ULTRA-LONG-RANGE WIRELESS BACKHAUL LINK

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INTRODUCTION

PROJECT BACKGROUND

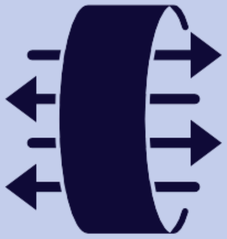
Introduction:

- An affordable and reliable high-speed Internet to remote and rural communities remains a significant challenge.
- Typical backbone infrastructure solutions are often uneconomical;
- Increasing the achievable tower-to-tower distance in wireless terrestrial backhaul links would result in a significant reduction of the number of wireless hops required to reach remote communities and enable new multi-hop paths based on locations where power and road access are available.

PROJECT BACKGROUND

Expected Outcomes:

User-Data Throughput



≥ 400Mbps

Spectral Efficiency

≥ 5bps/Hz

Distance b/w Hops

≥ 100km

Round Trip Latency

< 25ms

Existing Technology:

- typically operates in microwave bands or higher (i.e., 4 GHz and above)
- typical separation between hops is limited by the radio horizon
- microwave systems are limited by various factors such as high propagation loss, high weather attenuation and limited transmission power

TECHNOLOGY REVIEW

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Potential Technology:

- lower frequencies, especially the sub-1GHz frequencies
- low line-of-sight (LOS) propagation path loss
- better signal penetration
- increased resilience in Non-LOS condition
- robustness against fading

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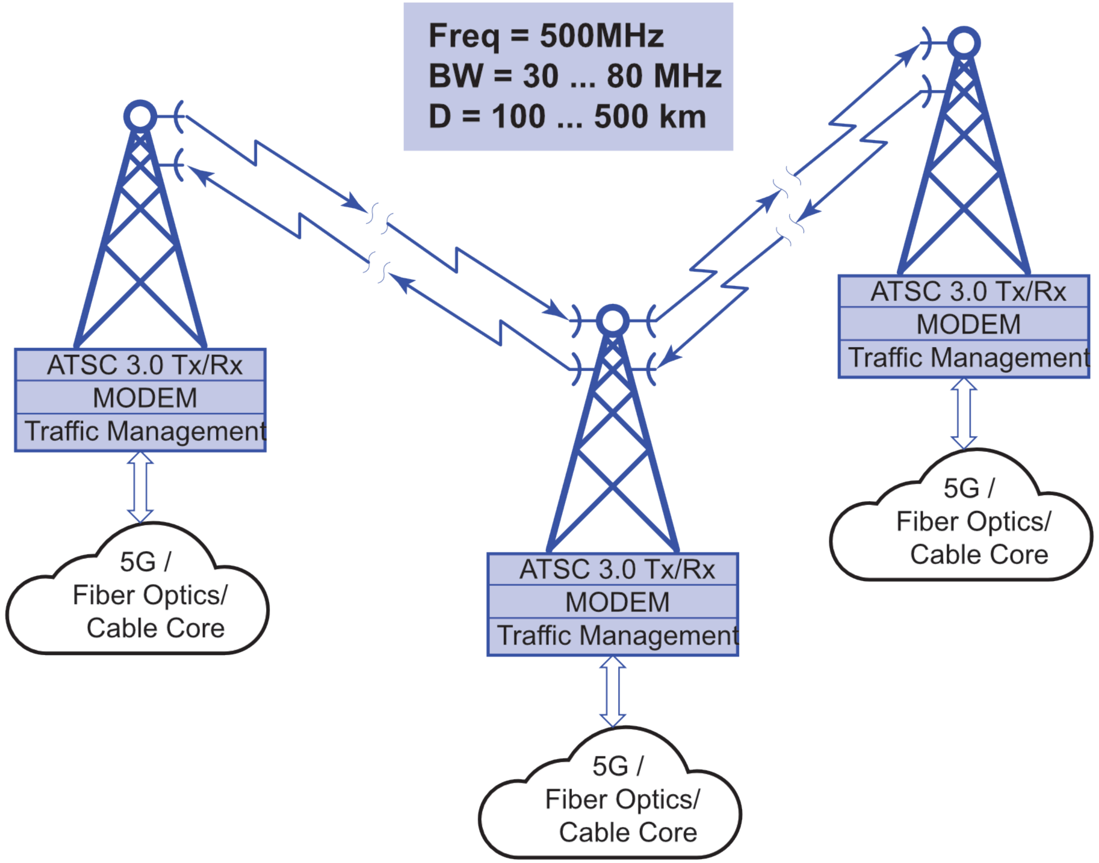
Proposed Solution:

