ENGINEERING REPORT

ATSC 3.0 (NextGen) Architecture and Workflow Challenges, an Invitation to Develop New and Improved Solutions

SMPTE ER 1007:2021

The home of media professionals, technologists, and engineers.

September 20, 2021

ATSC 3.0 (NextGen) Architecture and Workflow Challenges, an Invitation to Develop New and Improved Solutions

A Joint Task Force (JTF) has been created among the Society of Motion Picture and Television Engineers (SMPTE) and the Advanced Television Systems Committee (ATSC) to identify and develop solutions that may be put into practice when implementing NextGen transmission systems.

The initial goal and focus are to aggressively seek solutions to simplify the management of ATSC 3.0 air chains, and in particular to enable broadcasters to make configuration changes to their transport stream on the fly with negligible impact to the viewer. We believe this may be accomplished through common control of several key devices and software required in the ATSC 3.0 broadcast transmission chain. Thus far we have identified a number of functional blocks from the input of the encoder/packager through to the scheduler/gateway and we anticipate many other functions yet to be discovered as our work evolves.

The purpose of this document is to inform the industry of some critical needs of Broadcasters as they implement and operate NextGen systems. We are casting this document widely to make these needs known and to encourage solutions development in the marketplace. As Standards Development Organizations, ATSC and SMPTE strongly prefer the use of established standards rather than manufacturers develop each their own (proprietary). We see much opportunity in this area for improved and simpler workflows. Additionally, we know there will be remaining questions from this document and we stand ready to work together on identifying solutions. You may contact us to set up a discussion one of three ways:

1. As a commented document, or as an e-mail sent to atsc-smpte-chair@members.atsc.org
2. In a scheduled feedback session *(please contact via the above email)*
3. In a market or supplier workshop *(please contact via the above email)*

Work items and goals will evolve throughout the life of the project. The Task Force will not draft Standards, Recommended Practices, or similar technical documents, however it may draft requirements, recommendations or reports intended for internal use within SMPTE and/or ATSC. Additionally, both represented organizations will actively seek opportunities to implement one another's complimentary Standards, either current or yet to be developed.

In writing this document, we have assumed that the subject television station operator is either planning, starting or nearing completion of constructing an "ATSC 3.0/NextGen" facility. The work of this group will not be limited to Audio/Visual Television services as we know today but will also tackle new operating modes such as datacasting/Core Networks, interactivity, content substitution/dynamic ad insertion, Dynamic Content Security and the myriad of new services enabled in the new Standard. Also note that the mission of the JTF is not to "steer" any specific business, competitive or functional features. The team will only address the resolution of technical and operational challenges.

The Challenge

The ATSC 3.0 Standard is extremely flexible, incorporating a layered approach. With each layer abstracted from the other, it is necessary to make configuration changes individually addressing each layer. While this capability is great for flexibility and extensibility, it does require configuration changes that are laborious and time consuming and may result in noticeable interruptions to the viewer experience.

Broadcasters who have already begun transmitting NextGen over-the-air have expressed frustration over the numerous configuration settings required when either initially configuring or making changes to the system. Additionally, the JTF recognizes that there are several approaches to creating and changing configurations as well as many vernaculars, API's and protocols used by the various broadcast equipment manufacturers. This can lead to errors when configuration changes must be made quickly, possibly by staff who are not familiar with how to make them. Consequently, there needs to be a simple, reliable, and fast method to make these changes.

