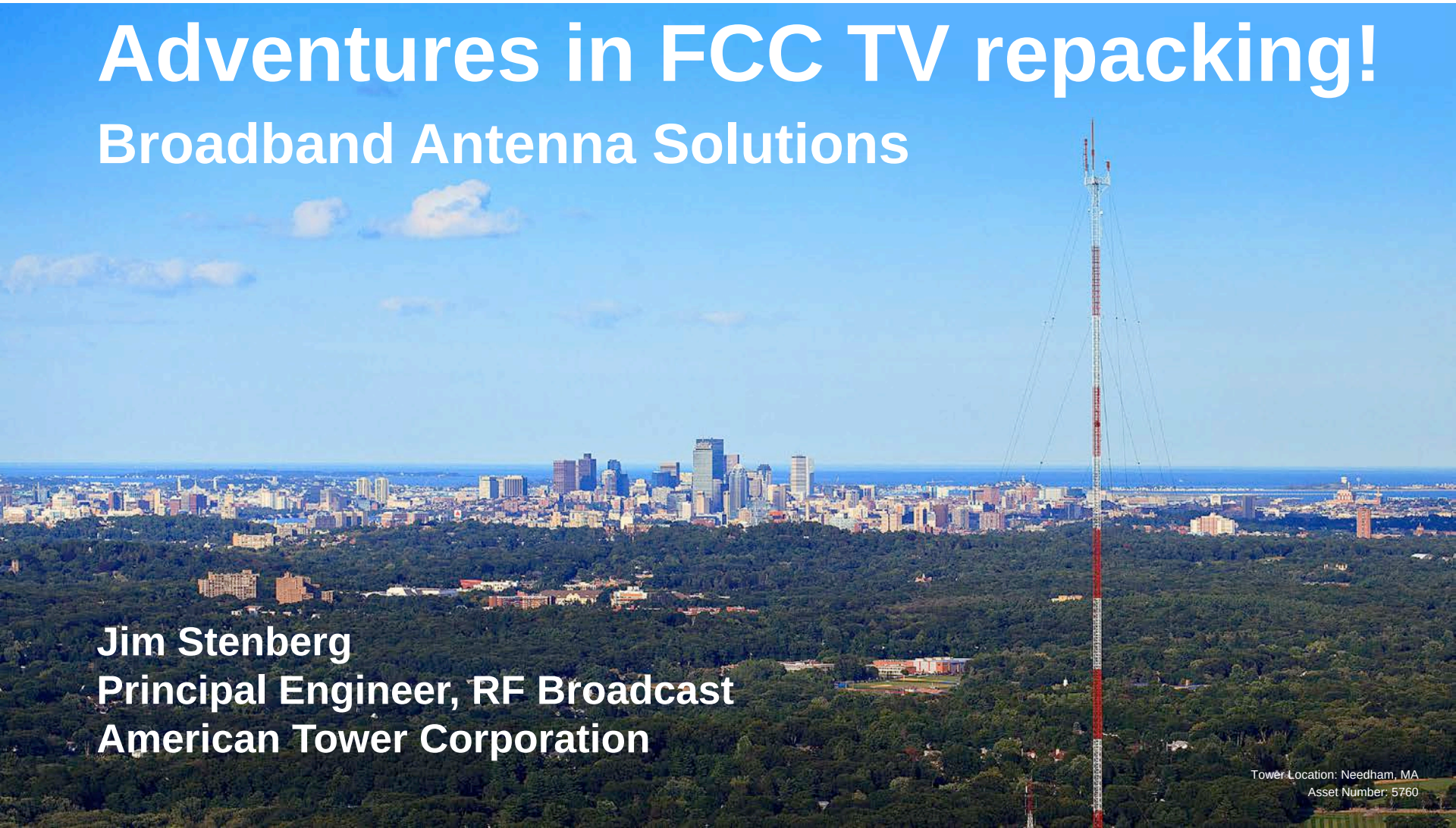
AMERICAN TOWER®

Adventures in FCC TV repacking!

Broadband Antenna Solutions

Jim Stenberg
Principal Engineer, RF Broadcast
American Tower Corporation



Tower Location: Needham, MA
Asset Number: 5760

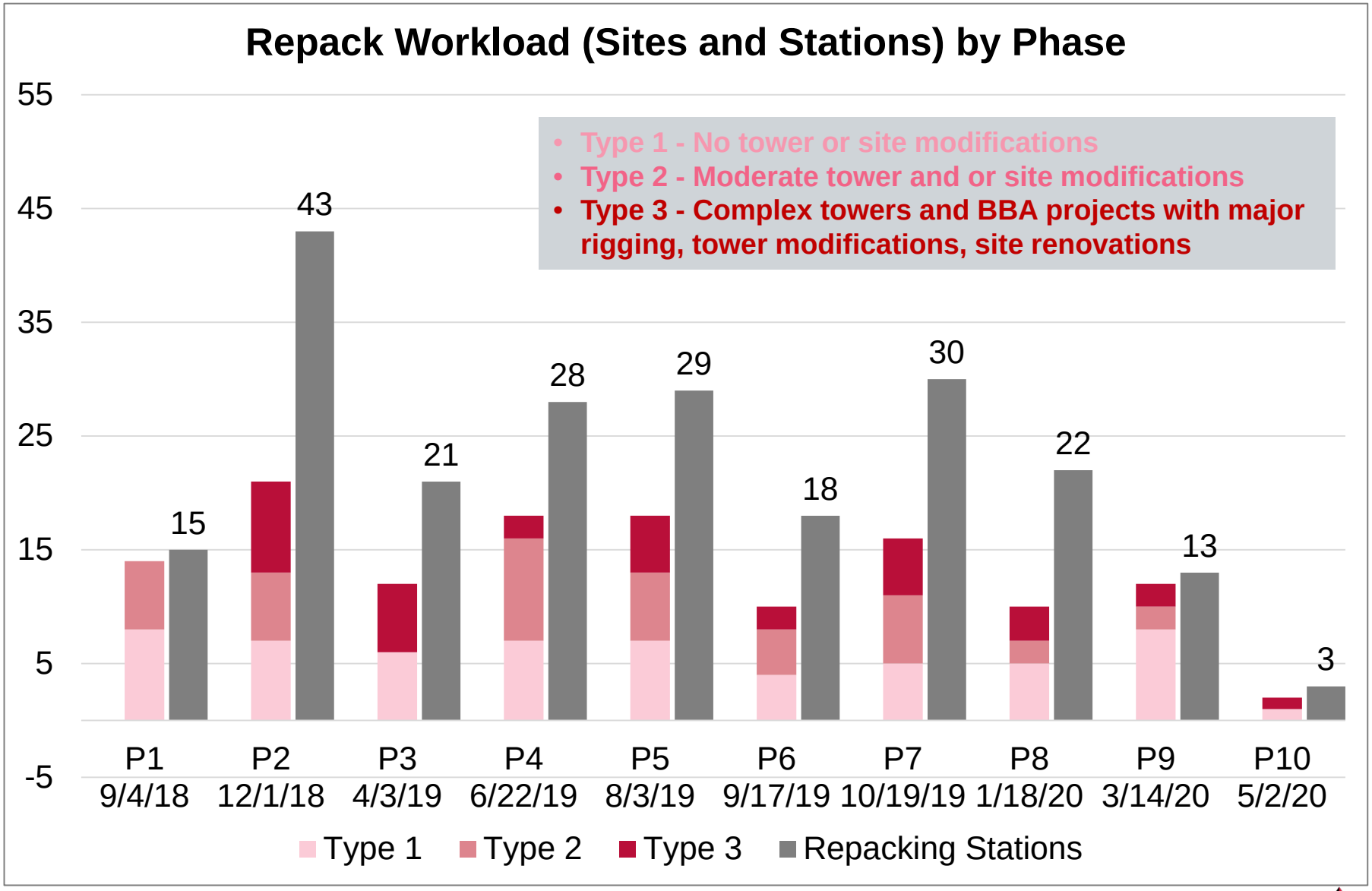
Agenda

- TV Repack and ATC customers
- Pre Repack accomplishments
- Timeline challenges
- Implementation challenges
- Our existing TV BBA fleet
- Goals of our repack BBA program
- Dynamic polarization and ATSC 3.0
- Market example and BBA design trade-offs

