Project Title	European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructure
Project Acronym	ESCAPE
Grant Agreement No	824064
Instrument	Research and Innovation Action (RIA)
Topic	Connecting ESFRI infrastructures through Cluster projects (INFRA-EOSC-4-2018)
Start Date of Project	01.02.2019
Duration of Project	42 Months
Project Website	www.projectescape.eu

MS22 – PROGRESS AND PRIORITIES AT IVOA (3)

Work Package	WP4, Connecting ESFRI projects to EOSC through VO
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Due Date	30.06.2020, M17
Date	30.06.2020
Version	1.0

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Project Summary

ESCAPE (European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures) addresses the Open Science challenges shared by ESFRI facilities (CTA, ELT, EST, FAIR, HL-LHC KM3NeT and SKA) as well as other pan-European research infrastructures (CERN, ESO, JIVE and EGO) in astronomy and particle physics. ESCAPE actions are focused on developing solutions for the FAIRness of large data sets handled by the ESFRI facilities.

These solutions shall: i) connect ESFRI projects to EOSC ensuring integration of data and tools; ii) foster common approaches to implement open-data stewardship; iii) establish interoperability within EOSC as an integrated multi-probe facility for fundamental science.

To accomplish these objectives, ESCAPE aims to unite astrophysics and particle physics communities with proven expertise in computing and data management by setting up a data infrastructure beyond the current state-of-the-art in support of the FAIR principles. These joint efforts are expected result into a data-lake infrastructure as cloud open-science analysis facility linked with the EOSC. ESCAPE supports already existing infrastructure such as astronomy Virtual Observatory to connect with the EOSC. With the commitment from various ESFRI projects in the cluster, ESCAPE will develop and integrate the EOSC catalogue with a dedicated catalogue of open-source analysis software. This catalogue will provide researchers across the disciplines with new software tools and services developed by astronomy and particle physics community. Through this catalogue ESCAPE will strive to cater researchers with consistent access to an integrated open-science platform for data-analysis workflows. As a result, a large community "foundation" approach for cross-fertilisation and continuous development will be strengthened. ESCAPE has the ambition to be a flagship for scientific and societal impact that the EOSC can deliver.

1. Introduction: IVOA Interoperability Meeting

The International Virtual Observatory Alliance (IVOA) interoperability meeting was originally planned to be held in Sydney, Australia 4-8 May 2020. The planning for this meeting was well advanced, however due to the global pandemic of the COVID-19 virus, on 10 March 2020 the IVOA Executive committee decided to cancel the physical meeting and instead develop concepts for holding a virtual event in its place. Following a number of discussions in the IVOA Executive Committee and the Technical Coordination Group (TCG) it was decided to hold a virtual meeting during the original dates. The schedule was arranged to accommodate participation from around the globe, with the opening session starting at 12h00 UTC, and then 4 days with three 2.5hr session blocks per day (4h30, 13h30, 20h30 UTC). Some IVOA working groups also organised follow up meetings in the weeks after the main meeting, and results and presentations of these extra meetings are included in this report.

This Interoperability Meeting was a formal milestone for the ESCAPE CEVO Work Package (ESCAPE Milestone 4.3 – Progress and priorities at IVOA(3)). It was the third IVOA meeting during the ESCAPE project, and was an important event for consolidating a number of CEVO activities where the priorities of ESCAPE partners have been brought to the IVOA and have led to progress for international standardisation for data sharing, in particular for the use of the VO framework for radio astronomy.

In this report we outline the progress of the CEVO Work Package activities that have been presented at the IVOA meeting, and we track the participation of ESCAPE partners (and also the wider European contributions) in IVOA. The means of verification for these milestones are the IVOA meeting website and the record of ESCAPE participation in the meeting.

The Interoperability meeting gathered 207 participants for the main 5-day meeting. This is the highest ever attendance of an IVOA meeting, which was clearly made more accessible by being virtual and not requiring travel to attend. The web pages, including the detailed schedule of the meeting and the list of participants are available at the links in the table below.

