EXTRATERRESTRIAL VIRTUAL FIELD EXPERIENCE. C. Million[1], R. Sullivan[2], M. St. Clair[1], A. Hayes[2,3], NASA RPIF Network Node Directors and Managers, [1]Million Concepts (chase@millionconcepts.com), [2]Center for Radiophysics and Space Research, Cornell University. [3]Dept. of Astronomy, Cornell University.

Introduction: To promote public access and use of planetary spacecraft data, the Spacecraft Planetary Imaging Facility (SPIF) at Cornell University, a member of NASA's Regional Planetary Imaging Facility Network (RPIFN) [1], has begun to participate in the Virtual Field Experience (VFE) program of the Paleontological Research Institute (PRI) [2]. The VFE program uses remote sensing data (e.g., images) of real terrestrial locations of geologic interest to create virtual environments that can be explored by teacher-led groups of students in an inquiry-based manner. In kind, SPIF has developed a prototype game-like classroom activity called the Extraterrestrial Virtual Field Experience (EVFE) that places students in the first person role of the mission operations team for the Opportunity Rover after its landing at Eagle crater on Mars [3]. Students are tasked to discover the source of hematite signatures detected from orbit by commanding the rover to move and make measurements. The students' ability to command movements and measurements are subject to limitations on consumable resources as an abstracted representation of the operational constraints faced by actual mission teams. The EVFE has the potential to convey key concepts in core scientific sub-topics as well as generalized scientific and systems thinking. We anticipate that the EVFE will be used as an enrichment activity in junior high to high school level science classrooms or after school programs. The EVFE project is part of a new series of programs sponsored by the NASA RPIFN [1] to utilize digital resources to disseminate and describe the data returned by NASA's planetary exploration missions to the general public [3].

Overview: Student-players are presented with a graphical interface that allows them to browse a panoramic image of a site as well as front and rear hazcam images. Footprints (quadrilateral regions), which denote areas of potential scientific interest are overlaid on these data. The footprints have hover-over text that describes why the location may be of scientific interest. Selecting a footprint can make one or more scientific instruments available in the instrument toolbar, indicating which kind of observations can be made. Selecting an instrument from the toolbar brings up a dialog that explains to the student-player what information potentially could be gained by using the specific instrument, and how much time would be consumed by the measurement. For example, a Mössbauer observation could reveal information about iron-rich minerals at the given location, and require 40% of a planning day's resources. The user has the option to enqueue the observation for "uplink" to the rover. When the rover "plan" or "queue" is full or the student-players are ready, they can execute their final plan by choosing to uplink it to the rover, along with providing a scientific justification for the selected observations (similar to actual rover planning strategies). The sol counter advances, and results of the observations are immediately returned in the form of a "Mission Manager Report" that contains data from requested observations (in the form of images or graphs), scientific interpretations of those data, and recommendations for future observations. This cycle repeats until all possible observations have been made or the mission ends at 90 sols. Users can download the complete set of Mission Manager Reports as both a reference and log of activities.

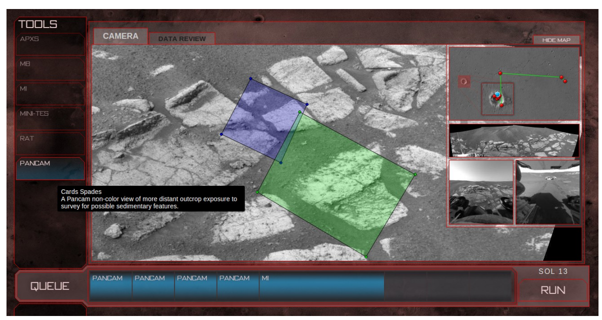

Figure 1. An example of target selection with available footprints in the main window, available instruments along the left, queue along the bottom, and navigation to the right.

