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Executive Summary / Abstract:

An update for year 3 of the Virtual European Solar and Planetary Access (VESPA) Virtual Activity of the Europlanet 2024 Research Infrastructure is provided.

Sustainability was the main focus during the third year of the project, with the EPN-TAP protocol validated as an international IVOA standard, major upgrades of the several data servers, cleaning of the IVOA registry, and the storage of most existing services in a single GitLab repository. In addition, 5 new services were published (3 were retired), ~15 services drafted, and many existing services upgraded to provide more functions (such as footprints). Both SSHADE and PVOL enlarged their content significantly, with addition of spectral bandlist to SSHADE and Juno data to PVOL. Individual DMP were started for data services.

The third implementation workshop is being prepared to be held in Graz in April 2023. 3 papers have been published, and many presentations given in international conferences and workshops.

Intense collaborative activity has taken place with international consortia, e.g. IVOA, IPDA, and IHDEA.

Table of Contents

1.	Explanation of VESPA WP6/VA2 Work & Overview of Progress	3
a)	Objectives	3
b)	Explanation of the work carried in WP	3
c)	Impact to date	7
d)	Summary of plans for Year 4	10
2.	Update of data management plan	11
3.	Follow-up of recommendations & comments from previous review(s)	11

1. Explanation of VESPA WP6/VA2 Work & Overview of Progress

a) Objectives

Task 1.

- Coordination — ObsParis, JacobsUni + CBK-PAN

Task 2.

- Enlarging VO content (beneficiaries) – BIRA/IASB, ObsParis + All
- Design and implementation of services from beneficiaries

Task 3.

- Enlarging VOcontent– JacobsUni, OeAW/IWF + CBK-PAN, ObsParis, CNRS/IRAP
- Design and implementation of services from calls to the community (external AO) and collaborations

Task 4.

- Amateur community linking / services – UPV/EHU, OeAW/IWF + ObsParis
- Design and implementation of selected services from the amateur astronomy community

Task 5.

- Consolidation – INAF/OATs, Heidelberg Uni + ObsParis
- A system to preserve data service definition files, perform technical reviews, and deploy them on EOSC when relevant

Task 6.

- Standards & Sustainability – ObsParis, Heidelberg Uni + JacobsUni, Bristol Uni
- Publication of VESPA standards, contribution to other standards of interest, dissemination through consortia and conferences

b) Explanation of the work carried in WP

The present report is one of the deliverables of WP6 VESPA VA (D6.14). The other deliverable due in year 3 is:

#	Title	Delivery date (internal)
D6.3	GEM-Mars GCM products and tools	18/3/2022

The schematic VESPA infrastructure is summarized in Fig. 1 of the VESPA JRA 3rd Year Annual Report (D7.7) 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 overall coordination and management of the VA and connection with the JRA. Deliverables and milestones are 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 focused on maintaining discussions in smaller groups during year 2, focussing on data services publication and updates, reports and documentations.

Task 2.

- Five new data services were published by VESPA beneficiaries during year 3:
 - Mars_dust (dust maps from the Mars Climate Database) (MS78)
 - VCD (Venus Climate Database: simulated atmospheric profiles) (MS82, in advance)
 - Mars_preTharsis (modeled topography) (MS69)
 - GEM_mars (Mars Global Circulation Model) (D6.3 from BIRA-IASB)
 - with "on the fly" interpolation of GEM-Mars simulations
 - NOMAD / GTO (vertical profiles of CO₂, O₃, H₂O + temperature in the atmosphere of Mars) (MS100, in advance)
- In the frame of the quality control activity, several early services installed during the previous Europlanet 2020 RI programme were retired:
 - The RadioJove demonstrator in ObsParis, to be replaced by a set of services from NASA PDS/PPI at UCLA
 - The IMPEX service at IWF/Graz, to be replaced by the complete IMPEX data tree from LATMOS/CNRS (Lathys service, drafted)
 - The VEx Mag service at IWF/Graz, which content is included in ESA's PSA service.