- **ATSC 3.0 Physical Layer (ATSC A/322)**
  - High degree of signal robustness combined with data capacity
  - Unmatched spectral efficiency that is closest to the Shannon limit
  - IP-based backbone for integration with ISPs and communication infrastructures
- AI-based channel estimation and adaptation
- MIMO technology for the spectral efficiency
- Innovative antenna system

TECHNOLOGY REVIEW



ATSC 3.0 Physical Layer (A/322):

6MHz BW 58Mbps

8MHz BW 78.5Mbps

2x2 MIMO with 8MHz BW 157Mbps

64/256/1024/4096 QAM ...... > 5bps/Hz

PROJECT CHALLENGES

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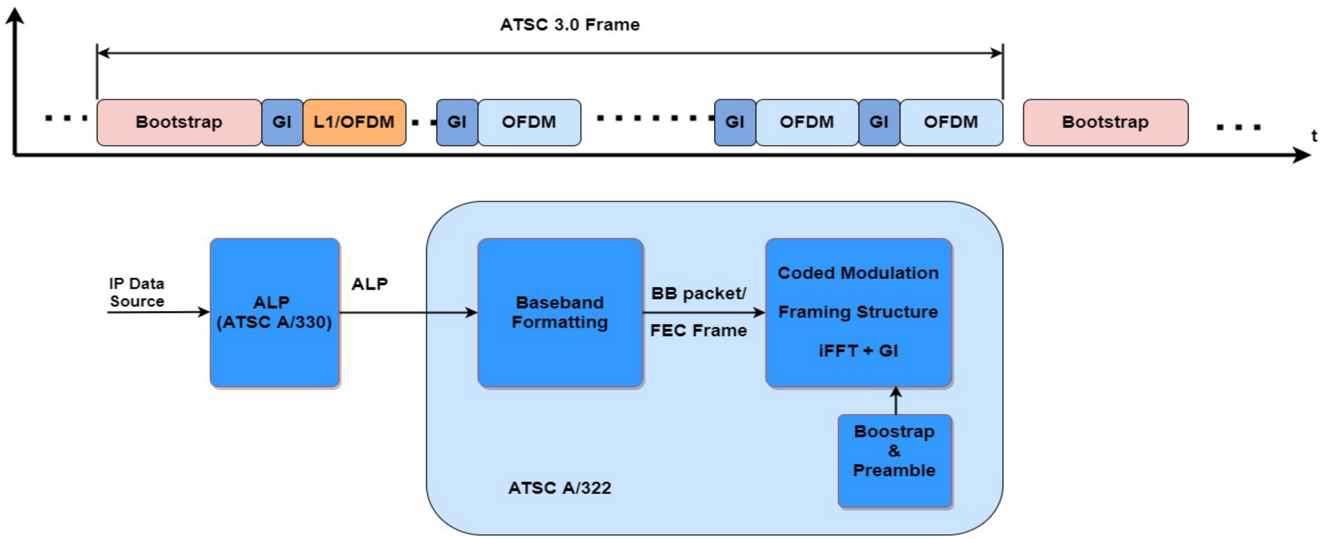
Round-Trip Delays:

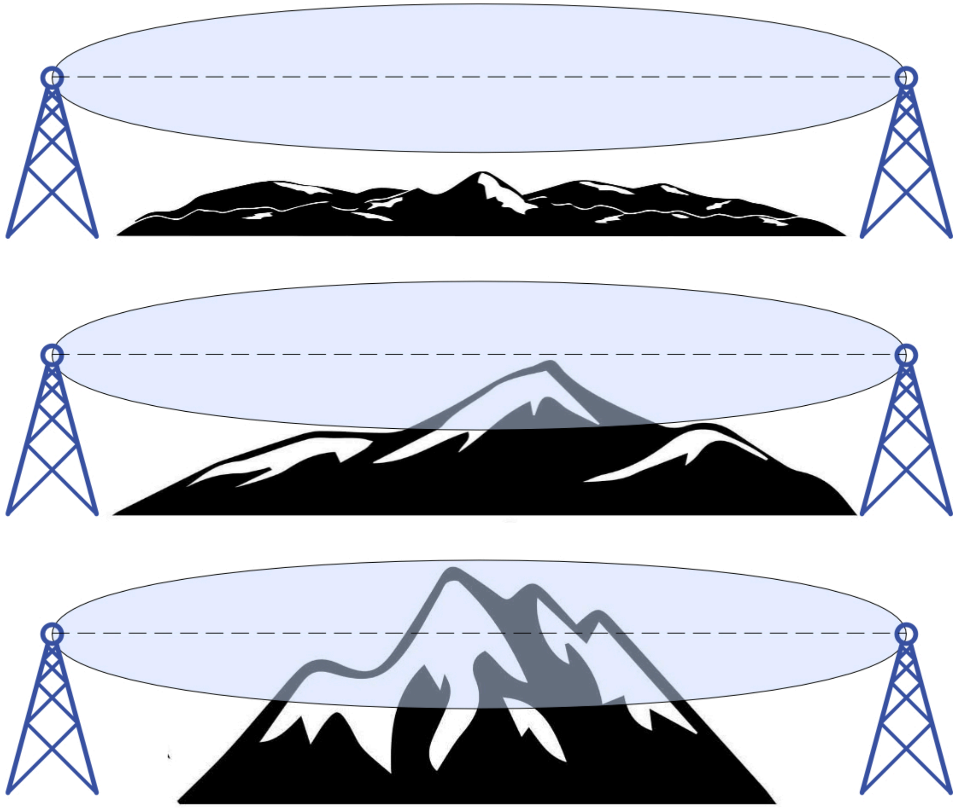
- Processing delays and buffering at ATSC 3.0 System Layer
- Delays resulting from the signal framing structure and block-oriented processing according to ATSC 3.0 Physical Layer



PROJECT CHALLENGES

Propagation Environment:

- Line-of-Sight (LOS)
- near-Line-of-Sight (nLOS)
- Non-Line-of-Sight (NLOS)



PROJECT CHALLENGES

Propagation Environment:

- free-space path loss
- rain and humidity related signal attenuations
- seasonal and periodical (including daily) fading
- rapid frequency-selective fading due to multi-path reflections
- signal diffraction over the obstacles and terrain
- cross-polarization discrimination for dual-polarized antennas for MIMO

PROJECT CHALLENGES

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Link Reliability:

- The link reliability is defined as **a percentage of time the SNR level at the receiver exceeds the minimal value** ensuring reliable signal reception (demodulation) with selected optimal ATSC 3.0 Phy Layer settings.
- For the signal reception with the normal distribution, a 3σ range of SNR variations is used to ensure **99.7%** probability the SNR values are inside of the selected confidence interval.

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B²C LAB TEST LINK IMPLEMENTATION

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MIMO One-directional Transmission:

- End-to-end MIMO solution for datacasting applications
- Commercial/customer MIMO antennas
- Full set of ATSC 3.0 analytical tools:
  - STLTP analyzer
  - Comprehensive RF measurements
  - PLP content and service component analyzer
  - Spectral efficiency estimator

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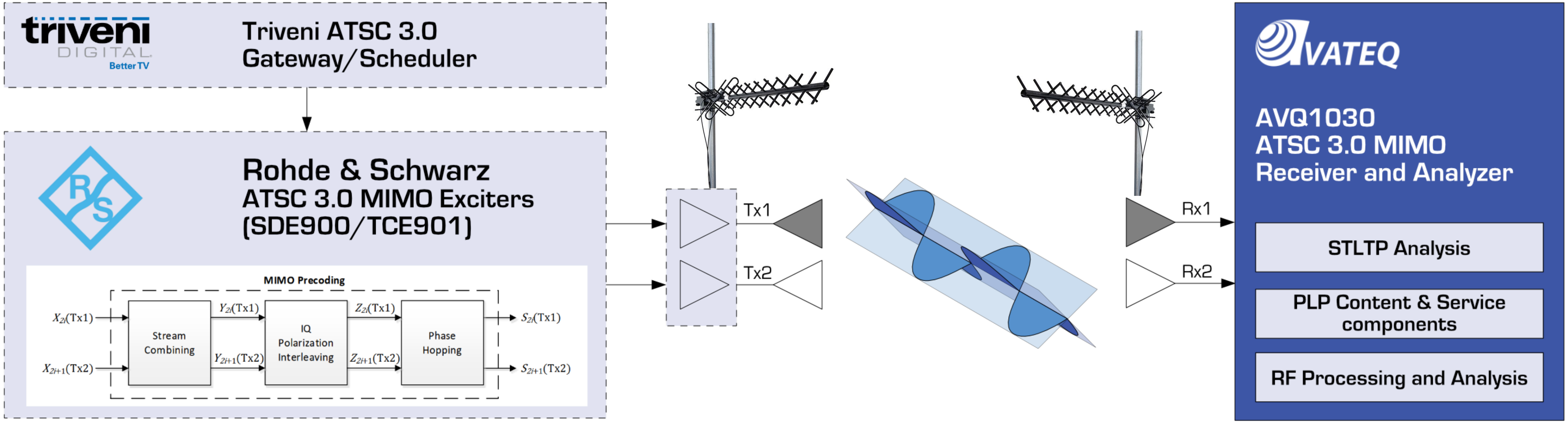
MIMO One-directional Transmission:



