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First European Data Provider Forum and Training Event

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Abstract

The First ASTERICS European Data Provider Forum and Training Event was held in Heidel-berg, June 15th through 17th, 2016. It convened 45 persons, bringing together the Virtual Observatory community with staff from data centres of vastly differing sizes. In a set of topic blocks, data centres presented their specific requirements, use cases, and solutions, documenting both the success of existing VO technologies and new challenges to VO devel-opment. Conversely, the VO community reached out to the data centres with discussions of new VO standards currently being developed or deployed, as well as in-depth views on leveraging the VO protocol stack in everyday data centre operations. The last day of the meeting was devoted to hands-on training sessions with experts introducing publishing tools and working with data providers on their concrete problems. The event provided valu¬able input to the DADI teams and contributed to advancing the awareness of the benefits of standards-compliant publishing in the wider community of astronomical data centres. It will be continued with a focus on the ESFRI partners in the next DADI Forum and Training Event (scheduled for December 2017), and again with a broad audience in another Data Provider Forum (scheduled for December 2018).

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II. DELIVERY SLIP

	Name	Partner / WP	Date
From	M. Nullmeier	UHEI / WP 4.1	28 September 2016
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III. DOCUMENT LOG

Issue	Date	Comment	Author / Partner
1	28-Sep-2016	First draft for discussion	M. Nullmeier, M. Demleitner / UHEI
2	29-Sep-2016	Updated draft with comments	F. Genova / CDS-CNRS
3	29-Sep-2016	Slightly updated draft, added terminology section	M. Nullmeier / UHEI
4	30-Sep-2016	Version sent to the Project Manager	F. Genova / CDS-CNRS
5	7-Oct-2016	Final version taking into account the comments of the project Manager and Project Scientist	F. Genova / CDS-CNRS

IV. APPLICATON AREA

This document is a formal deliverable for the GA of the project, applicable to all members of the ASTERICS project, beneficiaries and third parties, as well as its collaborating projects.

V. TERMINOLOGY

A&A	Authentication and authorisation (or vice versa)
ANTARES	Astronomy with a Neutrino Telescope and Abyss environmental RESearch project
ADASS	Astronomical Data Analysis Software and Systems conference
ADQL	IVOA Astronomical Data Query Language
AIP	Leibniz-Institut für Astrophysik Potsdam
Aladin	An interactive sky atlas
Aladin Lite	A lightweight version of Aladin running a web browser
Apache	Apache Software Foundation, or, Apache HTTP Server
APC	AstroParticule et Cosmologie
API	Application programming interface
ARI	Astronomisches Rechen-Institut
ASTERICS	Astronomy ESFRI & Research Infrastructure Cluster
ASTRON	Astronomisch Onderzoek in Nederland (The Netherlands' Institute for Radio Astronomy)
CDS	Centre de Données astronomiques de Strasbourg (Strasbourg astronomical Data Centre)
CNRS	Centre National de la Recherche Scientifique
ConeSearch	IVOA simple cone search protocol
CoSADIE	Collaborative and Sustainable Astronomical Data Infrastructure for Europe
CPPM	Centre de physique des particules de Marseille (Centre for particle physics of Marseille)
CTA	Cherenkov Telescope Array
ČVUT	Czech Technical University in Prague
DaCHS	GAVO's Data Center Helper Suite
DADI	Data Access, Discovery and Interoperability (ASTERICS WP4)
DataLink	IVOA's linking of data discovery metadata to other resources
DOI	Digital Object Identifier
DSA	Data Seal of Approval
E-ELT	European Extremely Large Telescope
Eduroam	Education Roaming
EGO	European Gravitational Observatory

EPN-TAP	Europlanet Data Model TAP
ESA	European Space Agency
ESAC	European Space Astronomy Centre
ESASky	Web application to visualise and download public astronomical data
ESFRI	European Strategy Forum on Research Infrastructures
ESO	European Organization for Astronomical Research in the Southern Hemisphere
EST	European Solar Telescope
Euclid	ESA's Euclid space mission
EUDAT	Collaborative Pan-European infrastructure for research data
Euro-VO	European Virtual Observatory
Europlanet	European Research Infrastructure for Planetary Science
FITS	Flexible Image Transport System
FP7	7th Framework Programme for Research and Technological Development of the European Union
GA	Grant agreement
Gaia	ESA space observatory for astrometry
Gaia DPAC	Gaia Data Processing and Analysis Consortium
GAVO	German Astrophysical Virtual Observatory
H2020	Horizon 2020, (8th) Framework Programme for Research and Innovation of the European Union
Hadoop	Apache framework for distributed storage and distributed processing
HDF5	Hierarchical Data Format (version 5)
HDFITS	Mapping of the FITS data model into HDF5
HEALPix	Hierarchical Equal Area isoLatitude Pixelisation
HiPS	Hierarchical Progressive Survey
ICSU	International Council for Science
Icube	Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie
IFU	Integral field unit
INAF	Istituto Nazionale di Astrofisica
INAF-IA2	INAF project for preserving and providing access to the astrophysical data heritage
INAF-OATs	Osservatorio Astronomico di Trieste
INFN	Istituto nazionale di fisica nucleare

INTA	Instituto Nacional de Tecnica Aeroespacial (National Institute for Aerospace Technology)
INTA-CSIC	Centro de Astrobiología
IVOA	International Virtual Observatory Alliance
JIVE	Joint Institute for VLBI in Europe
KM3NeT	Cubic Kilometre Neutrino Telescope
LOC	Local organising committee
LUTH	Laboratoire Univers et Theories
MOC	IVOA Multi-Order Coverage map
Munipack	General astronomical image processing software
MySpec-MyImg	A tool to publish 1D images and spectra in the VO through SIAP and SSAP
MySQL	A relational database management system
NoSQL	Non-SQL database management systems (structured storage)
OAS	Observatoire Astronomique de Strasbourg (Strasbourg Astronomical Observatory)
ObsCore	IVOA Observation Core components Data Model
OBSPAR	Observatoire de Paris
OpenID	"Open Identification", a decentralized authentication protocol
PADC	Paris Astronomical Data Centre
PDF	Portable Document Format
PDL	IVOA Parameter Description Language
PgSphere	Spherical data extensions for PostgreSQL
PostgreSQL	A relational database management system
PRIDE	Planetary Radio Interferometry and Doppler Experiment
RDA	Research Data Alliance
RFC	Request for comments
RIA	Research and Innovation Actions
Saada	An astronomical database generator
SAF	ESO Science Archive Facility
SCS	IVOA simple cone search protocol
SIA	IVOA Simple Image Access Protocol
SIAP	IVOA Simple Image Access Protocol
SIMBAD	Set of Identifications, Measurements, and Bibliography for Astronomical Data

SKA	Square Kilometre Array
SMEs	Small and medium-sized enterprises
SOC	Scientific and technical organising committee
Spark	Apache cluster computing framework
SPLAT-VO	A VO-enabled Spectral Analysis Tool
SSA	IVOA Simple Spectral Access Protocol
SSAP	IVOA Simple Spectral Access Protocol
SSO	Single sign-on
SVOCat	A tool to publish tables and catalogues in the VO through a ConeSearch service
TAP	IVOA Table Access Protocol
Tomcat	Apache Tomcat, a Java HTTP server environment
TOPCAT	An interactive graphical viewer and editor for tabular data
UEDIN	University of Edinburgh
UHEI	Ruprecht-Karls-Universität Heidelberg
UNISTRA	Université de Strasbourg
UWS	IVOA Universal Worker Service Pattern
VAMDC	Virtual Atomic and Molecular Data Centre
VIALACTEA	FP7 project "The Milky Way as a Star Formation Engine"
VizieR	CDS' database of astronomical catalogues and large surveys
VLBI	Very Long Baseline Interferometry
VO	Virtual observatory, cf. IVOA
VO-Dance	A set of INAF-IA2 VO publishing solutions
VOEvent	IVOA Sky Event Reporting Metadata
VOSpace	IVOA interface to distributed storage
VOTable	IVOA data format for tables
W3C	World Wide Web Consortium
WDS	ICSU World Data System
WFAU-IfA	The Wide Field Astronomy Unit at the Institute for Astronomy, University of Edinburgh
Wi-Fi	Wireless local area network
WP	Work package
WP4	Work package 4 of ASTERICS, i. e., DADI
XSAMS	International Atomic Energy Agency's XML Schema for Atomic, Molecular, and Solid Data

