EPN2020-RI

EUROPLANET2020 Research Infrastructure
H2020-INFRAIA-2014-2015
Grant agreement no: 654208

Deliverable: D11.3
Second VESPA incremental report

Due date of deliverable: 2017/08/31
Date of submission: 2017-08-28

Start date of project: 01 September 2015 Duration: 48 Months
Responsible WP Leader: Stéphane Erard

Project co-funded by the *European Union's Horizon 2020 research and innovation programme*		
Dissemination level		
PU	Public	•
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (excluding the Commission Services)	

Project Number	654208
Project Title	EPN2020 - RI
Project Duration	48 months: 01 September 2015 – 31 August 2019

Delivery date	2017.08.28
Title of Document	Second VESPA incremental report

Contributing Work package (s)	WP11
Dissemination level	PU
Author (s)	Stéphane Erard
Abstract: This document summarizes VESPA infrastructure progress (JRA) during the first year of the Europlanet 2020 contract	

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This document summarizes VESPA infrastructure progress during the second year of the Europlanet 2020 contract and deals with the JRA activity. Formal deliverables are mentioned when relevant. Actions taking place in the VA are mentioned wherever they interact directly with design and development

activities in the JRA. They are described in the second VA progress report: D6.7 Second VESPA progress report.
Illustrations are available in the VESPA tutorials accessible here:
http://www.europlanet-vespa.eu/tutos.shtml

Task1 - Coordination

Communication tools

Tools to circulate information in the WP have been installed from the beginning of the program:
- Wiki (for document elaboration and monitoring of actions): https://voparis-confluence.obspm.fr/
- GitHub (code repository): https://github.com/epn-vespa
- Slack (for real time interaction): https://vespa-epn.slack.com/
- a set of 8 mailing lists managed at Paris Observatory for internal communication, publicity of the annual call (in the VA), and newsletters

Their content is publicly accessible. See D11.1 - VESPA website/GIT
The VESPA web site, mostly intended for the general public, was installed as a VA action (D6.1 - VESPA Website): http://www.europlanet-vespa.eu/

Task2 - Tools and interfaces

Data Access Protocol

An important action during the first year was to perform a major upgrade of EPN-TAP (Europlanet Table Access Protocol) which is now in version 2. During year 2, the underlying EPNCore data model was rationalized and completed (ObsParis and all).
All data services have been converted to version 2, which results in easier and straightforward design for data providers, better documentation of data, and more services to the end users. Most services have then been reviewed in detail, which allowed for iterative improvements of the protocol based on actual use cases. Several EPN-TAP extensions have been defined, in particular to support lab spectroscopy of minerals, contributive telescopic observations, small bodies services, and planetary aurorae. Services covering the same field now use identical optional parameters to introduce the same quantities.
EPN-TAP parameters, value lists, and associated UCDs/Utypes have been closely checked for consistency with other protocols, in particular with the ObsCore protocol from IVOA (International Virtual Observatory Alliance), to ensure optimal consistency with VO tools maintained by IVOA developers.
A formal documentation of the protocol will be submitted to the IVOA for validation next year.

Service set up

A TAP server is now installed in all beneficiary institutes; the standard server retained in VESPA is DaCHS, which is maintained at Heidelberg University. A "manual" service installation procedure has been identified and reviewed during year 1, including server installation, service design, registration.
As scheduled last year, this procedure has been greatly enhanced during year 2 thanks to a close collaboration with DaCHS developer in Heidelberg Univ (ObsParis, JacobsUni, IRAP, IWF, all). The new procedure relies on the use of a dedicated EPN-TAP mixin and existing grammars, and a support tool was developed for it:
https://github.com/epn-vespa/DaCHS-for-VESPA/tree/master/qrdcreator2
The procedure is now lighter, less error-prone, and more powerful, allowing, e.g., for automatic handling of evolving content, or ephemerides retrieval from IMCCE's Miriade service during service setup.
Definition files of many tested services are available publicly to serve as guidelines or templates:
https://github.com/epn-vespa/DaCHS-for-VESPA

This collaboration also resulted in improved support to EPN-TAP in DaCHS and will be finalized and documented in the coming year for use outside VESPA. In parallel, a preliminary procedure has been identified for services using the alternative TAPlib server, which is used by ESA and a few other groups. Declaration of EPN-TAP services in the IVOA registry is currently still difficult in practice; this is pending discussions in the IVOA, and a temporary procedure has been designed for VESPA.

