Optimised Voice And Data Communications For Transportation Systems using TETRA

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4. CONCLUSIONS
Transportation is the 2nd largest vertical market for TETRA
- TETRA collects more than 2200 contracts across 104 countries
- The number of new Metro projects awarded with TETRA is close to 100% (not counting Japan, United States and Canada)
TETRA Advantages

- Open standard (several suppliers of terminals)
- Security: Encryption and authentication
- Ethernet/IP Connectivity
- Enhanced Data Transmission Capabilities => Allow to implement ITS applications & voice using the same network
- Simultaneous voice and data support
- Full duplex communications: hands free
- Benefits for surface transport: built-in GPS for AVL
- Worldwide implemented in transport and public safety
Transportation Industry: Different Scenarios, Different Requirements

- Buses and trams:
  - Require AVL systems to support economical models defined by operators.
  - Efficiency in AVL systems: requires to optimize the refresh rate
  - Reliable voice & data interaction

- Metros:
  - TETRA & TCMS (Train’s Control and Monitoring System) interaction: MVB, Ethernet and/or RS-485 buses.
  - Security!
  - Customised Man-Machine Interface
  - Remote control and monitoring: such as PA control, emergency braking, built-in emergency buttons

- Railways:
  - Success in Metro environment led the industry to think on TETRA as an alternative to GSM-R
  - The above is a reality outside Europe
  - Can TETRA meet the Railways Industry requirements?
  - AVL is also an important requirement
Trams and buses model
Buses and trams model

- Bus Traffic Regulation.
- Frequency Improvement.
- Customer Service.
- Investment optimisation.
- Passengers Safety

Bus Fleet Management Requirements

- Centralised Control of the buses by fleet division based on depot assignments.
- Data acquisition system for centralised control of the fleet.
- Maintenance units can communicate effectively with buses and depots.
- On-board solution that integrates together different systems (voice and data).
- Customer’s informative panels
- Buses Localisation (AVL), improving efficiency and security.
## Buses and trams model

<table>
<thead>
<tr>
<th>ONE TECHNOLOGY FOR ALL SERVICES PROVIDING COST OPTIMISATION.</th>
<th>Driver &amp; Maintenance Voice Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Half duplex and full duplex call with Control Centre</td>
</tr>
<tr>
<td></td>
<td>• Direct connection with PABX &amp; PSTN.</td>
</tr>
<tr>
<td></td>
<td>• Voice Communications between maintenance personal and Control Centre &amp; Depots.</td>
</tr>
<tr>
<td>Vehicle Sensors Transmission</td>
<td>• Status Messages (i.e. start of route indication)</td>
</tr>
<tr>
<td></td>
<td>• Short Data Message (i.e. sporadic bus data interrogation - Fuel level)</td>
</tr>
<tr>
<td>Localisation Data (AVL)</td>
<td>• Key Requirement: buses sending its position (GPS) on a periodic basic.</td>
</tr>
<tr>
<td></td>
<td>• If not handle correctly can affect to the others service of the system.</td>
</tr>
<tr>
<td>Passenger informative panels</td>
<td>• Controlled by the Control Centre for give information to passengers (i.e. bus stations)</td>
</tr>
<tr>
<td></td>
<td>• Suitable for Short Data Messages</td>
</tr>
<tr>
<td>Security Systems</td>
<td>• Emergency pedals or buttons enabling silent ambience call from Control Centre.</td>
</tr>
<tr>
<td></td>
<td>• Alarm triggers allowing communications between passengers and Control Centre.</td>
</tr>
</tbody>
</table>
Buses and trams model: Network

Bus / on board systems

- SAE
  - GPS
  - CPU

- SAM
  - Gateway
  - CAN Bus

- SPV
  - Billing
  - CPU

- SIC
  - External Info Panels

- SC-WiFi
  - Wi-Fi Router

- SC-Radio
  - CPU
  - TETRA

- SIU
  - PA system
  - TFT

- SEV
  - CPU
  - Video

Ethernet Network

Wifi Link

Bus link

Depot link

Control Centre Link

TETRA NETWORK

BUSES COMMAND CENTRE

- PABX
- TSC
- FEP
- PDH
- SERVE
- SwMi

Sun
Buses and trams model: On-board Equipment

- PTT
- Emergency button
- Call request
- Driver Login

Ambience listening microphone
Handset

Bus driver’s audio system

Bus driver’s MMI

GPS Antenna

TETRA MS

PEI

TETRA Antenna

Audio interface

Passenger information system

Hands-free audio kit

Control unit

Telemetry sensors

Billing system

Other peripherals

engine, speed, doors...
Buses and trams model: On-board equipment

- Control unit
- TETRA radio
- Bus system interface
- Passenger information system
- Driver’s MMI console
- Micro speaker & hands-free mic
Metro model
Metro Model: Network

ASYNCHRONOUS BACKBONE

Central Switch

Management System

IP Network

ISDN

API

ATC System

Analog Radio Network

Dispatching Centre

Radio Dispatchers

SBS 1

SBS 2

SBS n-1

SBS n
Metro Model: On board Equipment

CPU

To the train control system (TCMS) Input/Output Lines MVB Connection

Display MMI Console

Communications rack

MMI Console

LED Indicators

CPU

Piezoelectric Keypad

Auxiliary Buttons

Hands free system

Handset

To redundant rack and console

To the train control system (TCMS) Input/Output Lines MVB Connection Maintenance

TETRA Antenna

VHF Antenna

To passenger information system (addressing)

TETRA Radio

VHF Analog Radio

AUDIO INTERFACE

Hands free system
Redundant configuration
(2 Racks & 2 consoles, up to 200 meters between both systems)

