. This ability to move services to channels without audience disruption is the very basis of how the transition can be accomplished without additional spectrum allocations.

Host and Tenant Considerations

When a market partnership agreement is crafted, there needs to be a series of channel-sharing agreement(s) created to allow for the displaced services from the host and other stations to be legally bound. During that process there are several legal, FCC and capital ownership issues to be considered.

First, there are the channel-sharing agreements required for the primary HD signal and any multicast that will be required to be moved to free up the channel's payload capacity. This will require separate agreements between the broadcasters involved in addition to the required permissions from the networks and/or content owners involved. Additionally, as in the repack, and now part of the Next Gen TV FCC rules, the prime channel move must be authorized by the FCC.

Also, each partner must obtain FCC authorization for transmitting in ATSC 3.0. Fortunately, there is a streamlined method for obtaining this authorization as provided in the FCC Next Generation Television Report and Order.

Lastly, as part of the partnership agreement, there needs to be consideration about the ownership of all the equipment required to create a Lighthouse agreement. Some of the equipment will be unique to each station's use (as in encoding). However, much of the equipment will be used in common (as in packaging, route/guide building, broadcast gateway, exciter, transmitter, transmission line and antenna).

Additionally, common-site continuing costs will need to be included in all agreements. These include power, rent, equipment maintenance, etc.

Each licensee will be independently subject to all of the FCC's obligations, rules, and policies. The FCC retains the right to enforce any violation of these requirements against one, more than one, or all parties to a channel-sharing agreement. Because of this and other complexities involved in channel sharing, consideration should be given to reciprocal hold-harmless clauses in relevant agreements between licensees.

Single Frequency Network Considerations

Broadcasters will have the option to build SFNs for ATSC 3.0, which can improve existing coverage, particularly for more robust indoor and mobile device reception. The decision to add optional SFNs can be made at the start or after the initial rollout of ATSC 3.0 in a given market.

While broadcasters are sharing facilities for the transition to ATSC 3.0, the use of SFNs is possible in any Lighthouse scenario.

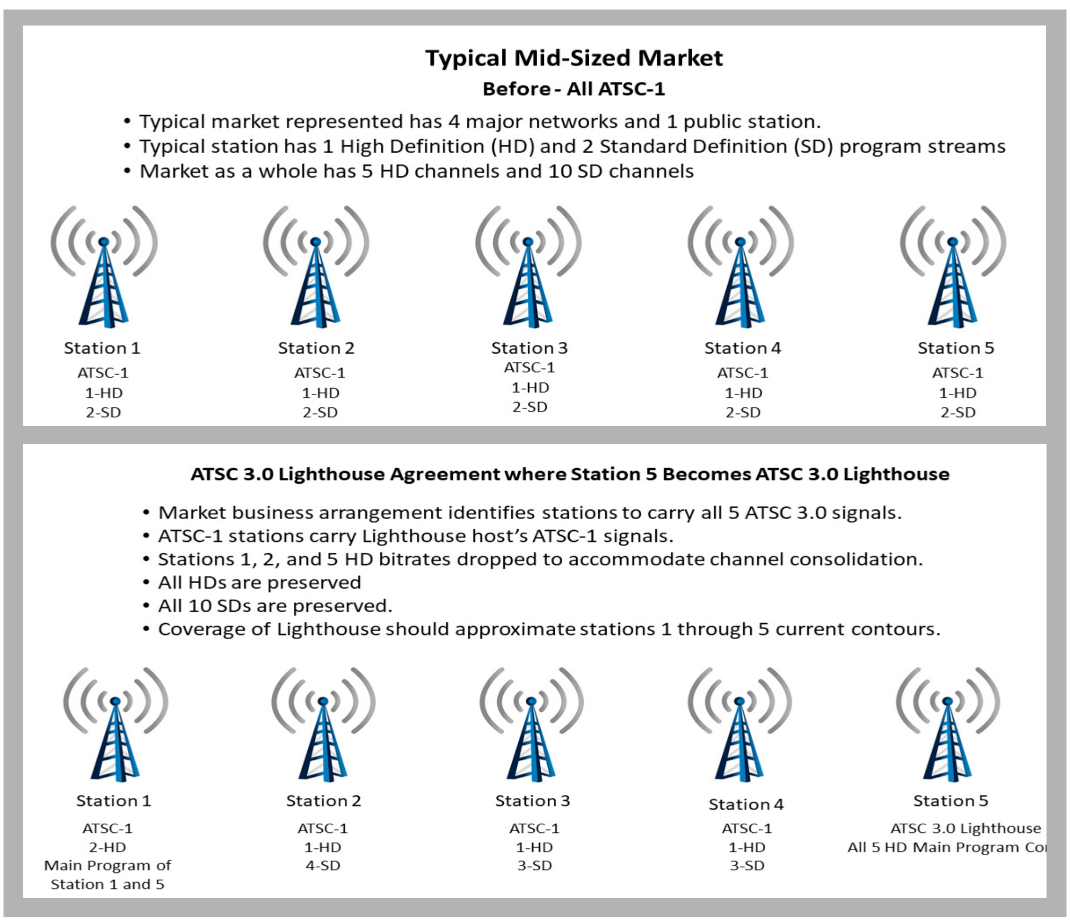
Since SFNs do not require additional spectrum, they provide a potential solution for ATSC 3.0 coverage issues in a channel-sharing market with poor partner-station coverage overlap or to provide better local signal levels near the edge of the market coverage.

As with some of the equipment that would be required in a single Lighthouse transmission facility, a local agreement will need to be created to cover the design, installation, legal and equipment ownership costs of a shared SFN. Additionally, there are likely to be ongoing operating costs associated with vertical and land rent, power, support and connectivity.

Any market partnership should consider the possibility of a future SFN while creating its initial partnership, even if it is not targeted to begin service at the start of the transition. Thinking ahead about this possibility, even if it is remote when the partnership agreement is created, removes a potential future barrier when the decision eventually needs to be made in earnest.

Example: ATSC 3.0 Lighthouse Scenario

The goal is to free the capacity of at least one channel (possibly more in a larger market) to provide space for the new Next Gen TV services. Fortunately, the new ATSC 3.0 services require less payload per service, so depending on service requirements (quality and coverage) five or more current HD services with similar coverage and quality are possible within a 6-MHz channel, as seen in *Figures 4a and 4b* depicting an ATSC 3.0 lighthouse scenario.



Figures 4a and 4b

SECTION 3: MARKET BUILDOUT

CHAPTER 5: HOW TO BUILD OUT ATSC 3.0

Once a decision to convert to ATSC 3.0 has been made, careful consideration must be given to the entire transmission path, starting at the antenna, and working back to the program stream generation point.

Upgrading from ATSC-1 to ATSC 3.0 is a task that involves many players. It is recommended to get all vendors involved early in the planning process.

Note: If you are a repack station, the incremental out-of-pocket cost of making upgrades now will be significantly lower than making them later.

Considerations for Proceeding

Antenna Contours

The signal contours of stations in any given market are often different, depending on licensed power, location of tower, interference protection and other factors. In a channel-sharing agreement, the ATSC-1 signal should replicate 95% of the original service (according to the FCC Report and Order), thus requiring a comparison between contours of participating stations.

