estec

European Space Research
and Technology Centre
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands
T +31 (0)71 565 6565
F +31 (0)71 565 6040
www.esa.int

DOCUMENT

PROSPECT Project Objectives & Requirements Document

Prepared by	**ESA PROSPECT TEAM**
Reference	**ESA-LEX-PRO-ORD-0001**
Issue	**1**
Revision	**0**
Date of Issue	**08/07/2015**
Status	**Approved/Applicable**
Document Type	**OBJ**

European Space Agency
Agence spatiale européenne

APPROVAL

Title PROSPECT Project Objectives & Requirements Document	
Issue 1	Revision 0
Author ESA PROSPECT TEAM	Date 08/07/2015
Approved by	Date
Bérengère Houdou	08/07/2015

CHANGE LOG

Reason for change	Issue	Revision	Date

CHANGE RECORD

Issue 1	Revision 0		
Reason for change	Date	Pages	Paragraph(s)

Table of contents:

1 SCOPE

The scope of this document is to record the high level objectives and requirements associated with the Platform for Resource Observation and in-Situ Prospecting for Exploration, Commercial Exploitation and Transportation (PROSPECT) package. Section 3 provides the link from the high level ESA Vision, through the European Lunar Exploration Programme objectives including those achieved through cooperation with Russia, down to the main objectives of the PROSPECT project. This context is provided to show the traceability of each PROSPECT project requirement and objective to the level of the Programme and the Vision.

Any changes to the PROSPECT objectives and requirements shall be tracked via updates to this document, and shall be verified to ensure they are still compliant with the Vision and Programme as outlined in this document. The contents of this document, including the traceability and verification, are under the responsibility of the ESA PROSPECT Project Team.

2 PROSPECT IN THE CONTEXT OF ESA'S VISION AND LUNAR EXPLORATION PROGRAMME

2.1 The Vision

"Provide access to the Moon's surface to drive European discovery, innovation and inspiration."

The overall ESA Exploration Strategy targets a European presence at three destinations: LEO, the Moon and Mars (see ESA/PB-HME(2014)12). Each of these destinations offers unique benefits and opportunities, and at the same time are complementary to each other. While activities in LEO are well underway and the exploration of the Martian surface has been initialised, the lunar surface remains a destination to be realised for Europe.

Europe's vision for the exploration of the Moon recognises the key role of this destination, and specifically the unique regions at the Lunar poles, as a stepping stone to advance human and robotic exploration of the Solar System and as a location offering direct benefits to Europe. Exploration is fundamentally the business of striving to reach a destination and overcoming the challenging conditions there, but it must also act to create opportunities and utilise this new environment. Following this logic, the European Vision for Lunar Exploration is built around a practical focus on 'Destination Moon' and how to maximise the benefits Europe can realise there to support the wider European exploration effort.

The vision itself is to enable European access to the Moon's polar regions and create the practical foundations from which to make discoveries, build capabilities and create opportunities. The scope of the vision encompasses in the near-term the pioneering exploration of the Lunar polar regions via robotic missions over the coming decade in cooperation with Roscosmos, and extends into the future with the start of human-robotic exploration of the Moon in the mid-2020s, for which Europe's role in the Orion-MPCV is

another key entry point. It is with this sustained and progressive effort that we can support preparation of human exploration of 'Destination Mars' in the long term, and at the same time derive direct benefits and realise specific opportunities on the Moon.

The vision draws lessons from history, and in particular the continuing story of our exploration of Antarctica. This began just over a century ago with the first pioneering expeditions striving to find a path to a specific destination, most famously the South Pole. Today Antarctica, while still a challenging environment, is not only host to expeditions of exploration but is now a location where nations work together to conduct research. More than 50 facilities are inhabited for part or all of the year including the Concordia station in which space exploration technologies are tested and important experience is gained. Today the location and environment are utilised to make discoveries relevant to Antarctica, fundamental science and to the Earth as a whole. Commercial enterprises now operate in and around Antarctica to support research activities and provide logistics services to small expeditions and entire facilities.