There are currently 62 EPN-TAP data services accessible through the VESPA portal. Others are pending publication.

- Advanced draft services include:
 - MESSENGER spectral maps of Mercury at DLR (will be MS66)
 - Radio services at CBK/PAN: parameters from ITUR propagation model (will be MS70)
 - NRH & ORFEES radio solar database at ObsParis
 - Stellar spectra to support calibration of planetary observations at ObsParis
 - POLARBASE planetary data at CNRS/IRAP
- In addition to services with evolving content, many older services from beneficiaries were significantly upgraded during year 3. These include:
 - HELIO catalogues of solar features, in particular hfc1ar: restored data & added coverages (as MOC)
 - SOIR / Venus profiles: entire dataset completed
 - TNOsAreCool: datalinks added (filter descriptions)
 - Meteor_showers: upgraded to use the new standard for generation of VOevents
 - cpstasm: service has been recovered and republished
 - AMDA: added HAPI interface to support long time series (MS64)
 - + SPEasy python module for Space Physics access
 - + datalink updated to access alternative formats
 - VVEx: geometry partly restored, footprints added (as MOC) + worked with ESA to restore the dataset in the PSA

- Spectro_asteroids : content increased by a factor of 13. With 6300+ entries, this now include most ground based asteroid spectra and is the largest collection after Gaia DR3

- NDA: datalinks updated / corrected; NewRoutine and Mefisto data to be added

- VizieR_planets: content enlarged by 30% (up to end of 2022), entirely reviewed; target_class is now always identified, target_name wherever possible (follow-up of MS25)

- Besides, services have been updated to comply with the new EPN-TAP standard and DaCHS server in several institutes: CNRS/IRAP (Toulouse); Jacobs Uni; CNRS/IPAG (SSHADE); BIRA; ObsParis (4 servers, including IMCCE). Discussions have started with ESA to provide a lighter access to the PSA service (now including more than 28 million files).

- SSHADE hosted almost 50 new datasets and about 1000 additional spectra during year 3, many provided by the 23 SSHADE partners, therefore maintaining the same cadence as during year 2. The SSHADE database now provides public access to 5300+ spectra of ices, minerals, rocks, organic matters and cosmomaterials (will be D6.13). Improvements in the user interface, in particular in the search tools and dynamic plotting tool, have been implemented. The simpler EPN-TAP service is now updated automatically from the SSHADE database.

The new bandlist database currently includes more than 29 absorption and Raman bandlists and 860 bands (from VUV to far-IR) of ices, organics and minerals (will be MS83). Its data model has been expended with new properties and its tools and interface to search, and display band lists and bands have been improved. The implementation of DOI has also started. Training sessions have been conducted for 6 SSHADE partners' database managers, to allow them to create and fill their SSHADE database.

- 68 planetary multiresolution maps (HiPS) are now available for use with tools such as Aladin. In particular, CNRS/CDS has produced and published the highest resolution Martian HiPS from MRO CTX data - this is by far the largest one with 31 TB of data: https://alasky.cds.unistra.fr/CDS_P_Mars_MRO-CTX/ (display in AladinLite)

A display demonstrator is also available from random thumbnails:

<https://aladin.cds.unistra.fr/AladinLite/showcase/mars-roulette/>

Task 3.

The third implementation workshop will be held in person at IWF/Graz in April 2023 – this has been slightly delayed because key local personnel have left during year 3. Preparation of the workshop has started, and the call to new projects is expected to open in February 2023.

In parallel, follow-on of the previous workshop (held on-line in Dec 2021) has led to advanced drafts of several services:

- The NASA/PDS Planetary Plasma Interaction Node (PPI), represented by UCLA, plan to make their complete data holdings available as EPN-TAP services. This encompasses ~ 200 datasets, 168 of which are currently installed as drafts. This is of course an

extremely demanding project which also impacts the layout and design of the VESPA query portal.