Lighthouse Choices

In a given market, the number and operating band of post-repack stations, along with the emergence of a clear Lighthouse candidate for ATSC 3.0, may impact the degree of ATSC 3.0 readiness to invest in now. **The most significant considerations are in tower related items, since a post-repack upgrade will essentially double those expenses for stations that are impacted by the repack.**

Duopoly Status

For an entity that has two stations, ie, a duopoly or SSA in the same market, this situation allows the stations' owner to utilize one of the two channels as its Lighthouse station. Clearly, this solves a cooperation dilemma that is foreign to most broadcasters. If either or both of the duopoly or SSA channels are repacking, this gives the potentially added incentive of new equipment from which to build the ATSC 3.0 systems. Consideration must be given to maintain equivalent coverage contours.

Upgrading the Physical Plant

Making your tower, antenna and transmission line ready for ATSC 3.0 are major considerations for repack stations because the incremental cost of structural work is likely to be significantly lower than a later upgrade.

Tower

The structural condition and capacity of your broadcast tower is the starting point for any change to your antenna and/or transmission line. Any change in antenna or transmission line will require a structural analysis and, potentially, structural work to the tower, in order to support changed equipment.

If you lease space on a tower, your provider will be able to determine the extent of work required.

Antenna

Existing antennas operating at their maximum power limit on ATSC-1 may not be capable of handling the additional peak-to-average ratio (PAR) needed for ATSC 3.0.

Since the ATSC 3.0 standard is tailored to both over-the-air broadcast and delivery of data and secondary content to mobile devices, one must consider the mobile market. Adding vertical polarization (V-pol) to the broadcast signal greatly increases reliable reception in mobile and other devices, both indoors and outdoors. However, V-pol necessitates more transmitter power, which affects all aspects of the RF path.

Another option to consider is adding null-fill to better serve densely populated areas, but this diminishes coverage in the outskirts for a given power level. This option is more viable if SFNs are installed in the outskirt areas, should population density warrant it.

Transmission Line
Just like antennas, if the transmission line is operating at or near its rated capacity with an ATSC-1 signal, it will most likely need to be replaced to carry the ATSC 3.0 signal. The new transmission line power capacity is determined based on the added power requirements of ATSC 3.0, as well as the additional power required to drive any added antenna V-pol or null fill.

Mask Filter
One of the prerequisites for the FCC approving the ATSC 3.0 standard was that it must meet the same emission mask requirements as ATSC-1. The occupied bandwidth of an ATSC 3.0 signal is slightly wider than an ATSC-1 signal, but most current filters are able to pass the specifications. However, if an ATSC-1 station currently operates with a sharp-tuned mask filter, the filter may need to be upgraded to handle the additional peak-to-average power. Keep in mind if transmitter power output (TPO) is increased to add V-pol to the antenna or to make up for the difference in PAR while keeping the same effective radiated power (ERP), the mask filter must be capable of handling the additional power.

Transmitter
If the transmission plant was installed when the station transitioned from analog to ATSC-1, several pieces of equipment will most likely have to be upgraded or replaced in order to pass the ATSC 3.0 data stream. **This also holds true for repack transmitters that were retuned rather than replaced.** The following factors must be considered when planning an ATSC 3.0 upgrade.

There is a 2-dB power difference between the PAR of an ATSC-1 8-VSB modulation and an ATSC 3.0 OFDM modulated signal. If the transmitter was sized to operate efficiently at the assigned TPO and ERP for ATSC-1, there's a good chance it won't produce enough power or meet linearity specifications for ATSC 3.0. You may be able to add additional power amplifiers; otherwise, the transmitter will have to be replaced. Keep in mind if you can add additional amplifiers, the reject loads and other ancillary equipment may have to be upgraded as well. For repack stations, some transmitter manufacturers 'de-rate' their specifications in anticipation of an ATSC 3.0 upgrade. It is important to check with your manufacturer about this when specifying transmitter power requirements.

Adding V-pol percentage means the transmitter power must be increased as well if you want to maintain the same ERP. Adding 30% V-pol means a 30% increase in transmitter power. Remember the FCC assigned ERP is based on horizontal polarization (H-pol) only, so you may add V-pol up to the limit of your H-pol FCC authorization.

Exciter
Since ATSC 3.0 content is delivered via IP and ATSC 3.0 uses OFDM instead of 8-VSB modulation, earlier exciters are not compatible. Some of the exciters manufactured recently are software based and can be upgraded, but others will have to be replaced (*Figure 5*). It is best to check with the manufacturer early in the planning phase. Refer to Appendix F for examples of ATSC 3.0 transmission settings.

Layer division multiplexing (LDM) consists of a lower data rate but more robust modulation and coding configuration injected at a higher power level, plus a higher data rate but less robust configuration

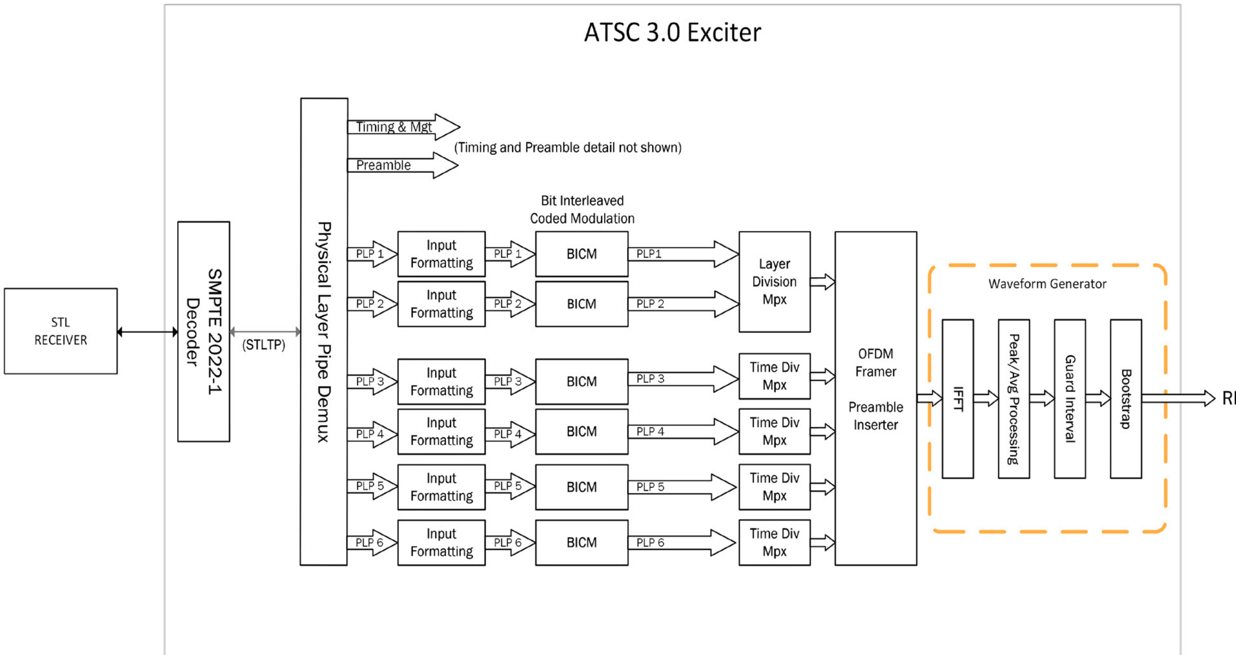


Figure 5. Example of an ATSC 3.0 Exciter using 2 Layer Division Multiplexing (LDM) Physical Layer Pipes, and 4 Time Division Multiplexing (TDM) Physical Layer Pipes

injected at a lower power level. This technique maximizes bandwidth and it can be employed on two PLPs while time or frequency division multiplexing techniques are employed on the remaining PLPs *(Figure 6)*.