ZAH   Zentrum für Astronomie der Universität Heidelberg

A complete project glossary is provided at the following page:
http://www.asterics2020.eu/glossary/

VI.   PROJECT SUMMARY

ASTERICS (Astronomy ESFRI & Research Infrastructure Cluster) aims to address the cross-cutting synergies and common challenges shared by the various Astronomy ESFRI facilities (SKA, CTA, KM3Net & E-ELT). It brings together for the first time, the astronomy, astrophysics and particle astrophysics communities, in addition to other related research infrastructures.

The major objectives of ASTERICS are to support and accelerate the implementation of the ESFRI telescopes, to enhance their performance beyond the current state-of-the-art, and to see them interoperate as an integrated, multi-wavelength and multi-messenger facility. An important focal point is the management, processing and scientific exploitation of the huge datasets the ESFRI facilities will generate. ASTERICS will seek solutions to these problems outside of the traditional channels by directly engaging and collaborating with industry and specialised SMEs. The various ESFRI pathfinders and precursors will present the perfect proving ground for new methodologies and prototype systems.

In addition, ASTERICS will enable astronomers from across the member states to have broad access to the reduced data products of the ESFRI telescopes via a seamless interface to the Virtual Observatory framework. This will massively increase the scientific impact of the telescopes, and greatly encourage use (and re-use) of the data in new and novel ways, typically not foreseen in the original proposals. By demonstrating cross-facility synchronicity, and by harmonising various policy aspects, ASTERICS will realise a distributed and interoperable approach that ushers in a new multi-messenger era for astronomy.

Through an active dissemination programme, including direct engagement with all relevant stakeholders, and via the development of citizen scientist mass participation experiments, ASTERICS has the ambition to be a flagship for the scientific, industrial and societal impact ESFRI projects can deliver.

VII.   EXECUTIVE SUMMARY

In DADI Task 4.1, ASTERICS has committed itself to maintaining close contact between the partners from the VO side and the ESFRIs, but also between the project and the wider European community of astronomical data centres. Acknowledging that intra-project communications has different characteristics from outreach and discussion with the wider community, DADI organizes both Forum and Training events geared specifically at the ESFRI partners (the first was held in Trieste in November 2015, D4.3) and events addressing both the ESFRIs and the wider community. The workshop reported on here was of the latter type, the first of those within ASTERICS.

Developing on a concept tried first in the CoSADIE project in 2013, the workshop assembled technical staff (about 2/3 of the participants) and science staff (about 1/3) from 23 institutions and 8 countries for three days of intense exchange on challenges and solutions in astronomical data publishing. Data centres of all sizes were represented and included, of course, were representatives from the data handling parts of the ESFRI DADI partners, as well as the associate partner ESO, and ESA.

Major fields of the oral contributions on the first two days included:
* Use of VO standards by data providers, in particular regarding how standards simplify common tasks ("success stories")
* Development of VO standards. This was very much a two-way communication, where the VO community on the one hand presented current developments, while the data providers on the other hand defined missing or non-matching aspects of the VO infrastructure
* Practicalities of publishing. Here, certain techniques, often for specific publishing problems, were presented in ways designed to be readily applicable.

A new feature in this event was the hands-on training on day three. After "elevator pitch"-style presentations of six publication tools in the plenary (the five toolkits SVOCat / MySpec-MyImg, CDS / ARI TAP libraries, VO-Dance, DaCHS, and Saada, as well as a comprehensive training on VizieR and the infrastructure technologies HiPS / MOC), participants could sign up for in-depth hands-on sessions, mostly with the authors of the respective tools. Although logistically something of a challenge, we consider the hands-on day a substantial success, to be repeated in later training events.

The workshop, including small break-out discussions during the lunches and dinner, has shown the usefulness of keeping open communication channels between staff directly involved in VO developments and staff in particular from small and medium data centres that usually have no means of participating, for instance, in IVOA's interoperability conferences. Even just raising awareness for existing technologies improves operation and interoperability of the data centres' services. The availability of standard software components and hands-on

training on their use is clearly particularly beneficial when resources are scarce, as is usually the case for small and medium data centres.

At the same time, the participation of the ESFRI partners in the workshop led to the realisation that many challenges in astronomical data handling are shared across the size spectrum of endeavours in astronomy. In that sense, the whole community assembled in this workshop will profit from the next DADI Forum and Training Event, currently scheduled for December 2017, despite the narrower target audience (ESFRI partners) of that event.

Another forum in the present form, including the wider data publishing community, is scheduled to take place in December 2018. With the development of the use of VO technologies in the community, as demonstrated at our workshop compared to the analogous CoSADIE meeting in 2013, and considering how publishing tools have matured since then, we look forward to hearing then the feedback from the various initiatives started or inspired during our workshop of 2016.

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1. Introduction

The overall goal of the ASTERICS work package 4 (DADI) is making the data of the ESFRI projects and their pathfinders available to the astronomical community, which requires actual institutions and people for curation, formatting, and publication that have a lot in common with the other astronomical data providers. Thus, the DADI "Technology Forums" with their focus on the VO framework, on standards, and on tools, as well as the "ESFRI Forum and Training Events" with a focus on networking the ESFRI and VO partners of DADI, are complemented by two "European Data Provider Forum & Training Events" during the project duration. One key aim of the first of these meetings, held from 15th to 17th of June 2016 in Heidelberg, was still to further links and collaboration between VO and ESFRI partners established at the previous DADI meetings (such as at the "First ESFRI Forum and Training Event", ASTERICS deliverable D4.3), with a special view on data publication activities. In

addition, the target audience was intentionally widened to all European stakeholders in on-line publishing of astronomical data and services, from small data producing projects to large institutions, in order to be open for the full breadth of challenges and problems, solutions, and perspectives that are common to them.

The meeting was organised by the DADI partner UHEI, who already ran a partially similar event in June 2013 in the context of the CoSADIE FP7 project. The date of the event was initially foreseen to be in November 2016, but taking into account the density of other meetings that potential participants had to attend after the summer break and up to the end of the year, it was decided in December 2015 to re-schedule it after a discussion during DADI's "First ESFRI Forum and Training Event" in order to minimize conflicts.

Within the context of DADI Task 4.1, this deliverable D4.6, the "First European Data Provider Forum & Training Event", covers its "networking and training" and the "gathering ESFRI project requirements and feedback" objectives. INAF-OATs and UHEI, the partners leading Task 4.1, are working to identify these requirements as input to Task 4.3 and are contributing to DADI's efforts to give technical support to the ESFRI partners. These and the associated networking activities seamlessly led to the remaining objective of Task 4.1, namely "direct support to implementation of ESFRI facility data in the VO framework", examples being the publication of ANTARES (KM3NeT pathfinder) neutrino observation data in the VO by UHEI or the usage of VO Tools by the gravitational wave community.

