Deliverable D4.9

Interface definition for input of GNSS (or ground-based train odometry) location data to monitoring technology

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Executive Summary

D4.9 Deliverable presents the technical solution adopted and the steps taken to develop it. The goal was to create a standard interface for connecting ABA and SATLOC systems, to transfer and concentrated data for achieving a complex and complete data acquisitioning message. This linkage, at the hardware but also the firmware levels, are focused to provide an update of the monitoring system developed in T4.2.

Each of the two systems, SATLOC and ABA, provides a set of information, relative to the main objectives set at the time of their development. The NeTIRail-INFRA project provided an opportunity to improve their functionality by installing the two systems in the same place, on the same train. Working in parallel, in the same location, the two systems can exchange information so the utility of each system is overall improved.

In a first stage of technical analysis, a technical solution was defined: this involves designing and the achievement of a hardware and firmware interface to connect the ABA and SATLOC systems. Following a more in-depth analysis of the technical characteristics and the communication interfaces performances, provided by the basic structures of the two systems, a direct interconnect solution between the two systems was adopted, with minor firmware changes. This option is considered a simplification of the first solution, without reducing the technical requirements.

In the first part of the D4.9 deliverable, the axle box acceleration (ABA) system is presented and analysed to its implementation in the study lines of the NeTIRail-INFRA project. At the current level of optimisation, this system is considered as a performant and complex development of the technology focused for track quality monitoring.

The NeTIRail-INFRA project granted opportunity for further achieving a higher grade of the ABA system; in this regards, preliminary studies were conducted in Romania and Turkey and also included the principles of the measurement systems used in the Slovenian railways. After that, followed steps towards by the measurement in Romania in the regional line near Brasov, with positive results.

The second part presents the SATLOC system, which is used by the RCCF partner. The SATLOC represents the low cost train control solution for regional and low traffic density lines. There are safety solutions on-line for rail application of the train control, speed supervision, traffic control and traffic management of low traffic lines (LTL). The system is functioning in real-life conditions and is fully compatible with European Train Control System (ETCS), which is part of the European Rail Traffic Management System (ERTMS) standards.

The main target of ERTMS is to promote the interoperability of trains in EU, mostly to enhance cross-border interoperability. It aims to greatly enhance safety and increase efficiency of trains operations for rail transport in Europe. This is achieved through changing national signalling equipment and operational procedures with one Europe wide standard for command and train control, see also Chapter 2.

In the last part are presented the technical elements made for the interconnection of the two systems, in order to exchange the information, acquired individually and in this way to obtain an integrated functionality and an extended message for the data acquisition of the ABA system.
Through the development of this technical solution the objectives of the T4.4.3 are achieved, as it is also explained in the Conclusions.
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# Abbreviations and acronyms

