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1. **Nature:** R = Report, P = Prototype, D = Demonstrator, O = Other
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Executive Summary / Abstract:

An update for Year 2 of the GMAP JRA's (WP9) activities 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 D8.4) and used in relevant workshops and schools. JRA activities were not too negatively affected by the pandemic situation. The 3rd year of JRA will see incremental updates of GMAP services and tools.

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1. List of acronyms and abbreviations

Table 1: List of acronyms and abbreviations

Acronym	Description
ASP	Ames Stereo Pipeline
DoA	Description Of Action
DEM	Digital Elevation Model
DL	Deep Learning
DTM	Digital Map Terrain
DOM	Digital Outcrop Model
EOSC	European Open Science Cloud
EPSC	Europlanet Science Congress
ESA	European Space Agency
EU	European Union
GMAP	Geologic MApping of Planetary bodies
ISIS	Integrated Software for Imagers and Spectrometers
JRA	Joint Research Activity
ML	Machine Learning
MOST	Ministry Of Science and Technology

NASA	National Aeronautics and Space Administration
NEANIAS	Novel EOSC Services for Emerging Atmosphere, Underwater & Space Challenges
PLANMAP	Planetary Mapping Project
QGIS	Quantum Geographical Information System
RI	Research Infrastructure
USGS	United States Geological Survey
VA	Virtual Access

2. Introduction

The GMAP JRA activities (see DoA) 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 second 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). The key deliverables from Task 9.1 in the reporting period are D9.3 (Rossi et al., 2021), D9.4 (Pozzobon, et al., 2021), D9.5 (Carli et al., 2021), which supports both VA (See Massironi et al, 2021; Rossi et al, 2022), and further JRA activities and deliverables.

Impact of the COVID-19 situation on the JRA

GMAP JRA activities, similarly to those of the VA (see D8.4, Massironi et al., 2022), did not entail large in-person interactions (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 day-to-day activities, producing some slight delays.

The impact of COVID 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.

3. Activities performed (per task) in the reporting period

The performed activities are described for each task. An outlook on the 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 are then consolidated in the GMAP wiki, both for JRA and VA.

Interaction with USGS Astrogeology, with the aim of sharing information and starting a potential cooperation, has been initiated. The coordination across workshops and developments will be carried out in Year 2 of the RI, and potential joint sessions, workshops or additional cooperative activities will be discussed.

Task 9.2 - Geological Mapping Standardisation

Interactions across partners and topical teams with incremental discussion and updates have been performed, while the next standard document iteration will be in early 2023.

Meanwhile, publications of parts of the deliverable (D9.1, Nass et al., 2020) are planned, see section on dissemination activities.

Topical teams and their role for VA

Topical teams, originally formed across beneficiaries to target various Solar System bodies and specific geologic processes, were mostly active in the VA, transferring the observations, standards and requirements from D9.1 (Nass et al., 2020) into the documentation and guidance of the community (See D8.3, Pondrelli et al., 2021; D8.4, Rossi et al., 2022).

Inputs from VA

In addition to the above inputs, the most direct - also technical - use of JRA developments for VA is to support training of the community via the periodic Winter School and upcoming additional events and workshops.

Feedback from the community is being collected and will be channelled into the live version of D9.1 and its later-consolidated deliverable version (D9.6) later in the course of the RI.

Task 9.3 - Basemaps and Pipelines for Geological Mapping Services

Most activities in Year 2 of the JRA were on Task 9.3, with the completion of 3 deliverables and related supporting documentation on the GMAP wiki:

D9.3: Imaging and Mosaicking Basemap Pipeline/Guidelines (Rossi et al., 2021)

Base mapping documentation and pipelines to support GMAP efforts were described in D9.3. Services to support mappers include GMAP cloud infrastructure instances of Open-Source tools to support the creation of base maps, as well as web services

provided by other projects and available to the GMAP infrastructure. Services and tools are documented on the GMAP wiki[1].

