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1. **Nature:** R = Report, P = Prototype, D = Demonstrator, O = Other
2. **Dissemination level:**

PU	PP	RE	CO
Public	Restricted to other programme participants (including the Commission Service)	Restricted to a group specified by the consortium (including the Commission Services)	Confidential, only for members of the consortium (excluding the Commission Services)

Executive Summary / Abstract:
An update for year 4 of the GMAP JRA activities (WP9) is provided. Technical and scientific support to the VA has been finalised, based on tool development, guidance and documentation for performing data reduction, processing and analysis tasks, though a series of deliverables. Developed tools and guidelines have been provided to the VA to be used in upcoming workshops and schools. The 4th year of JRA activities included minor incremental updates of GMAP codebase and tools, as well as code release for sustainable use of the GMAP infrastructure beyond the end of the Europlanet 2024 RI project.

List of acronyms and abbreviations

Table 1: List of acronyms and abbreviations

Acronym	Description
ASP	Ames Stereo Pipeline
DoA	Description Of Action
ERIM 2023	Europlanet Research Infrastructure Meeting 2023
ISIS	Integrated Software for Imagers and Spectrometers
JRA	Joint Research Activity

MOST	Ministry Of Science and Technology
USGS	United States Geological Survey
VA	Virtual Access
NA	Networking Activity
ML	Machine Learning
QGIS	Quantum Geographic Information System

Introduction

The GMAP JRA activities (see DoA, D8.4, Rossi et al., 2022) include several tasks:

- Task 9.1 - Coordination
- Task 9.2 - Geological Mapping Standardisation
- Task 9.3 - Basemap and Pipelines geological mapping services

Most activities during the third year of the JRA were focused on implementing Task 9.3, planned and prepared in the previous reporting period (See D9.6, Rossi et al., 2022). Interim updates of services and tools have been performed during the reporting period, supporting VA activities and deliverables.

Activities performed (per task) in the reporting period

The performed activities are described for each task. The formal end of JRA activities is common across the Europlanet 2024 RI. The outlook on the possible future use of JRA developments within the VA and beyond is provided in the final section

Task 9.1 - Coordination

Periodic online meetings and interaction across partners has been performed throughout the reporting period, as described in D9.2 (Rossi et al., 2021), D9.6 (Rossi et al. 2022; see also D8.4, Rossi et al., 2022).

Technical discussions and documentation have been updated on the GMAP wiki, as well as on relevant GitHub repositories of the Europlanet 2024 RI GMAP organisation[1]. Interaction with USGS Astrogeology is continuing. GMAP has been present at EPSC splinter sessions, ERIM 2023, and within the OpenPlanetary[2] Slack.

Task 9.2 - Geological Mapping Standardisation

Discussion and interaction across partners and topical teams continued, resulting in the standard document iteration (see D9.7, Naß et al., 2023) reflecting the technical aspects of the VA deliverable in the reporting period (see D8.10. Rossi et al., 2023). Still, publications of parts of the deliverable (D9.1, Nass et al., 2020; D9.7, Naß et al., 2023) are planned, see section on dissemination activities.

Inputs to VA, support for NA

JRA developments have been consistently used for VA to support training of the community via the annual Winter School, in its 3rd iteration, where technical support content has been added in a dedicated GitHub repository[3]. Additionally tutorial and materials building upon the previous winter schools have been developed and adapted for the recent ERIM 2023 workshop, also on a dedicated GitHub repository[4]

Feedback from the community is being collected and periodic VA community meetings and calls are also covering technical developments of the JRA.

Task 9.3 - Basemaps and Pipelines for geological mapping services

Most activities in year 3 of the JRA were on Task 9.3, with incremental updates to the services already described in D9.6, i.e. D9.3. D9.4, D9.5).

