Development of low cost railway monitoring equipment

Consortium Meeting, Brussels – 4th November 2016

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Content

- Acceleration of overhead line
- Acceleration of plain line and S&C
- ECVM - Equipment for current & voltage monitoring
- Low cost smartphone sensors for vehicle and infrastructure monitoring
The system is designed according with T3.4 and contains the next three types of devices:

- **WSDO** (*Wireless Sensor Device for Overhead Lines*)
- **WCDO** (*Wireless Concentrator Device for Overhead Lines*)
- **WLRCD** (*Wireless Long Range Communication Device*)
Acceleration of overhead line (2)

Schematic design of the devices placement
Acceleration of overhead line (3)

Block design of the system
General Considerations:

• As objective: to collect vibrations and displacement information at the contact point; these data will help modeling process.

• Electrical restrictions: electrostatic discharge and electromagnetic field intensity

• Mechanical restrictions: high difficulty of installing and maintenance of WSDO devices;
Acceleration of overhead line (5)

Similar applications: Power Line Monitoring

• Wireless powerline sensors hang from an overhead power line and sends data to collecting device.
Acceleration of overhead line (6)

Technical requirements:

**WSDO - Wireless Sensor Device for Overhead lines**

- Electronic components, battery and the pack of photovoltaic cells will be compound in a rigid block of transparent resin, sealing class at least IP67
- Mounting on grooves of the contact wire using a metal clamp;
- Total autonomy using battery and photovoltaic cells;
Acceleration of overhead line (7)

• Sensors used: three axis accelerometer (±2g/±4g/±8g/±16g selectable full scales; 1 Hz to 5.3 kHz selectable SPS) and centigrade temperature sensor.

• Data is transmitted over a short distance to WCDO type device, using IEEE 802.15.4 RF standard as 2.4 GHz and a ZigBee protocol stack.

• The firmware will make filtering of useful data as ”train in range”.
Acceleration of overhead line (8)

**WCDO - Wireless Concentrator Device for Overhead lines**

- Collects data from WSDO’s;
- Sent sensors data to the device WLRCD with data logger and long range communication capability.
- Gateway device for WSDO, of the external settings and commands.
- Total autonomy using battery and photovoltaic cells; Housing box with at least IP65;
Acceleration of overhead line (9)

WLRCD - Wireless Long Range Communication Device

• Receive data from WCDO, using RS485 full duplex standard.

• Provides data logger function using SD Card with 16 GB; is active when missing the long range comm.

• Default for Long Range Communication is Wi-Fi Ethernet; secondary will be GSM support.

• Total autonomy using battery and photovoltaic cells; Housing box with at least IP65;
The proposed system is very similar with acceleration for overhead line system. There are differences as placement on the foot of the rail, for sensor devices.

Types of devices:
- **WSDR** *(Wireless Sensor Device for Rail)*
- **WCDR** *(Wireless Concentrator Device for Rail)*
- **WLRCD** *(Wireless Long Range Communication Device)*
Acceleration of plain line and S&C (2)

Possible placing locations:
The purpose of the equipment:

• The equipment is designed for monitoring the electricity supply of the locomotive; will be measured the voltage at the entrance to the train, from the pantograph; the second value measured is the current absorbed through the main transformer.

The current situation:

• Currently there are electric equipment mounted on locomotives that measure voltage and current in order to count the energy absorbed for establishing the costs, but also to inform the locomotive driver about electrical parameters: voltage and current, but only as RMS values.
ECVM - system installation on the locomotive
ECVM - equipment features

• With the frequency as default 500 SPS, ECVM samples and evaluates the current of primary transformer and voltage from the main locomotive pantographs, it is using for this purpose the instrumentation transformers already installed for metering of electricity consumed;

• Forward the measured data to a Laptop, using a serial interface and save data on the storage drive(HDD, SSD, etc.).

• The laptop can add bookmarks as time and geographical coordinates using an external GPS.
ECVM – description (1)

• Installation and construction details are presented for EA060, Romanian locomotive

• ECVM is placed into the driver cab; in the same location will be also the Laptop for control and data storage.