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<th>Abbreviation / Acronym</th>
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<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FMEA</td>
<td>Failure Modes and Effects Analysis</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communications Technology</td>
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<tr>
<td>IM</td>
<td>Infrastructure Manager</td>
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<tr>
<td>LCA</td>
<td>Life-Cycle Assessment</td>
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<td>LCC</td>
<td>Life-Cycle Costing / Life-Cycle Cost</td>
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<tr>
<td>M&amp;R</td>
<td>Maintenance and Renewal</td>
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<td>ABA</td>
<td>Axle Box Acceleration</td>
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<tr>
<td>MRT</td>
<td>Mean Repair Time</td>
</tr>
<tr>
<td>MTTF</td>
<td>Mean Time To Failure</td>
</tr>
<tr>
<td>RAM</td>
<td>Reliability, Availability and Maintainability</td>
</tr>
<tr>
<td>RAMS</td>
<td>Reliability, Availability, Maintainability and Safety</td>
</tr>
<tr>
<td>UIC</td>
<td>Union Internationale des Chemins (International Union of Railways)</td>
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<tr>
<td>CM</td>
<td>Corrective Maintenance</td>
</tr>
<tr>
<td>FME(C)A</td>
<td>Failure Mode, Effects (and Criticality) Analysis</td>
</tr>
<tr>
<td>IM’s</td>
<td>Infrastructure Managers</td>
</tr>
<tr>
<td>MGT/MGTPA</td>
<td>A measure of traffic in units of million gross tonnes per annum</td>
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<tr>
<td>PM</td>
<td>Preventive Maintenance</td>
</tr>
<tr>
<td>RCF</td>
<td>Rolling Contact Fatigue</td>
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<td>SA</td>
<td>Safety Analysis</td>
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<tr>
<td>US/UT</td>
<td>Ultra-Sonic / Ultra Sonic Testing</td>
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<tr>
<td>S&amp;C</td>
<td>Switches &amp; crossings</td>
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<td>END</td>
<td>Environmental Noise Directive</td>
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<tr>
<td>OOR</td>
<td>Out Of Roundness</td>
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<tr>
<td>MEMS</td>
<td>Microelectromechanical Sensors</td>
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<tr>
<td>BER</td>
<td>Bit Error Rate</td>
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<tr>
<td>RF</td>
<td>Radio-Frequency</td>
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<tr>
<td>RCCF</td>
<td>S.C. RC-CF TRANS S.R.L.</td>
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<tr>
<td>CRC</td>
<td>Cyclic redundancy check</td>
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<tr>
<td>DMI</td>
<td>Driver machine interface</td>
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<tr>
<td>EGNOS</td>
<td>European geostationary navigation overlay service</td>
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<tr>
<td>FRS</td>
<td>Functional requirements specification</td>
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<tr>
<td>GNSS</td>
<td>Global navigation satellite system (GPS, GLONASS, EGNOS, GALILEO)</td>
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<td>GPRS</td>
<td>General Packet Radio Service</td>
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<tr>
<td>TCC</td>
<td>Traffic control centre</td>
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<td>LTDL</td>
<td>Low traffic density lines</td>
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<td>MA</td>
<td>Movement Authority</td>
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<tr>
<td>MMI</td>
<td>Man machine interface</td>
</tr>
<tr>
<td>ORS</td>
<td>Operational requirements specification</td>
</tr>
<tr>
<td>TSA</td>
<td>Temporary shunting area</td>
</tr>
<tr>
<td>TSR</td>
<td>Temporary speed restriction</td>
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1. Technical description of the involved systems: Axle Box Acceleration (ABA) System

1.1 Introduction

Track behaviour and the whole life costs depend on many factors: initial quality of infrastructure, quality of the ground and formation condition (e.g. good drainage), ballast quality, frequency of switches, traffic loading, type and quality of rolling stock, etc. To reduce LCC, in order to optimize the life costs for both infrastructure and vehicles various maintenance procedures are used, including tamping and ballast cleaning, rail grinding and renewal activities, sleeper and fastening renewal, investment in track-friendly traction units, etc (1). The costs of improving the track and ride quality will arise immediately, in the short-term, but benefits will emerge in the long term (2). In the case of regional railways, the availability of budget is limited for optimizing in the long term, which poses the challenge of having to perform only those maintenance activities that will produce the maximum benefits. For deciding which activities are the most important, a condition based monitoring strategy can provide crucial and actual information about the railway track.

Condition monitoring of the track quality over long periods of time can give information about the local dynamics of the track behaviour and the rate of wearing. Monitoring should cover all the kilometres of the widely distributed railway ground infrastructure to have actual information. In order to manage this requirement, the railway infrastructure contains various and spread sensors and actuators to provide information about its structural wear level and maintenance that will be needed. The sensors and actuators operate in real-time or periodically depending on their functions in different components.

With all the information extracted from the data, infrastructure managers can monitor the structural health of their assets and make maintenance decisions in a systematic way. The configuration and integration of sensors for structural health monitoring must be implemented in a way that ensures that good and sufficient data could be provided while having minimum impact or interventions on the infrastructure.