Metro Model: On board Equipment

Train Control Management System

Communications Rack (TETRA + VHF)

MMI Console

Communications Rack (TETRA + VHF)

MMI Console
Metro Model: On board Equipment

- Handset with PTT.
- Speaker.
- Free-hands microphone.
- Service indicators.
- Piezoelectric keypad.
- Emergency call key.
- LCD display.
- Connector for ISSI code box, to ease maintenance.
TETRA in automated Metros

- Security
- Exploitation
- Maintenance
- Can act as an emergency backup of the ATC system
TETRA in automated Metros: Application Model

- **TETRA Network**
- **Control Centre**
- **On Board TETRA Subsystem**
- **TCMS**
- **Commands**
- **TETRA**
- **SDS TL Service**
- **Application - Control**

*Image showing a control panel, a train, and a diagram illustrating the TETRA network, control centre, and on-board subsystem.*
### SDS-TL based Protocol: Security Commands

<table>
<thead>
<tr>
<th>TYPES OF COMMANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMERGENCY BRAKING</td>
</tr>
<tr>
<td>BYPASS OF BRAKE / TRACTION LOOP</td>
</tr>
<tr>
<td>PUBLIC ADDRESSING MESSAGE</td>
</tr>
<tr>
<td>DISABLE SERVICE BRAKE</td>
</tr>
<tr>
<td>FIRE DETECTION / FIRE EXTINGUISHERS ACTIVATION</td>
</tr>
<tr>
<td>DETECT ALARM HANDLE UNATTENDED</td>
</tr>
<tr>
<td>DOORS OPEN / CLOSE</td>
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</table>
### SDS-TL based Protocol: Exploitation Commands

<table>
<thead>
<tr>
<th>TYPES OF COMMANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAIN SWITCH ON / SWITCH OFF</td>
</tr>
<tr>
<td>TRAIN BIRTH (Number and Type of Train, Driver)</td>
</tr>
<tr>
<td>EXTERNAL / INTERNAL PANELS CONTENT</td>
</tr>
<tr>
<td>LIGHTS / MUSIC / VIDEO / CLIMATIZATION</td>
</tr>
<tr>
<td>TCMS CONFIGURATION/ DRIVING MODE</td>
</tr>
<tr>
<td>TRAIN LOCATION (SBS or BEACONS)</td>
</tr>
<tr>
<td>VOICE GROUP CHANGE (SBS or BEACONS)</td>
</tr>
</tbody>
</table>
## TYPES OF COMMANDS

<table>
<thead>
<tr>
<th>Command Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAGNOSIS / REQUEST / SENDING ALARMS</td>
<td></td>
</tr>
<tr>
<td>TRAIN TIME SETUP</td>
<td></td>
</tr>
<tr>
<td>PANTOGRAPH UP / DOWN</td>
<td></td>
</tr>
<tr>
<td>NEUMATIC SUSPENSION DISABLE / ENABLE</td>
<td></td>
</tr>
<tr>
<td>VOLTAGE INTERRUPTOR</td>
<td></td>
</tr>
<tr>
<td>REMOTE SOFTWARE DOWNLOADING (circuit data)</td>
<td></td>
</tr>
<tr>
<td>ATP SYSTEM RESET</td>
<td></td>
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</tbody>
</table>
SDS-TL based Protocol Example: Start-up sequence with TL reports

CCC = Command & Control Centre
TCMS = Train Control & Monitoring System
Railway model
At the end of 2006, the TETRA association (TETRA MoU) created the TETRA Rail Forum. The goal is to analyse the railways’ communications requirements and decide whether the TETRA’s successful Metro model can be used for this industry or not.

Outside Europe TETRA is already a serious alternative to GSM-R; although there are also technological reasons the main one is economical. Coverage studies demonstrate TETRA can cover the same area than GSM-R with the half base stations.

Next Steps for the TETRA Rail Forum:
- To understand the railway industry requirements
- To define the additional supplementary services that might be needed
- To analyse the set of safety standards to be accomplished
- To define a roadmap of TETRA for railways applications
Main ETSI Standards of applications in railways

- Safety related electronic systems for signaling (EN 50129)
- Software safety (EN 50128)
- Key Concepts
  - Safety Case (SC): 6 documents
  - Safety Integrity Level (SIL): from 1 to 4 (*)
    - $10^{-9} < \text{SIL} 4 < 10^{-8}$
    - $10^{-8} < \text{SIL} 3 < 10^{-7}$
    - $10^{-7} < \text{SIL} 2 < 10^{-6}$
    - $10^{-6} < \text{SIL} 1 < 10^{-5}$

- TETRA industry has started to apply for SIL certifications according to Safety Cases

(*) THR (Tolerable Hazard Rates)
TETRA vs. GSM-R

- TETRA achieves or improve the voice requirements of Railways systems (i.e. Call setup < 300 ms)
- TETRA current data rate (i.e. 19200 bps packet data rate) is more than enough for most of railway related applications. TEDS (expected during this year) will provide a significant higher bandwidth.
- TETRA works in 380-470 Mhz, requiring half the base stations (cost effective)
- TETRA doubles the frequency efficiency (4 channels in 25 Khz)
- TETRA has proven its conformance with high speed mobile operation, working at 574.8 km/h (ALSTOM, France, 2007)
Conclusions

- Professional Mobile Radio is dominant in transport today
- TETRA is the most implemented technology
- TETRA has proven to be the most adequate and cost effective technology for AVL, providing efficient voice and data communications with one communications system
- TETRA is suitable to support exploitation in Metros (Manual or Automated)
- TETRA allows to remotely control the trains, providing enhanced security, efficiency and cost effectiveness
- The new challenge for TETRA industry is to export its success in buses, trams and metro environments to railway industry.
Thank You

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