Deliverable D6.1

Current Catalogs

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CO	Only for the consortium members (including Commission Services)	

DOCUMENT STATUS

Issue	Date	Description
0.9	25/06/2018	First Draft
1	29/06/2018	Version 1 with introduction and conclusion added

DISTRIBUTION LIST

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1 INTRODUCTION

The report D6.1 present our current census and analysis of exoplanet catalogue and virtual observatory tools that offer potential benefits for building a Knowledge server including:

- Access to science products.
- Access to exoplanet datasets.
- Access to analysing tools.
- Retrieval of data produced by the Exoplanets-A.

This census and the conclusions might evolve over the next six months that will be used for defining the Knowledge server architecture.

For this purpose, the current online catalogues have been reviewed and summarised in one page format each. Catalogues were searched on the Web through Google and specific keywords as well as based on our actual knowledge. The census was compared to the catalogues listed in the paper "Exoplanet Catalogues" (by J. Christiansen, in Handbook of Exoplanets, 2018 - https://arxiv.org/abs/1803.11158) for completeness. Two specific transit and habitable exoplanet catalogues were added following this comparison. "VO tools of interest" census follows the same process and was based on INTA knowledge.

As an introductory work, two "citizen science" projects are described as potential source of imagination for the public outreach part of our project.

2 APPLICABLE DOCUMENTS (AD)

AD-1	ExoplANETS-A Grant Agreement	N° 776403
AD-2	ExoplANETS-A Consortium Agreement	Version 3, 2017-12-22; DRF 0647_X30423

3 REFERENCE DOCUMENTS (RD)

4 EXOPLANET ONLINE CATALOGUES AND CITIZEN SCIENCE PROJECTS

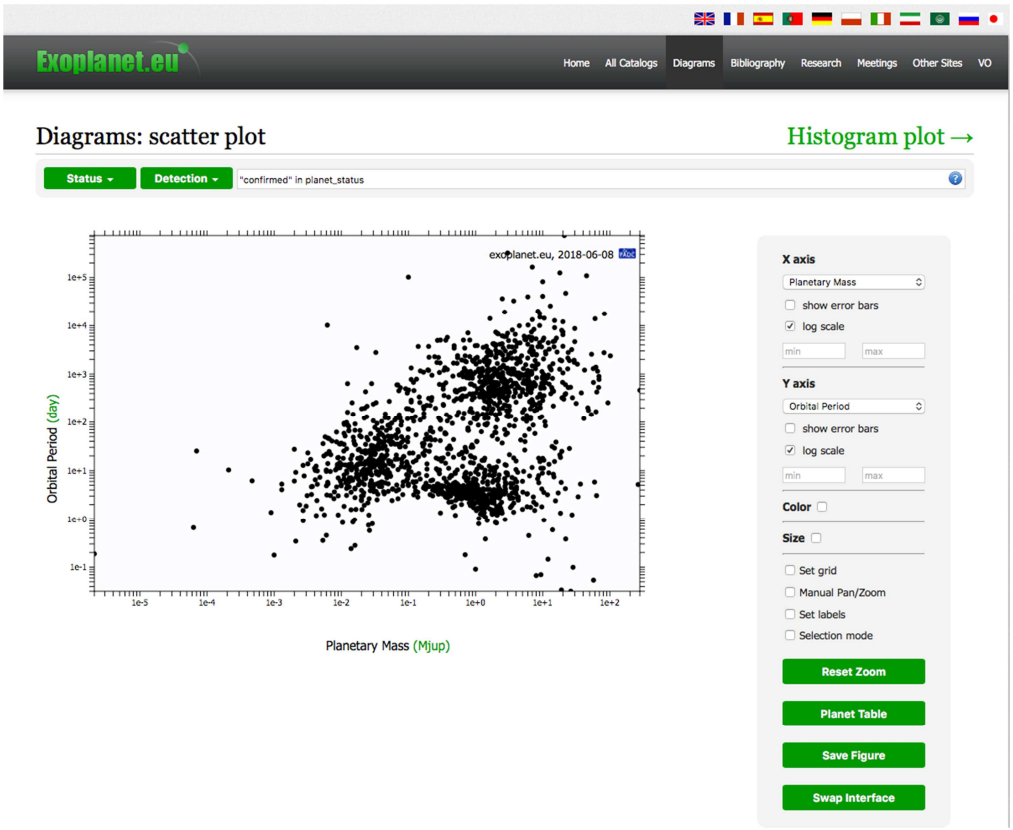
4.1 THE EXTRASOLAR PLANET ENCYCLOPEDIA

URL http://exoplanet.eu

Description This is the European catalogue of exoplanets. It is available in several languages. It provides a database of all exoplanets (candidates and confirmed) as well as graphic interface to build scientific plots. Historically developed by Observatoire de Paris and Jean Schneider, it is today supported by IVOA and follows Virtual Observatory standard. The Encyclopedia of Extrasolar Planets offers an interface to transfer data directly to Virtual Observatory plotting and analysis tools such as TOPCAT or Aladin. The Encyclopedia can be queried using various VO protocols.

What is of interest for WP6 The availability of a complete database that can be exported in standard format within our knowledge server.