SISO/MIMO ATSC 3.0 TX Link Manager:

- Extracts PLP data and PLP service content
- PLP data is sent to ISP network via an adaptation layer
- PLP service is used for adjusting PLP data subframe Phy settings
- Link Margin estimator:
  - ✓ Performs channel estimation at a receiving point
  - ✓ Resolves multi-parametric task for defining optimal ATSC 3.0 Phy Layer settings to maintain the link reliability
  - ✓ Prepares the recommended settings to be used as PLPserv by the gateway

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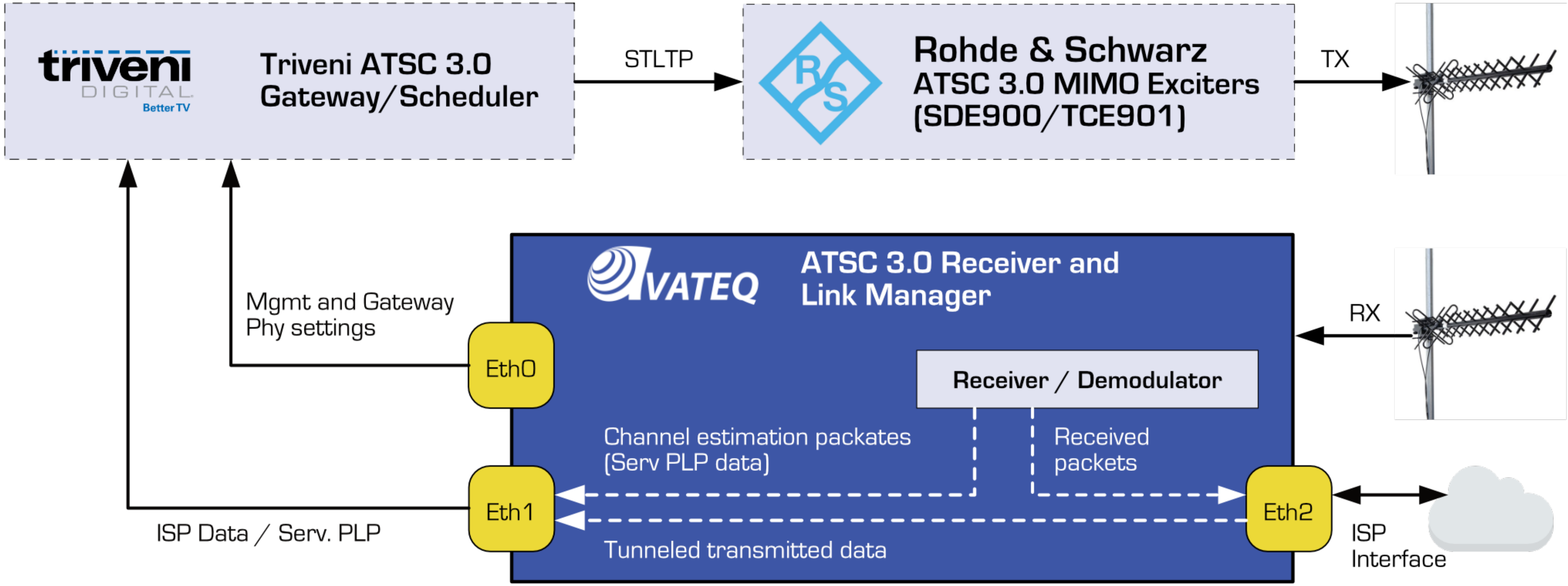
SISO/MIMO ATSC 3.0 TX Link Manager:



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THANK YOU!