VIRTUAL ASTRONAUT DEVELOPED FOR SELECTED SITES ON MARS. J. Wang, K. J. Bennett, R. E. Arvidson and E. A. Guinness, Washington University in St. Louis, 1 Brookings Drive, CB 1169, St. Louis, Missouri, 63130, {wang, bennett, arvidson, guinness}@wunder.wustl.edu.

Introduction: Several hundreds terabytes of digital images and other data has been collected for Mars from a number of NASA's orbital and landed missions. A Virtual Astronaut (VA, [1]) has been developed at the Geosciences Node of NASA's Planetary Data System (PDS) to help visualize the data and provide local and regional geologic contexts for rover-based observations. The VA is a desktop and web-based interactive virtual 3D environment that allows users to view observations from the rover's perspective and to "look around" and "walk around" the rover to place the rover's observation in the context of the overall terrain, soil, and bedrock exposures. This simulates an astronaut cooperating with a rover. This is accomplished by combining images and topographic data obtained from orbital spacecraft with the high quality rover-based observations.

Overview: The first version of the VA was built for the MER Opportunity's campaign at Santa Maria Crater on Mars. Figure 1 presents a view of the VA for Santa Maria with multiple image mosaics overlaid on a digital elevation model ([1]). Santa Maria Crater is located at the center of the view. The image data is a combination of orbital HiRISE (High Resolution Imaging Science Experiment) data from Mars Reconnaissance Orbiter (MRO) mission and ground-based Panoramic Camera (Pancam) and Navigation Camera (Navcam) images acquired by the MER (Mars Exploration Rover) Opportunity Rover. Opportunity is located in the red circle in the figure.

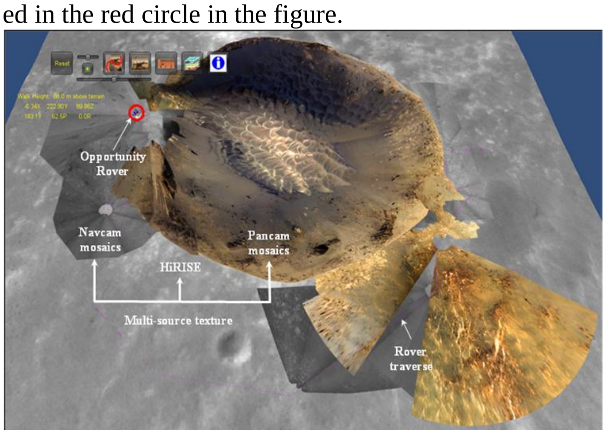

Figure 1. View of the Virtual Astronaut for Santa Maria, a fresh ~100m wide impact crater.

Additional versions of the VA are being developed for Opportunity's exploration of Endeavour Crater, including several areas of its rim along Cape York (Fig. 2), and for selected areas studied by the Mars Science Laboratory rover.

Figure 2. The Virtual Astronaut for south end of Cape York on the Endeavour's rim showing Navcam and Pancam data overlaid on a HiRISE scene.

Building the Virtual Astronaut System: The VA was built on the Unity3D Game Engine and development environment (Version 3.4). Figure 3 shows the process for building the VA for a region of interest.

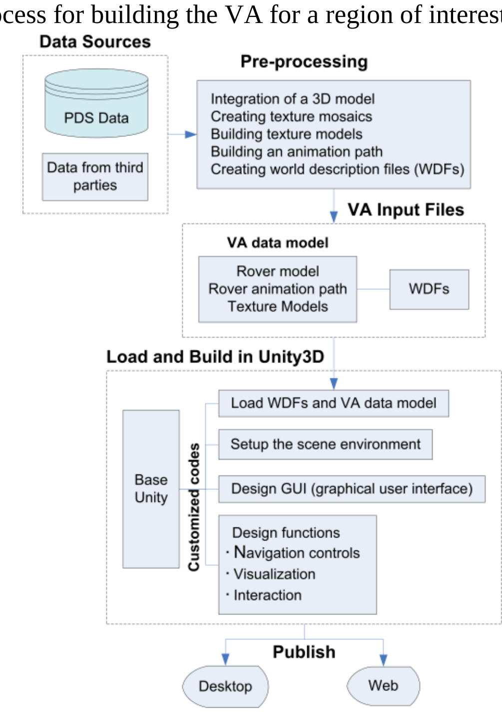

Figure 3. Work flow used to build the Virtual Astronaut ([1]).

