The Challenges of Replacing C-Band Satellite with Fiber

28 JUNE 2019

C-band Alliance Membership

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Introduction

C-band satellite systems have a number of inherent features that have made them the distribution choice for many services throughout CONUS

- **Scalable** one-to-many delivery
- High **reliability** and availability
- Accessing the **remotest** of locations
- **Simplicity** in design

In contrast, terrestrial (i.e., fiber) alternatives do not share these features. To overcome these deficiencies and establish a replacement fiber network, the following challenges arise:

- **Complexity** of a massive fiber Infrastructure design, development, implementation and operation as well as a overhaul of existing practices and procedures
- **Timing** to design, develop, implement, troubleshoot and transition to a new ecosystem
- **Acceptance** by broadcaster and other current C-band satellite users of a new architecture and workflow with different quality and performance measures than what has been in place for decades
- **Cost** assessment on a total lifecycle basis of every individual element of the new ecosystem, both non-recurring and recurring – orders of magnitude more expensive than C-band satellite

Challenge #1: Complexity of Massive Fiber Infrastructure

- Creating a large-scale geographically disperse content delivery system over a large number of disparate networks is extremely challenging. Operating the system is challenging as well, especially in troubleshooting network issues.
- Thousands of the earth stations will be required to connect to hundreds of content sources including cable TV, broadcast TV, private radio and TV (e.g., religious programming), data networks and government networks. It is impractical to connect all of these sources directly to thousands of earth stations.
  - Due to a number of factors, content sources such as cable TV programmers will not want to connect individual fiber lines to hundreds or thousands of earth stations. Likewise, cable system earth stations will not want individual connections to hundreds of content sources.
  - An aggregation point will be necessary
- The transition from C-band satellite to fiber will be complex; two independent systems (fiber and satellite) will need to operate side-by-side for an extended period of time while services are brought on line, tested, and made ready for commercial use.
- Terrestrial solutions are much more complex than satellite and require levels of expertise that are not typically found at many earth stations, especially those that are small and/or remote. New training and personnel will be required.

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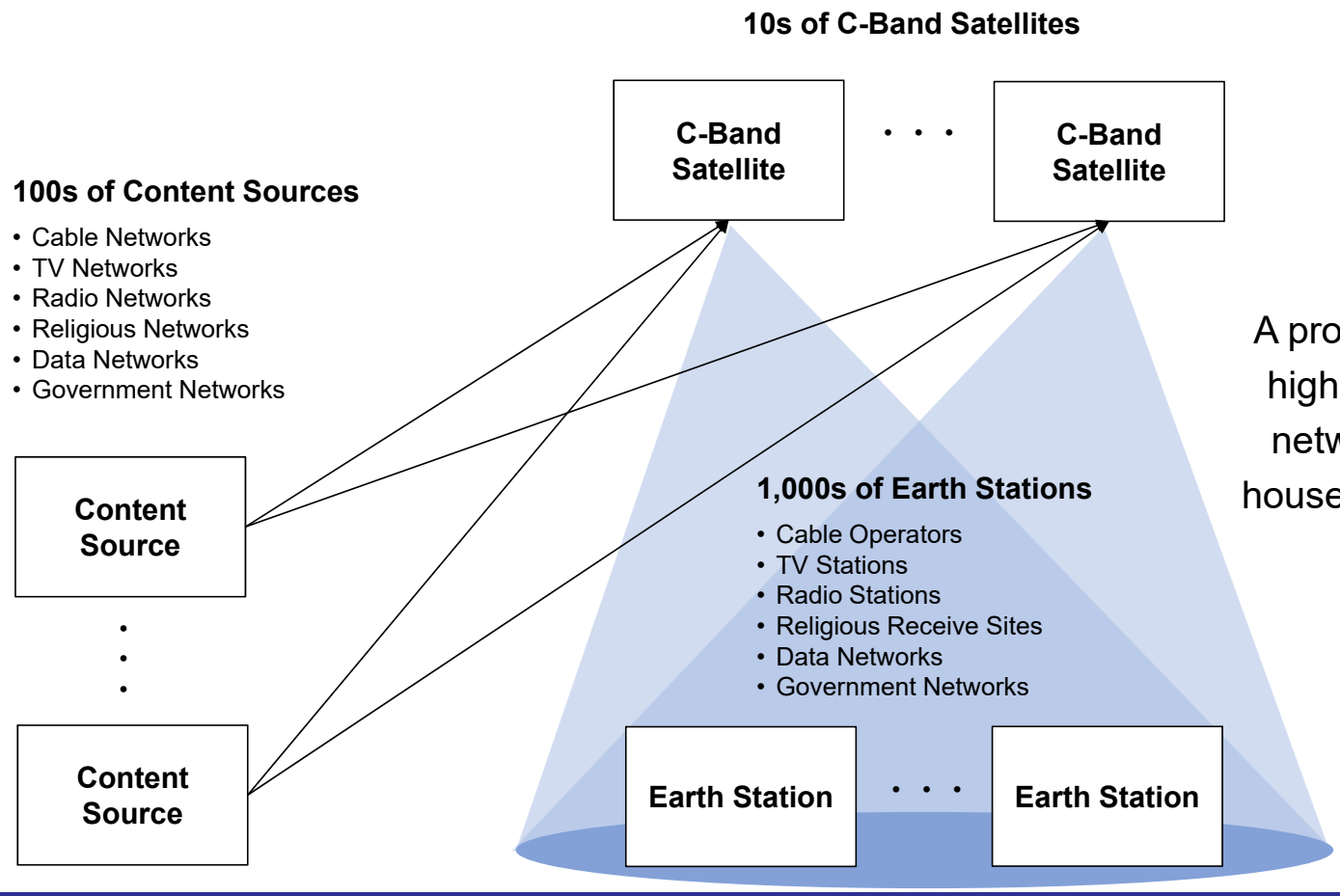
Current Satellite Ecosystem



