
# WHITE PAPER

## TERRESTRIAL DISTRIBUTION OF LINEAR CHANNELS

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Connecting and Protecting the Networked World℠

## Executive Summary

Major linear television broadcasters and MVPDs[1] are increasingly using terrestrial networks to deliver content to distribution partners. These fiber-optic connections provide high-performance signal transport with enhanced security for point-to-point and multipoint topologies. Higher signal bandwidths that can be accommodated on fiber permit the use of mezzanine-level compression, which can improve the quality of signals delivered to distribution partners and, ultimately, viewers. What's more, terrestrial networks have outstanding reliability records.

The following pricing and market trends also favor increased use of terrestrial networks: (1) fiber optic transport costs continue to decline year over year; (2) consolidation continues to occur among large and small MSOs as well as in other segments of the MVPD market; (3) new formats such as UHD/4K and HDR are increasing the bit rates needed for new linear channels even after HEVC and other advanced compression systems are deployed; (4) the total number of linear channels continues to increase as audience segments narrow and become more targeted, thus creating the need for even more distribution paths to be established; and (5) the growing number of digital/OTT platforms offering customized "skinny" bundles are creating new demand for high bitrate IP streams that can be transcoded and repurposed into multiple streams for HTTP-based delivery.

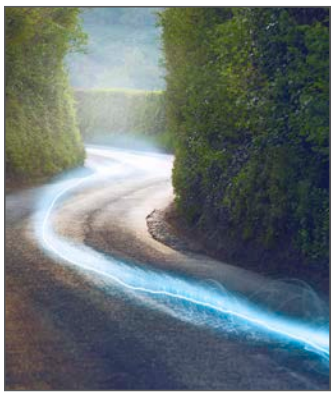
Together, these factors are making terrestrial distribution of linear channels an attractive choice for many broadcasters across a wide range of applications.

### Mezzanine-Level Compression

Similar to how 'mezzanine' refers to a floor in a building located between the ground and the first floor, 'mezzanine-level compression' refers to compressed signals that operates at a bit rate significantly lower than uncompressed signals, but higher than those used for consumer delivery. At these compression levels, the signal quality is measurably better than when fully compressed, while at the same time being more economical to transport than fully uncompressed signals. For example, one popular format, H.264 4:2:2 8-bit, is used because it is easy to compress to lower bit rates and supports the higher signal rates used for OTT delivery to larger screens, while still being economical to transport over fiber-optic networks. Note, however, that the bandwidths commonly used today for mezzanine-level signals (typically 20-40 Mbps) greatly reduce the number of channels that can be accommodated by a satellite transponder.

## Introduction

Since the dawn of the geosynchronous satellite age, television program originators (i.e. television networks) have predominantly used fixed satellite service space segments for delivering linear programming to multiple destinations. All types of MVPDs access a single, highly compressed stream from a satellite feed, including cable TV networks, IPTV providers, direct-to-home satellite companies, internet/OTT (over-the-top) video aggregators and local broadcast stations. It is not uncommon for program originators to deliver many of their most popular channels to over three thousand individual receive locations using satellite distribution, although many channels are delivered to far fewer receivers.



Due to shifting economic and technical forces, however, this status quo is starting to change. Large broadcasters and MVPDs are increasingly using terrestrial networks to transport programming between a growing number of sources and destinations, taking advantage of the higher signal quality, greater flexibility and better reliability that these networks are able to offer.

To fully understand the transition of linear distribution from satellite to terrestrial networks, it's important to consider why linear channels are still so prevalent in a market infiltrated with on-demand and OTT services. Additionally, the factors that broadcasters use to compare network technologies — cost, quality, controllability and reliability — all need to be analyzed. In order to make an informed decision about their choice of distribution technologies, broadcasters and MVPDs must finally consider whether terrestrial network providers can support all of the other functions required to implement a next-generation linear channel distribution system.

[1]In this document we will use the term "MVPDs" to denote both those companies formally designated by the US Federal Communications Commission as multichannel video programming distributors such as CATV multiple-system operators (MSOs) and home satellite providers, as well as any other company in the business of delivering linear television channels to consumers (including services that use internet/OTT or any other consumer delivery technology).

## The Longevity of Linear Programming

Decades ago, a handful of linear broadcast networks, in addition to a few independent channels in large populated areas, were the only sources of television programming for viewers. Later, through the ability of cable television and direct broadcast satellite (DBS) to provide a greater number of signals, channels began to appear that had never been broadcast previously. But these new offerings still used the same model of content delivery: a single linear feed to all viewers simultaneously. Today, linear programming remains dominant and represents the majority of audience viewing hours. By some counts, there are more linear broadcast channels available today than ever before. According to Nielsen's Q2 2016 Total Audience Report, the average U.S. home with a TV received 205.9 channels in 2016 — a significant jump from 2008 when the average was 129 channels.[2]

Three market forces contribute to the lasting popularity of linear broadcasting today.