Screen shots



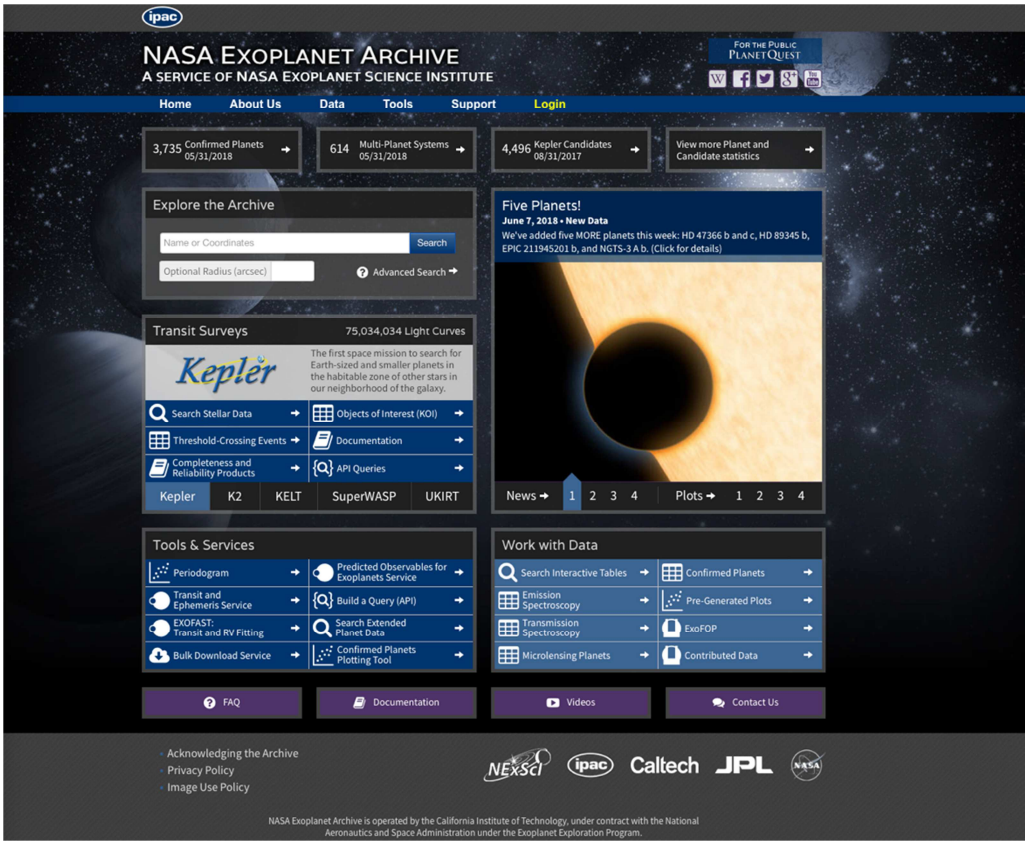
4.2 NASA EXOPLANET ARCHIVE

URL https://exoplanetarchive.ipac.caltech.edu

Description The NASA Exoplanet Archive is an online astronomical exoplanet and stellar catalog and data service that collates and cross-correlates astronomical data and information on exoplanets and their host stars, and provides tools to work with these data. The archive is dedicated to collecting and serving important public data sets involved in the search for and characterization of extrasolar planets and their host stars. These data include stellar parameters (such as positions, magnitudes, and temperatures), exoplanet parameters (such as masses and orbital parameters) and discovery/characterization data (such as published radial velocity curves, photometric light curves, images, and spectra). Operated by Caltech (IPAC), Nasa Exoplanet Archive is the official exoplanet database supported by US institutions. In particular, it offers an access to Kepler database.

What is of interest for WP6 Access to Kepler database as well as host stars parameters.

Screen shots



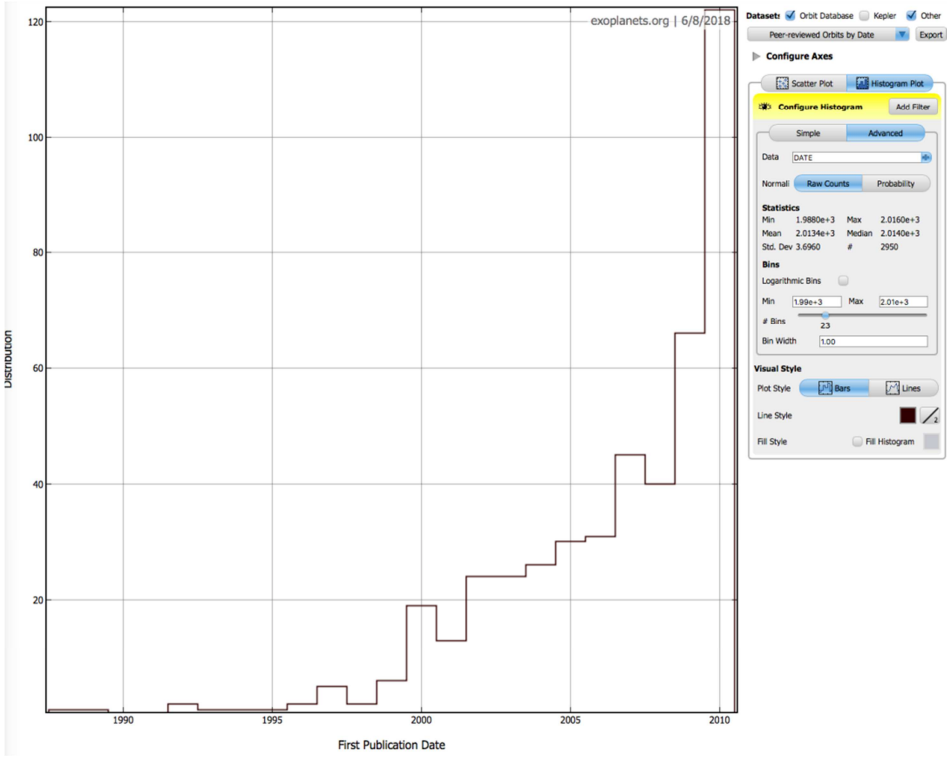
4.3 THE EXOPLANET DATA EXPLORER

URL http://exoplanets.org

Description The Exoplanet Data Explorer is an interactive table and plotter for exploring and displaying data from the Exoplanet Orbit Database. The Exoplanet Orbit Database is a carefully constructed compilation of quality, spectroscopic orbital parameters of exoplanets orbiting normal stars from the peer-reviewed literature, and updates the Catalog of nearby exoplanets. It is supported by US institutions, but not clearly still maintained at this date. It seems to only publish confirmed exoplanets in peer-reviewed papers. Then 2900 confirmed exoplanets instead of 3700 in other sites.

What is of interest for WP6 The plot interface is easy to use. The methodology has been published.