C-Band Satellite

A proven, efficient, scalable and highly reliable content delivery network serving 100% of U.S. households and other distribution systems

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Fiber Approach #1: One-to-One Fiber Connections

100's of Content Sources

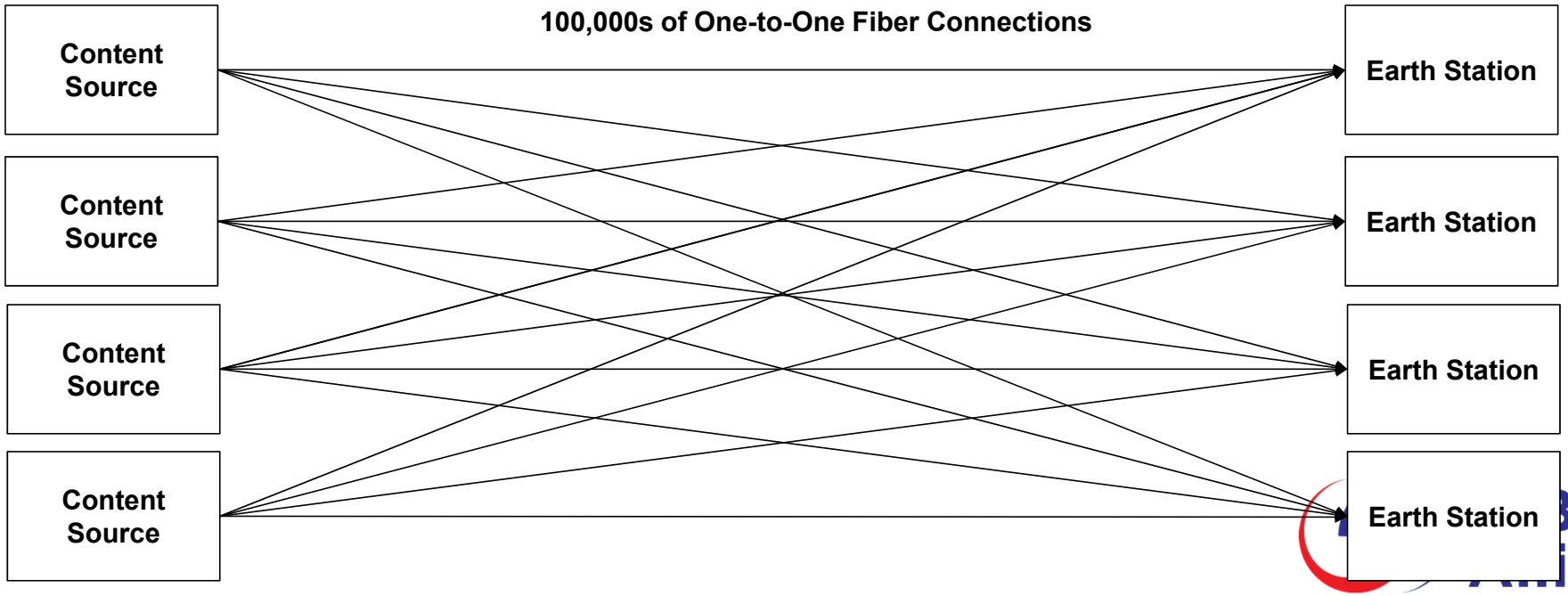
- Cable Networks
- TV Networks
- Radio Networks
- Religious Networks
- Data Networks
- Government Networks