In the Dutch railways, the axle box acceleration (ABA) system was employed to detect defects such as squats, corrugation and poor quality welds. In other countries like Korea (3), Japan (4), Poland (5), Italy (6), ABA systems have also been implemented for analysis of railway track defects. All these reflect the higher usability of one very modern technology.

1.2 Rail defects detected with ABA system

1.2.1 Squats

Squat is a type of rolling contact fatigue (RCF). Squat has been known in Europe since about 30 years ago. Squats appear on the running band in straight track and large curves, independent on the type of track. The origins of squats are diverse. Some of them could be due to corrugation, bad quality welds, and small indentations. See Figure 1.1, Figure 1.2 and Figure 1.3 for examples of squat type defects in the line near Brasov in Romania.
The growth of squats depends on the dynamic contact between wheels and rails. There are defined three classes of squats: light (squat A), moderate (squat B), and severe (squat C). For class C, a
widening of the rolling band and the typical two lungs shape is observed. Cracks will develop from the surface, yet their depth is not observable without ultrasonic or phase array technologies. As the length of the crack is unknown, the risk is that the rail will break if the squat has been severe for too long.

The most important variable of a squat is the length of it; it is related to the duration of the impact and provide the wavelength characteristic and therefore the frequency of the dynamic contact force. The width parameter is less relevant than length, as it is related to the severity of the defect and its growth becomes non-linear.

1.2.2 Corrugation
Rail corrugation is a periodic wave-like rail surface defect, see examples in Figure 1.4 and Figure 1.5 for the track near Brasov in Romania. Some types of corrugation are up to date explained by a damage mechanism and a wavelength-fixing mechanism (7).

In the case of short pitch corrugation, which appear without a visible excitation, its origin and development are still an enigma. Short pitch corrugation refers to the corrugation with wavelength falling in the range of 20 – 80 mm, and with amplitudes (peak-to-trough distance) up to 100 µm. In the Dutch railway network, the most commonly recorded corrugation has the wavelength of 20 – 40 mm (8) (9). It mainly forms on straight tracks or at smooth curves under comparably light axle loads. It appears in different tracks, from traditional ballast tracks to modern slab tracks, from heavy rail to light rail and rapid transit, e.g. metro or tram lines, from discretely supported tracks to continuously embedded tracks (10).

Figure 1.4 – Example 1 of corrugation in track line, near Brasov, long wave and short pitch corrugation
Figure 1.5 –Example 2 of corrugation in track line, near Brasov, long wave and short pitch corrugation

On the other hand, corrugation can result in rolling contact fatigue, e.g. rail squats (11). If still now there is no complete explanation for the corrugation phenomena, the ABA system represent a potential tool for getting additional insights into their development.

1.3 General description of the ABA System, developed by the TU Delft

For the Dutch railways, the vertical axle box acceleration (ABA) system was employed to detect defects such as severe corrugation and poor quality welds. The ABA system measures longitudinal and vertical vibrations, and it is focused for detection of short wave irregularities (see in the Figure 1.6). Lateral ABA has been employed in the railway literature in the frequency range below 100Hz, applicable for longer wave track irregularities, and it was not considered in the measurement campaign in Brasov. See in Figure 1.7 and Figure 1.8 - some photos during the installation of the ABA system in Brasov, in the workshop of RCCF.

Figure 1.6 - Wheel and directions, Source: (12).
A vertical track irregularity like a squat causes an impact to a wheel in the vertical direction (y direction), which induces vibration of the wheelset. The vibrations caused by the impact are transmitted from the wheel-rail contact force to the axle. In the case of longitudinal and vertical acceleration (x and y directions). The axial plane of the wheel permits to analyse some correlation between plane x-y and squats.

