euroPLANET 2024
Research Infrastructure

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Deliverable D4.3

Deliverable Title:	Validation of functionality of the new capabilities with presentation at conference and deliver of new capabilities for TA call 3
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Contributing beneficiaries:	VUA, AU, DLR, CNRS, ATOMKI, UNIKENT
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Project Duration:	54 months
Co-ordinator:	Prof Nigel Mason

1. **Nature:** R = Report, P = Prototype, D = Demonstrator, O = Other
2. **Dissemination level:**

PU	PP	RE	CO
Public	Restricted to other programme participants (including the Commission Service)	Restricted to a group specified by the consortium (including the Commission Services)	Confidential, only for members of the consortium (excluding the Commission Services)

Executive Summary / Abstract:

JRA1 involved six projects associated with TA2 facilities. Five were designed to develop world-leading capabilities to beyond the current state-of-the-art by providing improved analytical (4) and experimental capabilities (1) relevant to the planning, implementation and scientific exploitation phases of current and forthcoming missions. A sixth project focussed on knowledge transfer to a URS facility involving direct training at a facility recognised as the world leader in the field. All these capabilities were implemented close to on time despite the impact of COVID.

The under-utilisation of TA3 facilities during the first years of the project due to COVID allowed additional potential upgrades to the facilities to be recognised. Five of the six initial planned JRA projects were expanded to provide additional capabilities with the aim to complete and implement upgrades by the end of 2022 (see previous annual report for details). The goal was to provide TA applicants to use the upgraded facilities in TA Calls 2 and 3.

All upgrades have been implemented and TA applications were carried out to use the facilities in Calls 2 & 3. All facilities had applications and five of six had applications approved in the peer review process. Numerous conference presentations have been made and there have been multiple peer reviewed publications only made possible due to the successful implementation of the JRA program.

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Validation of JRA1 functionality

1. Objectives

Objective 4: *D4.3 - Validation of functionality of the new capabilities with presentation at conference and deliver of new capabilities for TA call 3*

JRA1 aimed to develop 5 world-leading TA2 facilities to beyond the current state-of-the-art by providing improved analytical (4) and experimental capabilities (1) relevant to the planning, implementation and scientific exploitation phases of current and forthcoming missions to Mercury, Mars, asteroids, comets and the icy moons of Jupiter. The expanded capabilities should be offered for TA access in Years 3 & 4 of EPN-2024-RI. An additional goal of two tasks is knowledge transfer to two active facilities in URS, one involving the joint development of new capabilities, the second direct training at a facility recognised as the world leader in the field. Validation that the facilities are operational will be by their use by TA users and conference presentations and publications.

The scope of JRA1 was expanded upon successful completion of the first JRA due to additional capabilities recognised during COVID. Five projects were expanded with the final implementation of the second phase scheduled for the end of 2022. Validation of the successful implementation of the JRA1 projects was that they were offered for Trans-national access in Call 3.

2. Explanation of work carried out

The specific scientific and methodological goals of the JRA reflect the overall EPN-2024-RI TA strategy (i.e. i) expansion in European capabilities to study icy moons in preparation for the JUICE mission: ii) non-destructive/minimally invasive sample characterisation/analysis) and the overall project objectives of building closer ties to industry and developing capacity in URS.

JRA 1 included six initial specific tasks involving 11 research institutes and three industrial partners. The six tasks were planned to be completed within the first two years of the project to deliver the improved capabilities for TA calls in the final two years of the project. With the impact of COVID and extension of the project, the deadlines were extended by 6 months and all implementation goals were realised and the facilities offered for TA access in the Fast Track TA call. A second set of JRA1 goals were introduced to be undertaken during year 3 for delivery for Call 3. The management of the JRA is coordinated by the TA Sub-Committee (VUA NHM, DLR, UNIBO and AU) and supported by the TA office at the VUA that also provides the secretarial support.