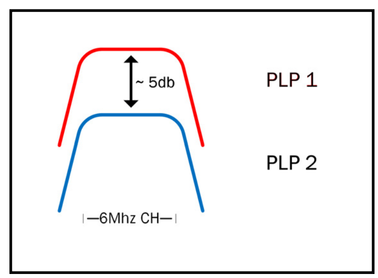


Figure 6

Broadcast Gateway and Studio-To-Transmitter Links (STL)

The Broadcast Gateway is a new concept with ATSC 3.0. It combines live and non-real-time content, advanced emergency alerting, program guide, program-related data and control data, and then produces an IP stream called the STL transport stream (STLTP), which can be deployed by a Society of Motion Picture and Television Engineers (SMPTE) 2022-1 compliant microwave and/or fiber equipment (*Figure 7*). Existing ATSC-1 STL systems are not compatible with ATSC 3.0.

While planning the STL upgrade, remember that you still need to keep an ATSC-1 STL operational, and depending on how your market addresses the transition, you may need to provide STL links to your channel-sharing partner(s). Direct feeds to MVPD providers should also be considered, keeping in mind the provision of the correct ratings watermark to all feeds. **STL considerations are common to repack and non-repack stations.**

Auxiliary Transmission Systems

Many stations have backup transmission systems. One must consider what to upgrade in the auxiliary system. All of the above items usually apply with auxiliary systems, but at lower power levels.

CHAPTER 6: SINGLE FREQUENCY NETWORKS (SFNs)

Description

SFNs are multiple transmitters emitting the same content on the same frequency at the same time. As long as the various signals, and their echoes, arrive at the receiver within the OFDM guard interval,

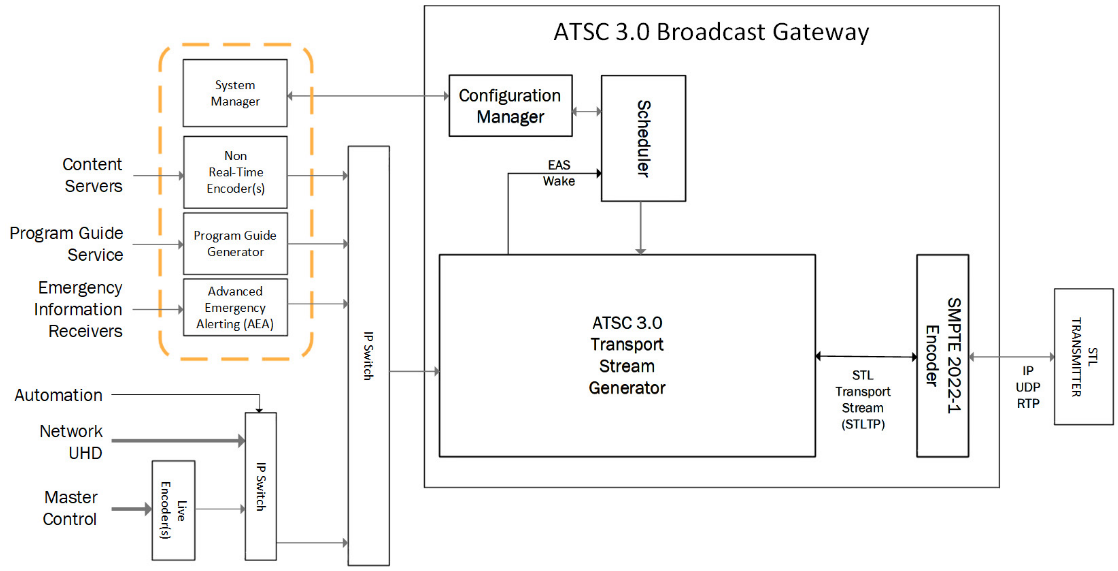


Figure 7. Example of Broadcast Gateway

then the reception is enhanced. Outside the guard interval, and of sufficient amplitude, SFN signals can lead to destructive self-interference that will actually decrease signal levels. SFNs can help provide more uniform signal strength throughout the service area, which may ultimately be necessary for phone manufacturers to install ATSC 3.0 chipsets in their smartphone and tablet devices, and for automotive manufacturers to install consumer gateways in vehicles. In the older ATSC mobile handheld system, signals were not consistent throughout the DMA for most stations and resulted in poor reception. ATSC 3.0 SFNs can provide geographical diversity, in that the receiver "sees" multiple signal sources from different directions. It can create a much wider deployment and solve difficult terrain-related signal issues in a particular DMA.

The efficient use of SFN technology in ATSC 3.0 is made possible by the OFDM modulation scheme. The OFDM modulation and coding in ATSC 3.0 has over 40,000 possible configurations, of which only a small subset of those will probably be used to transmit the ATSC 3.0 signals. We can use SFNs to supplement a station's main ATSC 3.0 signal and thereby improve service, increase over-the-air audience, and enable new revenue sources, including better reception by mobile and portable devices and 5G-type data delivery. An SFN will allow reliable mobile reception at highway speeds, and it will be IP-based. It will give the opportunity for targeted advertising, conditional access, and is scalable/configurable/adaptable. In order to take advantage of these new services we need to ensure strong reception throughout service areas; thus, SFNs will be necessary to maintain a higher signal level throughout all areas of a DMA, including highly populated interstate highway corridors. It is well documented that a signal of 73 dBu or more is necessary for mobile/portable and indoor reception. In order to achieve this high level of high RF penetration and keep the ATSC 3.0 service quality similar to ATSC-1 and its bit rates above 25 Mbps, SFNs will definitely be necessary.

Content delivery to portable/mobile devices is one of the most attractive and important elements of ATSC 3.0. Many broadcasters who intend to adopt ATSC 3.0 as their new broadcast standard share this view. Reliable reception by relatively small antennas becomes a priority which, in turn, requires better and more uniform distribution of signal throughout the stations DMA and possibly beyond. ATSC 3.0 is OFDM-based, which facilitates the deployment throughout a given DMA of multiple transmitters operating on the same frequency as the main transmitter. The inherent guard interval, added to the start of each symbol, is the enabling OFDM feature that permits SFN deployment. SFNs consist of multiple transmission sources, possibly five to seven additional sites in any given market, using the same content on the same frequency. Multiple signals from multiple incidence angles dramatically improves the probability of reception. There is wide deployment throughout the world for these types of OFDM-based SFNs, especially in Asia and Europe. The success of these networks is well documented.