According experiments, there are observed correspondence between the peaks and dips of the vertical and longitudinal signals, in the region between 400Hz and 2000Hz; that signifies that there are many excited modes in common for both directions. Having three indications to the three directions makes possible to get measurement over the real wheel. This is the theoretical foundation for the use of longitudinal ABA, to sense vertical impact and to improve sensitivity. The mode shapes of the wheelset can be classified into two groups: wheel modes and axle modes. According to Thompson (13) and Periard (14) all the wheel modes are symmetric or anti-symmetric with respect to the axle. For this reason, squat-induced wheel vibration can be measured both in vertical and longitudinal directions on the axle box. As for the axle modes, according to Periard (14), they are classified into 3 groups: flexural, torsional and compressional. Flexural modes will be excited by vertical impacts and
have components in the x and y directions, while in the z direction this component will be smallest, even negligible. Torsional is a non-symmetric mode with respect to the wheel and the axle and has no components in z direction. In the case of compressional modes, they are mainly in the lateral (z) direction. They have, however, no components in the longitudinal or vertical directions, so the chance for them to be excited by a vertical force is small.

Therefore, in summary, the vibration modes excited by a vertical force will mostly be in the vertical (x-y) plane. It becomes clear that lateral ABA sensing is more sensitive to lateral excitation, thus to be excited by flange contact rather than by squats. In the case of light squats, their length is typically 10 to 30 mm. For normal traffic speed of 140 km/h and for the speed of the measuring train (100 – 110 km/h), they cause frequency contents of 1.0 – 4 kHz for the forced vibration/impact part. In other words, light squats cause higher frequency vibrations because its effects on the signals are more like an “ideal” impact, which in its perfect form has zero time duration. In Figure 1.9, the peaks of the scaled average wavelet power (SAWP) signals after processing are more intense and evident, which makes the detection procedure easier. The defects are denoted by red asterisks. The defect at 3.8 m is a moderate squat. The other defects are all trivial defects.

Figure 1.9 - SAWP before and after signal processing. Visible defects are shown with red asterisks on the horizontal axis. Source: (9).

1.4 ABA Equipment description

In Figure 1.10, a schematic overview of the ABA system is shown. Data is collected from accelerometers but also from one GPS receiver and either a tacho or speed-sensor for positioning.
For ABA measurements, a number of accelerometers are mounted on the axle boxes of at least one bogie. For mounting the sensors, three small mounting studs have to be glued on each axle box. Therefore, a small spot of approximately 2x2 cm should be cleaned and be free of paint and grease, see Figure 1.11.

Sensor cables are routed from the bogie frame to the measurement box in the train, preferably through a cable entry. If a cable entry is not available, the cables can be routed through an open window. As it is for temporary use, the cables are attached by cable ties so they can easily be removed after the measurements. The mounting studs are not removed after the measurements.

Installation of the sensors and cabling can be carried out in one full day. It is strongly recommended to have the train placed indoor, as the axle boxes should be protected from rain during the gluing process. For safety reasons, it is also recommended to have the train in a workshop in order to mount the GPS antenna on the roof of the train (strong magnets are used to hold the antenna). The measurement box (see Figure 1.13) contains the data acquisition. The box requires a 230V /50Hz power supply.

The measurement box is represented by a process calculator and a number of interfaces and communication channels with sensors, with the Laptop and other auxiliary devices. One of the serial interfaces, available on the main board processor, will be used to integrate data from the SATLOC onboard computer (15).
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Figure 1.11 - Mounting stud for accelerometer glued on an axle box, Source (12)

Figure 1.12 - Measurement box, during measurement campaign in Brasov, Romania.
2. Technical description of the involved systems: SATLOC System

2.1 SATLOC System - characteristics and innovation

The system application target is the low traffic lines (UIC E lines category) which represent large market (40% of the European network, and much more world-wide), in full complementarity and migration to the ETCS when GNSS is applied in a global approach.

The SATLOC system could be considered as result of at least 15 years of satellite applications studies, in the rail sector, which were led by the UIC, ETCS and ERTMS, Regional IFSTTAR and SPIRENT and include many simulation of geo-referenced conditions. Also other major companies, like SIEMENS, ANSALDO and INVENSYS RAIL, integrate newest industry technologies in train control telecommunications and use of ETCS standards.

