Rail2X: Demonstration of Vehicle2X Technologies for Rail-Related Applications

Michael Meyer zu Hörste(✉), Andreas Kluge, and Tobias Frankiewicz

DLR, Institute of Transportation Systems,
Lilienthalplatz 7, 38108 Braunschweig, Germany
{Michael.MeyerzuHoerste,Andreas.Kluge,Tobias.Frankiewicz}@dlr.de
http://www.dlr.de/ts

Abstract. Transportation vehicles are more and more communicating with their system environment. In the Road Transport Domain the Vehicle2Vehicle communication standard is developed and components are commercially available. Those technologies are suitable to be used for road-rail interactive uses cases (e.g. level crossings) as well as for pure railway use cases (e.g. information at platforms). To show this potential a demonstration has been done at a level crossing in the area of the dock railway in Braunschweig, Germany. This contribution presents the approach, the demonstration and some results.

Keywords: Vehicle2X · Car2X · Rail2X · IEEE 801.11p · Level crossing

1 Introduction

The communication standard IEEE 802.11p has been set together with a specific purely software-defined protocol for the information exchange between road vehicles [1,2]. Hence it is called Vehicle2Vehicle (V2V) or sometimes Car2Car (C2C) communication standard. Nevertheless it can be used to communicate to the infrastructure as well and is than called Vehicle2X (V2X) communication or Car2X (C2X), respectively. Broader use in the automotive environment will lead to a high market penetration and availability as well as extremely low cost for the technology.

For the rail transport a broader distribution of information and a more intensive exchange with other traffic participants as well as with rail users is an increasing demand. One possible idea to solve this demand could be to use common-off-the-shelf technologies as even Vehicle2X. The V2X communication is fitted with an adopted software protocol for railway purposes while leaving the hardware unmodified. This can be used to distribute additional information inside the railway system as well as to other interested users. Nevertheless the automation and protection systems of the railways need to ensure the safety and performance of the operation. Hence they will stay unchanged and the Rail2X systems will either give additional information without safety requirements or act as an overlay.

J. Mendizabal et al. (Eds.): Nets4Cars/Nets4Trains/Nets4Aircraft 2016, LNCS 9669, pp. 10–14, 2016.
DOI: 10.1007/978-3-319-38921-9_2

2 Application Use Cases

The Rail2X technology opens many possibilities in the rail domain. The different application use cases can be classified by many characteristics as e.g. safety-relevance, internal or external, train control, maintenance or informative. Some examples are given in Table 1.

Table 1. Example use cases

Nr.	Use case	Type	Safety relevance
1	Level Crossing Information Broadcast	Broadcast	no
2	Passenger platform stop demand	unidirectional	no
3	Actual arrival time information	unidirectional	no
4	Level Crossing Activation	bidirectional	yes
5	Maintenance status and data information transport	unidirectional	no

Many use cases are possible, which are different with respect to their communication type as e.g. broadcast, uni- or bidirectional peer-to-peer communication. Safety relevance is another important aspect of the use cases. This aspects need to be analyzed in each individual use case. For the demonstration only one should be discussed here in further detail: Broadcasting traffic information at a level crossing.

2.1 Traffic Information Broadcast at Level Crossing

The selected one for the demonstration is the distribution of dynamic information at a level crossing (LX). The train sends an activation message to the road-side unit (RSU) located at the LX. The LX broadcasts the closing information to the road users. For the first demonstration it is easier to implement use cases without safety relevance. Hence the selected use case demonstrates an information overlay system to inform road users about the status of the LX and - if closed - about the expected remaining closing time. It is not foreseen to replace the regular LX activation system.

2.2 Idea

The global idea is shown in Fig. 1. On the railway track, the rail vehicle - in this case the DLR-operated Road-Rail vehicle RailDriVE® approaches the level crossing coming from the upper side [3]. At the same time, the road vehicle approaches from the right side. Whenever a rail vehicle passes the make contact, the light signals at the railway crossing are activated, indicating road vehicles to leave the crossing. According to German regulations, the rail vehicle would have the right of way and would be prioritized to road vehicles. The lights signals on the road indicate road vehicles to leave the crossing, or to stop in front of the crossing, respectively.

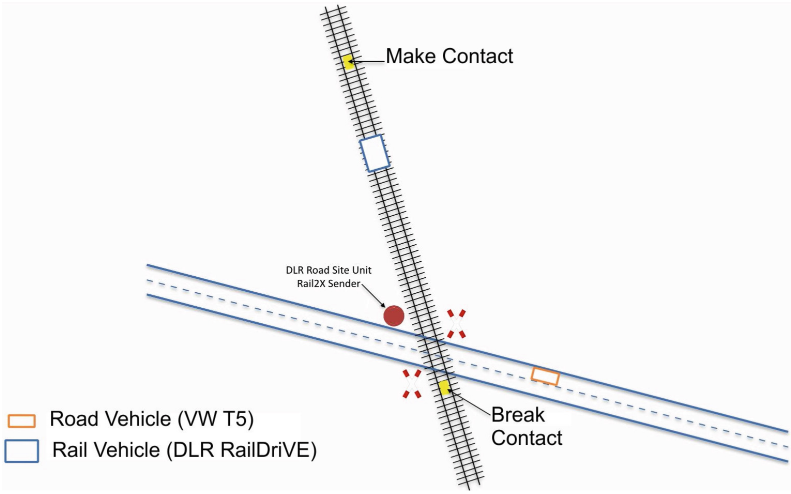

Fig. 1. Demo topology layout

At the same position the V2X Unit of the train identifies by geo-fencing that the LX has to be activated and sends via Rail2X the activation message to the RSU located at the level crossing.

