# EURO-CARES project

***European Curation of Astromaterials Returned from Exploration of Space***

***Horizon 2020 - European Commission***

The objective of the EURO-CARES project is to create a roadmap for the implementation of a European Extra-terrestrial Sample Curation Facility (ESCF). There have been some previous studies, which have typically been either country-specific (e.g. Counil et al, 2002) or mission/target specific (e.g. for Marco Polo-R; Brucato et al, 2012). We propose to move onwards from these specific studies to look at what would need to be done to create a European facility that would be suitable for the curation of samples from all possible return missions likely over the next few decades, to the Moon, asteroids and Mars.

Study and long-term curation of extra-terrestrial samples imply to keep the samples as clean as possible from any possible contaminants, while ensuring they remain contained in case of biohazards. The requirements for a combined high containment and ultraclean facility will naturally lead to the development of a highly specialised and unique facility that will require the development of novel scientific and engineering techniques.

EURO-CARES team work is organized around five distinct technical Work Packages (WP), led by competitive institutions and scientists and engineers from all over Europe. Along with the scientific and technical requirements, EURO-CARES project is also focused on a high impact public engagement plan that engages children, university students, the general public and policy makers, as well as our academic and industrial peers. A significant risk to the development of an ESCF is the public perception of extra-terrestrial samples, potentially containing biological entities, being deliberately returned to Earth without going through the "sterilising" process of exposure to cosmic-rays and space environment. This could be of great concern to many people and could lead to major delays in the establishment of an ESCF. Hence, open communication is of great importance.

The planning of the facility design needs to start as early as possible (i.e., several years before the planned return sample date), ideally to finish the construction and interior design of the building at least one or two years before any sample return, to have enough time to properly test the facility on analogue samples and to train a dedicated team. Such a facility will have to preserve (and protect) samples for decades of research to be carried out on them, so its lifespan must be sufficient enough.

## WP2: Planetary Protection

Although lunar and asteroidal samples are now known to be sterile, this might not be the case for all Martian rocks. It will be necessary to address the risks involved in handling possibly biogenic material and to examine how we can mitigate them. Mars Sample Return (MSR) mission planning, including sample receiving and curation, requires a high level of planetary protection in order to break the chain of contact between Mars and the terrestrial biosphere. Approximately 500 g are envisaged in the first MSR within the 2020s. This will require a specific biohazard assessment protocol to determine the potential threat to the terrestrial biosphere prior to release the samples

from containment for investigation by the wider scientific community. Planetary protection requirements and implementation approaches are determined by the best multidisciplinary scientific advice according to international policy (COSPAR, 2005) and recent recommendations from the European Science Foundation (ESF-ESSC Study Group, 2012). A *plan for terrestrial planetary protection will be devised: it has to be effective, legally compliant and realistic, while minimising risk to current scientific study and optimising access to researchers for future studies.*

The first step of a biohazard assessment protocol is to select a representative portion of the returned samples for life and biohazard detection. If there are evidences or even suspicions of biohazard, sterilization methods may be necessary to ensure a quick distribution of the samples to the scientific community. The existing sterilization methods and techniques will be reviewed under the new discoveries of phenomena associated with terrestrial microbial extremophiles, which could survive in a Martian environment.

**WP3: Facilities and Infrastructure**

The objective of this work package is to define the state of the art facilities required to receive, contain and curate extra-terrestrial samples and guarantee terrestrial planetary protection. All the aspects, from the building design to the storage of the samples as well as the curation will be covered by this work package. Knowing that the primary function of the curation facility is to contain the samples, all the specificities of the samples, including their origin, if from Mars, the Moon, and/or from asteroids, their size, their form, etc., will be considered in this activity.

*Building design:* The infrastructure should be designed to prevent sample contamination and alteration on one hand, and to prevent potential biohazards from the sample on the other hand (input from WP2). All should be done to avoid not only terrestrial particles and organism contamination but also terrestrial gas and liquid contamination. The facility will be composed at least of a receiving laboratory, a cleaning and opening laboratory, a bio assessment laboratory, a curation laboratory and a storage room. The facility will have to be highly adaptable, to follow instrumentation development, or to add new laboratories.

