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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:

The implementation of the JRAs was affected by COVID. The employment process of early-stage researchers was hindered as was movement of new staff. Moreover, intense interactions were required in order to design, manufacture and validate new instrumentation. Five of the six JRAs have suffered delays. Atomki has completed their work and hosted two TA visits. The JRA hosted at the VUA conducted in collaboration with Nancy was completed in November 2021 and a publication has been produced. The other four projects are delayed but close to completion and will provide new capability to TA visitors in the next TA call.

Further potential developments of the facilities have been recognised and will be undertaken in 2022 to introduce more capabilities at the end of 2022 for inclusion in the final TA Call.

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1 Explanation of WP4 Work & Overview of Progress

a. Objectives

Objective 4: to provide ground-breaking capabilities to determine isotopic and elemental compositions of planetary samples, including analyses at high spatial resolution, high precision and high sensitivity.

b. Explanation of the work carried in WP

Task 4.1 Management (NHM, VUA, DLR, AU)

Management of JRA1 is overseen by the Transnational Access Sub-Committee ([TASC](#)), which is responsible for coordinating the exchange of personnel and samples between institutions, ensuring optimal synergy between tasks and the timely achievement of deliverables. Communication within JRA1 during Year 2 has been achieved through bi-monthly telecons. Despite the Covid-19 pandemic, the TASC anticipates that the deliverables (new capabilities and publications) should be on schedule (although a possible delay in 4.2.6 is noted) and the new capabilities should be available through the TA programme in the last two years of the Europlanet 2024 RI project. Regular progress reports have been submitted to the TASC and the Annual Report delivered in Project Month 12, which summarised the status of the design, commissioning and implementation of new capabilities at AU, DLR and Atomki and the training of Isotoptech staff and the development of new analytical techniques at NHM-CRPG-VUA.

Task 4.2 Expansion of Facilities (NHM, DLR, CNRS-IPAG, AU, LTU1, Atomki, OU, UniKent, Bruker Nano GmbH, ThermoFisher, CNRS-CRPG)

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

All test measurements have been performed to verify the parameters required for the setup. This was achieved before DLR went into a second Covid-19 lockdown. Several industrial providers have been contacted to build the vacuum chamber and

the integrated cooling system. Detailed discussions have been undertaken with a company that could potentially 3D print the complete system. If this solution could be implemented it would lead to significantly improved performance, reduced need for maintenance and faster implementation. It would also be a trailblazer for future setups. Due to the Covid-19 situation, initial discussions with companies were challenging but the system has been designed and manufactured and will be functional before the summer of 2022 allowing use in future TA calls.

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)

This task has been completed. A UHV chamber was supplied by a collaborating institute, enabling the facility to be upgraded and made operational ahead of schedule. The first TA visit using the facility took place in November 2020/February 2021 (*A Systematic Study of Sulphur Ion Radiolysis of Simple Oxide Ices* by Zuzana Kanuchova and Duncan V. Mifsud). The results of this work are being submitted for publication and were presented at EPSC2021. A second chamber from Queen's University Belfast has been transported to Atomki and will be installed on schedule for Call 3 of the TA programme. Additional funding to support these facilities has been awarded by Hungarian national funding agencies.

Task 4.2.3 New Capabilities for Icy Jet Simulation at Aarhus Wind Tunnel (AU, LTU, OU)

By improving the vacuum capabilities (reducing the ultimate pressure) and allowing ice aerosol generation, the upgrades planned for this activity will allow enhanced simulation of icy moon environments. Procurement, installation and testing of a new pump system (consisting of roots pumps and turbo pumps) has been carried out. The process of designing the new cryogenic injection/aerosolisation system is finalised and the new instrumentation is now scheduled to be completed before the summer of 2022 allowing use in future TA calls.

Task 4.2.4 Non-Destructive Characterisation of Meteorites (NHM, UniKent, Bruker Nano GmbH)

The aim of this task is to develop quantitative analysis of platinum group element (PGE) abundances using Secondary Electron Microscopy and energy dispersive x-ray spectroscopy (EDX), which is challenging because of spectral overlaps of the regions of interest. The PGEs are important elements in planetary sciences as they are depleted compared to cosmic abundances in planetary crusts and mantles, and highly enriched in planetary cores. The technique requires use of a low accelerating voltage to enable high spatial resolution that will allow analysis of submicron PGE nuggets known to be present in meteorites and in impactites. The JRA has been partly delayed due to Covid-19, as local restrictions prohibit the required in-person training in the laboratory. The project is now underway; natural standards (from NHM mineral Mertie collections) have been identified and characterised by conventional SEM and electron microprobe (WDS) techniques prior to development work at low accelerating voltage.

Task 4.2.5 Improvement of Analytical Methodologies for the Use of 1013 Ohm Resistors in State-of-the-Art Analytical Instrumentation (VUA, ThermoFisher, CNRS-CRPG)

Covid-19 has had some impact on recruitment of junior researchers to work on this task. CNRS-CRPG hired a post-doc (Xiaoyu Zhou) who started in September 2020 for one year, with partial funding from Europlanet 2024 RI. Training in the lab has been challenging but ultimately successful. Preliminary data are very promising and will lead to publication of an application note involving the industrial partner, ThermoFisher.

The VUA has completed the appointment process of an ESR who started on 1 February 2021, who will be optimising methods to analyse NdO⁺ to reduce still further the sample size needed to analyse planetary material. The new capability was validated in November 2021 and is ready for inclusion in the next TA call.

