

Wireless Study: Investigation of 160MHz RF-Band Usage and Optimization

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The NGEC will provide national leadership
in standardization, acquisition, and
management of passenger rail equipment.

Outline

- An Overview of UNL's TEL Lab
- Introduction to Project
- RF Challenges in Rail Industries
- Solutions and Contributions
- Results
- Conclusions
- Publications



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Overview of UNL's TEL Lab

- TEL is a part of the Electrical and Computer Engineering Department at the University of Nebraska-Lincoln.
- TEL is a research facility with state-of-the-art infrastructure in computing and communications.
- TEL is equipped with:
 - Real-Time Simulation platforms such as OPAL-RT,
 - Network Simulation platforms such as OMNet++, ns-3, QualNet,
 - Wireless capabilities such as Channel Emulator (Azimuth System),
 - High-Performance computing platforms,
 - Access to UNL's supercomputing infrastructure.



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Overview of UNL's TEL Lab

- Research Projects:
 - Wireless and RF Systems
 - Communication Networks
 - Cybersecurity
 - Sensors and IoT
 - Embedded System Design
- Projects supported by NSF, DOT, FRA, DOD, DOE, National Labs, and Rail Industries.



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Challenges to RF Proliferation

- RF Resources need to be available across the industry's entire North American operating area
- Limited Radio-Frequency (RF) spectrum resources in the rail industry
- Unlicensed bands highly congested
- Extremely expensive to license new RF bands
- Example: Positive Train Control (PTC)
 - PTC primarily operates at 220 MHz
 - Significant congestion in some areas such as: the Chicago area, Northeastern Corridor
 - Spectrum resources are limited within those areas, no additional channels are available, and coexistence problems when deploying additional PTC radios



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Solution

- Exploring the adoption of underutilized or abandoned RF bands for wireless applications development in the railroad industry.
- Evaluate the suitability of specific bands for voice + data applications, as well as providing additional operating channels for congested rail traffic areas.
- Specifically, study 160MHz for applications such as onboard signaling and long-range wayside communications.
- 160MHz is underutilized, but licenses are owned by the railroad industry across North America.
- Design and develop extensive computer simulation models to evaluate the 160 MHz communications system for railroad applications. Evaluate design using software radio prototypes.



