Innovative Measuring System Unveiled

The POS/TG system, developed by Applanix in partnership with Plasser, implements innovative solutions to track geometry measurement that should overcome the deficiencies of traditional methods of measuring track geometry.


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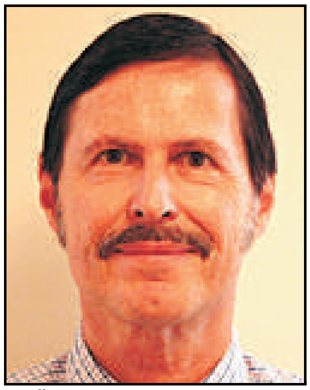
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ACCURATE measurement of track geometry is critical in the assessment of railway safety. Major railways and infrastructure owners measure track geometry systematically to monitor track deterioration and identify defects. This data allows them to estimate the rate of track deterioration, optimise track maintenance schedules, and establish maximum line speed limits.

Determining track geometry involves measuring an individual rail's geometric properties, as well as the relative displacement of one rail with respect to the other. To quantify the rail geometry, the rails are modelled as lines in three-dimensional space, and these lines are then projected onto two-dimensional planes. Once track geometry is measured, each measurement's geographic location must be identified.

A variety of railcar-based geometry measurement systems has been developed over the past century, and many of these designs are still in operation today. The most common use mechanical sensors with movable feeler points that are in constant contact with the rails. The sensors' movement is an indication of the track geometry. For example, the outputs of three horizontal feelers, mounted on three telescopic axles continuously touching the rails, can be used to measure rail alignment.

Although these systems represent a significant improvement over manual on-ground geometry measurement, geometry systems that use contacting sensors cannot be used on high-speed track, as the sensors will not maintain constant contact with the rails.

Many newer systems use non-contact optical laser sensors in conjunction with accelerometers and a vertical gyroscope to derive the desired track geometry measurements. This approach overcomes the speed restrictions of mechanical sensors. However, the use of accelerometers and a vertical gyro creates its own problems.

When the accelerometer output is double-integrated to compute the railcar's displacement, the inherent accelerometer bias error produces a displacement error that grows quadratically with time. This renders the accelerometer-derived displacement unusable for track geometry measurement at slow car speeds. In addition, vertical gyros are known to produce false orientation readings when subjected to centripetal force, which may result in inaccurate measurement of superelevation during curves.

The UFM-120 track geometry car owned and operated by Eurailscout.

Track Geometry Features

The location of measured track geometry features has traditionally been determined by measuring the distance travelled from a predetermined reference (zero) point. For geometry feature measurements to be meaningful, railways need to have the location of track geometry features referenced (or synchronised) to railway landmarks such as mileposts, crossings, and switches. This is done either manually by the track geometry operator, or automatically using automatic location detectors (ALDs). Both approaches are less than ideal, since manual synchronisation is error-prone, while ALDs are costly to install and can be easily damaged or dislocated by track maintenance machines.

Given the inherent deficiencies of existing track geometry and feature localisation systems, Plasser American Corporation was interested in developing a new contact-free system.

The solution came from Applanix Cor-

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poration, a provider of Integrated Inertial/GPS navigation solutions for precision commercial applications. Applanix proposed the development of a new track geometry measurement system based on its Position and Orientation System (POS) technology. This technology blends data from a Global Positioning System (GPS) receiver and inertial sensors, giving a continuous, robust and accurate navigation solution. The proposal was to design a system that would combine the navigation data of POS with optical gauge measurements to measure track geometry accurately and identify its geographic location.

POS/TG can be used simultaneously for both track geometry measurement and railway surveying

POS/TG is compact and lightweight, and therefore easy to install and set up.

The combination of Plasser's railway expertise and Applanix's proficiency in integrated navigation resulted in a new system called POS/TG (POS for Track Geometry). As a railcar-based system, POS/TG allows for geometry measurement under normal load conditions. It is compact and lightweight, and therefore easy to install and set up. Since it is not a mechanical system, it should also be easy to maintain. All POS/TG sensors are manufacturer-calibrated; therefore, no field calibration is necessary. With its use of aerospace technology in both its sensors and data processing, POS/TG is designed to operate in a variety of environments. Because the POS technology is robust, vehicle dynamics and direction of travel will not affect POS/TG's accuracy.

POS/TG is capable of continuously computing track geometry measurements at a user-selectable interval (typically every 0.25m), within a speed range of near-zero to more than 300km/h. The lower speed threshold refers to the mean speed over a chord length (typically 10m or 20m) or space curve wavelength (typically 30m or 50m), allowing for brief stationary periods without invalidating the geometry measurements.

For example, in order to maintain accuracy when measuring geometry at slow speeds, the chord length must be travelled in under 300 seconds. Thus, for a 10m chord length, the minimum mean railcar speed is 0.03m/s or about 0.1km/h. Tests are underway to further reduce this lower speed threshold requirement.

In addition to being a track geometry measurement system, POS/TG is also a navigation system. As such, it continuously provides accurate geographic position (latitude, longitude, and altitude), velocity vector, orientation (roll, pitch and heading angles) and vehicle dynamics (acceleration and angular rate vectors).

As a result, POS/TG can be used simultaneously for both track geometry measurement and railway surveying. POS/TG's ability to provide accurate geographic location of the railcar, even during GPS signal outages, allows the implementation of a unique Location Synchronisation (LS) functionality. LS correlates geometry data to physical landmarks without any additional hardware.

POS/TG consists of the POS/TG Computer System (PCS) and four sensors: an Inertial Measurement Unit (IMU), a GPS receiver, a Distance Measurement Indicator (DMI) and an Optical Gauge Measurement System (OGMS). The modularity of the POS/TG configuration allows for simple installation on any rail vehicle.

The IMU is an integrated sensor assembly consisting of silicon linear accelerometers and fibre optic gyros. The GPS receiver processes signals from a network of 24 satellites, providing worldwide coverage and position accuracy to within a few metres. If better position accuracy is required, differential GPS (DGPS) can be used.

The DMI outputs pulses representing fractional revolutions of the wheel. The summed pulses provide a measure of the distance travelled by the vehicle. POS/TG uses the DMI data to schedule the computation of track geometry parameters and to improve the accuracy of the navigation data, particularly during GPS outages.

The OGMS is a laser range measuring system that measures the displacement of each rail from a reference point, such as the centre of the IMU. When combined with positional data, the OGMS pinpoints the location of each rail and allows for the computation of accurate alignment and horizontal space curve parameters. Like the IMU, the OGMS is usually mounted to either a single axle or a bogie.

During operation, POS/TG constantly calibrates its sensors to maintain the best possible performance. If any sensor shows degraded performance, POS/TG will isolate it and reconfigure itself to preserve data integrity.

The ability of POS/TG to continuously compute and output at high frequency the geographic position of the track geometry railcar lends itself to an elegant implementation of LS. During a measurement run, LS minimises the distance between the current location of the car and the synchronisation locations stored in a GIS database. Once the minimum is reached, LS issues a synchronisation message and signal. This process is fully automatic, and it is being successfully employed by Austrian Federal Railways (ÖBB).

POS/TG includes a number of features never before available in a track geometry measurement system, while allowing concurrent use for railway surveying and GIS generation

POS/TG includes a number of features never before available in a track geometry measurement system, while allowing concurrent use for railway surveying and GIS generation. Simple installation, configuration, and minimal maintenance requirements allow it to be incorporated into almost all conventional rail vehicles or locomotives, allowing track geometry measurements during revenue service at track speeds. **IRJ**

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