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# Intellectual Property Rights



# Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

# Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

# Executive summary

The availability of data has central importance for secure, efficient and demand-oriented mobility. In automotive technology, standards are therefore currently being defined for V2V and V2X communication. V2X communication allows improved communication between vehicles or between vehicle and infrastructure. Due to their use in the automotive industry, it is to be expected that standardized communication components will soon be also adopted for the railway sector in large quantities at low costs.

On this basis, applications in the field of public transport will be exemplarily implemented.

The functionality will be demonstrated with an example use case.

Use case "service and diagnosis" shows how maintenance can be improved with up-to-date data.

In this use case, data from central sources such as the mCloud is used as well as enriched or newly acquired data.

# Introduction

In the present document the "diagnosis and status" service describing concepts and messages which can be used for maintenance service between ITS-Stations is presented. The diagnosis and status service will support the healthiness during the lifecycle of ITS system (e.g. of devices on a railroad track).

# 1 Scope

The present document provides a common understanding of the technical concepts of the Diagnosis, logging and Status Service between ITS-Ss. The proposed service supports e.g. the communication of measurement data for maintenance and information purposes. One field of application will be the predictive maintenance of devices on rail tracks, the status information of the train platform to the train vehicles, etc.

# 2 References

## 2.1 Normative references

Normative references are not applicable in the present document.

## 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long-term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 302 637-2 (V1.4.1) (04-2019): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[i.2] Federal Ministry of Transport and Digital Infrastructure: mCLOUD: "The open data portal of the BMVI".

NOTE: Available at https://www.bmvi.de/SharedDocs/EN/Articles/DG/mCLOUD.html.

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the following terms apply:

**Rail2X:** communication between rail to rail or between rails to infrastructure

**V2X:** communication between Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2X) and/or Infrastructure to Vehicle (I2V), or Vehicle to Network (V2N) and/or Network to Vehicle (N2V)

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

| | |
|---|---|
| CAM | Cooperative Awareness Message |
| DSM | Diagnosis, logging and Status Message |
| GNSS | Global Navigation Satellite System |
| ITS | Intelligent Transport Systems |
| ITS-S | ITS-Station |
| OBU | On Board Unit |
| Rail2X | Rail to Rail/Infrastructure |
| RSU | Road Side Unit |
| UML | Unified Modeling Language |
| V2V | Vehicle to Vehicle |
| V2X | Vehicle to Infrastructure |

# 4 The concept of Diagnosis, logging and Status Service

## 4.1 Use case Service and Diagnosis

The central objective for the use case "service and diagnosis" is the establishment of Rail2X technology for applications in the field of maintenance and remote diagnosis of infrastructure elements. The focus is on improving the data transmission technology. The core of the use case is the presentation of Rail2X technology as an alternative to wired solutions and the cost-intensive cable are to be avoided.

The transmission of diagnostic data is also possible from distant, largely self-sufficient infrastructure units such as level crossings with monitoring signal, electrically remote-controlled switches, electrically localized switches or speed test sections.

With these mentioned infrastructure elements there is usually only one power supply, which does not allow to transmit the relative information. Here, Rail2X technology can offer possible solutions for data transmission. With Rail2X, diagnostic data is transported by data carriers (trains) from a data source (infrastructure element) to the data sink (e.g. server in the depot). The train acts as an information carrier and is the link between autonomous infrastructure elements along the track and a central diagnostic platform, e.g. in the infrastructure depot.

The core of the research work in the Rail2X lies in improving the transmission technology of small, non-safety-relevant data packets in the railway sector. In order to transmit the messages, the V2X communication standards are used (e.g. ITS-G5). The source of the data is irrelevant, since it is primarily about the design of the transmission interface using Rail2X. Using Rail2X technology, small data packets from passing trains can be received and returned elsewhere, e.g. in the depot for data storage.

In order to demonstrate the benefits for stakeholders in the railway sector, it makes sense to maintenance and diagnosis of infrastructure elements. Infrastructure elements are the objects located along the track or at operating points. The elements have no data connection to the interlocking or other communication systems and operate autonomously. The task of the Rail2X technology is to transmit the measured data by passing trains to a central data server. In addition to a switch, there are numerous other conceivable infrastructure elements whose diagnostic data could be transferred via Rail2X. The measuring device is used to determine fixed parameters on the infrastructure element and thus the desired measurement data or diagnostic data is collected. The measuring equipment includes wheel sensors, temperature sensors or acceleration sensors. The measurement data is transferred to a Rail2X unit, which may contain several different recorded measured values. The use case is summarized in Table 1.