Initial Work Item

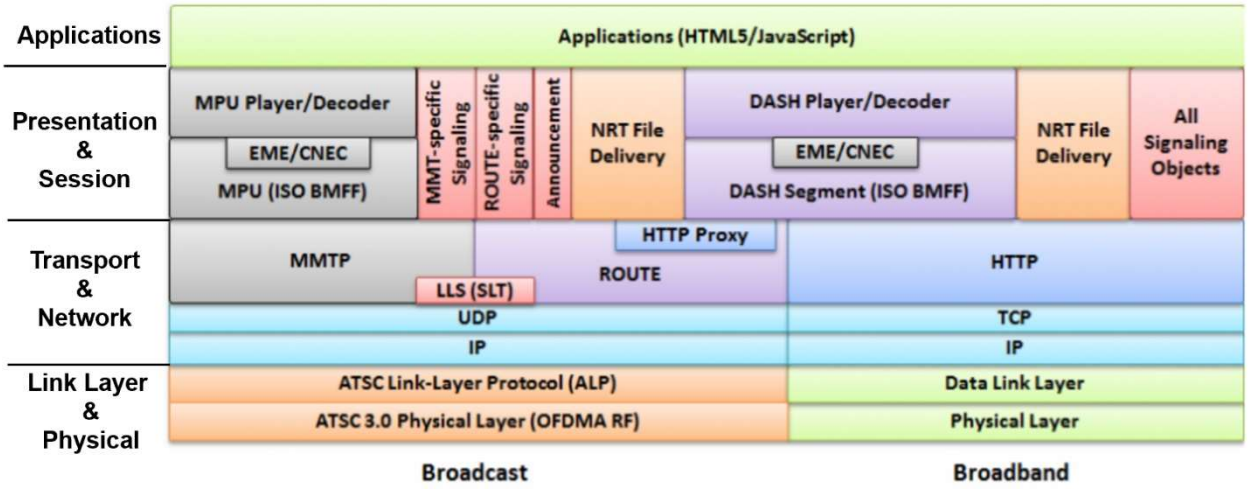
Our current focus is to define a method of executing rapid configuration changes by station operators during a black insert to a commercial break. Our approach for this project will be to:

- Identify the highest priority (few) configurations that need to be addressed at a typical Television Station to meet the requirements of their business.
- Identify the areas that need to be changed.
    - High-level Signaling
    - Low-level Signaling
    - Service-layer Signaling
    - Management of latency
- Leverage Networked Media Open Specifications (NMOS) discovery to identify when equipment is changed out or software updates are applied by a manufacturer to notify the system manager and apply patches as necessary; see https://www.amwa.tv/nmos-overview .
- Pull together a list of the devices and software that need to be reconfigured.
- Identify and engage equipment and software vendors.

Issues of Consideration

There are a number of technology factors that must be considered as we look to optimize ATSC 3.0 air-chain operations. Some key factors are identified below.