In coordination with the WP4 lead, a scientific and technical organising committee was established for overseeing this event, including representatives of all DADI partners. The organising committee was involved in the dissemination and program planning activities from the very beginning.

The event was open to all European data providers, big and small. The call for contributions of the official announcement e-mail[1] solicited contributions in any relevant area of on-line astronomical data publication and services, especially for
- current challenges in data publication
- publication tools, libraries, and techniques
- developments to facilitate data exploitation by astronomers
- use and adoption of Virtual Observatory standards.

There was also opportunity to disseminate outcomes of previous specialised DADI events such as the DADI Meeting on Gravitational Waves to a wider audience. Furthermore, the previous meeting within DADI Task 4.1, the "First ESFRI Forum and Training Event", bred the idea to set up a whole extra third day dedicated to training in VO publication toolkits. Experts for these (which often meant their primary authors) were invited to give hands-on sessions and/or tutorials, which were open to all participants. After the programme of two days was filled with

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1   http://www.g-vo.org/edp-forum-2016/announcement.txt

oral contributions and discussions and the training sessions were confirmed, the stage was set for the participants to share methods and lessons learnt and to identify data providers' needs, including those of the ESFRI partners.

ASTERICS Deliverable 4.6 "First European Data Provider Forum and Training Event", organised by UHEI on 15th to 17th of June 2016, was the sixth event organised by ASTERICS WP4, following the two first Technology Forums, the First DADI School, the First ESFRI Forum & Training event and the Meeting on Gravitational Waves. Section 2 of the document describes the activities undertaken in advance of the meeting. Section 3 details participation in the event, while Section 4 reports on the programme of oral contributions, the training day being described in Section 5. The results of the concluding discussion session including analysis and feedback on the organization of the meeting are described in Section 6. Finally, Section 7 lists the next steps ASTERICS WP4 is going to take. The event website with all relevant information will remain available as http://www.g-vo.org/edp-forum-2016 and is linked from DADI wiki page.

2. Planning, organisation, and preparation

Organising committees

The organisation of the event was distributed between a scientific and technical organising committee (SOC) and a local organising committee (LOC). The SOC was composed of one representative from each ESFRI and VO partner of DADI (two in case of the organiser UHEI), namely:

- Mark Allen, CNRS/OAS
- Catherine Boisson, CNRS/LUTH for CTA
- Eric Chassande-Mottin, CNRS/APC for EGO
- Paschal Coyle, CNRS/CPPM for KM3NeT
- Markus Demleitner, UHEI
- Marco Molinaro, INAF
- Keith Noddle, UEDIN
- Enrique Solano, INTA
- Joachim Wambsganß, UHEI
- Michael Wise, ASTRON for SKA.

The LOC was staffed by Markus Nullmeier and Hendrik Heinl.

The SOC was especially involved in working out the text of the official announcement, in its dissemination, and in planning and approving of the programme. In addition to e-mail communication, a SOC conference call was held on the 21st of March 2016. The fields of activity allocated to the LOC were the meeting website, the venues, e-mail dissemination, registration issues, and related tasks.

Dissemination of the announcement

The announcement of the event was first sent out via e-mail on the 2nd of March 2016 to DADI ESFRI and VO partners, as well as to ESO as an associate partner, and from the 16th of March 2016 to a list of a few hundred people of the European astronomical community, comprising staff from data providers (including potentially future ones) and individuals that have been known to be involved in VO activities in the past. The announcement was also sent to various international, national and local lists and to various individual contacts related to the SOC. Finally, the event was publicised on several web sites, including the main ASTERICS web site. These activities were collaboratively recorded in the DADI section of the internal ASTERICS wiki pages, with a mirror web page at http://www.g-vo.org/edp-forum-2016/edp2016ft-dissemination-log1.html.

A website http://www.g-vo.org/edp-forum-2016 was set up to communicate all useful information related to the event, and it was progressively updated, especially with pro-gramme content. It also featured an on-line registration system that allowed the participants to enter post-registration changes, including those for dietary choices.

During the event, the speakers were encouraged to upload PDF files of their slides directly to the website, which featured a suitable functionality. In this way, the slides were available to all participants as soon as possible, and, more importantly, the effort spent on collecting the slides was considerably reduced for both the speakers and the organisers. Another benefit was that the slide-presenting computer had to be changed only if it was to display live ele-ments of a presentation.

Venues

The main venue of the First European Data Provider Forum and Training Event, located on the main science campus, was the new facilities of the "Marsilius-Kolleg", a specialised institution of the University of Heidelberg that works towards fostering diverse approaches to in-terdisciplinary research. Here the plenary oral contributions of the first two days were given, with on-site catering during all breaks being handled by an external provider. Network con-nectivity was assured via Eduroam, individual Wi-Fi conference accounts, and wired access.

The individual sessions of the subsequent training day, each equipped with video projectors and network access, took place in seminar rooms and offices of the "Astronomisches Rechen-Institut" (ARI), which is part of the Centre for Astronomy of the University of Heidelberg (ZAH, "Zentrum für Astronomie der Universität Heidelberg"), with locally provided coffee breaks and lunch at a nearby university cafeteria.

**Picture 1: Conference room of the plenary sessions**
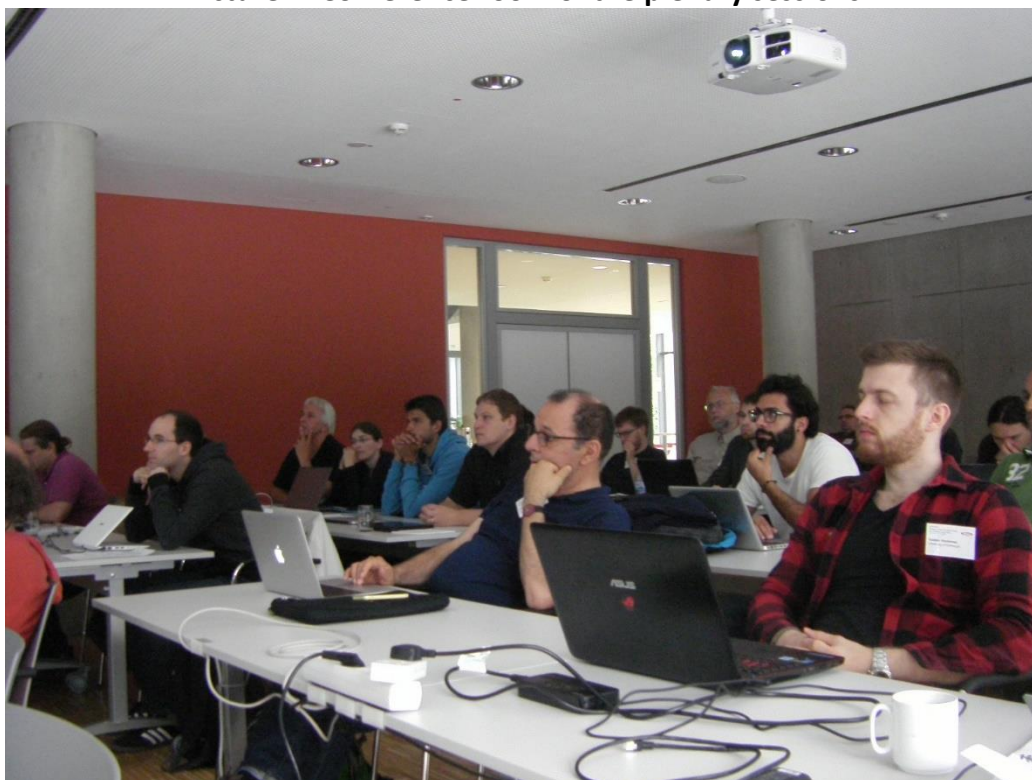
Picture 2: Seminar room during the training day

3. Participants

The forum was attended by 45 participants. All DADI partners CNRS/OAS, CNRS/LUTH, CNRS/APC, CNRS/CPPM, INAF, INTA, UEDIN, UHEI, and ASTRON, as well as the third parties UNISTRA and OBSPAR, were represented. Two persons each were affiliated to the associate partner ESO and to ESA. 13 participants were affiliated to ten other institutions, making for a total of 23 participating institutions and showing that the inclusion of European data providers outside the DADI project was achieved in a balanced way. Also, in terms of participants, the balance of small, medium and large data providers was approximately 2:4:3. About a third of all participants were scientific personnel with two thirds being technical staff, meaning that matters of science did not fall behind.

