Exploration Ground Data Systems (xGDS) Overview

xGDS supports rapid scientific decision making by synchronizing the time and mapped location of observation notes, instrument data, photos, video, samples and other data. xGDS is a suite of web tools, developed at NASA Ames Research Center to support remote science operations in analog missions and prototype new ideas for planetary exploration.

During operations, xGDS displays science data in real-time with geographic context, supporting key decisions (e.g. sample site selection). Post-operations, xGDS enables efficient analysis of data by correlating data products in time and on the map.

xGDS has been developed in close collaboration with science teams since 2009, and used enthusiastically by upwards of 100 scientists to support scientific field research and data analysis.

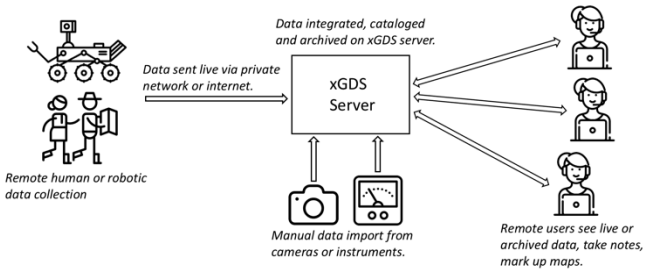

Figure 1. xGDS data flow overview

1. Remote Exploration Phases

Planning Phase: A-priori data (e.g. bathymetry, satellite imagery) can be imported and viewed in xGDS. xGDS also provides a traverse planner with a simple model of vehicle capabilities (e.g. speed, data collection activities) to estimate the duration and distance covered. This helps the science team reach consensus on an exploration strategy before arriving at a remote site.

Live Operations Phase: During operations, xGDS provides a dynamically updated map showing vehicle position with markers for observation notes and sample sites as the information is collected. This provides the situational awareness needed to make rapid decisions, such as sample site selection and revisions to traverse plans. Data can also be manually imported. xGDS can be configured to simulate time delay to test operational concepts for planetary missions.

Post Operations Phase: Post-operations, xGDS provides an efficient way to find events and data in time and on the map, to make inferences informed by the context in which the data was collected.

2. xGDS Features

Map: The Map Server is a central part of xGDS. It provides the ability to import and organize a hierarchical set of maps and view them within xGDS or Google Earth.

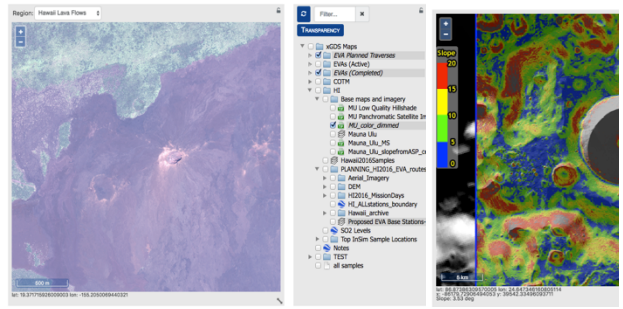

Figure 2. 2D map with tree, Lunar slope data with legend & value

Map Markup —Within xGDS, users can annotate maps with polygons, lines and points, with various colors and icons. KML files from Google Earth can also be imported.

Raster maps and data — GeoTIFF map data (e.g. color bathymetry) can be imported and viewed as a multi-resolution map. GeoTIFF scalar data (e.g. slope, depth) can be imported with a legend. The data value at the current mouse position is displayed below the visible map image.

External Tile Link—xGDS supports linking to maps on external WMS servers.

Track: xGDS provides the ability to collect, manipulate and display vehicle position and track, and imported GPS data.

Plan: The Plan Editor lets users create traverse plans interactively on a map. As points are moved, distance and duration update. A timeline shows the plan's duration and data values (e.g. depth) along the planned path.

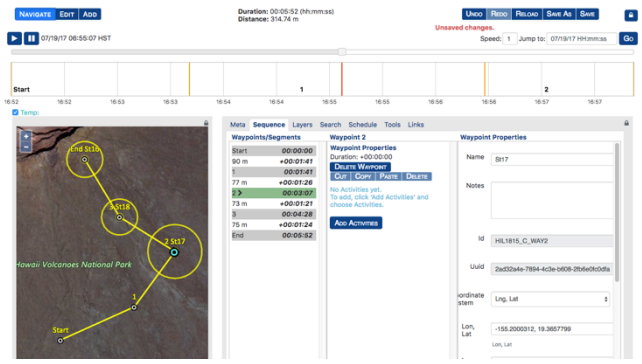

Figure 3. Plan Editor

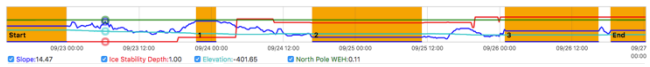

Figure 4. Timeline with data plots in Plan Editor

Notes: xGDS supports recording of geo-located, tagged notes on any collected data. xGDS captures the role, location and author for each recorded note.

Users build a custom hierarchy of tags to label notes. Multiple tags can be associated with each note. When searching, the hierarchy helps to group results.

