Journal of large-scale research facilities

Journal of large-scale research facilities, 3, A116 (2017) http://dx.doi.org/10.17815/jlsrf-3-148

Published: 10.08.2017

UTRaLab – Urban Traffic Research Laboratory

Deutsches Zentrum für Luft- und Raumfahrt e.V.,
Institute of Transportation Systems *

Instrument Scientists:
- Karsten Kozempel, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR); Institute of Transportation Systems, Berlin, Germany, phone +49 30 67055 466, email: karsten.kozempel@dlr.de
- Andreas Luber, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR); Institute of Transportation Systems, Berlin, Germany, phone +49 30 67055 317, email: andreas.luber@dlr.de
- Marek Junghans, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR); Institute of Transportation Systems, Berlin, Germany, phone: +49 30 67055 214, email: marek.junghans@dlr.de

Abstract: The Urban Traffic Research Laboratory (UTRaLab) is a research and test track for traffic detection methods and sensors. It is located at the Ernst-Ruska-Ufer, in the southeast of the city of Berlin (Germany). The UTRaLab covers 1 km of a highly-frequented urban road and is connected to a motorway. It is equipped with two gantries with distance of 850 m in between and has several outstations for data collection. The gantries contain many different traffic sensors like inductive loops, cameras, lasers or wireless sensors for traffic data acquisition. Additionally a weather station records environmental data. The UTRaLab's main purposes are the data collection of traffic data on the one hand and testing newly developed sensors on the other hand.

1 Motivation

Precise and reliable traffic data are the basis for a realistic traffic simulation and prediction and for a powerful traffic control. To develop and validate methods and sensors under authentic conditions, the German Aerospace Center installed a research and test track of approximately 1 km length. Each day about 30,000 vehicles use this track between the district Adlershof and the motorway BAB 113 providing valuable information about traffic and the environmental conditions.
The UTRaLab is used for the following purposes

* **Cite article as:** DLR Institute of Transportation Systems. (2017). UTRaLab – Urban Traffic Research Laboratory. *Journal of large-scale research facilities, 3*, A116. http://dx.doi.org/10.17815/jlsrf-3-148

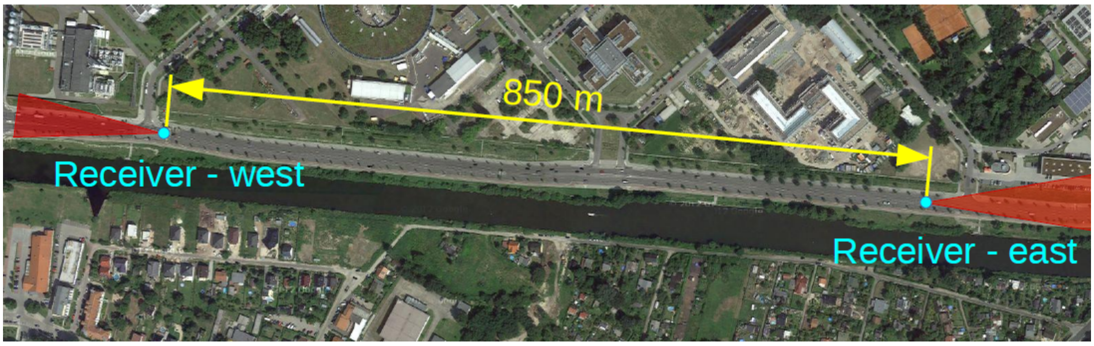

Figure 1: UTRaLab and its two gantries.

- **Traffic and situation detection**
  Different local sensors, e.g. inductions loop detectors, spatial sensors, e.g. digital camera systems and laser scanners, and wireless communications systems, e.g. Bluetooth, WiFi and Tire Pressure Monitoring Systems (TPMS), are installed for traffic and situation detection. Novel methods for traffic participant detection, classification and tracking are developed and tested. Trajectories of the tracked traffic participants are processed to obtain accurate and reliable information about the ongoing situation, e.g. collision prediction due to the interaction of traffic participants, critical traffic state estimation, etc., which enable conventional traffic performance and novel traffic safety analyses. Journey times, origin-destination and turning relations are quantified and analyzed with regard to improved traffic management.
- **Traffic model calibration and evaluation**
  The detected traffic and environmental data are permanently stored in databases, visualized as diagrams, time charts, level-of-service charts and tables. These data are used to calibrate and evaluate microscopic traffic models.
- **Sensor tests and validation**
  The combination of different sensors for traffic and traffic situation detection and environmental situation enables an efficient validation of quality and reliability of the installed sensors. Due to the accessible gantries novel overhead sensors can be easily tested and cross-validated over long testing periods, e.g. 24-hour, 7 days a week. Maintenance work can be realized without negatively affecting road traffic.
- **Carrier platform for environmental sensors, Vehicle-to-Infrastructure components, etc.**
  The gantries of the UTRaLab are perfect for mounting and testing environmental sensors, e.g. emissions monitoring, and for other purposes, e.g. Vehicle-to-Infrastructure communication.