Main user interface

The VESPA user interface is the main EPN-TAP search interface, which allows the user to discover and explore EPN-TAP data services (http://vespa.obspm.fr).
The interface has been completely redesigned to support EPN-TAP v.2, and many functions were added (version released in September 2016).
During year 2, more helper applications were connected to the interface, and specific query modes were improved, e.g. for spectral data. The result page has also been considerably accelerated by using pagination, and now supports larger services. Searches on inclusion/intersection of complex contours have also been improved in direct query mode.
Developments were based on use cases involving VESPA, CASSIS, Aladin, TOPCAT, 3Dview, and Mizar, e. g., direct VESPA connection to Mizar and Aladin for footprints on planets/satellites, to APERICubes for spectral cubes, and to CASSIS for reflectance spectra. Other use cases involve simultaneous work with related data services, in particular for small bodies, atmospheres, magnetospheres, and spectroscopy. Tutorials have been written to document these use cases (in the VA).
The next major upgrade of the main search interface will include merging the query and service pages, and retrieving results from many services together for cross-examination.
See VESPA interface on-line help: http://vespa.obspm.fr/planetary/data/epn/help
and roadmap for development: VESPA user interface
The client is available in an svn repository for installation on a private network, or on a virtual machine not connected to the internet (intended for service developers):
https://voparis-svn.obspm.fr/django-europlanet_client/Trunk/europlanet_client

Alternative data access

Alternative accesses to EPN-TAP services are now possible directly from VO tools.
For this purpose, an EPN-TAP library was developed by IRAP/CNRS in both java and javascript. This is intended to provide a lower-level and more direct access to individual services than the dedicated VESPA search interface, and will result in increased visibility of Planetary Science data in the VO. IRAP/CNRS coordinated the EPN-TAP v.2 library specifications (VESPA EPN-TAP Library specification) and performed the implementation during year 1. The library was first implemented with a GUI in 3Dview (D11.5) then in AMDA and CASSIS during year 2, and is still being tested. A more limited version is also used in IRAP's Propagation Tool to access some relevant data services, in particular APIS for observations of planetary aurorae.
The EPN-TAP library is currently available in v5.0: https://gitlab.irap.omp.eu/OV-GSO-DC/EpnTAPClient
Besides, a Google Sheets add-on was developed during year 1 to query generic TAP servers (IWF). It has been finalized and reviewed by the Google team, and is now available in their web store:
https://chrome.google.com/webstore/detail/tap-sheet/jojpnlhhnkcapkghjpeeojccpcoljdgg
Extensive tests of EPN-TAP alternative access from existing generic TAP clients progressed during year 2, in particular from TOPCAT and TapHandle (JacobsUni, ObsParis, IRAP). These access methods will ensure complete access to EPN-TAP services through the more general TAP mechanism, even in case the VESPA search interface and EPN-TAP disappear.
Finally, the initial design study of a VESPA access mobile App has been performed during the Planetary mapping workshop in Roscoff (April 2017, JacobsUni):
https://github.com/epn-vespa/vespamap17-hackathon/blob/master/vespa-app-design.md

Other access protocols were also explored:

• A general purpose VOevent server was installed in ObsParis during year 1. This will be used mainly for the PSWS WP but also for some applications in VESPA, e.g., the FRIPON meteorite fall alert system (in collaboration with GEOPS) and coordination of Jupiter radio observations in support of the Juno mission. Modifications to adapt the VOevent protocol to Planetary Science needs have been identified and passed to IVOA during year 2.
• Two web services were set up during year 2 to support pipeline activities (ObsParis). The file grabbing web services bypass the usual search interfaces to retrieve files directly from one or several EPN-TAP services more rapidly than a standard TAP query. This will fulfill the main usage of the older PDAP protocol (still used by space agencies):
https://voparis-confluence.obspm.fr/display/VES/File+grabbing+interface
• Another protocol has been sketched to access computing services using EPN-TAP parameters. This is intended in particular to launch atmospheric simulations (on-line radiative transfer codes) and will be developed during year 3:
https://voparis-confluence.obspm.fr/display/VES/EPN-ping

