Mars INteractive Exploration based on Reconstruction and Visual Analysis: The MINERVA Concept

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MINERVA is an integrated framework for planetary scientists allowing members of different instrument teams to cooperate synergistically in virtual workspaces by sharing observations, analyses and annotations of heterogonous mission data.

MINERVA Scope

The ExoMars 2020 mission will provide a heterogeneous set of data from different instruments captured on the surface of Mars [1]. It encompasses different types of imagery, various spectra, ground penetrating radar observations, and lab examinations of samples.

The goal of MINERVA is to provide planetary scientists with an integrated framework that supports a comprehensive, holistic and efficient analysis of this wealth of heterogeneous science data. New interactive visualization methods considering semantics, meta-information and data modalities are investigated. The tight interoperation of a 3D explorer with GIS functionality and a visual analytics component will not merely make the analysis workflow more efficient but will allow insights, which would be hard or impossible to obtain using isolated methods.

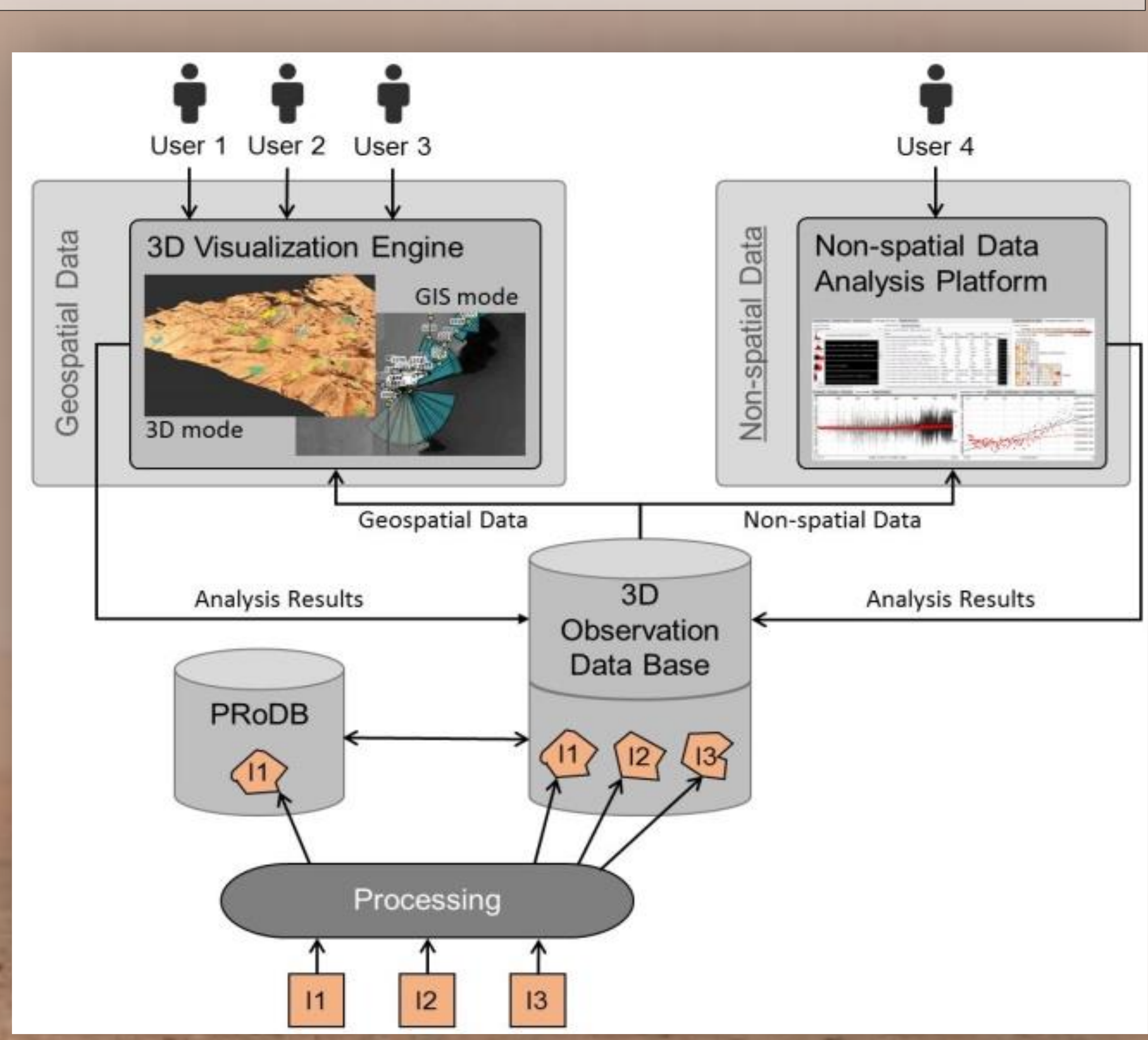

Figure 1: The Instrument Teams (I1…I3) use generic (PDS4) importer tools to ingest mission data into the 3D Observation Data Base. It is available to PRo3D and the Non-spatial Data Analysis Platform. Users can share locations & observations and launch visual analysis of different instrument data at the same time.