TV Repack and ATC customers

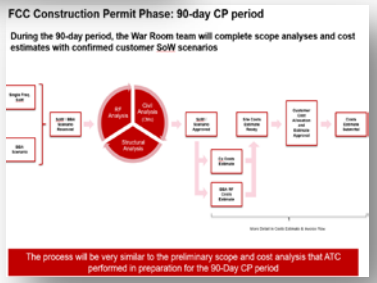
- **987** Class A and Full Power TV Licensees requiring new “repack” channels for 84 MHz spectrum clearing
  - **217 repack licenses on 133 ATC towers**
- **175** Class A and Full Power license reverse auction “winners” each surrendering their 6 MHz license
  - **52 auction winners on ATC towers**
  - **8 auction winners on ATC towers moving from UHF to VHF**
  - **44 going off air in the next six months**

TV Repack and ATC customers



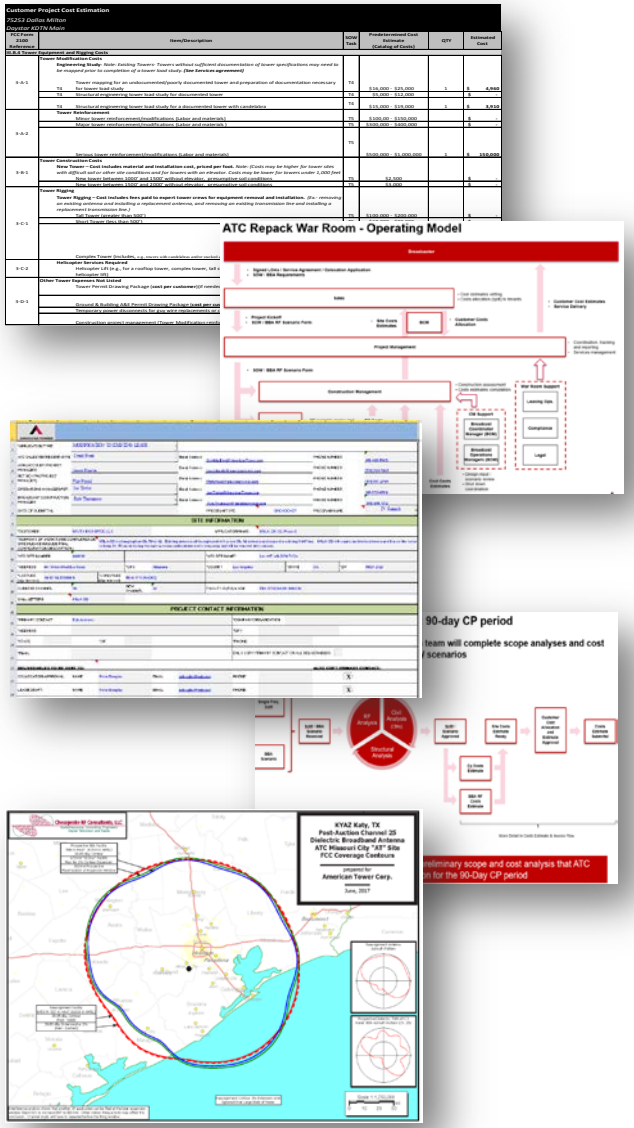
Pre Repack Accomplishments

- 100+ tower mappings, inspections and civil audits completed
- Equipment uploaded to ATC records and leases reviewed
- Tower DNA scrubbed, existing structural baselines completed and reviewed
- Structural baselines with projected load scenarios completed
- Broadcast Repack Services Scope-of-Work (SoW) in place



Pre Repack Accomplishments

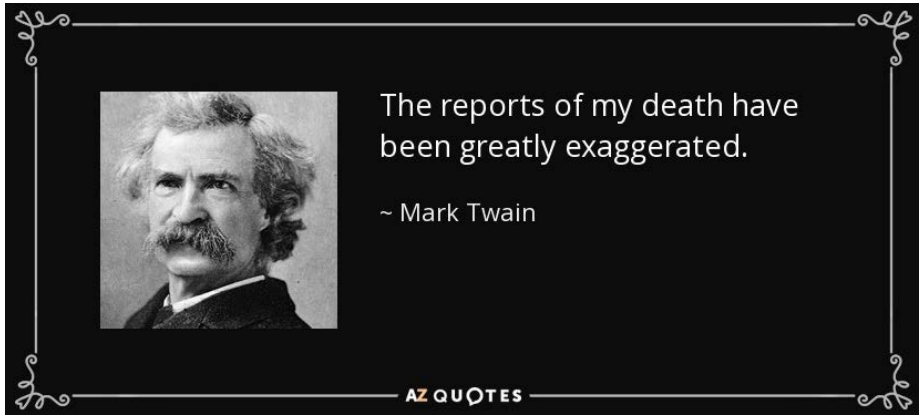
- ATC Repack Cost Estimate forms (aligned with FCC Form 2100; Sched. 399) completed
- ATC Repack team structure, roles and responsibilities in place
- “Repack” broadcast lease application in service and applications rolling in
- Procurement of $3.8M transmission line and antennas completed
- Ongoing selection of engineering vendors, GCs and tower crews for sourcing strategies
- BBA coverage analysis for many markets completed



Timeline Challenges

- FCC reimbursement budget
  - Stations are cautious to begin
  - Concern over RF system “upgrades”
- Maximization window
  - Further restricting commitments to equipment
  - Recommend maximization be prioritized by phase.
- Scheduling does not take into account weather
- Construction delays by non-repack and FM stations

Implementation Challenges



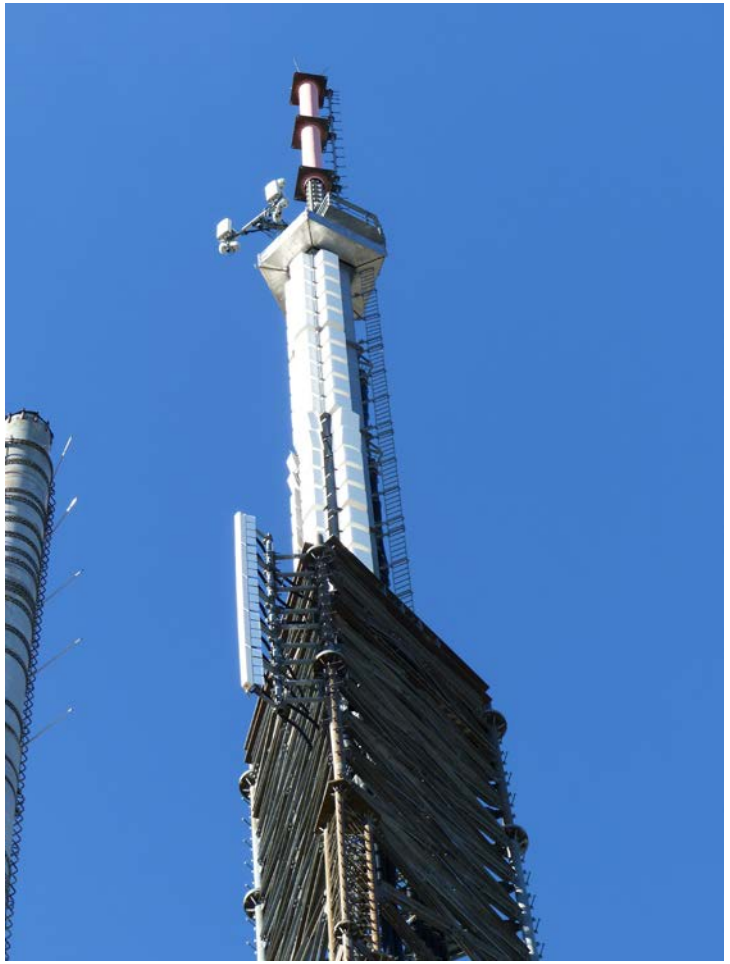
BROADCASTERS SHOULD NOT UNDERVALUE THEIR OFF-AIR SIGNAL AND SPECTRUM!