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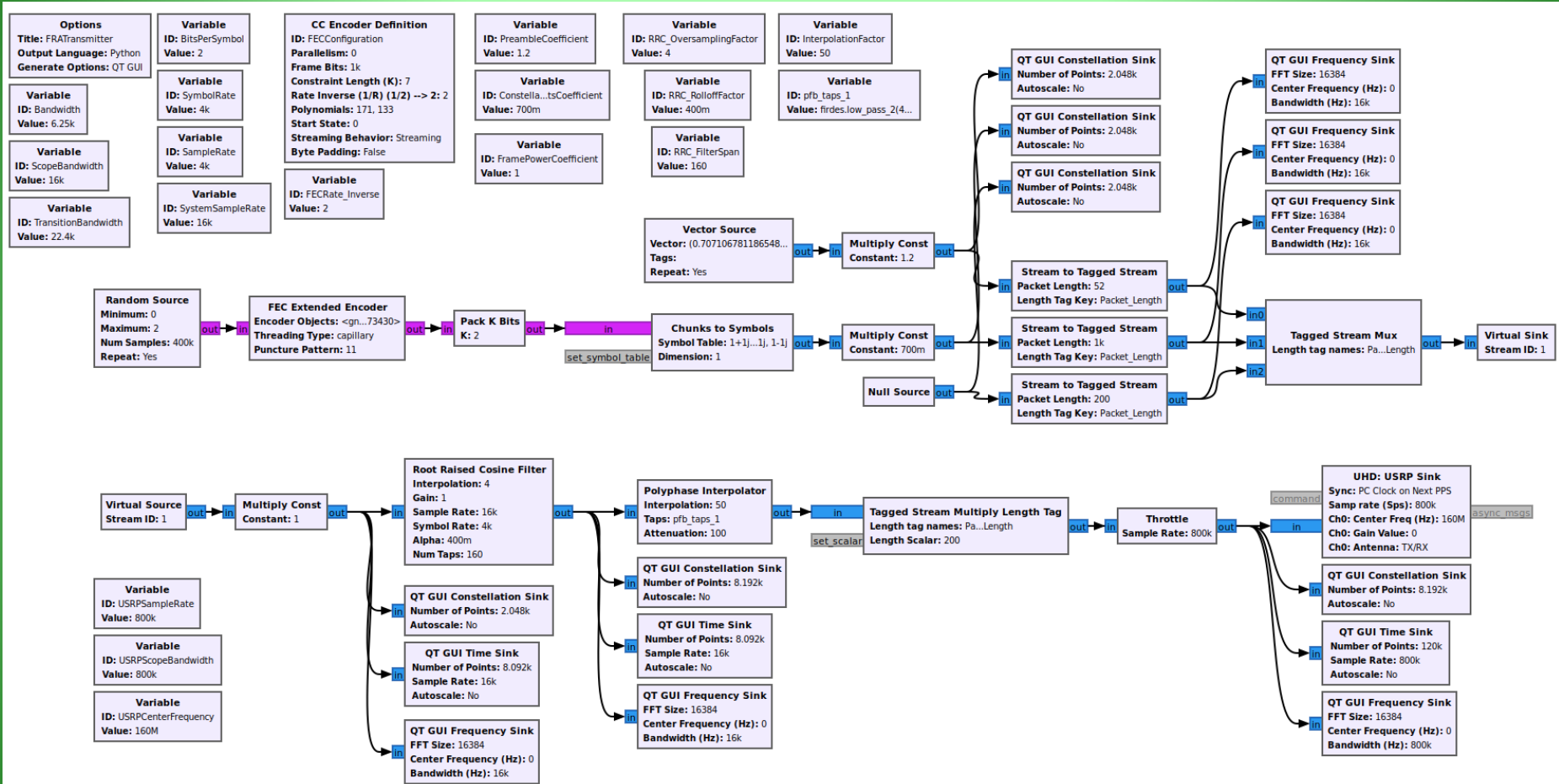
Contributions

- Simulation-driven performance Analysis
 - Single and multi-carrier (OFDM) transceiver
 - Railroad-applicable channel models
- Protocol stack model and analysis for railroad applications
 - Analyze and maximize its end-to-end performance
- Hardware implementation and evaluation using Software Radios
 - Implementing the designed system on USRP X310 & USRP B210
 - Prototype testing to validate the simulation-based analysis

