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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.

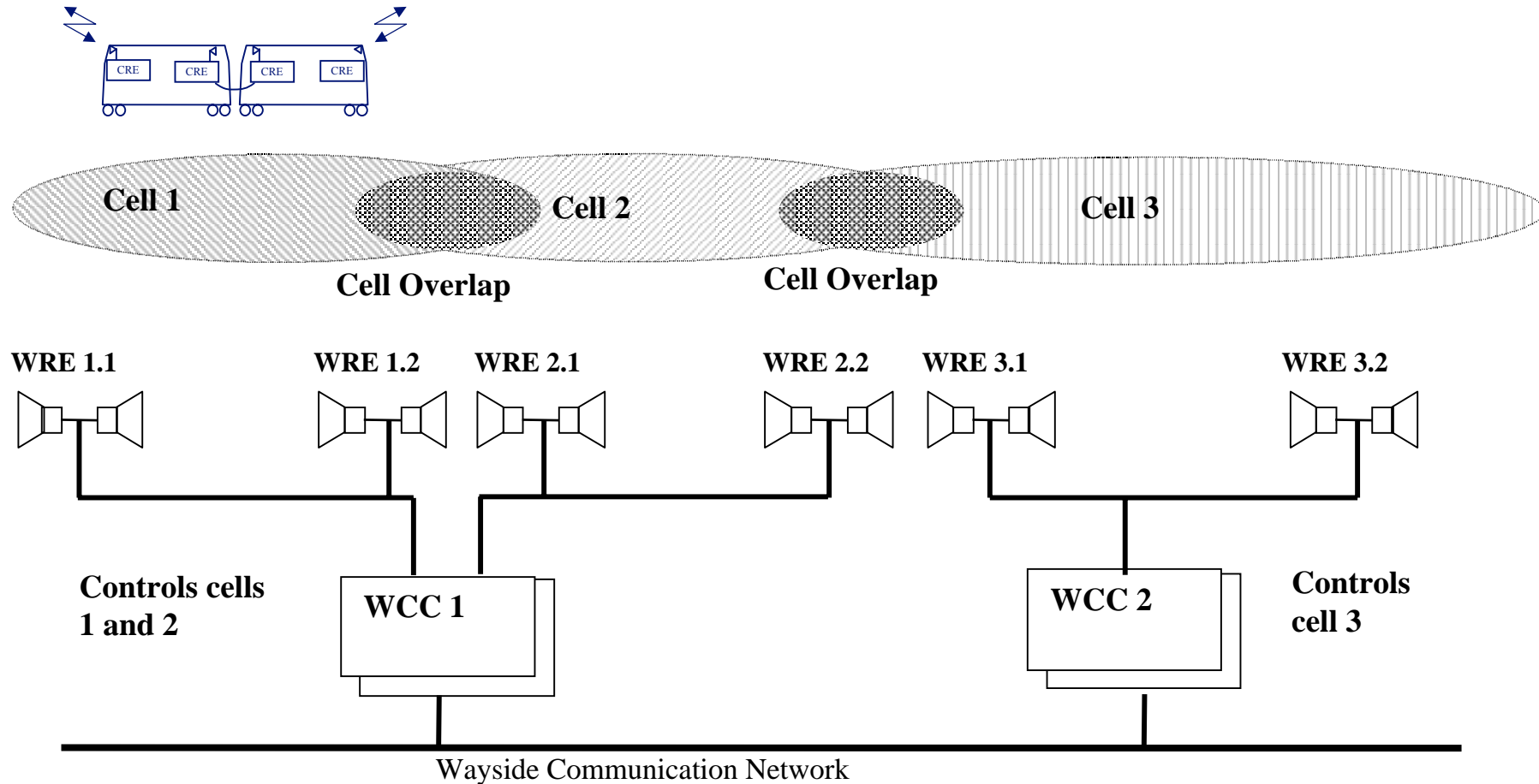
Siemens Transportation Systems RF choices