Direct Fiber Connections

Extremely inefficient delivery system with complex operations and management; prone to outages

1,000's of Earth Stations

- Cable Operators
- TV Stations
- Radio Stations
- Religious Receive Sites
- Data Networks
- Government Networks



Fiber Approach #2: Content Aggregation Points

100's of Content Sources

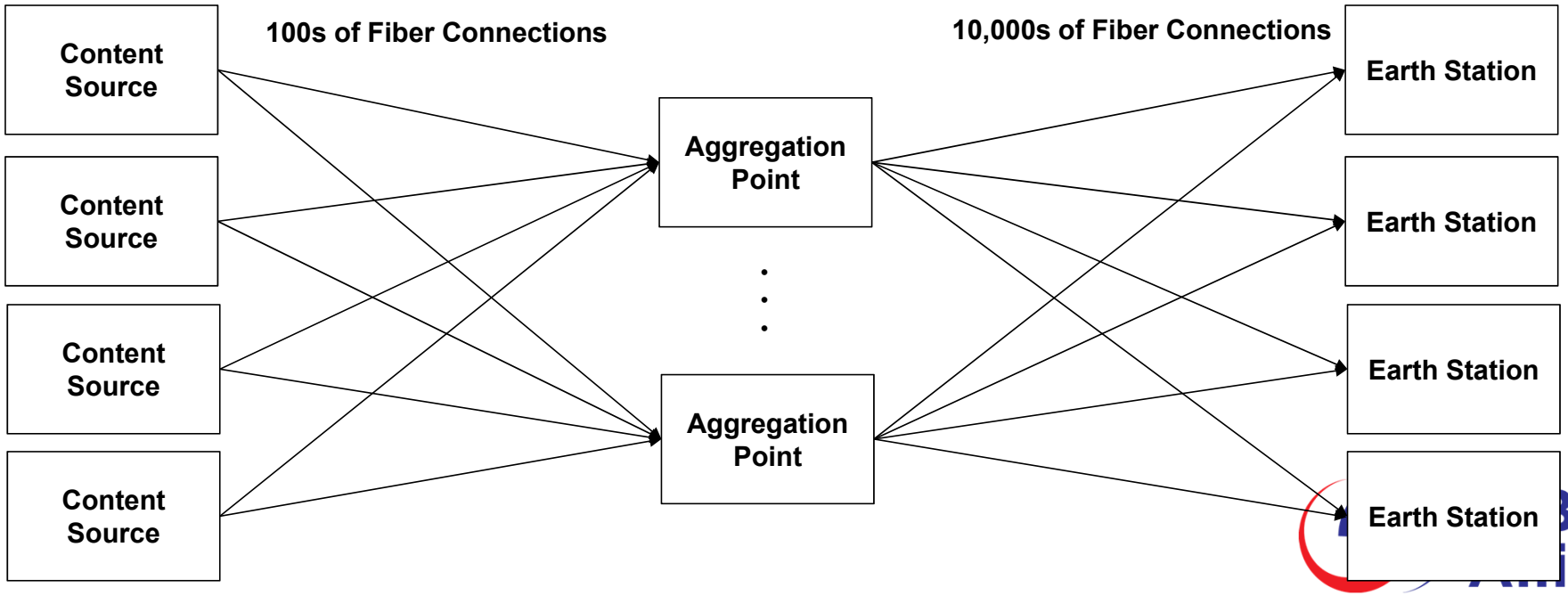
- Cable Networks
- TV Networks
- Radio Networks
- Religious Networks
- Data Networks
- Government Networks