MINERVA Components

The MINERVA prototype (Figure 1) will consist of three tightly integrated components:

1. A data base for scientific data products that also maintains analysis results [2].
2. A 3D Visualization Engine (PRo3D [3], Figure 2) to explore surface reconstructions and make extensive geological/morphologic interpretations [4] using a variety of interactive measurement tools. PRo3D also offers important GIS functionalities such as orthographic view, superimposed rover tracks and data locations.
3. A non-spatial visualization component [5], Figure 3, for in-depth investigation of data, to discover relations, properties and coherencies otherwise hidden.

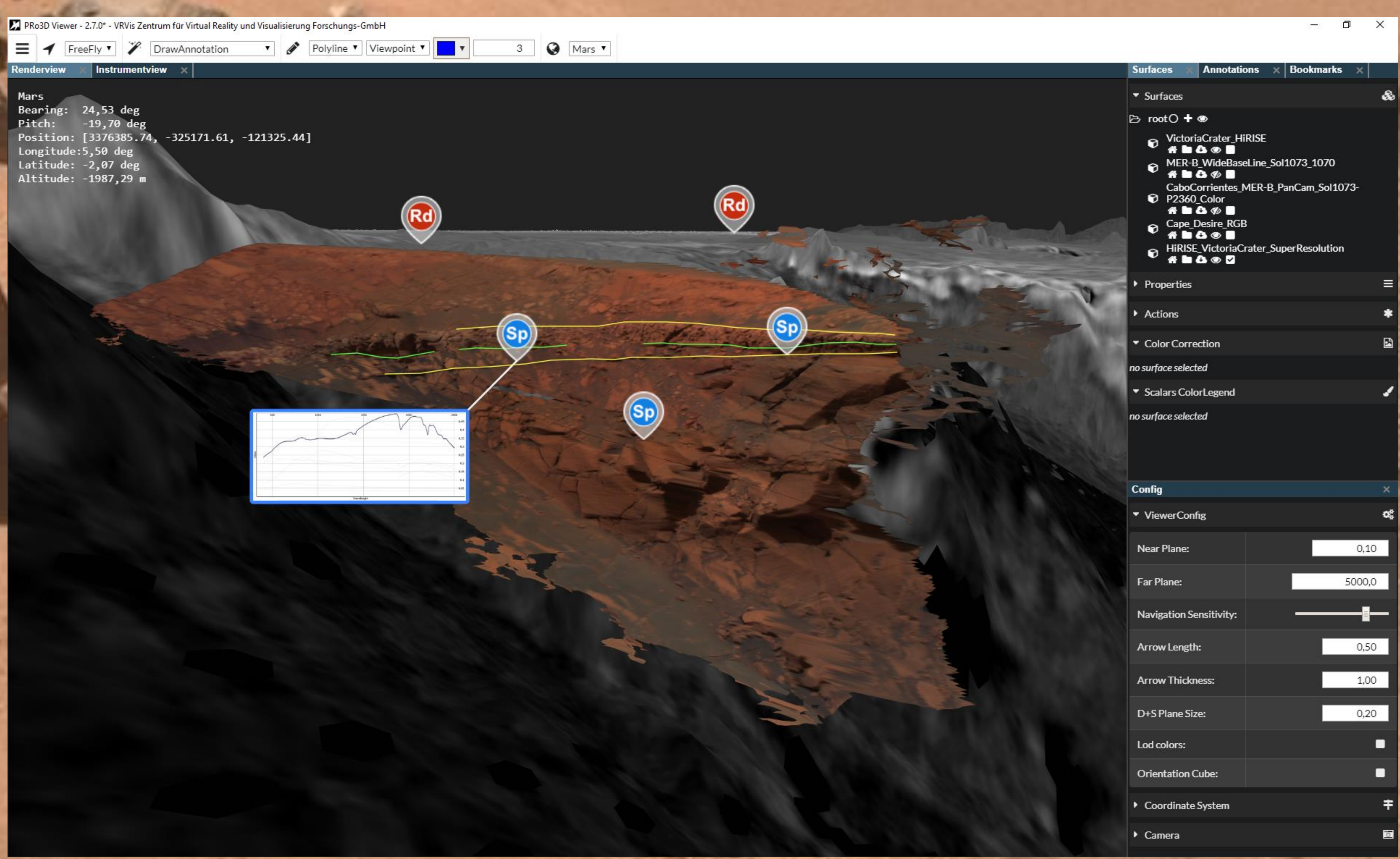

Figure 2: As part of the planned 3D GIS functionality, pins show measurement positions of different instruments in the 3D reconstruction of Cape Desire at the Victoria Crater. Blue ones indicate spectra and red ones radar data. A preview of one spectrum is shown as billboard. The yellow and green lines are part of a geologic interpretation. Data courtesy USGS/NASA/JPL/Caltech/ASU