For the road side of the demo scenario the RSU uses the regular V2V standard. After receiving the activation trigger the RSU broadcasts the information to the road users. It will now start to send "signal, phase and timing messages" (SPAT messages), which has been modified to reflect the operational rules for LX.

The demonstration shows both communication domains: The V2X communication between RSU and car as well as the railway part between RSU and train. So it can be seen that the hardware and radio layer are interoperable while the communication protocol software is specific for each domain.

2.3 Implementation

The demonstration was presented at a level crossing of the port railway of Braunschweig, Germany. The minimalistic demo implementation consisted out of the following three elements:

- **Train:** The Road-Rail-Vehicle RailDriVE® of the DLR was equipped with an OBU and a experimental user interface. It was equipped in addition with a high precision digital map of the railway track and a suitable localization unit [4]. They were used for the geo-fencing-based triggering of the RSU. The OBU is fulfilling the current standard and was modified for the demo purpose. A further automotive PC was used for the application itself.
- **Car:** A Volkswagen T5 van was equipped with an OBU and an experimental user interface. The OBU is fulfilling the standard.

- **Infrastructure:** The level crossing at the local road was equipped with the RSU to communicate with the train as well as with road vehicles. The RSU was equipped with a digital map representing the road and rail topography. A RSU according to the current standard was used.

Bounding conditions for the demo were defined as e.g.:

- No modification or interaction with the regular LX.
- Only experimental displays were used without integration in the vehicles.
- Only the regular scenario was demonstrated. No failure scenarios were examined.
- Standard hardware was used as far as possible.

2.4 Demonstration

The demonstration was done at the end of 2015. The Fig. 2 show the perspective of the road and rail vehicles in almost the same moment.

Fig. 2. User Interface in the train (left) and car (right) at Demo Situation with LX activated.

The demonstration was executed successfully and showed that the Vehicle2X technologies can be used for Rail2X applications as well. The user interfaces used in the demo are not designed as usable products, but as demonstrator units to show the data exchange and the current system states. The user interfaces can be seen in Fig. 3.

2.5 Main Findings

The Demonstration showed the functional feasibility as well as the suitability of the communication properties. Further detailed tests have to be done to check the robustness and other requirements of the Rail2X technology.

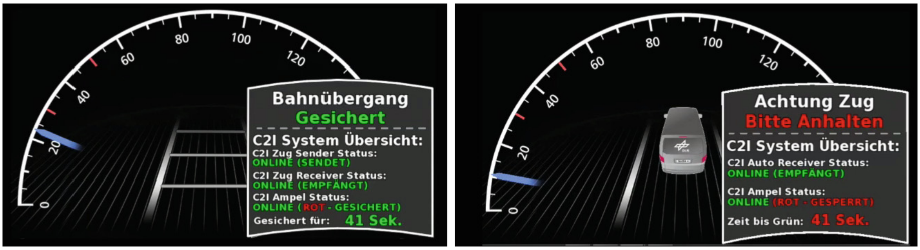

Fig. 3. User Interface design in the train (left) and the car (right) at Demo Situation with LX activated

3 Conclusion and Perspective

A simple and easy-to-demonstrate application showing an overlay system for LX using Rail2X communication technology has been developed and demonstrated in a "real life" scenario on a public road and a private railroad segment. Because of the passive system design, safety at level crossings can be improved by warning the road drivers without the need of modifications to the rail systems at the level crossing. In future work, a nonreactive way of interaction with the level crossing systems will be designed and implemented, and dedicated messages for interaction between railway and road vehicles shall be specified.

References

1. IEEE: IEEE 802.11p wireless access in vehicular environments (WAVE) (2013)
2. ETSI: ETSI EN 302 663. Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band. ETSI (2013)
3. Lüddecke, K., Kluge, A.: Mobiles Labor RailDriVE - Synchrone Erfassung von Sensordaten. Der Eisenbahningenieur EI **65**, 46–49 (2014). (in German)
4. Gerlach, K., Meyer zu Hörste, M.: Precision and availability evaluation for road and rail localisation platforms. In: NAVAGE 2008, Prague (2008)

http://www.springer.com/978-3-319-38920-2

Communication Technologies for Vehicles
10th International Workshop,
Nets4Cars/Nets4Trains/Nets4Aircraft 2016, San
Sebastián, Spain, June 6-7, 2016, Proceedings
Mendizabal, J.; Berbineau, M.; Vinel, A.; Pfletschinger, S.;
Bonneville, H.; Pirovano, A.; Plass, S.; Scopigno, R.;
Aniss, H. (Eds.)
2016, XII, 187 p. 92 illus., Softcover
ISBN: 978-3-319-38920-2