**Table 1: Service and diagnosis use case**

| | |
|---|---|
| **Use Case Name** | Service and diagnosis. |
| **Category** | Safety. |
| **Actors** | Information are collected by:<br>• Trains ITS-S equipped with sensors.<br>• Roadside ITS-S equipped with sensors.<br>DSM message received by ITS-Ss (with or without sensor):<br>• ITS central systems/central diagnostic platform. |
| **Infrastructure Roles** | A roadside ITS-S equipped with stationary sensors obtains information from the train track and broadcast via the DSM message to the surrounding ITS-Ss (including passing trains). |
| **Train Roles** | ITS-Ss that are equipped with sensors transmit and receive DSM messages. |
| **ITS Central Data Server Roles** | The central ITS-S at an ITS central system receive the recorded data via DSM message and analysis of the received data for maintenance of the track. |
| **Goal** | • To record all the diagnosed data of the train track.<br>• Improving the data transmission technology. |
| **Constraints/Presumptions** | ITS-S equipped with sensors. |
| **Geographic Scope** | Applicable to railway system. |
| **Pre-Conditions** | • Train of road side ITS-S equipped with sensors.<br>• Rail2X communication among ITS-Ss. |
| **Main Event Flow** | All the diagnosed information about the train track is sent by ITS-Ss to other ITS-Ss including central ITS-Ss. |
| **Post Conditions** | Central data server is informed about the diagnosed data. |
| **Information Requirements** | Diagnosed data from the train track. |

## 4.2 System architecture

A railway system as shown in Figure 1 can be used to connect track and other diagnostic devices with the Rail2X transmitter unit. The advantage of this system lies in the large number of universal interfaces to different types of sensors which is important in service and diagnosis use case.

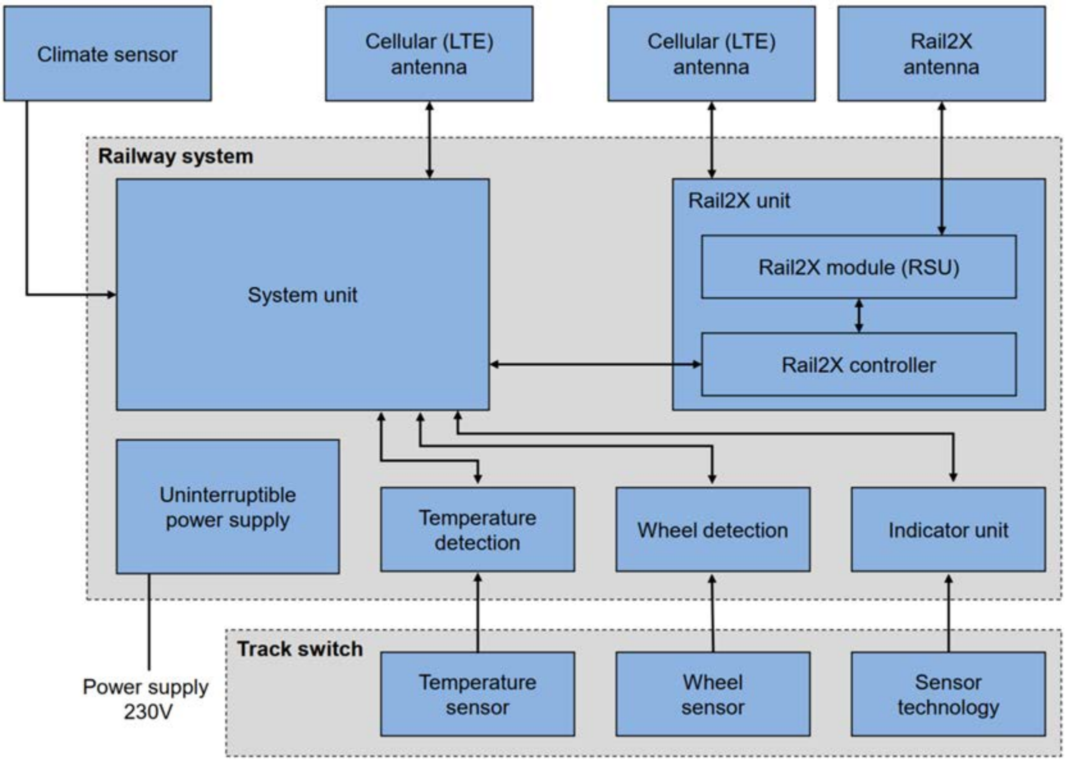


**Figure 1: Schematic representation of the railway system architecture**

The following components are used to set up the unit for service and diagnosis purposes on the switch:

- **Temperature sensors on the heating point or on the track:** The points are heated to melt snow or ice so that safe switching is still possible. If the switch is heated, there is a temperature difference and the proper function of this heater can be verified.
- **Climate sensor/weather station:** This sensor provides information on air temperature, wind direction and speed as well as the type and amount of precipitation.
- **Wheel sensor:** With this sensor, every wheel that drives over the switch is recognized. The direction of travel, the train speed, the number of axles and the number of bogies are determined on site by analysing the signal curves of the four sensor systems. Furthermore, the vehicles, the vehicle sequence, train length and train type can be determined. This data is aggregated and provides a temporal distribution of the train crossings.
- **Sensor technology:** The indicator unit is used for analysis in the common area and it detects the state of wear condition of the crossing in the track and forwards information to the system unit. If the vehicle is heavily worn, there is a risk of derailment.