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

This task involves the training of researchers from ISOTOPTECH (Hungary) to allow them to offer a TA facility from Year 3. A detailed training schedule has been put in place and exchange visits were set up. Despite the impact of Covid-19, several training visits have been conducted. Due to the physical exchange and training elements of this task, it is the one part of JRA1 that may suffer delays in full implementation.

c. Impact to date

The potential impact of the new technical development through the JRA1-DPLF remains as described in the DoA. The enhanced capabilities of the completed ice-spectroscopy UHV chamber at Atomki (Task 4.2.2) have already been demonstrated through TA visits (e.g. 20-EPN-043, which has already led to ongoing collaborative work).

The initial development work conducted at CRPG, undertaken as part of the method development in using 1013 Ohm resistors studying the Re-Os isotope system, will lead to the publication of an application note by the Industrial partner, ThermoFisher.

In January 2021, VUA secured a 4.85 million Euro grant to upgrade all its isotope facilities to beyond the current state-of-the art, ensuring that its leading international status will be maintained for at least the next 5-10 years. This upgrade will enhance the impact that the TA programme is able to have and will be able to have in future.

d. Summary of plans for Year 3

Due to the reduced number of visits taking place to TA laboratory facilities, there has been greater focus on the JRAs related to the TAs since when laboratories have reopened for local staff. The facilities have been able to work on JRAs faster without having TA visitors. Several potential improvements/upgrades have been identified

that would provide greater capabilities for the benefit of the community. All the identified upgrades are related to the current JRAs that are part of work package 4. We therefore sought permission from the EC to expand five of the current JRAs in work package 4 and provide additional deliverables. All work would be implemented before the end of 2022 making the new capabilities available for use by successful applications in the fourth TA call. Brief outlines of the work required to deliver new capabilities to the community are given below. The implementation of the JRA activities will continue to be monitored by the Transnational Sub-Committee (TASC).

Task 4.2.1: Cryogenic reflectance spectroscopy under vacuum conditions for outer planets exploration: DLR, CNRS-IPAG, AU, LTU

The current task involves extension of spectral capabilities in low-T reflectance measurements under vacuum conditions at DLR.

New Goal: *Deliver increased analytical capability at DLR for spectral and gas analysis of icy samples under low-pressure atmospheres comparable to outer Solar System bodies for expansion of capabilities to TA 2.5.* Specifically:

- Improve the automation of the cooling system and mechanical parts under high vacuum
- Add a gas analyzer to monitor gases released by the sample during the whole process of icing and measuring
- Design and implement a sample lock mechanism inside the cold chamber
- Add 2 diamond windows to the existing design (one to the spectrometer, one to the external sources) to allow measurement of increased wavelength ranges.

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

The current task involves installation of an ultra-high vacuum (UHV) chamber at the beamline of the 2MV Tandatron accelerator in Atomki to determine the structural-chemical modifications induced by the ion-impact on ices. This task is complete.

New Goal: *The main goal of the extension is the installation an additional UHV chamber (named BIC) gifted from Queens University of Belfast on the beamline of the electron cyclotron resonance (ECR) source at Atomki for expansion of capabilities to TA 2.12.*

The new installation will provide an analytical facility to enable vacuum ultra violet (VUV) irradiation as well as ion beam irradiation. Fourier-transform infrared spectroscopy (FTIR) measurements for spectroscopic investigations of ice samples may be conducted simultaneously with quadrupole mass spectrometry during irradiation. This is a powerful addition to the offered facilities. The FTIR instrument will be purchased from local funds.

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

The current task involves improving vacuum capabilities and development of a dedicated cryogenic aerosol generator to simulate airless bodies (moons, comets, asteroids) and water ice/CO₂ snow transport under Martian conditions.

New Goal: *A dedicated test section (seen rolled out in the figure) specifically designed to cater for Europlanet TA users to allow additional and enhanced capabilities to TA 2.4 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)

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

The current task will deliver non-destructive mineralogical characterisation at smaller scale using state of the art scanning electron microscopy (SEM) combined with energy-dispersive spectrometry (EDS).

New Goal: *Developing an analytical protocol for SEM-EDS quantification of topographic samples*

We will develop an analytical protocol for energy-dispersive (EDS) analysis in a scanning electron microscopy (SEM) of topographic complex samples and common minerals using the high sensitivity, 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. Furthermore, we will initiate a collaboration with DLR, Berlin, to transfer our knowledge to the third annular SDD in European Planetary Sciences that will be installed in the third quarter of 2022.

Task 4.2.5: Improvement of analytical methodologies for the use of 10^{13} Ohm resistors in state-of-the-art analytical instrumentation (VUA; CNRS:CRPG; ThermoFisher)

The current task is to develop new analytical methods that effectively reduce sample size, opening up new analytical possibilities. The project has already yielded great success with ~10 times reduction of Os and Nd at CNRS and VUA respectively (publications in preparation).

New Goal: *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 will allow sampling of unique material, for example in a museum setting under supervision of curators. A PDRA at VUA will collaborate with the industrial partner before transfer of knowledge to CRPG ultimately providing expansion of capabilities to TA 2.1 and 2.10.*

2 Update of data management plan

An update of the Data management Plan is due at the end of March 2022.

3 Follow-up of recommendations & comments from previous review(s)

N/A