Task 4.2.1 Delivering a Cryogenic Reflectance Spectroscopy under Vacuum Conditions for Outer Planets Exploration (DLR, CNRS-IPAG, AU)

Spectral observations are core to all planetary missions but their interpretation relies on databases produced in terrestrial laboratories under conditions generally incomparable to the actual planetary body. The two spectral facilities offered in TA2 (DLR and CNRS-IPAG) have unique capabilities in performing laboratory measurements under analogue conditions. The community, however, requires more comprehensive spectral and photometric information under extreme conditions pertinent to planetary surfaces. Following the success of the EPN-2020-RI in developing greater spectral range and resolution of a spectro-gonio radiometer at IPAG [Potin et al. 2018] and high temperature capabilities at DLR [Maturilli et al. 2014], a new low temperature, low vacuum chamber was manufactured and validated by a team led by the DLR Planetary Emissivity Laboratory (PEL). This development will ultimately provide the database under a range of temperatures and atmospheric conditions required to allow unambiguous identification of the mineralogy and physical nature of the surfaces of many planetary bodies.

The first and second phases of the JRA1 development were offered for TA access in Call 2 and 3 respectively. Three TA visits of ten days each made use of JRA improved facilities in 2022: Darby Dyar, Molly McCanta and Erika Kohler.

The presentations and publication list of the project (Europlanet 2024 RI Publications – Europlanet Society (europlanet-society.org)) demonstrates that visitors to the DLR facility made presentations at the International Venus Conference, Lunar and Planetary Science Conference, AGU, COSPAR, Infrared Remote Sensing and Instrumentation XXVIII and EPSC.

Task 4.2.2 Upgrading an astronomical ice-spectroscopy UHV chamber with UV/Vis and mass spectroscopy extensions for improving its TA potential: Atomki- UNIKENT-DLR

In a related task, ATOMKI and UNIKENT developed vacuum chambers to study the structure of the ion-impact modified ices. An existing chamber was modified to provide a better vacuum (ultra-high vacuum (UHV)) and the capability to perform VIS/UV spectrometry and trace gas analysis. These improved capabilities are of direct relevance to on-going and planned missions to comets, asteroids Saturian and Jovian moons.

The initial JRA1 task involved installation of an ultra-high vacuum (UHV) chamber at the beamline of the 2MV Tandetron accelerator in Atomki to determine the structural-chemical modifications induced by the ion-impact on ices. The work further involved upgrading an astronomical ice-spectroscopy ultra-high vacuum (UHV) chamber with UV/Vis and mass spectroscopy extensions. The project was completed ahead of schedule due to supply of a UHV chamber from a collaborating institute. Moreover, the first TA visit commenced ahead of schedule in November 2020: “a Systematic Study of Sulfur Ion Radiolysis of Simple Oxide Ices”. Initial results of this work were presented at EPSC 2021.

The second JRA1 implementation has also been completed on time. This involved transport and up grading a second chamber from Queen’s University Belfast and coupling to the beamline of the electron cyclotron resonance (ECR) source at Atomki. The project was made possible with additional funding to support upgrade of the facility from the Hungarian national funding agencies, which funded, for example, a new Bruker VERTEX 70v FTIR spectrometer. The second stage of the JRA (the chamber is named AQUILA), has also been completed and offered for access in TA Call 3. The popularity of, and need for, the two new capabilities is evident by the high number of TA applications in Call 3. Six applications were highly ranked in the peer review process but not all could be awarded due to the limited time available at the facility.

Presentations from the first JRA phase took place at EPSC and other international conferences in 2021 & 2022: inlcuding:
The 32nd International Conference on Photonic: Chemistry and Physics at low temperatures; 29th international conference on atomic collisions in solids; 11th international symposium on swift heavy ions in matter; Helsinki, Finland; International Workshop on Electron Cyclotron Resonance Ion Sources, Gandhinagar, India. See portal for full list of presentations and peer reviewed publications Europlanet 2024 RI Publications – Europlanet Society

(europlanet-society.org). The latter includes papers in: Space Science Reviews; Review of scientific instruments; European physical journal; Physical Chemistry Chemical Physics; Astrophysical Journal; Atoms.