With the components described above, a large amount of local information is obtained from the areas of the state of the switch, the climatic conditions and the train journey distribution.

## 4.3 System components and functionality

### 4.3.1 Introduction

Clauses 4.3.2 to 4.3.7 provide an overview of how the system for use case service and diagnosis is basically structured. Figure 2 shows an overview of the system components used, which are explained in more detail in the individual clauses.

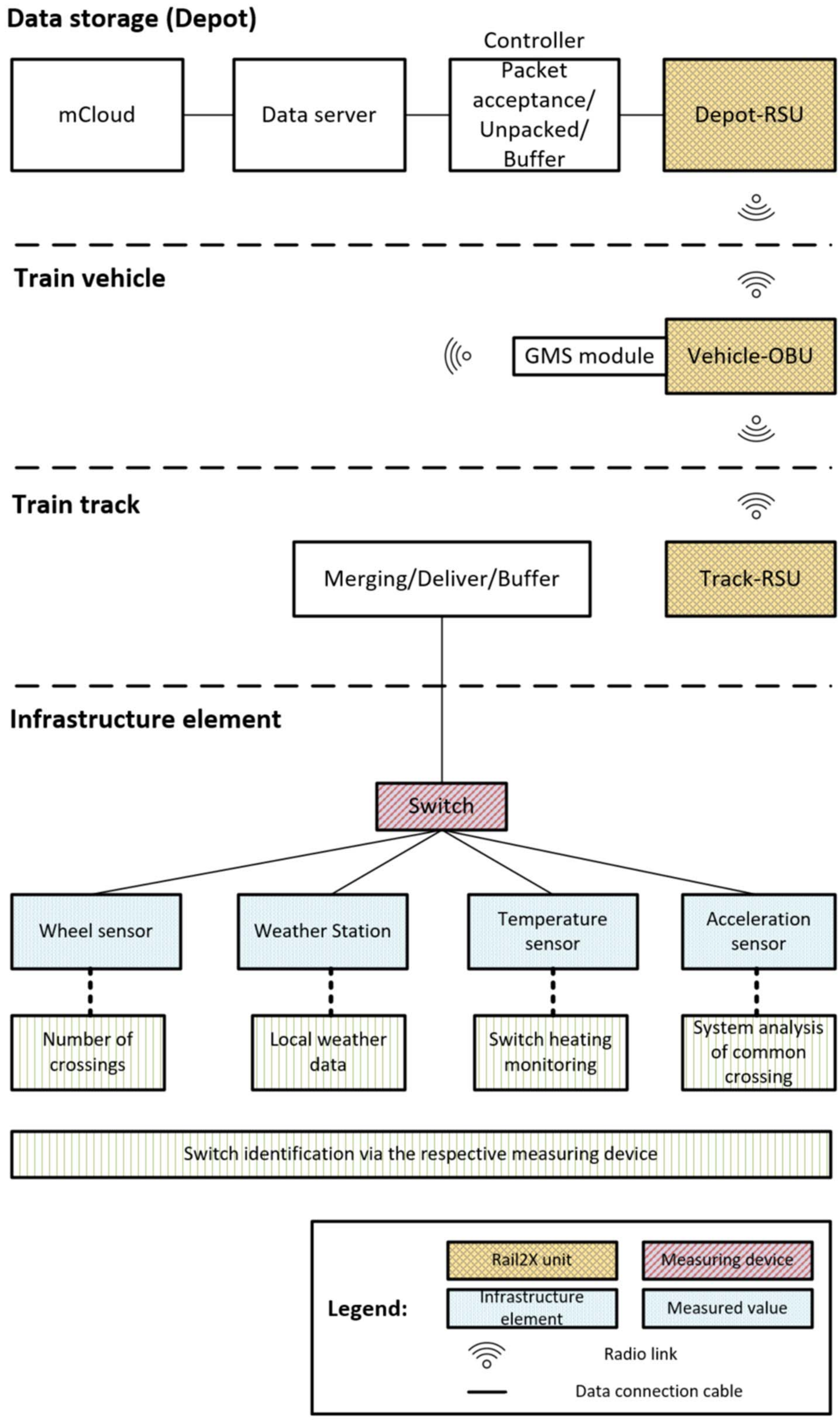


**Figure 2: Overview of system components of use case service and diagnosis**

### 4.3.2 Infrastructure element

Using Rail2X technology, small data packets can be received from passing trains and transferred elsewhere, e.g. to be returned to the depot for data storage. In order to show the benefits for the stakeholders in the railway sector, it makes sense to consider the maintenance and diagnosis of infrastructure elements. Infrastructure elements are the objects that lie along the track or in operating locations. The elements have no data connection to the interlocking or other communication systems and act independently. These include e.g. the diagnostic equipment of a switch. The task of Rail2X technology is to transmit the measurement data that has accumulated to a central data server by means of passing trains. In addition to a switch, there are numerous other conceivable infrastructure elements whose diagnostic data could be transmitted via Rail2X.

