Wireless Train Backbone (WLTB)

Igor Lopez, CAF

CONNECTA has received funding from the European Union’s Horizon 2020 research and innovation programme under agreement No: 730539. Safe4RAIL has received funding from the Shift2Rail Joint Undertaking under grant agreement No: 730830. This Joint Undertaking receives support from the European Union’s Horizon 2020 research and innovation programme.
What is WLTB?

• The Wireless Train Backbone (WLTB) is a new train-level network proposed for TCMS.

• WLTB removes the inherent cost of cabling and connectors of traditional wired Train Control networks.

• A reliable and performant wireless TCMS allows the introduction of new functions with relative low cost:
  – Train Integrity function which will help to reduce trackside.
  – Virtual Coupling which supposes a new paradigm in railway operations.
## Why WLTB?

<table>
<thead>
<tr>
<th>Today</th>
<th>With WLTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple wired network in a single train, increasing cost and weight.</td>
<td>Removes wires decreasing drastically the associated cost and weight.</td>
</tr>
<tr>
<td>Difficult to install new wired networks in existing train units.</td>
<td>Possible to install simply in modernization projects.</td>
</tr>
<tr>
<td>Coupling has to be done when consists are stopped and the process takes couple of minutes, reducing the capacity of the infrastructure.</td>
<td>The units are automatically associated to the WLTB and the wireless link is transparent for onboard devices. WLTB allows faster coupling.</td>
</tr>
</tbody>
</table>
WLTB tests in detail

- No couple units in Bilbao’s underground -> Tests from the front to the rear of the same consist.
- To validate the maximum throughput, additional traffic will be injected on the Test Setup network (ECN)
Field Tests Results of WLTB

WLTB Dissemination video
Conclusions (I)

- **Depot tests:**
  - Theoretical performance: 50Mbps Downlink and 25Mbps Uplink.
  - Tests at 3.2 Mbps have been supported with low FER and latency; not at 256 Mbps.

<table>
<thead>
<tr>
<th>Uplink-downlink configuration</th>
<th>Downlink-to-Uplink Switch-point periodicity</th>
<th>Subframe number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5 ms</td>
<td>D S U U U D S U U U</td>
</tr>
<tr>
<td>1</td>
<td>5 ms</td>
<td>D S U U D D S U U U</td>
</tr>
<tr>
<td>2</td>
<td>10 ms</td>
<td>D S U U D D D D D D</td>
</tr>
<tr>
<td>3</td>
<td>10 ms</td>
<td>D S U U D D D D D D</td>
</tr>
<tr>
<td>4</td>
<td>10 ms</td>
<td>D S U U D D D D D D</td>
</tr>
<tr>
<td>5</td>
<td>5 ms</td>
<td>D S U U U D S U U U</td>
</tr>
<tr>
<td>6</td>
<td>5 ms</td>
<td>D S U U U D S U U U</td>
</tr>
</tbody>
</table>
Conclusions (II)

• **Field Tests:**
  - Much better performance in the DL than in the UL:
    - UL uses a single-carrier modulation, which is less robust against multipath and Doppler effects.
    - UL is also based on 1x2 MIMO, while DL is based on 2x2 MIMO and multicarrier modulation.
Conclusions (III)

• General conclusions:
  – Current architecture is complex and expensive: 1 eNB+EPC per consist.
  – Up to 100 Mbps throughput can only be achieved with broader bandwidth: difficulties to obtain such big frequency reservation.
  – High effect of environment, need for more directive communications, pay special attention in the installation phase (RF cabling, antenna positions, etc).
Next station is

- Evolve to PC5-based communications: 1UE per consist instead of eNB+EPC+EU.
- Evaluate the division of C2C communications in 2 networks:
  - TCMS->Cellular-based communications. High reliability, low latency, low throughput needs.
  - OMTS->802.11-based communications. Best effort traffic, high throughput needs.
- Evaluation of a Safe Wireless Inauguration.
- Apply MIMO and higher transmission power (below the legal limits) to improve the SNR.
- Adapt the SDTv4 (Safety Layer) for wireless channel (e.g. apply EN50159)
- Standardization activities:
  - Propose WLTB Use Case in ETSI/3GPP to be adopted by upcoming releases
  - IEC 61375-2-7