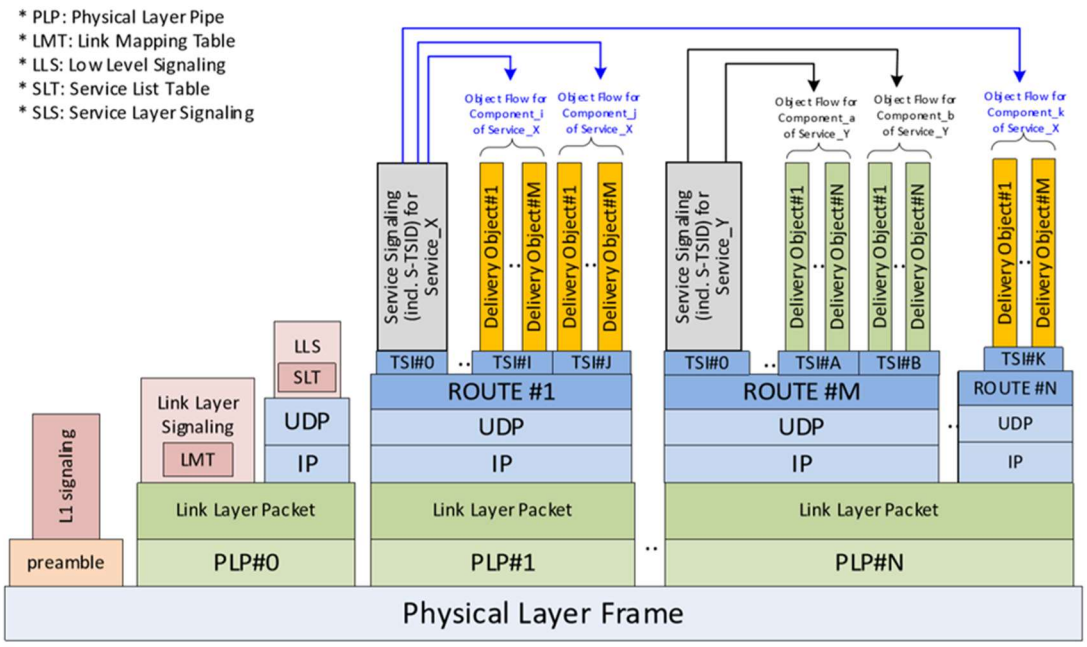
Overall Complexity and Span of Control



ATSC 3.0 Protocol Stack

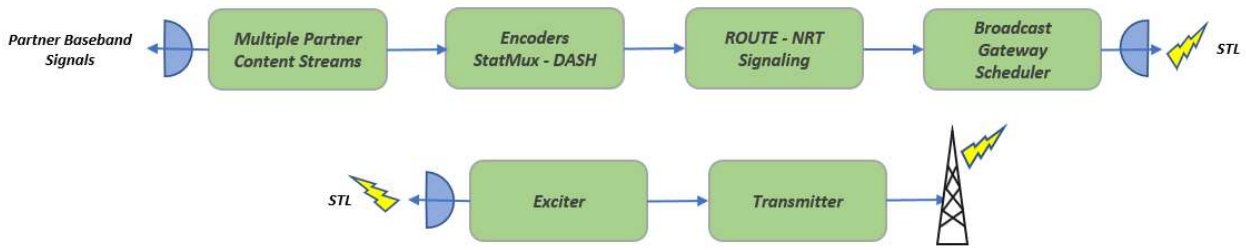
As you can see there are numerous parts of the ATSC 3.0 system that must be configured. While an initial configuration can be readily defined, to broadcast one HD channel and three subchannels, there will ultimately need to be future changes to take advantage of the new capabilities of ATSC 3.0. For example, if a station decides to broadcast 4k during prime time and the initial one 2K HD and three subchannels during the other dayparts, the challenge is who and how can the changes be made with no/minimal impact. Of course, the number of possible configurations is almost unlimited.

Drilling down even deeper you can see this quickly gets very complicated.



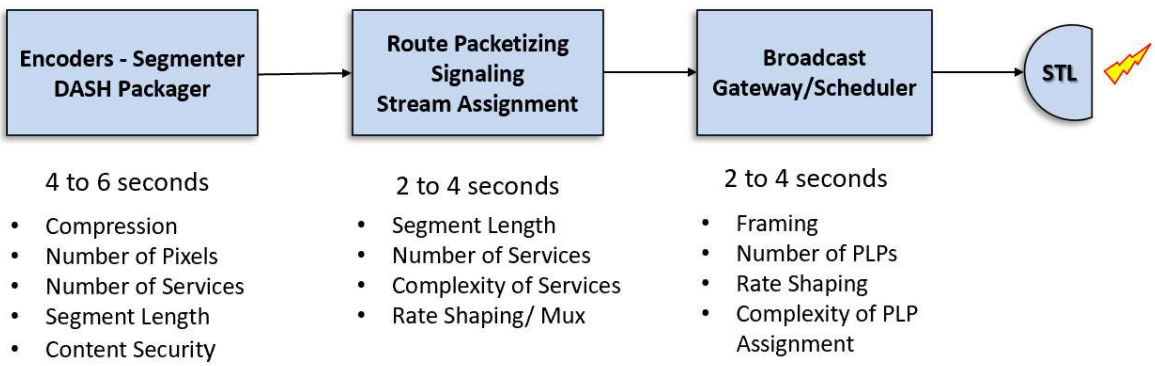
Television Station Areas Affected

This diagram depicts the NextGen station air-chain. Items in green are those that require some level of configuration per operating mode.