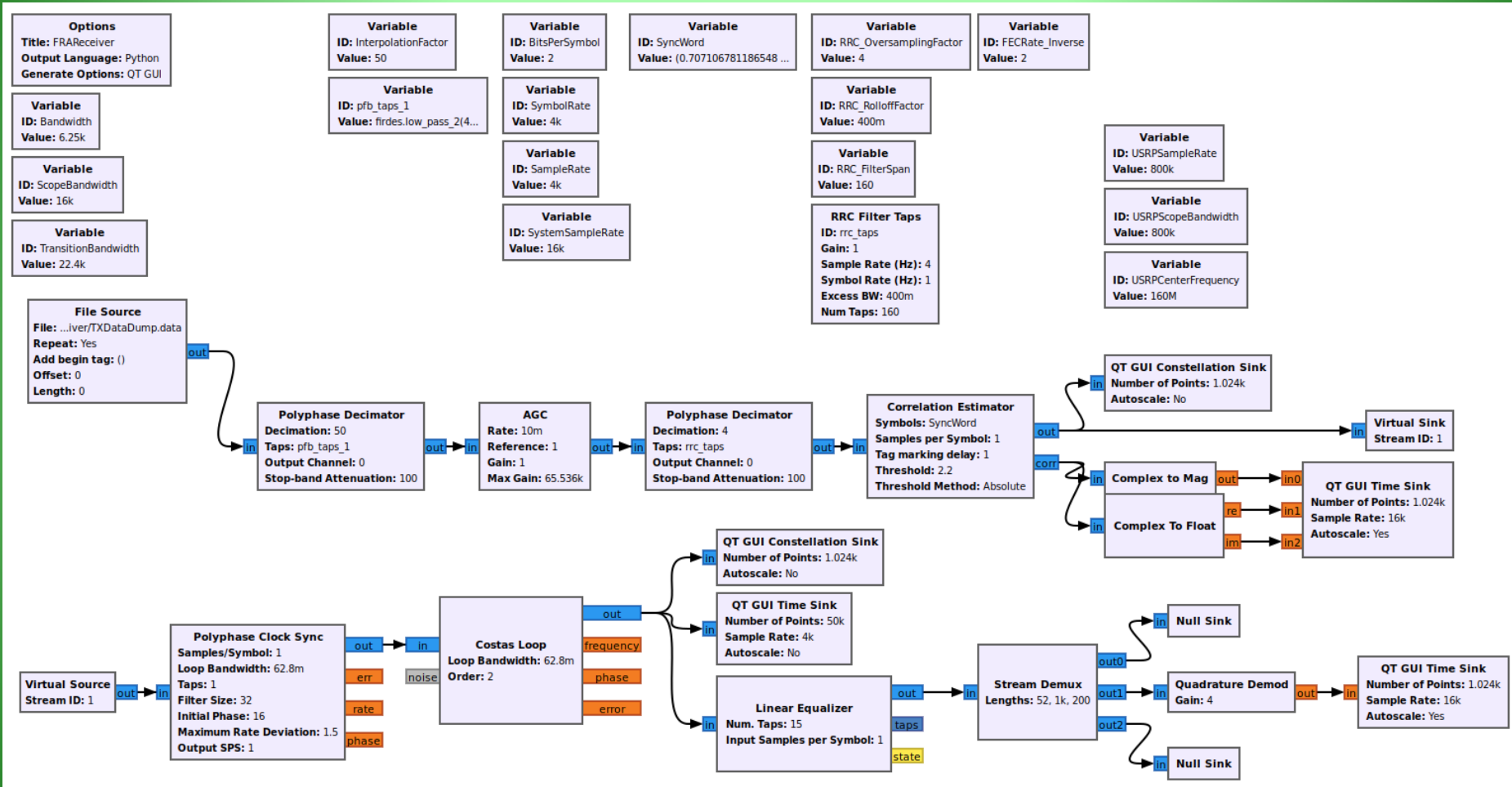


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Prototype Implementation - Transmitter