*Storage of the samples:* Long-term curation of samples is challenging, especially because their pristine nature should be preserved as far as possible knowing that in case of biohazardous samples some specific planetary protection constraints will have to be undertaken. The facility will have to operate at controlled pressure, temperature, and atmospheric environment, depending on the samples requirements. Contamination should also be monitored with specific witness materials to be already placed inside the sample catcher/container on the spacecraft.

*Curation:* It mainly consists in the handling, documentation, preparation, preservation and allocation of limited amount of sample for research. Curators should already be consulted during the mission design, not only as expert of the samples to be collected, but also to be able to help in designing the sampling devices and to insure proper monitoring of the contamination. Each of the collected and curated samples have a unique history and come from different environments, therefore, the different types of samples present specific and unique challenges for appropriate curation and to insure their integrity. Different documentation, handling, and preparation technologies were designed, developed, and tested in the last decades but still some issues remains to be further investigated; a specific challenge is the manipulation of small samples (micrometer-sized).

**WP4: Instruments and Methods**

The objective of this work package is to determine which analyses should be performed within the ESCF while ensuring minimal contamination and minimal damage to the sample. The space limitation inside the facility, the cost of some instruments and the specificity of some techniques of investigations will have to be considered and necessary measures taken to ensure rapid dissemination of samples to selected researchers. This WP will need the input of various fields of research and importantly will have to follow and anticipate technical developments since samples will not be returned before some years from now. Specific objectives of this Work Package are as followings:

- To determine the types of instruments that are necessary for preliminary examination (and curation) in the facility, and which analysis will have to be conducted outside of the facility.
- To determine the types of analysis that may be carried out on pristine samples within sample containers and those that would require samples to be extracted from their containers.
- To determine if destructive analyses are required and to assess the risks and opportunities of carrying out such analyses within the facility.
- To determine the analytical instrumentation required for bio-hazard assessment protocols (input from WP2).
- Minimising sample contamination from both organic and inorganic materials.
- Minimising sample consumption especially during preliminary examination.
- Ensuring contamination control through use of innovative methods and high-level contamination mitigation and identification protocols.

Based on the information required, sample interaction restrictions and the nature of the measurements themselves, it is expected that the instrument types will fall into five distinct categories.

- Non-destructive techniques:
  - Optical methods for documentation
  - Methods for characterisation of physical properties
  - Spectroscopic methods
- Destructive and potentially destructive techniques:
  - Scanning and electron probe methods
  - Chemical methods and other destructive techniques

**WP5: Analogue Samples**

Analogue proxies are necessary in a curatorial facility for testing sample handling, storage and preparation techniques. This includes the testing of planetary protection measures as well as validating new analytical methods. For practical reasons, it may be necessary for the curation and analytical facility to have its own collection of analogue samples.

Not only are analogue samples critical for instrument testing during the design and building of robotic exploration spacecraft, they will also be necessary for a first level of readiness in the event of returned samples.

The analogues selection will be constantly evolving, to take into account the rapid changes in the understanding of Mars that are resulting from current missions (Curiosity and MER) and studies of Martian meteorites.

**WP6: Portable Receiving Technologies**

The objective of this work package is to propose methods for the recovery and transport of samples from the landing site to the permanent curatorial facility. These methods are of the utmost importance to break the chain of contact between Earth and extra-terrestrial matter. The Earth re-entry capsule from a sample return mission is targeted at a specific landing ellipse on Earth, possibly at considerable distance from the curatorial facility. Once the capsule has landed, an assessment of the state of the spacecraft will lead to a recommended recovery procedure. A portable receiving facility may be used to inspect, document and package the sample container(s). It will then be transported to the permanent curatorial facility using a safe and secure method. In addition, methods for the transport of samples from the facility to the outside institutions will have to be studied, to insure security and non-contamination of the samples.

Each WP will be hosting an international meeting in 2016, with experts from all over the world (dates and program to come).