

Railway Positioning in Tunnels: Regionalverkehr Bern–Solothurn Case Study

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This case study describes tunnel tests conducted by Regionalverkehr Bern–Solothurn and highlights the results achieved using GNSS and dead reckoning for railway positioning.

Regionalverkehr Bern – Solothurn (RBS) or Bern – Solothurn Regional Transport Services and u-blox, a high-tech company from Thalwil, which specialises in positioning and wireless communications, have jointly tested an enhanced GPS receiver. It has a distinct feature. It can not only determine a position in the open air like most of these kinds of devices, but also in areas that are partly or completely covered. Particularly in tunnels that are entirely cut off from the outside world. The new kind of receiver has been installed and tested on an RBS train for the first time. The tests provided very promising results.

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The challenge of GPS tracking in tunnels

Traditional GPS receivers depend on signals from satellites that are directly visible. When vehicles enter a tunnel or other covered areas, however, they lose the satellite signals relatively quickly and can no longer determine the position of the vehicle.

The new technology from u-blox resolves this problem by combining various sensors and processes. The new, enhanced receiver has accelerometer and gyroscope sensors for each space dimension. If the satellite signals are lost, the sensors automatically continue to calculate the current position using the changes of direction and movement (acceleration or delay).

To further enhance the accuracy, signals made available by the train to measure distance (wheel ticks) and the direction of travel (forwards/backwards) are also taken into consideration. This technology is known as “dead reckoning” (DR). The process using wheel ticks and direction of travel is referred to as “automotive dead reckoning” (ADR).



1: The tests were conducted on this RBS regional train.



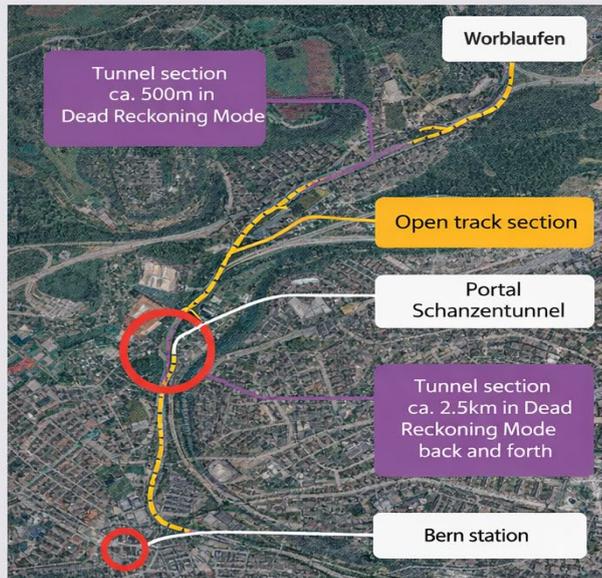
2: GPS receiver using wheel-tick and drive-direction signals

Test results on the Bern – Worblaufen line

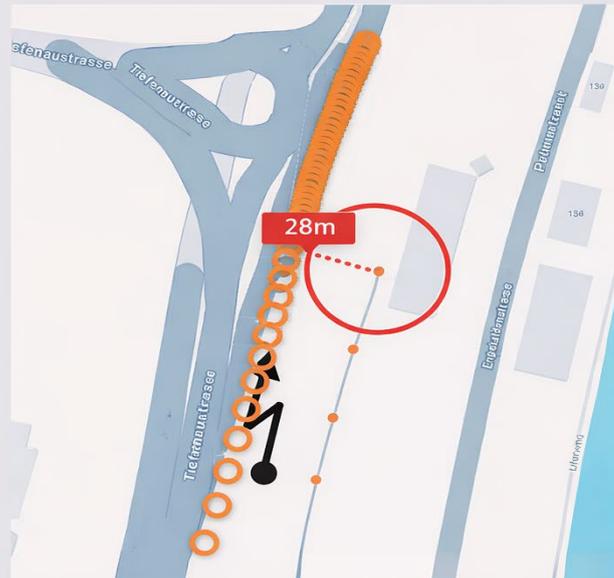
The new technology proved successful in the first series of tests during the journey from Worblaufen to Bern and back, a route that has many tunnels. After automatic calibration within a few hundred metres, the receiver was able to maintain a continuous position signal.

While travelling through the Schanzen Tunnel (approx. 1.3 km long) and back, the divergence was less than 30 metres after more than 2.5 kilometres of travel using DR without GPS signals.

- GNSS modules for meter- to centimeter-level accuracy
- Dead reckoning uses motion sensors to bridge signal gaps
- Sensor fusion and map matching to stay on track, always



3: Test track between Bern and Worblaufen with tunnel sections



4: Signal deviations at entrance (circles) and exit (points)

Potential applications for railway operation

The technology could be very interesting for the railways. It opens up new fields of applications such as vehicle detection and scheduling within the entire network.

A problem emerges very often when the detection is lost in enclosed railway depots, for example. Now, using the GPS receiver, it is possible to continually track and optimize all vehicles within the entire area with much greater accuracy, including automatic train operations.

Today's interlocking technology is often based on discrete track vacancy detection sections (up to 2 km long). A GPS-based system enables more precise vehicle tracking, particularly in tunnels, for non-safety-critical applications.

Experience gained and prospects

Based on the successful RBS tests, a new version of the u-blox [ZED-F9R module](#) has been launched. It supports and is specially optimised for railway applications.

The collaboration between RBS and u-blox has significantly contributed to the development of this product. It demonstrates how innovative solutions can be found with relatively low investment, adding value to the railway market.