Latency

A major consideration of making reconfigurations is the latency between sending a command and the implementation of the actual change required through each of the components. These latencies may be cumulative resulting in substantial program interruption.

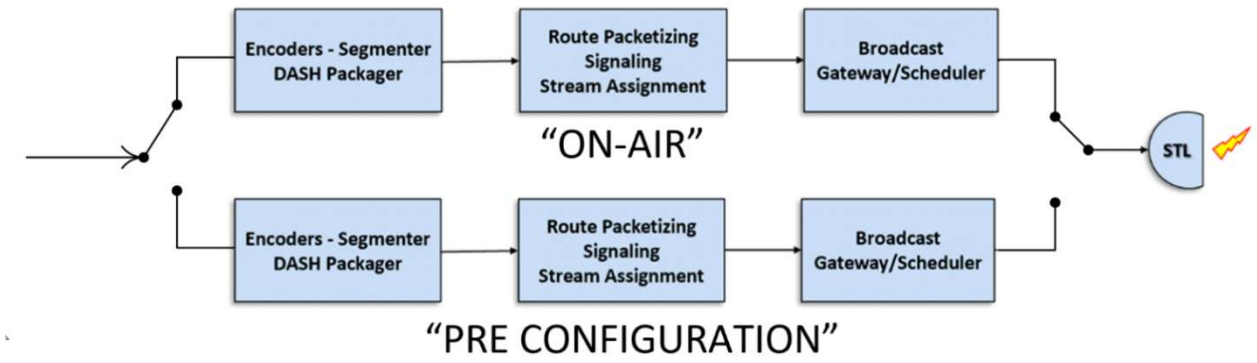


Potential Requirement for A and B Airchains

The concept of dual air-chains in a television station is not new. Usually considered a “main” and a “backup” in the event of a single-point failure the other path can be placed into service. While only one is on the air the alternate is considered a “warm standby” and must/should be identical in functionality.

Going forward, however, we may wish to modify this approach. To avoid latency issues, we propose allowing for brief periods where one air chain is on-air and the other is being migrated to a new configuration, with an A-B swap ultimately used to implement changes in stream type or count. While this would involve instantiating two instances of each function in the air chain, we anticipate potential virtualization of these functions facilitating common images to be run on COTS platforms.

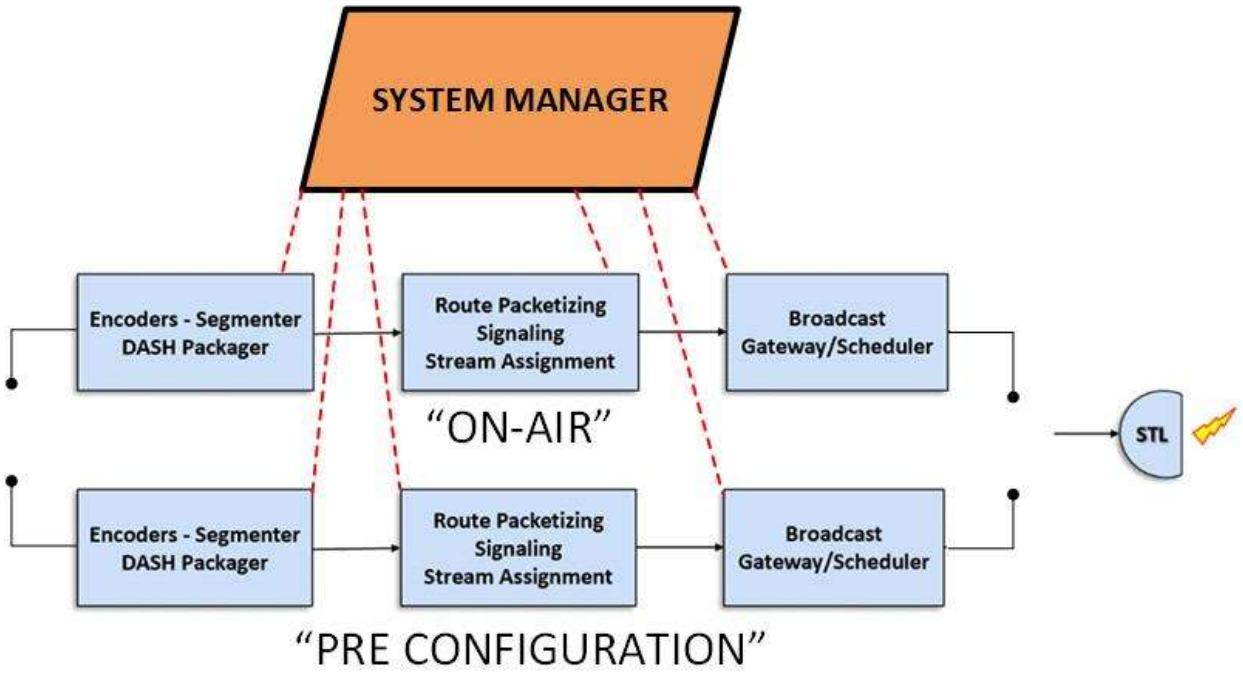
During the period of time required to reconfigure the redundant portion of the air-chain, there is a liability should something in the primary air-chain fail. Give the anticipated short duration of time where this may occur, it is likely to be an acceptable risk for the broadcaster. The logical switching between A and B air-chains could be made using the station’s existing automation system.