Improvement of standard VO tools

CASSIS (IRAP)
Version 5 of CASSIS was released in July 2017. As mentioned above, it includes the latest version of the EPN-TAP library for direct access.
CASSIS now supports radiance and reflectance spectra, which are quantities specific to Planetary Science. In parallel, a standard description of spectral data in VOtables has been identified (fits format still has to be assessed in details). A very flexible input and conversion system has been implemented to support data from non-VO services (e.g., providing simulated spectra of atmospheres), which significantly enlarges the scope of the tool.
The direct display mode makes it a very handy spectrum visualizer associated to the VESPA search interface. Connections with TOPCAT and other tools have also been improved.
Aladin (CDS)
As of v.9, Aladin correctly builds 3D spherical models of planets from cylindrical maps and processes them as a hierarchical tiling scheme (HiPS). Footprints defined via the s_region parameter in ObsCore and EPNCore, as well as surface features from catalogues, can be plotted directly on such 3D HiPS thanks to a refined implementation of Planetary mapping conventions in Aladin.
Another use of HiPS is to publish multi-resolution 3D models of planets from large image datasets. This system has been tested in some situations, including a High Resolution Mars HiPS from Themis/Mars Odyssey mosaics. A third application is to navigate HR panoramic images from the Curiosity lander. These test products are available for download in Aladin:
http://alasky.u-strasbg.fr/Planets/HipsList
Aladin is also being tested as a MOC generator - where spatial coverages are defined as lists of healpix cells to provide very quick spatial search functions at least on regular bodies.
Finally, a TAP client has been implemented in Aladin to query object catalogues. This is particularly convenient to handle EPN-TAP services that provide features spatially located on planets.
3Dview (GFI & IRAP)
Capacities of 3Dview have been enlarged during year 1 by reading Spice kernels from the original repository at JPL/NAIF - this allows the user to access any mission definition directly, as well as spacecraft attitude and fields of view for several individual instruments. User-specific kernels can be imported to study hypothetical configurations, e.g., for observation planning (see: D11.4 - Spice Kernels and Instrument FOV in 3Dview). The EPN-TAP java library from IRAP has then been integrated in 3Dview by GFI (D11.5).
During year 2, GFI implemented the projection of images from the APIS service on 3D shapes of planets, with proper time location (D11.7). This action completes the scheduled upgrades of 3Dview during Europlanet2020/VESPA.
Planetary Cesium Viewer (GEOPS)
A new multiresolution 3D viewer has been developed to handle 3D shapes (alternative to Mizar,

supporting ellipsoids). This application is based on the open source Cesium library, and has VO and GIS compliant interfaces, allowing it to interact with both TAP and WMS servers. It currently uses many maps and feature catalogues (selected and adapted from close collaboration with USGS), and proposes tools to add and flag vector objects. It can potentially display dynamic and vertical data. PCV has already been used in a collaborative work to update the reference catalogue of Martian craters.
http://134.158.75.177/viewer/Apps/PlanetaryCesiumViewer/index.html
APERICubes (ObsParis)
The spectral cube slicer for the VIRTIS instrument (on Venus-Express and Rosetta) has been upgraded to load other types of spectral cubes, and to send extracted/averaged spectra in CASSIS and TOPCAT:
http://voparis-apericubes.obspm.fr/

Other, external tools are also discussed with their developers in the IVOA framework:
TOPCAT (Bristol Univ)
Among other things, healpix maps available in TOPCAT are now used to integrate sparse measurements from some datasets (i.e., VIRTIS/Rosetta).
Mizar (CNES)
Has been used since year 1 to display 3D views of planets and satellites from the VESPA interface, and to overplot contours and footprints.
VOSpec (ESA)
During year 1, the VESPA team has provided user requirements to ESA for a possible upgrade of VOSpec, with use in Planetary Science. However, developments appear to be stalled at present. An open source solution is being discussed with ESA.