1. **Nature of the Content:** For news, sports, awards programs, audience-participation shows and similar genres of entertainment, live broadcasting is essential to the value of the content.
2. **Advertising and Audience Size:** Linear channels are preferred by advertisers who may have their own needs for timeliness such as seasonal sales and want to reach the greatest number of viewers.
3. **Declining Cost of Linear Channel Production:** So-called "channel in a box" products have greatly reduced the costs of production, making it feasible for a wide range of non-traditional broadcasters to create their own channels and for established broadcasters to create a growing number of highly targeted linear channels such as regional sports networks.

## Linear Channel Distribution

Creating a linear channel is one thing. Choosing a distribution method that covers a multitude of MVPDs is quite another. Successful distribution of a linear channel requires a system that supports several key functions. These include: (1) a cost-effective way to transport a multi-megabit stream from a single source to many destinations; (2) a method to help ensure that only authorized destinations receive streams on a public or antenna-based network; (3) a control system to manage, monitor and administer the network; and (4) a reliable delivery system.

**Cost:** When comparing satellite to terrestrial networks, cost-effective multi-point distribution comes down to the standard analysis of variable versus fixed costs. With a satellite-based system, the fixed costs consist primarily of building and staffing an uplink facility and negotiating transponder space on a satellite, which is often a multi-year contract. Variable costs include providing a satellite dish and a receiver/decoder (IRD) for each destination. For a point-to-multipoint fiber-optic network, the fixed costs are little more than the connection from the signal source to the network core, whereas variable costs are incurred for each new destination added to the network. The break-even point, based on total number of destinations served at the same cost by both terrestrial and satellite networks, has been evolving towards an increasing number of endpoints as the cost of optical networking continues to decrease. Over time, terrestrial networks can more cost-effectively deliver across a large number of end-points than satellite platforms. Plus, as signal bandwidths increase to accommodate higher quality mezzanine-level streams (see sidebar), the costs of bandwidth grows slower on fiber-optic than on satellite systems.

**Security:** Signal security is essential for any linear channel delivery system to help ensure that only authorized users and signal distributors are accessing valuable content. On a public terrestrial network, this requires encryption, whereas secure transmission on a private network can sometimes be attained through the use of network connection controls alone.

**Control:** Content distribution agreements often have specific rules and restrictions. This presents challenges for sports content where both professional and collegiate league rules dictate distribution territories, device restrictions and blackouts. In such cases, the programmer must control regional programming changes by providing alternate content and/or implement a market-specific blackout. In order to support these highly dynamic requirements in an IP environment, programmers are adopting

[2]Nielsen, The Nielsen Total Audience Report: Q2 2016, Sept. 2016

a new standard, SCTE224/ESNI (Event Scheduling and Notification Interface), to communicate out-of-band data in conjunction with the in-band SCTE35 media points. This allows real-time event changes to be conveyed with additional content policies such as those associated with distribution territories, device restrictions and start over/look back. This standard allows programmers to implement a highly granular control over the legacy satellite platforms and enables a transition to an all-IP terrestrial two-way distribution architecture that can support both the current MVPD's IP backbone infrastructure with edge conversion to QAM, as well as the new OTT entrant requirements.

**Reliability:** Failures of signals that are feeding service to thousands, possibly millions, of viewers can have a major financial impact. Even short interruptions can cause a significant drop in viewership and immediate loss of advertising revenues. Private terrestrial networks based on fiber-optic technology have an outstanding reliability record. This can be further enhanced through the use of redundant signal feeds that can support hitless switchover (i.e. zero signal interruption) to a backup circuit, a function that is not currently available on satellite services. What's more, terrestrial networks are not affected by weather systems and seasonal sun outages.

## Choices for Terrestrial Distribution

Just as there is a variety of terrestrial networks, several technology options are available when deploying a terrestrial linear channel distribution system. Broadcasters and MVPDs can (1) use the public internet with signal adapters at either end, (2) lease private point-to-point circuits to connect to programmers, or (3) work with a network provider to take source signals and deliver them to multiple destinations by replicating the streams within the network core. Each of these alternatives bears deeper scrutiny.

The first choice may sound attractive on the surface, but deeper analysis shows that content reliant on constant network delay and high levels of service quality is not well suited for internet delivery. Network routes cannot be controlled by an end user on the public internet, and priorities cannot be assigned to individual streams. These factors make it difficult to establish a predictable signal path with consistent delay and long-term repeatability. While non-time-critical file delivery systems using the internet have become commonplace, consistent and continuous delivery of high-bandwidth linear channels remains a risky proposition.