Multiple orbital and surface data sets obtained from the NASA's PDS or third parties are pre-processed to build a VA data model using a combination of tools. The VA data model includes a texture model, which is a 3D model of the surface with texture derived from image mosaics, animation paths, and a rover model. A set of world description files (WDFs) are created to describe the objects of a VA data model. This data pre-processing is the key step of generating a specific instance of the VA. Once generated, the VA data model and WDFs are loaded into a Unity3D-based virtual environment. A set of in-house tools and procedures have been developed for visualization and interactive functions within the VA, supplementing the basic modules and functions provided by Unity. These include visualization, navigation and interactive functions that evolved based on user feedback. The final application is published as a desktop application and on the web.

The VA was developed based on user inputs and feedback. Before release, the system was evaluated by members of target planetary scientist audience. It was also demonstrated before dozens of scientists and specialists during conferences or meetings. The evaluations and feedback resulted in many refinements in the tool.

System Functions: The VA supports navigation through the virtual environment with various controls including a mouse, keyboard shortcuts, and a gamepad. The VA provides three modes: walk, drive, and target. Each mode gives you a unique viewpoint to investigate the Martian surface. Additional tools are provided to make measurements, adjust the contrast of the scene, and change the terrain.

Walk mode. The walk mode allows one to simulate freely along moving any direction around the terrain and to look left, right, up and down. The viewpoint is set at a few meters above the terrain. The viewpoint altitude is adjustable by the user.

Drive mode. The drive mode simulates a rover driving along the actual traverse taken by Opportunity. Figure 4 presents a close up view of the rover near Odyssey Crater and rock target, Tisdale, after a drive mode positioned the rover to the west of the rock and the south of the crater. The pink line is the actual traverse taken by Opportunity.

Figure 4. Rover located at the target, Tisdale, near Odyssey Crater.

Target mode. The target mode lets a rover directly jump to a surface target where *in-situ* observations were acquired. The rover is positioned where it was while making a series of *in-situ* measurements (Fig. 5). The menu on the right side of the screen expands to include a list with the MI focal section merge and Hazcam images available for viewing. In this example, the pop-up window shows the image taken by the rover front Hazcam camera to document the placement of the MB (Mössbauer) spectrometer on the target. A red arrow shown above the rock is pointing to the target where the MB experiment was carried out. Functions are provided in the pop-up window to open the full-resolution image or link to the MER Analyst's Notebook [2] for data downloading.

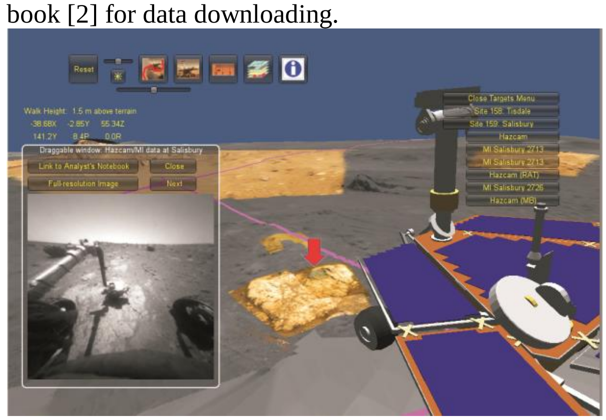

Figure 5. Rover observes the Salisbury target near the south end of Cape York.

Conclusions: The VA for Santa Maria Crater and for the south end of Cape York demonstrate a cost-effective VR system built with the free Unity3D game engine software.

Contact Information: The Geosciences Node welcomes questions and comments from the user community. Specific questions and comments about the VA can be sent to va@wunder.wustl.edu.

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References: [1] Wang, J. et al. (2012) *Future Internet*. *4(4)*:1049-1068. [2] Stein, T.C. et al. (2010), LPS XLI, Abstract #1414.