Fiber Connections via Aggregation Points

More efficient than direct fiber connections but still prone to outages

1,000's of Earth Stations

- Cable Operators
- TV Stations
- Radio Stations
- Religious Receive Sites
- Data Networks
- Government Networks



Challenge #1: Complexity of Massive Fiber Infrastructure

- A major project management and systems integration entity will need to be commissioned to lead the design and implementation of the vast fiber architecture.
- The aggregation points will be extremely complex. They will need to accommodate a multitude of services with differing service quality requirements, as well as operation and management approaches.
  - They will need to be redundant and diverse.
  - Operational expertise will need to be developed.
  - Commercial agreements will need to be put in place with the content sources for the rights to aggregate and protect the content.
  - Commercial agreements will need to be put in place with thousands of entities to account for an entirely new business model.
  - The responsibility for end-to-end service quality will need to be defined.
- A significant amount of new equipment will need to be added to the existing infrastructure at content sources, the aggregation point, and at the earth stations to adapt the new content delivery network to current distribution systems; otherwise a massive changeout in equipment, processes and procedures throughout the entire delivery chain will be required.

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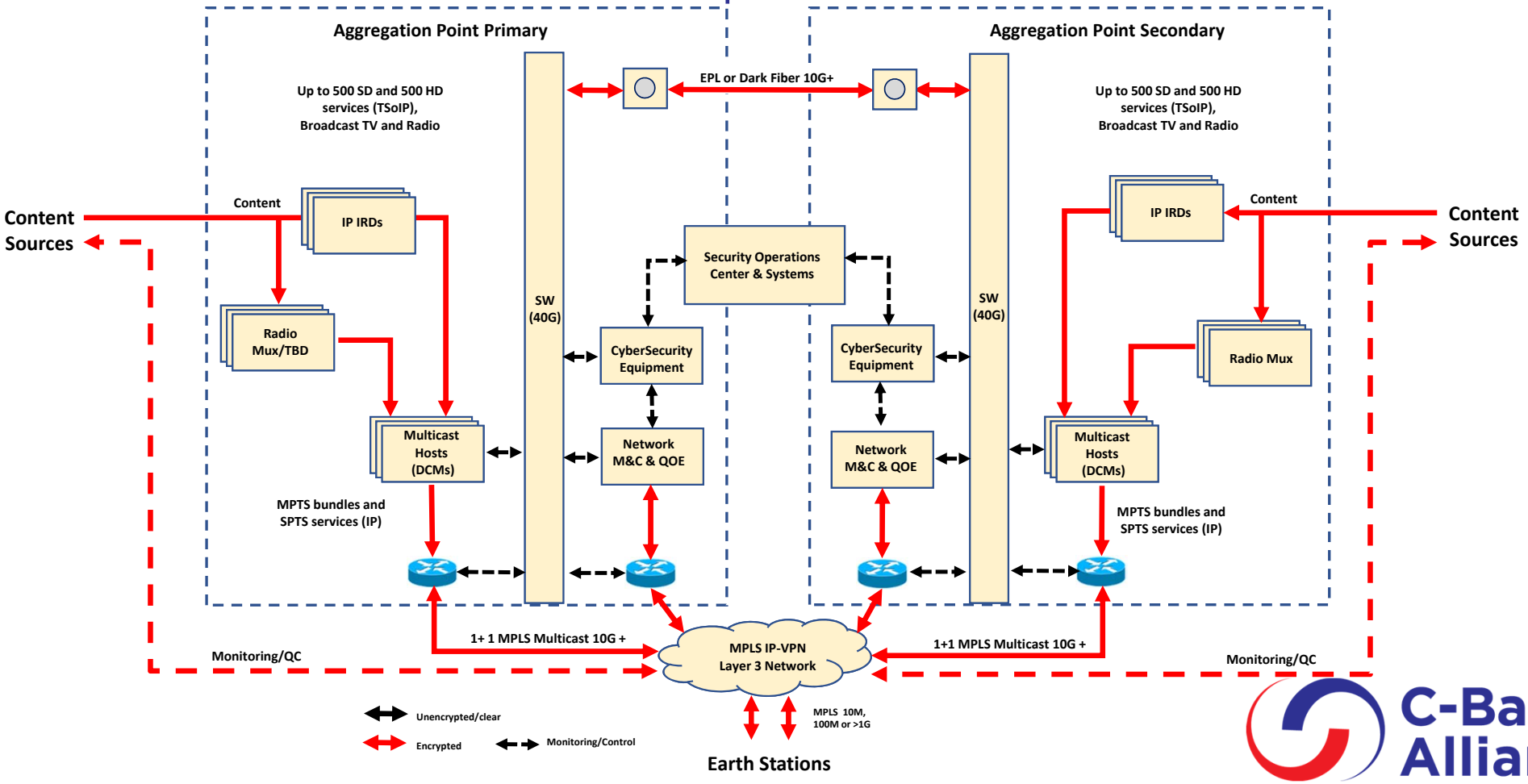
Potential Aggregation Point Architecture