Design: The prototype EVFE user interface and behavior was designed to mimic, but in a greatly simplified way, the tools and procedures used by actual mission scientists requesting observations by robotic spacecraft. In this case, the interface is an abstracted representation of the "maestro" toolkit [4] used by the Mars Exploration Rover team and, whereas real mission scientists must balance a number of limited spacecraft resources including power, data capacity, and bandwidth, all spacecraft consumables within the EVFE are abstracted as simply "time." That is, each activity takes a specific amount of time to perform and must be optimized against the limited amount of time per day for activities and the limited number of days in the expected mission lifetime.

While all images and graphics within the activity are derived exclusively from real mission data, not all mission data are available within the activity. Rather, a specific module or scenario contains a curated subset of the available data for that location. Descriptions and interpretations of the data are written by an actual mission scientist and closely track the thought processes of the actual mission science teams. The data and descriptions included within each module form a cohesive whole with a core narrative thread meant to convey specific key pieces of information and general concepts, not unlike a digital museum installation.

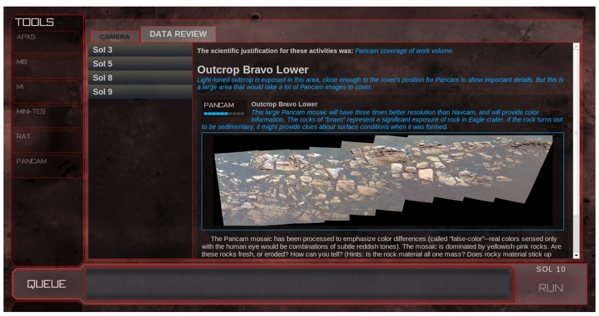

Figure 2. An example of the data review panel and "mission manager report" with activity justification and scientific analysis.

The prototype software runs in a browser environment from a development web server, but the graphical interface and its modes of interaction were developed with the intention of the software eventually being deployable to mobile and tablet platforms as well as a desktop environment.

In addition to the front-end module, we have designed an underlying content format--an XML database with a carefully defined structure--to be extensible to a number of manned and unmanned planetary surface mission data sets. In the expectation of developing future modules for other NASA missions, we have also developed a prototype content creation tool called SiteManager which assists a user in the creation of correctly formatted XML modules.

Future Work: The appropriate amount or level of content for the target audience and environment remains an open challenge. It is likely that multiple modules will need to be developed--even for the same scenario--which can fit into different educational environments. Play-testing in junior high and high school classrooms, expected to take place starting in Spring of 2014, should prove extremely helpful in refining these elements. Full deployment of the module to classrooms, including detailed teacher guides and mapping of modules and content to specific Common Core [5] and Next Generation Science Standards [6], may begin as early as late summer of 2014. We expect to generate new EVFE modules at a rate of at least one per year with data from a variety of missions.

RPIF Network: The NASA Regional Planetary Imaging Facilities (RPIFs) are a network of 9 domestic and 7 international planetary image libraries. These facilities, which are open to the public, maintain photographic and digital data as well as mission documentation and cartographic data. Each facility's holdings contain images and maps of planets and their satellites taken by solar system exploration spacecraft. By placing users in a reconstructed first person narrative of discovery, the EVFE addresses the long term vision of the RPIF Network to serve as a resource that provides the complete story of space exploration through archived data products, historical documentation, and outreach materials [7].

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References: [1] Hagerty, J. (2013) RPIF 5-year plan *USGS Tech. Report.* [2] Auer, S.L. et al. (2009) *Geo. Soc. of Am. Abstracts with Programs*, Vol. 41, No. 7, p. 385 [3] Squyres, S. W. et al. (2004) *Science*, 306.5702: 1698-1703. [4] Fox, Jason M. et al. (2006) *JPL, NASA.* [5] Council of Chief State School Officers. (2010) *Nat. Gov. Ass. Center for Best Practices*. [6] NGSS Lead States. (2013) *Achieve, Inc.* [7] Hagerty, J. J. (2012) *LPSC Abstracts*. Vol. 43.