- Cord cutting is increasing in almost all markets
- Lack of interest in interim alternatives when work is being completed
- Minimal value placed on auxiliary capabilities that can keep you on-air

Existing ATC TV BBA fleet

BBA = Broadband Antenna = Multichannel system

- 29 UHF systems
- 1 VHF system
- 23 Impacted by Repack w/ 1 or more changes
- All except 1 are horizontally polarized only
- Limitations to consider
  - VSWR bandwidth
  - Pattern bandwidth
  - Power input capacity
  - Number of feedlines

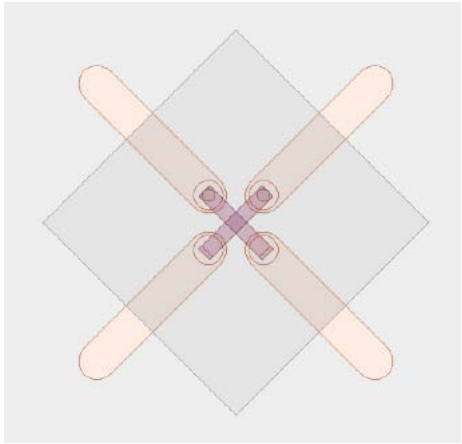


Goals of our repack BBA program

- Optimize repack changes
  - Locate where an antenna has to be changed out
  - Include as many stations as possible in design
- Minimize on air disruptions
  - Provide side mount interim antennas
- Reduce overall tower loading
  - Remove unused lines/antennas
  - Re-use lines wherever practical
- Meet aggressive FCC timelines
- Minimize overall economic impact to all parties
- Provide future proof systems

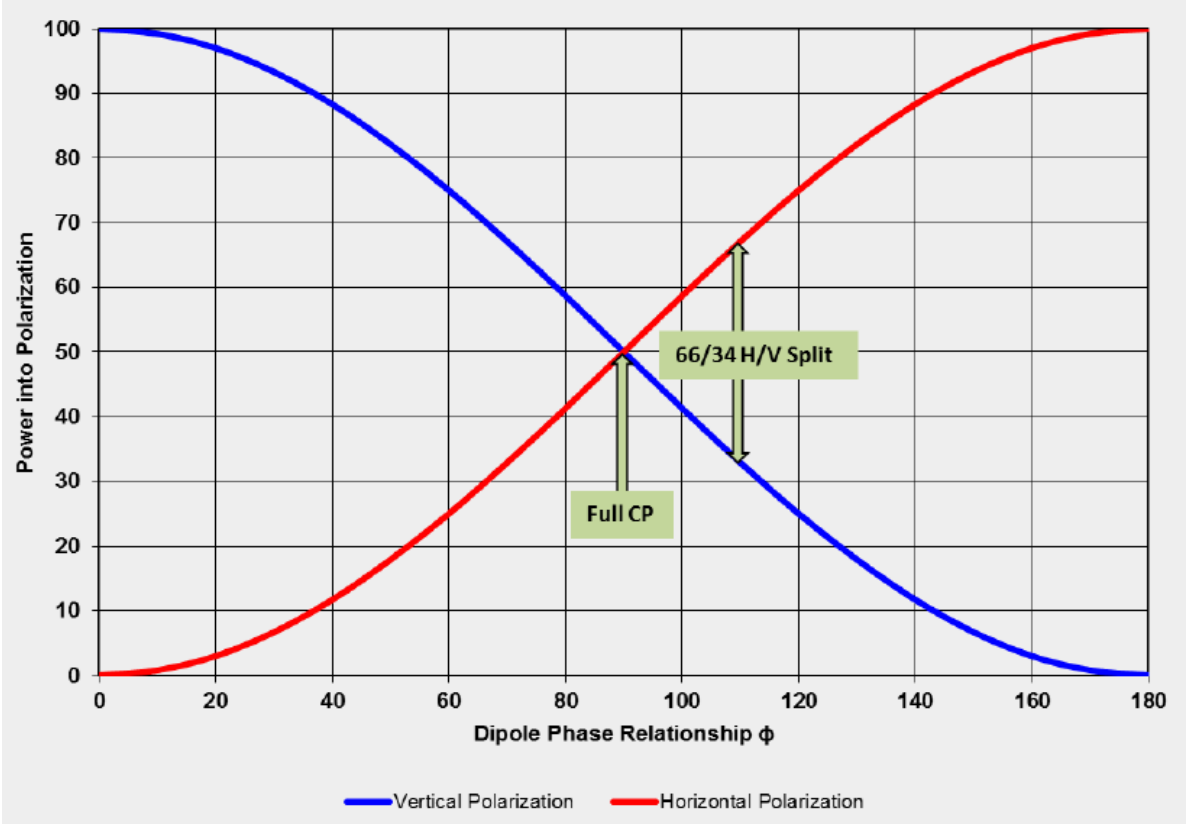
Dynamic polarization and ATSC 3.0

New antenna technology provides future upgrade path



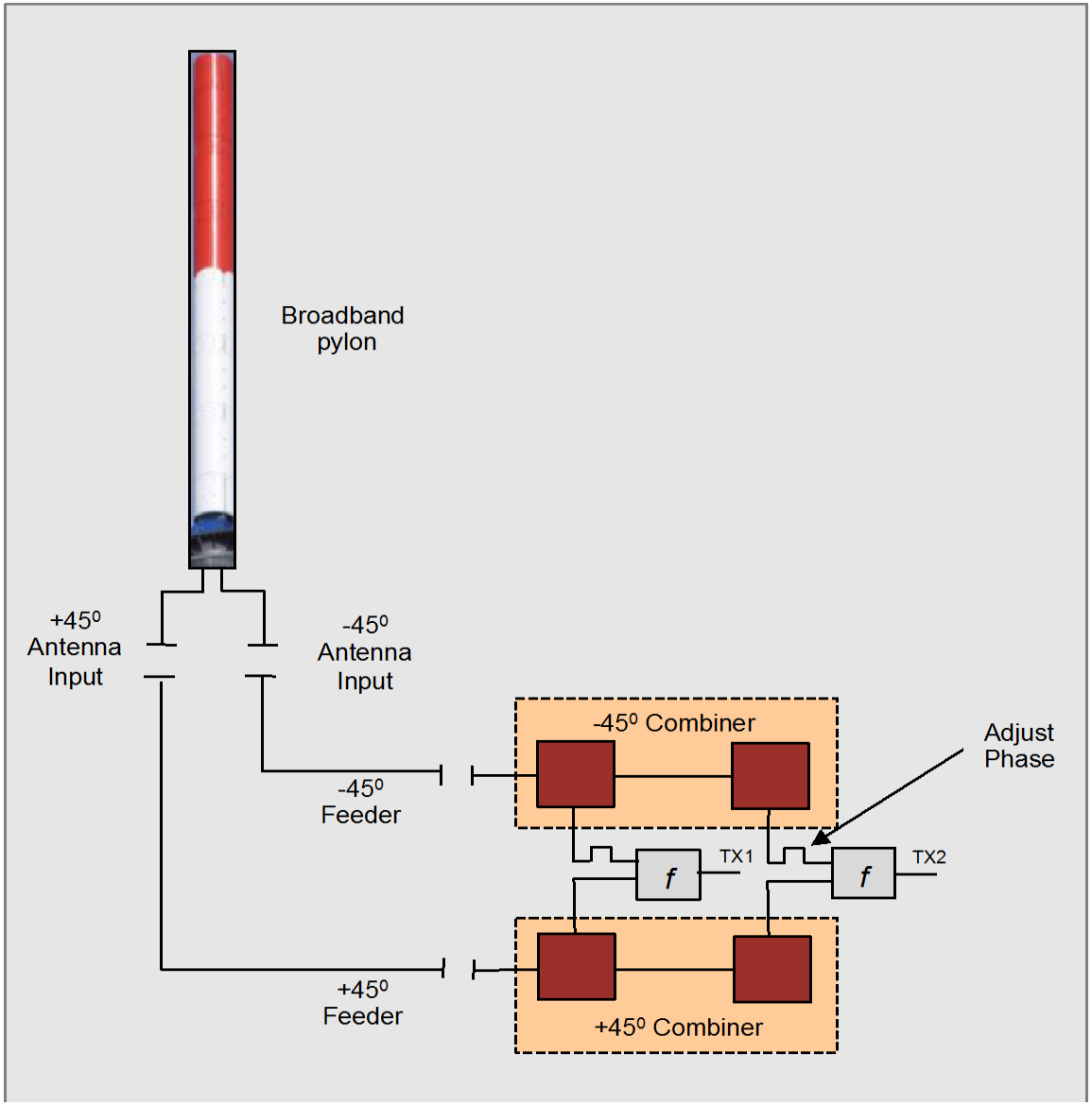
Crossed 45 Dipoles

With independent feed systems for each 45, varying phase inputs varies H pol to V pol ratio



