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EURO-CARES: GETTING EUROPE READY FOR SAMPLE RETURN MISSIONS - AN EMPHASIS ON RESTRICTED MISSIONS.

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EURO-CARES (European Curation of Astromaterials Returned from Exploration of Space) was a three year (2015-2017) multinational project funded under the European Commission's Horizon 2020 research programme. The objective of EURO-CARES was to create a roadmap for the implementation of a European Extra-terrestrial Sample Curation Facility (ESCF) suitable for the curation of samples from all possible return missions, to the Moon, asteroids, Mars, and other bodies of the Solar System. Here we summarize the main recommendations from the final project report for design and infrastructure requirements to allow the curation of samples from restricted bodies such as Mars.

Over the course of the project, the team has visited various facilities and companies, to gather best practices, bring innovative ideas, and build a strong network with the international sample curation community. Visits were made to the astromaterials curation facilities of NASA and JAXA, and to related facilities from the nuclear, cleanroom and BSL-4 sectors. Two successful collaborations with architects (Space architecture department of the Technical University of Vienna (Austria), then Merrick and Co. in Kanata (Canada) [1]) resulted in the development of more refined requirements and tentative designs for a Mars Sample Return (MSR) facility.

All possible activities that would take place in a MSR facility were first identified. All activities related to receiving, assessing, and opening the Earth Return Capsule are performed in a Sample Receiving Facility. Further activities, such as curation, Sample Early Characterization, and

storage would be performed in a Sample Curation Facility (SCF). The SCF would also include a suite of instruments necessary for analyses defined in a Biohazard Assessment Protocol and for Life Detection. In addition, an Analogue and Mock-Up Facility (to be constructed first) would be used to assemble an analogue material collection, to test instruments and building materials/techniques, and to train staff members.

A MSR facility needs to integrate both cleanliness and containment principles, to keep the samples pristine, and to fulfill the Planetary Protection requirement of having a probability of release $P<10^{-6}$ for an unsterilized particle larger than 0.1 μm [2]. Primary enclosures for restricted samples were considered: depending on the activities, it was recommended that cabinets similar to the ones used in BSL-4 laboratories, or Double-Wall Isolators should be used [3]. Laminar flow cleanrooms were recommended for limiting cross-contamination while allowing flexibility in the future.

Because of the European nature of the project, the facility should be located in Europe. Other parameters, such as limited natural hazards, countries with histories of BSL-4 laboratories and space exploration expertise, would also need to be taken into consideration. Owing to so many uncertainties and decisions to be taken (such as the possible widespread use of robotics), it is impossible to evaluate a precise financial cost for such a facility, however, we estimate that a fully fitted MSR facility would cost at least 200 M€. Location, use of robots, cleanroom regime, instrumentation capacities, etc. are amongst the parameters that can drive the costs for the initial construction, and during the life of the facility.

It is estimated that a minimum of 7 to 10 years would be necessary to define the requirements, design, build, and commission the facility, while training the necessary staff. It is highly probable that such a facility will have various funding partners (space agencies, institutions, countries, etc.); a complex financial arrangement takes time to come to completion.

A MSR facility is a complex project, not only for the engineering aspects but also for financial and political reasons. In view of the timeline of sample return missions from Mars, it is imperative to move forward with this project as soon as possible. The design we developed encompasses the principles of *Flexibility*, *Modularity*, and *Adaptability*.

References: [1] Hutzler A. et al. (2017) 47^{th} ICES, 323. [2] Ammann W., et al. (2012. ESF-ESSC Study Group on Mars Sample Return Requirements, ISBN: 978-2-918428-67-1. [3] Vrublevskis J. B. et al. (2016) EURO-CARES WP3 Meeting, p. 27.

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