Cable / Broadcast TV and Radio Example



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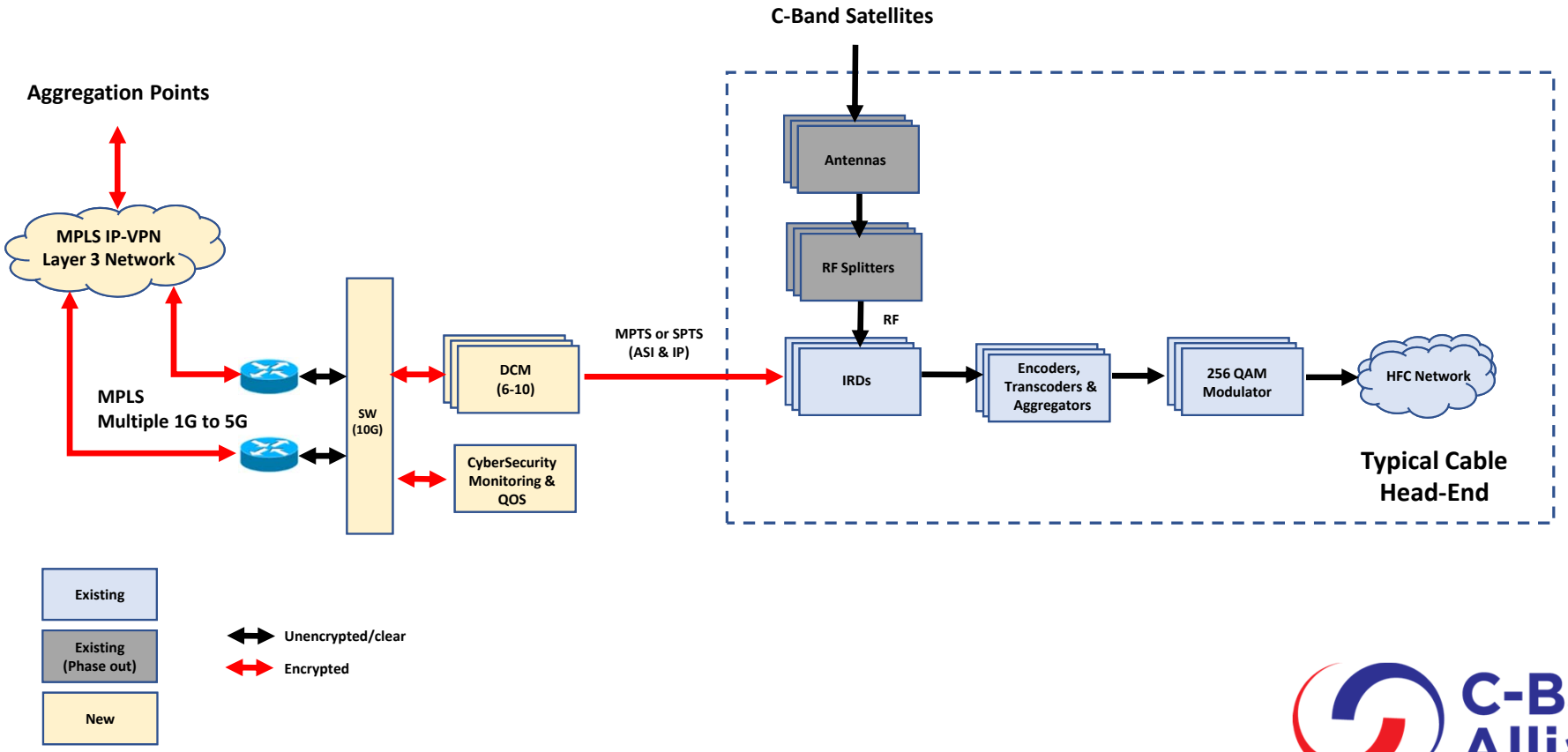
Potential Earth Station Architecture

