

European Curation of Astromaterials Returned from the Exploration of Space (EURO-CARES) – A roadmap for a European Sample Return Curation Facility

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Abstract

EURO-CARES (European Curation of Astromaterials Returned from the Exploration of Space) was a three year (2015-2017), multinational project, funded under the European Commission's Horizon2020 research programme to develop a roadmap for a European Extra-terrestrial Sample Curation Facility (ESCF). The ESCF is designed to receive and curate samples returned from Solar System exploration missions to asteroids, the Moon and Mars.

Introduction

So far there are only two sample receiving and curation facilities dedicated to samples returned from space missions to Solar System bodies - the NASA Johnson Space Centre in Houston (USA) and the JAXA Hayabusa curation facility in Sagamihara (Japan). Previous studies for an ESCF were either country-specific or mission/target-body specific. With the EURO-CARES project have progressed from these specific studies by incorporating and rationalizing relevant expertise and experience from a variety of individuals and institutions around Europe and the world. These include both NASA and JAXA, various laboratories and museums that curate meteorites, biosafety laboratories, cleanroom manufacturers, electronics and pharmaceutical companies, nuclear industry and the aerospace industry etc.

A challenge in the EURO-CARES work was to design a roadmap for an ESCF capable of receiving and curating samples from both 'unrestricted' and 'restricted' sample return missions. The requirements for a combined high-containment and ultraclean facility will naturally lead to the development of a highly specialized and unique facility that requires

the development of novel scientific and engineering techniques.

The EURO-CARES team work was organized around five technical Work Packages (Planetary Protection, Facilities and Infrastructure, Instruments and Methods, Analogue Samples and Portable Receiving Technologies), led by scientists and engineers from leading institutions across Europe. Along with the scientific and technical aspects and resulting recommendations, the EURO-CARES project also developed on a high impact public engagement plan. More details about the project, the specific Work Packages and their results can be found here: <http://www.euro-cares.eu/home>.

Recommendations

Europe has curated samples of extraterrestrial material for over 200 years, ever since first recognition that stones falling from the sky were valuable objects for scientific investigation. Europe has an extremely strong and internationally-recognised community of scientists and engineers that specialise in study of extraterrestrial materials their terrestrial analogues, and in handling and containment of biologically-sensitive material. The combination of skills and knowledge ensures that Europe is strongly placed to curate samples collected by the next generation of sample return missions, including material from asteroids, the Moon, Mars and other restricted targets. We do not make recommendations about the location of the facility. That decision is dependent on considerations beyond the scientific and technical, and was not part of our mandate. The facility is likely to cost from in the 10s M Euros for a basic curation facility for unrestricted samples, to > €100M for a bespoke facility for Mars Sample Return. To put this into context, current sample return missions to asteroids (e.g. Hayabusa 2

and OSIRIS-Rex) are costed in the 100s of millions of Euros and a Mars Sample Return mission campaign is likely to cost billions of Euros. Hence the cost of any curation facility will make up a very small part of the overall budget of these exploration missions. In addition, we expect that the facility can be used for all future sample return missions with European involvement, and so the burden on a single mission or funding agency is diminished.

Our major recommendations are:

1. There is an urgent need to update the Planetary Protection Protocols. We strongly recommend a cross-European effort with significant international participation to update the Planetary Protection protocols, utilising the significant expertise in the life and Earth sciences as well as analytical instrumentation innovation that exists within Europe.
2. Funding for a European Sample Curation Facility must be budgeted. Given we anticipate that the required time to build an ESCF is a minimum of 7 years, and perhaps longer in view of the administrative barriers that must be overcome, it is essential that a funding line for an ESCF is identified as soon as possible. We strongly recommend that a European Sample Curation Facility becomes part of the ESFRI roadmap.
3. Appropriate training of staff working in the facility is critical. The amount of time required should not be underestimated and is a major part of the 7 year (minimum) facility development time. We also have a need to promote links between European researchers and combine efforts around Europe to take advantage of complementary skill sets and expertise and to avoid duplication of work or knowledge gaps. We strongly recommend that a training programme for curators is established.
4. There are several complementary activities involving terrestrial analogues in Europe that have a direct link to curation facility development. We recommend that a well-defined and fully characterised suite of analogue materials is assembled for the ESCF before the arrival of material returned from space.
5. As the major European space agency, ESA should be a leading stakeholder in the curation effort, enabling technological development and scientific studies to oversee work undertaken and to develop

products that match their future space mission requirements. Individual national space agencies also have their own priorities and bilateral agreements with other space-faring nations.

6. We considered various building designs in terms of separate functional units, each one with its own purpose, such as curatorial space, communications, analogue samples etc. This maximises flexibility and allows for growth of the facility as more missions are returned to Earth. We recommend that the building that houses the ESCF is built as a series of modules, to maximize flexibility.
7. We considered six potential landing sites, and the strengths and weaknesses of each in terms of weather, accessibility and population. From our work, the best site for landing a European sample return mission appears to be the Esrange Space Center, Sweden. However, specific considerations for each individual mission may favour another site.
8. Early characterisation of the samples returned must be undertaken in the ESCF as part of curatorial best practice, and in view of the requirements for handling restricted samples. However, to the extent possible given potential planetary protection constraints, we recommend that detailed examination of returned samples is undertaken by specialists outside the ESCF. This enables the broader science community to engage in the missions and is more cost effective, as it negates the need for multiple large laboratories.
9. Engagement with the public and with decision makers is essential for the ongoing support of the facility. Methods for outreach, education and communication with the public should be at the heart of the ESCF. We recommend continuation of a public awareness programme based on the resources that we have developed.

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