Reference: *Adaptive Polarization Technology*, D. Small, Dielectric, NAB 2017

Dynamic polarization and ATSC 3.0

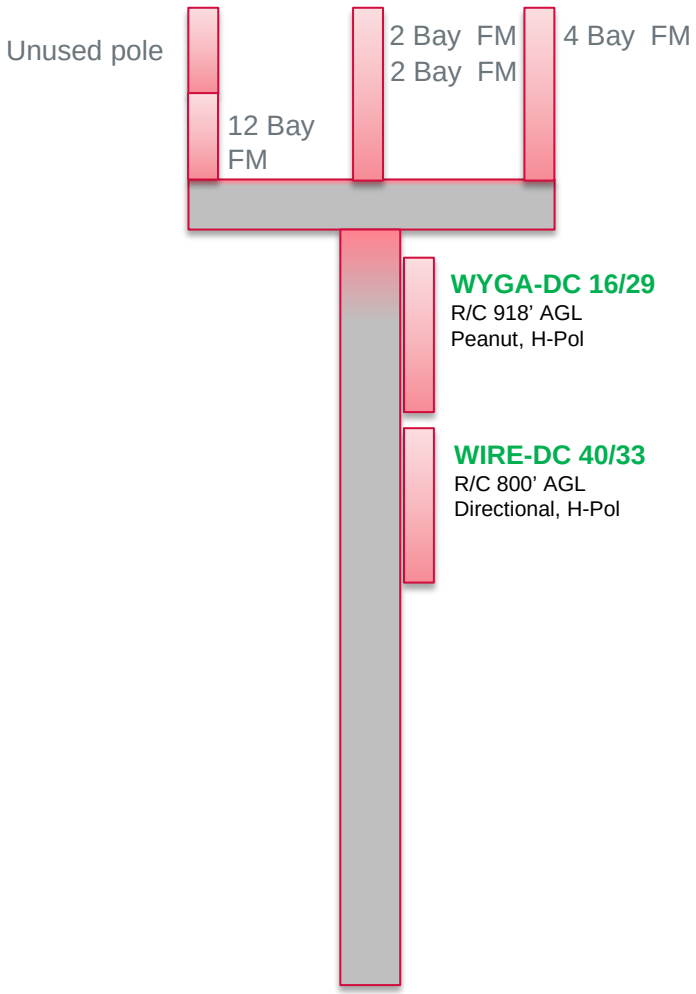


Dual Chain Feed System

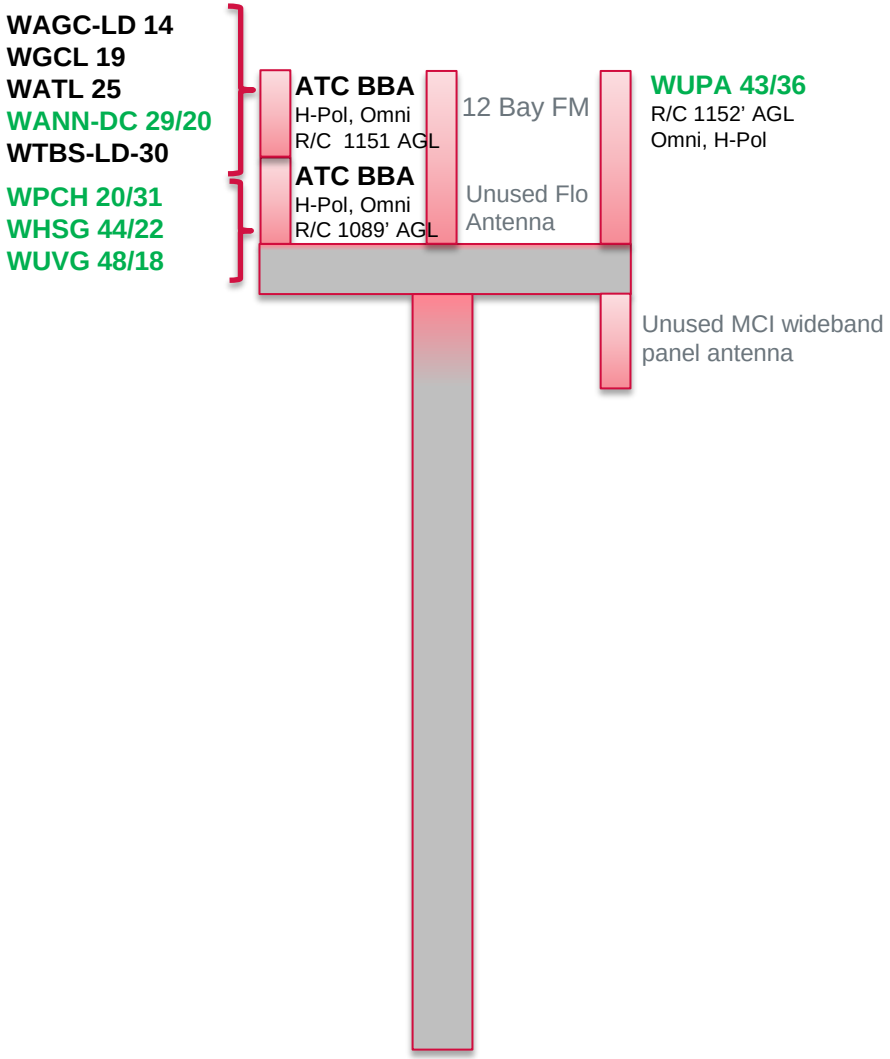
With dual feed lines and dual combiner chains, each station can independently choose/change their H/V ratio