### 4.3.3 Measuring device

With the help of the measuring device, specified parameters are determined on the infrastructure element and thus the required measurement data or diagnostic data are collected. The measuring devices include, for example, wheel sensors, temperature sensors or acceleration sensors.

### 4.3.4 Rail2X unit on the track

The measurement data are transferred to a Rail2X unit, which can possibly record several different measured values simultaneously. Figure 3 shows an example of the structure of a Rail2X unit. The Rail2X units on the vehicle and in the depot work according to the same principle. The controller records data from the measuring device via sensors or data interfaces and prepares them for further transport. The V2X sender & receiver (the Road Side Unit) will send and receive the diagnostic messages via the "V2X antenna".

In the Rail2X unit, the measurement data is converted into a Rail2X-compliant format. The measurement data is thus available in a telegram type that is sent directly as a Rail2X broadcast message. New measurement data trigger an update of the telegram content. The oldest measurement data is overwritten. The telegram is sent after the measurement data has been transferred to the Road Side Unit (RSU), which then regularly sends the diagnostic messages in broadcast mode. A passing train receives several of these telegrams.

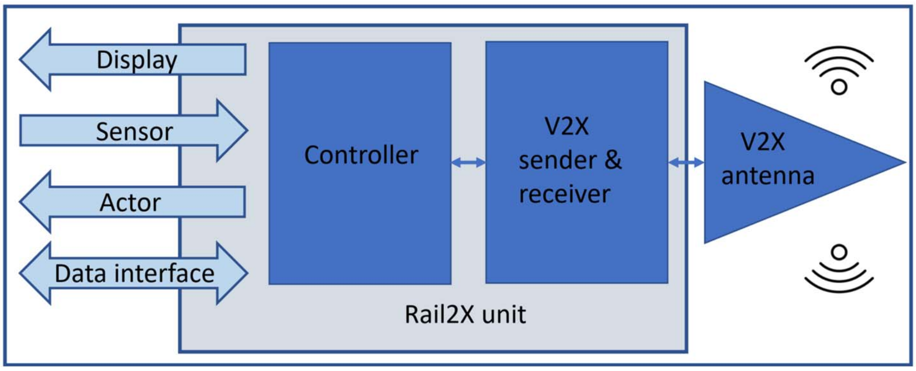


**Figure 3: Rail2X unit with controller, V2X components and interfaces**

### 4.3.5 Rail2X unit on the train (Train OBU)

The train is equipped with a Rail2X On Board Unit (OBU). This enables the train to receive Rail2X broadcast telegrams from infrastructure elements along the track and to transmit them further. Telegrams received are temporarily stored on the train during transport. The collected data is transferred to the Depot-RSU when the train stops at the depot. The transmission of the data to the depot RSU can be triggered manually or automatically.

The transport time of a telegram between the measured infrastructure element and the data server can possibly take several hours since the train collects numerous data packets during its schedule and initially stores them. In order to be able to transmit urgent measured values and alarm messages to the relevant points much faster, the train's OBU is also equipped with a 4G/5G module. The measured values are monitored within the measuring devices. In case, the measuring devices exceed with the defined measuring time then the Rail2X broadcast telegram is additionally provided with an alarm signature. If the telegram was transmitted to the train via Rail2X, the OBU on the train tries to transmit such a message with high priority over the cellular network as soon as a cellular network is available. Less priority measured data without alarm marking remain on the train data storage and are only later transferred to the depot RSU and then to the data server via Rail2X.

### 4.3.6 Rail2X unit in the depot (Depot-RSU)

As soon as the train with OBU stops in the depot, data transmission to the Rail2X unit in the depot begins. This unit is called the Depot-RSU in the depot. The collected measurement data is transmitted to the Depot-RSU. From the Depot-RSU, the data is sent to a controller, which converts the data into a format that allows it to be saved on a data server. The controller serves as a buffer for the incoming data.

### 4.3.7 Data server

The data server is connected to the depot via a cable connection and receives the measurement data from the buffer described above. The server serves as a data sink for long-term storage and evaluation of the measurement data. Various services such as the mCloud [i.2] can be connected to the data server via an interface. The data can thus be made available for other purposes of use, for example for an evaluation using algorithms.

# 5 Application scenarios for data transmission

## 5.1 Introduction

In order to demonstrate the benefits of the present use case in the railway sector, it makes sense to consider the maintenance and diagnosis of infrastructure elements. For the presentation of benefits in the railway sector, the current challenges in the field of maintenance and diagnosis will be addressed. It will be checked in which areas the Rail2X technology can offer solutions or improvements for maintenance.