Figure 1: Countries and types of participants' workplaces
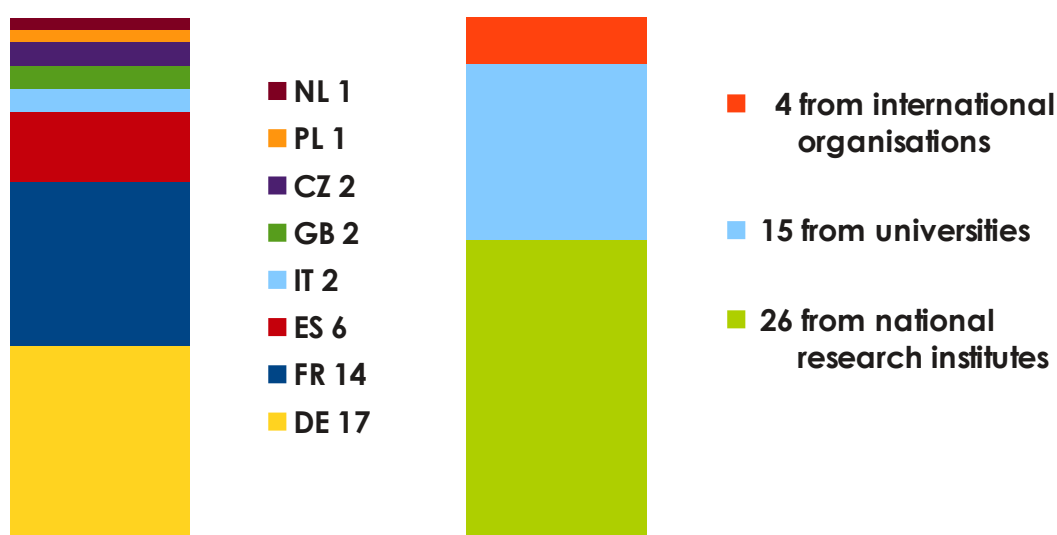
Finally, Figure 1 counts the participants according to country of residence and type of institution, both with respect to their affiliation.

4. Programme of the data provider forum days

In accordance with the call for contributions referenced in Section 1, the meeting was really seen as a forum for data providers and received a quite diverse range of proposed contributions. As nearly all were on topic, this diversity is reflected in the actual programme, which included 29 talks, gathered under the following themes:

- Introduction to ASTERICS and to DADI [P1]
- Data providers' case studies and specific challenges [P1, P2]

- Evolution of the VO with additional facilities [P2]
- New requirements for the VO [P3]
- Practical aspects of providing data via the VO [P3]
- Recent developments in the VO [P4]
- Specifications for particular types of published data [P5]
- New infrastructure work for publishing data and services [P6],

where the tags [P1]..[P6] denote assignment of the topics to one of the six plenary sessions that were held during the two days of the forum. Most of the oral contributions were assigned 15 minutes, followed up by 5 minutes of nearly always intense discussion that very often had to be cut short. In addition, there were so-called "elevator pitch" time slots of 5 minutes, during which the hosts of the training day sessions introduced and advertised the toolkits that they were going to teach. Next to the summary of contributions listed below, Annex A shows the schedule of forum days, including the titles of all agenda items and links to their slides.

Compendium of the topic blocks

Naturally, the talks started with the **introduction to ASTERICS and to DADI**, where first the ASTERICS project scientist *Giuseppe Cimò* described the structure of the overall project with its multi-wavelength / multi-messenger core ideas.
Then DADI lead *Françoise Genova* gave a specific overview of this ASTERICS work package including its setup, past achievements, and connections to the wider world of IVOA, EUDAT and RDA.

There were eight contributions of **data providers' case studies and specific challenges**, commenced by *Mathieu Servillat* who presented, specifically for the complex gamma-ray observations of the CTA project, a VO data diffusion prototype that is also driving various advances of the VO.
Michael Sterzik explained how ESO works to fulfil its mandate to provide data under the many aspects of it being scientifically meaningful, including plans for new archive services that also feature VO-compliant access.
Kristin Riebe gave detailed insights into data curation and tools usage at a medium-sized VO data centre, inviting the audience to profit from various locally developed relevant software.
Marco Molinaro showed the anatomy of running and tooling a national astronomical data centre and its evolution in the face of challenges such as internationally distributed archives, authentication and authorisation (A&A), and adequately publishing multi-format data collections via the VO.

The second plenary session on the above topic shared generally more specialised contributions as exemplified by *Nazaret Bello González* who conveyed requirements and first steps towards a solar virtual observatory in the light of catering for multi-instrument observations and upcoming solar telescopes such as the EST.
Pierre Le Sidaner reported how the Paris Astronomical Data Centre benefits from the generic and client-agnostic TAP protocol to provide VO access to such diverse data as from CTA, Gaia, and planetary science.

Cristina Knapic presented the on-line publication of diverse and hierarchical radio-astronomical data via necessarily bespoke data models, database designs, and web front ends, asking the question in which ways TAP could be used for these to provide a VO access.

Petr Škoda showcased (semi-)automatic publishing of spectra, images and light curves to the VO directly from instrument pipelines of two telescopes, thus employing VO tools and protocols as integral parts of the original observation process.

Two contributions targeted the future **evolution of the VO with additional facilities**, with *Mathieu Servillat* introducing the IVOA work on provenance that is extending the W3C provenance data model for VO use, employing as guidelines expert insights into concrete use cases such as spectra, data pipelines, or surveys, and anything else they might get hold of.

Harry Enke made the case that the VO should make allowance for (and that all data providers are to ensure) persistent access via DOIs by showing their benefits, and also their technical and administrative workings, together with a use case for photographic plates.

Three presentations focused on **new requirements for the VO**. *Eric Chassande-Mottin* shared the outcomes of the recent DADI workshop on gravitational waves that resulted in several new collaborative DADI projects in addition to the one already set up earlier, plus use cases for the evolution of VOEvent and the inclusion of time series into the VO.

Françoise Genova described the positive impact of certification for data centres, which the CDS has now obtained by WDS and also by DSA, two organisations that have partnered in an RDA working group to define a common certification framework.

Giuseppe Cimò discussed the challenges met by VLBI ground-based measurements of spacecraft in the PRIDE project, the help that could come from VO experience, and suggestions for the VO.

The first forum day concluded with two talks teaching **practical aspects of providing data via the VO**. *Markus Demleitner* showed the concrete steps of several alternative ways that a data provider can follow to publish their metadata into the VO registry, a prerequisite for visibility of data products by VO clients such as TOPCAT.

Grégory Mantelet described the landscape of the VO protocols and standards and used the central TAP protocol to explain how the software solutions of the training day fit into the process of compiling all building blocks required to run a customised TAP service.

This was followed by most of the "elevator pitch" statements for the training day that were mentioned above.