Reference: *VPT for Broadcast Repack* , N. Wymant, RFS, 2016

ATC Atlanta TV Market – repack results



Chester Avenue #23656
2049' Overall AMSL

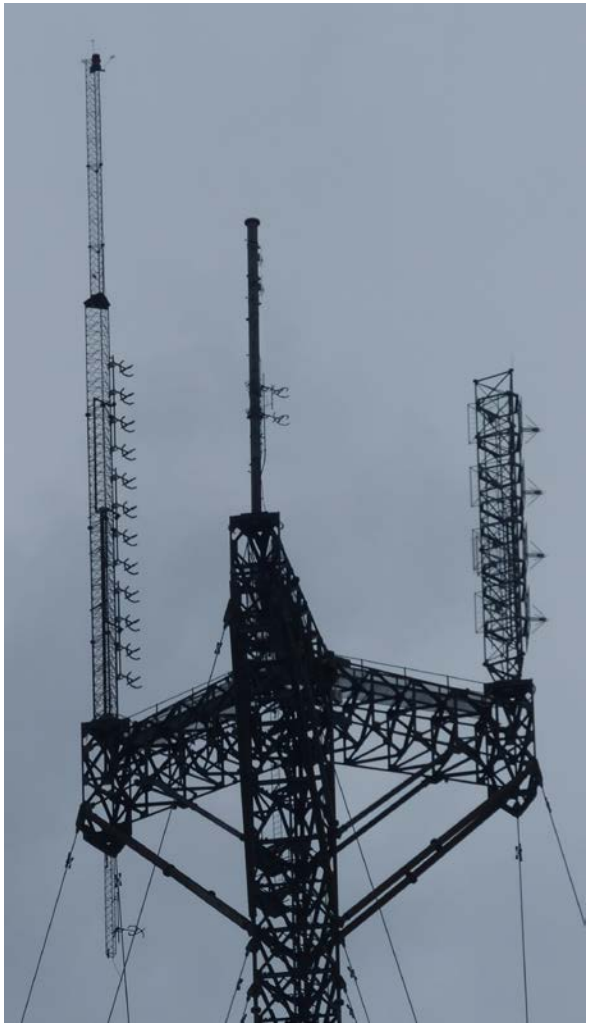


Briarcliff 2 #282650'
2049' Overall AMSL

XXXX = no change
XXXX = repacked

XXXX = Winner and/or Hi-V, Lo-V
XXXX = repack solution

ATC Atlanta TV Market



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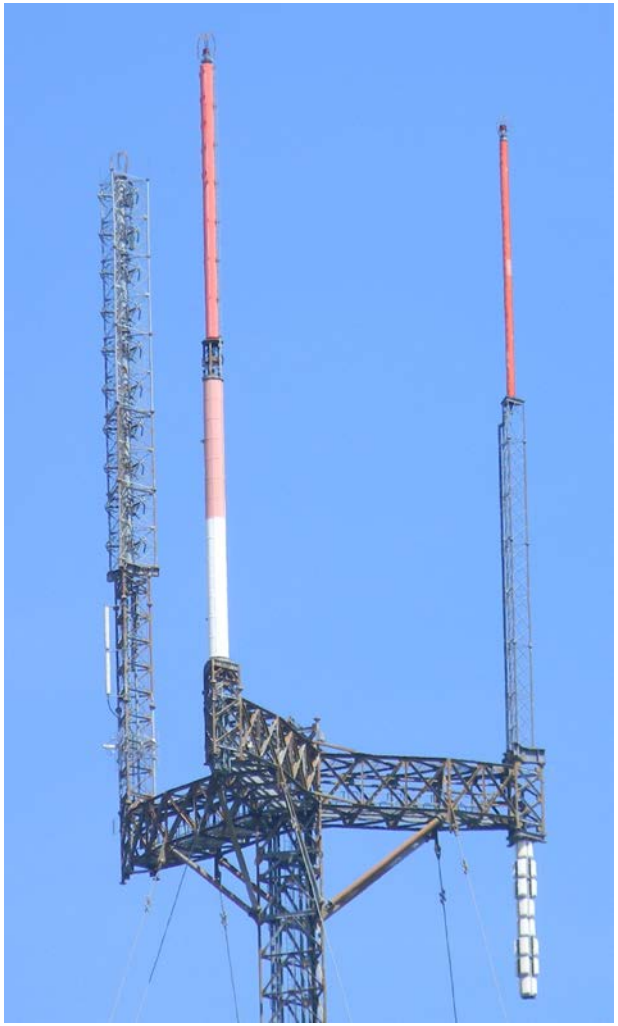
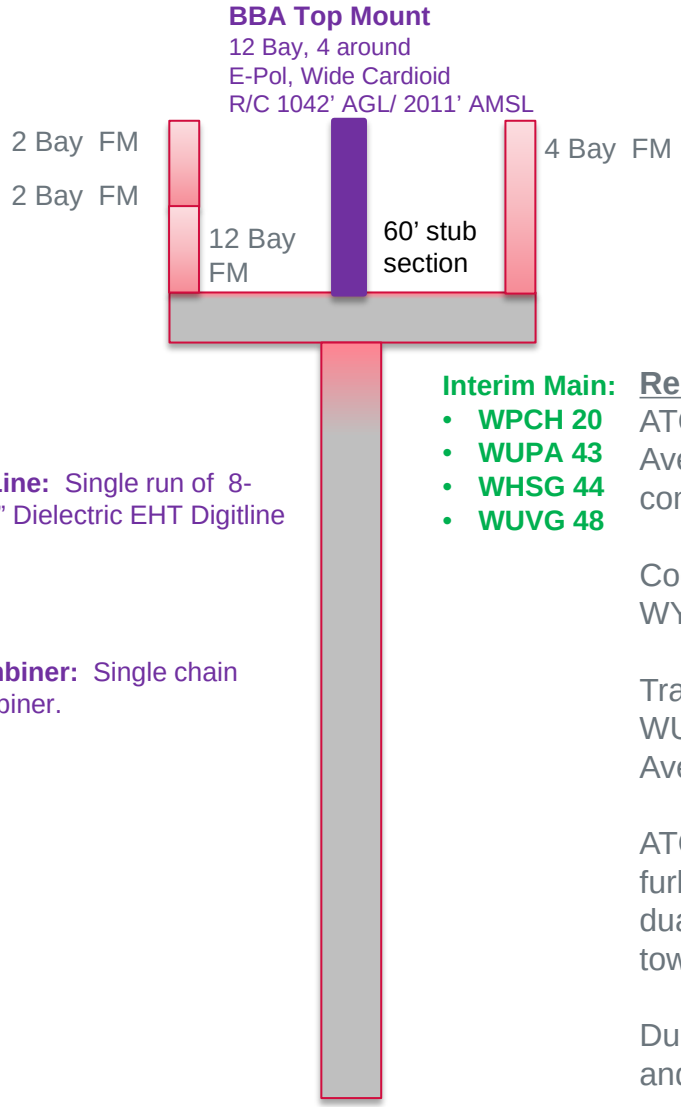


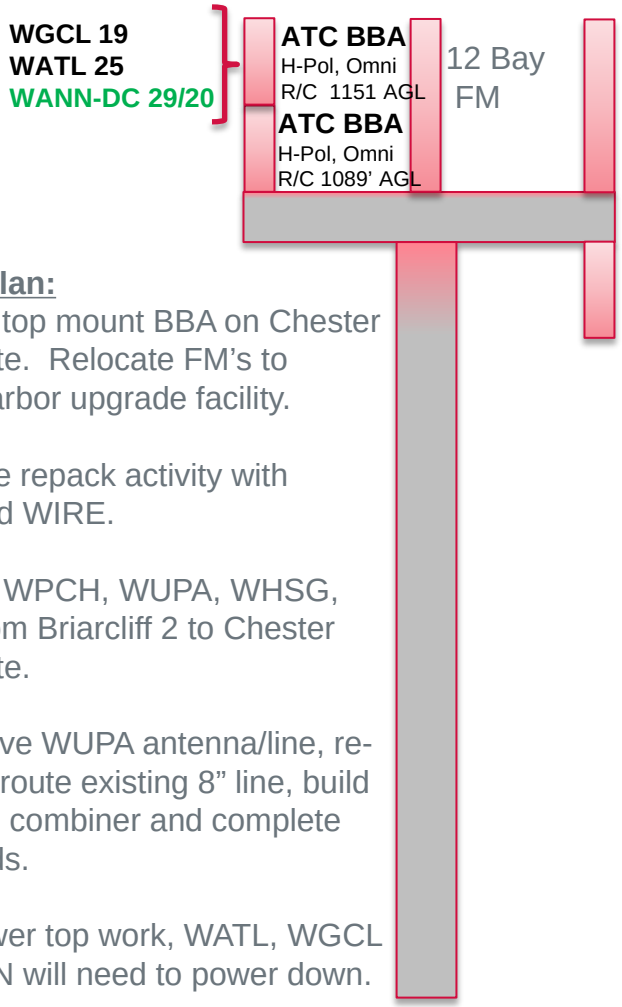
Briarcliff 2 #282650’
2049’ Overall AMSL

Atlanta Market Design Criteria

- Minimize repack disruption – 7 repack customers + LPTV
  - Development of robust Interim Main system
- Meet Phase 5 Deployment Schedule
  - Testing period 8/3/2019
  - Phase 5 completion 9/6/2019
- Maintain optimal coverage contour during repack tower work
- Design around pattern and adjacent channel interference
- Availability of tower crew and existing customer site coordination
- Reduce cost of re-building combiner systems
- Maximize repack reimbursement economics
- Future-proof RF systems – incorporate ATSC 3.0 capability into design

ATC Atlanta TV Market – pre-phase 5 Interim Main





TX Line: Single run of 8-3/16" Dielectric EHT Digitline

Combiner: Single chain combiner.

Interim Main:

- **WPCH 20**
- **WUPA 43**
- **WHSG 44**
- **WUVG 48**

Repack Plan:

ATC build top mount BBA on Chester Avenue site. Relocate FM's to common arbor upgrade facility.

Coordinate repack activity with WYGA and WIRE.

Transition WPCH, WUPA, WHSG, WUVG from Briarcliff 2 to Chester Avenue site.

ATC remove WUPA antenna/line, re-furbish/re-route existing 8" line, build dual chain combiner and complete tower mods.

During tower top work, WATL, WGCL and WANN will need to power down.

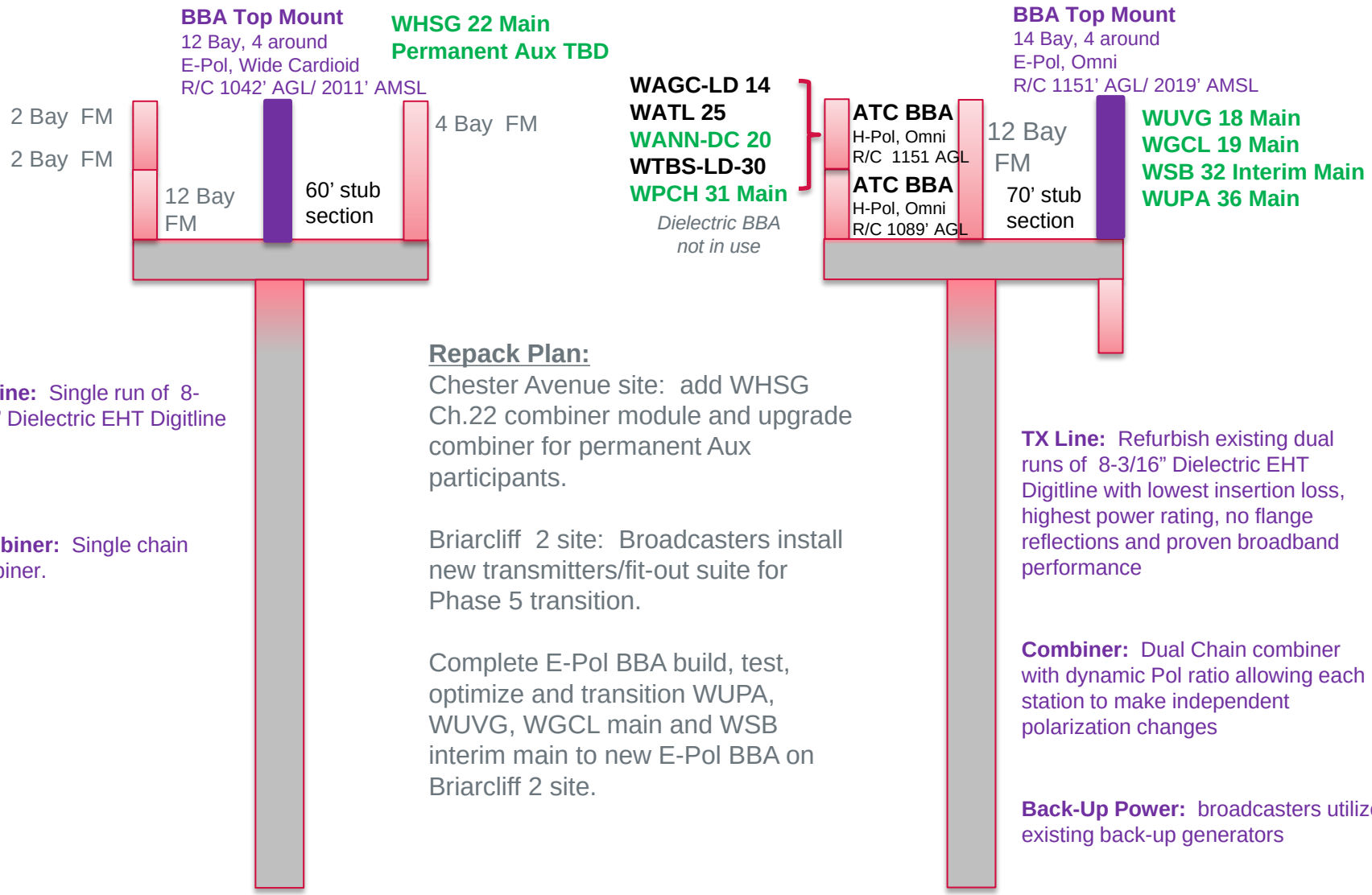
Chester Avenue #23656
2049' Overall AMSL