The main part is to focus on the core element i.e. switch. As a central infrastructure element of the railway, the switch is particularly suitable for maintenance issues due to its system importance. In the following clauses, various applications are described which take up the measurement of parameters in the area of the switch (see Figure 4).

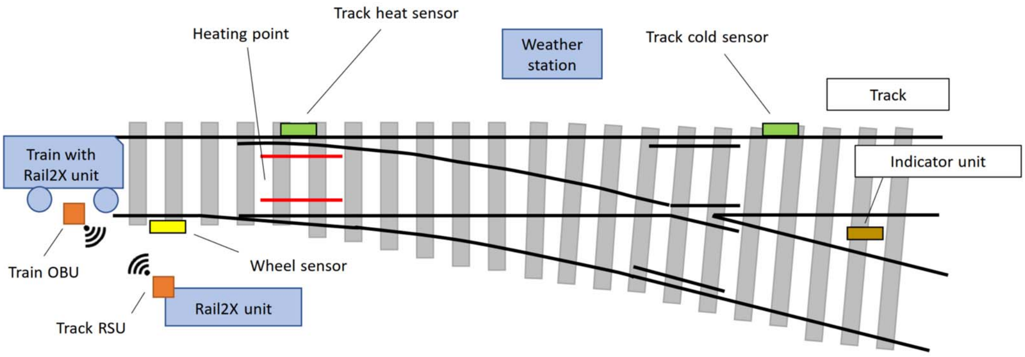


**Figure 4: Overview of points, presentation of the application scenarios**

## 5.2 Switch identification

For diagnostic and test purposes, it makes sense to send a clear identification of the switch to passing trains using Rail2X. Each switch is given an ID, which can be the switch number, for example. For this purpose, the ID is stored permanently in the track RSU and transmitted as a static value in every telegram that is sent. This means that important properties of the switch can be referenced on the receiver side. Information on the type and age of the switch and the types of sensors installed is therefore available. The track switch ID generates useful properties for maintenance. When crossing the track switch, the train receives a position indication along the track. The Cooperative Awareness Message (CAM) [i.1] of the track RSU provides the GNSS position of the switch. A CAM message is the status message of each V2X station and contains in particular the current GNSS position.

**Table 2: Track switch identification**

| Track switch Identification | Comments |
| --- | --- |
| What should be transferred? | Switch ID and location of the switch |
| What should be measured? | --- |
| How often should it be measured? | Not necessary, as static value |
| Which components? | No special components required |
| What is transferred to the track RSU? | Switch ID and location (permanently stored on the track RSU) |

## 5.3 Number of crossing points

In the "Switch Identification" application scenario, the switch ID and the location of the switch are transmitted. The information should now be supplemented by dynamic parameters. The switch not only sends its ID and location to the environment, but also dynamic data that is measured directly on the switch. The number of train crossings for many switches can only be estimated roughly based on a timetable. However, there are already systems that can determine the exact number of passes. However, these systems are not installed across the board and are not available for every switch. The incentive at Rail2X is to give the information directly to the train. By saving cable runs when using Rail2X, investments in switch diagnostics can be reduced. This means that more switches than before can be equipped with a counting device. The railway infrastructure companies receive a much more comprehensive picture of the condition of their switches in the track network, which makes it easier to plan maintenance measures. The data can meaningfully supplement existing measurement series for predictive maintenance and thus improve the wear forecast.

The system on the track always has the latest information available. The diagnostic system on the switch continuously measures and determines values and sizes and keeps them ready as a data package for the next train crossing. The tack RSU regularly sends a telegram with the current measurement data to the environment. A passing train that is equipped with Rail2X can receive the telegram and transport it on. According to the V2X standards such as CAM [i.1], no multimedia data can be sent and so the data to be sent can only be alphanumeric characters. For this, new text-based data types may have to be developed. The content consists of static and variable information. The listed metadata are contained in every telegram. The listed measured values are examples. This also applies to the following application scenarios.

**Metadata (available in every telegram):**

- Ident: one-digit number e.g. 1
- Time stamp: time of generation of the data packet e.g. 29/09/20 12:45: 34.123
- Location data of the switch via CAM message from the track RSU

**Values from train crossings (the list is exemplary):**

- Speed of the last train
- Last train journey: number of minutes that passed the last train journey
- Trains per day: number of train journeys in the last 24 hours
- Trains per month: number of train journeys in the last 30 days
- Trains since the reference date: number of train journeys since the reference date

- Axes per day: number of axes in the last 24 hours
- Axes per month: number of axes in the last 30 days
- Train speed per day: highest train speed in the last 24 hours in km/h e.g. 128
- Train speed per month: highest train speed in the last 24 hours in km/h e.g. 130

In order to detect the train crossings, a wheel sensor per track is installed on the switch. The wheel sensors are attached to one side of the rail at a distance of a few meters. In order to be able to record every switch crossing, the wheel sensors are mounted at the beginning of the switch on the pointed side (see Figure 4). The distance between the two wheel sensors is stored in the measuring system. The wheel sensors are able to recognize individual pull axles. Trains stopping or starting again could be considered separately. A drive-through time can be determined by recording the individual axes that pass the respective sensor. From the known length of the measuring section and the determined drive-through time, e.g. deduce the speed of the train. In addition, numerous other parameters can be calculated in the measuring unit (see values from train crossings).