The SATLOC System has main characteristic as follows:

- Low cost train control solution for regional and low traffic density lines – the same basic functions and high safety target as ETCS.
- Compatibility with ETCS – interoperability on long term.
- Highest flexibility of implementation – to satisfy pragmatic, workable and best options for cost efficiency.
- Application of new technologies for train localization, train completeness, mobile radio communication with trains.
- Improved testability and validation for easier approval of applications.
- Expandability to new functions and services based on IT, UMTS-LTE and GNSS as integration and optimization platforms.
Innovation facilities of the system:

- Opportunity for using of technologic progress in application: IT, satellite navigation, radio-communication, automation.
- Absolute location of trains with GNSS, route map and virtual beacon.
- Train tracking function to supervise train running by the TCC for high safety target with lower SIL components.
- Use of UMTS-LTE high performance mobile radio in VPN-sec technology for data transport at marginal cost / cab radio on UMTS with IP address.
- Adaptation of operations to maximize the effect of technology and reduce cost (i.e. spring switches for crossing the trains, de-centralized shunting, etc.).

### 2.2 System architecture

The SATLOC system, using SOL databases, provides the train location, speed and precise timing for the train control. The fix integrity and high-level safety are assured by close-loop integration of train traffic and movement authority control from the control centre. The high degree of innovation in the integrated train-track behaviour enables lower safety integrity components to achieve a very high safety target.

The SATLOC system is built up of at least one TCC (Traffic Control Centre) for train protection and supervision and trains equipped with SATLOC on board equipment. Each train registered in the SATLOC area is linked to the TCC via a mobile network. Figure 2.1 - SATLOC architecture shows the SATLOC system architecture with the TCC and a train in the SATLOC area, linked to the TCC via SATLOC network.

![Figure 2.1 - SATLOC architecture](image-url)
2.3 Components of the SATLOC system

2.3.1 TCC Traffic control centre
The SATLOC TCC consists of the following subsystems described:

- TCC computer subsystem.
- MMI.
- TCC router.

Track computer subsystem
The TCC computer subsystem is the core of the TCC. It includes three main functions and software components:

- The TCC application, consisting of all functions for protection and supervision of the SATLOC trains, their position, MAs etc., TSAs, TSRs, SATLOC borders.
- Database server for the route map, logging events, messages and states.
- GUI as interface to the MMI.

MMI (Man Machine Interface)
Description:
The TCC’s MMI consists of at least two displays:

- One (or more) display(s) for visualisation of the line (including trains, their positions, MAs, TSAs, TSRs etc.).
- One display for visualisation of the timetable.
- Keyboard and mouse are used for data input.

TCC router
The TCC router is related for the GPRS connection between TCC and train via a SATLOC network. Via SATLOC network’s APN and the TCC router, the mobile terminal (in the train) is connected to the TCC network. Interface(s) used:

- TCC router: Track-side computer <-> TCC computer: network interface device for
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connecting to the APN network.

- TCC router: Mobile terminal, inside the train, for sending and receiving data.

2.3.2 SATLOC On-Board equipment

The SATLOC on-board equipment includes the following subsystems described in the following:

- On-board computer.
- DMI (Driver machine interface).
- Mobile terminal.
- GNNS receiver.
- Distance pulse generator.
- Beacon antenna.
- Digital I/O board.

On-board computer

The on-board computer is the core of the SATLOC train equipment. Three main functions as SW components are realized on this computer:

- The train application responsible for deriving the train position, speed etc. based on the information collected from connected devices:
  - GNNS receiver.
  - Distance pulse generator.
  - RFID beacons antenna, as passives tags.

In link with the RFID tags, placed in track supervision of MAs, TSAs, TSRs etc. and automatically operating the train’s brake or traction lock if the driver fails to adhere to the MA, allowed speed etc.

- Database server for the route map, logging events, messages and states, and
- GUI, also as interface to the DMI.