• ECVM will be placed close to the junction box with input cables from voltage and current transformers.

• ECVM connection with the Laptop is done via a duplex serial cable

• The main components of the ECVM are DCVM (Device for Current and Voltage Monitoring) and PSM (Power Supply Module)
ECVM – description (2)

ECVM Components

- **PSM (Power Supply Module)**
- **DCVM (Device for Current and Voltage Monitoring)**

ECVM - Equipment for current & voltage monitoring
PSM - Power Supply Module

PSM are supplied from the storage battery of the locomotive; for EA060 this voltage is 110 Vdc. In the technical data, as well as from the experience of operation, the battery voltage may vary from -30%, + 20%, which is in the range 77V - 132V of the first DC/DC Converter.

PSM consists of two blocks:
- One DC / DC converter, which supplies the 24 Vdc output from locomotive power supply (110 Vdc). The converter has input/output galvanic isolation transformer.
- An inverter powered by 24Vdc, with output of 220V/ 50Hz sine or modified sine. The inverter has galvanic isolation transformer Input/ Output
DCVM is powered by 24Vdc from PSM and the laptop is supplied from inverter of the PSM, at 220Vac
DCVM characteristics

• DCVM energy power, as 24Vdc, is supplied through a converter with galvanic isolation transformer, which provides -5V and + 5V output, using own ground.

• The current information is taken from the measuring transformer of the locomotive, which has a ratio of transformation from 500A to 5A.

• Voltage of the contact line is achieved from instrumentation transformer of the locomotive; which is a transformer from 25kV to 100V.
Low cost smartphone sensors for vehicle & infrastructure monitoring

The main goals of this activity is development an application for a Low Cost Smartphone:

• Using Android SDK

• Based on smartphone accelerometer and GPS (global positioning system)

• For data collection in order to measurement of ride comfort and obtain the track inputs through a low-cost approach which will collect large volumes of data.
Propose System Architecture
Use case diagram of the Sensor Acquisition, represent the functionalities of the application at rail unit (user) level.

- **The Add Data** functionality helps the user to create and record data of interest based Location and Vibration Data.

- **View Saved Data** functionality lists all the saved data (Location + Vibration) of the user, it helps the user to create specific log and share / send his saved log by data transmission services.

- **The Settings** functionality helps the user to Accelerometer setting characteristics, data connection for external GPS, modality to transmission data to the Server (Adhoc OR Automatic by Scheduler).
Android application service for sensor acquisition data (2)

A) **Android application gateway for data transmission** - This component of the mobile system is responsible for reading data collected locally and sending them to crowd-data system via Internet.

B) **Android application for local reporting and interrogation data** - This component of the mobile system is responsible for reading data collected locally and display information in graphic format.
Design of crowd-data system (1)

In the following table are the list of API calls.

<table>
<thead>
<tr>
<th>URL</th>
<th>Method</th>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>/login</td>
<td>POST</td>
<td>username, password</td>
<td>User login</td>
</tr>
<tr>
<td>/vibrations</td>
<td>POST</td>
<td>vibration</td>
<td>To create new vibration</td>
</tr>
<tr>
<td>/vibrations</td>
<td>GET</td>
<td></td>
<td>Fetching all vibrations</td>
</tr>
<tr>
<td>/vibrations/:id</td>
<td>GET</td>
<td>sessionid, railunitid</td>
<td>Fetching single specific session vibration</td>
</tr>
</tbody>
</table>

The crowd-data system is responsible for data collection from mobile terminals via the communication module described above, and from physical point of view it is an application that contain the following functional components: data communication, processing and storing data received, user interface functions through dedicated graphical controls (database query, display information in analysis format, commands and queries toward the local device, etc.).
Design of crowd-data system (2)

Reporting web interface for crowd-data server

This component of the Crowd-Data system is responsible for user interface functions through dedicated graphical controls (database query, display information in analysis format, commands and queries toward the local device, etc.).
Thank you!