BACKPACK PERSONAL LASER SCANNING SYSTEM FOR GRAIN-SCALE TOPOGRAPHIC MAPPING. Antero Kukko[1], Harri Kaartinen[1], Juha Hyyppä[1], and Michael Zanetti[2],[1]Centre of Exellence in Laser Scanning Research, Finnish Geodetic Institute (Geodeetinrinne 2, FI-02430 Masala, Finland, Antero.Kukko@fgi.fi), [1]Washington University in St Louis and the McDonnell Center for Space Science (1 Brookings Drive, St Louis, MO 63130, Michael.Zanetti@wustl.edu).

Introduction: New developments in mobile laser scanning (MLS) provide potential to acquire rapidly topographic information of river channel bedforms at the resolution of grain-scale upwards [1]. This research aims at developing an integrated methodology to quantify morphodynamic changes on rivers at reach-scale, and to explore new opportunities for applications in quantification of e.g. hydraulic parameters, morphometric analysis and sediment budgeting but also for modeling and analysis of impact craters. Further possibilities may be found in adapting the system to planetary analog missions.

The potential of a newly developed Akhka R2 backpack personal laser scanning (PLS) in acquiring point cloud data is demonstrated here by a case study at 8 km long test area located in the lower reach of Rambla de la Viuda, eastern Spain, with a hydrological regime characterized by large floods. Accuracy analysis on 41 spherical targets shows that Akhka R2 PLS system could capture surface topography at 36 mm 3D RMSE prior to project-wise field calibration. PLS provides with an efficient tool for high precision measurements of coarse fluvial sediments over large survey areas.

Laser scanning at close ranges provides high-precision and high resolution topographical data, which allows estimation of river bed topography. Terrestrial laser scanning (TLS) for fluvial morphology has been studied e.g. [2]. However, data acquisition with TLS is limited to a plot scale survey range and limits a synoptic understanding of any larger study area [1].To improve the spatial and temporal coverage, MLS systems have been put into use [3]. The limitations in mobility of vehicle-mounted systems hamper the operability of MLS. Therefore development of a backpack personal laser scanning system (PLS) has been taken place [4].

Table 1: AkhkavR2 System and data acquisition parameters

GNSS-IMU system	NovAtel Flexpak6, UIMU-LCI
Navigation data rate	200 Hz, post-processing
Scanner	FARO Focus 3D 120 S
Point measurement rate	488 kHz
Scan frequency	95 Hz
Angular resolution	1.2 mrad

Akhka R2 is an application of mobile laser scanning on a backpack platform allowing improved mobility and thus data collection in rugged terrain in environments of interest e.g. for planetary analog research. The system observes navigation satellites and senses the platform movements during data collection using its synchronized position and attitude system coupled with laser scanner for producing 3D topographic data. Table 1 lists for the main system components of Akhka R2 and data acquisition parameters used for the data cases presented in this study.

Figure 1: Akhka R2 PLS system can be operated by one person (Weight 21 kg) on rugged terrains. System utilizes multi-constellation GNSS-IMU for positioning and ultra-high-speed laser scanner for mapping.

Figure 1 shows the system layout and principle of operation. The scanner operates in cross-track profiling manner (305 degree field of view) for collecting precise 3D data of the environment at maximum practical ranges up to 120 metres. The area to be mapped is covered by walking all regions and features of interest. With the PLS complementary data with minimal shadowing can be effectively collected for geomorphological modeling and analysis.

Results: The length of the study area along the approximate center line of the river channel was 8 km. The data was acquired in June 2013 with Akhka R2 PLS system (see Fig. 1 and Table 1) in less than six (6) hours, trajectory run length being in total 22.2 km, and consist in total of 662 data blocks, 3000 profiles in each. 14 Spherical targets (∅199 mm, ATS SRS system) as pairs for 7 calibration gates and 27 sporadic spheres (∅145 mm) were erected along the reach site for accuracy assessment, target center locations were surveyed with Trimble R8 RTK-GPS equipment.

