EXPERIMENETAL RESULTS OF GEOMETRIC MODELING AND ACCURACY ASSESSMENT OF AN EXOMARS ROVER PANCAM PROTOTYPE. R. Li[1], D. Li[1], K. Di[1], G. Paar[2], A. Coates[3], J. P. Muller[3], A. Griffiths[3], J. Oberst[4], and D. P. Barnes[5]. [1]Mapping and GIS Laboratory, CEGE, The Ohio State University, 470 Hitchcock Hall, 2070 Neil Ave., Columbus, OH 43210-1275, USA, li.282@osu.edu; [2]Institute for Information and Communication Technologies, Joanneum Research, Graz, Austria; [3]Mullard Space Science Laboratory, Dept. of Space and Climate Physics, University College London, London, UK; [4]Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany; [5]Space Robotics Group, Dept. of Computer Science, Aberystwyth University, UK.

Introduction: The goal of this research is pre-launch quantification of uncertainty in mapping and localization of the European Space Agency (ESA) ExoMars 2018 mission PanCam (panoramic camera) vision system. This analysis is being conducted both in theoretical terms and through experimental verification based on a PanCam prototype. The ExoMars PanCam system consists of two Wide-Angle Cameras (WACs) and one High-Resolution Camera (HRC) [1]. A mathematical model has been developed for estimating the mapping and localization accuracies of this WAC stereo visioning system based on photogrammetric principles and error propagation theory [2]. To support evaluation of mapping and localization accuracy of the theoretical model, a PanCam prototype has been assembled based on current ExoMars PanCam specifications. We have completed a field experiment to study the attainable level of localization accuracy of the ExoMars PanCam across multiple traverse sites using our PanCam prototype.

Here we present results from an experiment conducted using the PanCam prototype at the Alum Creek Reservoir north of Columbus, Ohio in March, 2012. This test site has rich image features of sand, pebbles and rocks similar to the terrain encountered on Mars by the MER rovers. The entire traverse consisted of multiple traverse segments (around 35 m each). The PanCam cameras acquired panoramic images at each site from different tilt angles to image the landscape along the traverse.

Data Processing Overview: This data processing procedure is extended from that for MER 2003 rover localization [3]. The stereo image pairs were linearized to eliminate lens distortion and correct alignment between stereo images. Initial EO (exterior orientation) parameters were then estimated for each image using the pan and tilt angles when the image was acquired. From the linearized images, a number of evenly distributed landmarks were selected to link all the images into an integrated image network. Finally, an incremental bundle adjustment (BA) was used to calculate the refined EOs for the images and thus to obtain an accurate position for the rover at each imaging site. For accuracy assessment of the theoretical rover localization model, these BA-derived rover positions were compared to reference rover positions measured using GPS. Fig. 1 shows a conceptual flow chart of this rover localization accuracy analysis and its validation through field experiment.

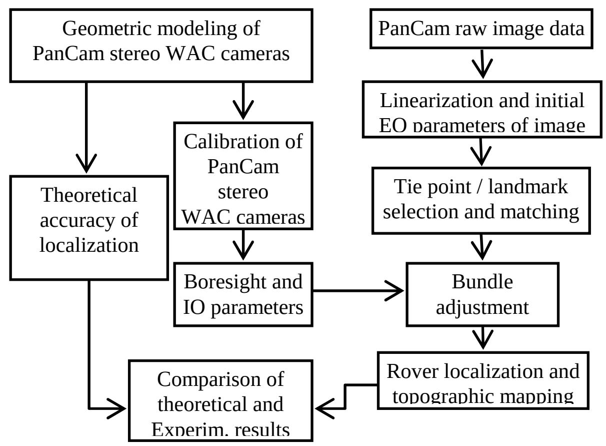

Fig. 1. Flow chart of rover localization accuracy analysis by theoretical modeling and field experiments.

PanCam Prototype: In order to systematically test and evaluate the localization and mapping capabilities of the ExoMars PanCam, we assembled a PanCam prototype consisting of a pair of stereo WACs and one High-Resolution Camera (HRC) based on current ExoMars specifications. This prototype (Fig. 2) is mounted on a pan/tilt system that can precisely control rotation (both horizontal and vertical) through a host computer.