Meeting Page (hosted via INAF)	https://indico.ict.inaf.it/event/1056/overview
Detailed IVOA Schedule Page	https://wiki.ivoa.net/twiki/bin/view/IVOA/InterOpMay2020
Social Media	*Hash-tag :* #ivoa20virtual, *Twitter :* https://twitter.com/IVOAastro

2. ESCAPE CEVO and European participation

There was a high level of European participation in this meeting, with 14 of the 16 ESCAPE CEVO partners being represented. The list of European contributions with a link to the slides presented, is tabulated in Appendix A of this report, with the ESCAPE CEVO contributions indicated. ESCAPE CEVO partners have also contributed to the planning of the meeting in the IVOA Executive Committee and the TCG. The ESCAPE INAF/OATS partner provided the registration and meeting planning pages in support of this international meeting, and overall ESCAPE was highly visible in the meeting.

3. State of the IVOA and Scientific Priorities

The state of the IVOA [1] was presented by the current chair, Chenzhou Cui (National Astronomical Observatory, Chinese Academy of Sciences).   The overall concept, structure, governance and progress of the IVOA was described, including a renewed initiative to collect the roadmaps[1] of the IVOA member projects, with ESCAPE activities included within the Euro-VO plans. Information on the status of WP4 CEVO activities of ESCAPE was provided for this opening talk, and was presented alongside other major VO projects (China-VO, Canadian VO and the US VAO and NAVO projects).

The international priorities for VO developments are managed within the IVOA by the Committee for Science Priorities (CSP) and the IVOA Executive Committee. The CSP presentation by B. Merin (ESA) highlighted that the current scientific priorities within the IVOA are time domain astronomy, multi-dimensional data, and radio-astronomy data. A strong focus in the future will be on access to VO services via python, in particular using *pyVO* as an entry point to the VO and VO services, as well as science platforms as a way of accessing and analysing large amounts of data.

The opening and CSP presentations [3] announced the establishment of the IVOA Radio Astronomy Interest Group. This formal structure enables direct input on the needs of the radio astronomy community for the development of the VO. ESCAPE partners CNRS-OBAS, and the radio astronomy related partners ASTRON, JIVE and SKA are involved in this process. Details are provided in the summary of the first session of this new Interest Group in section 4.

The presentation by the TCG [2] outlined the overall technical process of IVOA standardisation and the architecture of the standards. Given the wider audience participating in this virtual meeting this served as an important introduction to newcomers, and as such is also a good reference for ESCAPE partners. The recent approval of the Provenance Data Model 1.0 was announced, which is an excellent result following significant efforts made towards this by ASTERICS partners, and also contributions from ESCAPE. The TCG presentation was followed by a charge to the Working and Interest Groups (WGs and IGs), outlining the sessions planned for the virtual meeting. Highlights from the sessions are provided in the next section.

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1 https://wiki.ivoa.net/twiki/bin/view/IVOA/RoadMap

4. Highlights from the IVOA Working- and Interest Groups relevant to ESCAPE CEVO

Data Curation and Preservation Interest Group Session

The DCP-IG session focused on the recommendations of the RDA FAIR Data Maturity Model. F.Genova (CNRS-ObAS) presented the state of the RDA recommendations and their possible impact on the IVOA standards (04. FAIR Data Maturity Model- Licenses in Astronomy). VO services largely rely on community ethics ("cite the origin of what you reuse") rather than on explicit licenses. A Test of a preliminary version of the criteria performed in the framework of the ESCAPE project found, that FAIR practices differ from one discipline to another and that the FAIR practices in astronomy, largely built on the IVOA standards, can differ from the FAIR criteria seen as "Essential" in other disciplinary fields. Keeping track of the progress in the RDA collecting and evaluating practices and defining and sharing best practices on machine readable licenses in astronomy will be a responsibility of the DCP-IG and will have impact on ESCAPE in general, and on CEVO in particular. Other WGs in IVOA will have to tackle the evolution of IVOA standards if some are deemed necessary following the RDA recommendations, in particular the Data Access Layer, Data Model, Registry WGs.

Data Model Working Group sessions

Four sessions of the Data Model WG took place during this Interop meeting with many cross-WG connections.