The second alternative, where MVPDs build their own aggregation locations, has been used by some participants in the market. Typically, these networks are custom-built and require space to be allocated in the equipment room at signal providers' facilities for each individual MVPD. Inefficiencies can result from the lack of commonality between these different networks, forcing the use of separate monitoring systems. This creates a complex web of point-to-point connections that can be a headache to manage, maintain and troubleshoot. What's more, these installations can burden broadcasters serving multiple MVPDs due to the cost of space, power and connectivity to support multiple shelves of equipment and their associated network connections.

The third option uses a fiber-optic based common carrier to distribute signals from linear channel sources to a population of MVPDs and other signal destinations. By using high-capacity network links at each signal source and destination, streams can be delivered to multiple destinations via stream replication in the core of the network. This removes the need for direct circuits between individual source/destination pairs, while still allowing connections to be added or removed independently to stay current with carriage agreements that can change over time. Using this common-carrier model helps reduce costs and simplify maintenance activities by collapsing monitoring, maintenance and troubleshooting activities onto a single platform.

## Signal Replication

Transponders on geosynchronous satellites are specifically designed to replicate an uplinked signal to one or more receivers located at the signal downlink locations. In an IP-based terrestrial network, this function is performed by packet processing devices that accept incoming packet streams and generate multiple copies of each stream to then be addressed to different destination devices. Unlike SONET and ATM-based signals, IP video streams adhering to SMPTE 2022 standards can be economically replicated at any point along their path.

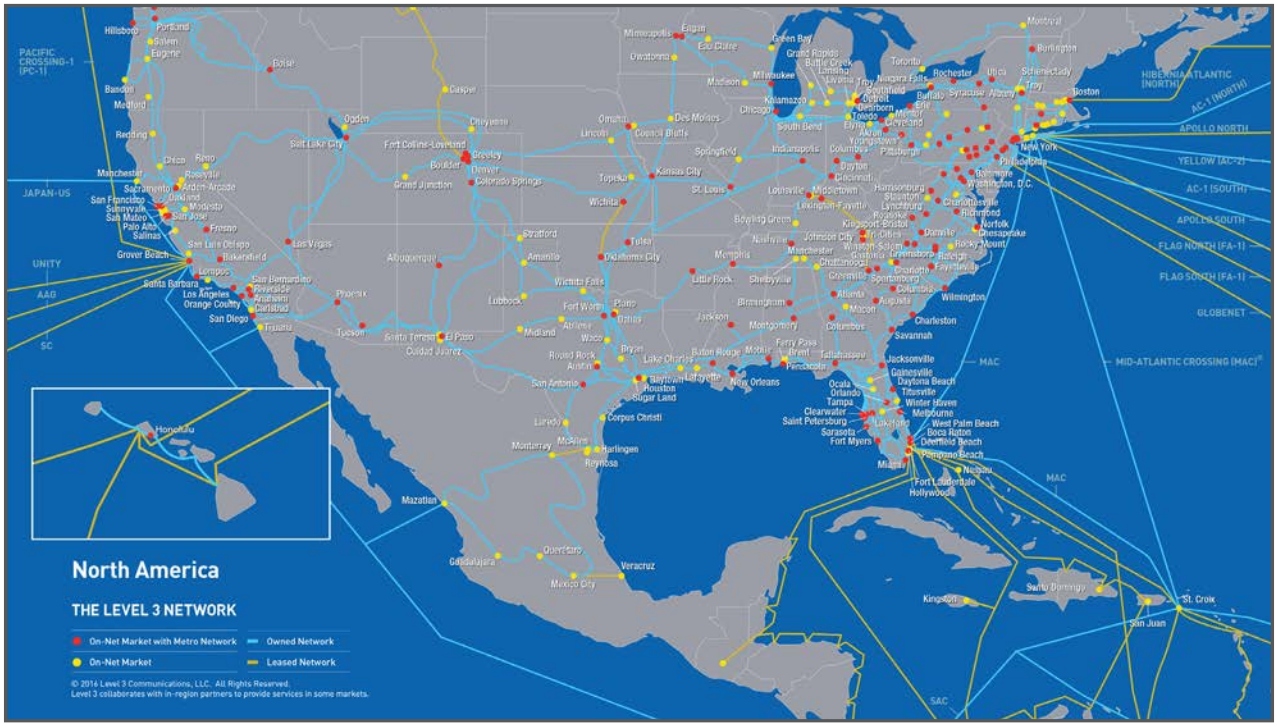
Replication can technically be done either at the signal source or within the network core. If it is done at the signal source, the amount of bandwidth needed to transport signals out of the source destination increases as each new endpoint is added to the network. In contrast, if replication is done inside the network core, the source connection remains constant as the network grows. This strategy also allows the replication function to be made redundant for greater system reliability.

