Development and Evaluation of a Geodetic Measurement System for IMU-Based High-Precision Azimuth Transfer

Lorenz Schmid, Nino Kracher and David Salido-Monzú (Switzerland)

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SUMMARY

In cases where traversing or a geodetic network do not allow sufficiently accurate azimuth transfer north-seeking gyroscopes are usually applied. However, these are very sensitive and expensive instruments, and there is a lack of independent control. Based on an idea realized several years ago by TU München and ETH Zürich for the Gotthard Base tunnel, we have developed a prototype system for high accuracy azimuth transfer based on an Inertial Measurement Unit extended with autocollimation. It differs from the previous solution (i) in terms of the IMU used, which is now a less costly and less accurate Fiber Optical Gyroscope (FOG-IMU), and (ii) in terms of a newly developed Matlab-based processing software and a numerical simulation tool for predicting the attainable accuracy with a variety of variable design parameters.

In this contribution, we present the platform, experimental results and results of numeric simulations. A KVH 1750 IMU and an autocollimation prism collocated on a rigid base form the transfer platform. The main area of application, and thus the focus of the investigations, is the transfer of azimuth along a vertical trajectory (e.g. an elevator-shaft, in our paper) but the applicability of the approach and system to approximately horizontal azimuth transfer (e.g. from above ground to below ground at the portal of a tunnel) is also evaluated and discussed.

Spectral analysis of the noise behavior of the gyroscopes and of the relevant frequency components of actual elevator movement in a multi-story office building enabled adjusting the data processing parameters within the custom processing software computing the orientation offset between two epochs where the platform is at rest. Initial alignment measurements help to estimate and compensate for gyroscope drifts. In a realistic measurement scenario in an elevator, we obtained a standard deviation of 3.5 mgon of the azimuth difference over a vertical distance of 27m. We also show evaluations of the system for other application cases using numerical simulations and the

empirically derived noise characteristics of the sensors.