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Deliverable D9.2
GMAP JRA 1st year report

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Executive Summary / Abstract:

A summary of the initial GMAP JRA3 activities and preparations for the upcoming VA call and call for GMAP users are provided. The impact of COVID-19 on the WP is also described. An outlook for the upcoming GMAP JRA activities and overall timeline for Year 2 is provided. Task 9.2 developed the first version of the GMAP standard definition document based on work from topical teams with cross-partner members. Technical support to mapping within Task 9.3 included tool development and integration, leveraging on Open Source tools, instrumental to the VA activities (see D8.1).

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)

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1. List of Acronyms and abbreviations

Table 1: List of acronyms and abbreviations

Acronym	Description
ASP	Ames Stereo Pipeline
CBK-PAN	Centrum Badań Kosmicznych - Polskiej Akademii Nauk
CNN	Convolutional Neural Network
DoA	Description Of Action
DL	Deep Learning
DLIS	Deep Learning Image Segmentation
DLOD	Deep Learning Object Detection
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DTM	Digital Terrain Model
INAF	Istituto Nazionale di Astrofisica
ISIS	Integrated Software for Imagers and Spectrometers
GIS	Geographic Information System
GMAP	Geologic MApping of Planetary bodies
JACOBSUNI	Jacobs University Bremen
JRA	Joint Research Activity
ML	Machine Learning
MLIS	Machine Learning Image Classification
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 Geographic Information System
RI	Research Infrastructure
UDA	Università D'Annunzio
UNIPD	Università degli Studi di Padova
USGS	United States Geological Survey
VA	Virtual Access
VICAR	Video Image Communication And Retrieval
WWU	Westfalische Wilhelms Universitat Munster

Introduction

The GMAP JRA activities, as set out in the DoA, include the following tasks:

Task 9.1 - Coordination

Task 9.2 - Geological Mapping Standardisation

Task 9.3 - Basemap and Pipelines geological mapping services

Most activities during the first year of GMAP JRA3 were focused on Task 9.2 and planning and developments for Task 9.3. The key deliverable from Task 9.1 in the reporting period is D9.1 (Standard Definition Document - 1st Iteration, Nass et al., 2020), which supports both VA3 (See Massironi et al, 2021) and further JRA3 activities and deliverables. The path leading to D9.1 (see task) included the formation of a topical team and their interaction.

Impact of the COVID-19 situation on JRA3

GMAP JRA3 activities did not entail large 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 has had a certain impact on the 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. Therefore, the planning for 2021-2022 has been rescheduled with some delays on relevant deliverables and milestones requested in the Grant Amendment, summarised in Table 2:

Table 2: GMAP JRA deliverables and COVID-related delays planned

No.	Deliverable name	Lead partner	OLD Due project month	NEW Due project month
D9.1	Standard definition Document 1st iteration	DLR	6	7
D9.2	GMAP JRA 1st year report	JACOBSUNI	12	12
D9.3	Imaging and mosaicking basemap pipeline/guidelines	JACOBSUNI	17	19
D9.4	Stereo-DTM and Digital Outcrop Model pipelines/guideline	UNIPD	24	24
D9.5	Hyperspectral mapping pipeline	INAF	25	26
D9.6	GMAP JRA 2nd year report	JACOBSUNI	25	26
D8.7	Standard definition Document 2nd iteration	DLR	26	27
D9.8	GMAP JRA 3rd year report	JACOBSUNI	26	27

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

The activities carried out over Year 1 of the project for JRA3 are described for each task. The anticipated outlook on upcoming activities of the various tasks is provided in the final section.

- **Task 9.1 - Coordination**

Periodic online interaction across partners has been performed throughout the reporting period. In order to serve both JRA3 and VA3 for discussion and task tracking, a git version control system[1] has been set up to support internal development. Additionally, publicly available code and tools are going to be delivered to the public GitHub organisation[2].

Technical discussions have been consolidated in the GMAP wiki[3], both for JRA3 and VA3.

Also, interactions have been initiated with USGS Astrogeology, with the aim of sharing information and starting a potential cooperation. Coordination with USGS is planned in the workshops to be carried out in Year 2 of the RI, and the potential for joint sessions, workshops or additional cooperative activities will be discussed.

- **Task 9.2 - Geological Mapping Standardisation**

While the deliverable D9.1 (Nass et al., 2020) of this Task has been a document that refers to several sources for the state-of-the-art, the process by which the task arrived at the production of the document was based on topical teams. All beneficiaries participated in this activity, in order to address the relevant geologic-cartographic issues for all Solar System bodies and their peculiar geologic processes.