2 Technical Description

The UTRaLab is based on the German TLS standard “Technical supply conditions for roadway stations” (Technische Lieferbedingungen für Streckenstationen), which is a guideline for the construction and operation of traffic and transportation management systems. The TLS structure of the UTRaLab is shown in Figure 1, which is briefly described in Table 1.

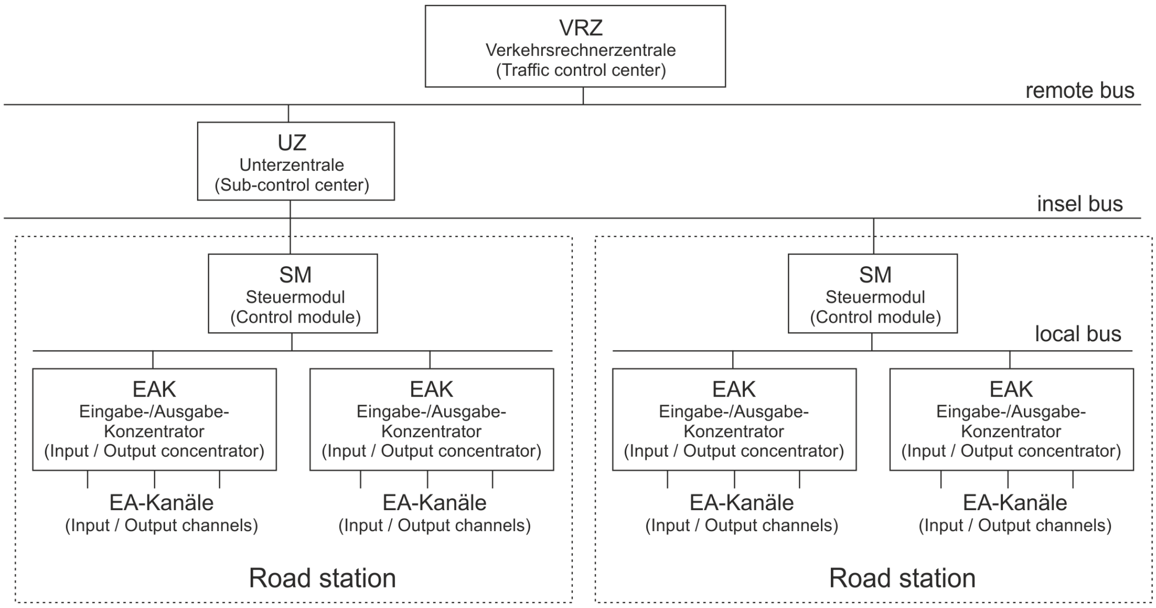

Figure 2: General TLS structure.

Level	Component	Main function
1	**VRZ** Traffic control Center	- Central control room of the motorway network of a German federal state - The UTRaLab does not have a VRZ
2	**UZ** Sub-control Center with database access	- Storage, evaluation and visualization of the measured traffic and environmental data
3	**SM** Control module and transmission system of the local road stations	- Control of the data exchange between UZ und EAK - Control of the query and transmission procedures for the EAK on the local bus
4	**EAKs** Input and output concentrators	- Detection and aggregation of traffic and environmental data of the installed sensors - Functional monitoring and status messaging

Table 1: Description of the UTRaLab components

2.1 Inductive Loops

The track is equipped with 45 conventional inductive loop detectors, which can count and classify cars as well as measure velocities according to TLS standard. They are double inductive loops, a fact that allows them to determine both, the vehicles' speed and length. Analyzing the signal shape of the vehicle its class can be identified too (8+1).
The loops' data is collected and analyzed in one of the outstations next to the test track. The processed traffic data (count, class, velocities) are transferred to servers inside the institute and stored in a database.