In order to deploy an ATSC 3.0 system in a particular market, a channel-sharing agreement, as described in Chapter 4, must first be implemented. This cannot be accomplished by using existing ATSC-1 signals or combining both. Stations within a market must agree on their SFN goals. Do they want better reception for UHD 4K/fixed/mobile/indoor reception? If so, the SFN must be initially designed for this type of service reception and probability. Development of accurate propagation models are thus essential, much like in a cellular type-based system. Field strength alone is not sufficient. Robustness, or the probability of good signal reception over time, is critical. Remember that ATSC 3.0 has over 40,000 possible configurations. The use of sophisticated software tools to design and optimize the SFNs is essential.

Since FCC rules allow stations to operate SFNs within their theoretical maximized contour and/or their table of distances circle, it is possible to merge the main station's coverage area with those of associated SFN transmitters, forming a coverage polygon that will be called the allotment area. The allotment area is used to constrain every SFN transmitter's contour. We start the planning process by selecting candidate transmitter sites and entering ERP and height above ground level values for omni-directional antenna. Tower sites are then chosen that can also be used to fill in the contours at a later time by using them as "gap fillers". There is also the possibility being discussed of extending these allotment areas outside of DMAs in order to connect hyphenated DMA or highway corridors for national reception. This will require further testing and FCC rule changes and new agreements with networks on sharing their content.

The cost of creating a SFN network can be millions of dollars for each site and DMA. Most stations will collaborate with other stations in the market to share these facilities and to lower costs. Some third-party companies are planning turnkey SFN sites, and the stations that participate will only be required to pay monthly use fees that will ramp up over time as new businesses mature using this technology.

Figures 8 through 10 show a real world example of how an SFN in San Francisco was developed and how it significantly increases the ATSC 3.0 over-the-air coverage in a difficult RF environment.

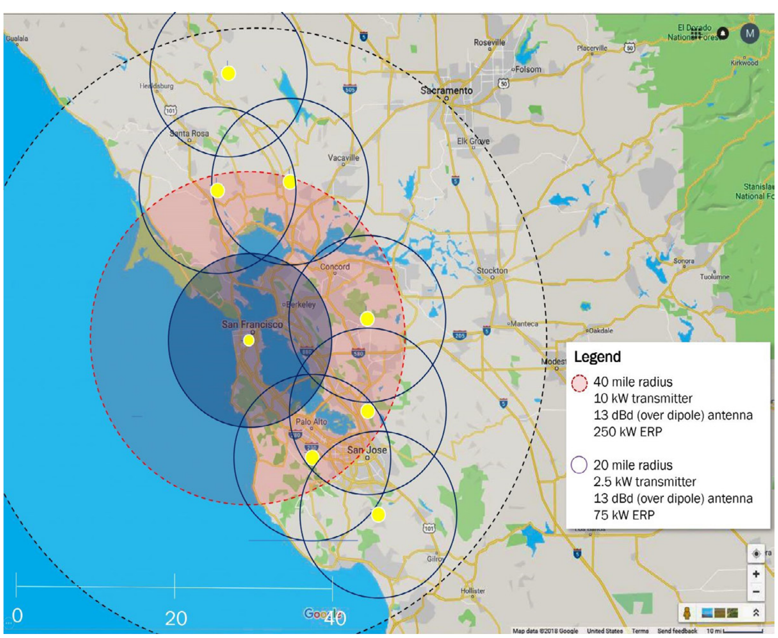
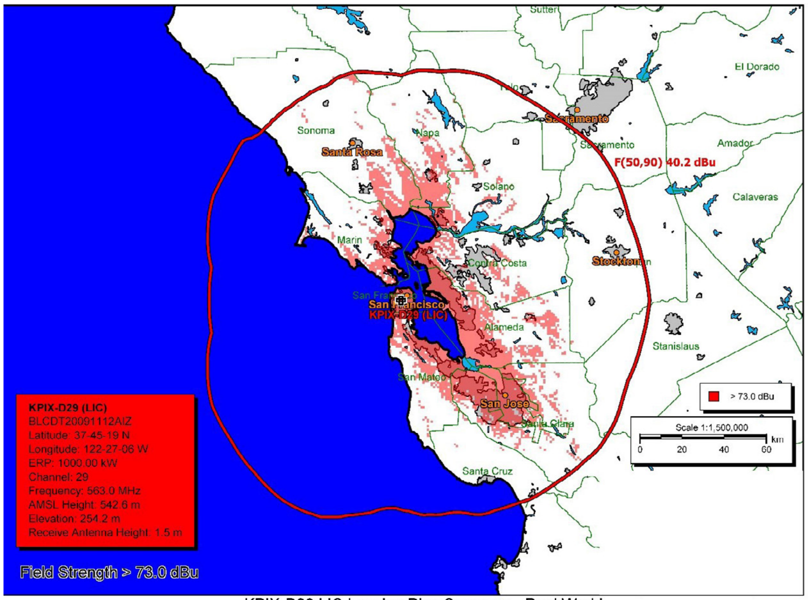


Figure 8

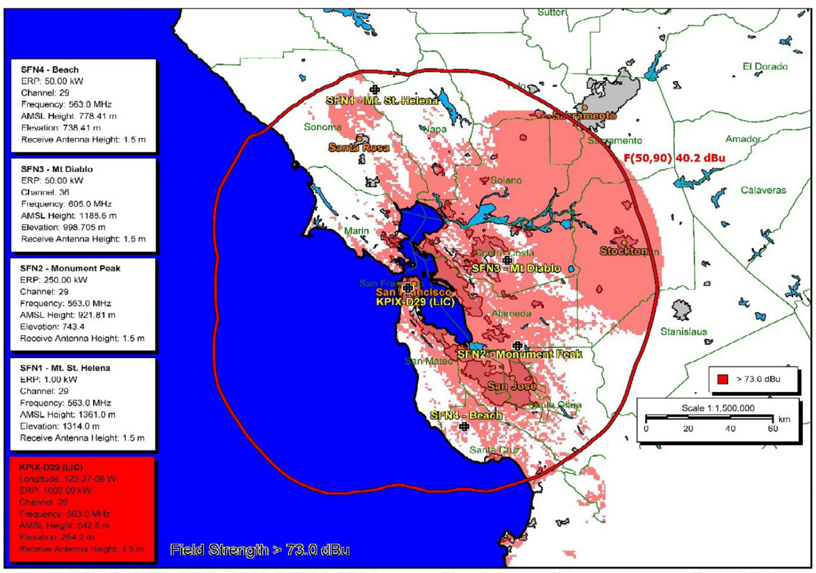
Figure 8. In San Francisco, the first step was to identify the existing tower sites that would be available for SFN transmitters. The distance between these sites determines the ATSC 3.0 parameters that the engineers will use to determine the best network design.



KPIX-D29 LIC Longley-Rice Coverage - Real World

Figure 9

Figure 9. In San Francisco, TV signals are limited by terrain. The real-world coverage of a current, single transmission site channel is shown based on signal levels that are greater than 73 dBu, which is widely accepted as the minimum signal for mobile, hand held, and indoor reception. Only about one-third of the homes in the DMA now get this signal level or better.