Link with non-VO applications

Existing tools developed outside the VO realm have been enlarged with VO interfaces to interact with VESPA:
Autoplot (Iowa Univ)
A SAMP interface has been installed to retrieve radio and planetary plasma data from VESPA services. This is particularly handy for time series.
QGIS (dev at JacobsUni)
A SAMP plug-in has been developed to work with spectral data and images from VESPA and other VO tools. This will provide a GIS-VO bridge for surface studies (see Surfaces task below)
ImageJ (dev at ObsParis)
A SAMP plug-in is being developed to exchange images with VO tools. This will provide format conversion and interactive image processing functions in the VO. This plug-in is currently functional with VESPA, Aladin, and TOPCAT. Still in assessment phase, will be distributed when stable.
MATISSE (ASI and IAPS)
A SAMP interface has been installed on MATISSE. Use cases were designed to improve the interaction with VESPA data services, especially those related to planetary surfaces.
Suggestions of improvements of external tools interface have been issued:
- WebGeoCalc from Spice/JPL – VOTable output is being implemented
- Improved connections with WMS Mars maps servers at USGS and Arizona State Univ (available in Planetary Cesium Viewer)
- QFitsView from Max-Planck-Institute for Extraterrestrial Physics - VOTable support and SAMP interface (pending answer)
- Several on-line spectral simulation services have been contacted to provide VOtable output compliant with the standards used in VESPA, but non-VO solutions have been identified to enter the data in CASSIS.
- Use of JPL's Treck tool in VESPA is being studied.

Workflows

A goal here is to assess the use of a workflow engine such as Taverna to chain successive operations. An instance of Taverna has been installed at UCL, and a tutorial is being written. This action will develop when more data services belonging to the same field are connected.
• Currently, test workflows are implemented in the frame of use cases with simple scripts (mostly python): https://github.com/epn-vespa/vespamap17-hackathon/tree/master/vespa-mapping-jupyter-samp
Possible applications include state-of-the-art methods to analyze spectroscopy of planetary surfaces, e.g., multivariate analyses and retrieval of Hapke's radiative transfer parameters. Other workflows will be studied in relation with magnetosphere and atmosphere themes (e. g., comparison of simulated and observed atmospheric profiles in the atmospheres of Mars and Titan), or small bodies properties.
• Helper applications to be used in workflows are being developed, most notably the new list of observatories and spacecraft - this will be implemented both as a resolver available from the search interface and as an EPN-TAP data service; it will also be used by the VISION method of Miriade to prepare observation runs (ObsParis, IWF):
https://github.com/epn-vespa/FacilityList
This list will include amateur facilities, and a public input interface will be available to amateurs to describe their observatory characteristics. This interface is being adapted from an older FP7 prototype at IWF as part of the NA1 activity (http://europlanet-na1.oeaw.ac.at/matrix/index.php?page=browse). The new code is available here:
https://github.com/epn-vespa/Matrix

Task3 - SSHADE

SSDM data model

The Solid Spectroscopy Data Model (SSDM) is now in version 0.8.3, which is the final version of the core part and already includes many specific extensions (IPAG + contributors). With respect to v 0.7 delivered at the end of year 1, it contains descriptions of much more sample types, including molecular solids, minerals, liquids, and various kinds of extra-terrestrial samples; in addition, many types of spectral measurements are now included, reflecting the wide range of data produced by the contributing laboratories. This also includes band lists, optical constants, etc. The SSDM was implemented in the global infrastructure and tested intensively with a large set of actual data (> 500 spectra).
In addition, the parameters mostly relevant to observers trying to interpret their spectral measurements have been identified in a spectroscopy extension of EPN-TAP, and matched with the SSDM (ObsParis, IPAG, DLR).