Solution Characteristics

“System Manager”

The initial approach to solve the challenge is to develop a software-based System Manager that would be responsible for holistically managing the air-chain operations across all elements. Creating a single GUI for the operator to make changes and monitor status should streamline the workflow and allow for presets of most-desired configurations. Later phases of this program will need automated background operation to enable the faster-than-human response times required in that segment of datacasting operations.



General Requirements and Use Cases

General requirements and use cases for System Manager operations are outlined below. General requirements pertain across all use cases.

General Requirements:

1. The System Manager will operate in a manner consistent with traditional Broadcast operations, with changes in stream type and count occurring in a manner that does not disrupt other streams in the lighthouse or SFN, does not disrupt monitoring or measurement platforms, does not disrupt the experience of current viewers, and does not require the viewer to make manual changes to receiver settings to receive the new payloads.

2. System Manager will accommodate any practical combination of suppliers across the air-chain components and across the Lighthouse or SFN members. There is an express desire to enable 'mix and match' component selection.

3. System Manager actions may be triggered manually, or by API command, which may come from station automation, trafficking systems, a core network (for broadcasters participating in a regional/national Broadcast Network Operation), or internal logic.

4. System Manager actions must be logged with a clear audit trail enabling proof of performance/as-run documentation.

5. System Manager actions must be visible to and auditable by all Lighthouse/SFN member stations and reportable to a core network (for broadcasters participating in a regional/national Broadcast Network Operation).

6. System Manager must expose its current state and configuration to authorized users or applications for the purpose of reporting and assurance.

7. Member stations have the ability to trigger changes for their portions of the bandwidth at will. (Note: this may be restricted by policy or agreement among the members, but the functionality must exist in the system.)

8. System Manager functionality must be secured against unauthorized use. Content Protection and Service Protection configurations and control must also be addressed in the solution. *Example;* in a Lighthouse each service will have separate Content Security requirements as well as Service Protection for the whole station's channel's signaling as well as individual broadcaster applications.

9. System Manager must be at least as redundant as the air-chain components that it manages.

Example Use Cases – Broadcast Only

1. A Lighthouse or SFN wishes to assign bandwidth across stations with fixed total bandwidth per station. Individual stations decide bandwidth allocations per stream on their own within their allowed bandwidth.

2. A Lighthouse or SFN wishes to divide bandwidth across stations using statistical multiplexing with a minimum bandwidth guaranteed per station. Individual stations decide bandwidth allocations per stream on their own within their allowed bandwidth.