L. Michel (Observatoire de Strasbourg) introduced into the state of Data Models in the VO, the advantages and limits of using *utypes* or VODML, and identified what future development needs to be addressed to make VO data models automatically understandable by client software (05. DM Status report). The status of Measurements, Coordinates and Transformation Models and ongoing developments was reported by M. Cresitello-Dittmar (06. Meas, Coords, Transform Model Status report). The Measurements and Coordinates Model are in a state where input from usage projects is needed for further development.

The Provenance Data Model was approved as a recommendation on 11 April 2020, and this Interoperability meeting saw presentations of different Implementations of this new VO standard. Contributed presentations of work in the frame of ESCAPE was given by M. Servillat (07. Implementations of the Provenance Data Model) and F. Bonnarel (10. ProvHiPS An "on top" provenance implementation). Closely related work was also presented by M. Louys (09. Annotating FITS Files with VO tags - SVOM case).

L.Michel also presented the progress of the Source DM effort. The so-called CAB-MSD allows to gather and relate various MCT measurements as well as additional features for sources. Serialisation through VODML-lite mapping was presented and prototype functionalities described.

Radio Astronomy Interest Group Session

This interop saw the new Radio Astronomy IG established, which will bind the radio astronomy community with the IVOA. Establishing this Interest Group is of crucial importance for ESCAPE WP4

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CEVO. Within this IG the radio astronomy community, including the ESCAPE ESFRI and other Research Infrastructure partners LOFAR, JIVE and SKA, give direct input regarding their demands towards interoperability standards to the IVOA. The definition and implementation of these standards will be a key task towards embedding the ESFRI/Research Infrastructure data into the EOSC in accordance with FAIR principles. F. Bonnarel (CNRS-ObAS) is the vice-chair of this new Interest Group.This very first session of the radio astronomy IG saw several presentations on Implementations of VO standards at various radio astronomy data services.

Amongst those, contributions from ESCAPE partners came from F. Bonnarel (15. ESCAPE radio astronomy developments), A. Loh (NenuFAR usage of VO standards for low-frequency radio astronomy), Y. Grange (18. Use of VO standards at ASTRON) and M. Kettenis (19. Use of VO standards at JIVE).

Time Domain Interest Group Sessions
In three sessions the TD-IG covered the annotation of light curves in VO-Tables, the new developments in VO-Event and in a joint session with the Data Access Layer WG (DAL WG) a revision of the Cone Search standard.

Following the IVOA note on a light curve annotation in April 2020, A. Nebot (CNRS-ObAS) introduced the proposed Time series standard (21. Annotations of light curves using VOTable) which is based strongly on ESCAPE contribution. The following discussion was a rather technical one around the use of *utypes* and other specialized VOTable tags. The need to keep this work focused on simple use cases was re-emphasised. The current model is focused on optical observations, and it was noted that use cases for other wavebands would require extension of the current vocabulary. Overall implementations and use cases are needed for further development.

B.Cecconi (Observatoire de Paris) proposed changes to the VO-Event standard to prepare it for Solar System Science (22. Proposed changes to VOEvent for Solar System Sciences). In his presentation he indentifies three extensions that should be added to the standard: the capability to use target name as a location, the capability to use a planetary body reference frame to identify a location, and the capability to specify a time range. These developments are likely to be relevant to Solar Physics data as pursued in the context of EST in ESCAPE.

In the joint session with the DAL-WG, A. Nebot (CNRS-ObAS) and M. Molinaro (INAF-OAT) gave an overview (32. ConeSearch "status & discussion") of an update of the IVOA Cone Search standard. The current Version 1.03 became recommendation in 2008, and with recent development in IVOA data models and demands from the community, the update is necessary. Among the discussed features, the addition of time domain metadata and input parameters was the most prominent.

Grid & Web Services Interest Group Sessions
The three GWS-WG sessions focused on science platforms and the related topic of Authentication & Authorization. Contributing presentations showed existing science platforms and which VO standards they use for interoperability, which standards should be extended or where the development of new standards seems necessary. The contributions on science platforms from the ESCAPE partners is in the context of making VO data available in platforms which is a strong link between ESCAPE WP4 and WP5.

A key point was the discussion about the future development of the Single Sign On standard (SSO), which provides the possibility for client software to easily access private data.