SSHADE infrastructure

A first prototype of the SSHADE infrastructure has been delivered in August 2016 (D11.6), together with SSDM v0.7.0, a complete data ingestion system, and simple interfaces for data producers and users. The prototype database was filled with a large set of generic fundamental data (molecules, minerals, bonds, chemical functions, publications, etc) and a small test set of spectral data of ices, minerals, and rocks from 3 laboratories of the SSHADE consortium (IPAG/CNRS, CML/IGS-PAS, PGL/IGS-PAS) to assess its ability to manage a set of databases.
During year 2, this prototype has been upgraded so as to:
- implement the changes, extensions, and fixes in SSDM from v0.7 to 0.8.3
- develop a file reader for the multiangle spectrum data file format (IRAP & Unibe)
- develop a backup/restorer tool in order to migrate imported data
- develop user accounts and groups, and manage database access authorizations
- enhance the data importer
- implement a versatile unit conversion system
- support data DOI

- develop the first level of a search engine
- implement a first version of the VO output (EPN-TAP interface)
Several iteration steps were required to accommodate special needs from some data providers. The final infrastructure will be delivered in January 2018 (according to the recent Europlanet amendment).

Task4 - Surfaces

• A plug-in for the QGIS open source application has been developed to exchange data between the VO and GIS (JacobsUni). Currently, this provides the QGIS open source application with SAMP connectivity and VOtables parsing, plus handling of simple polygonal footprints. In practice, QGIS can now receive WMS links (maps and spectral cubes) and VO footprints from an EPN-TAP service, and send footprints to Aladin or spectra to CASSIS (in addition, a small widget to extract spectra from cubes is available in the CRISM data service). The plug-in is distributed on the VESPA github:
https://github.com/epn-vespa/VO_QGIS_plugin/archive/v0.2.zip
In the future, the QGIS plugin will also convert GIS vector layers to data easily ingestible into DaCHS, inside a skeleton EPN-TAP table (currently on planning stage). Possible applications include ingestion of extra data to complement existing datasets, or building new EPN-TAP services from results of geospatial analyses.
• New use cases have been designed for large planetary imaging datasets (CDS and ObsParis). These involve in particular multiresolution maps (HiPS, Healpix) and coverages (MOC) in TOPCAT and Aladin. Distribution of MOC libraries (for coverages of arbitrary complexity) and planetary HiPS (for multiresolution maps of major bodies) from a general repository is being studied, together with possible connection with GIS applications.
• Requirements to easily compare experimental and observational spectroscopy data have been issued, with applications to surface composition (ObsParis in collaboration with DLR, and IPAG). This involves the VESPA search interface, CASSIS and SSHADE, and will extend to QGIS in the future.
• The geofits convention (an extension of fits for planetary surfaces) is finalized. Requirements for use with Aladin for planetary surfaces have been studied, and fits / GDAL conversion routines have been written (GEOPS in collaboration with USGS, and CDS):
https://github.com/epn-vespa/fits2vrt
• The Planetary Cesium Viewer tool is finalized, as described above (GEOPS):
http://134.158.75.177/viewer/Apps/PlanetaryCesiumViewer/index.html

Task5 - Magnetospheres

• A large EPN-TAP extension has been defined to ensure compatibility of new services with APIS. Several TAP servers & services were installed in Tohoku Univ (Sendai, Japan) following this model.
• CDF formats for spectral matrices (input to iPECMAN) and iPECMAN output has been finalized and implemented in iPECMAN in order to improve interoperability with VESPA and VO tools. The iPECMAN user interface has been redesigned (IAP/Prague).
• The Das2server system is tested to distribute space physics data with client-specified temporal resolution. This is needed for high-resolution datasets, such as the Juno-Ground-Radio products. This framework is developed by University of Iowa, and is fully compliant with Autoplot (ObsParis).
• The MASER python library has been enlarged to include CDPP, Nancay, Juno-Ground-Radio, Cassini, RadioJove data services. Methods to load files with various formats are being implemented (ObsParis):
https://github.com/epn-vespa/JUNO-Ground-Radio