The second forum day started with five contributions centered around more or less **recent developments in the VO**. *Juan Gonzalez Nuñez* reported how the ESAC Science Data Centre is VO-enabled while integrating Gaia and Euclid consortia's needs into their archive infrastructure, plus "code to data", cloud, and data mining requirements.

Maria Henar Sarmiento demonstrated the ESASky web application that uses VO protocols to uniformly access data of catalogs, images, and spectra from multiple space missions, with a front end that was built using Aladin Lite and the Google Web Toolkit.

Vladimir Kulikovskiy reported on the integration of the ANTARES and KM3NeT projects into on-line and off-line multi-messenger programs and how DADI enabled publication of neutrino-like events to the VO at the GAVO data centre, together with respective TOPCAT use cases.

Mireille Louys spoke about the VO's Observation Core components Data Model (ObsCore), with its latest version 1.1 being an IVOA proposed standard as of June 2016, describing how to use it for proper publishing and retrieval of metadata via TAP.

Pierre Le Sidaner presented how the EPN-TAP metadata framework made the VO infrastructure usable for planetary science, why it evolved into the form that it has today, and in which way this framework achieves flexibility towards future extensions.

There were three talks about **specifications for particular types of published data** that are not IVOA standards but are still closely related to the VO. *Christoph Deil* reported on a working group established in 2016 by members of all major imaging atmospheric Cherenkov telescopes in order to specify a common FITS-based data model for data level 3 products, on associated open tools, and on an upcoming test data release.

Nicolas Moreau introduced VAMDC, a distributed infrastructure for atomic and molecular databases that uses adapted variants of core VO building blocks, namely, the registry, VOResource, and TAP, while defining its own data format (XSAMS).

Carlo Maria Zwölf described a solution for reproducible citations of database queries by adapting an RDA recommendation for VAMDC use, centered around a universal persistent query store and a versioning layer on top of existing data formats.

The final plenary session featured four contributions of **new infrastructure work for publishing data and services**. *Dave Morris* introduced projects that facilitate working on real-world issues when implementing new ADQL features from the upcoming version 2.1: a collection of operating system containers with database back ends and a syntactic and semantic ADQL test suite.

Markus Nullmeier reported recent improvements achieved by the developers of the PgSphere back end software used by most ADQL implementations: much faster spatial queries and crossmatching, numerical stability, and fixes for long-standing bugs.

Carlo Maria Zwölf showcased client and server implementations of the IVOA PDL, a flexible type system complemented by constraints, which provides for semantic interoperability in the VO, with use cases such as automatic generation of value-restricted entry forms and service discovery.

Jiří Nádvorník reported a toolkit for automatic photometry and light curve extraction from images using HEALPix as well as Munipack's astrometry and photometry, which is tightly integrated into publication to the VO, using ObsCore 1.1 and the N-Dimensional Cube Model.

Picture 3: The event's group photo

5. The training day: participation and programme

Participants

Participation in the training day was optional, with registration offered via the event on-line registration form. Also, after the "elevator pitch" statements were scheduled at the end of each forum day to advertise the individual training sessions, the participants could still register on paper sheets at the venue. 17 participants signaled their interest by registering, and as many showed up for the training (although three registered participants left after the forum days and three of those who came forgot to register). Taking into account that eight of the data provider forum participants had to host the sessions of the third day, slightly less than half of the forum participants (46%) did actually join.

Training sessions

As the event targeted data providers, the training day concentrated on software solutions that provide the necessary machinery to publish data into the VO. These publication toolkits take astronomical data and their metadata in a variety of formats, store these internally (typically in databases), and provide server functionality to make them available to VO client software via the cone search, ADQL (TAP), spectra and image access, and other related VO protocols. Some toolkits publish the data on automatically created web pages as well. See http://wiki.ivoa.net/twiki/bin/view/IVOA/PublishingInTheVONew for details.

Table 1: Overview of the training sessions

| VO publication toolkit	Interested participants	Teachers and affiliation
SVOCat / MySpec-MyImg	5	Carlos Rodrigo Blanco & J. Manuel Alacid, INTA
The CDS / ARI libraries	6	Grégory Mantelet, Gaia DPAC consortium
VO-Dance	5	Marco Molinaro, INAF
DaCHS	12	Markus Demleitner, UHEI
VizieR, HiPS, and MOC	11	Pierre Fernique & Gilles Landais, CNRS/OAS
Saada	8	Laurent Michel, CNRS/OAS

All VO partners in DADI that have developed and are supporting VO publication toolkits offered a training session of their own. The "VizieR, HiPS, and MOC" session offered themes that went beyond those mentioned above. Since some of the six sessions were expected to run for a full day and others only for half a day, the participants could register for more than one session. Table 1 gives the sessions' titles, the number of interested participants, plus their teachers and affiliations. More detailed descriptions of the subjects can be found in Annex B.

Apart from plenary demonstrations, participants were also expected to work with the publishing toolkits on their own mobile computers. A pointer to an installation guide for certain prerequisite software was sent out to all participants some time before the event. Some session published teaching resources on the DADI wiki[2].

The actual distribution of the 17 participants with respect to the training sessions was a bit more uneven than the one shown in Table 1, which records initial wishes, might suggest, but there was at least one person attending each session. The actual participation was not recorded, also because some participants switched sessions according to their specific needs. Generally, participants and teachers were highly motivated, resulting in an intensive learning experience that carried on into the discussions during the breaks, where evidently everyone was very much involved as well.

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2   at https://www.asterics2020.eu/dokuwiki/doku.php?id=open:wp4:wp4edpforum1

Picture 4: The training day's group photo
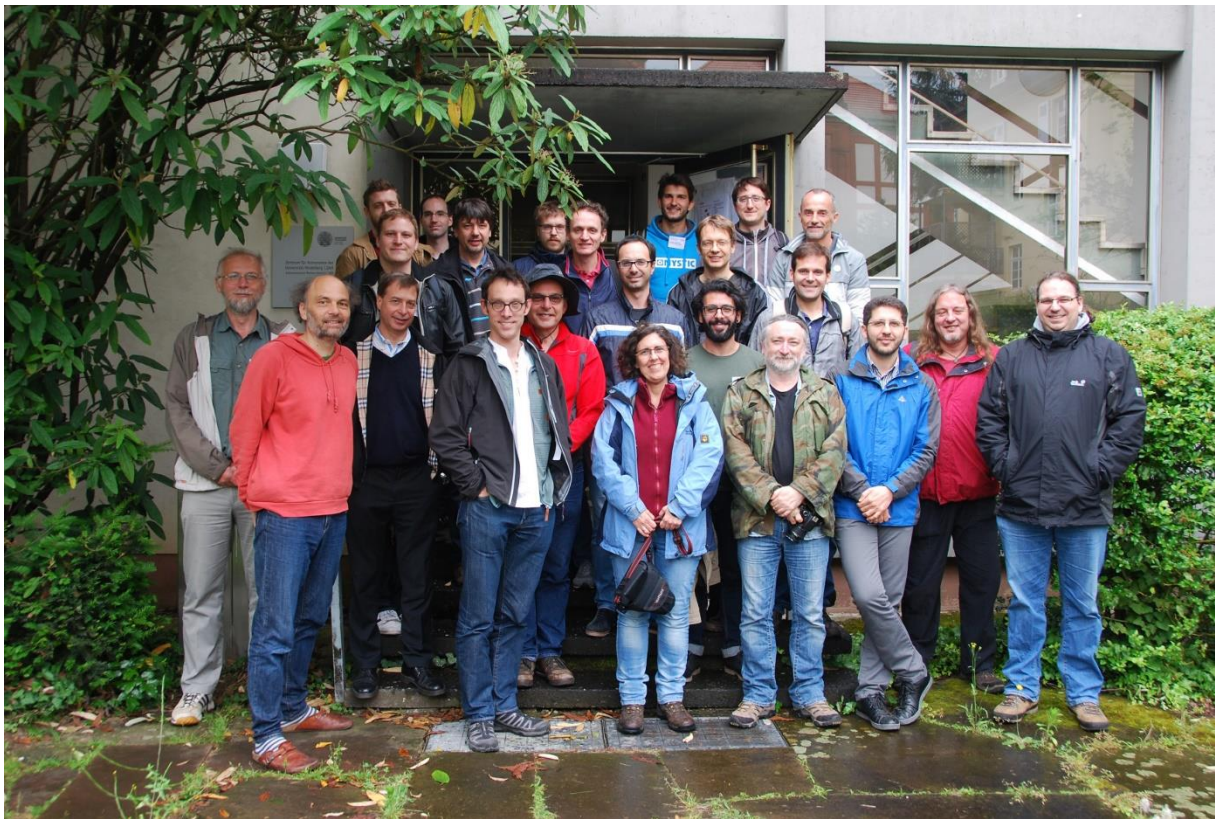
# 6. Concluding discussion with feedback