3. A Lighthouse or SFN member wishes to air a short-term special event in UHD (e.g.: The Superbowl).

4. A Lighthouse or SFN member wishes to add additional streams in UHD or HD formats for a long-duration special event (e.g.: The Olympics)

5. A live sporting event runs long and a Lighthouse or SFN member wishes to spawn an additional stream to allow the event to conclude while the main channel maintains its normal schedule.

6. An individual member wishes to temporarily use a larger allocation of bandwidth, perhaps to enable one of the scenarios above.

7. A Lighthouse or SFN group wishes to re-partition bandwidth across the member stations, and at the same time, the stations wish to reallocate bandwidth across their streams.

8. A Lighthouse or SFN member wishes to permanently add or delete a stream.

9. A new station and its streams join an existing lighthouse operation with no increase in total bandwidth. Bandwidth is reapportioned across the member stations manually or ratably or via statistical multiplexing with guaranteed minimums.

10. A second or third ATSC 3.0 transmitter is stood up in a market and one or more stations move their streams from the original transmitter to the second transmitter.

11. A second or third ATSC 3.0 transmitter is stood up in a market. Stations and streams are reallocated across the expanded bandwidth.

12. A new Lighthouse is configured from scratch.

Broadcast plus Core Network

What is a Core Network?

A Core Network provides mobility management (which tower), session management (which UDP or TCP session) and transport management (which channel) for Internet Protocol packet services in GSM, WCDMA and ATSC-3.0 networks. The core network also provides support for other functions such as billing and lawful interception. Core Networking makes sure that the right infrastructure is being used to locate and target user sessions, avoids waste and assures successful migration from one set of network assets to another while mobile.

Example Use Cases

1. A Lighthouse or SFN wishes to permanently carve out bandwidth for datacasting and delegate responsibility for that segment of bandwidth to another system or a third-party system.

2. A Lighthouse or SFN wishes to permanently carve out bandwidth for datacasting and the system(s) that manage those segments are added to the purview of the System Manager.

3. A group of Lighthouses or a large SFN wish to align their datacasting operations so that a common frequency and stream size are used across neighboring DMAs.

4. Bandwidth allocated for datacasting varies in a predictable manner by time or daypart, or in a pre-scheduled (trafficked) manner and these changes are affected autonomously by the System Manager.

5. Bandwidth for datacasting is consumed ad-hoc by a third party, on short or no notice, but within fixed limits, and these changes are affected autonomously by the System Manager.

6. Bandwidth for datacasting varies in one of the manners discussed above, and the bandwidth pool is also subject to demand from temporary UHD Channels for special events, and/or live event overruns. The System Manager handles these changes on the fly using pre-designed policies.

7. Some datacasting is sold locally, but a third party may sell it regionally/nationally as well. The System Manager is expected to maintain an inventory and allow reservations against that inventory by the selling parties.

8. The System Manager is tasked to act as the 'Point of Presence' or 'Endpoint' for the Core Network in a given DMA.

9. The System Manager is tasked to provide as-run documentation or verification functionality for datacasting services.

10. More than one ATSC 3.0 Lighthouse exists in a market with different business owners. Both decide to offer datacasting, both sell locally, and both are accessible by a third party to fulfill regional and national orders.

11. Portions of the broadcast RF spectrum are reallocated permanently or temporarily to small cell use (5G).

System Manager Key Features

A With execution of the above use cases in mind, a proposed list of key features for System Manager has been developed. It is shown below. We would appreciate feedback on the importance and relative priority of each feature.

