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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:

A progress report for year 3 of the Virtual European Solar and Planetary Access (VESPA) Joint Research Activity of the Europlanet 2024 Research Infrastructure is provided.

The overall VESPA infrastructure has been significantly upgraded following the validation of the EPN-TAP data access protocol as an international standard (see VESPA VA report). Validation tools have been published as generic Virtual Observatory tools (in TOPCAT and DaCHS), the service registration process has been made more compliant with standard VO practices and most data servers located in beneficiary institutes have been updated accordingly. The study of the usability of EOSC in the context of VESPA was also continued.

The main tools provided by the astronomical community and used by VESPA to visualise and analyse the data were upgraded in this period, most notably TOPCAT, Aladin and CASSIS.

User interfaces (SSHADE UI and VESPA portal) are being upgraded from user feedback and design studies, with new functions added – this activity is expected to carry on until the end of 2023.

Several services requiring a specific design have been studied and validated, in particular related to spatial footprints and support of spectral data.

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1. Explanation of VESPA WP7/JRA2 Work & Overview of Progress

a) Objectives

Task 1.

- Coordination – ObsParis, CBK-PAN + JacobsUni

Task 2.

- Infrastructure – ObsParis, CNRS/IRAP + UCL, CBK-PAN, CNRS/CDS
- Setting the stage for use of EOSC in VESPA (for services and computation); Implementing the code-on-line platform OPUS to analyse data.

Task 3.

- Tools & Interfaces – JacobsUni, CNRS/CDS + Heidelberg, Spacefrog, Bristol Uni, ObsParis, CNRS/IRAP
- Improving user interfaces, visualisation / analysis tools, and data servers

Task 4.

- Design of internal services – CNRS/IPSL, CNRS/IRAP + ObsParis, JacobsUni, DLR
- Studies of services requiring specific design, such as Global Climate Models, VO-GIS interfaces, etc

b) Explanation of the work carried in WP

The present report is one of the deliverables of WP7 VESPA VA (D7.7). Other deliverables due in year 3 are:

| # | Title | Delivery date (internal) |
|------|--|--------------------------|
| D7.3 | Report on extended Planetary Science support in Aladin beta, with use cases (and possibly new release of Aladin) | 2/5/2022 |
| D7.4 | Report on extended Planetary Science support in CASSIS beta, with use cases (and possibly new release of CASSIS) | 24/5/2022 |
| D7.5 | New release of TOPCAT or report including extended Planetary Science support, with use cases | 11/1/2022 |
| D7.6 | Run on demand platform (OPUS) with applications to Planetary Science context & Study for installation on EOSC | 23/9/2022 |

The schematic VESPA infrastructure is summarised in Fig. 1 to help follow this discussion.

Acronyms are explained here: <http://www.europlanet-vespa.eu/glossaire.shtml>

Tools of interests are listed here: <http://www.europlanet-vespa.eu/tools.shtml>

Task 1

Task 1 is responsible for the overall coordination and management of the JRA. Interaction tools to support the VESPA JRA team have been installed at the start of the project. Deliverables and milestones are listed and linked from this page:

<https://voparis-wiki.obspm.fr/display/VES/Deliverables+and+milestones%2C+EPN2024>

The VESPA Confluence site also contains extensive material about the WP activity.

Coordination of the two VESPA WPs has again focused on discussions in smaller groups during year 3, with a broader meeting taking place at EPSC 2022 in Granada. Small group interactions are particularly efficient for the JRA / WP7, as the activity mostly involves technical developments.

Task 2

- The VESPA infrastructure has been upgraded following the validation of the EPN-TAP data access protocol as an international standard in August (see VESPA VA report). The complete EPNCore vocabulary is implemented in DaCHS to provide automated definition of standard parameters when setting up a data service, and an EPN-TAP validator is now included in taplint (generic TAP validator associated to TOPCAT). Most published services were updated to be made compliant with the standard.

- The service registration process has been updated to be more in line with (evolving) VO practices, and most data servers located in beneficiary institutes have been updated accordingly. The central IVOA registry has also been cleaned up to remove early and deprecated assessments of EPN-TAP services (including from external teams).

- The DaCHS server (recommended to install new EPN-TAP services) has been updated to v2.6 to include specific support for EPN-TAP and incremental updates of service contents (MS63).