The last agenda item of the two forum days was a plenary discussion labelled "requirements, feedback, and lessons learnt". It was chaired by the DADI lead Françoise Genova, who structured the discussion through a set of slides showing a comprehensive list of conclusions, which she updated during the session to include participants' contributions. The slides are available on the meeting web site. A cross section of the discussion follows below.

Characterisation of the meeting

The forum featured contributions on many different topics. Several talks presented core parts of the VO as such: on its overall fabric, on its registry, and on metadata. The VO as a framework of standards and tools, being used for interoperability and as a set of building blocks of the data provider system, was referenced throughout all the talks, with many relevant citations of standards: e.g., the central role of TAP, VOSpace for distributed storage, ObsCore for metadata, ADQL, and PDL.

In contrast, at the first meeting of this kind in 2013, organized within the CoSADIE FP7 project, the ifs, whys, and hows of using the VO were still a major issue. Now the VO is manifestly part of the landscape where data providers thrive, with in addition awareness of matters that are hot topics beyond the astronomical community, such as DOIs, certification, and the RDA. It is well in line with the fact that a liaison with the latter is one of DADI's subtasks.

Picture 5: Impression of an oral contribution
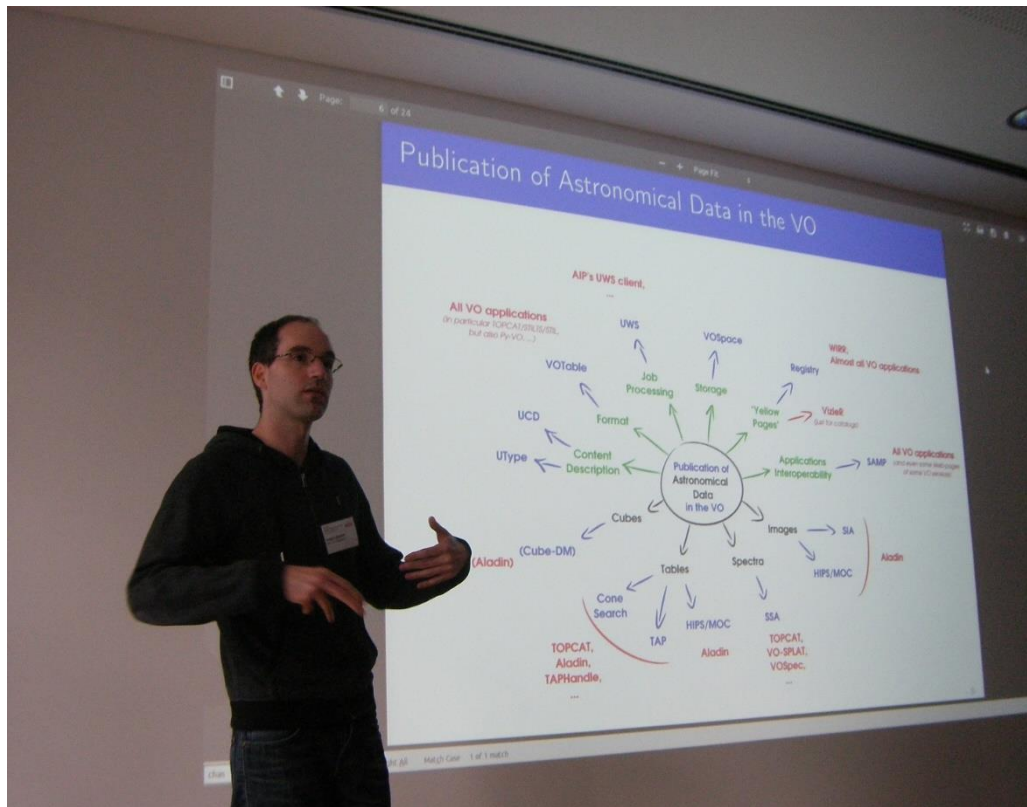
The composition of the participants was representative of the high diversity of the population of European data providers. The presence of large, medium, and small organisations, as well as disciplinary or specific projects, and also observatories, was noted, including ESO and ESA international organisations, the ESFRIs and other large projects, and data centres playing a national role and/or aggregating data sets from different projects. All in all, a rather large sample of data publication issues within current and future projects was put forward; and the legacy of plate collections was not forgotten.

Among participants not linked to large projects explicitly included in DADI, the presence of representatives from the EST (included in the ESFRI Roadmap in 2016) was particularly welcome. Communication with the project will continue to share the knowledge and lessons learnt accumulated in building the astronomical VO.

Highlights of the presented results

Of particular significance for ASTERICS WP4 were two presentations of collaborations between DADI ESFRI and VO partners, namely, the on-going work on strategies for the follow-up on gravitational wave events using VO tools (CNRS/APC, INFN, and CNRS/OAS) and the VO publication and usage of ANTARES neutrino-event data (CNRS/CPPM and UHEI).

In accordance with ASTERICS high level goals, there was a broad range of contributions on both astronomy and astroparticles, covering multi-wavelength and multi-messenger aspects. In addition, nearby disciplines such as solar and planetary science, plus atomic and molecular physics, also contributed. The meeting showed how several disciplines customise the VO standards and tools (e. g., EPN-TAP, VAMDC), demonstrating the VO framework capacity to fulfil the potential specific requirements of the ESFRI partners in DADI.

Among the many topics detailed in Section 4, one can identify various creative ways to use the VO. Quality was also an important keyword at the event. There, the questions arise of which kind of data to publish: processed data, steps below processed data, and/or raw data. Conceding that the notion of quality has many meanings, it was noted that data providers should and will make case-by-case decisions depending on the needs: they are the ones that have instrument knowledge at their disposal and have the means to keep track of calibration and processes. In this vein, documentation of the data-generating procedures is one measure for quality.

The contributions confirmed that DOIs apparently "have won the battle [for persistent identifiers], if there ever was one". They are more and more important, in particular because of the increasing requirement to make data citable in publications, also with observatories wanting to measure the impact of their data, and with many data centres that are moving towards implementing DOIs. There are still challenging questions, however. E.g., apart from technical aspects, DOIs are also marks of authority that describe who is responsible for which aspect of the data. Also, there are contradictory points of view about DOIs, either allowing them to identify evolving data, or requesting that they reference only data that is "set in stone", as if by a checksum.

Highlights of interest for future work and collaboration

The topics at this forum resonated well with the two current IVOA priorities, which are also DADI initial priorities, i.e., time domain data, where progress on time series is expected soon, and multi-dimensional data, (e.g., 3D / IFU, radio, multi-epoch photometry). The underlying idea is to achieve a convergence to a few stable advanced protocols for data access beyond the current operational ones.