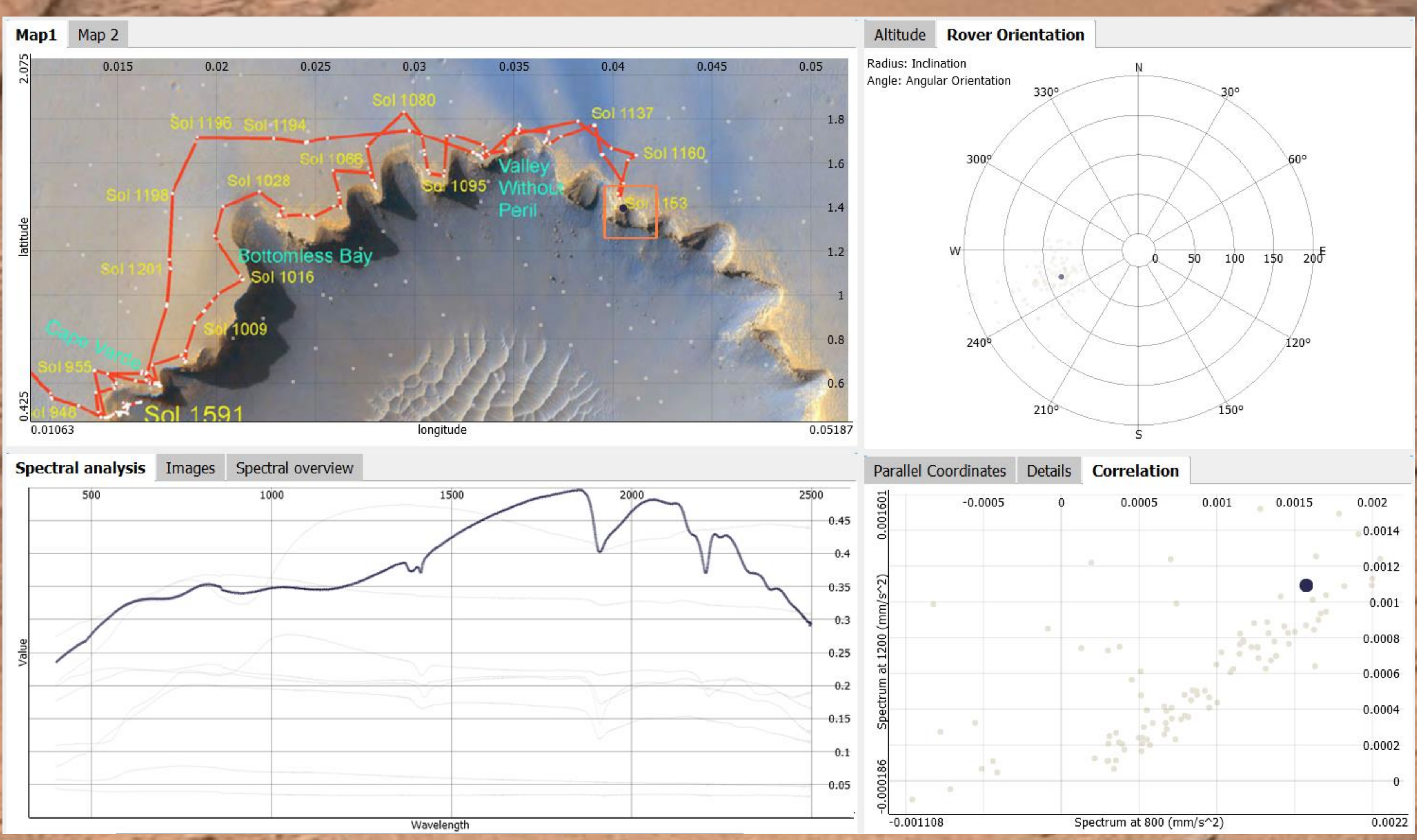

Figure 3: Mockup of a dashboard for analyzing products. It combines information about the sample such as the location and the rover orientation, and it shows measured results such as spectra. The shown spectral data is courtesy of the USGS Spectral Database, all other views show simulation data which are courtesy of AVL List GmbH.

MINERVA Use Cases

MINERVA will offer the users the opportunity to visualize, analyze, and annotate the mission data in a spatiotemporal context that also considers interrelations:

- Support scientists in geo-referencing of scientific products (e.g. spectra) for the characterization of regions and the identification of their boundaries.
- To enable a holistic overviews of products, their correlations and their distribution by time / rover orientation / etc.
- Measure / annotate on 3D surfaces with PRo3D and share this with peers.
- Search for spatial and temporal correlations in laboratory instruments data (spectrometers etc.).
- Get geospatial overview of products' locations having certain characteristics (e.g., a spectrum with a certain shape).
- Simultaneous inspection of ensembles of spectra / images. This may include a characterization of the overall dispersion, a pairwise comparison of particular products, and the clustering of products by their characteristics (e.g., the shape of their spectrum).
- Identify bidirectional relation of product locations to corresponding product characteristics, e.g. potentially non-contiguous regions where objects have certain characteristics.

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MSL Mastcam Sol 538, Data Courtesy NASA/JPL-Caltech/MSSS, data processing JOANNEUM RESEARCH / PRoViDE www.PRoViDE-space.eu