A DaCHS installation on Docker has previously been published and is available at: <https://github.com/gavodachs/docker-dachs> (MS41 during year 2)

This has been fine-tuned for VESPA during year 3 and is documented here:

<https://voparis-wiki.obspm.fr/display/VES/Deployment+of+a+VO+Server+with+Docker>

This version is particularly handy to test new data services, and will be used for future VESPA implementation workshops in the VA.

- The OPUS platform developed in H2020 ESCAPE was installed for VESPA on a fixed machine at ObsParis during year 1, and is currently used by the MASER services and the SPIDER WP. The deployment on a local cluster and on EOSC servers has been successfully achieved (D7.6) and provides a strong basis for future applications in the programme. An Authentication and Authorisation Infrastructure (AAI) is used to manage the user community's access in simple cases, based on the collaboration with EduTeams / GÉANT during year 1 - this system is now commonly used to provide external access to the VESPA Gitlab where services files are maintained. Cluster configuration and management on EOSC (e.g., shutting off unused nodes to save power, or dynamically adding new nodes to face peak activity periods) require familiarity with EOSC interfaces and will be studied in a next step.

- Two Europlanet-VESPA communities have been declared:

in EUDAT / B2share: <https://b2share.eudat.eu/communities/Europlanet-VESPA>
and Zenodo: <https://zenodo.org/communities/europlanet-vespa>

These can be used to store data produced by other WP (most notably the TAs) with a reduced set of metadata consistent with EPN-TAP. These are intended as backup solutions to make challenging data available with minimal effort, which seems

required, e. g., for field measurements — such data will not be searchable by content, but will gain visibility.

- Mirroring of resources is being studied to increase the sustainability of VESPA data services. A basic prototype has been set up using a set of features in Git, namely Large Files Support (LFS) and Submodules.

Task 3

The main tools provided by the astronomy community were developed or upgraded for use with Planetary Science data, from identified use cases:

- (D7.3) From version 11.122, Aladin supports non-celestial coordinate frames and MultiOrder Coverages (MOC) on planetary surfaces. Version 12 was released afterwards, exposing planetary data directly in the standard data tree (this was previously only available in beta versions). This provides access to 60+ planetary HiPS (multiresolution maps), including a new, full resolution CTX map of Mars (16 GB).
- (D7.4) The last update of CASSIS (version 6.3) includes extended support for spectra in reflected light. The specific EPN-TAP client developed during Europlanet 2020 RI was updated to reflect the final version of the protocol. A CASSIS plugin is now available in Aladin to allow the exploration of spectral cubes. Finally, the SSHADE bandlist system has been implemented to provide quick identification of spectral features in observational data.
- (D7.5) A new update of TOPCAT has been released (v4.8.7) with full support of EPN-TAP (service validator) and improvements for datalink, MOC footprints, and spectral data included in tables.
- A plugin for the open source application ImageJ has been developed in Europlanet 2020 RI, to enlarge format support and add image processing functions in the VO. This plugin has been updated for recent versions, and now also works with the AstrolmageJ variation which is broadly used by the amateur community – the new plugin is under assessment and will be published on the VESPA Github (<https://github.com/e pn-vespa>).

VESPA is contributing in France to the CNES/INSU project of a Planetary Surface data node. In this context, ObsParis has implemented two on line services provided by CNES, which connect OGC/GIS standards used by geologists with the VO ones, used by astronomers:

- a converter of multiresolution maps (HiPS from the VO <=> WMS from OGC) at <http://voparis-vespa-hips-wms.obspm.fr:8080>
- a registry of Coordinate Reference Systems (CRS) for planetary bodies at <http://voparis-vespa-crs.obspm.fr:8080>

Planetary CRS defined by CNES and USGS in the planetary working group of OGC will be used in VO tools to describe planetary coordinates systems.

User interfaces are also active:

- (follow-on of MS38) The main SSHADE interfaces for users and providers have been further improved, and new functions added – in particular the bandlist interface published during year 2.
- (MS47 & 48) The collection of user feedback on portal usage was pursued during year 3 during Europlanet meetings and EPSC. The VESPA portal is redesigned from this user

experience feedback. An intermediate version has been released prior to EPSC (Sept 2022) to test it with the users.

- Tests on the ElasticSearch interface are going on to allow users to query services in natural language. Metadata from all services have been copied in ObsParis, allowing very rapid plots and exploration of content. However, regular updates appear difficult to perform (mostly due to the huge size of the PSA archive at ESA). This system is currently used as an additional tool to validate contents, and is expected to become the basis for an alternative query mode in the access portal.

