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Two-Year Long Digital Zenith Camera VESTA Deflection of Vertical Measurements at the Test Site

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In 2016 design of a digital zenith camera (DZC) (named VESTA – VErtical by STArs) for deflection of vertical (DoV) component measurements was completed in the Institute of Geodesy and Geoinformatics (GGI) of the University of Latvia [1]. The DoV at a point on the Earth is a measure of how much gravity normal has been inclined by local anomalies such as terrain and geological features. Several units of VESTA have been developed and assembled in GGI, series of successful observations have been performed and applied for calculation of regional quasi-geoid parameters [2]. In 2019 one unit after international tender was sold to the Louisiana State University (USA) and is successfully working there.

Differently from other known DZCs [3, 4, 5, 6], VESTA is a highly portable instrument (12 kg, mounted on a light tripod) and can be operated by a single person. It consists of a small (16 inch) vertically oriented telescope with a CCD camera and attached computer-controlled focuser, mounted on a rotating levelable platform. All involved equipment and actuators are controlled by an on-board computer; the process of measurements is almost completely automated and requires operator intervention only for setting up. A measurement session typically includes zenith star observations in 30-90 rotation positions, usually 10 short exposure frames in each position. Star field images are complemented with high sensitivity tiltmeter data, thus providing link to both star-defined orientation in inertial coordinate system and gravity field direction. A minimal measurement session takes less than an hour and offers about 0.1 arc second DoV accuracy; longer sessions give more accurate results.

Post-processing of measurements includes analysis of star field images, automated star image identification with reference catalog data (a subset of GAIA catalog is currently used), calculation of apparent places of stars (using NOVAS vector astrometry package), calculation of projections of ellipsoidal zenith on CCD image, corrections for instrument tilt, and, finally, calculation of DoV. The whole process is automated and requires only minimal operator intervention.

More detailed analysis of optimal measurement conditions and error sources of DZC VESTA is currently performed. This study focuses on testing various parameters of DZC VESTA measurement session: session length, image binning, exposure time; monitoring changes of DoV values over 2-year time at the same site and considering influence of external conditions: average number of observed stars, temperature, humidity, pressure, wind speed, sky, microseismic.

For measurement purpose, a test site with 4 points at a 50x50 meter distance was established and DoV measurements by DZC VESTA were started there in May 2021. Moreover, measurements were continued for two years to obtain DoV time series at all 4 points of the test site, so currently regular measurements are completed.

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Primary author: Dr VARNA, Inese

Co-authors: Dr ZARINS, Ansis (University of Latvia, Institute of Geodesy and Geoinformatics); Mr RUBANS, Augusts (University of Latvia, Institute of Geodesy and Geoinformatics)

Presenter: Dr VARNA, Inese

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