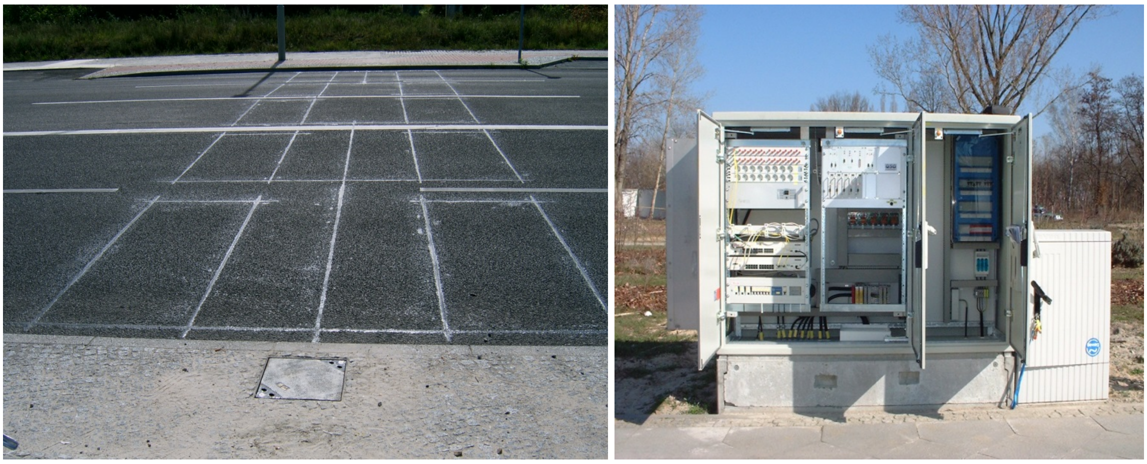

Figure 3: Inductive loops (left) and outstation (right).

2.2 Optical Sensors

Different kinds of traffic detection cameras are installed on both gantries. The video data are transmitted to computer vision servers where they are stored and processed. Different computer vision algorithms are applied to the video images in order to detect, classify, re-identify and track traffic objects.

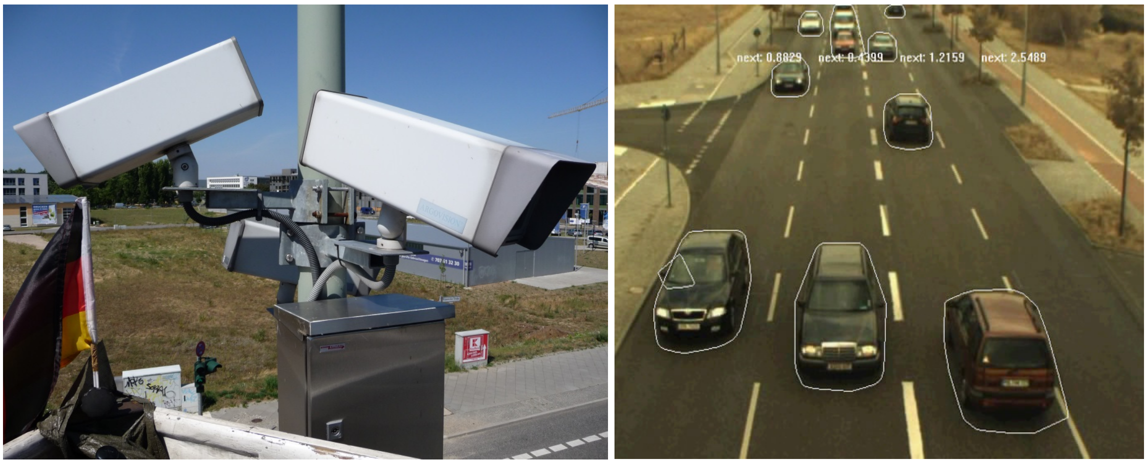

Figure 4: Traffic cameras and video images.

The most important output data of this sensor system are trajectories describing the spatio-temporal motion of traffic objects, which can be used for many applications. Trajectories contain information about vehicles' and pedestrians' count, direction, velocity and even interactions between two or more objects. Thus, not only classical traffic data like traffic amount and flow can be obtained but also statistics about the exact ways taken along the road (e.g. lane changes or turning).
Furthermore interactions between vehicles and/or pedestrians can be detected and even predicted. These mechanisms allow the user to identify critical situations according to certain safety measures (e.g. time to collision TTC or post encroachment time PET).

2.3 Laser Scanners (3D profilers)

One of the gantries is equipped with two 3D profiling laser scanners which cover both directions with all four lanes. Their direct output data are 3D point clouds representing the vehicle's shape. Post-processed data can provide vehicle counts, classes and velocities.

Figure 5: Profiling laser scanners.