KPIX-D29 LIC, DTS1, DTS2, DTS3 & DTS4 Longley-Rice Coverage (Strongest Server) - Real World

Figure 10

Figure 10. With just four SFN sites, the signal density of the same station is much improved and over 80% of the homes in the DMA will receive signal greater than 73 dBu. More SFN sites will likely be added in the final design.

Role of Guard Intervals in SFN Deployment

Consider two signals, both on the same channel, arriving at a vehicle. In our example drawing (*Figure 11*), the signal from transmitter 2 arrives slightly earlier. The difference in arrival time can be addressed by building a Guard Interval into the signal that is broadcast from both transmitters. In the drawing, distance 2 is the main (shortest) path. If the time difference between both signals is less than the guard interval setting entered into the transmission system, then the two signals can work together to improve reliability of the received information. The actual value of the guard interval determines the maximum allowed spacing between transmitters. The length of the guard interval detracts from the data capacity of the channel. The longer the guard interval, the lower the data capacity.

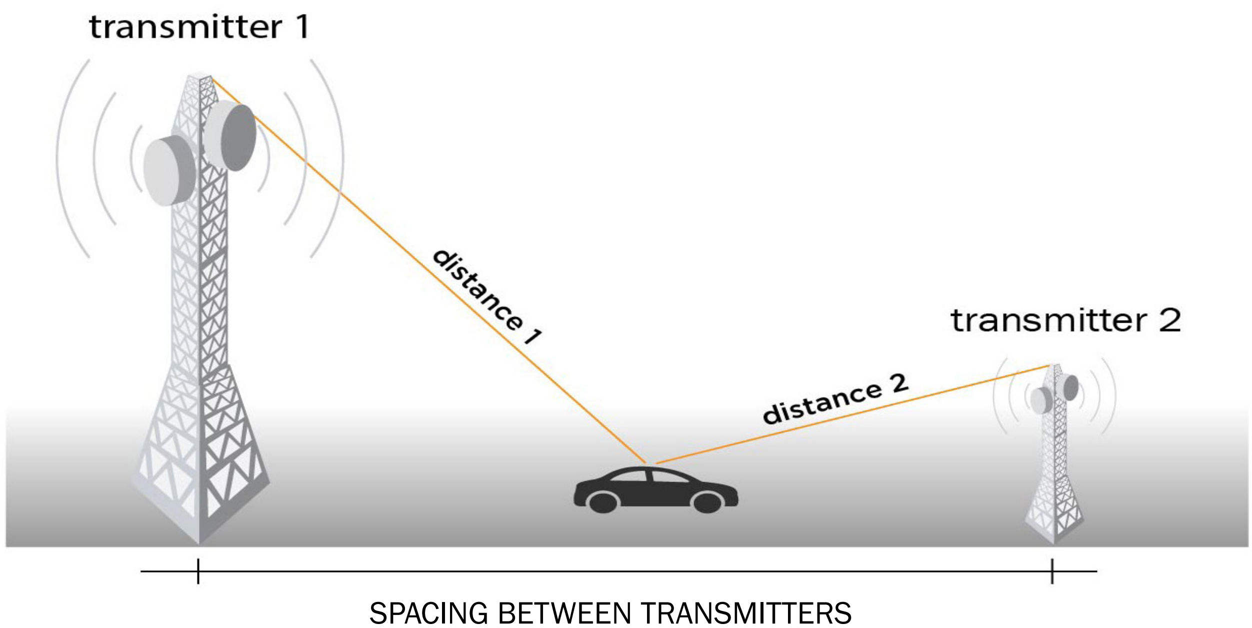


Figure 11

CHAPTER 7: COSTS ASSOCIATED WITH CONVERTING TO ATSC 3.0

Figure 12 is an example of an ATSC 3.0 transmission system. When estimating the costs to implement ATSC 3.0 there are several areas to consider:

- Base Costs
- New Features Costs
- Transition Considerations

Base Cost

Base Costs items are meant to be those required to enable the ATSC 3.0 platform. These costs do not include those of making a station or market-coordinated conversion for any new services.

All costs illustrated are meant to be ballpark ranges for planning purposes and not suitable for defining actual budgets.

A typical broadcast chain has several sections that will need to be converted to handle IP-based data streams rather than transport streams and the HD-SDI format so pervasive in today's broadcast studio infrastructure. Antenna, tower and transmitter equipment may need to be upgraded.

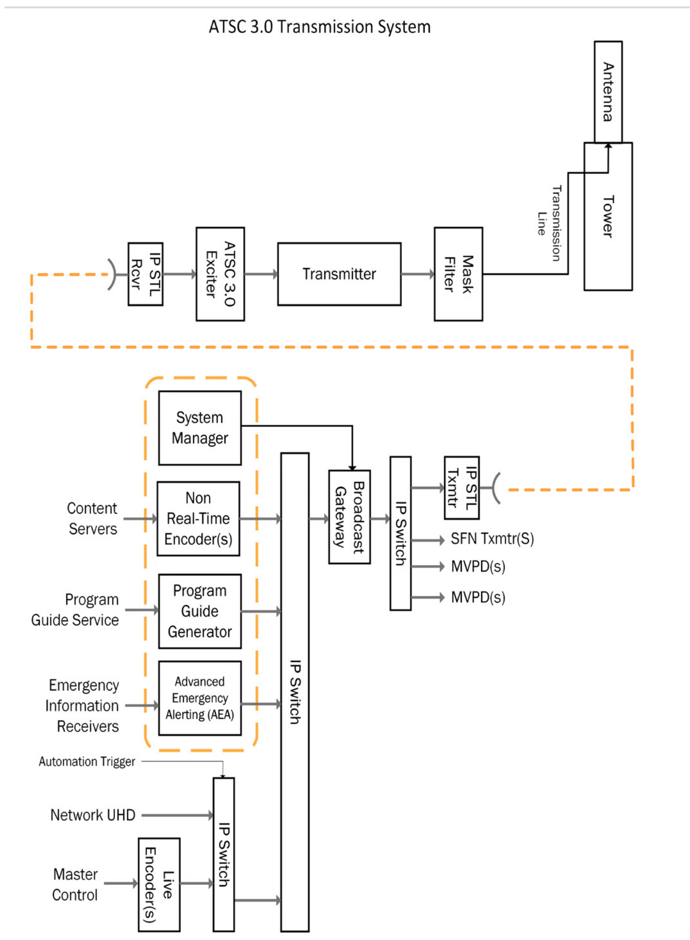


Figure 12

Several factors impact base costs. The amounts shown in *Table 4* are estimates based in part on FCC Repack Guidelines found here: https://www.fcc.gov/sites/default/files/Widelity%20Report.pdf

Table 4.