The stereo WACs are two identical Pantera TF 1M30l cameras with Zeiss Distagon T* 2.8/21 ZE lenses. These two cameras have a focal length of 21 mm, pixel size of 12 µm, frame rate of 30 fps, and resolution of 1024 x 1024 pixels. The Camera Link interfaces of the stereo WACs are connected to the host computer through an image acquisition device, the EPIX PIXCI ECB2 frame grabber, whose data transfer rate of 191 megabytes per second guarantees full capture of the image data from the stereo WACs

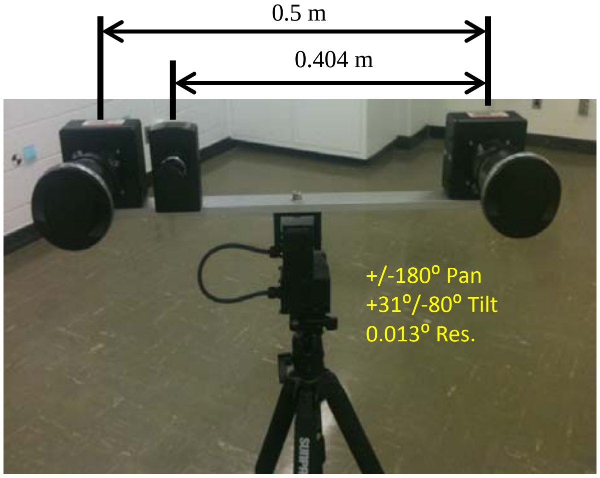

Fig. 2. OSU PanCam prototype.

without any information loss. The HRC was simulated by a Lucam 575C camera having a Pentax C5028-M lens, focal length of 50 mm, pixel size of 2.2 µm, frame rate of 7 fps, and image size of 2592 x 1944 pixels. These three cameras were placed at the specified locations on a metal bar that was mounted on a pan/tilt system, the FLIR PTU D46-70. This FLIR system has a pan range of +/-180° and a tilt range of +31°/-80° with a position resolution of 0.013°. The host computer can send ASCII-based commands to control this system via an RS232 serial port. Currently the entire PanCam prototype is mounted on a tripod in order to achieve high mobility while simplifying system design.

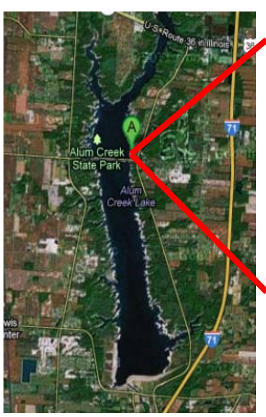

Fig. 3. Site of the OSU field experiment at the Alum Creek Reservoir near Columbus, Ohio (left) and the reference traverse as measured by GPS (right).

Field Experiment Results using PanCam Prototype: We carried out a field experiment on a beach deposit at the Alum Creek Reservoir just north of Columbus, Ohio in March, 2012 to test the attainable level of localization accuracy (Fig. 3). Due to the limited size of this beach area, we were able to perform the test across only three sites, with each traverse segment measuring approximately 35 m. Reference positions for each traverse site were measured using GPS. Panoramic images were acquired at each traverse site at different tilt angles. Applying the same processing procedure as that used for the MER 2003 data processing, we obtained localization results using image data from the stereo WACs. In Figure 4 the BA-derived locations of the "rover" at three traverse sites are represented by solid blue dots, the reference rover locations from GPS are represented by red circle, and the landmarks linking all the images are illustrated by solid green triangles. The BA-derived localization accuracy over a 70-m traverse was 0.83 m, or 1.2 percent, while the relative accuracy projected by the theoretical model was 0.9 percent.

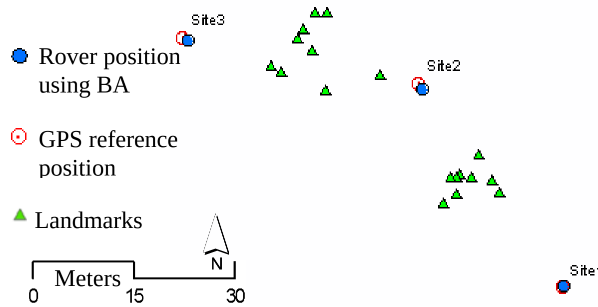

Fig. 4. Rover localization results from the BA method compared to the GPS reference rover positions.

The rover localization accuracy achieved for this short traverse is comparible to that MER 2003 mission results. Experimental results with longer traverses and HRC images will be presented in later papers.

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