Contributions from ESCAPE projects came from G. Taffoni (24. Science Platforms), A. Dissanto (25. MEGAVIS Real-time spectra analysis, also in KDD-IG session), D. Morris (26. Describing Science Platforms), S. Bertocco (27. Single sign on: towards a new standard) and Sonia Zorba (29. An OAuth2-based GMS).

Data Access Layer Working Group Sessions
The DAL WG session saw updates on several VO standards, their current state and development in progress. With DataLink, ADQL, Cone Search (see TDG-IG), SIA2 and SODA the key standards of the IVOA are about to see significant changes, and strong improvements, in the near future. One result of the discussion became very obvious: standards should be revised more often, to adapt to errors in their description, and to keep the amount of changes low.

The contributions from ESCAPE or European VO partners were: F.Bonnarel gave status reports on DataLink (30. DataLink-next progress report), SIA2 and SODA (34. Feedback on SIA2/SODA including PyVO developments), G.Mantelet presented the way towards ADQL 2.1 (31. ADQL "status & discussion"), J. Salgado presented the progress on Object Visibility Simple Access Protocol and ObsLocTAP (33 Object Visibility SAP & Observation Locator TAP).

Another interop follow-up meeting on remaining issues in DataLink 1.1 was organized on 28 May 2020 and was co-chaired by F. Bonnarel and P. Dowler. It mainly concentrated on how to achieve URL templating in service descriptors.

Semantics Working Group Session
In the Semantics Session, M. Demleitner (UHEI) presented the progress towards a VO Vocabularies 2, which will be necessary to cover the ongoing progress of other standards within the VO (35. Vocabularies 2: "Towards RFC ?").

Knowledge Discovery from Databases IG Session
The KDD-WG session took place after the main virtual Interop had ended. The focus of this session was on Science Platforms and their future development. K. Polsterer (HITS) introduced this topic (41. Future of Science Platforms), followed by presentation of specific use of Science Platforms by P. Skoda (42. Active Learning in the VO-Cloud Science Platform and 44. Self Organizing Maps in the VO-Cloud). J. Nadvornik presented the use of hierarchical cubes (43. Hierachical Cubes with Uncertainties). The megavis spectral analysis machine learning software was introduced by A. Dissanto (HITS) (45. MEGAVIS Real-time spectra analysis) related to work in Task 4.3 of ESCAPE WP4.The session is an example of the link between ESCAPE WP3 and WP4.

5. Conclusions and next steps

The IVOA interoperability meeting was a successful milestone for CEVO. This first *virtual* IVOA Interoperability meeting proved to be a successful event, even if the organisation only converged in the days before the event. The virtual meeting did have some challenges, such as the difficulty for participants to attend all sessions because of the timing spread over global time zones, and also limited informal interactions. Nevertheless the ESCAPE project was very visible, with 19 CEVO-led contributions, and progress was made on establishing CEVO connections within IVOA so that the priorities of the ESFRI and other research infrastructures participating in CEVO were well represented at the IVOA.

A prominent success for CEVO at this milestone is the establishment of the IVOA Radio Astronomy Interest Group, which was largely motivated by CEVO activities and on the initiative of CEVO partners. This structure will facilitate the priorities of ESCAPE radio and millimetre astronomy infrastructures to be taken into account at IVOA for the development of common global standards for sharing of radio astronomy data. Active CEVO participation in the follow-up actions of this group is expected in the next months.

Another important success at this milestone is the approval of the Provenance Data Model 1.0 which was a major effort in the ASTERICS project, and finalised within ESCAPE. Follow-up actions related to the CTA and KM3NeT use of this model are planned, including a special Provenance meeting in Paris before the end of 2020.

The next IVOA interoperability meeting was planned for 13-15 November in Granada, Spain. This meeting was to follow the annual ADASS conference at the same location. In June 2020 it was decided that the ADASS conference will instead be held as a virtual event due to travel restrictions and other on-going effects of the global pandemic. In these conditions a virtual interop meeting will be organized and the WP4 plan will continue towards this next milestone.