## Terrestrial Network Design Considerations

Proper implementation of a multi-source, multi-destination network requires meticulous implementation of a few carefully chosen technologies. First, the right choice of topology needs to be made between unicast, multicast and managed multipoint systems that use replication. A system also needs to be provided to control which sources are distributed to each designated recipient. Finally, source and route diversity is necessary for high-value streams that require redundant support across the network fabric.

Consider the choice of topology. A matrix of unicast point-to-point connections grows exponentially more complex as the number of network endpoints increases, quickly becoming cost-prohibitive and difficult to manage. IGMP multicasting, where each endpoint autonomously joins a multicast group, makes network access control hard to enforce and can interfere with configuration of diverse routes needed for redundant feeds. A managed point-to-multipoint network that replicates streams within the network combines the best features of the two alternatives by pairing the routing efficiency of a multicast network with a pure unicast system's ease of control.

Control and monitoring also needs to be provided for the carrier, signal providers and the recipients. Different sets of privileges need to be provided for each type of organization, allowing, for example, a signal provider to make decisions about which endpoints will be permitted to receive each of the channel streams. More advanced architectures can easily be employed on terrestrial networks where customized versions of streams (i.e. different sets of SCTE-35 ad triggers) can be routed only to targeted MVPDs. Terrestrial networks, which predominantly use bidirectional connections, are also inherently well-suited for gathering rich sets of performance data across a population of signal endpoints, providing end-to-end visibility and advanced troubleshooting support. Source diversity and route diversity can

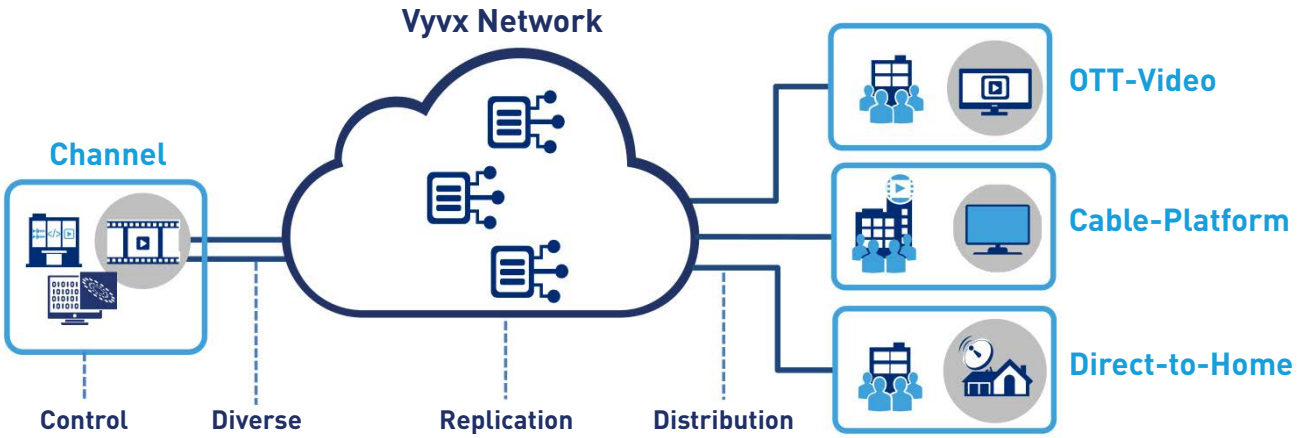


increase overall distribution network reliability by eliminating single points of failure. This often takes the form of having duplicate feeds into the network from separate physical source locations and redundant routes through the network core. Automatic protection switching can then be employed at the network outputs to minimize or eliminate signal interruptions in the event of a component failure. Bear in mind, care needs to be taken to not overdo this, as adding too much redundancy to a network can increase complexity to the point of diminishing returns.

## Conclusion

Terrestrial networks are increasingly being used to distribute linear channels to MVPDs. Key factors driving this transition are the demand for higher-quality mezzanine-level signals that require greater signal bandwidths, the increasing consolidation of MVPDs with more centralized head-ends, the expanding requirements for stream versioning and end-to-end monitoring, the growing population of linear channels (including non-traditional broadcasters), and the constant search for improved distribution network reliability and diversity.

Level 3 launched the Vyvx® Linear Channel Distribution service to provide a multi-client approach to terrestrial distribution of linear channels. This service benefits both signal originators and MVPDs by simplifying the construction and operation of point-to-multipoint networks. Through the use of signal replication within the network core, the solution combines the flexibility of a multicast network with controllability of a unicast mesh network — while keeping a lid on service costs. This innovative architecture allows terrestrial links to increasingly replace and surpass satellite-based systems for virtually any linear channel distribution requirement.

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