Screen shots



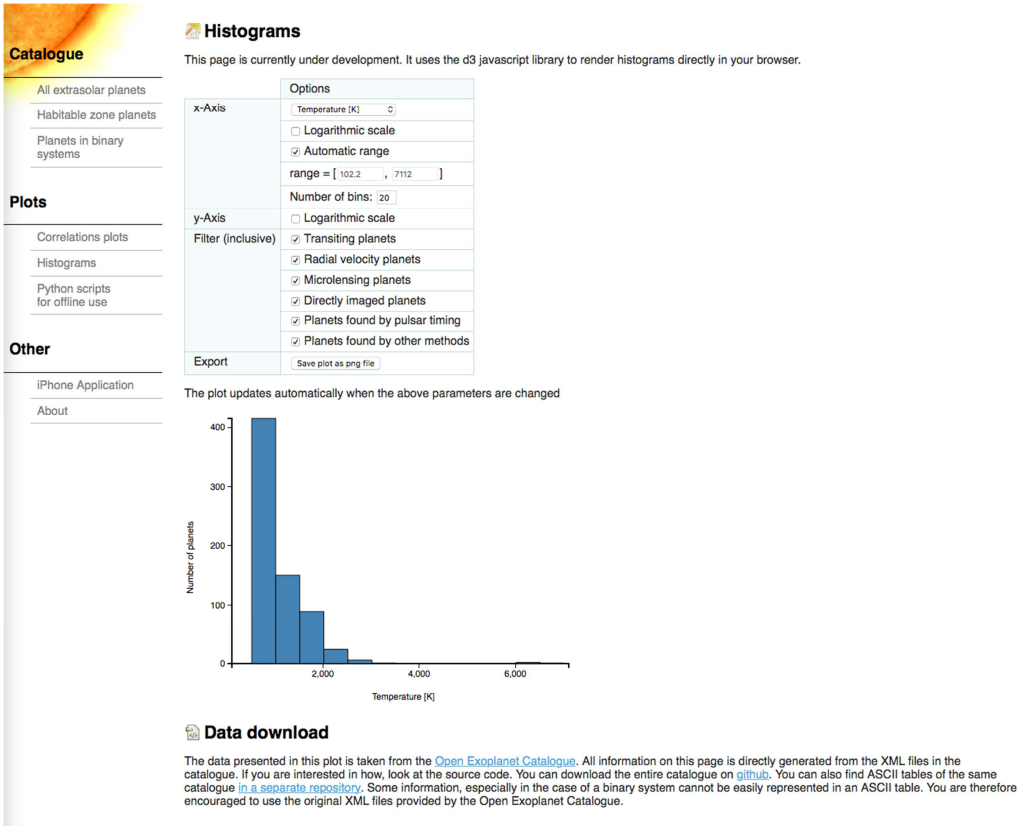
4.4 OPEN EXOPLANET CATALOGUE

URL http://www.openexoplanetcatalogue.com

Description The Open Exoplanet Catalogue is a catalogue of all discovered extra-solar planets. It is a new kind of astronomical database. It is decentralized and completely open. This website is just a front end that displays the database in a browser. The actual database is stored in a distributed version control system. There are multiple ways to download the entire database if you want to dive deeper. As a starting point, visit the main repository of the Open Exoplanet Catalogue on github. The website itself is also open source and hosted over at github.

What is of interest for WP6 An open source database of all discovered extrasolar planets. iPhone APP. Python scripts published here : https://github.com/OpenExoplanetCatalogue/oec_plots

Screen shots



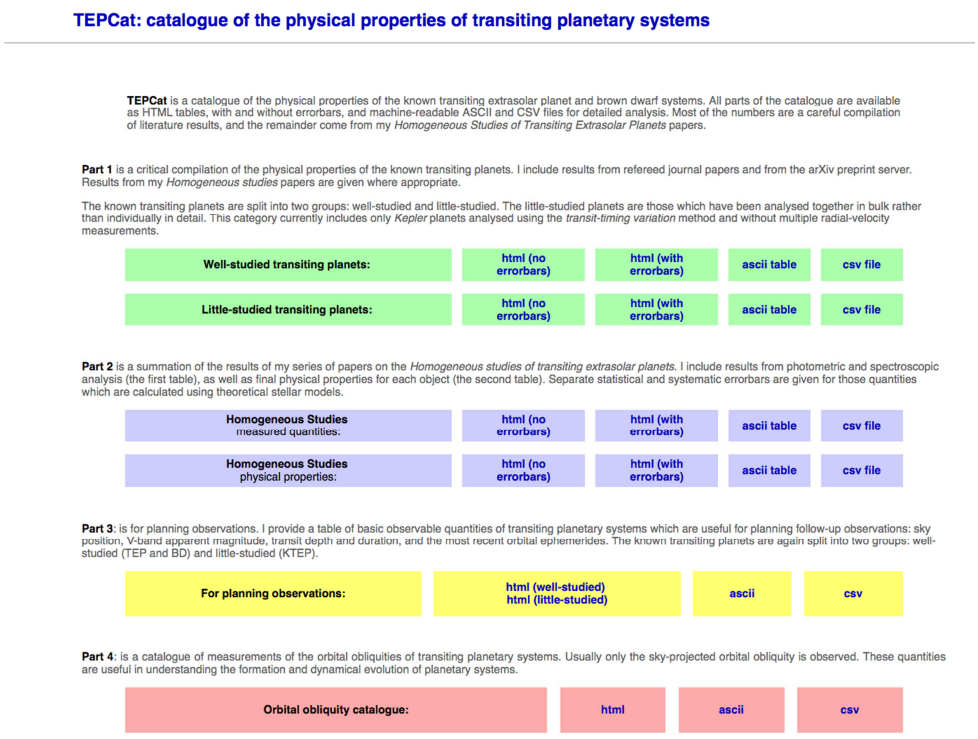
4.5 TEPCAT : CATALOGUE OF THE PHYSICAL PROPERTIES OF TRANSITING PLANETARY SYSTEMS

URL http://www.astro.keele.ac.uk/jkt/tepcat/

Description **TEPCat** is a catalogue of the physical properties of the known transiting extrasolar planet and brown dwarf systems. All parts of the catalogue are available as HTML tables, with and without errorbars, and machine-readable ASCII and CSV files for detailed analysis. Most of the numbers are a careful compilation of literature results, and the remainder come from the *Homogeneous Studies of Transiting Extrasolar Planets* papers.

What is of interest for WP6 This catalogue provides an homogenous re-analysis of many transiting exoplanets.