Item	Description	Cost Range	Notes
Tower Structural Study	Tower integrity	5,000 - 16,000	Needed if any antenna or line modifications are made
Antenna Change	Addition of vertical polarity	125,000 - 300,000	If not already incorporated in existing
Transmission Line Upgrade	Handle increased power	96,000 - 327,000 (based on 1,000')	Only if V-pol is added
Tower Upgrade	Structural work	160,000 – 1,300,000 (includes rigging)	If needed based on above
Mask Filter	Handle increased bandwidth	6,000 - 90,000	Only if sharp tuned filter
Transmitter	Handle increased power	250,000 - 1,075,000 (Solid State)	Depends on existing transmitter power rating and licensed ERP
Exciter	ATSC 3.0 capable	20,000 – 45,000	May be included with newer transmitters
STL Transmitter/ Receiver	Change to IP-based system	130,000	Existing STL needs to be maintained as well
Broadcast Gateway	Converts to ATSC 3.0 standard	50,000 – 75,000	Encapsulates data and works with ATSC 3.0 exciter
IP Equipment	Glue to connect everything	25,000	Specified for applicable protocols and speed
UHD Net Pass-Through	Depends on how network delivers UHD material	10,000	UHD pass through without MC upgrade
Live Content Encoders	HEVC standard for each program stream	75,000 – 150,000	Improved efficiency, compliant with 3.0 standard
System Manager	Handles setup and monitoring of system	50,000	Some or all of the following items may be combined into the system manager hardware
Non-Real-Time Encoders	For optional second screen and apps	5,000	
Program Guide Generator	Program schedule insertion	5,000 – 8,000	
Emergency Alerting	ATSC 3.0 Standard	5,000 – 8,000	Opportunities for picture in picture, device wake up, etc.
System Integration	Contractor to install and test	10,000 – 25,000	
FCC and Legal	Filing fees, consultant, etc.	5,000 – 7,500	

New Features: Building from the Base Configuration

Assuming the above systems are in place, you can now transmit on the new platform. At this stage you should carefully consider the new services to be deployed and those utilizing back channel data paths, which require IP connectivity back to the content origination point. As additional services, using the new platform come into play, we must next add in the IP distribution chain *(Figure 13)*.

While it is yet to be determined when the new services will be rolled out widely within the broadcast industry, you can consider some features that could differentiate you in a market or as a company.

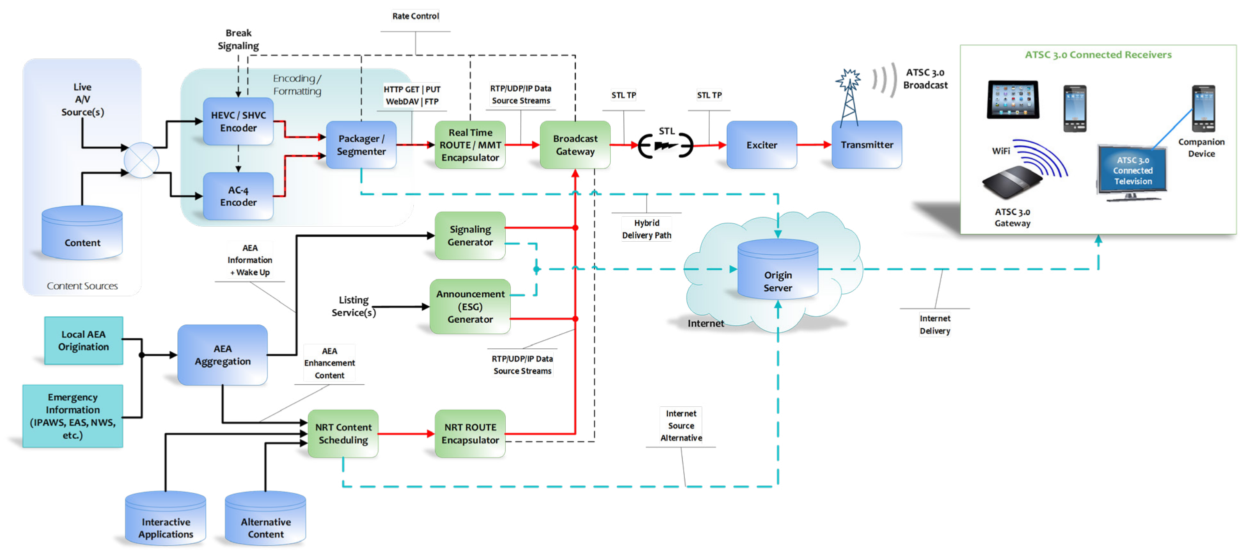


Figure 13. Example of ATSC 3.0 New Features

Some examples to consider:

- Advanced Emergency Information Systems
- Local Studio Production:
    - Capital cost for converting news studio to HD 60p or 4K UHD TV
- News Production:
    - Capital cost for converting electronic news gathering/satellite news gathering trucks to 4K UHD TV
    - Capital cost for newsroom/Control room workflows
- Single Frequency Networks:
    - Capital cost for a single SFN site
    - Operating expense for SFN site including: AC power, HVAC, fiber circuits, building rent, tower rent, security systems, remote control, depreciation, taxes, maintenance

Transition Considerations

Costs will vary depending on the amount of cooperation in your market, the Lighthouse scenario chosen and operating expenses for legal, marketing coordinator, shared capital and operating costs. Some specifics include the following:

- Upgrade of existing encoders to increase channel capacity
- Broadcast gateway and STL upgrades/additions
- Shared build-out and operating expenses for Lighthouse
- Public relations expenses
- Shared costs of optional SFN deployment

SECTION 4: CONCLUSIONS AND APPENDICES

CHAPTER 8: CONCLUSIONS

When our current ATSC-1 system was launched over 20 years ago, Mark Zuckerberg was a young teen. Nobody knew what an iPhone was. Netscape was the browser of choice, and the compact disc was in. It seems like only yesterday to many of us, but a lot has changed since the era of cordless phones.

Advances in technology foster advances in entertainment and information. Facebook, Twitter, and instant messaging have taken over our lives. YouTube, Google and Amazon are household names. Cable TV is feeling the heat, and so is broadcasting.

But all is not doom and gloom. **Standard TV viewing is at 3 hours and 10 minutes per day. Reach is at 91.3%.** More time is spent watching screens, big and small, than ever before, and everything about anything is at just about everyone's fingertips.

Over-the-air broadcasting can take the next step in providing untethered services and UHD video with theater quality sound all wrapped up in the same signal. Second screen and advanced emergency information can be delivered to anyone with a device, regardless of their data budget. All of this and more continue to grow the value of our spectrum and our licenses.

Next Gen TV is designed and built from the ground up to be flexible, extensible and upgradeable. By adopting the same technology that powers the internet and marrying it with the technology that make today's wireless environment possible, we will build the best of the best into a system that is competitive with today's and tomorrow's communications revolution.

But the journey is never easy or simple. Challenges lay ahead. The next step is complicated and it's voluntary, but the potential is great.

Hard business decisions are in our futures, and specific market conditions are a bigger factor than ever before.

Next Gen TV - The Next Generation of entertainment and information delivered with no strings (or wires) attached. Coming soon to a device near you, as we meet the challenges of tomorrow.

APPENDIX A: EXECUTIVE SUMMARY

What is ATSC 3.0?
ATSC 3.0 is a major upgrade and expansion of our existing over-the-air broadcast platform.