Appendix A. – Presentations

The table below contains a list of all the contributions at the IVOA interoperability meeting that are relevant to CEVO. Presentations made by members of CEVO partner institutes are indicated, and we also identify the European contributions. A link to the presentations files on the IVOA interoperability meeting web pages are provided for each contribution. Additionally a repository of the presentations has been created with the original presentation files (with the filenames prefixed with the presentation number in the table).

Opening plenary sessions	
01. Opening Plenary Presentation: State of the IVOA Link to presentation	C. Cui *(NAOC)* *(input from ESCAPE-CEVO)*
02. State of the Technical Coordination Group Link to presentation	P. Dowler (CADC), J. Evans (CXC, Harvard)
03. Committee for Science Priorities Status Link to presentation	B. Merin (ESA) and CSP [incl. M. Allen (CNRS-ObAS) - *ESCAPE-CEVO*]
RDA WG session	
04. FAIR Data Maturity Model (RD WG) Link to presentation	F. Genova (CNRS-ObAS), F.Bonnarel (CNRS, ObAS), M. Allen (CNRS, ObAS), M. Molinaro (INAF-OAT) *ESCAPE-CEVO*
Data Model sessions	
05. DM Status report Link to presentation	L. Michel (ObAS), J. Salgado (ESA) *European contribution*
06. Meas, Coords, Transform Model Status report Link to presentation	M. Cresitello-Dittmar (CXC, Harvard)
07. Implementations of the Provenance Data Model Link to presentation	M. Servillat (ObsParis, FRANCE), C. Boisson, F. Bonnarel (CNRS-OBAS), M. Louys (I-Cube), M. Sanguillon (LUPM - IN2P3 - CNRS), J-F. Sornay *ESCAPE-CEVO*
08. Provenance and CTADIRAC Context Link to presentation	M. Sanguillon (U. Montpellier) *European contribution*

09. Annotating FITS Files with VO tags SVOM case Link to presentation	L. Michel (ObAS), M. Louys (CNRS-ObAS, iCube) *European contribution*
10. ProvHiPS An « on top » provenance implementation Link to presentation	F. Bonnarel (CNRS-ObAS), M. Servillat (ObsParis), M. Louys (I-Cube), M. Nullmeir, M. Sanguillon (LUPM - IN2P3 - CNRS), L. Michel (ObAS), a. Egner, D. Durand (CADC) *ESCAPE-CEVO*
11. Provenance and Pollux Link to presentation	M. Sanguillon (LUPM - IN2P3 - CNRS), *European contribution*
12. Python module: voprov Link to presentation	M. Sanguillon (LUPM - IN2P3 - CNRS) *European contribution*
13. Source model progress report Link to presentation	L. Michel (ObAS), F. Bonnarel (CNRS-ObAS), G. Landais (ObAS), M. Louys (I-Cube) *European & ESCAPE-CEVO contribution*
Radioastronomy Interest Group session	
14. Motivation and summary of work done so far in the Radioastronomy Interest Group Link to presentation	M. Lacy (NRAO), F. Bonnarel (CNRS-ObAS) *ESCAPE-CEVO*
15. ESCAPE radio astronomy developments Link to presentation	F. Bonnarel (CNRS-ObAS) *ESCAPE-CEVO*
16. Use of VO in CASDA and other Australian Radio Archives Link to presentation	J. Dempsey (CSIRO) *(relevant for ESCAPE Radio Ast. Partners)*
17. NenuFAR usage of VO standards for low-frequency radio astronomy Link to presentation	A. Loh & B. Cecconi (LESIA, Paris Observatory) *European contribution*
18. Use of VO standards at ASTRON Link to presentation	Y. Grange , M. Mancini, M. Sipior (ASTRON) *ESCAPE-CEVO*
19. Use of VO standards at JIVE Link to presentation	M. Kettenis (JIVE) *ESCAPE-CEVO*