Screen shots



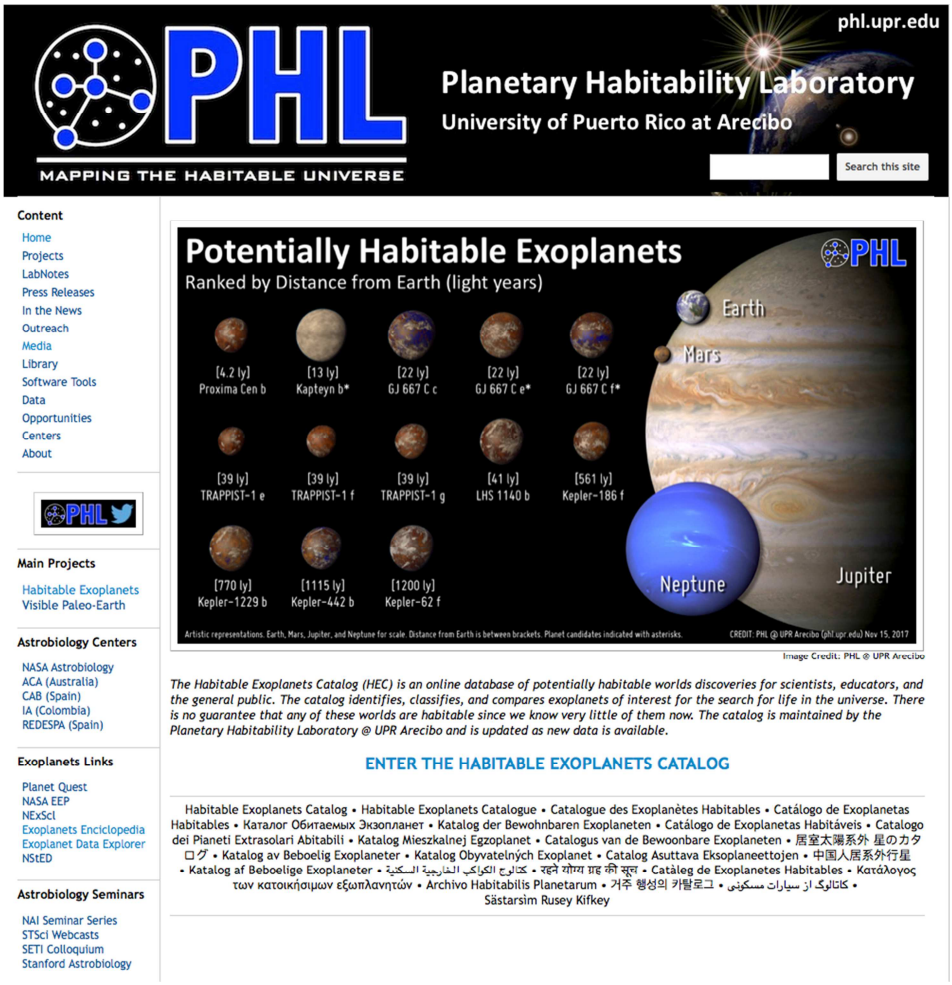
4.6 PLANETARY HABITABLE LABORATORY

URL http://phl.upr.edu

Description The Planetary Habitability Laboratory (PHL) is a research and education laboratory dedicated to studies of the habitability of Earth, the Solar System, and exoplanets. Check the projects link for more details about the scientific projects. There are also links to scientific and educational materials, data and software tools related to planetary science and astrobiology that might be of interest to scientists, students, and the general public. The PHL is managed by the University of Puerto Rico at Arecibo.

What is of interest for WP6 It focuses on habitable planets and provides very useful charts.

Screen shots



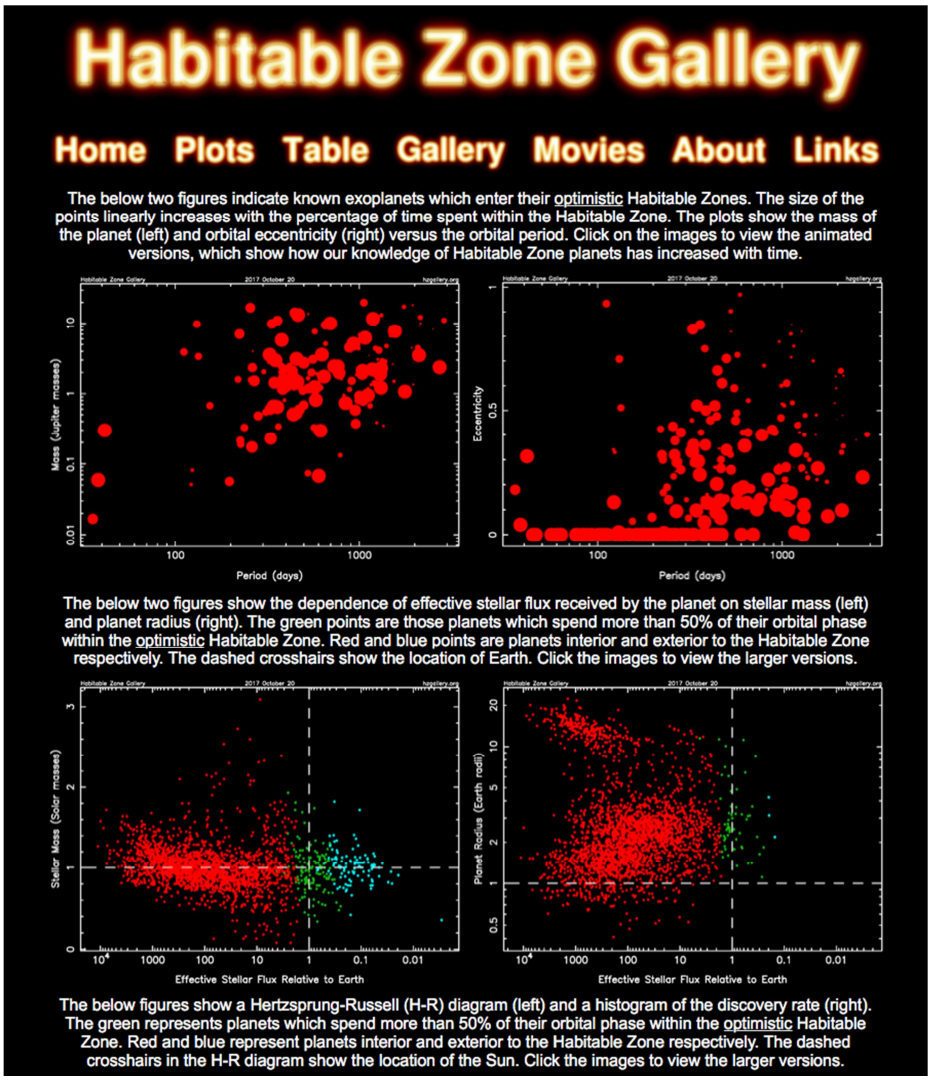
4.7 HABITABLE ZONE GALLERY

URL http://www.hzgallery.org/

Description This site is dedicated to tracking the orbits of exoplanets in relation to their Habitable Zones. It is based upon the work of Stephen Kane & Dawn Gelino on the topic of Habitable Zones, particularly for planets in eccentric orbits.