There was also the case of expanding the domain the VO covers, such as the evolution of ObsCore or provenance, with a call for additional use cases from the latter, where both the VO and CTA are committing resources. Provenance within the VO as a use case for provenance

in general is also visible from and closely followed by the RDA. The authentication and authorisation topic provoked a longer stretch of discussion, which is reported further below.

Concerning back end matters, the required further evolution of ADQL seeks more use cases. The related PgSphere technology raised only a few but explicit marks of interest, commensurate with its high impact due to its high level of usage in data centres. The potential of combining PDL and UWS was raised, as were the recent trends of NoSQL, operating system containers, Hadoop, and Spark. Several of the participants are actually evaluating and testing NoSQL technologies, while the aspect of query languages would require further discussions.

As for the usage of file formats, FITS appears to be still predominant and HDF5 was not mentioned too often. There is apparently no consensus yet on how to proceed if an evolution is needed. On the one hand, the shortcomings of FITS were referred to in conjunction with making the case for HDF5 (which is for instance used by CTA on its lower data levels), but on the other hand, the FITS serialisation with its specific profiles was also seen as a fully established standard well capable of handling any type of data relevant for the VO. Finally, the HDFITS initiative was put forward, which has ported the FITS data model and also software libraries to the HDF5 storage format.

Regarding the detailed list of requirements for the new ESO archive service, parts of them already have solutions in the VO. For instance, VO accessibility of textual descriptions can be readily achieved by the DataLink standard, which may even provide links to services providing additional information. For the need of assigning object categories, there was considerable pertinent work that was put into SIMBAD, which can serve as the beginning of an answer. Solutions for FITS serialisation of new data models and dynamic visualisation of spectra/cubes in a web page appear feasible as well, but anecdotal evidence of Javascript crashing web browsers beyond data sizes of 15 MB was mentioned for the latter question.

Authentication and authorization infrastructures

For handling non-public data, proprietary periods, usage statistics, and any other purposes that necessarily have to discriminate among users, the requirement is obvious to properly include A&A in the VO ecosystem, including fine-grained access. There is already an IVOA SSO document in the Request for Comments phase based on OpenID. The most relevant questions appear to be those of which (pre-existing) A&A standards to use and who runs authentication services.

Because of its complexity, it is well known that A&A can lead to endless discussions. The same effect started to show at this forum. It was then noted that A&A is anyway also discussed in different work packages of ASTERICS and in other European projects, which shows the importance of the subject.

Especially the astroparticle ESFRIs have to use A&A, with CTA using OpenID (also used by the Astronomical Observatory of the Jagiellonian University, which was represented in this event).

Requirements for fine-grained data access were highlighted; however, the discussion concluded with the remark that the specific problems of A&A as such are mostly outside the scope of both ASTERICS WP4 and the IVOA, which concentrate on interoperability questions. Actions should be taken to organize exchange of information among interested people from the different ASTERICS work packages.

The state of software tools for the VO

First, software tools that fulfill many kinds of VO needs do exist. Tools supporting data publication were presented in detail on the training day (see Annex B for details). Also, tools supporting data usage were prominently used in the forums' contributions, such as TOPCAT, Aladin, Aladin Lite for dynamic visualisation, and SPLAT-VO for spectra.

In addition, individual groups are developing tools, with some development work shared between groups. The question for VO-wide documentation and dissemination, and also tool sustainability, remains open, especially for these tools. A related issue is how to avoid reinventing the wheel. An IVOA wiki page with a list of libraries and tools had been created, and it has to be maintained. Thus, information about and links to sustainable and maintained sources can be included. The DADI deliverable D4.8 "Repository of WP4 products" is due in April 2017, and its content will be discussed, in particular during the next Technology Forum.

Feedback on the event

Since there will be a second European Data Provider Forum and Training Event (ASTERICS deliverable D4.13) two years after the first, feedback on this meeting and suggestions for the next one were explicitly asked for. Starting with issues about the programme and its schedule, it was agreed that there was not enough time for discussion during this forum. Contentwise, there should be room for more focus on the presentations, and possibly also for a specific discussion session regarding the VO framework. Regarding newcomers to the VO, there was consensus on the fact that the meeting would be more efficient for them if there would be an introductory session to present the VO. Thus, it is planned that the next forum will have an afternoon or morning session for newcomers before the global start of the meeting.

Several suggestions were made with respect to supporting material and documentation. Starting with the plea to put all helpful content on the DADI wiki page, the idea of producing screen cast movies of people using the VO was put forward. Also, it should be quite helpful to have a means to discover contacts for different kinds of VO topics, kinds of data, and so forth. There were two ideas to help in this respect, first, providing a basic overview document showing where the topics are in the big picture of the VO, i. e., a kind of "VO introduction" also featuring a list of VO acronyms with descriptions. Second, it was deemed necessary to have a contact list of VO professionals indicating their domains of expertise. The request to link to the presentation slides on the programme web page was fulfilled soon after the event (see also Annex A).

Picture 6: Discussions during a training day's break

Not all of the many topics that were brought up at the forum will be eventually tackled under the auspices of DADI. Non-WP4 participants are also part of the community that is entitled to participate in the evolution of the VO. One idea for this was the possibility of new collaborations between the participants for future projects. On the other hand, everyone was asked to send in additional points of concern, including requests for subject-specific DADI meetings.

7. Next steps

The events relevant for ASTERICS WP4 following this one started with the 8th RDA Plenary Meeting, held together with the International Data Week, which took place from the 11th to the 17th of September 2016 in Denver, Colorado, USA. Then there will be the ADASS XXVI conference from the 16th to the 20th of October 2016 in Trieste, Italy, with several contributions from DADI members. It will be followed by the Interoperability Workshop of the IVOA with many participants from DADI at the same venue, from the 21st to the 23rd of October 2016, where core matters of the VO, including the requirements identified at this first European Data Provider Forum and Training Event, will be worked on.

The next DADI deliverable will be the second ASTERICS European School, to be held from the 15th to the 17th of November in Strasbourg, France (ASTERICS deliverable D4.5). The following WP4 meeting, i.e., the third ASTERICS DADI Technology Forum (ASTERICS deliverable D4.7), will take place at the same venue in early 2017. It is expected that several threads of work fueled by the present event will come to first fruition by then and there.

The following DADI deliverable D4.8, "Repository of WP4 products", due in April 2017, was already discussed in Section 6. It is also anticipated that there will be one or more subject-specific DADI meetings in the foreseeable future.