Interface(s) used:

- On-board computer <-> DMI:
- On-board computer <-> Mobile terminal:
- On-board computer <-> GNNS receiver:
- On-board computer <-> Distance pulse generator
- On-board computer <-> Beacon antenna:
- On-board computer <-> Digital I/O board:

DMI (Driver machine interface)

The train DMI is composed of a display and included operational controls (by means of buttons on a touch screen). The display shows the relevant data for the respective train:

- Date and time;
- Train position (kilometre on the track);
- Train running number;
• Train length, number of vehicles;
• Maximum speed allowed – this shall depend on the train type and the permanent speed restrictions.

MAs or shunting permissions together with expected operator control actions and optional additional orders (e.g. pulling into an occupied track) are displayed in plain text. Incoming messages generate a sound signal.

Operational controls include numeric keys, cursor, delete, cancel and enter keys for data input (train running number, length etc.) and keys for:
• Train registration/de-registration.
• Request for MA.
• Request for shunting permission/end of shunting.
• Confirmation of arrival at a station/leaving a station.
• Emergency call by means of sending a digital message to the TCC.

A button can have two different labels and functions during data input and driving the train. Further operational controls are normally not part of the actual DMI but also used for SATLOC and therefore considered as part of the component DMI:
• Main control switch (switch on/off of on-board SATLOC equipment).
• Acknowledge button.
• Free button (release of forced brake) – This button shall be operated according to the regulation in force at RCFF-TRANS (to be established).
• Automatic train stop override.

These controls are connected to the on-board computer via a Digital I/O board.

Interface(s) used on this level:
• DMI <-> On-board computer.

Mobile terminal
The mobile terminal links the train respective on-board equipment to the TCC ground network via SATLOC network.

Interface(s) used on this level:
• Mobile terminal <-> TCC router.
• Mobile terminal <-> On-board computer.

GNNS receiver
The GNNS receiver is the main device that is used for determination of the train’s position and speed. For high safety integrity and accuracy, the EGNOS Safety of Live (SOL) service will be used. With an appropriate receiver an accuracy of about 4m with four fixes per second should be achievable.
Interface(s) used on this level:
- GNSS receiver <-> On-board computer.

**Distance pulse generator**
The distance pulse generator is installed on one of the engine’s axles – preferential a non-powered one to prevent inaccuracy from slip. Its information is used for the determination of the train’s speed, direction of travelling and – together with the information from the RFID beacon antenna and the route map in the on-board computers database – for the calculation of the train’s position. The generator should at least emit x pulsed per revolution and achieve an accuracy of x%.

Interface(s) used on this level:
- Distance pulse generator <-> On-board computer.

**RFID beacons antenna, as passives tags.**
RFID beacons, as passive tags, mounted in the track are used as a reference for determination of the train’s position, especially for track selectivity (which usually cannot be achieved by GNNS).

![Figure 2.3 – Tag beacons for track selectivity](image)

The tag beacons antenna reads out the tags information while the train passes it. According to the route map, in the on-board computers database, the exact train position is identified.

Interface(s) used on this level:
- Tag beacon antenna <-> On-board computer:

**Digital I/O board**
The digital I/O board comprises the interfaces to the train.
The interfaces are to:
- The brake.
- The traction locking.

Interface(s) used on this level:
- Digital I/O board <-> On-board computer.
3. SATLOC System and ABA System - interfacing solution developed for the monitoring technology

3.1 General considerations and hardware interface characteristics

Last experimentis of the ABA systems in Romania provided the frame of interactions with SATLOC systems, owned by RCCF. According to the specific protocols, direct interfaces between ABA and SATLOC were made; in this way, the Laptop used by ABA system also collects and integrates short messages, from SATLOC on board equipment (GPS positioning data, odometer data, in field tag codes), see Figure 3.1. This solution is better than using one external device, placed between ABA and SATLOC to integrate data from both systems.