Task 4.2.3 New capabilities for icy jet simulation at Aarhus wind tunnel: AU-LTU

The task involved modifications to the Aarhus wind tunnel facility that improved the vacuum capabilities and developed a dedicated system for cryogenic aerosol generation allowing exploration of entirely new avenues of planetary simulation; specifically the study of icy jets and cryo-volcanism observed on icy moons. The development included constructing a new (dedicated) section to the facility.

The JRA involved installing and testing a two stage roots pump system. This reduced the lowest achievable pressure by more than an order of magnitude giving improved simulation of airless bodies such as moons, comets and asteroids. A dedicated system for cryogenic aerosol generation system was designed and manufactured. It allows controlled icy jets/plumes to be generated (both water and CO_2 snow) under Martian conditions and at even lower atmospheric pressures. This facility was completed in 2021 and offered for TA access in the Fast Track and Call 3.

Extension of the JRA involved constructing a new module that allows enhanced capabilities, including;

- Specialized access port for icy samples
- Dedicated optical access for aerosol detection
- Various new cryogenic orientations (faster/efficient cooling/heating)
- Specific modifications for vacuum operation (without wind flow)

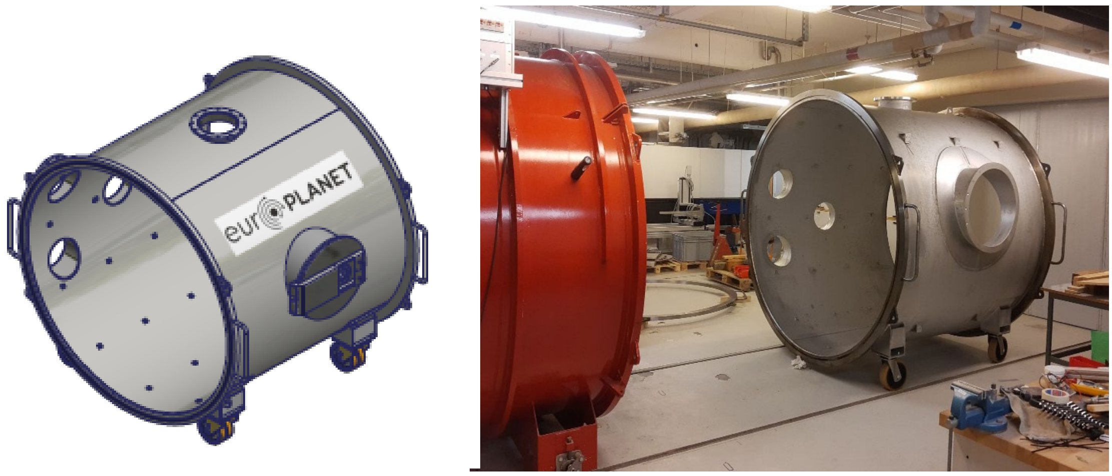


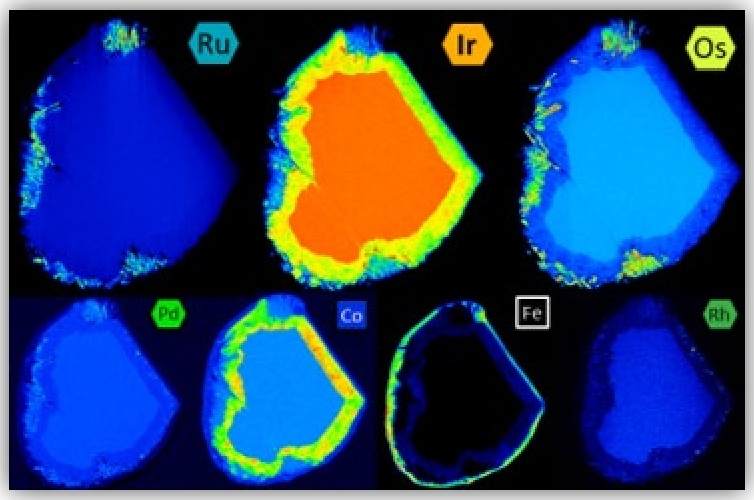
Figure: left schematic (CAD) of the new module and right a photograph of the final constructed module delivered to the facility, which is now available for use to the TA visitors to the PEF laboratory, as of January 2023.
The new facilities through TA visits have led to presentations made at EPSC, LPSC and IAVCEI and a series have already been accepted for EGU and IUGG in 2023. A peer reviewed paper was published in 2023 Planetary and Space Science, Waza et al. 2023.