Europe's Vision for Lunar Exploration is that in the decades to come the Moon shall not only support our continued exploration of the Solar System but, as with Antarctica today, the Moon shall become part of the human sphere of activity delivering benefits, many of which cannot even be imagined at these early stages.

In terms of Europe's role the vision recognises that exploration should and will be realised in international cooperation. Europe must have the ambition to play a key role if it is to have access to the Lunar surface and the associated benefits and opportunities there. The vision's ambition must therefore be matched with a practical and robust implementation approach, which capitalises on investments made in Europe to secure roles in missions carried out with our partners, and to create opportunities for our industries, researchers and the public to participate. for Lunar Exploration

2.2 Benefits of Destination Moon

The Moon, in particular its South Pole region, offers a large range of benefits, which combined together build a very strong case for Europe to engage in Lunar Exploration.

Technology is the principal enabler of exploration missions, and is driven by the challenges posed by new destinations. Accessing and utilising the Lunar South Pole region, with its hazardous terrain and extreme surface conditions, will be a major driver for technology development and innovation. Near term robotic missions require the development of technologies to enable landing, surface survival, and sample acquisition and handling. The location will also drive in the long term technologies for habitation and life-support, as well as transportation. In striving to access and work at this location, technologies and expertise will be developed which are also relevant to 'Destination Mars', and which also serve to make activities on the Moon sustainable and bring benefits back on Earth.

Scientific discovery has always reaped the benefits of exploration, and access to new and unexplored locations on the Moon will enable important new scientific research. Such investigations are important for future exploration as they will lead to a better understanding of the environment and its implications, and quantify the opportunities for exploitation of resources in the polar regions, such as water ice and volatiles. These resources which include hydrogen and oxygen, are the key to realising sustainable exploration of the Moon and beyond, as well as providing the potential for future endeavours.

The Moon is also of fundamental importance for understanding the history of the Solar System and our own planet, including the context for the emergence of life. The ancient surface preserves an archive of the shared history of the Earth-Moon system, which has long since been lost from our geological record. Later missions, with enhanced capabilities at the surface, in particular the capabilities that humans bring, will expand considerably on these themes, and enable the utilisation of the Moon as a platform for scientific research in areas as diverse as astronomy, life sciences and fundamental physics.

Inspiring the public and young people in particular to engage with Science, Technology, Engineering and Mathematics (STEM) is a widely recognised requirement for growth in modern economies and a demonstrated outcome of ambitious exploration ventures (Benefits Stemming from Space Exploration, ISECG, 2013). People are inspired by journeys to unknown and challenging destinations. The Lunar polar regions represent the next challenging step into the unknown, and promise to usher in a new era and paradigm of robotic and human exploration of the Solar System. The Lunar poles in particular are inspiring destinations through what they can tell us of the story of our own planet, including the context for the emergence of life – where we came from – as well as through what they can provide us in terms of a platform to explore further, utilising resources and gaining experience of working on a planetary surface. Europe must be involved in this human adventure, which has STEM at its heart, if it is to capitalise on the value of Lunar Exploration as an inspiration for future European inventors, innovators, scientists and engineers.

2.3 European Lunar Exploration in Cooperation with Russia

Lunar Exploration is a high national priority within Russia. Roscosmos is actively planning a sequence of robotic missions (“Luna”) targeting the lunar polar regions in the next decade. The goals are to perform cutting-edge scientific investigations at this specific location, with a clear aim to return samples back to Earth, as well as to build-up mission capabilities in a stepwise manner, allowing more and more ambitious exploration objectives.

Based on the complementarity of interests identified between the two Agencies and building upon the existing cooperation on the ExoMars programme, ESA is starting to implement the first step of its Vision for Lunar Exploration in cooperation with Roscosmos. ESA shall provide in an incremental manner products and services on the critical path of

the Luna missions. Developing capabilities together with Russia is an example of cooperation that can be extended to a more global exploration scenario as discussed by ISECG. This participation shall enhance programmatic robustness and mission benefits.

The European Lunar Exploration Programme prepares the elements which Europe would contribute to the series of robotic missions to be carried out together with Russia (see Figure 1).

