H2020-INFRAIA-2019-1

Europlanet 2024 RI has received funding from the
European Union's Horizon 2020 Research and Innovation Programme under

Grant agreement no: 871149

Deliverable D9.8

Deliverable Title:	GMAP JRA 3rd Year Report
Due date of deliverable:	31 January 2023
Nature[1]:	Report
Dissemination level[2]:	Public
Work package:	WP9
Lead beneficiary:	JacobsUni
Contributing beneficiaries:	UNIPD, UNICH, DLR
Document status:	Final

Start date of project:	01 February 2020
Project Duration:	48 months
Co-ordinator:	Prof. Nigel Mason

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 3 of the GMAP JRA activities (WP9) is provided. Technical and scientific support to the VA has been performed via continued tool development, guidance and documentation for performing data reduction, processing and analysis tasks, though a series of deliverables. Developed tools and guidelines have been implemented in the VA (See D8.10) and used in relevant workshops and schools. JRA activities were not too negatively affected by the pandemic situation. The 4rd year of the JRA will include minor incremental updates of GMAP standards, as well as use/heritage for sustainability.

Table of Contents

1. List of acronyms and abbreviations

Table 1: List of acronyms and abbreviations

Acronym	Description
ASP	Ames Stereo Pipeline
DoA	Description Of Action

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

Introduction

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

- Tak 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 JRA were focused on implementing Task 9.3, planned and prepared in the previous reporting period (See D9.2, Rossi et al., 2022). Interim updates of services and tools have been performed during the reporting period, supporting VA activities and deliverables.

Continued impact of the COVID-19 situation on the JRA

GMAP JRA activities, similar to VA (see D8.10, Rossi et al., 2023) did not entail much in-person interaction, being (mostly online data services), with limited in-person events. Nevertheless, the overall difficulties in organising intra- and inter-partner cooperation during the pandemic had a certain impact on the day-to-day activities, producing some slight delays.

The impact of COVID-19 has been both on the infrastructure-participating partners and the community as a whole. Planned delays, as detailed in D9.2 (Rossi et al., 2021), have been implemented in the last Grant Amendment of the RI.

Activities performed (per task) in the reporting period

The performed activities are described for each task. Outlook on upcoming activities of the various tasks is provided in the final section.

Task 9.1 - Coordination

As is customary, periodic online interaction across partners has been performed throughout the reporting period, as described in D9.2 (Rossi et al., 2021; see also D8.4, Rossi et al., 2022).

Technical discussions and documentation have been produced and consolidated in the GMAP wiki, as well as on relevant GitHub repositories of the Europlanet GMAP organisation[1], for both JRA and VA.

Interaction with USGS Astrogeology is continuing. GMAP has been present at EPSC splinter sessions, and interaction with OpenPlanetary[2] activities occurred and are further planned.

Task 9.2 - Geological Mapping Standardisation

Interaction across partners and topical teams with incremental discussion and updates have been performed, while the next standard document iteration will be in early 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) are planned, see section on dissemination activities.

Inputs to VA

JRA developments have been consistently used for the VA to support training of the community via the annual Winter School.

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

[1] https://github.com/europlanet-gmap
[2] https://openplanetary.org

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).

The GMAP Jupyter Hub instance[3] 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. 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 also the recommendations fo the VA Board (D1.8, Rough, et al. ,2022) a reorganisation of the GMAP GitHub page[4] and related repositories has been performed.

Templating, including map sheets design templates, was produced and are available from one of the GMAP GitHub repositories[5].

Mapping aids (Mappy)

The development of Mappy[6] has further advanced in year 3 (See for more details the Appendix 3 of D9.1, Nass et al., 2020 as well as D9.2, Rossi et al., 2021): several updates were released and the plugin, already available to the official QGIS plugin repository[7], now has extensive documentation[8].

Data sharing

[3] https://jupyter.europlanet-gmap.eu
[4] https://github.com/europlanet-gmap
[5] https://github.com/europlanet-gmap/gmap_metadata/tree/main/layouts
[6] https://github.com/europlanet-gmap/mappy
[7] https://plugins.qgis.org/plugins/mappy/
[8] https://mappy.readthedocs.io

Appropriate and meaningful options for licensing released data deriving from VA community mapping projects will be evaluated and provided as options to VA contributors. 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 (see D8.10, Rossi et al, 2023) allows for discovering data either on the specific GMAP community, or from legacy projects (Planmap H2020), as well as from external sources (other data repositories or USGS Astropedia)[9].

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, based also 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 (see. Open Geospatial Consortium) file containing all the points of all detected features. A more advanced tool that produces shape polygons, instead of simple points, for all the detected features is under development and is based on Deep Learning Instance Segmentation (Nodjoumi et al., 2023).

Dissemination activities

Scientific dissemination

Early joint developments across PLANMAP and GMAP have been presented at EPSC 2022 (e.g. Penasa et al., 2020). The creation of specific GMAP communities on Zenodo has been performed, in order to ease discovery of code and data[10].

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

[9] https://data.europlanet-gmap.eu
[10] https://zenodo.org/communities/gmap

Training and outreach

GMAP JRA supported the 2nd Winter School[11] (see for details also D8.10 Rossi et al., 2023). GMAP also reached out consistently to the community via OpenPlanetary (500+ members), and webinars within the Europlanet Society describing GMAP tools and services are being planned for 2023.

1. Timeline and outlook

The upcoming year of GMAP JRA is mostly devoted to the developments of Task 9.3, with a minor - but significant - emphasis on Task 9.2, particularly gathering VA community inputs and driving them into the JRA activities. The top-level plan for the various tasks of the GMAP JRA are outlined in Table 2.

Table 2: Envisaged activities of GMAP Va for Year 4

Task no.	Name	Plan for Y4 of RI
9.1	GMAP JRA Coordination	Continued coordination and interaction with non-EU initiatives, e.g. USGS, Task 9.3
9.2	Geological Mapping Standardisation	Final updates and feedback from VA community
9.3	Basemap and Pipelines geological mapping services	Incremental updates, integration with VA (e.g. community support via task 8.2), support for VA activities (e.g. Winter School)

[11] https://www.planetarymapping.eu

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