Task 4

- (follow-on of MS25) The VizierR_planets service was published during year 2 in a somewhat preliminary form (incomplete description of the content) due to specificities of Planetary Science data not necessarily implemented in a mainly astronomical archive. The service was updated during year 3 to extend the period of interest (up to present), remove remaining outliers and reach a higher level of accuracy. All catalogues are now identified in term of target class and (whenever possible) target name. Work is however still required to finalize an efficient procedure to describe planetary data related to publications.

- So far, spatial footprints were described in VESPA using a system of contours. We started this year to assess the use of MOCs, which are lists of healpix cells at varying resolution. This system can handle non-connected regions and the addition of time coverage, which is ideal to describe the acquisition time lines of, e.g., space instruments or observing programmes. It also proves to be much quicker when searching for intersections or overlaps. MOC have already been included in two data services and are supported by TOPCAT and Aladin.

- Since TOPCAT can now exploit spectra provided in tables cells, an assessment is being performed to present observations of Mercury this way. This allows direct searches on the data content (e. g., albedo or spectral ratio), at the expense of access time and complexity.

- Work is going on with ESA and NASA PDS/PPI (UCLA) independently, to optimize access to space agency data.

VESPA: infrastructure

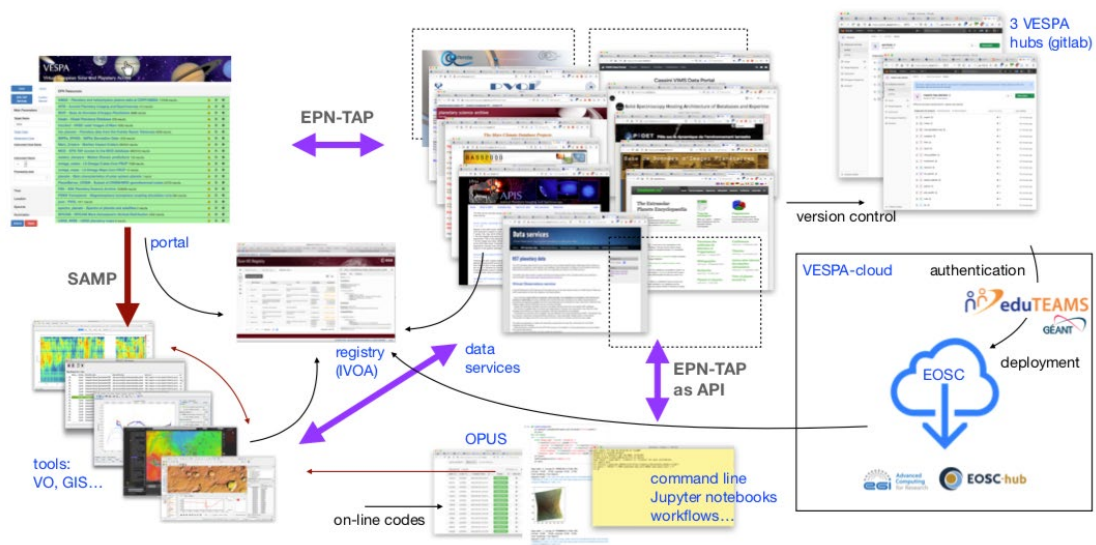


Figure 1: VESPA schematic infrastructure

c) Impact to date

The VESPA JRA is mostly in support of the VA, which delivers most of the impact. For the JRA specifically, the addition of functions in support of Planetary Science in the standard VO tools certainly tightens the links with the Astronomy community and increases the visibility of Planetary Science in the Astronomy VO. This is reinforced by regular contributions of the VESPA team to the Solar System Interest Group of IVOA, to IPDA meetings with space agencies, and to the IHDEA meetings for heliophysics. The validation of EPN-TAP as an IVOA standard has produced a step change in the way the infrastructure proposed by Europlanet / VESPA is seen by these communities.

d) Summary of plans for Year 4

Objectives for year 4 include:

- Finalization of the VESPA portal update
- Finalization of the Elasticsearch study, and possibly alternative query system
- Increase congruence between VO and OGC tools and standards (to make Earth observation tools usable for Planetary Science)
- More evolutions of VO tools (TOPCAT, Aladin, CASSIS) from user inputs
- Further study of stability of services on EOSC

2. Update of data management plan

Not applicable for JRA2 WP7.

3. Follow-up of recommendations & comments from previous review(s)

The review panel recommended to move the VESPA portal to https, which has been done.