[1] https://github.com/europlanet-gmap
[2] https://openplanetary.org
[3] https://github.com/europlanet-gmap/winter-school-2023
[4] https://github.com/europlanet-gmap/erim-2023/

The GMAP Jupyter Hub instance[5] is serving the VA for training, as well as for developing workflows aiming at reproducible planetary basemap processing.

Guidance, documentation and tools

Task 9.3 supported the development of tools, scripts and QGIS plugins, such as the newly released OpenCraterTool[6] (Heyer et al., 2023). In addition to those, the use of web services based on existing Open Source tools (e.g. USGS ISIS, NASA ASP) are developed in order to provide support to the VA users, Additional developments, especially for the ML data exploitation supportive of geologic mapping, made also use of the exploitation within the EXPLORE H2020 project (see also Nodjoumi et al., 2021; 2023).

Restructuring of GMAP GitHub organisation

Following the recommendations of the VA Board (D1.8, Rough, et al., 2022), a reorganisation of the GMAP GitHub page[7] and related repositories has been performed.

Mapping aids (Mappy, OpenCraterTool)

The development of Mappy[8] has seen incremental updates and fixes, as well as improved documentation. The plugin, already available in GitHub, is now also directly available in the official QGIS plugin repository[9] has now more extensive documentation[10]. Moreover, a new QGIS plugin to aid crater size-frequency age determination called OpenCraterTools has been released (Heyer et al., 2023), and became recently available in the official QGIS plugin repository as well. Such tools, as customary, are going to be demonstrated and used for hands-on activities at the GMAP Winter School.

Data sharing

Best practice from existing projects and efforts will be adopted (see also Dissemination activities). Zenodo has been the natural choice as default repository for data and code linked to VA. The GMAP data integration portal has been updated[11] (see D8.10, Rossi

[5] https://jupyter.europlanet-gmap.eu
[6] https://github.com/europlanet-gmap/OpenCraterTool
[7] https://github.com/europlanet-gmap
[8] https://github.com/europlanet-gmap/mappy
[9] https://plugins.qgis.org/plugins/mappy/
[10] https://mappy.readthedocs.io
[11] https://wiki.europlanet-gmap.eu/bin/view/Main/Documentation/data%20sharing%20guide/

et al, 2023), allowing for data discovery and access from several sources, including external sources (other data repositories or USGS Astropedia)[12].

Machine learning tools and algorithm development

Development of both Machine Learning (ML) and Deep Learning (DL) tools for automated landform detection and mapping have been started, also based on developments within the EXPLORE H2020 project (see sustainability task in D8.10, Rossi et al., 2023).

A first easy-to-use tool based on Deep Learning Object Detection was released and tested on pit and skylight landforms on Mars (see Nodjoumi, et al., 2021). This tool produces a geopackage file (see. Open Geospatial Consortium) containing all the points of all detected features. A more advanced tool that produces shape polygons, instead of simple point entities locating the detected features, is currently under development and is based on Deep Learning Instance Segmentation (Nodjoumi et al., 2023).

Dissemination activities

Scientific dissemination

Developments have been presented at the Planetary Data Workshop (Rossi et al., 2023). The creation of specific GMAP communities on Zenodo has been performed, in order to ease discovery of code and data[13].

The dissemination of GMAP-related outputs, both in terms of development and map production is continuing.

Training and outreach

GMAP JRA supported the 3rd Winter School[14] (see for details also D8.10 Rossi et al., 2023). GMAP also reached out consistently to the community via OpenPlanetary (500+ members), and ERIM 2023, with dedicated workshops.

[12] https://data.europlanet-gmap.eu
[13] https://zenodo.org/communities/gmap
[14] https://www.planetarymapping.eu

Technical heritage and sustainability

The remaining part of the GMAP VA activity will make use of the developments of the JRA across its 3.5 years of duration. The entire code and documentation base, respectively on the GitHub organisation[15] of GMAP and its wiki[16] are going to be available long-term for the community and for follow up local or European projects and activities.

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