The wheel sensors on the points are connected to a measuring unit and then to the Rail2X unit. Passing trains record the data for onward transport.

**Table 3: Number of switch crossings**

| Number of switch crossings | comment |
|---|---|
| What should be transferred? | Number of train crossings over a switch |
| What should be measured? | Acquisition of axes, travel time of measuring section |
| How often should it be measured? | With every train crossing |
| Which components? | Use of one wheel sensor per track, arrangement of the wheel sensor at the start of the switch (pointed side) |
| What is transferred to the Rail2X unit? | Number of train crossings over a switch 30 days in retrospect |

# 5.4 Local weather at the switch

Often no local weather data is known in the vicinity of the switch. Weather stations are several kilometers away. Rail-specific special cases such as cuts, embankments or elevated positions in the track area are not sufficiently taken into account in the conventional stations and accordingly lead to deviations in the assessment of the local weather situation at the switch. The direct measurement of meteorological measured values at the switch leads to improved predictive maintenance, since the weather in the immediate vicinity can be related to the wear behavior of the switch.

For the application scenario, a weather station (see Figure 5) is installed directly next to the switch and connected to a Rail2X unit. Passing trains also record the data for onward transport.

**Metadata (available in every telegram):**

- Ident: one-digit number e.g. 1
- Time stamp: time of generation of the data packet e.g. 29/09/20 12:45: 34.123
- Location data of the switch via CAM message from the track RSU

**Values from the weather station (the list is an example):**

- Air temperature, current temperature
- Air humidity, current air humidity
- Mean wind speed
- Wind direction
- Amount of precipitation
- Type of precipitation (rain, snow)

- Air pressure
- Dew point

**Table 4: Local weather at the switch**

| Local weather at the switch | Comment |
|---|---|
| What should be transferred? | local weather in the direct vicinity of the switch |
| What should be measured? | Air temperature and humidity |
| How often should it be measured? | Every 60 seconds |
| Which components? | Weather station with sensors for air temperature and humidity |
| What is transferred to the Rail2X unit? | Current air temperature, current air humidity, daily minimum and daily maximum for air temperature and air humidity of the last 30 days |

**Figure 5: Example for a weather station: measuring system, here with additional noise component, the weather station at the top**

# 5.5 Monitoring of the heating point

The point heating is used to keep the point free of snow and ice in very cold and frosty weather. The function of the point heating is very important, especially in high-altitude, where there are poorly accessible sections of the track. The temperature of the rails in the area of the point heating is an indicator of proper function. Here there is the possibility of directly accessing the temperature value of the heated and the unheated rail and transmitting it to the train via Rail2X. The correct function of the point heating can be monitored by comparing the unheated and heated rails. To do this, setpoints should be specified. When classifying the rail temperatures, it makes sense to link them to the measurement data from the weather station (see clause 5.4).

For the application scenario, the points are equipped with several temperature sensors in the area of the point heating and the unheated rails as well as for the ground and sleeper. The elements are connected to the Rail2X unit. Passing trains record the data for onward transport.

**Metadata (available in every telegram):**

- Ident: one-digit number e.g. 1
- Time stamp: time of generation of the data packet e.g. 29/09/20 12:45: 34.123
- Location data of the switch via CAM message from the track RSU

**Measurement data (the list is exemplary):**

- Rail temperature heated rail, left and right
- Rail temperature unheated rail, left and right
- Ground temperature at a depth of 20 cm
- Temperature threshold

**Table 5: Monitoring of the point heating**

| Monitoring of the point heating | Comment |
|---|---|
| What should be transferred? | Temperature values in connection with the point heating |
| What should be measured? | Rail temperature heated rail, rail temperature unheated rail, temperature of the ground at a depth of 20 cm, temperature threshold |
| How often should it be measured? | Every 2 seconds |
| Which components? | Use of up to seven temperature sensors (type PT100) |
| What is transferred to the Rail2X unit? | 2x current track temperature heated left and right, 2x current track temperature unheated left and right, 2x temperature ground, 1x temperature threshold |

# 6 Derivation of system requirements

## 6.1 General

Forms of representation based on the Unified Modeling Language (UML) are particularly suitable for specifying the use case service and diagnosis. In the present document the Rail2X function for use case service and diagnosis is described with the aid of a representation of the system flow.

The functional and non-functional requirements are derived based on the presentation of the system flow as well as other specifications and necessary fall-back levels, described in the clauses below.

A distinction is made between potential requirements that should be fulfilled from the very beginning and potential non-functional requirements that should be fulfilled later on (see clause 6.3).