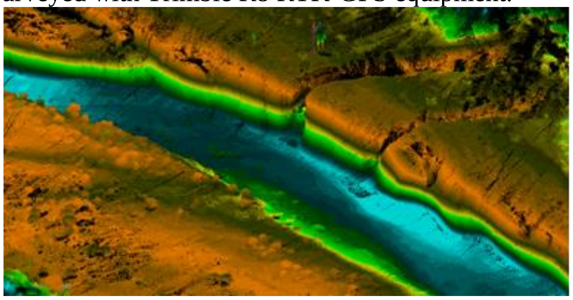

Figure 2: Riverbed topography collected with the Akhka R2. Deep erosion channels, as seen in the middle of figure, could be effectively covered with PLS data to the finest detail. An 1.8 m tall person captured in the data gives the scale (in the top-middle of figure).

The targets were detected altogether 95 times from the point cloud data, fitted with model sphere of the right size, and analyzed for the geometric accuracy of the point cloud. RMSE for the 3D position of the targets was 36 mm when compared againts the target centers measured with RTK-GPS. Fig. 2 shows the system potential in capturing detailed topographic data from a rugged terrain. One of the target gates captured with the PLS data on the site is shown in Fig. 3.

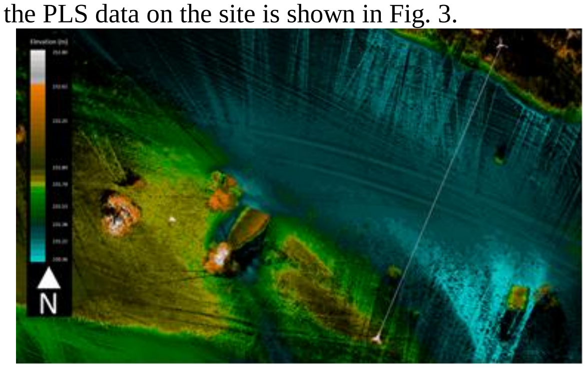

Figure 3: One of the target gates set for calibration and quality control of the PLS data. Sphere center positions were determined with RTK-GPS. The width of the gate, the white line connecting the two spheres on tripods, was 21.849 m.

Akhka R2 PLS system and data collection method could be easily adapted to planetary analog missions, as shown by an another case study conducted in Kaali crater, Saaremaa, Estonia. For more details of the current work on the crater see [Zanetti et al., this conference]. Fig. 4 shows the PLS data captured from the main crater. The blue line in the figure shows the data collection trajectory. The crater diameter measured from the top of the rim is about 100 meters. The challenge in this case for the data capture was the full-crown broad-leaved forest obscuring the satellite visibility to the positioning system.

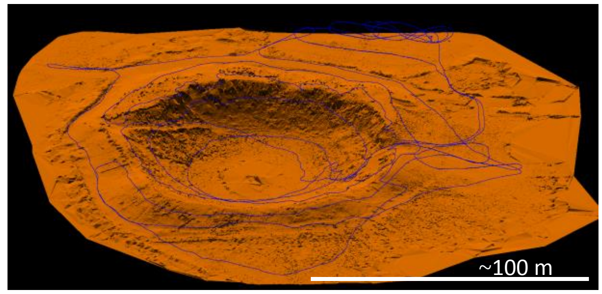

Figure 4: Triangulated digital elevation model of Kaali crater based on the AkhkaR2 PLS point cloud. The PLS trajectory is shown in blue line.

Conclusions: Mobile laser scanning on a backpack platform provides with complementary 3D topographic data for complex feature fields with minimal shadowing. PLS allows fine-scale topographic data to be effectively collected over large areas for geomorphological modeling and change analysis. In comparison to TLS, the point distribution from PLS is more even and data gaps due to object shadowing are much faster to cover with data. Direct georeferencing with GNSS-IMU positioning reduces need for redundant data required in TLS for data co-registration. Comparing to airborne laser scanning instead the point precision of PLS is superior, as well as the point of survey is more suitable in capturing features with obscured view from the top. In the wider context PLS system seems to be suitable to be adapted to planetary analog missions in terrestrial environments and provides with an efficient methodology to fill the data collection performance deficiencies found in TLS and ALS. New direction of the technology is to change the scanning operation suitable for 3D SLAM to eliminate the need for GNSS navigation.

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References:

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