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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 (ie 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

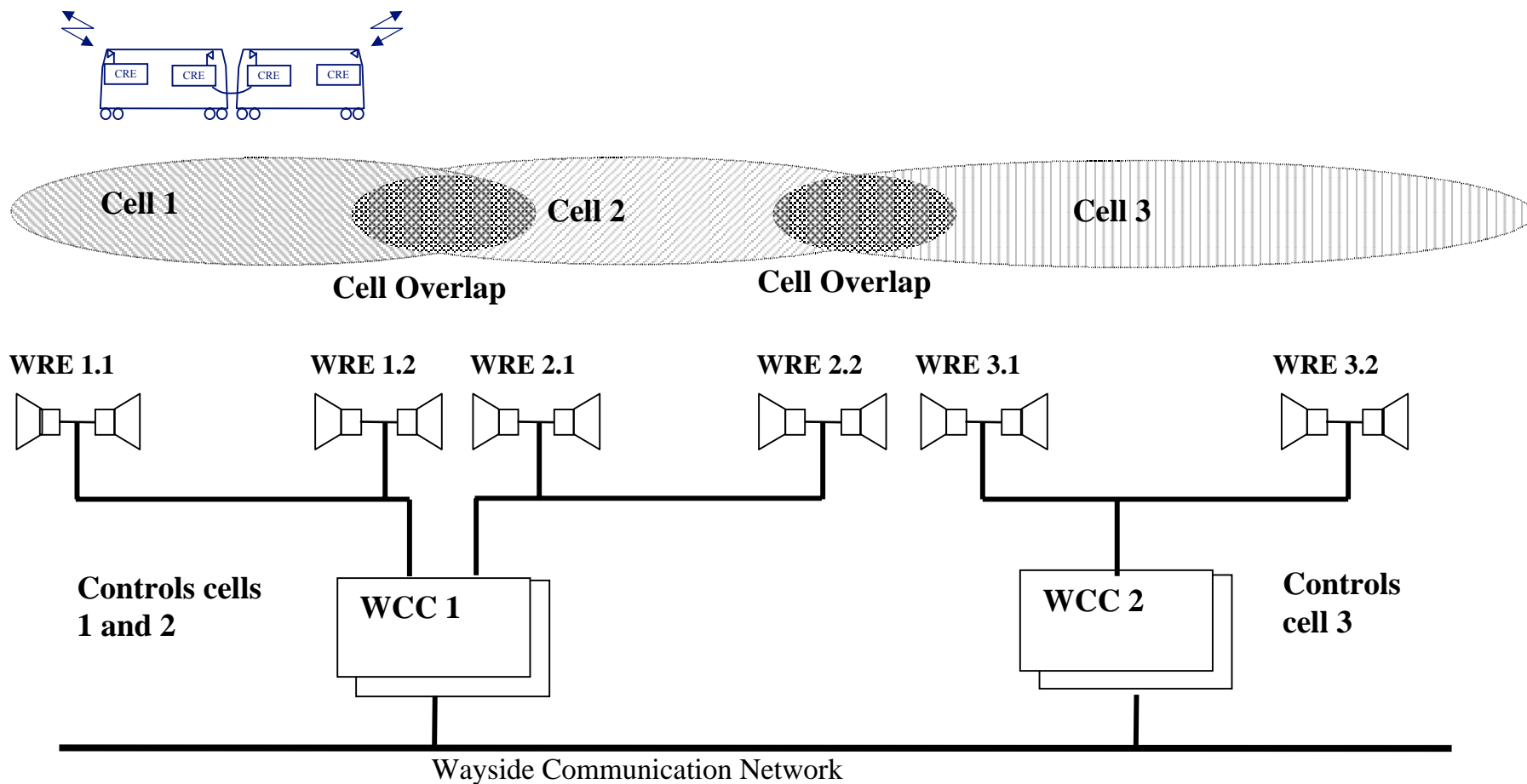
- **Free propagation with discrete antennas in outdoor and tunnel area (more flexible than leaky cables/guides)**
- **Cellular architecture focused on a deterministic behavior**
 - › **TDMA Mac layer**
 - › **Use of the train localization when available for cell handover**
- **Low bit rate, matched to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