- two solar projects from the Royal Observatory of Brussels (sunspot and coronal holes catalogues), connected to the H2020 ESCAPE programme, are being finalized.
- The MP3C service in OCA, Nice (global properties of asteroids) is nearly finalized. The last point to solve is the compliance with the standard IAU naming scheme – for historical reasons, the service uses encoded target names which are difficult to resolve.

Besides, access to data from the TAs was studied after a first assessment during the 2021 workshop. Most spectral data produced by the TAs are or can be included in SSHADE; the situation is more difficult for the rest due, e. g., to file format (often proprietary) and size. These may however be made available on Europlanet/VESPA communities in EUDAT or Zenodo, with a minimal set of metadata. A global EPN-TAP service may later provide access at dataset level, making them accessible from the VESPA portal.

Task 4.

- PVOL was updated with new JunoCam images, with the addition of Perijoves 33 to 38 (April-November 2021) (MS65). PVOL now includes more than 62,000 amateur images (an increase of nearly 10% this year).

VESPA representatives attended the NA2 telescopic and fireball networks meetings during year 3, where the VESPA infrastructure and workflow were presented and applications discussed.

- The NA2 Telescopic Network data will be distributed at Adam Mickiewicz Univ, Poznan (“Parsec” EPN-TAP service, drafted with data input interface).
- Fireball network data will be assessed from the FRIPON database in Marseille. A service has been designed during year 3. Compliance of retrieved trajectories encoded as ECSV files with TOPCAT and Aladin has been checked.

Task 5.

The “VESPA hubs” activity installed during year 2 relies on a Gitlab server at ObsParis, where service definition files and server configuration files are stored and maintained by several teams (including Heidelberg Uni, and INAF/OATS). This is a by-product of the VESPA-Cloud activity in the JRA during year 1, reusing the AAI system provided by GÉANT for EOSC access.

More services and institutes have been accommodated during year 3. These services may be easily deployed on institutes’ servers, or possibly on EOSC VM, using the DaCHS docker installation developed in the VESPA JRA.

Two systems of DOI attached to the data have been installed, the first one internal to SSHADE (for spectra during year 1, then for bandlists during year 3), the second for general use in VESPA. The latter (based on Dataverse) was assessed during year 2 on test datasets; variations related to the new [recherche.data.gouv](https://recherche.data.gouv.fr/) Open Science platform in France are now being studied.

Finally, DMPs have been drafted for several services, see section 2.

Task 6.

Considerable efforts have been made to address sustainability and to finalize the VESPA standards with international consortia:

- The EPN-TAP protocol and the EPNCore metadata vocabulary from VESPA are now an IVOA Recommendation: <https://ivoa.net/documents/EPNTAP/>

This has therefore become the international standard to publish Planetary Science data in the Virtual Observatory. This is a major outcome of the VESPA activity and a large part of D6.11 due in year 4.

- In parallel, the final version has been reflected in the DaCHS server to support service implementation (EPN-TAP mixin plus extensive documentation) and in TOPCAT / taplint (service validator) to check compliance (MS63 and MS96).
- The generic VO web validator in ObsParis data centre now supports TAP (including EPN-TAP) and HiPS services.
- The SSDM bandlist Data Model from SSHADE has been completed to encompass new properties of materials.
- A new protocol TFCat has been proposed to IVOA to describe features in dynamical radio spectra. A validator has been added in TOPCAT / taplint.
- The "Observation facility nomenclature", started during Europlanet 2020 RI and also of interest to the astronomy community, has been revived:
 - The initial list has been updated with new sources.
 - Wikidata has been identified as a major on-line resource maintained by Internet users, however with many blind spots. This resource has been completed with our current list, and Wikidata administrators contacted for information on the tools available to track updates and new contributions.
 - The list will feed a name resolver similar to IMCCE's Quaero for target names. A documentation has been prepared for maintenance.
 - A meeting has been held with CDS (Strasbourg, France) for coordination of work between institutes. An IVOA Draft Note has been issued: <https://github.com/BaptisteCecconi/ObsFacilityWikidata>
- Simplified tutorials to install services have been produced to prepare the next implementation workshop.