Task 4.2.4 Non-destructive characterisation of meteorites: NHM, UniKent, Bruker Nano GmbH (plus new partner DLR)

This JRA was designed to deliver non-destructive mineralogical characterisation at smaller scale using state of the art scanning electron microscopy (SEM) combined with energy-dispersive spectrometry (EDS). The work was undertaken on an annular Bruker FlatQUAD silicon drift detector (SDD) for expansion of capabilities to TA 2.3 at NHM and University of Kent in collaboration with Bruker Nano GmbH, Berlin. The initial work was successful using PGE nuggets from terrestrial geological settings to optimize quantification procedures under conditions suitable for small (<1mm) extra-terrestrial grains. The successful implementation of the method was reported at RMS Microscopy and Microanalysis in Geological and Archaeological Sciences Conference in November 2022; Heard et al.

The JRA extension developed an analytical protocol for SEM-EDS quantification of samples with a topography. Using a variety of mineral species relevant to extraterrestrial samples (apatite, olivine, calcite, SiC, glass) a method has been developed that allows quantification, albeit with higher errors than is possible for polished samples.

The work on the JRA projects is complete and the techniques were offered in TA Call 3. The images below are element maps of alloys from the Mertie collection used as standards.



The technique to find and characterise PGEs was used in the newly fallen Winchcombe meteorite in Meteoritics & Planetary Science (Suttle et al., 2022) and a publication reporting the method in detail is scheduled for imminent submission.

Task 4.2.5 Improvement of analytical methodologies for the use of 1013 Ohm resistors in state-of-the-art analytical instrumentation (VUA; CNRS:CRPG; ThermoFisher)

The initial task to develop new analytical methods to reduce sample size and open up new analytical possibilities was completed on time. The project has yielded ~10 times reduction of Os and Nd at CNRS and VUA respectively. The new capabilities were offered in the fast track and call 3 and several applications past the peer review process and multiple TA visits have been undertaken. The work has led to two publications (Reisberg et al. 2021; Weiss et al, 2022) with more expected in the near future. Several presentations were made at Goldschmidt in 2021 and 2022 and invited presentations are scheduled at this conference in 2023.

The JRA extension was to further develop the Os method at CNRS and develop improved and cleaner sampling and chromatographic techniques to reduce sample blanks for Pb to allow in situ sampling of smaller samples with a portable laser ablation instrument. This latter work will allow sampling of unique material, for example in a museum setting under supervision of curators. All work was completed and initial validation of the Pb isotope work was conducted in collaboration with the Rijksmuseum Amsterdam led to a major public outreach event related to the origin of gold in the state coach. The work was nationally number 1 on twitter on the day of the press release; https://www.dutchnews.nl/news/2022/09/gold-in-gouden-koets-came-from-suriname-experts-conclude/. An invited presentation will be made at the forthcoming Vermeer Symposium, which is the science outreach event associated with the current Vermeer exhibition (sold out) at the Rijksmuseum.

Task 4.2.6 An Adaptation and Improvement of Noble Gas Analysis in Rock and Mineral Samples (ETH-Zurich, ISOTOPTECH)

Led by ETH Zurich, this task involved the training of researchers from Isotoptech, (Hungary) to allow them to offer a noble gas laboratory of the SME Isotoptech Ltd as a TA facility from year three of the project. Despite the impact of COVID on planned training visits, this goal has been achieved. Both Kata Temovski-Molnár have László Palcsu had several training visits to Zurich and standards were developed and exchanged to allow Isotoptech to publish validated data in future. Successful applications were made to TA Call 3 and a visit is planned in the early summer (22-EPN3-016, Noble gas tracing the paleofluids involved in the origin of Crystal caves.