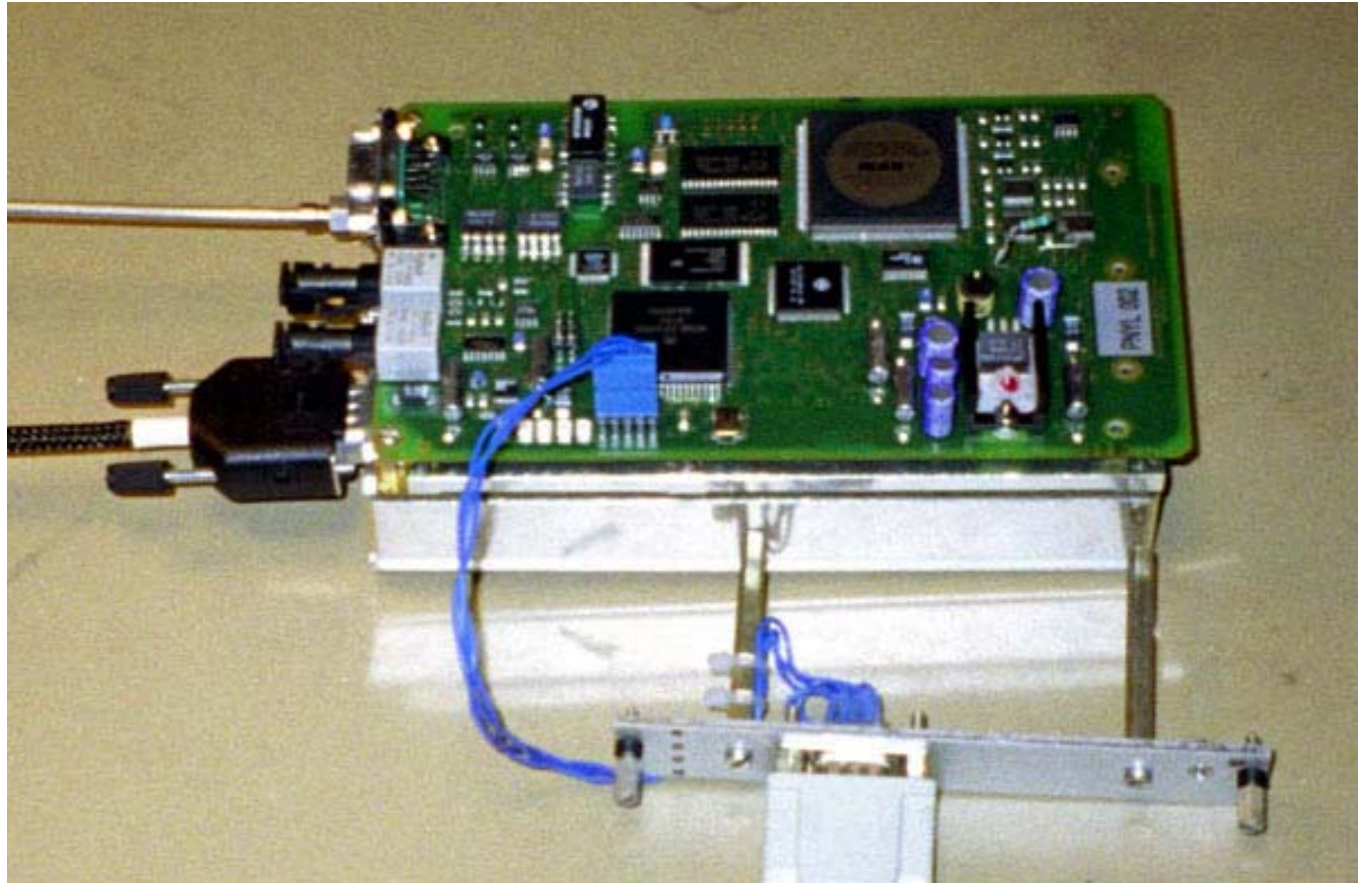


SIEMENS CBTC Radio Status

- **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).