c) Impact to date

Interactions with international consortia and projects continued during year 3:

- The adoption of EPN-TAP by the IVOA and representation of the Europlanet Society in the IPDA have triggered interest for use in the context of space agencies: NASA PDS/PPI (planning to provide all their data holdings with EPN-TAP), ESA PSA Guest storage facility (supplementary, non-PDS, datasets) and ESAsky (planetary data in an astronomy archive interface). JAXA and ISRO are also studying the use of EPN-TAP on their archives.
- The project of EPN-TAP data dictionary for PDS4 has also been revived. Withdrawal of the older and limited PDAP protocol is discussed in the IPDA, which would leave EPN-TAP as the basic standard to exchange data between space agencies.

- The two data hub projects supported by CNES and CNRS in France (Planetary surfaces and Small bodies) are progressing. VESPA will provide VO interoperability at least to the first one. Nearly all CNRS/INSU certified data services in Planetary Science and Heliophysics are now connected through EPN-TAP and the VESPA portal (MP3C being finalized, FRIPON drafted).
- As the importance of Open Science and FAIR access to the data progresses in many EU countries, we expect the VESPA data publication and access system to gain significant visibility at this scale.
- Involvement in international consortia such as IVOA in astronomy, IPDA for space missions, IHDEA for heliophysics, Research Data Alliance, and EOSC-related bodies is continued.

Conferences and meetings:

- A dedicated data session (MITM11) was organized at EPSC 2022 (Granada, 18-23 Sept, following EPN council) with 4 presentations and 3 posters related to VESPA. VESPA was also invited to present its infrastructure in the Open Science session (ODAA6) while several beneficiary teams were involved in the amateur astronomy sessions.
- The VESPA team attended the AGU meeting (Chicago, 12-16 Dec) and contributed to the IPDA booth. Presentations were also given at the PSIDA conference (ESAC, 21-23 June). SSHADE was presented at the 23rd International Mineralogical Association General Meeting (Lyon, 18-22 July 2022).
- VESPA was presented at the EOSC Symposium (Prague, 14-19 / 11 / 2022) and attended the EOSC workshop (Strasbourg, Jan 2023).
- VESPA and PVOL contributed to the Europlanet fireball network (4 Feb 2022), telescopic network (9-11 Feb 2022) and comet (Prague, 11 June) internal meetings.
- VESPA activities were presented at IVOA spring and fall Interop (24-29 April and 22 Nov, 6 and 3 presentations resp.) and IPDA meetings (Steering Committee on Sept 14-16 at ESAC, 2 on-line meetings earlier that year).
- At national level, VESPA and SSHADE were presented at the French meetings of CNES planetary surfaces data node (3 Feb and 12 Sept); at ASOV (French VO) annual meeting (ObsParis, 11-13/4/2022); at SF2A (French professional astronomy society) annual meeting (invited, 10 June, Besançon) and at PNP (French Planetary Science) meeting (29 June, Lyon).

Publications

At least 3 peer-reviewed papers using VESPA have been published during year 3, another one is in press.

Although not a science paper, the EPN-TAP IVOA Recommendation has also passed a deep review.

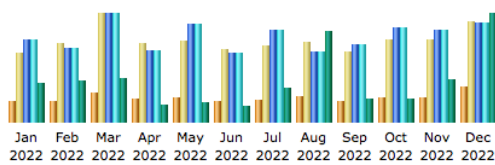
The VESPA 2018 PSS paper has reached 1000 reads on ResearchGate.

A 2 pages paper was also written for the Europlanet Magazine.