D9.4: Stereo-DTM and Digital Outcrop Model Pipelines/Guideline (Pozzobon, et al., 2021)

D9.4 explores and illustrates the various possibilities for gathering datasets for digital elevation models (DEM) and the creation of digital outcrop models (DOM). Moreover, the basic steps in the data processing and their meaning are discussed, and the most common processing pipelines are illustrated. Finally, the available Open Source and commercial tools that can be used to create such models for planetary surfaces are introduced.

D9.5 - Hyperspectral Mapping Pipeline/Guideline (Carli et al., 2021)

The main multispectral and hyperspectral datasets relevant to planetary geologic mapping are introduced, as well as their use for reflectance studies, analysis and mapping. Examples of datasets and their spectral characteristics are described for the case of the Moon, Mercury, Mars and Vesta, in each case including general spectral properties and dataset specific relevant information. High-level and derived products specifically useful for geologic mapping products are introduced. Finally, access to datasets, tools and supporting literature is included in the document.

Guidance, documentation, and tools

Task 9.3 activities include various developments 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. The mosaicking web services are being developed, building upon also on Open-Source developments of the NEANIAS H2020 project (see D9.3, Rossi et al., 2021). Future developments, especially for the Machine Learning (ML) data exploitation supportive of geologic mapping, will also make use of upcoming results from EXPLORE H2020 (see also Nodjoumi et al., 2021).

Updates on specific developments

Specific developments and sub-activities within Task 9.3 are listed here, with incremental updates from D9.2 (Rossi et al., 2021). See also the Appendix material in D9.1 (Nass et al., 2020).

[1] https://wiki.europlanet-gmap.eu/bin/view/Main/Documentation/

Templating (fields and vector data) and map-wide metadata, map sheets.

For more details, see Appendices 1, 2 and 6 of D9.1 (Nass et al., 2020). The initial provision of template files is for vector fields and mapping aids (see also next section and Appendix 3 of D9.1), due to their more urgent use for performing mapping within VA community mapping projects.

Map sheet design templates were produced, and are available from one of the GMAP GitHub repositories[2].

The reference entry point for such templates will be the GMAP web site.

Mapping aids (Mappy)

The development of Mappy[3] has advanced in Year 2 (for more detailst, see 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 is now available to the official QGIS plugin repository[4], with easy installation for multiple platforms.

Symbology

Symbology will be made available based on the existing state of the art with Open-Source implementation. See for more details Appendices 4 and 2 of D9.1 (Nass et al., 2020)

Review workflow

The review workflow has been further discussed, and its application to the workflow of community mapping projects is going to be rolled out when the first results of new community mapping projects are ready for initial internal/external publication, presumably later in 2022.

Data licensing

Appropriate and meaningful options for licensing released data deriving from VA community mapping projects will be evaluated and provided as options to VA

[2] https://github.com/europlanet-gmap/gmap_metadata/tree/main/layouts

[3] https://github.com/europlanet-gmap/mappy

[4] https://plugins.qgis.org/plugins/mappy/

contributors. Best practice from existing projects and efforts will be adopted. Feedback from the community is planned through the periodic winter school/workshops, and throughout the year inbetween GMAP VA calls (see also D8.1).

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 D8.4, Rossi et al., 2022).

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. The first tool is already available for early use[5]. The second tool will be released in the near future.

4. Dissemination activities

Scientific dissemination

Early joint developments across PLANMAP and GMAP were presented at EPSC 2021 (e.g. Penasa et al., 2020).

Outreach

GMAP was presented at EPSC 2021 via a dedicated splinter meeting session, as well as at the Planetary Data Workshop organised by USGS[6].

5. Timeline and Outlook

The upcoming year of the 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.

[5] see also https://github.com/Hyradus/DeepLandforms-YOLOv5

[6] https://aprossi.github.io/planetdata2021/

Table 2: Envisaged activities of GMAP VA for Year 3

Task no.	Name	Plan for Y3 of RI
9.1	GMAP JRA Coordination	Continued coordination and interaction with non-EU initiatives, e.g. USGS, and with MOST partners for Task 9.3
9.2	Geological Mapping Standardisation	Incremental 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)

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