## 6.2 System process

To illustrate the system sequence, a representation showing the chronological sequence of the transmission path is shown in Figure 6.

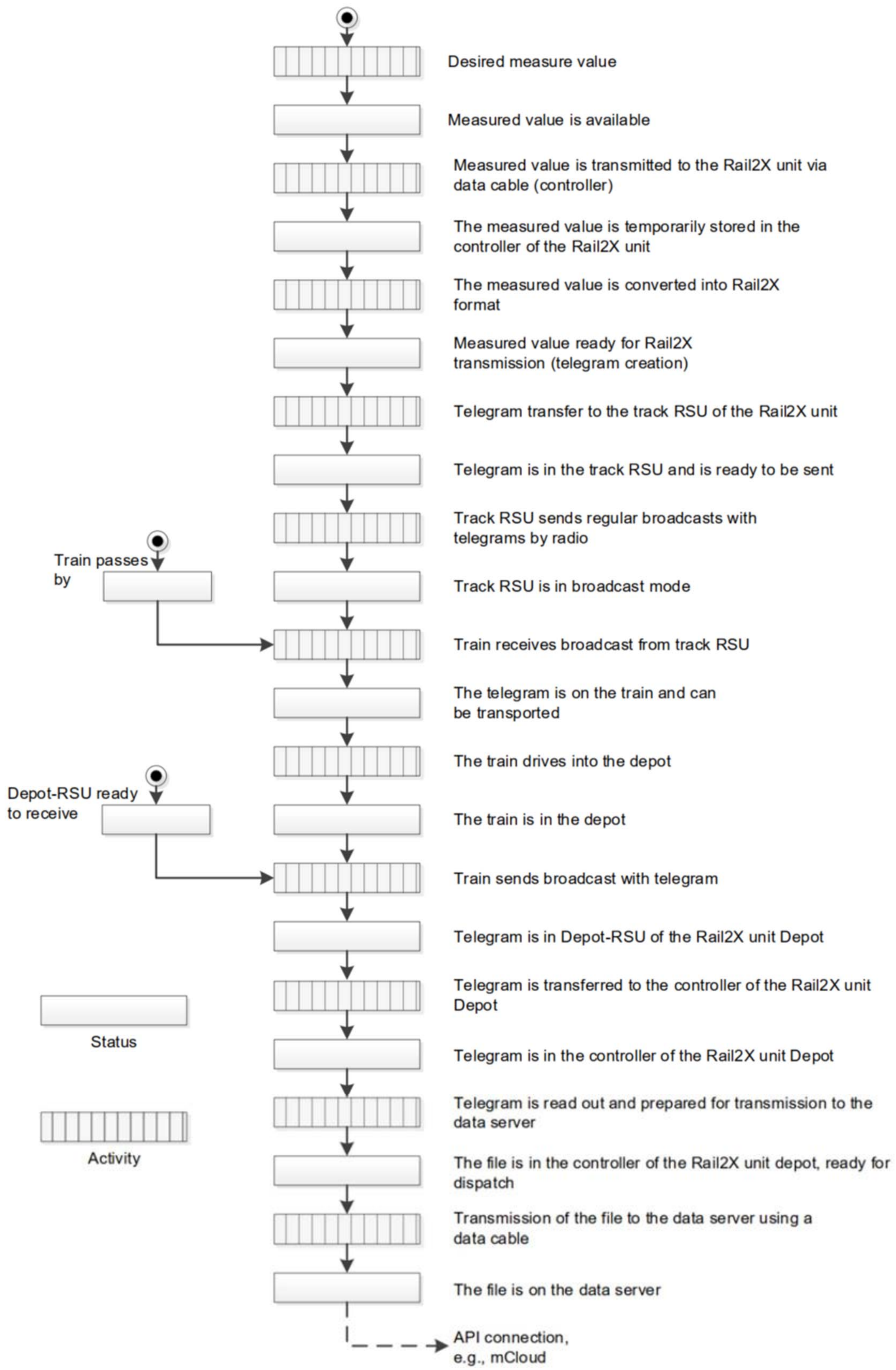


**Figure 6: System flow of use case service and diagnosis**

## 6.3 Demands on the demonstrator

Potential functional and non-functional requirements that the Rail2X system should fulfil for service and diagnosis are shown in Table 6 and Table 7. It is not guaranteed that the table is complete or that the shown potential requirements are sufficient to fully describe the system. It may be necessary to introduce changes with time. The individual potential requirements are identified with an ID (R.x where x is the requirement number) incremented continuously.