VESPA Access provisions to Research Infrastructures

Data access is difficult to monitor with a system of distributed servers. VESPA access can however be extrapolated from statistics of the main planetary science server in ObsParis, which hosts 25% of VESPA services, then checked for consistency with analysis of connections on the heliophysics and radio servers (another 25%). The figures are as clean as possible, with bots and spiders filtered.

In slight increase during year 3, there are each month estimated server accesses from 500-800 unique visitors and 2000 visits (download volume is not actually monitored). The largest shares are from JAXA (nearly 50%), French institutes (including the VESPA portal), ESA (mostly ESRIN), and various academic institutes in Europe and the US (including NASA centres). Occasional peaks occurred from unexpected countries: Norway (up to 8000 visits/month from March to July and at least 500 before that); Russia 500-1000 visits/month starting in Sept; Swiss (500+ in Dec) – the reason is unknown.



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2022	133	423	28,230	28,230	946.71 MB
Feb 2022	131	488	25,375	25,380	1.00 GB
Mar 2022	182	667	37,084	37,084	1.04 GB
Apr 2022	148	483	24,458	24,460	423.07 MB
May 2022	155	500	33,551	33,552	489.89 MB
Jun 2022	129	447	23,556	23,556	385.60 MB
Jul 2022	140	473	31,699	31,699	840.33 MB
Aug 2022	160	494	24,255	24,261	2.17 GB
Sep 2022	130	434	26,555	26,555	568.05 MB
Oct 2022	151	504	32,545	32,545	567.10 MB
Nov 2022	153	506	31,689	31,689	1.02 GB
Dec 2022	222	618	34,197	34,197	2.59 GB
Total	1,834	6,037	353,194	353,208	11.94 GB

Countries (Top 10) - Full list					
Countries		Pages	Hits	Bandwidth	
Japan	jp	162,324	162,324	2.87 GB	
France	fr	131,000	131,007	5.66 GB	
Norway	no	19,958	19,958	105.87 MB	
European country	eu	17,104	17,104	169.42 MB	
United States	us	6,725	6,725	594.18 MB	
China	cn	3,714	3,714	743.60 MB	
Russian Federation	ru	3,472	3,472	180.71 MB	
Great Britain	gb	2,520	2,520	150.20 MB	
Germany	de	1,091	1,091	133.55 MB	
Switzerland	ch	984	984	75.72 MB	
Others		4302	4309	1.30 GB	

Fig. 1: 2022 statistics for main server at ObsParis, providing 25% of VESPA content. Download volume is not actually monitored

In 2022, the VESPA portal alone (<http://vespa.obspm.fr>) has received ~ 180 visits / month, a slight increase but with a more even world repartition (Europe: 55%, N America: 16%, Asia: 23%, Other: 6%). Access statistics on the servers are more comprehensive than the portals, as they also reflect connections via tools, command line, and other APIs; conversely, many queries can be issued during a single visit of the portal. Use of the VESPA portal however seems to become a more standard way to access the servers — apart apparently from a regular mirroring at JAXA.

The public web site (<http://www.euoplanet-vespa.eu/>, entry to tutorials and docs) has received ~100 visits / month, again with a marked peak in October after EPSC

and IVOA meetings. The VESPA Confluence wiki (<https://voparis-wiki.obspm.fr>, mostly for data providers and beneficiaries) has 170 connections / month.



Fig. 2: VESPA portal use in 2021-22 (average visit duration in violet, max value is 10 min) – monitoring was down in July 2022.

SSHADE is simpler to monitor, as regular users are registered: currently 460 (increasing by more than 25% since last year). The main access is through a single dedicated interface, not the VESPA portal; SSHADE access statistics should therefore be added to the VESPA servers above. Raw aggregate statistics indicate 1800 visitors and 2800 visits per month (most are not registered), with ~6 GB downloaded each month (with stable repartition: Europe 45%, N America 28%, Asia 23%, Other 4%). PVOL now has 453 registered contributors (~100 more than at the beginning of the project), and the service content enlarged by ~10% again during year 3. Since it opened in 2003, this reflects a very strong increase in use. The number of views jumped from 70,000 to 400,000 between 2021 and 2022; the extra number mostly originates from China, probably reflecting a large but unknown part of bot access.