![Block structure of the linked ABA and SATLOC systems](image)

Figure 3.1 – Block structure of the linked ABA and SATLOC systems

Software to collect data from SATLOC on board equipment and also integration of data collected with TU Delft equipment was develop by TU Delft, based on information below:

3.1.1 Serial port characteristics:
- Baud Rate: 115200 bauds.
- Parity: none.
- Data bits: 8.
- Stop bits: 1.

These characteristics are RS232 standard and simplified parameters; not used the signals for handshaking. In next figures are presented the connector used (see Figure 3.2) and the significance of the signals for 9 pins connector (see Figure 3.3). As we said, for interconnection were used one simplified serial connection:
Pins used: 2 – Received Data; 3 – Transmitted Data; 5 – Signal Ground.
Pins not used: 1 - Data Carrier Detect; 4 - Data Terminal Ready; 6 - Data Set Ready; 7 - Request to Send; 8 – Clear to Send; 9 – Ring Indicator. In the Figure 3.4 is presented the formation of one byte in serial RS232 communication.

![Figure 3.2 – RS232 connector as mechanical seeing](https://arcelect.com/rs232.htm)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Data Carrier Detect</td>
</tr>
<tr>
<td>2</td>
<td>Received Data</td>
</tr>
<tr>
<td>3</td>
<td>Transmitted Data</td>
</tr>
<tr>
<td>4</td>
<td>Data Terminal Ready</td>
</tr>
<tr>
<td>5</td>
<td>Signal Ground</td>
</tr>
<tr>
<td>6</td>
<td>Data Set Ready</td>
</tr>
<tr>
<td>7</td>
<td>Request to Send</td>
</tr>
<tr>
<td>8</td>
<td>Clear to Send</td>
</tr>
<tr>
<td>9</td>
<td>Ring Indicator</td>
</tr>
</tbody>
</table>

![Figure 3.3 – RS232 connector as pins significations](https://arcelect.com/rs232.htm)

\[1\] https://arcelect.com/rs232.htm
The SATLOC system has command and control messages defined; they were also directed to the serial interface and were made available for interconnection with ABA.

The ABA system has been customized to send orders and receive SATLOC’s predefined messages. This information, required for integration into the ABA data package, refer to the GPS location of the train and to the locomotive odometer information.

3.2 List of commands (request) for data in SATLOC PC:

3.2.1 Commands for SATLOC, used for sending GPS data to the ABA System

Interrogation for sending GPS data – to the SATLOC:

GPS +/- (Request Output GPS-Data ON / OFF)

Response for the GPS data interrogation – from the SATLOC:
Example:
09:49:21;$GPS;GPS-TIME,9:48:54,LON,25.626539,LAT,45.665085,dGPS,1,DOP,1.2,#SAT,8

Explanation:
09:49:21 - time for PC of onboard SATLOC System (from bios)
$GPS - ID response to command “GPS +”
GPS-TIME,9:48:54 - GPS time
LON,25.626539 - longitude
LAT,45.665085 - latitude
dGPS,1 – differential GPS enabled/disabled
DOP,1.2 - HDOP
#SAT,8 - number of satellite.

3.2.2 Commands for SATLOC, used for sending GGA data to the ABA System

Interrogation for sending GGA data – to the SATLOC:

GGA +/- (Output GGA-Data ON / OFF).

---

2 Rs232_oscilloscope_trace.jpg: Samuel Tardieu
Response for the GGA data interrogation – from the SATLOC:
Example:
09:56:28;GGA;GPGGA,095601.00,4539.90591,N,02537.59371,E,2,08,1.2,566.36,M,35.41,M,2.0,01 20*46

Explanation:
09:56:28  - time of PC board of the SATLOC System (from BIOS)
$GGA  - ID response to command "GGA +"
$GPGGA,095601.00,4539.90591,N,02537.59371,E,2,08,1.2,566.36,M,35.41,M,2.0,0120*46  - this is line of geographic position data in NMEA format, from GPS.

3.2.3 Commands for SATLOC, used for sending WEG data to the ABA System
Interrogation for sending WEG data – to the SATLOC:
WEG +/- (Output odometer data: ON/OFF).