What is of interest for WP6 For planets with a complete or- bital solution, the catalogue calculates both the conservative and optimistic habitable zones for the host star, based on Kane & Gelino (2012), and the percentage of the planet's orbit that it spends within those zones.

Screen shots



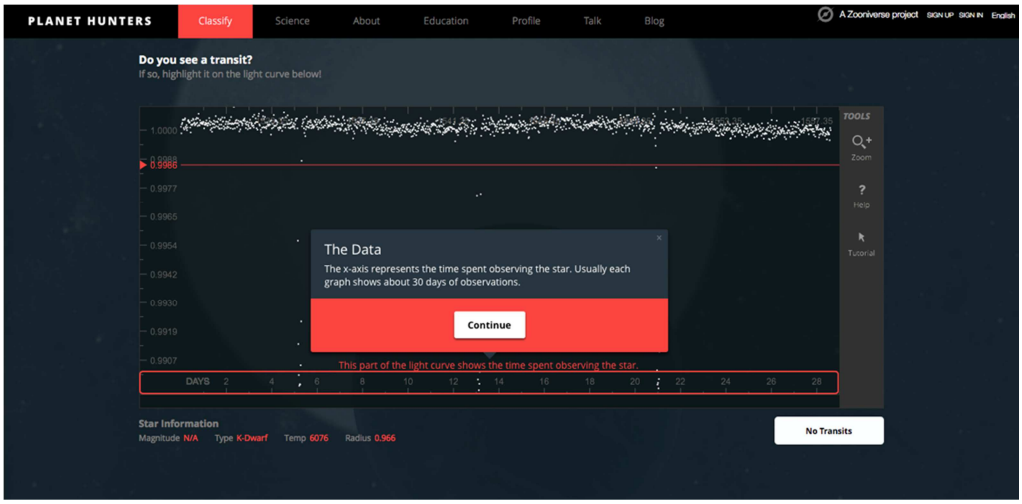
4.8 PLANET HUNTERS

URL https://www.planethunters.org

Description On December 16, 2010, the *Zooniverse* launched the original Planet Hunters to enlist the public's help to search data from the NASA's *Kepler* spacecraft for the characteristic drop in light due to an orbiting extrasolar planets (exoplanets) crossing in front of their parent stars. Back then we didn't know what we would find. The project was a gamble on the ability of human pattern recognition to beat machines just occasionally and spot the telltale dip from a transiting planet that was missed by automated routines looking for repeating patterns. It may have been the case that no new planets were discovered and that computers had the job down to a fine art. The gamble paid off. The original Planet Hunters project discovered a bounty of unknown planet candidates and several confirmed planets, resulting from the efforts of nearly 300,000 volunteers worldwide. You can learn more about the discoveries and scientific results from the first iteration of Planet Hunters with our *list of published papers* and the *project blog*.

What is of interest for WP6 It demonstrates how general public could be included in a "citizen science" effort.

Screen shots



4.9 EVE ONLINE – PROJECT DISCOVERY

URL

https://www.eveonline.com/discovery/

https://www.eveonline.com/article/exoplanets-the-next-phase-of-project-discovery

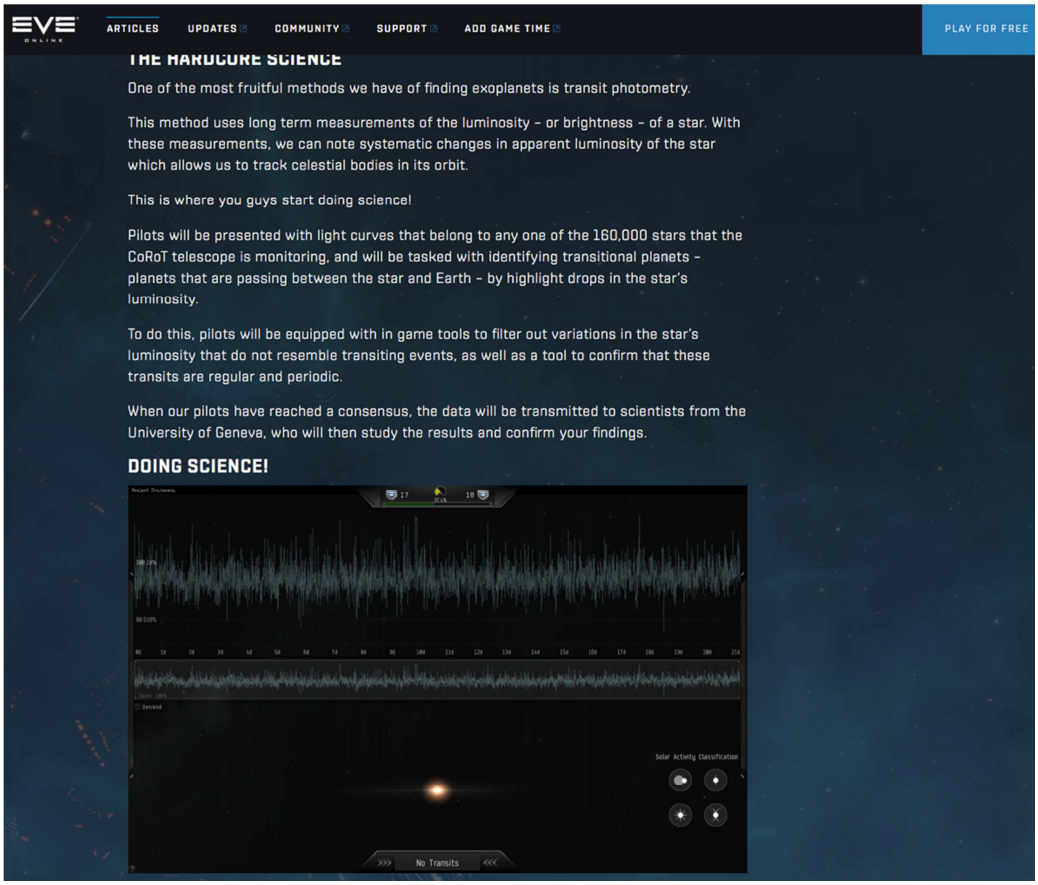
Description

Project Discovery is the citizen science initiative launched as a collaboration between independent games developer CCP Games, Massive Multiplayer Online Science (MMOS) and Reykjavik University. Its aim is to use EVE Online's famously dedicated community to aid in scientific research. The pilots of EVE Online have the opportunity to search for real life exoplanets from within EVE's virtual universe. By playing Project Discovery, they will directly contribute to science. Players will achieve higher ranks through their efforts as well as receiving unique in-game rewards, PLEX and ISK (in-game currency).