ANNEX A: Schedule of forum days with linked slides

Wednesday, 15th of June 2016	
09:30 – 10:00	Registration and get-together with coffee and snacks
10:00 – 10:55	Introductions
10:00 – 12:15	**Plenary session 1**, chair: Markus Demleitner
10:00	Markus Demleitner (GAVO / Uni Heidelberg) Short self-introduction of all participants
10:25	Giuseppe Cimò (JIVE / ASTRON) Introduction to the ASTERICS project
10:40	Françoise Genova (CDS (Centre de Données astronomiques de Strasbourg)) ASTERICS WP4 – DADI Data Access, Discovery and Interoperability
10:55	Mathieu Servillat (Observatoire de Paris – LUTH) Data diffusion for ground-based gamma-ray astronomy
11:15	Michael Sterzik (European Southern Observatory) ESO's role as science data provider: strategies and challenges
11:35	Kristin Riebe (Leibniz Institute for Astrophysics Potsdam (AIP)) Data publication at AIP
11:50	Marco Molinaro (INAF – OATs) The INAF IA2 data provider experience, including the VIALACTEA knowledge base effort
12:15 – 13:20	Lunch
13:20 – 15:20	**Plenary session 2**, chair: Marco Molinaro
13:20	Nazaret Bello González (Kiepenheuer-Institut für Sonnenphysik) Data archiving for the next generation of solar high-resolution telescopes
13:40	Pierre Le Sidaner (Observatoire de Paris) Data publication at PADC using TAP ObsTap for CTA, Gaia, ... and EPN-TAP for Europlanet

14:00	Cristina Knapic (INAF – OATs) Radio Data Model for Medicina and Noto telescopes
14:20	Mathieu Servillat (Observatoire de Paris – LUTH) Provenance of astronomical data
14:40	Petr Škoda (Astronomical Institute of the Czech Academy of Sciences) (Semi-)automatic VO publishing pipelines of Czech stellar data
15:00	Harry Enke (Leibniz Institute for Astrophysics Potsdam (AIP)) Usage of the DOI system for data centres in Astronomy
15:20 – 15:50	Coffee break
15:50 – 17:20	**Plenary session 3**, chair: Markus Nullmeier
15:50	Eric Chassande-Mottin (APC CNRS) Data-related issues in gravitational wave astronomy
16:10	Françoise Genova and Gilles Landais (CDS (Centre de Données astronomiques de Strasbourg)) Certification of data repositories: CDS experience and RDA outputs
16:30	Giuseppe Cimò (JIVE / ASTRON) VLBI observations of spacecraft: joining space science and planetary data with almost classical radio astronomy
16:50	Markus Demleitner (GAVO / Uni Heidelberg) How to register your data
17:20	Grégory Mantelet (ARI / Uni Heidelberg) How to create your own customised VO data access service easily
17:40 – 18:10	"Elevator pitch" introductions of tutorials on the 17th
17:40	Carlos Rodrigo Blanco (Centro de Astrobiología (INTA-CSIC), Spanish Virtual Observatory) SVOCat
17:45	J. Manuel Alacid (Centro de Astrobiología (INTA-CSIC), Spanish Virtual Observatory) MySpec-MyImg

17:50	Grégory Mantelet (ARI / Uni Heidelberg) The CDS / ARI libraries
17:55	Marco Molinaro (INAF – OATs) VO-Dance
18:00	Markus Demleitner (GAVO / Uni Heidelberg) DaCHS
18:05	Laurent Michel (CDS (Centre de Données astronomiques de Strasbourg)) Saada
19:30	Conference dinner
Thursday, 16th of June 16 2016	
09:30 – 11:00	**Plenary session 4**, chair: Catherine Boisson
09:30	Juan Gonzalez Nuñez (European Space Astronomy Centre (ESAC)) Maximizing data accessibility and exploitation through VO protocols at the ESAC Science Data Centre
09:45	Maria Henar Sarmiento (European Space Astronomy Centre (ESAC)) ESASky, a new way to discover and share astronomical data
10:00	Vladimir Kulikovskiy (CPPM (Centre de physique des particules de Marseille)) ANTARES / KM3NeT multi messenger programs
10:15	Mireille Louys (CDS, Icube, Université de Strasbourg) How to describe your observations' metadata? The Observation Core components DM
10:35	Pierre Le Sidaner (Observatoire de Paris) Origin and specificity of EPN-TAP
10:55 – 11:30	Coffee break
11:30 – 12:30	**Plenary session 5**, chair: Markus Nullmeier
11:30	Christoph Deil (MPIK Heidelberg) Open data specifications and tools for gamma-ray astronomy

11:50	Nicolas Moreau (Observatoire de Paris) Standardizing atomic and molecular data search and publication: the VAMDC infrastructure
12:10	Carlo Maria Zwölf (Observatoire de Paris) From RDA Data Citation Recommendations to new methods for citing data from VAMDC
12:30 – 13:30	Lunch
13:30 – 14:50	**Plenary session 6**, chair: Markus Demleitner
13:30	Dave Morris (WFAU-IfA, University of Edinburgh) Current projects at the WFAU archives, with an emphasis on ADQL
13:50	Markus Nullmeier (GAVO / Uni Heidelberg) Accelerating access to data archives with the new version of PgSphere
14:10	Carlo Maria Zwölf (Observatoire de Paris) The IVOA Parameter Description Language (PDL)
14:30	Jiří Nádvorník (Czech Technical University in Prague (ČVUT)) Light Curve Generation and Publishing of the Ondrejov Southern Photometry Survey
14:50 – 14:55	"Elevator pitch" introduction of a tutorial on the 17th
	Pierre Fernique (CDS (Centre de Données astronomiques de Strasbourg)) VizieR, HiPS, and MOC
14:55 – 15:30	Coffee break
15:30 – 16:50	Discussion of requirements, feedback, and lessons learnt Chair: Françoise Genova (CDS (Centre de Données astronomiques de Strasbourg))
16:50 – 17:00	Conclusion and final remarks (Markus Demleitner)

See the on-line version of the programme at http://www.g-vo.org/edp-forum-2016/programme.html for abstracts.

ANNEX B: Description of the training day topics

Friday, 17th of June 2016	
09:30 – 10:30	Tutorials
10:30 – 11:00	Coffee break
11:00 – 12:30	Tutorials
12:30 – 13:30	Lunch
13:30 – 16:00	Tutorials

SVOCat / MySpec-MyImg

SVOCat is an application intended to facilitate the publication of an astronomical catalogue, both as a web page and as a Virtual Observatory ConeSearch service. It has been intentionally designed so that it helps the service maintainer to understand what is being done, so that it can be used as a starting point to build more complex VO services in the future. It is developed in PHP and requires only a web server (Apache for instance) and a MySQL database.

MySpec and MyImg are applications intended to facilitate the publication of spectra and images, both as a web page and as Virtual Observatory SIAP and SSAP services. They have been designed to build the services from a collection of spectra or images and without any previous knowledge of a programming language. The applications have been developed in Java and require only a web server (Tomcat and Apache) and a PostgreSQL database. Both spectra and images have to be in FITS format.

The CDS / ARI libraries

The CDS / ARI libraries form a set of four generic Java libraries, each of them implementing an IVOA standard: ADQL-Lib for ADQL, UWS-Lib for UWS (a protocol for asynchronous execution of computations), TAP-Lib for TAP (Table Access Protocol) and SCS-Lib for Simple Cone Search. Thanks to the latter three libraries, you will be able to set up a standard or custom UWS, TAP, or SCS service easily, either with a single text configuration file or by directly using the respective Java APIs.

VO-Dance

INAF-IA2 publishing solutions: Under VO-Dance goes a couple of deployable applications capable of publishing catalogues, images, tablesets and spectra. Plus, we offer a modular re-working of the above, currently under development, which is more pluggable and customizable.

DaCHS

DaCHS is a comprehensive, VO-integrated data publishing solution, providing almost all major VO protocols in a package with seamless metadata management.

VizieR, HiPS, and MOC

VizieR provides access to the most complete library of published astronomical catalogues and data tables available on-line, organized in a self-documented database.

HiPS is the hierarchical tiling mechanism, which allows one to access, visualize, and browse seamlessly, image, catalogue, and cube data.

MOC, the Multi-Order Coverage map method, allows to specify arbitrary sky regions, with very fast comparisons between them. It is based on the HEALPix sky tessellation algorithm.

Saada

Saada transforms a set of heterogeneous FITS files or VOTables of various categories (images, tables, spectra, ...) into a powerful database deployed on the Web, which operates VO services (SSA, SCS, SIA, and TAP) as well. Exposed data can be linked to each other in order to provide a global view on complex data sets.