Briarcliff 2 #282650'
2049' Overall AMSL

XXXX = no change
XXXX = repacked

XXXX = Winner and/or Hi-V, Lo-V
XXXX = repack solution

ATC Atlanta TV Market – phase 5 cutover



TX Line: Single run of 8-3/16" Dielectric EHT Digitline

Combiner: Single chain combiner.

Repack Plan:

Chester Avenue site: add WHSG Ch.22 combiner module and upgrade combiner for permanent Aux participants.

Briarcliff 2 site: Broadcasters install new transmitters/fit-out suite for Phase 5 transition.

Complete E-Pol BBA build, test, optimize and transition WUPA, WUVG, WGCL main and WSB interim main to new E-Pol BBA on Briarcliff 2 site.

TX Line: Refurbish existing dual runs of 8-3/16" Dielectric EHT Digitline with lowest insertion loss, highest power rating, no flange reflections and proven broadband performance

Combiner: Dual Chain combiner with dynamic Pol ratio allowing each station to make independent polarization changes

Back-Up Power: broadcasters utilize existing back-up generators

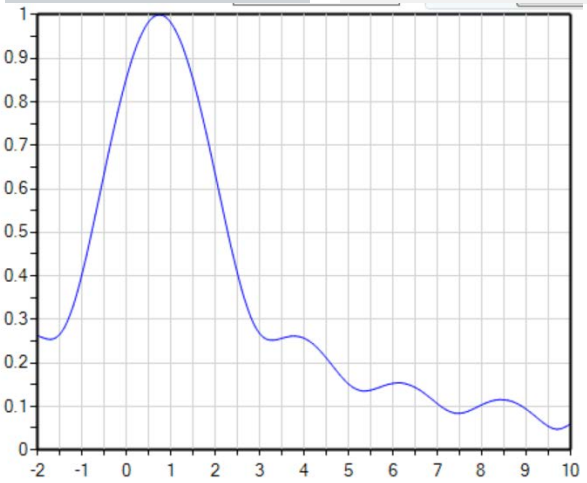
Chester Avenue #23656
2049' Overall AMSL

Briarcliff 2 #282650'
2049' Overall AMSL

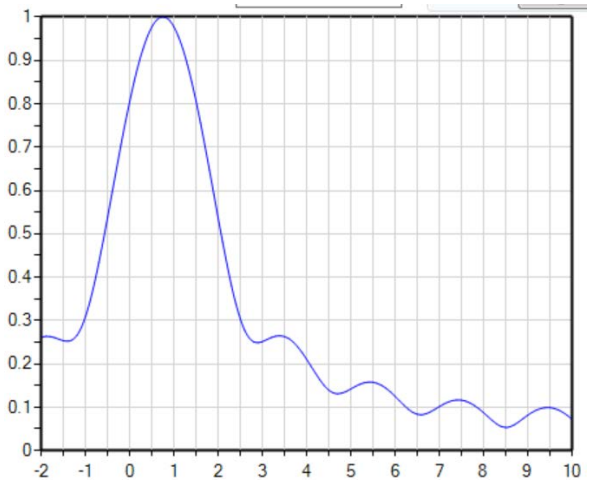
BBA System Design Trade-offs

Elevation Pattern Gain

- Higher gain = less TPO
- Higher gain = more stations
- Lower gain = better near in coverage
- Lower gain = less windload

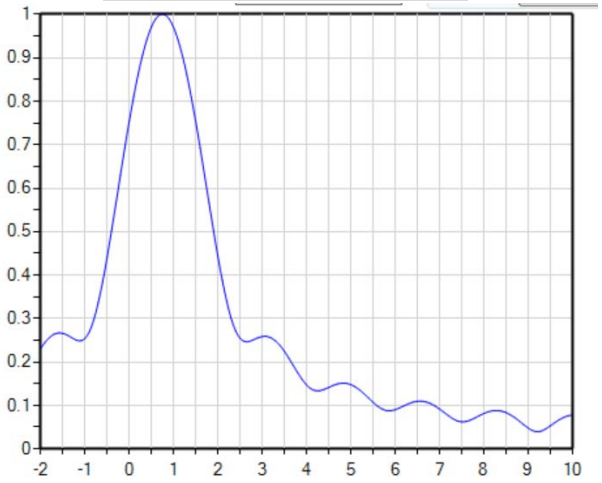


12 Bays
Gain = 22.2 x
TPO = 45 kW
WA = 91 sq ft



14 Bays
Gain = 25.6 x
TPO = 39 kW
WA = 104 sq ft

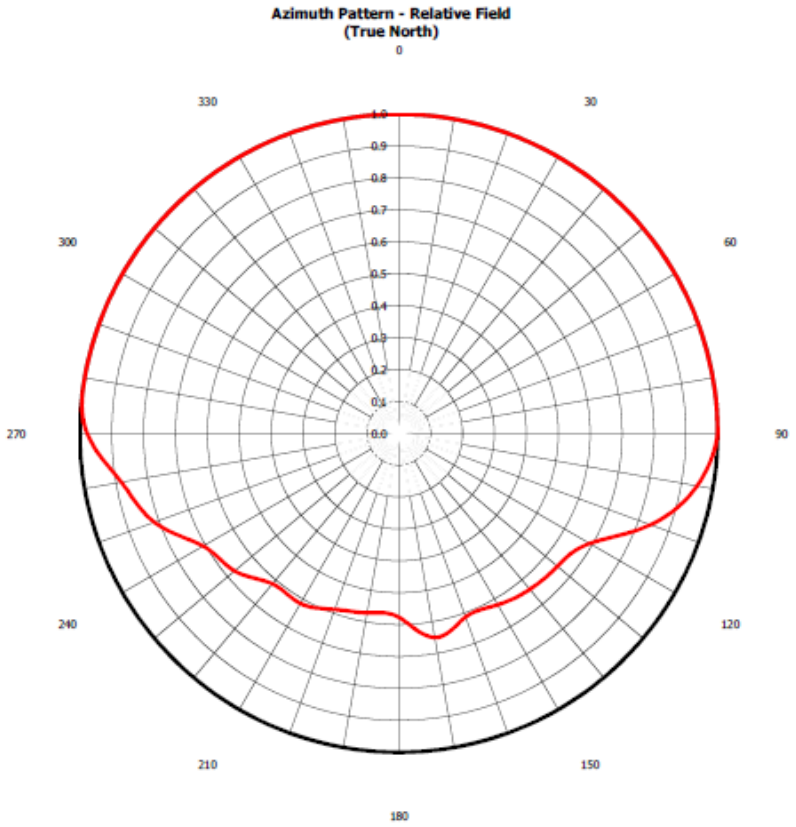
16 Bays
Gain = 29.0 x
TPO = 34 kW
WA = 118 sq ft