- **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

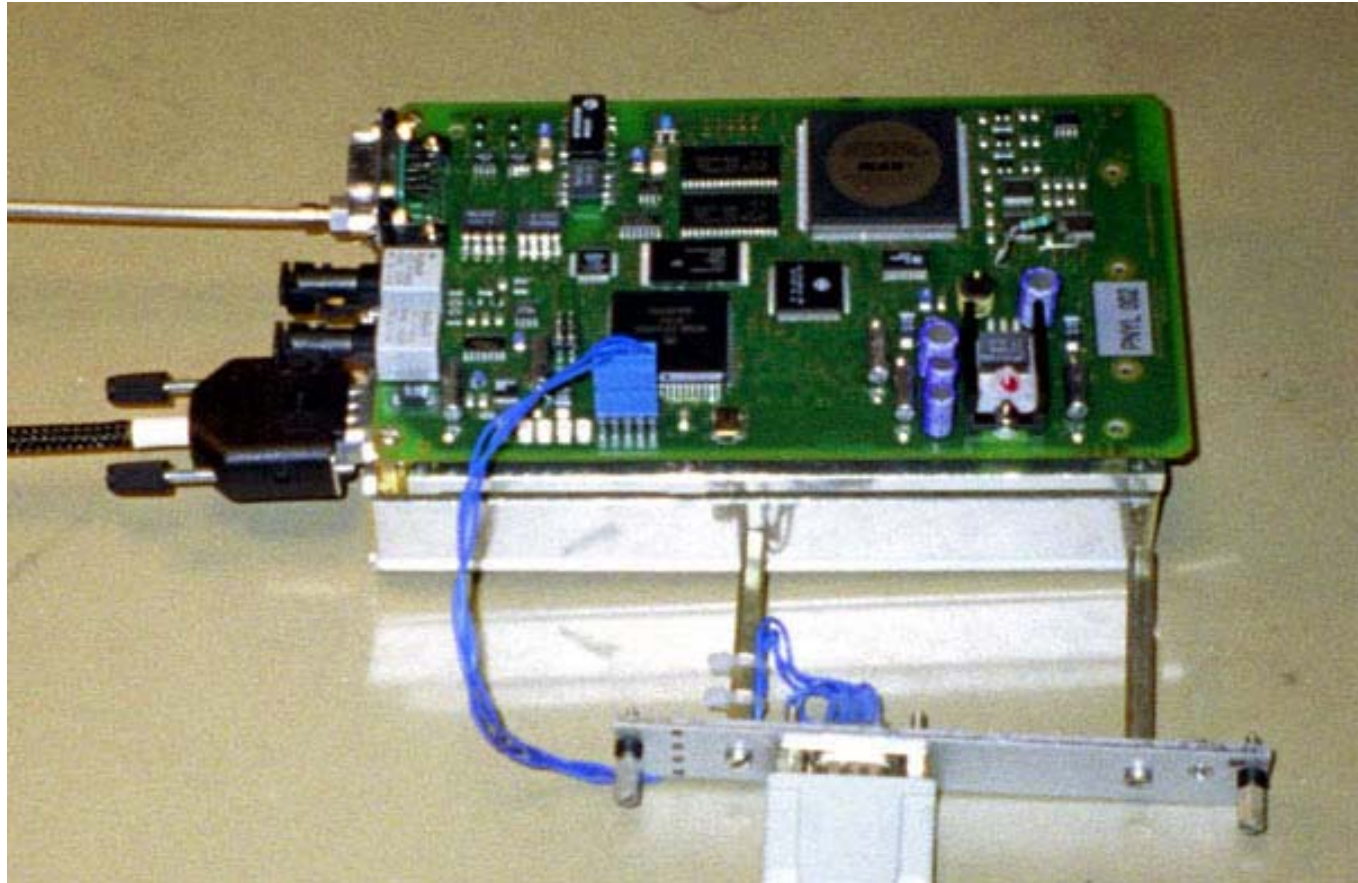


SIEMENS CBTC Radio Status

- **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).***