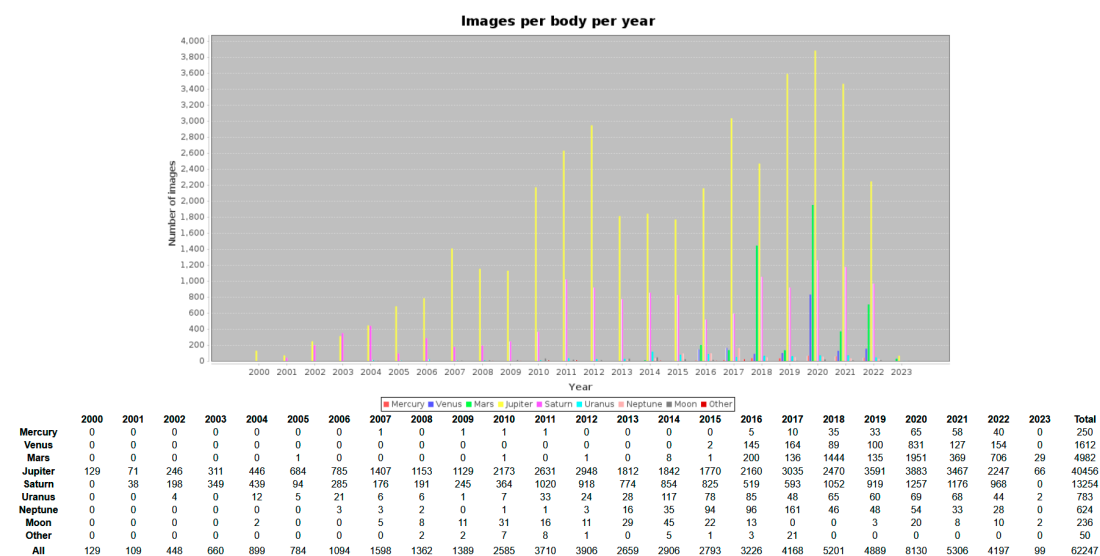


Fig. 3: PVOL content statistics

d) Summary of plans for Year 4

Objectives for Year 4 include:

- Organizing the 3rd VESPA implementation workshop in Graz, and finalizing projects started during the 2021 combined workshop and discussed in the meantime.
- Adding more content from beneficiaries in providing the milestones and deliverables — especially in the fields of exoplanets and celestial mechanics which are a bit behind. Our roadmap is visible here:

<https://voparis-wiki.obspm.fr/display/VES/EPN-TAP+Services>

- Practical installation of data distribution systems for various activities in NA2 (telescopic network, fireball networks...) and TAs (lab and field measurements)
- Finalizing the modernization of the registry, in compliance with new IVOA standards.
- Finalizing the Observation facility list and using it with EPNCore.
- Continuation of interactions with consortia: attendance to both IVOA Interop meetings; IPDA Steering Committee and other meetings; organisation of an IHDEA meeting at ObsParis on 10-13 July 2023.

2. Update of data management plan

The VESPA contribution to the Europlanet DMP has been updated in February 2022 (and praised by the review board).

Detailed DMPs have been implemented during year 3 for several individual EPN-TAP services in various institutes:

<https://voparis-wiki.obspm.fr/display/VES/Individual+DMP+of+EPN2024RI+collections>

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

The 2nd report from the VA review board (Deliverable D1.8) was received at the end of July, 2022. Concerning VESPA, they included:

- 1) Visual presentation of access statistics, including for PVOL — see above
- 2) VESPA DMP to be used as a model for other WP (this is not on our side)
- 3) Move portals and services to https domain — this has been done for the VESPA portal, with redirection from the original http site.