- *Topical teams*

Topical teams were formed by exploiting expertise from several beneficiaries and covered the following topics, bodies and processes, i.e.:

- The Moon and Mercury
- Mars sedimentary processes
- Mars volcano-tectonic processes
- Venus
- Icy satellites
- Asteroids / dwarf planets
- Comets

The reasons for forming specific teams on different tasks were

- To find the most user-centric standardisation for the mapping process and the final products as possible to create the most common visual (via symbology) and textual (via metadata) description of the map and map objects as possible
- To define the right procedure for mapping in each of the mapping topics.

Topical teams for the standard definition (cartographic, process-related, body-related, etc.) were comprised of 3-5 (or more, as needed) individuals. Members could participate in one or more teams.

Each group of Solar System bodies has its own planetary geologic issues, e.g. the challenges of mapping in full 3D a comet (See Nass et al, 2020, and ref. therein).

The inputs initially used to build D9.1 are described in Table 3. The TOC of D9.1, particularly for sections 3, 4, 5 of D9.1, reflects the input from the topical teams and the consolidated responses to the questions posed in Table 3.

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[1] https://git.europlanet-gmap.eu/
[2] https://github.com/europlanet-gmap
[3] https://wiki.europlanet-gmap.eu/

Table 3: Topical teams questions, for each Solar System group / geologic process

Type of question	Question no.	Description
General Info	1.1	What is your scientific education/background, or that of the team (multiple answer in the same box OK)
General Info	1.2	What is the main planetary body for your work?
General Info	1.3	What is your main scientific topic?
Experience	2.1	Did/do you produce some digital map? YES/NO If NO jump to SCIENTIFIC QUESTIONS (section 4 of the questionnaire) If YES please continue here. Please feel free to elaborate and provide example, links DOIs, scientific references, link to datasets, etc.
Experience	2.2	Was the map computational (e.g. compositional, albedo)?
Experience	2.3	Was the map interpretative (e.g. geological, geomorphologic)?
Experience	2.4	Do you use other maps (analog or digital) as basis data for your research? If yes, which type of maps (e.g. geologic, geophysical, structural maps ...)?
Experience	2.5	Do you use any additional data type not covered by the questions above? Please elaborate
DATA AND SOFTWARE / TOOLS	3.1	Which types of data sets are important for your work (e.g. orthoimages, controlled mosaics, DTM, spectral/thermal ...)
DATA AND SOFTWARE / TOOLS	3.2	Which technical tools and/or software do you use (GIS, web-based services like JMars, Image processing ...)?
DATA AND SOFTWARE / TOOLS	3.3	How much do you depend technically on other/external processing tools v.s. own/institutional ones? Please elaborate, e.g. gis-ready products, spatial data infrastructures vs. raw DATA and own processing, or proprietary tools (e.g. DLR-VICAR, or non-public code/tools/datasets).
DATA AND SOFTWARE / TOOLS	3.4	Are you experienced and willing to support (or just test) any development of Open Source (e.g. crater size-frequency analysis) related to GMAP?
SCIENTIFIC QUESTIONS	4.1	Which are the most characteristic surface features of the planetary body you are interested in (up to five)?
SCIENTIFIC QUESTIONS	4.2	Which are the most interesting subjects for geologic mapping?
SCIENTIFIC QUESTIONS	4.3	Could you list some key references in geologic mapping / published maps of the last 5 years or so?
SCIENTIFIC QUESTIONS	4.4	How do you represent geology vs. geomorphology and which challenges are you facing in doing/distinguishing the two approaches?

(TECHNICAL) MAPPING QUESTIONS	5.1	Do you already use a cartographic symbol or textual description for features you listed under 4.1.?
(TECHNICAL) MAPPING QUESTIONS	5.2	Process of digitalisation (e.g. worked on contacts, vs. polygons)?
(TECHNICAL) MAPPING QUESTIONS	5.3	At which scales and resolution?
(TECHNICAL) MAPPING QUESTIONS	5.4	Which projection(s) do you use?
(TECHNICAL) MAPPING QUESTIONS	5.5	Do you make calculations based on the mapping results (e.g. crater size-frequency counting, volumes/areas)
(TECHNICAL) MAPPING QUESTIONS	5.6	Which reference documents, handbooks, resources, standards do you use for creating your map?
(TECHNICAL) MAPPING QUESTIONS	5.7	How do you deal with discontinuous data coverage interpolation/extrapolation, data gaps?
(TECHNICAL) MAPPING QUESTIONS	5.8	How do you envisage the use of 3D data (meshes and point clouds) for geologic mapping in your use case(s)?
(TECHNICAL) MAPPING QUESTIONS	5.9	How do you map in 3D / perform mapping instrumental to 3D geologic modelling? Which tools did you use (Open Source / Proprietary)?
(TECHNICAL) MAPPING QUESTIONS	5.10	What is missing or needs to be improved within the whole mapping process to support your scientific mapping process (e.g. exchange platforms, templates, guidelines, standards)?
(TECHNICAL) MAPPING QUESTIONS	5.11	Can you exemplify (e.g. it is enough to quote a paper/map, or put excerpt of papers/map) some symbology already for your mapping projects and/or you can mention literature (e.g. a published map)?
ADDITIONAL INPUT/FEEDBACK	6	Please feel free to add any additional comment or feedback (e.g. this question is missing, this dataset problem is important and not covered by current questions)

