GROUND DATA SYSTEMS FOR REAL TIME LUNAR SCIENCE. M. C. Deans[1], T. Smith[2], D. S. Lees[2], E. B. Scharff[3], T. E. Cohen[3], D. S. S. Lim[4], [1]NASA Ames Research Center, Moffett Field, CA, USA, matthew.deans@nasa.gov, [2]Carnegie Mellon Silicon Valley, Moffett Field, CA, USA, [3]Stinger-Ghaffarian Technologies, Moffett Field, CA, USA, [4]SETI Institute, Mountain View, CA, USA.

Introduction: We designed, developed, and tested science operations support software using our Exploration Ground Data System (xGDS) framework[1] for the Regolith and Environmental Science, Oxygen and Lunar Volatiles Exploration (RESOLVE)[2] field test, culminating in the test on Mauna Kea in July of 2012.

Background: xGDS has been developed under the Human Robotic Systems (HRS) project[3]. The architecture and core system are designed to be flexible to scientific field work and mission operations, covering planning, operations, and post-mission data analysis. Instances of xGDS have been tailored to the K10 rover [4], piloted submersibles [5,6] and surface vehicles[7], and now RESOLVE. These represent analogs to human and robotic planetary missions, with different constraints on objectives, operations concepts, comms, *a priori* knowledge, goals, etc.

System Architecture: xGDS core systems include a map content management system, a traverse planner, plots, a data product archive, a console log and search tools. Our system is designed to be flexible, modular and based on open standards. Supporting multiple different field tests has helped our team to keep the software modular since any one deployment may use a distinct subset of the core capabilities.

We built xGDS using Python and the Django web framework backed by a MySQL database. xGDS was designed to be accessed primarily through web browsers and Google Earth, so that we could focus on data management and dynamic content while leveraging familiar user interfaces. This minimizes our development time and users' training time.

The RESOLVE project included 5 operations centers and about 100 simultaneous users. Rover and payload telemetry used two different protocols and information was integrated in xGDS on the ground. xGDS was required to produce real time plots and maps of data that would be immediately visible to any users.

xGDS Tools for RESOLVE: We deployed several xGDS tools for the RESOLVE mission.

Planning: The xGDS traverse planner uses the Google Earth web plug-in embedded in a web page to enable map-based editing of traverse plans with other plan parameters, such as distances, time estimates, range and bearing reflected in the same page.

Monitoring: We added real-time 2D plotting and grid-based mapping to xGDS specifically for RESOLVE. These tools generate plots of 1-D quantities to show temporal variations and correlations in measurements vs. time, and 2-D heatmaps of measurements vs. vehicle location (Fig. 1) to aid in localizing geographic points of interest for prospecting.

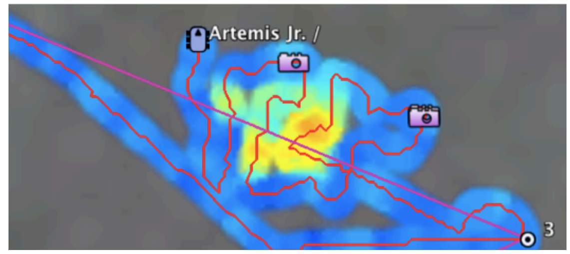

Fig 2. xGDS raster map of Neutron Spectrometer data.

Console Log: Every console operator kept their own time-tagged log by entering free-form text and twitter-style hashtags. All consoles could browse entries chronologically or search by text or hashtag to find entries related to events, observations, etc.

Archive: xGDS supported browsing or search of discrete data products, such as images, in a paginated chronological list and in a map containing georeferenced links in context with satellite images, plans, rover tracks, and any other map content available.

Assessment: We also established a means of assessing the utility of our software for the operations team, primarily in the Ames science back room. The approach leveraged the metrics developed and used at PLRP[4] over several field seasons.

Results: Field testing showed that real time science is feasible with fast diagnostics (esp. band depth plots) and visualizations, that xGDS tools and capabilities are valuable assets for a science team to make decisions quickly, and revealed improvements we can make to the system for a flight mission.

References: [1] M. Deans, et al. (2011) LPSC XLII #2765 [2] B. Larson et al. (2012) GLEX-2012.11.1.8 [3] R. O. Ambrose (2012) ICAPS [4] T. Fong et al. (2009) IAC-09.A5.2.-B3.6.7 [5] D. Lim, et al. (2011) GSA Special Papers 2011, v.483, p.85-115 [6] A. Abercromby, et al. (2012) Acta Astronautica [7] S. Lee, et al. (2012) Acta Astronautica

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