20. Use of VO standards at IDIA Link to presentation	J. Collier (IDIA) *(relevant for ESCAPE Radio Ast. Partners)*
Time Domain Interest Group sessions	
21. Annotations of light curves using VOTable Link to presentation	A. Nebot, F. Bonnarel (CNRS-ObAS), M. Demleitner (UHEI), M. Louys (I-Cube), L. Michel (ObAS), D. Morris (UEDIN), M. Taylor (U. Bristol), J. Salgado (ESA) *ESCAPE-CEVO + European contribution*
22. Proposed changes to VOEvent for Solar System Sciences Link to presentation	B.Cecconi (ObsParis) *European contribution*
23. Next steps - registering and finding services Link to presentation	D. Morris (UEDIN) *ESCAPE-CEVO*
Grid & Web Services sessions	
24. Science Platforms Link to presentation	G. Taffoni (INAF-OATS) *ESCAPE-CEVO*
25. MEGAVIS Real-time spectra analysis Link to Video	A. Dissanto (HITS) *ESCAPE-CEVO*
26. Describing Science Platforms Link to presentation	D. Morris (UEDIN) *ESCAPE-CEVO*
27. Single sign on: towards a new standard Link to presentation	S. Bertocco (INAF) *ESCAPE-CEVO*
28. Authentication Link to presentation	P. Dowler (CADC) *(relevant to AAI work in ESCAPE)*
29. An OAuth2-based GMS	Sonia Zorba (INAF)

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Link to presentation	*European contribution*
Data Access Layer sessions	
30. DataLink-next progress report Link to presentation	F.Bonnarel (CDS), P. Dowler (CADC), L.Michel (ObAS) *ESCAPE-CEVO + European contribution*
31. ADQL "status & discussion" Link to presentation	G.Mantelet (CNRS-ObAS) *European contribution*
32. ConeSearch "status & discussion" Link to presentation	M. Molinaro (INAF), A. Nebot (CNRS-ObAS) *ESCAPE-CEVO*
33. Object Visibility SAP & Observation Locator TAP Link to presentation	J. Salgado (Quasar), A. Ibarra (Quasar), R. Saxton (TPZ-VEGA), J-U. Ness (ESA), E. Kuulkers(ESA), C. Gabriel (ESA), B. Merin (ESA), P. Kretschmar (ESA), M. Ehle (ESA), E. Salazar (ATG), C. Sánchez (ATG) *European contribution*
34. Feedback on SIA2/SODA including PyVO developments Link to presentation	F. Bonnarel (CDS) + Dal WG *ESCAPE-CEVO*
Semantics session	
35. Vocabularies 2: "Towards RFC ?" Link to presentation	M. Demleitner (UHEI) *ESCAPE-CEVO*
Applications sessions	
36. Lifecycle of a document change Link to presentation	T. Donaldson (STScI) *(relevant to ESCAPE partners for contributing to IVOA process)*
37. Automatic builds of the ADQL Standard Link to presentation	J. Dempsey (CSIRO) *(relevant to ESCAPE partners for contributing to IVOA process)*
38. A Python based TAP Server at Caltech/IPAC-NExScI Link to presentation	B. Berriman (USVOA/NAVO) *(relevant to European contributions to pyVO and access in Topcat)*
39. PyVO and the end User	Tess Jaffe (NASA/GSFC)

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Link to presentation	*(relevant to European contributions to pyVO and its use in WP4 schools)*
40. Maintenance of externally-facing IVOA resources Link to presentation	R. D'Abrusco (Harvard) *(relevant to visibility of European tools/services at IVOA)*
Knowledge Discovery in Database sessions	
41. Future of Science Platforms Link to presentation	K. Polsterer (HITS) *ESCAPE-CEVO*
42. Active Learning in the VO-Cloud Science Platform Link to presentation	P. Skoda (ASU) *European contribution*
43. Hierachical Cubes with Uncertainties Link to presentation	J. Nadvornik (CTUP) *European contribution*
44. Self Organizing Maps in the VO-Cloud Link to presentation	P. Skoda, L. Lopatovský, J. Koza (ASU, Czech Ac. Sci) *European contribution*
45. Short introduction to real-time spectra analysis with MEGAVIS Link to pdf	A. Dissanto (HITS) *ESCAPE-CEVO*

Appendix B. – IVOA Standards Approved

IVOA Standards Approved at the meeting

Acronym for standard	IVOA Standard and link to document
ProvenanceDM 1.0	IVOA Provenance Data Model Link to document

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