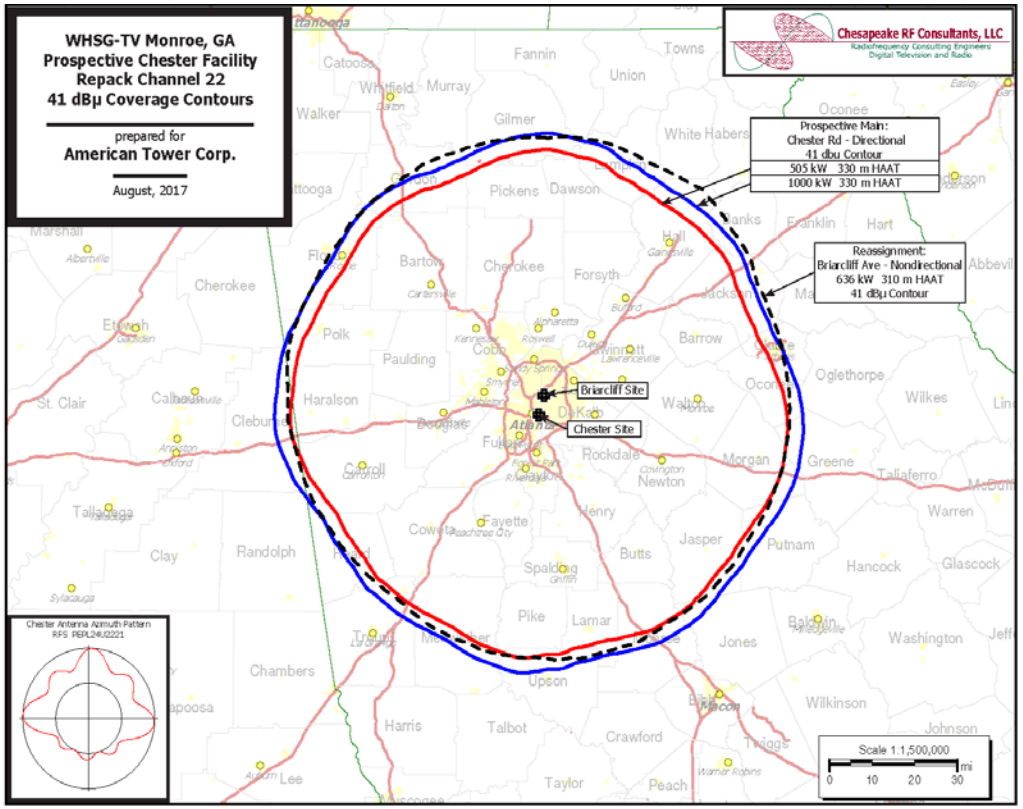


BBA System Design Trade-offs

Azimuth Pattern Optimization

- Minimize ripple with # of elements around
- Directional vs Omni
- Attempt to fit multiple stations in one pattern
- Understand maximization potential





BBA System Design Trade-offs

Transmission Lines

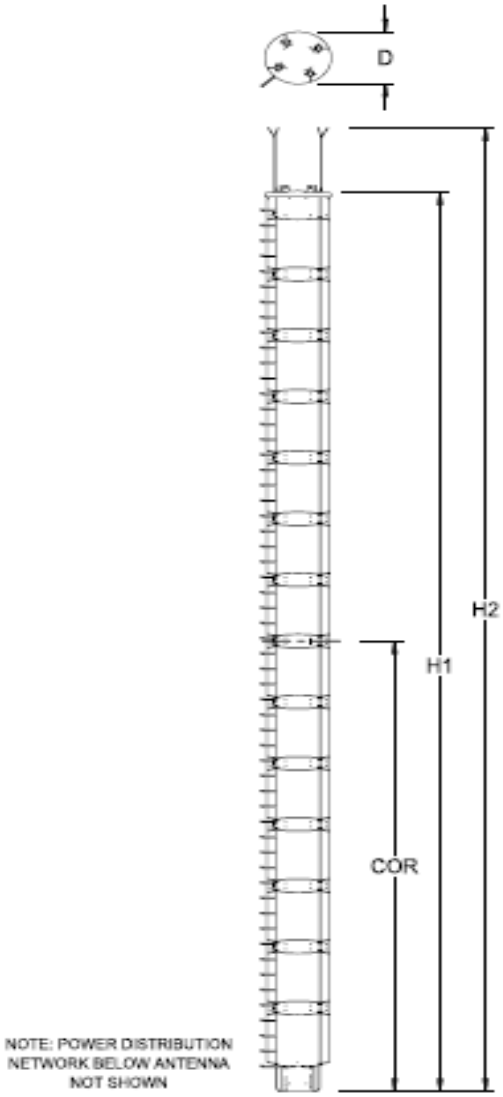
- Must be fully broadband
- Longer length = higher loss
- Longer length = higher TPO
- Larger diameter = lower loss
- Larger diameter = higher capacity
- Larger diameter = higher windload

	6-1/8”	7-3/16”	8-3/16”
% Efficiency	66 %	70 %	74 %
Power Capacity	69 kW	90 kW	115 kW
TPO for 1000 kW 14 bay BBA	59 kW	56 kW	53 kW

1500 ft of 75 ohm Coax

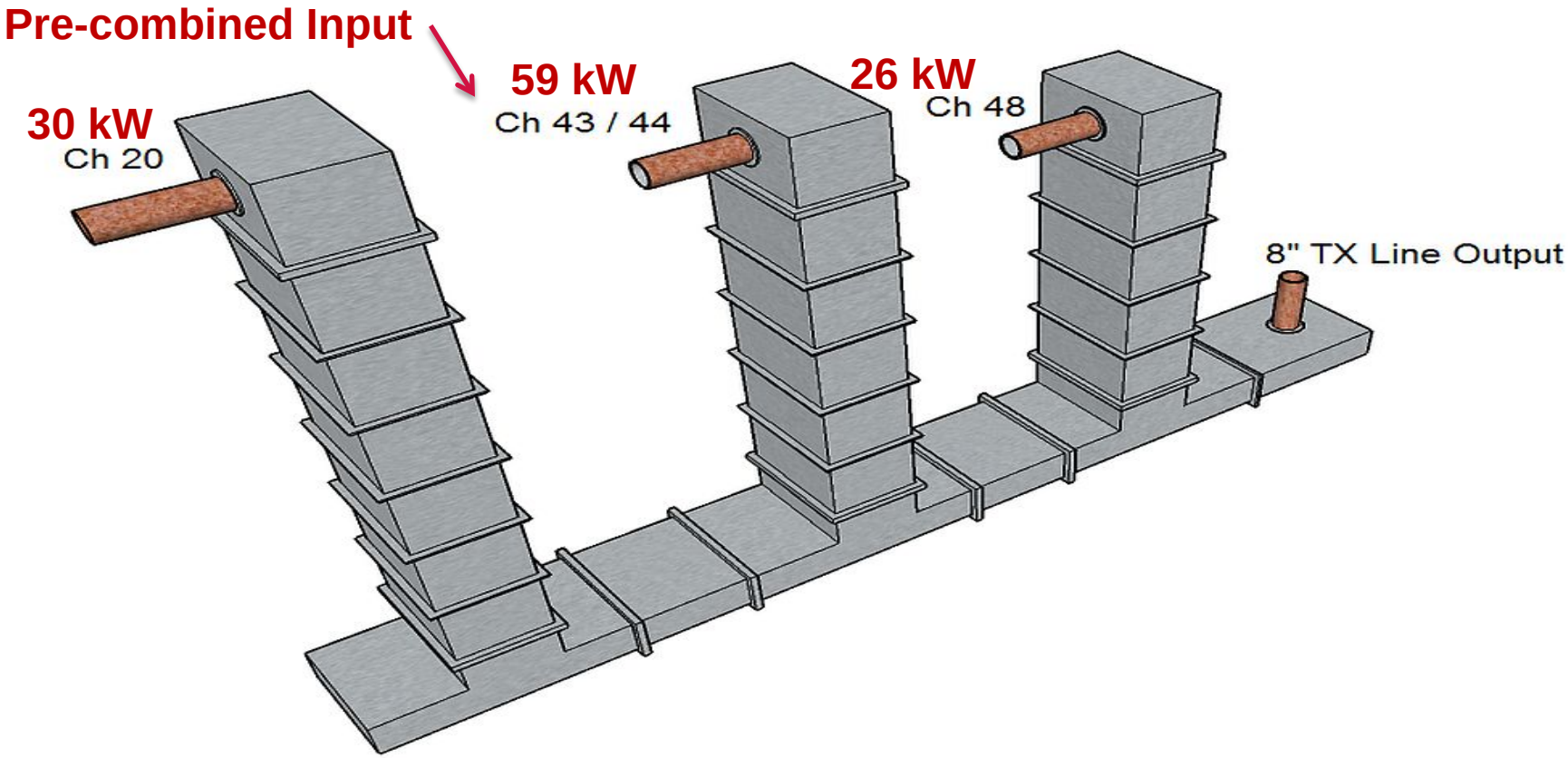
ATC Atlanta TV Market – Chester Ave System