Response for the WEG data interrogation – from the SATLOC:
Example:
09:57:45;$ODO;ZAEHLER,1,WEG[m],0,POS-WS[m],28469,RTG-WS,0,V-WS[mm/s],0,A-WS[mm/s2],0

Explanation:
09:57:45  - time of the PC board SATLOC System (from BIOS).
$ODO  - ID response to command "WEG +".

3.2.4 Commands for SATLOC, used for sending odometer data to the ABA System
Interrogation for sending odometer position data – to the SATLOC:
POS +/- (Output Position data ON/OFF).

Response for the odometer POS data interrogation – from the SATLOC:
Example:
06:45:32;$ODO;Raddurchmesser = 890[mm], Impulse pro Umdrehung = 220 Find_Streckenpunkt_Feinsuche-d: Punkt_In_Polygon=TRUE
06:45:33;$ODO;ZAEHLER,1,WEG[m],0,POS-WS[m],28469,RTG-WS,0,V-WS[mm/s],0,A-WS[mm/s2],0
OR
09:59:36;$ODO;ZAEHLER,1,WEG[m],0,POS-WS[m],28469,RTG-WS,0,V-WS[mm/s],0,A-WS[mm/s2],0
***************************************************************
09:59:36;$GPS;ID-BAL,107,RTG-BAL,2,ID-SEG,76,WEGSENSOR_MESSWERT,POS-GPS[m],28468,POS-WS[m],28469,POS-GPS-ID,3036,POS-WS-ID,3036,V-GPS[mm/s],166,V-WS[mm/s],0,RTG-WS,0,A-WS[mm/s2],0,dGPS,TRUE,#SAT,8,SYSTEM_OK
09:59:36;$GGA;$GPGGA,095909.00,4539.90528,N,02537.59263,E,2,08,1.2,569.60,M,35.41,M,1.9, 0120*47.
In the next images are presented the SATLOC equipment with system main components:
Figure 3.5 – SATLOC on train equipment

Figure 3.6 – SATLOC on board computer and MMI
Figure 3.7 – TCC SATLOC terminal
Conclusions

Although in the first stage of system analysis, from a neutral position, was considered the adaptation and transfer of information between the ABA and SATLOC systems, using a solution through the development of a specialized hardware and firmware interface, at a later stage, a detailed analysis of the components and interfaces of the equipment for the two systems has helped to find a more efficient and easier to implement solution.

The new technical solution was possible due to the complexity of the equipment, making up the both systems. These, primarily the central computing and process equipment, have additional back-up communication interfaces that allow for further development. To achieve interconnection, a RS232 serial communication interface with a standard performance (8 bits, no parity, 1 bit stop, 115000 bauds) is required.

The interconnection of the two systems, for information exchange, has been achieved successfully. This is confirmed by a test session made in the summer of 2016 on the Bartholomeu - Zarnesti line, in Brasov. In this session, the ABA system functioned with GPS and odometer data taken from the SATLOC system.

It can be concluded that the objectives, set out in T4.4.3, have been achieved; has been achieved an integrated system that performs at the same time two functionalities: low cost train monitoring and control functionality, for regional and low traffic density lines and also, in the meantime, a second functionality of permanent monitoring of the integrity and quality of the track line. It is a major step ahead in implementing the maintenance “as request”, one of the most important objective of the NeTIRail project. Through using specialised equipment for monitoring and analysing of the track integrity, it is providing fast information of eventually faults and help decision for maintenance activities.

All interconnections and modifications made in the both systems applications there are in accordance with the requirements and conditions of ERTMS. This is proved by the next few considerations.

As defined in the report, SATLOC is built in full compatibility with the ETCS standard, which is part of ERTMS standards. The changes made to the SATLOC system for interconnection are additions and no changes to the already implemented application. This has been verified by the SATLOC system developers who have not allowed any kind of basic functional variant. Even more than that, the SATLOC System (software and firmware applications, hardware, algorithms, etc.) is in the process of homologation and certification.
References