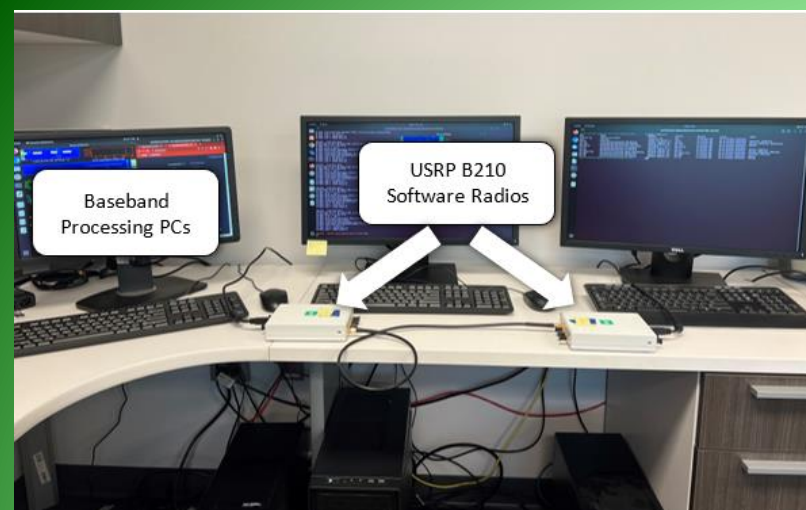
Prototype Implementation - Receiver



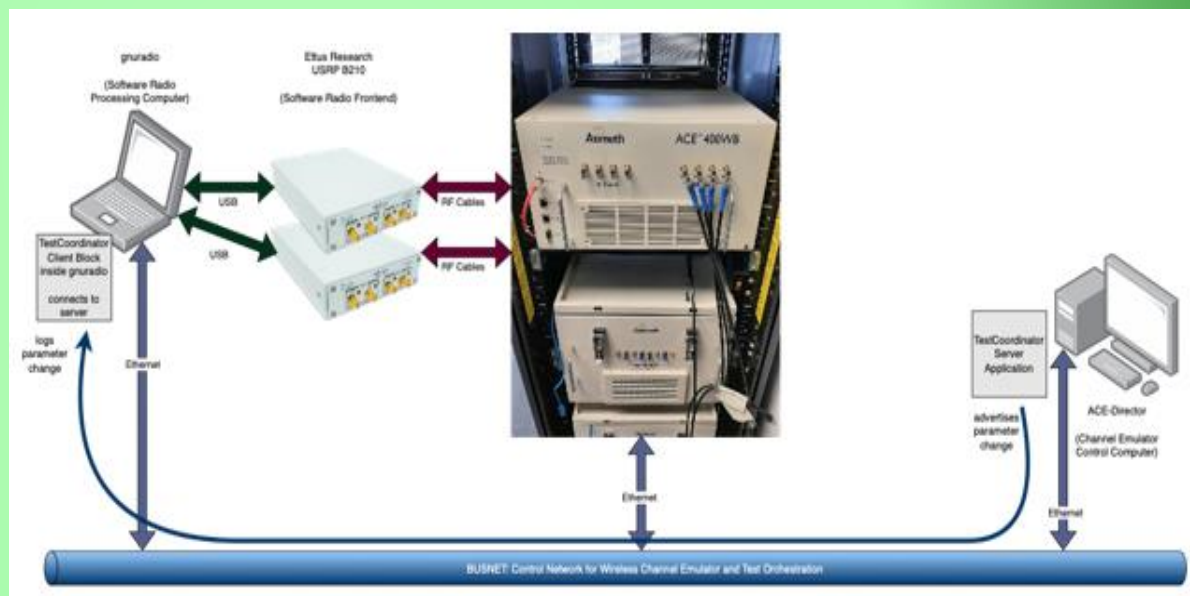
Prototype Implementation

- Transmitter and Receiver are being implemented on TEL Lab's USRPs for lab and field testing
- Utilizes GNURadio Open-Source Software Radio Suite
- Effort aims to be modular, reusable
- Also provisions Cognitive Radio capabilities
 - Coexistence with primary services in the target RF band





Prototyping Setup in our Lab



Channel Emulator Setup and TestCoordinator Logging

Publications

- Ghasemzadeh, Pejman, Michael Hempel, Hamid Sharif, and Tarek Omar. "Maximizing RF Communications Throughput for Railroad Applications at 160 MHz." In **ASME/IEEE Joint Rail Conference**, vol. 85758, p. V001T03A004. American Society of Mechanical Engineers, 2022.
- Ghasemzadeh, Pejman, Michael Hempel, Hamid Sharif, and Tarek Omar. "Modeling and Performance Evaluation of an RF Transceiver System at 160 MHz for Railroad Environments." In **ASME/IEEE Joint Rail Conference**, vol. 85758, p. V001T03A005. American Society of Mechanical Engineers, 2022.
- Ghasemzadeh, Pejman, Michael Hempel, Hamid Sharif, and Tarek Omar. "An OFDM-Based Transceiver Analysis for Railroad Applications." In **2022 International Wireless Communications and Mobile Computing (IWCMC)**, pp. 748-753. IEEE, 2022.



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Thank you!

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