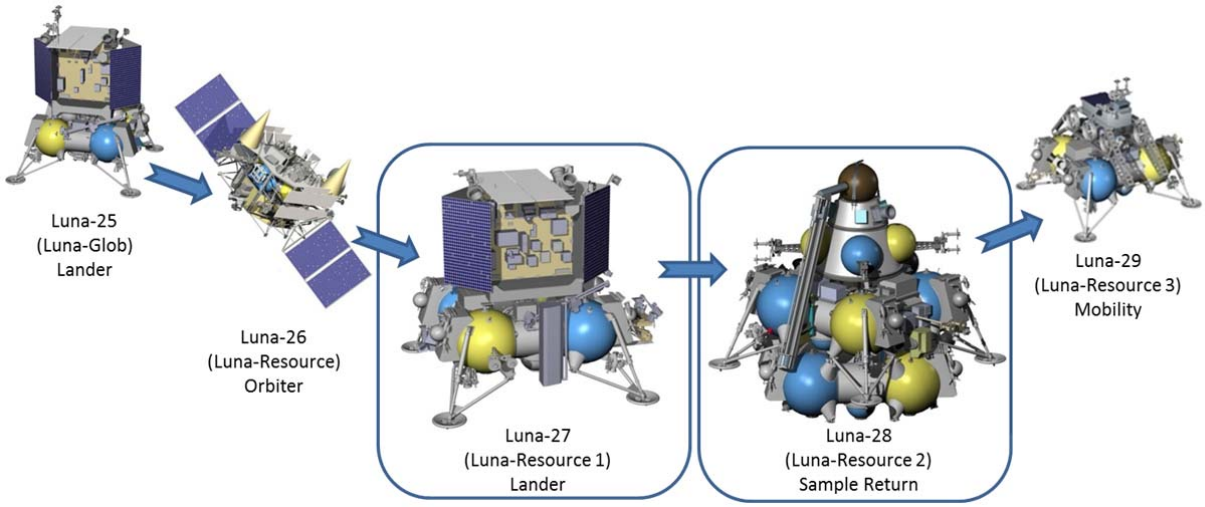

Figure 1: Russian lunar mission roadmap, with major missions including European cooperation highlighted.

Cooperation is planned starting with the Luna-Glob (Luna-27) lander, followed by the Luna-Resource-O (Luna-26) orbiter, with a major focus on the Luna-Resource-L (Luna-27) lander mission.

These three missions will provide Europe and Russia with the combined technical, scientific and operational experience to develop a joint Lunar Polar Sample Return (LPSR) mission early in the 2020s. In this longer term cooperation perspective ESA would seek a more important participation at element level.

Taking into account this mission framework, the content of the proposed programme addresses specific European objectives, in line with ESA's overall Vision for Lunar Exploration. These objectives are:

1. Prepare technologies and capabilities for future exploration missions, focusing on strategic areas, relevant for more than one mission and leveraging European investment and experience.
2. Gain knowledge with a focus on enabling future human exploration, through characterisation of the exploration environment, assessment of resource potential, identification of hazards and fundamental science opportunities.

3. Secure long-term roles for Europe in future international exploration scenarios.

To achieve those programme objectives and taking into consideration current and foreseen budgetary constraints in Europe, priority areas targeted by the programme have been selected considering:

- European interests and capabilities,
- state of European experience and expertise,
- opportunities and boundary conditions of cooperation with Russia,
- potential for application in other missions and to other destinations,
- effects on industries and institutes in terms of skills, jobs and investment.

Two major areas targeted as a result of this consideration are acquisition and analysis of samples.

Acquiring samples on the surface provides the primary means of enabling the analysis and understanding of a location. As such it is one of the highest priority surface activities, and can be expected to be a principle activity for lander missions to any destination. Accessing and handling those samples is both an engineering challenge and a crucial scientific operation, during which care must be taken to preserve the value of the sample. This is true regardless of destination, however the demands of the lunar polar regions and the cold icy materials expected there make this application an important driver for this technology.