What is of interest for WP6

It demonstrates how massive online game can be used to trigger "citizen science".

Screen shots



5 VIRTUAL OBSERVATORY TOOLS OF INTEREST FOR THE PROJECT

5.1 EURO-VO AND IVOA

URL

http://www.euro-vo.org

http://www.ivoa.net

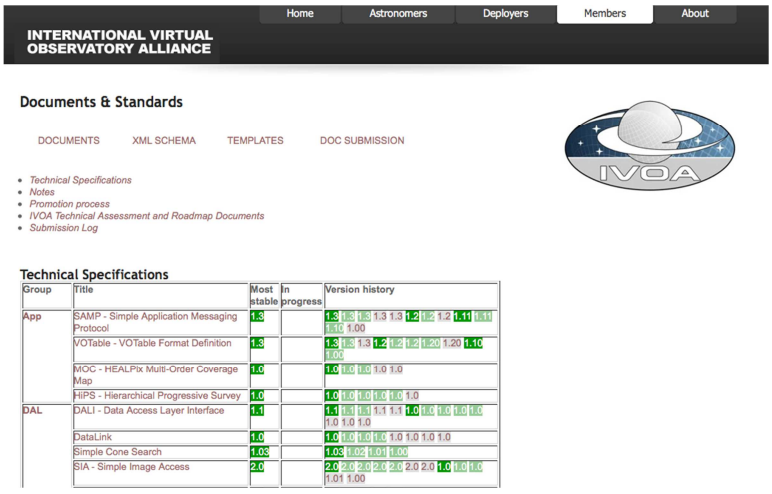
Description

The Virtual Observatory is an international astronomical community-based initiative. It aims to allow global electronic access to the available astronomical data archives of space and ground-based observatories and other sky survey databases. **EURO-VO** aims at deploying an operational VO in Europe. It supports the utilization of VO tools and services by the scientific community, technology take-up and VO compliant resource provision, and building of the technical infrastructure. The **International Virtual Observatory Alliance (IVOA)** was formed in June 2002 with a mission to "facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory." The IVOA now comprises 20 VO programs from Argentina, Armenia, Australia, Brazil, Canada, Chile, China, Europe, France, Germany, Hungary, India, Italy, Japan, Russia, South Africa, Spain, Ukraine, the United Kingdom, and the United States and an inter-governmental organization (ESA).

What is of interest for WP6

The work of the IVOA focuses on the development of standards. Working Groups are constituted with cross-project membership in those areas where key interoperability standards and technologies have to be defined and agreed upon. The Working Groups develop standards using a process modeled after the World Wide Web Consortium, in which Working Drafts progress to Proposed Recommendations and finally to Recommendations. Recommendations are ultimately endorsed by the Virtual Observatory Working Group of Commission 5 (Astronomical Data) of the International Astronomical Union. The IVOA also has Interest Groups that discuss experiences using VO technologies and provide feedback to the Working Groups.

Screen shots



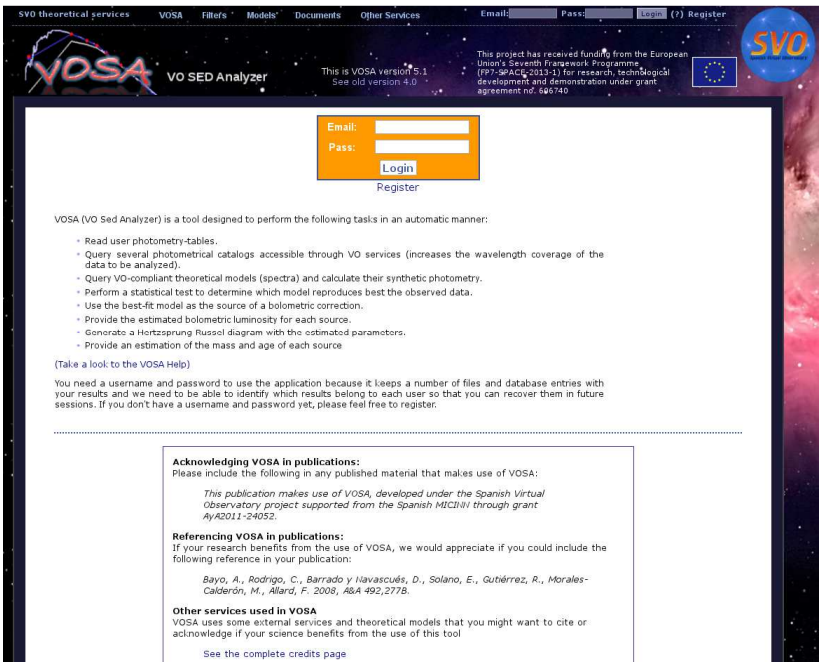
5.2 VOSA (VIRTUAL OBSERVATORY SED ANALYZER)

URL http://svo2.cab.inta-csic.es/theory/vosa/

Description VOSA is a tool maintained by the Spanish Virtual Observatory. In operation since 2008, VOSA is designed to estimate physical parameters (effective temperatures, radii, masses, ages,…) of thousands of stellar objects at a time, from the comparison between the photometric Spectral Energy Distribution and different collections of theoretical models. VOSA is a robust and well-tested tool as demonstrated by the fact that, since 2012, almost 1500 users have analyzed more than 3 700 000 objects and have publised almost 100 refereed papers making use of VOSA.

What is of interest for WP6 VOSA is a fundamental tool for massive estimation of physical parameters (in particular effective temperatures and radii) of star hosting planets.

Screen shots



5.3 FILTER PROFILE SERVICE

URL http://svo2.cab.inta-csic.es/theory/fps/

Description The Filter Profile Service is a service maintained at the Spanish Virtual Observatory that provides standardized information, including transmission curves and calibration, for more than 4000 astronomical filters. The service is designed to be compliant to the Virtual Observatory Photometry Data Model and all the information is provided both as a web portal and VO services so that other services and applications can access the relevant properties of a filter in a simple way.