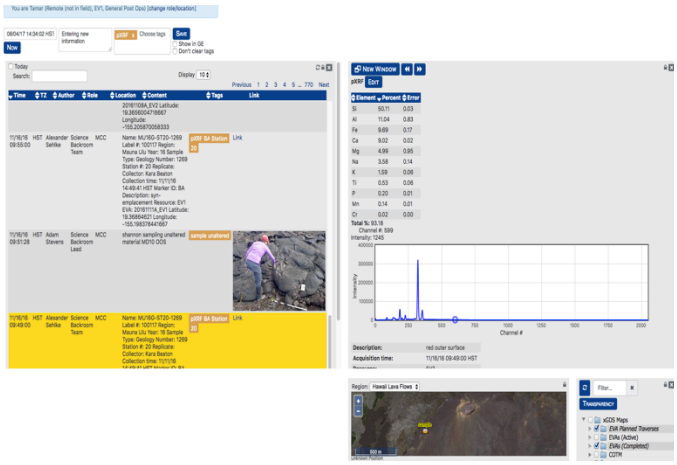

Figure 5. Notes with tags, notes search and instrument data

Instrument Data and Plots: xGDS collects and manages both discrete instrument data products and continuously streamed data (e.g. CTD from an ROV). It provides summary information and basic plots for quick analysis of data. Raw data files are available for download and detailed analysis.

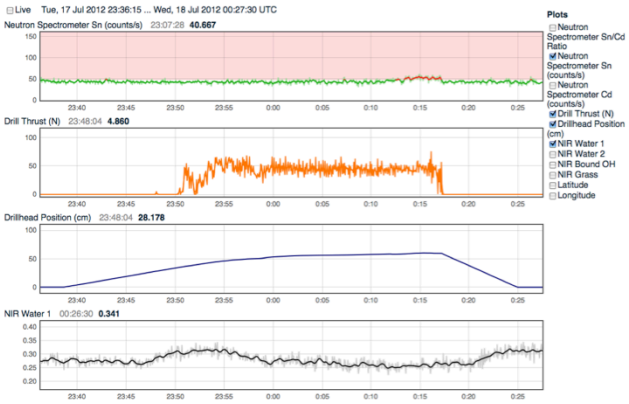

Figure 6. Dynamic, interactive linked data plots

Images and Annotation: xGDS manages still images from cameras or video capture. Users can annotate images with multi-colored arrows, rectangles, ellipses, and text. Images can be viewed in xGDS or downloaded with or without annotations for detailed analysis.

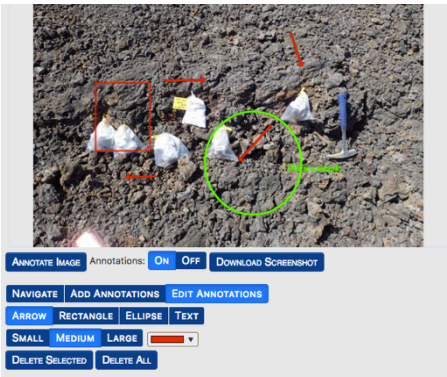

Figure 7. Image annotations

Video: xGDS allows users to watch live, delayed, or recorded videos. xGDS stores the video files and metadata about the video. It handles dropouts in the video and supports multiple concurrent related video streams.

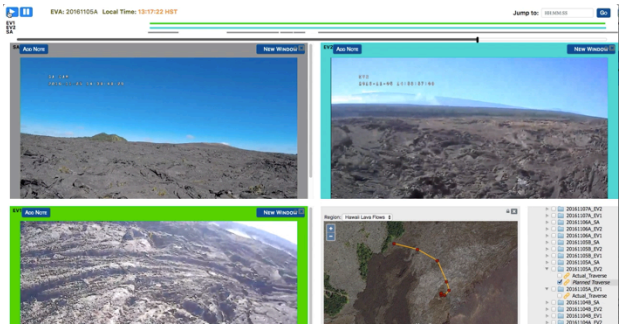

Figure 8. View of multiple video feeds with dropouts

Sample: xGDS allows users to organize metadata about physical samples. xGDS provides uniquely numbered, printable labels with QR Codes. When a sample is collected, the user enters the label number and associated metadata. Collection time and the vehicle position provide the mapped location. The sample's naming pattern can be customized.

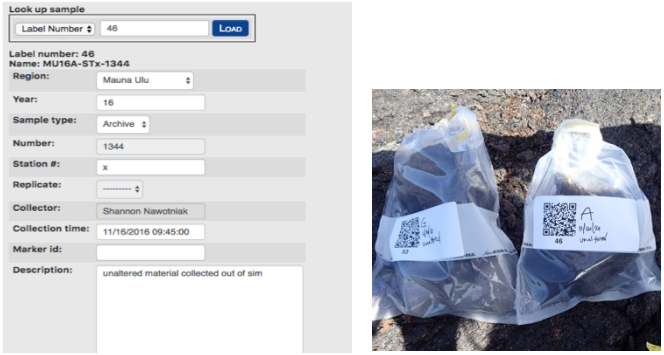

Figure 9: Sample metadata and labels

Search & Navigation: Once data is collected, users can explore it by day, see summary information (e.g. number of notes, images, etc.) and search through it based on multiple criteria. Search results are shown in both tabular and map views and can be exported for detailed analysis.

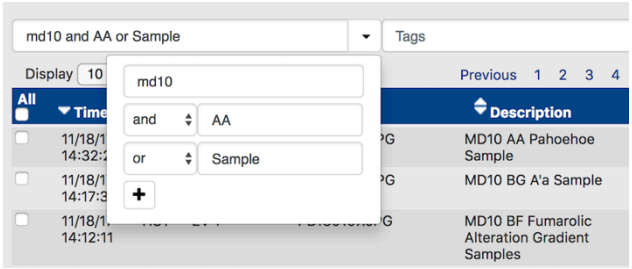

Figure 10: Keyword search and results

Collectively, the capabilities in xGDS are designed to make field science planning more efficient and to make collected data easier to locate, organize and interpret during and after field deployment.

Visit https://xgds.org to learn more.

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