**Table 6: Potential functional requirements for the demonstrator**

| ID | Requirement |
|---|---|
| R.1 | The measurement data size should not exceed 200 kB, as the Rail2X telegram only allows a limited file size. |
| R.2 | All measuring systems should support the error disclosure and signal implausible measured values in the Rail2X protocol. |
| R.3 | All stationary systems are located by means of a CAM message using a clear GNSS position. |
| R.4 | In the demo system, the LTE connection of the measuring systems should be provided in order to perform remote monitoring. This serves to successfully provide measurement data for transmission with Rail2X. Remote monitoring also allows individual circuits or measuring systems to be switched on and off. There could be a possibility to restart the (measurement) equipment wirelessly. |
| R.5 | The measurement data should be transferred to the track RSU in a standardized format. |
| R.6 | The measuring devices should be able to transfer the measured data to the Rail2X unit on the track. The controller of the Rail2X unit should be able to work with various input data. The measurement data are converted into a uniform format in the controller of the Rail2X unit and prepared for transport by data telegram. |
| R.7 | The measurement data should be in a telegram type that can be sent directly as a Rail2X broadcast. New measurement data lead to an update of the telegram content. The oldest measurement data is overwritten. The limiting factor for the number of measured values is the size of the useful content of the telegram. |
| R.8 | The Rail2X unit on the line should be able to temporarily store several telegrams and send them out one after the other. |
| R.9 | Alarm message: if threshold values are exceeded in the measured values, the measured data are provided with an alarm message; the alarm values are set and monitored in the measuring equipment; If the telegram was then transmitted to the train via Rail2X, the OBU in the train tries to transmit the message with high priority over the cellular network as soon as the cellular network is available; Less priority measurement data without an alarm label remain on the rail vehicle and are only later transferred to the data server via Rail2X in the depot. |
| R.10 | The following transmission method is to be implemented: the CAM message of the track RSU is sent regularly; the line RSU waits for the CAM message from the approaching train and then sends a current data telegram; the telegram is sent until the train's CAM message is no longer received for five seconds. |
| R.11 | All trains that run on the equipped track should be equipped with Rail2X OBU. |
| R.12 | All trains traveling on the equipped track should send standardized position messages. Each RSU and each OBU regularly sends a CAM message with its location data to the environment. |
| R.13 | Every train that is equipped with Rail2X should be able to receive and transport the messages from the track RSU. |
| R.14 | The OBU on the rail vehicle should be able to receive and save several messages and send several messages one after the other upon arrival at the depot. |
| R.15 | The Rail2X unit in the depot should be able to temporarily store several messages and send them out one after the other. |
| R.16 | The telegrams should arrive at the data server completely and correctly. |
| R.17 | If there are no status messages from a system component, the system should be displayed as faulty. |

**Table 7: Non-functional requirements for the demonstrator**

| ID | Requirement |
|---|---|
| R.18 | The V2X standards should be used for information transmission via air interfaces and the changes could also be possible according to the objectives. |
| R.19 | A uniform telegram format should be defined for the transmission of the measurement data. The V2X message type should not be changed. |
| R.20 | V2X messages should be used to transfer the measurement data. |
| R.21 | No multimedia data can be sent. For this reason, the data to be sent can only be alphanumeric data. |
| R.22 | The data telegrams should be protected against manipulation. |
| R.23 | If possible, standardized procedures should be used for the transfer of information within the system. |
| R.24 | The system should be able to save the essential messages sent and received in the form of log files. |
| R.25 | The system should be designed in such a way that it can be retrofitted for other use cases (e.g. integration of additional measuring devices). |
| R.26 | The system should be scalable, e.g. when monitoring several infrastructure elements. A Rail2X unit on the line should be able to process data from several infrastructure elements, for example. |
| R.27 | The infrastructure element from which data is received does not necessarily have to be mounted directly on the track but it can also be up to ten meters away from the track. The distance between the track RSU and the vehicle OBU can therefore be up to ten meters. |
| R.28 | The system should recognize system faults independently and immediately. |
| R.29 | The system should not go into the fault status more than once a month for a maximum of ten minutes. |
| R.30 | If available, system components that have proven themselves in use in the railway or automotive sector should be used. |
| R.31 | The system components on the infrastructure side should be suitable for use outdoors (e.g. air temperature -33 °C +40 °C; relative humidity 15 % - 100 %; precipitation; direct sunlight). Influences of vibrations and shocks as well as the aspect of electromagnetic compatibility should be taken into account for the system components on the rail vehicle. |
| R.32 | The system should not use other systems, such as, signal systems in the vehicle or along the railway line affect. The electromagnetic compatibility should be ensured. |
| R.33 | In the context of this use case, no security-relevant data may be transmitted, e.g. information from control and safety technology. |
| R.34 | The use of the system should not pose any dangers to passengers, staff, technology, operations or the environment. The system should be non-reactive. |
| R.35 | If no external power supply is available via mains voltage, an independent power supply should be available for the system components. |
| R.36 | All electrical systems should have an uninterruptible power supply. |
| R.37 | The power supply for the system components in the depot is to be provided via mains voltage. |
| R.38 | The trackside systems should have surge and lightning protection. |

# History

| Document history | | |
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| V1.1.1 | May 2021 | Publication |
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