What is of interest for WP6 With the advent of large area photometric surveys, many astronomical studies are taking an increasingly multi-wavelength approach. The efficient combination of photometric data coming from different sources requires this information be described and characterized detailed enough to allow for the conversion to compatible flux density and spectral energy units. This is done by the Filter Profile Service in a seamless way for the user.

Screen shots

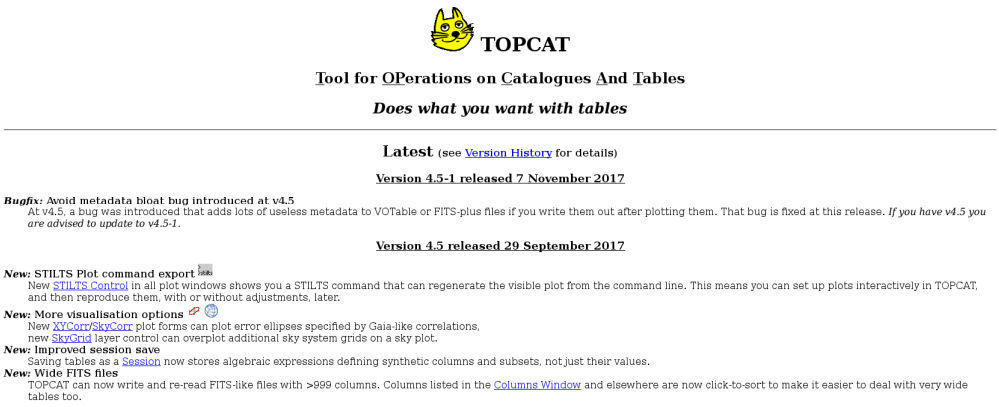
5.4 TOPCAT

URL http://www.star.bris.ac.uk/~mbt/topcat/

Description TOPCAT is an interactive graphical viewer and editor for tabular data. Its aim is to provide most of the facilities that astronomers need for analysis and manipulation of tables. It understands a number of different astronomically important formats (including FITS, VOTable and CDF). It offers a variety of ways to view and analyse tables, including facilities for sophisticated interactive 1-, 2-, 3- and higher-dimensional visualisation, calculating statistics and joining tables using flexible matching algorithms.

What is of interest for WP6 TOPCAT is written in pure Java and available under the GNU General Public Licence, though some of the library code is LGPL. Its underlying table processing facilities are provided by the related packages STIL and STILTS. TOPCAT is a flexible and very powerful tool able to efficiently manage large datasets (millions of rows/hundreds of columns),

Screen shots



TOPCAT

Tool for OPerations on Catalogues And Tables

Does what you want with tables

Latest (see Version History for details)

Version 4.5-1 released 7 November 2017

Bugfix: Avoid metadata bloat bug introduced at v4.5
At v4.5, a bug was introduced that adds lots of useless metadata to VOTable or FITS-plus files if you write them out after plotting them. That bug is fixed at this release. *If you have v4.5 you are advised to update to v4.5-1.*

Version 4.5 released 29 September 2017

New: STILTS Plot command export
New STILTS Control in all plot windows shows you a STILTS command that can regenerate the visible plot from the command line. This means you can set up plots interactively in TOPCAT, and then reproduce them, with or without adjustments, later.

New: More visualisation options
New XYCorr/SkyCorr plot forms can plot error ellipses specified by Gaia-like correlations,
new SkyGrid layer control can overplot additional sky system grids on a sky plot.

New: Improved session save
Saving tables as a Session now stores algebraic expressions defining synthetic columns and subsets, not just their values.

New: Wide FITS files
TOPCAT can now write and re-read FITS-like files with >999 columns. Columns listed in the Columns Window and elsewhere are now click-to-sort to make it easier to deal with very wide tables too.

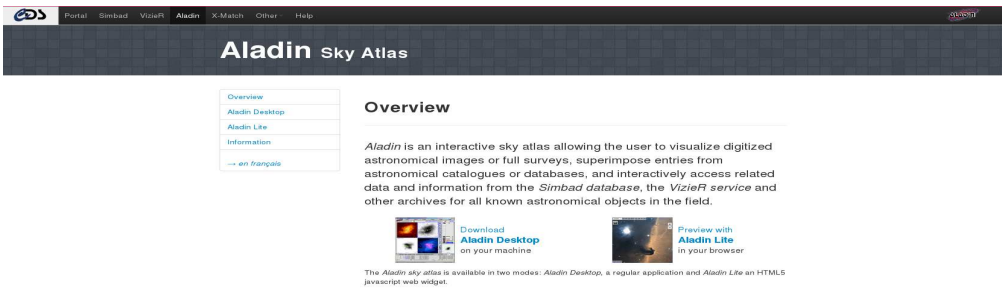
5.5 ALADIN

URL http://aladin.u-strasbg.fr/

Description Aladin is an interactive sky atlas allowing the user to visualize digitized astronomical images or full surveys, superimpose entries from astronomical catalogues or databases, and interactively access related data and information from the Simbad database, the VizieR service and other archives for all known astronomical objects in the field. Compliance with existing or emerging VO standards and interconnection with other visualisation or analysis tools are key topics allowing Aladin to be a powerful data exploration and integration tool as well as a science enabler.

What is of interest for WP6 Aladin Desktop is a widely-used java tool capable of addressing challenges such as locating data of interest, accessing and exploring distributed datasets, visualizing multi-wavelength data. It is based on Java techonology. It requires a classical installation on the user machine.