Cable TV Example



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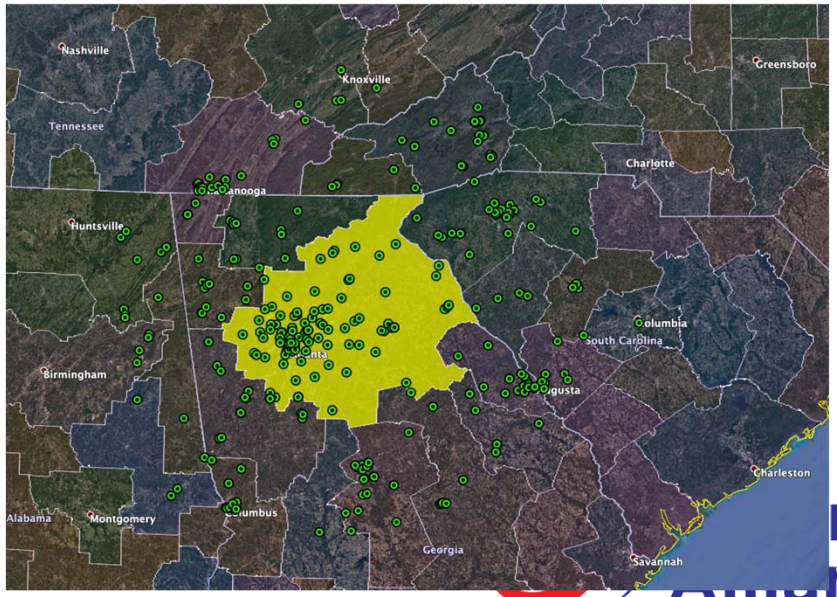
Challenge #1: Complexity of Massive Fiber Infrastructure

- In the case of implementing a fiber alternative only in some service areas (e.g., major metro PEAs) versus utilizing fiber in all of CONUS, additional complexities must be considered.
- As noted in the CBA's May 9, 2019 ex parte filing, co-frequency wireless interference from a "fibered PEA" into a non-fibered PEA will be problematic. Therefore, in addition to fibering earth stations in major metro PEAs, fiber will also be required for earth stations in adjacent PEAs located at distances up to 100 km from the major metro PEA boundary. The image below demonstrates the potential challenge in PEA 11 (Atlanta) where 193 earth stations outside of PEA may need to be fibered in order to prevent interference from base stations within the fibered PEA. Also note 40% of urban and 60% of rural will need new fiber installs..

Earth Station Type	Number of Earth Stations		
	PEA 11	Adjacent PEAs	Total
Cable Network	27	31	58
Data Network	2	3	5
Education	3	1	4
Entertainment/Media	0	0	0
Other	0	3	3
Radio Broadcast	15	67	82
Religious Radio Broadcast	12	4	16
Religious TV Broadcast	53	40	93
Satellite Operator / Teleport	1	4	5
TV & Radio Broadcast	0	5	5
TV Broadcast	4	35	39
	117	193	310



Challenge #2: Timing of C-band Ecosystem Changeout

As a result of the enormous complexity, the timeline to implement and bring into service a fiber-based architecture to replace the current C-band satellite infrastructure is well-beyond the 18-36 months in which satellite operators can clear the lower 200 MHz of C-band downlink.