Unlike the move to ATSC-1, adoption of ATSC 3.0 is voluntary, and it is not backwards compatible with our existing ATSC-1 standard.

What makes ATSC 3.0 TV Different?
The core difference is the framework around which it is built. There are two main components of the new framework:

1. It is based on IP, which is the same protocol used to power the internet.
2. The way the signal is modulated is a robust, proven technology found in cellular telephone architecture and in other broadcasting standards around the world.

The new framework makes several advanced features available, including the following:

1. UHD TV and beyond, with immersive audio, a wider color palette which brings out even the subtlest color shades, and high dynamic range video which significantly increases the shades between dark and light.
2. Dynamic Scaling, providing different combinations of quality vs. signal robustness within the same broadcast. This same concept is used when you stream a video on your smart TV or wireless device.
3. Data streams within the signal to supply second-screen applications.
4. Advanced life-safety services, including the ability to signal first responders and to wake up your TV or smart device in the event of an emergency.

Pros and Cons – Cost
Costs vary by several factors, most notably repack status and market specifics.

<u>The Population Shape of Your Market</u>
For both repack and non-repack stations, population density in relation to your transmitter location can be a factor to consider. For example, consider maximizing your contour for ATSC 3.0 if your population distribution warrants it.

<u>Repack Stations</u>
If you are a repack station, a relatively small incremental investment to upgrade your transmission system during the repack can make you Next Gen TV ready. The investment includes:

1. Adding some V-pol to your new transmitting antenna.
2. Increasing the power rating of your new antenna and transmission line if necessary.
3. If transmitter replacement is called for to make you whole in the repack, then upgrades in power rating and an ATSC 3.0-compatible exciter is worth considering.

Remember, repack reimbursement only covers what is necessary to make you whole based on your pre-repack facility. However, depending on your specifics, the additional power needed for ATSC 3.0 may be within the ratings of available transmitters and antenna systems, thereby limiting the incremental expense involved.

Non-Repack Stations

If you are not a repack station, factors that determine cost include:

1. Transmission system considerations include the addition of V-pol, null fill and the ability of your existing system to handle the power increase required (transmitter, filter, line, antenna.)
2. Condition and ownership status of tower.

Infrastructure

While network pass-through of UHD material may be the most logical starting point for most stations, factors to consider for syndicated programs and local production include:

1. Status of your STL
2. Central-casting status (Master Control, Traffic, Graphics)
3. Age of facility
4. Opportunity to migrate to an IP-based workflow
5. Virtualization of some studio workflows

Pros and Cons – Rollout

Because the transition to Next Gen TV is voluntary, and the FCC will not allocate additional channels to facilitate the transition, several scenarios have been developed. At this time, the most popular scenario utilizes a channel-sharing plan as a way to move forward. At its core, this plan requires sharing existing payload capacity between stations in the market. Features of the existing ATSC-1 standard allow virtual channel info to move with services, thereby protecting branding, marketing and channel position once consumers re-scan their sets.

Factors to Consider Include:

1. The ability for your market to cooperate with competitors
2. Similarity (or lack thereof) of coverage patterns among the stations in the market
3. The placement of a market coordinator
4. The number of duopolies and SSAs
5. A fallback plan should Next Gen TV adoption stagnate
6. Distribution rights and minimum required bit-rates in some agreements
7. Patent clearances for Next Gen TV technologies.

The Chicken-and-the-Egg Factor:

1. Adoption and rollout of the ATSC 3.0 standard by consumer equipment manufacturers
2. Availability of UHD programming

APPENDIX B: ATSC 3.0 PLANNING CHECKLIST

Item	Comments
Are you a Repack station? ☐ Yes ☐ Physical Post-Repack ☐ Channel ______________ ☐ No ☐ Physical Channel ______________	Repack stations should consider adding ATSC 3.0 incremental upgrades to Antenna, Line and Transmitter at time of repack. UHF (14 and above) Most suitable for mobile and smart devices. High-band VHF (7 – 13) Suitable for fixed. Mobile and smart devices may be reached through consumer WiFi gateways. Low-band VHF (2 – 6) Suitable for fixed with external antenna.
Other TV or Radio Broadcasters on Tower? ☐ Yes ☐ No Tower Condition ☐ Good ☐ Fair ☐ Poor	Considerations of planning and cost of tower modifications, and work that may be necessary to add V-pol to radiated signal, which will enhance reception to mobile and smart devices.
Holes in Coverage area (Terrain/Urban clutter)? ☐ Yes ☐ No	May benefit from SFNs which are feasible in ATSC 3.0. These are most effective on UHF channels.
Translators or LPTVs? ☐ Yes ☐ No	May be possible to replace or augment with SFN. Conversion cost and timeline considerations.

Do you have an Auxiliary Transmitter Facility?
☐ Yes
☐ Co-Located with Main?
  ☐ Yes
  ☐ No
☐ No
	Cost considerations to convert. May help to facilitate any needed tower work, especially if not co-located.

Are you part of a Duopoly or SSA?
☐ Yes
☐ Do both stations have similar coverage contours?
    ☐ Yes
    ☐ No
☐ No
	Consideration for determining Lighthouse options in order to maintain substantially similar programming and 95% replication of ATSC-1 (current) coverage.

Are all the transmitters in your market in the same area? ☐ Yes ☐ No Do all the stations in your market have similar coverage contours? ☐ Yes ☐ No	Considerations for Lighthouse options. If an ATSC-1 Lighthouse scenario is used, then the Lighthouse station should have a coverage contour that provides at least 95% population coverage for each participating station.
Likelihood for market cooperation between stations in your market? ☐ Good ☐ Fair ☐ Poor Is there a station or stations that stand out as Lighthouse candidate(s)? ☐ Yes ☐ No	Considerations for developing a plan and time-table to transition from ATSC-1 to ATSC 3.0
Other Considerations ☐ Cable penetration ☐ Number of VHF stations in the market ☐ Direct feeds to MVPD head-ends ☐ Sub-channel availability and programming agreements	

APPENDIX C: ENGINEERING CHECKLIST TO CONVERT TO ATSC 3.0

The technical infrastructure for an ATSC 3.0 ready facility requires careful planning and consideration that addresses the standard today and where it plans to be in the future. It's important that as stations discuss and decide on their plans for deployment, that they reach out to key vendors for input.