Screen shots



5.6 SPLAT-VO

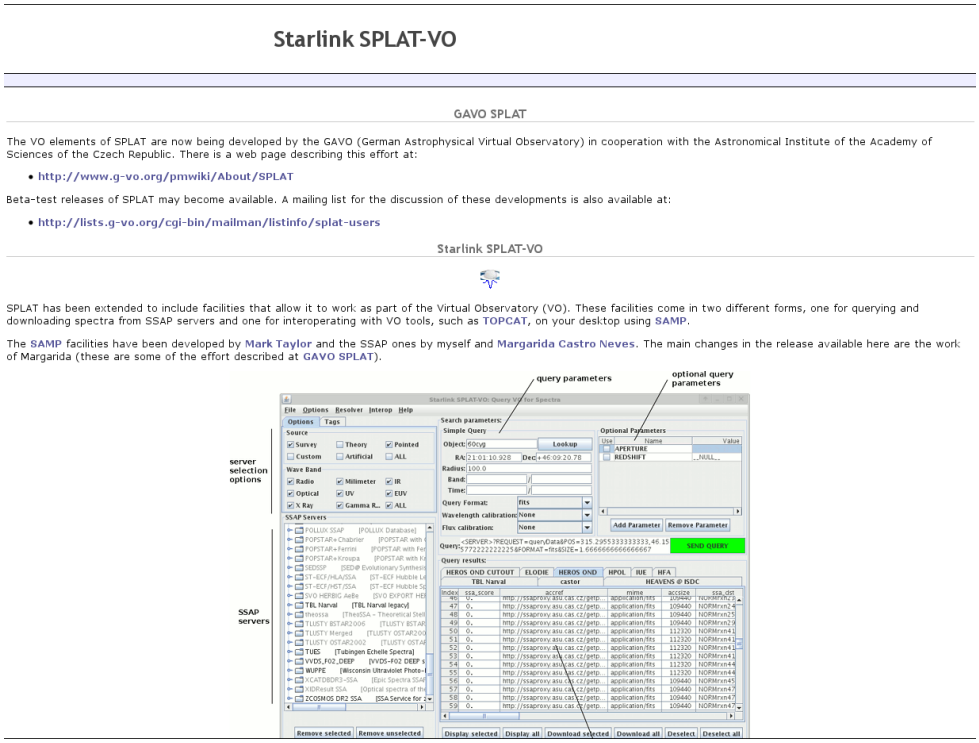
URL http://star-www.dur.ac.uk/%7Epdraper/splat/splat-vo/

Description SPLAT-VO is a graphical tool for displaying, comparing, modifying and analysing astronomical spectra stored in several file formats. Spectra can be read from local files or retrieved through VO protocols. SPLAT-VO can handle many spectra at the same time. Display windows can be interactively zoomed and scrolled, centred

on specific wavelengths, provide continuous coordinate readout, annotated, produce printable hardcopy and be configured in many ways. They also provide the basis for interactive analysis facilities.

What is of interest for WP6 SPLAT is the most adequate tool to handle and compare spectroscopic information in the Virtual Observatory framework.

Screen shots



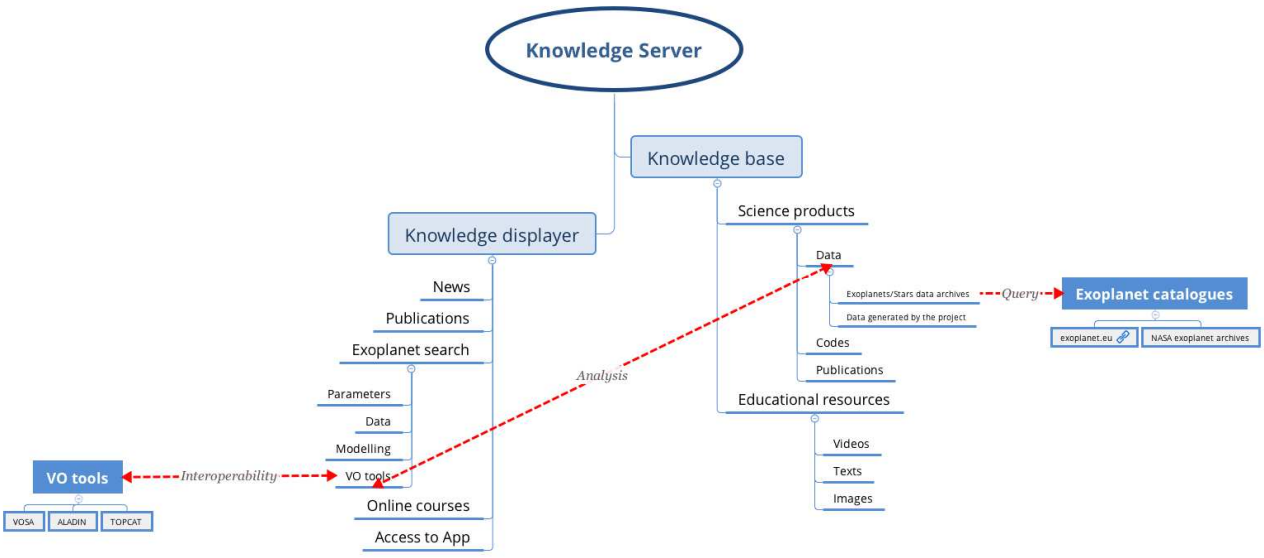
6 CONCLUSIONS

There many different types of exoplanet catalogues. The first category aggregate tables of exoplanet parameters based on the most recent observations and data analysis (ex : exoplanet.eu). A second category provides access to datasets through search target engine (ex : NASA exoplanet archive). Finally, a third category focus on exoplanets observed with a given technique (ex : transit in TEPcat) or with given properties (ex : habitable exoplanets in PHL and hzgallery).

Most of these catalogues allow the download of the tables and data in user formats (ex : .csv) and give the proper paper references for an observed or a derived parameter. They respect the "best practice" described in the paper "Exoplanet Catalogues" (by J. Christiansen, in Handbook of Exoplanets, 2018 - https://arxiv.org/abs/1803.11158). For our purpose, we will select one general catalogue (probably exoplanet.eu) for retrieving tables of parameters and one catalogue for retrieving datasets (ex : NASA exoplanet archive). More specific catalogue might be used if needed.

Besides the exoplanet catalogues, D6.1 reports on Virtual Observatory (VO) tools of interest for the Exoplanets-A project. These tools must 1/ follow the international standard of IVOA, 2/ be interoperable with the exoplanet catalogues and 3/ be accessible within our Knowledge server. Exoplanet.eu would be interoperable with VO tool analysis such as TOPCAT and Aladin.

The Knowledge Management principle chart is presented below. The Knowledge base will retrieve exoplanet and star host parameters from a public catalogue (here the exoplanet.eu catalogue). VO tools will be used through the knowledge displayer, either by using interoperable standards or by adding an html iframe of the tools within the displayer.



In conclusions, we propose to select exoplanet.eu as the main exoplanet catalogue with complement from the NASA exoplanet archives and possible additional sources for specific sources (or observations). A panel of VO tools will be proposed to fulfill all scientific analysis needs.