- 12 bay Wide Cardioid UHF Panel BBA
  - SW Arm location at max AGL
  - Optimized beam tilt and null fill
  - Optimized coverage in market
- Final pattern with low ripple
  - Pattern designed to replicate Briarcliff coverage
  - Wide cardioid/offset omni
  - Minimum ripple towards downtown
- Dynamic Polarization with dual feed systems



ATC Atlanta TV Market – Chester Ave System

- Single 8” EHT Digitline transmission line
- Single chain four station/three input manifold combiner system
  - Common polarization ratio setting with single chain/single line



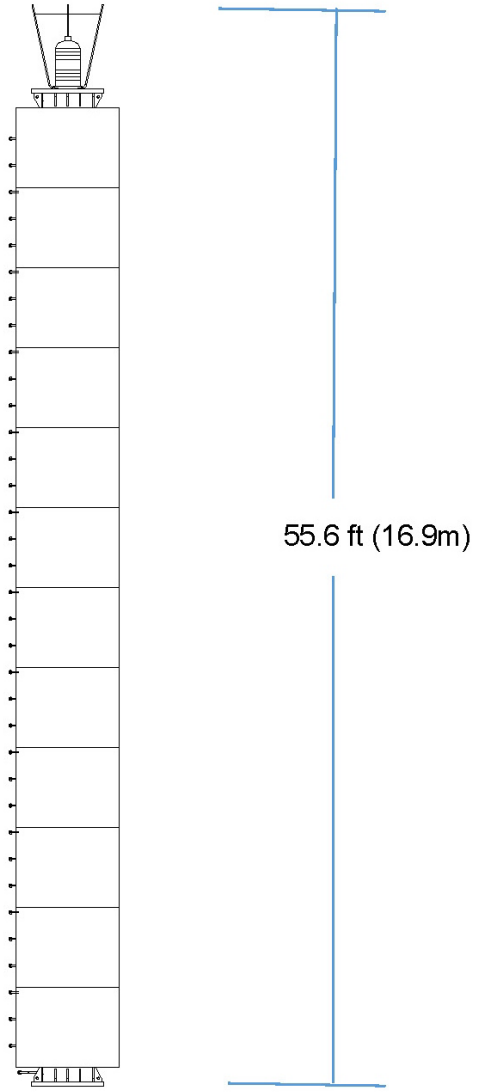
ATC Atlanta TV Market – Chester Ave System

Station	Call	Implementation Channel	H-POL ERP	V-POL ERP	V-POL	TPO	Line Input Power	Line Capacity	Antenna Input Power	Antenna Input Capacity
1	WPCH	20	805	0	0%	31	28	20%	22	19%
2	WUPA	43	960	0	0%	33	31	25%	24	20%
3	WHSG	44	760	0	0%	26	24	20%	19	16%
4	WUVG	48	825	0	0%	26	24	20%	19	16%
Totals			**3345**	**0**		**117**	**108**	**85%**	**84**	**70%**
		Antenna:	12 Bay Wide Cardioid							
		T Line:	8-3/16							
		Number:	1							

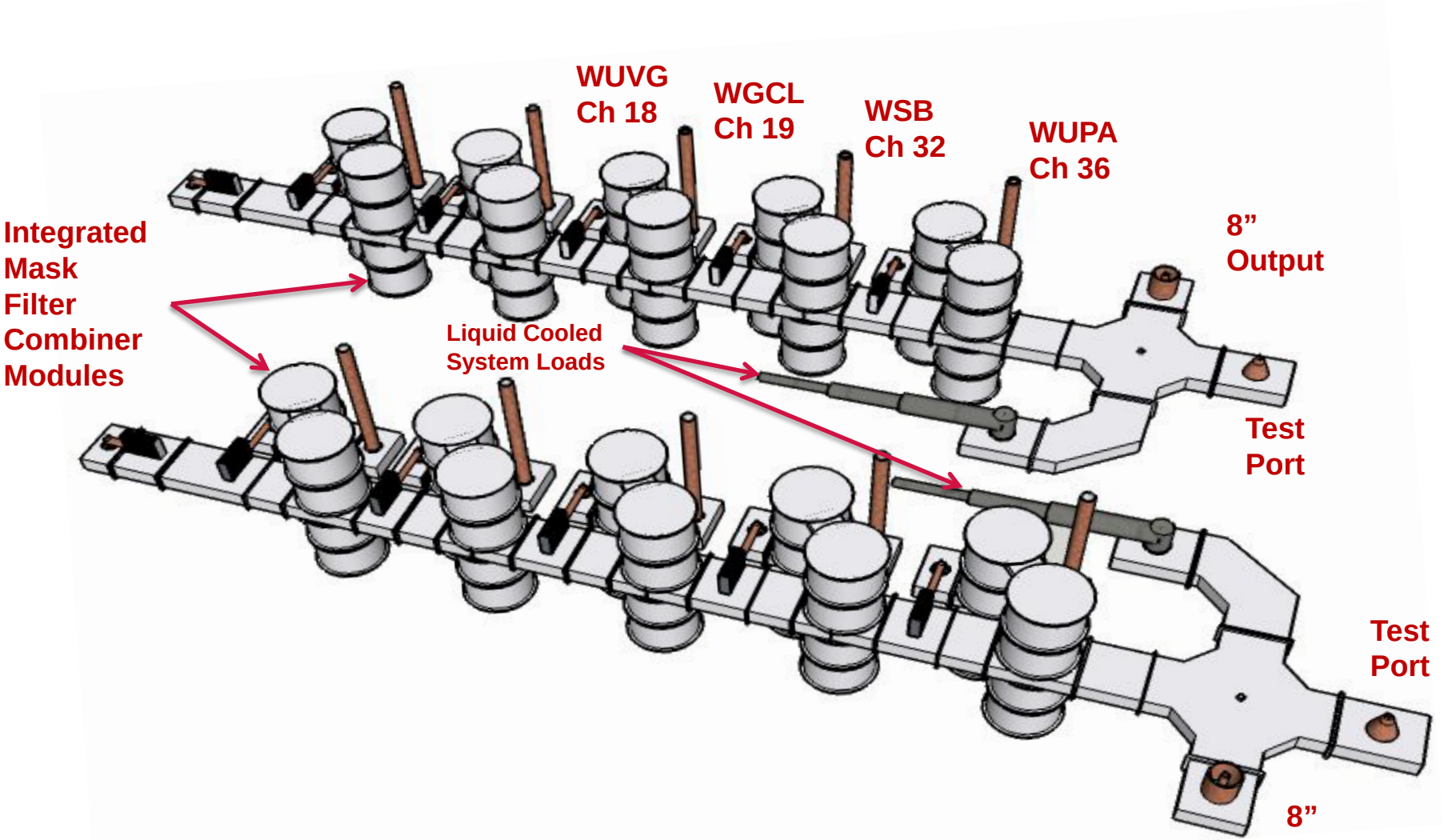
Existing Channels
Interim Main Power Budget

ATC Atlanta TV Market – Briarcliff System

- Omnidirectional 14 bay E-pol UHF BBA
  - Optimized beam tilt and null fill
  - High gain for lower TPO
  - Optimized coverage in market
  - 70 ft support structure
- Pattern optimized for low ripple
- Dynamic Polarization with dual feed systems
- Dual existing 8” EHT Digitline transmission lines
- Dual chain combiner system
  - Independent adjustment of polarization ratio for each station



ATC Atlanta TV Market – Briarcliff System



Dual Chain Five Input Constant Impedance

ATC Atlanta TV Market – Briarcliff System

Station	Call	Implementation Channel	H-POL ERP	V-POL ERP	V-POL	TPO	Line Input Power	Line Capacity	Antenna Input Power	Antenna Input Capacity
1	WUVG	18	1000*	250	25%	66	61	23%	48	23%
2	WGCL	19	1000	250	25%	66	61	22%	48	23%
3	WSB	32	305	76	25%	19	18	7%	14	7%
4	WUPA	36	975	244	25%	61	57	22%	44	21%
Totals			**3280**	**820**		**212**	**197**	**74%**	**155**	**74%**
		Antenna:	Dielectric TUM-AP-O4-14/56H-2-T							
		T Line:	8-3/16							
		Number:	2							

Repack Replication Power Budget

* Reflects WUVG waiver grant

Questions?

Please feel free to contact me with any questions.

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