Feature	Detail	Use Cases	Feature Priority
Multi-Tenant	Air chain management across multiple tenants/entities incl. security/views	X	
Abstraction	Enable mix-and-match of suppliers within/across stations	X	
Day 1 Configuration	Air chain configuration from scratch, end-to-end, main and backup.	X	
Single Pane of Glass	Single pane of glass air chain operations monitor	X	
Day 2 Ops	Add/Drop/Change Video and Data Streams; Self-Heal, Failover, Maintenance	X	
Bandwidth Inventory	Bandwidth allocation, reservations, authority for Lighthouse/SFN	50%	
Policy-based Autonomy	Policy Based Autonomous Ops - Across Stations and Core Network	-	
Core Network PoP	Receiver or Cache for Core Network; Insertion of Data Stream	-	
SFN Integration Mesh	Peer-to-Peer alignment of System Managers	-	
Controls 'Scheduler'	Control of 'Scheduler' in Broadcast Gateway	-	
Proof of Performance	Auditable record of video and data delivery	50%	

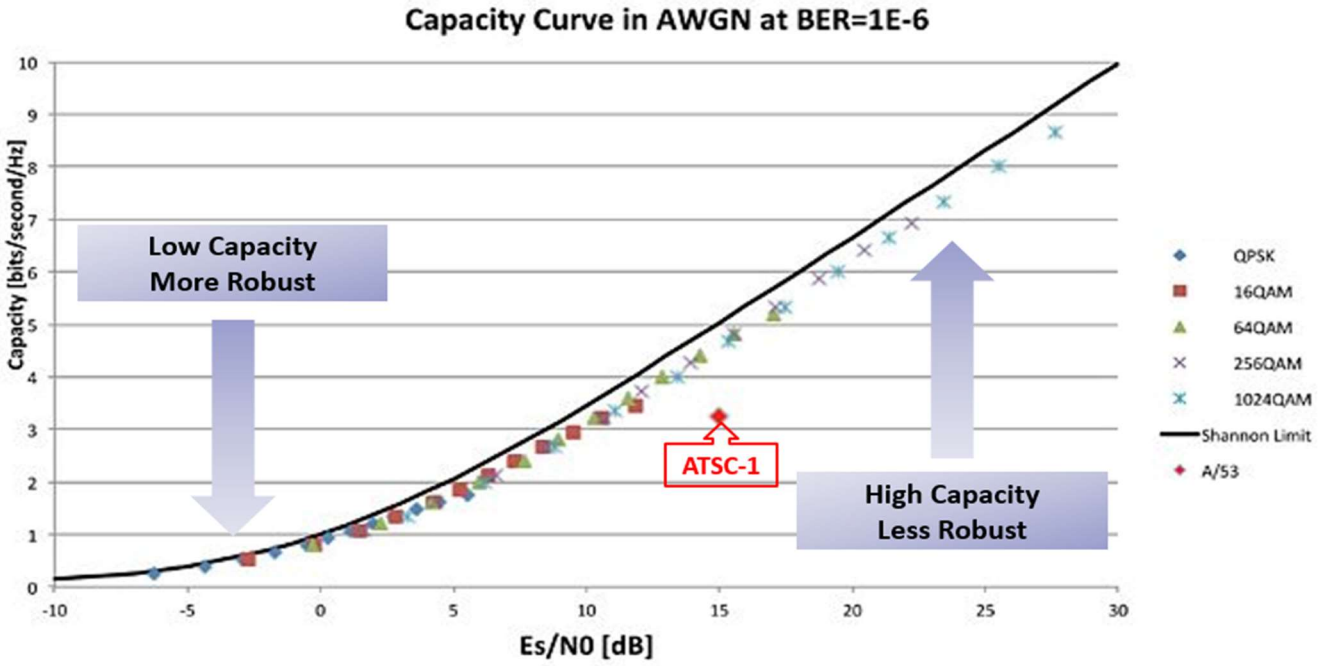
Practical PLP Configurations

A major challenge for both automated and manual configuration of ATSC 3.0 Air Chains is the sheer number of settings available, and the sensitivity of settings to each other. Add in the fact that different suppliers also have different names for the various settings and you already have serious challenges. Start mixing and matching suppliers across the different stages of the air chain, and now the task of bringing an SFN online can become quite difficult.