Task6 – Small bodies

• SAMP has been installed on MATISSE; requirements for use with EPN-TAP services have been issued (IAPS)

• The computing system to retrieve Near-Earth Asteroids orbital parameters has been finalized during year 2 and validated by comparison with the older AstOrb service from Lowell Observatory. It runs automatically each time the source data are updated in the Minor Planet Center database (ObsParis/IMCCE).
The results are distributed in an EPN-TAP data service (DynAstVO) which has been publicly open in January 2017.
A non-interactive procedure has been identified to use the Spice kernels produced by DynAstVO in the Cosmographia tools distributed by JPL/NAIF.
• The Miriade ephemeris system has been updated to produce extra outputs (IMCCE/ObsParis): http://vo.imcce.fr/webservices/miriade/
The development is twofold:
1) Apparent magnitudes in many filters
- A database of spectral classes of asteroids and color indices in various photometric bands was built from multiple sources (PDS, literature). Apparent magnitudes in these filters can now be requested when using the ephemcc method (positional ephemeris) of Miriade.
2) 3D visualization in physical ephemerides
- Codes to retrieve and ingest shape models and spin solutions have been installed and tested. Existing shape models and spin solutions are collected from the PDS Small Bodies Node and from the DAMIT database in Prague. New models included in DAMIT are ingested in Miriade on a regular basis, so that newly available data are readily accessible.
- The interface can now produce realistic 3D views of the requested targets when using the ephemph method (physical ephemeris) of Miriade. This takes into account the magnitudes of the targets, background stars, and even potential background Solar System objects. Views are produced in FITS for simulations and PNG for on-line visualization.
- The system is publicly open but still under development. Future goals are to automatized the ingestion process of new DAMIT data, to accelerate the rendering, and to offer additional options related to observing conditions: magnitude range (saturation and zero point), PSF convolution (seeing, diffraction, or even user-supplied FITS image of a PSF), size of the field of view, etc. This will constitute the Planetary Scene Viewer functionality.

Task7 - Atmospheres

• Use cases to compare profiles observed (SPICAM/Mars-Express) and simulated (Mars Climate Database) have been developed. This underlines the need for helper applications to average profiles and spectra in a spatial region or during a time period.
• Requirements to run on-line radiative transfer codes have been issued, in particular for the ASIMUT code at IASB/BIRA.
• Data provided in the usual HDF5 format need to be converted to VO-compliant formats. Scripts/routines will be provided to convert the data into a format handled by VO tools.

Task8 - Exoplanets

Design of a new section on atmospheric properties in the Encyclopedia of extra-solar planets, and test implementation on the development server (see, e.g., planet hd_189733_b) has been performed during year 1.
During year 2, the AMD-stability (Angular Momentum Deficit) calculator has been included in the web site pages for ~ 30 planets.

Prospects

During year 1, VESPA delivered a redesigned access protocol, an updated interface implementing powerful search functions, and VO tools adapted to handle planetary science data correctly. In addition,

requirements for specific fields were studied and issued, in particular for spectroscopy, planetary maps, small bodies and atmospheric studies.
Building on these developments, VESPA has now improved all aspects of the infrastructure:
- the EPN-TAP protocol has been extended to address new science fields
- the main search interface allows better access to data services
- more helper applications are connected to the main search interface
- several alternative access modes have been implemented
- the VESPA system is now compatible with the major VO tools in many fields
- support for Planetary Science in VO tools has been hugely enlarged
- relevant non-VO tools have been connected to provide extra functions
- the connection with the GIS world is now effective
- the SSHADE set of experimental databases is progressing according to schedule

Most of the developments are approaching completion, and the infrastructure is actually used for science applications. The next steps will be to finalize the search interface (handling of several services together), SSHADE, the GIS-VO bridge, and several functions in the tools.
Although the JRA VESPA has been extended to accommodate extra developments, the main activity in the program will now be to enlarge the data content, to provide training to users, and to formalize the documentation – all of which pertains to the VA.