- Towers
  - Structural integrity of the tower must be validated by a licensed firm prior to installation of any new antennas, transmission line or other equipment. If you are involved in the repack process, it's likely an antenna and possibly line replacement is necessary. For those not involved in the repack process who plan to replace antenna and/or transmission line, a structural analysis and possible structural upgrades will be necessary.
- Antenna and Transmission Line
  - The antenna specification will be a determining factor in the quality of service for ATSC 3.0 to viewers. Things to be considered when selecting an antenna include:
    - Polarization
      - Consider adding V-Pol to improve reception to built-in antennas and portable/mobile performance
      - Null fill should be considered depending on tower location and terrain
    - Power handling capacity
      - Consider higher PAR for ATSC 3.0
      - Consider power needed to drive any V-pol and/or null fill addition
- Transmitter
  - Power requirements for ATSC 3.0 are higher than for ATSC-1.
    - ATSC 3.0 has a PAR about 2dB higher than ATSC-1. Check with your manufacturer to determine if there is enough headroom in your existing transmitter. *Note:* Some manufacturers "de-rate" their transmitters to include the necessary headroom for ATSC 3.0, while others do not. It is important to clarify this point with your manufacturer.
    - The addition of V-Pol or Null fill will require additional power.
    - If a transmitter upgrade is necessary, upgrade of utility power feed, generator, and uninterruptible power supply systems may be necessary.
    - Other considerations like overall age, condition of IOT(s) and cost of operation should be addressed.
  - If your RF system utilizes a sharp-tuned mask filter, it may require an upgrade, depending on its power rating. This is because the bandpass of ATSC 3.0 is slightly wider than ATSC-1. Consult your manufacturer.
- Exciter
  - Some ATSC-1 exciters are upgradeable via software to support the new ATSC 3.0 standard. If your transmitter is being replaced due to the repack, chances are your new exciter will be upgradeable. Check with manufacturer to verify.
- Broadcast Gateway and Studio-to-Transmitter Link
  - Existing STL links that handle SMPTE 310 or a 20 Mbps ASI stream will not work for ATSC 3.0. ATSC A/324 describes a Broadcast Gateway that produces a SMPTE 2022-1 IP stream that can be transported using microwave or fiber designed for IP. The Broadcast Gateway signal can be used to feed multiple destinations, including SFNs and MVPD.
  - NOTE: Depending on the specific method used to transition to ATSC 3.0, it may be necessary to operate your existing ATSC-1 STL in parallel with the ATSC 3.0 system.

APPENDIX D: SINGLE FREQUENCY NETWORK FACILITIES CHECKLIST

SFN Considerations

Several factors are involved in the decision to deploy a SFN. Because of the nature of how a SFN works, some of the trade-offs between the number and location of sites, contours and distance from the main transmitter are significant.

The following is an overview checklist intended to be a guide in the decision process:

1. For each SFN:
   a. ERP
   b. Tower Height
   c. Antenna Polarization
   d. Antenna Directivity (Pattern)
   e. Beam Tilt of the antenna
   f. Null fill
   g. Shared Site Considerations
      i. Combiners
      ii. Antenna/Line Bandwidth specifications
      iii. Sharp-Tuned transmitter output filters (Active Tuning)

2. Site considerations:
   a. Distance from main transmitter, proper Guard Interval selection
   b. Utility Power, UPS and Backup Generator
   c. Space availability for Transmitter and Filters
   d. Availability of Fiber Connectivity and/or STL feasibility
   e. Ease of access to the Site
   f. Local Zoning and Permitting
   g. Tower Loading Analysis
   h. Frequency Coordination with other Tenants as necessary
   i. FCC Licensing and FAA Notification
   j. Strategy for Remote Control and Monitoring systems
   k. Interface to GPS 10-MHz reference
   l. Procedure for handling loss of reference

APPENDIX E: POST REPACK LANDSCAPE BY THE NUMBERS

This document is derived from the FCC Post-Auction Parameters data found at:
https://data.fcc.gov/download/incentive-auctions/Current_Transition_Files/

Post-Repack Stations	No Change	Repacked In Band	Repacked to High-band VHF	Repacked to Low-band VHF	Totals	Pct.
Full Service UHF Stations	501	688	11	15	1215	73%
Full Service High-band VHF Stations	354	64	-	1	419	25%
Full Service Low-band VHF Stations	39	0	0	0	39	2%
Totals	**894**	**752**	**11**	**16**	**1673**	**100%**
Class A UHF Stations	146	203	2	1	352	
Class A High-band VHF Stations	16	3	-	0	19	
Class A Low-band VHF Stations	6	0		0	6	
Totals	**167**	**205**	**2**	**1**	**377**	
Total Stations					**2050**	
Post-Repack Percentages	**No Change**	**Repacked In Band**	**Repacked to High-band VHF**	**Repacked to Low-band VHF**	**Totals**	
Full Service UHF Stations	41%	57%	1%	1%	100%	
Full Service High-band VHF Stations	84%	15%	-	0%	100%	
Full Service Low-band VHF Stations	100%	0%	0%	0%	100%	
Class A UHF Stations	41%	58%	1%	0%	100%	
Class A High-band VHF Stations	84%	16%	-	0%	100%	
Class A Low-band VHF Stations	100%	0%	0%	0%	100%	

APPENDIX F: EXAMPLES OF ATSC 3.0 TRANSMISSION SETTINGS

This table describes some of the physical layer choices. Optional technologies for constructing SFN networks are not included. See ATSC A327-2018 for more information.

PLP Parameters	Description	Values	Notes
Frame Length	Data frame including Bootstrap and Preamble	50ms – 5 sec	Longer equates to less overhead. Shorter equates to faster receiver acquisition time
FEC Code Length	Forward Error Correction	Code Length: 64Kbits or 16Kbits	Frame size comes from length of inner code (LDPC)
FEC Code Rate	Useful Bits / Total Bits	2/15 – 13/15	
Constellations	Modulation Choices	QPSK, 16 – 4096 QAM	
Multiplexing	PLP multiplexing Up to 64 total PLPs allowed per 6-MHz ch. A single service can be spread across 1 to 4 PLPs	Time Domain (TDM) Freq Domain (FDM) Layer Domain (LDM)	Use of LDM provides better spectrum use efficiency. Currently 2 levels, Core and Enhance. May not be suitable for uses involving SFN configurations.
System Parameters	**Description**	**Values**	**Notes**
FFT	Fast Fourier Transform	8k, 16K, 32K	Number of transfer points
Pilot Patterns	Number and persistence of pilots mapped to a frame	Scattered (16 choices) Continual Edge Subframe boundary	Inserted into Frame during waveform portion of encoding.
Guard Intervals	Length of guard interval	12 Choices	Important consideration in SFN network design.

The following table is representative of selectable choices for the ATSC 3.0 Physical Layer in a 2 PLP LDM configuration.
Source: ATSC A327-2018 Physical Layer Recommended Practices

Frame Length			245.704 ms (Including Bootstrap)
Bandwidth			6 MHz
Preamble Parameters	FFT Size		16K
	Guard Interval		GI6_1536
	Pilot Pattern		SP D_x=4
	Signaling Protection		L1-Basic / Detail Mode 1
	# of Preamble Symbols		1
	Reduced Carriers		None
Payload OFDM Parameters	FFT Size		16K
	Guard Interval		GI6_1536
	Pilot Pattern		SP D_x=8, D_y=2
	Pilot Boosting		No Pilot Boosting
	# of Payload Symbols		93
	Time Interleaver		CTI (1024 depth)
	Frequency Interleaver		On
	First / Last SBS		Off / On
Payload BICM Parameters	Core PLP (PLP 0)	Outer Code	BCH
		Inner Code	4/15 LDPC (16200)
		Constellation	QPSK
	Enhanced PLP (PLP 1)	Outer Code	BCH

NOTES

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