- Specifying the massive replacement architecture itself will take at least 24 months, likely much longer.
- The timeline to procure and deploy a new broadcast-quality architecture, not including the new fiber lines that need to be trenched or pole mounted, will take 48 months or more after the specifications are developed.
- The time required for obtaining permitting, easements, and rights-of-way, all of which are controlled by local governments, must be considered. Typical installation schedules for just one new fiber link runs into months; extending this to 10,000s of fiber connections will take an extensive amount of time.
- The time it will take to install not only the fiber but also the components required to interconnect the fiber with 13,500 earth stations, 60% of which are rural, will take many years.
- Once the network is fully operational, a transition time will be needed where all earth stations continue to receive C-band satellite services to ensure there is no gap in content delivery and emergency services while issues regarding the fiber system are resolved. This alone is likely a multi-year process.
- All in, assuming it is even technically feasible, the timeline for changing the “status quo” throughout CONUS will likely take more than a decade.

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Challenge #3: Acceptance of Fiber by C-Band Satellite Users

A new fiber-based delivery ecosystem must achieve the same level of reliability that content distributors and U.S. consumers have come to expect. Current C-band customers enjoy an industry leading level of reliability; availability is approximately six-sigma (99.999%). This translates to loss of service of less than 6 minutes annually. Fiber network reliability can be improved with the installation of redundant, geographically separated fiber lines, but the improvements still will likely not achieve the six-sigma reliability offered by satellite.

- A single instance of a fiber cut lasting one day will result in an availability of 99.7% which is unacceptable for many services currently delivered by satellite and could take out millions of end-users at the same time. It would take approximately 250 years for satellite distribution to suffer outages equal to this one-day fiber cut.
- Fiber outages are not theoretical – Comcast experienced a massive outage of its internet service a year ago due to a fiber cut (*see* https://www.wired.com/story/friday-comcast-outage-cut-fiber/). Also, fiber outages can be caused for reasons other than cuts (*see* https://www.ppc-online.com/blog/the-six-biggest-causes-of-damage-to-fiber-networks).
- Unlike satellite, which provides delivery paths that are operated by different vendors and are geographically separated to ensure performance in the event one path fails, single-vendor non-geographically-diverse fiber is a single point of failure that can result in service outages for millions of end-users at a time. To mitigate this risk, at least two fiber lines operated by separate vendors that are geographically separated from one another must be installed at each earth station site with separate points of ingress. This translates into the significant time and cost of implementing a fiber-based architecture.

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Challenge #3: Acceptance of Fiber by C-Band Satellite Users

Broadcasters and other users of the C-band satellite spectrum have gone on the record as saying that fiber distribution is not a suitable replacement for satellite for their business.

- *"[F]iber does not provide the 99.999% reliability that NCTA's members have come to rely on from C-band. Unlike C-band spectrum, fiber connectivity is subject to disruption from cuts caused by construction, severe weather, and other damage. To achieve comparable reliability to C-band spectrum, providers would need multiple redundant fiber links with geographic routing diversity, adding to both the complexity and cost of transitioning earth stations to fiber."* Comments of The NCTA—The Internet & Television Association, at 10.

- Those advocating for fiber as an alternative to C-band spectrum *"fail to address the high likelihood of disruption due to fiber cuts, lack of redundancy, inability to lay fiber due to government-related or nature-related conditions, and high deployment and maintenance costs."* Reply Comments of GCI Communication Corp., at 8.

- *"While fiber and other technologies play a role in distribution, these are complements, not substitutes, to the C-band. For example, ESPN uses both fiber and C-band downlinks in the production and delivery of content, but it is the C-band downlinks that ensure delivery of programming to all affiliates and other distributors. No other distribution method matches the C-band in ubiquity and reliability"* Content Companies ex parte, June 7, 2019

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Challenge #4: Total Lifecycle Costs

- Total lifecycle costs for the massive fiber infrastructure that connects thousands of the earth stations to hundreds of content sources will be enormous based on a detailed CBA assessments. Considering both non-recurring and recurring costs, the total estimated 30-year incremental (above current ecosystem costs) rate-adjusted lifecycle cost could be in the range of $20 billion to $30 billion or more.
- It is unclear that at even these cost levels, broadcast-quality performance can be achieved.

	Non-Recurring	Annual Recurring
Aggregation Infrastructure and Equipment	$400,000,000	$80,000,000
Earth Station Equipment	$750,000,000	$150,000,000
Fiber Network*	$1,500,000,000	$775,000,000
	$2,650,000,000	$1,000,000,000

*Includes diverse and redundant routing which may not be sufficient to achieve broadcast-quality performance

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