2.4 Wireless Communication Detection (Bluetooth, Wi-Fi, TPMS)

Next to the typical traffic detectors we use specially developed sensors to automatically detect wireless communication devices. For Bluetooth, Wi-Fi and even Tire Pressure Monitoring systems (TPMS) there are detectors which are sniffing the related frequency range for typical signatures in order to identify messages from related devices. Their address/serial number is encrypted and stored in a central database to re-identify them approaching at other detectors. The output data is useful to obtain relative vehicle traffic amounts at single nodes as well as travel times between them.

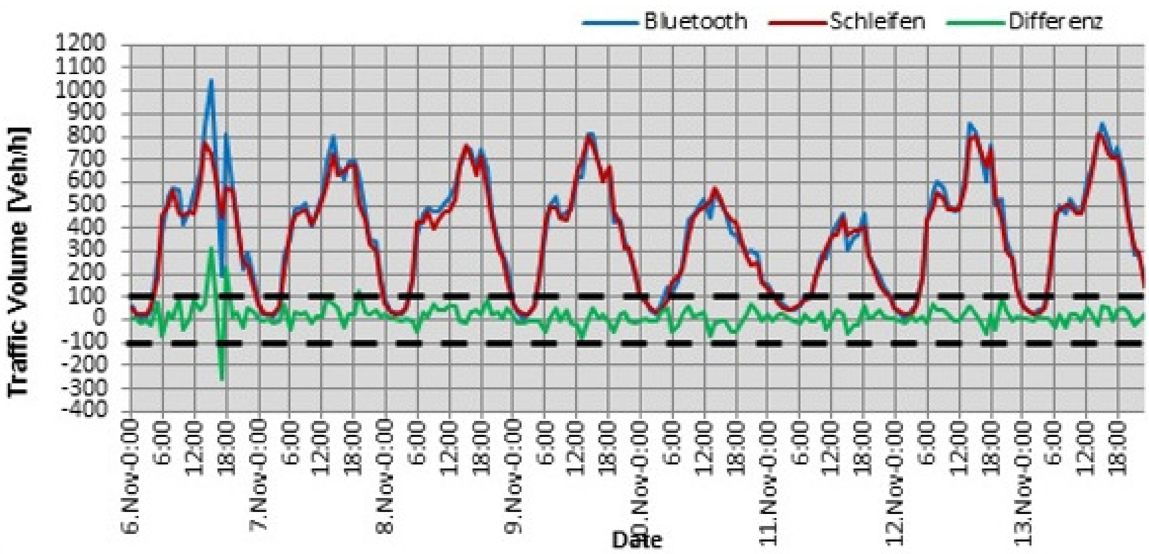

Figure 6: Bluetooth detections compared to loop data.

2.5 Weather Station

Furthermore, a weather station is recording and storing almost any kind of environmental or weather data. These data are e.g. air/ground temperature, wind speed/direction, humidity, atmospheric pressure, insolation, light intensity or precipitation.

Figure 7: Weather station.

3 Project Application Examples

The UTRaLab serves as a measuring instrument for answering traffic related research questions with regard to traffic behavior, performance and safety analyses, detection of critical situations e.g. accidents and near-misses (Kozempel et al., 2014; Saul et al., 2014)).
Furthermore, the development and test of wireless communication technologies for journey time measurements (like Wi-Fi, TPMS and Bluetooth sniffers) can be and has been be performed at the UTRaLab ((Saul et al., 2014; Savić et al., 2014)).
Moreover, the UTRaLab was used as carrier and test platform to compare industrial and particularly developed optical traffic sensors in long term measurements (Reulke et al., 2008).

References

Kozempel, K., Saul, H., Haberjahn, M., & Kaschwich, C. (2014). A Comparison of Trajectories and Vehicle Dynamics Acquired by High Precision GPS and Contemporary Methods of Digital Image Processing. In *20th international conference on urban transport and the environment* (Vol. 138, pp. 381–391). Retrieved from http://elib.dlr.de/89391/

Reulke, R., Meffert, B., piltz, B., Bauer, S., Hein, D., Hohloch, M., & Kozempel, K. (2008). Long-term investigations of quality and reliability of the video image detection system m3. In *International Workshop on Traffic data Collection & its Standardization. IWTDCS 2008.* Retrieved from http://elib.dlr.de/56584/

Saul, H., Kozempel, K., & Haberjahn, M. (2014). A comparison of methods for detecting atypical trajectories. In *20th International Conference on Urban Transport and the Environment* (Vol. 138, pp. 393–403). Retrieved from http://elib.dlr.de/89352/

Savić, N., Junghans, M., & Krstić, M. (2014). Traffic Data Collection Using Tire Pressure Monitoring System. In *Telematics - Support for Transport: 14th International Conference on Transport Systems Telematics* (pp. 19–28).