It has been suggested that this task could become significantly easier if ATSC developed a develop a handful of commonly used PLP configurations, perhaps 12-20 in total, that would cover the most common stream configurations - from 8K and UHD broadcast through standard definition and on down to small kilobit and megabit data streams. We would appreciate feedback on the feasibility of such a plan. Could we create a recommended practice that effectively standardizes the size of the building blocks we create a multicast out of, or is that impractical?

A sample list of commonly used PLP configurations is below. Could these, or something similar work for your organization?

Parameter	Higher Capacity	ATSC 1 - Like	Very Robust	Near Equal ATSC-1 Coverage with Robust Mobile PLP		Less Robust Coverage PLP with Data PLP	
	PLP-0	PLP-0	PLP-0	PLP-0	PLP-1	PLP-0	PLP-1
Type	S-PLP, SISO	S-PLP, SISO	S-PLP, SISO	SISO, w/ subframes	SISO, w/ subframes	SISO, w/ subframes	SISO, w/ subframes
FFT Size	32K	16K	8K	subframe 0: 8K	subframe 1: 16K	subframe 0: 8K	subframe 1: 16K
Pilot Pattern	24_2	12_4	6_2	subframe 0: 6_4	subframe 1: 12_4	subframe 0: 4_2	subframe 1: 8_2
Pilot Boost	1	1	4	4		1	
Guard Interval	G5_1024	G5_1024	G5_1024	G5_1024		G4_768	
Preamble Mode	(Basic: 3, Detail: 3) Pattern Dx = 12	(Basic: 3, Detail: 3) Pattern Dx = 6	(Basic: 1, Detail: 1) Pattern Dx = 3	(Basic: 3, Detail: 3) Pattern Dx = 3		(Basic: 3, Detail: 3) Pattern Dx = 4	
Frame Length	246 msec	201 msec	201 msec	155 msec		193 msec	
Time Interleaver	Convolutional (1024 cells)	Convolutional (1024 cells)	Convolutional (1024 cells)	Hybrid 16 FEC Blocks 1 TI Block (51.1msec time spread)	Hybrid 63 FEC Blocks 2 TI Block (47.8msec time spread)	Hybrid 12 FEC Blocks 1 TI Block (43.2 msec time spread)	Hybrid 93 FEC Blocks 3 TI Block (50.8 msec time spread)
Modulation	Very Robust 256 QAM	256 QAM	QPSK	subframe 0: 16 QAM	subframe 1: 256 QAM	subframe 0: 16 QAM	subframe 1: 256 QAM
Code Rate	9/15	8/15	5/15	subframe 0: 7/15	subframe 1: 10/15	subframe 0: 7/15	subframe 1: 11/15
Code Length	64K	64K	16K	64K		64K	
Net Bit Rate [Mbps]	24.9 Mb/sec	21.4 Mb/sec	3.0 Mb/sec	Subframe 0: 3.1 Mb/sec	subframe 1: 18 Mb/sec	Subframe 0: 1.87 Mb/sec	subframe 1: 22.85 Mb/sec
Required C/N [dB]	17.26 (est. AWGN)	15.5 (est. AWGN)	.2 (est. AWGN)	5.2 (est. AWGN)	17.1 (est. AWGN)	5.28 (est. AWGN)	18.91 (est. AWGN)



Looking Ahead

As we explore options for solutions the Joint Task Force is releasing this paper to the industry to provide insight into the challenges faced by Broadcasters *today and going forward.* Our mission is solely to identify and help facilitate solutions for the broadcast community; we are not for profit nor a business entity but see ourselves as facilitators between Broadcasters, Manufacturers and Software Developers.

I Invite your company to explore how you may develop new products and services, including new business opportunities, by partnering with us to bring solutions to the marketplace.

If interested in contributing to this effort, please reach out to:

Dave Siegler, ATSC/SMPTE Joint Task Force Chair
atsc-smpte-chair@members.atsc.org
(678) 237-3892