Wireless Communication for Signaling in Mass Transit

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CBTC Context

- Communication Based Train Control Signaling - CBTC
  - train movement Authority & Enforcement by computers.
  - there may be an attendant or not on the train.
  - safety critical sub-system - wrong side failure (unsafe behavior)
    rate typical target: one every 100,000 years / unit (addressed by CBTC protocols, low impact on communication).

- Highly Demanding Communication Availability
  - communication losses disrupt the CBTC and stop trains.
  - typical accepted loss rate: once every 10 years/train.

- CBTCs are in operation now, most with inductive loop communication and few (if any) with a radio link.

- CBTC and Radio Communication breakthrough is a challenge for Mass Transit Agencies and Signal Industry.
Railway Context

- harsh environment: mechanical strength, dust (metallic), Power Rails, EMC…
- for radio: tunnel propagation, multiple paths…
- track equipment vulnerable and at risk of damage during track works.
- signaling equipment typical lifetime: 30 to 50 years

Radio Link Requirements

- typical need: 40 kbps in a control area with 8 trains for top performance CBTC.
- emergent requirement for video monitoring of trains.
Communication Standards

- **Railways (Intercity) Signaling**
  - European Railway Operators association (UIC) chose GSM-R for European Train Control System.
  - it is a GSM with Railways specific functions.
  - a dedicated frequency band is licensed in Europe.

- **Mass Transit Signaling**
  - different needs (many tunnels, more trains, short headway)
  - communication standards, if applicable, are not optimized
  - no regular licensed bands
  - due to propagation physics, best tunnel propagation in microwaves
Signal Companies Offer

- ISM band systems for licensing issue
- either based on customized RLAN products or dedicated design
- potential high interference (i.e., Wi-Fi / Bluetooth).
- some suppliers offer on leaky cable or leaky guide systems, with an air gap between 0.5 m and 2 m. These designs are intermediate between track cables and wireless communication.
Industry Trend

➢ Mass Transit Standards (RATP & NYCT lead)
  › interoperability / interchangeability standards, with multiple sources procurement.
  › country specific application for licensed band
  › a CBTC signaling is now required in most projects worldwide.

➢ Few Signal Industry actors in this field.
  › Siemens Transportation Systems is fully involved in the CBTC technology. A radio system dedicated to Mass Transit has been developed for 10 years.
Siemens Transportation Systems RF choices

- Free propagation with discrete antennas in outdoor and tunnel area (more flexible than leaky cables/guides)
- Cellular architecture focused on a deterministic behavior
  - TDMA Mac layer
  - Use of the train localization when available for cell handover
- Low bit rate, matched to CBTC needs
Siemens Transportation Systems RF Design

- DSSS (Direct Sequence Spread Spectrum) based on LETI technology
- A RAKE demodulator turns multiple path into diversity - mitigates the fading
- Additional diversity by synchronization of multiple transmitters
  - Within a radio cell on the track
  - At both train ends.
  - Some units are redundant.

STS specific design
SIEMENS CBTC Radio Status

- Installed on the NYCT L line (Canarsie) in 2003, as well as the CBTC: forerunner for the CBTC standard.
- Candidate for NYCT and Paris subway standards.

- Sustainable Interference Strategy for CBTC
  - be more robust than other users.
  - benefit of the natural market adjustment: users limitation when there is too much noise.
Radio Unit with baseband signal processing.
Radio Cardfile (during FCC certification test)
New York City Transit CBTC. Equipment of a train.

radio unit at the bottom.
New York City Transit CBTC. Wayside Radio Equipment, with FO connections and uninterruptible power supply.
New York City Transit CBTC. Wayside Antennas in tunnel
**New York City Transit CBTC. Wayside Antennas in outdoor area.**
New York City Transit CBTC. Wayside Antennas in outdoor area (closer view).