- *Inputs from VA*

The collection of further inputs from beyond those directly available from Europlanet 2024 RI participants and accessible in the literature will be extended through wider consultations with the the GMAP VA3. This will be initiated via the Geology and Planetary Mapping Winter School[4] and inputs will be collected throughout the duration of the EPN-2024-RI project. The inputs will be embedded in the live version of D9.1 and its later consolidated deliverable version (D9.6).

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

○ Task 9.3 - Basemaps and Pipelines for geological mapping services

The planned activities, as described in the appendices of D9.1 (Nass et al., 2020) 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 planned in order to provide support to the VA users, also with documentation (see also GMAP VA3 report), guidance, and cloud services for the users.

Mosaicking web services are being developed, building upon Open Source tools delivered by the NEANIAS H2020 project[5]. Future developments, especially for ML data exploitation supportive of geologic mapping, will also make use of upcoming results from the recently funded EXPLORE0[6] H2020 project (November 2020 - October 2023).

Base maps from recent Chinese missions are going to be used and integrated with additional data (mainly for the Moon).

■ *Specific developments*

Specific developments and sub-activities within Task 9.3 are listed here. Please refer also to the Appendix material in D9.1 (Nass et al., 2020).

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

For more details see the 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 the next section, and Appendix 3 of D9.1), due to their more urgent requirement for performing mapping within the GMAP VA community mapping projects.

Map sheets templates will be designed and tested in the course of 2021 for rolling out initial versions in the second part of 2021.

The reference entry point for such templates will be the GMAP web site[7].

- *Mapping aids (Mappy)*

See fAppendix 3 of D9.1 (Nass et al., 2020) for more details. Additional mapping aids not specifically developed by GMAP but adopted and or slightly modified, updated and integrated are listed within the same Appendix 3.

A curated list of tools will be available on the GMAP Git repositories and from the GMAP web page entry point[8].

- *Symbology*

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

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[5] https://www.neanias.eu/
[6] https://astro.acri-st.fr/explore/
[7] https://europlanet-gmap.eu/templates
[8] https://europlanet-gmap.eu/tools

- *Review workflow.*

The design of the review workflow has been initiated. Some minimum viable product will be tested in 2021 and it is planned to roll it out for the first batch of VA3 community mapping projects in the second part of 2021.

- *Data licensing*

Appropriate and meaningful options for licensing released data deriving from VA3 community mapping projects will be evaluated and provided as options for VA contributors. Best practice from existing projects will be adopted. Feedback from the community is planned through the periodic winter school / workshop and throughout the year in between GMAP VA calls (see also D8.1).

- *Machine learning tools and algorithm development*

To develop tools for automated landform detection and mapping, both Machine Learning (ML) and Deep Learning (DL) have been utilised.

Deep Learning Object Detection (DLOD) is an advanced technique based on Convolutional Neural Network (CNN) for detecting single-to-multiple objects in an image or video with a bounding box and centroid of the detections as results, while Deep Learning Image Segmentation (DLIS) divides the images in areas of different types (based on user class definitions) at a pixel-wise level, thus returning polygons instead of bounding boxes. DLOD and DLIS python tools are in development, meanwhile training datasets are in image collection phase and labelling.

Machine Learning Image Classification (MLIS) is an advanced technique that is simpler than Deep Learning, hence not based on CNN but on other algorithms with the aim of classifying an entire image based on the relevant content present. MLIS python tools are also in development, with the dual aim of conducting a preliminary image classification and assisting the DL training dataset image collection.

Also, image pre-processing and data augmentation python tools have been developed (e.g. Nodjoumi, 2020) for automatic processing of large amounts of images. This tool has been developed specifically for high-resolution georeferenced planetary images, but works also for normal images. See also the GMAP VA3 report (Massironi, et al, 2021)

○ **Dissemination activities**

■ *Scientific dissemination*

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

■ *Outreach*

GMAP has been presented as an invited keynote at the DLR Software System internal workshop in November 2020.

3. Timeline and outlook

In the next year of GMAP JRA3 will be mostly devoted to the developments of Task 9.3, with a minor - but significant - emphasis on Task 9.2, particularly gathering VA3 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 3.

Table 3: Envisaged activities of GMAP JRA for Year 2

Task no.	Name	Plan for Y2 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	Development and technical implementations of data services, integration with VA (e.g. community support via task 8.2)

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