Analysing samples provides the primary benefits from investments in landing capabilities, which provide access to a location of interest, and in capabilities associated with acquiring samples at the site. Analysis of samples, and of the broader lunar environment and its effects, is also the principal method by which we obtain data to fill Strategic Knowledge Gaps, that is to advance our understanding in key fields which will help us design better exploration systems, technologies and means of operation for future missions. Investigation of samples obtained in the polar regions in particular is fundamental to establishing the utilisation potential of water and other resources. It also has a high scientific value, revealing fundamental planetary processes and providing information of likely importance for understanding life on Earth and its origins.

2.4 A Drill and Sample Package for Luna-27

In the context of the Luna-27 mission, Russia have requested the provision of a drill from ESA. This drill should be capable of drilling to depths of up to 2m. The drill should be able to extract samples from these depths, whilst ensuring preservation of any icy volatile content, and deliver them to a Russian robotic arm, which would then deliver the samples to Russian analysis instrumentation.

In response to this request ESA have determined to provide such a drill and to commit the resources required to do so. It is also important however that ESA and its European

stakeholders also benefit for the provision of this hardware, in line with ESA's strategic goals and the vision for lunar exploration. These benefits can be achieved through including a European end to end sample handling, processing and analysis chain.
Such an end to end package can provide for Russian needs whilst:

1) Preparing technologies and capabilities for future exploration missions in the area of drilling, sampling, sample handling and analysis and resource utilisation.
2) Generating knowledge on surface properties, in-situ resources, surface operations and fundamental science.
3) Demonstrating a key exploration end to end capability to secure long-term roles for Europe in future international exploration scenarios.
4) Engaging with the public and other stakeholders and increasing their awareness and understanding of lunar exploration and its benefits

This drilling, sampling, sample handling, processing and analysis end to end chain is called the Package for Resource Observation and in-Situ Prospecting for Exploration Commercial exploitation and Transportation, PROSPECT.

3 PROSPECT PROJECT HIGH LEVEL OBJECTIVES

A number of objectives have been identified for PROSPECT at programme level in the areas of drilling, sampling and sample analysis.

PR-OB-01. Provide samples that meets Russian requirements and expectations for the Luna-27 mission.
Justification: Provision of subsurface samples for analysis by Russian instruments, via a drill onboard Luna-27, covers an important part of the ESA responsibility as part of the ESA-ROSCOSMOS Lunar exploration cooperation.

PR-OB-02. Ensure that Europe benefits from the provision of samples to Russia for the Luna-27 mission.
Justification: European stakeholders, including ESA, should see specific benefits which may be balanced against the resources expended to provide Russia with subsurface samples. While some benefits may be realised at programme level, benefits should also be realised within the scope of the PROSPECT project.

PR-OB-03. Establish and demonstrate European competence in key areas for future international missions in the areas of:

- Drilling
- Sampling
- Sample handling and processing
- Sample analysis.

Justification: Europe will realise long term exploration benefits only if it continues to participate in exploration. In order to participate via cooperation with international partners, Europe must take opportunities to demonstrate its competences and technological capabilities via real surface operations. A large number of exploration benefits can only be realised through accessing, handling and analysing the material found at the destination, e.g. the Lunar regolith. Europe has therefore placed a priority on demonstrating technologies and capabilities specifically in the area of drilling, sampling, sample handling, processing and analysis, many of which are particularly relevant for Lunar Polar Sample Return amongst other future exploration missions.

PR-OB-04. Generate knowledge which addresses unknowns for resource utilisation and fundamental scientific questions.
Justification: future decisions on the architecture(s) which shall enable further exploration of the Moon and on to Mars must consider the question of whether resources on the Moon (including water) can be utilised. This question currently cannot be answered due to the limited data available, including virtually no relevant direct measurements of the regolith itself particularly at the lunar poles. There is therefore a priority on generating knowledge associated with understanding the usability of lunar in-situ resources.

PR-OB-05. Engage and increase public and stakeholder interest and understanding of lunar exploration and its benefits.
Justification: Engaging stakeholders, including the public at large, can ensure the maximum possible exposure to and realisation of the direct benefits of the PROSPECT project. Such engagement can also increase stakeholder interest in and support for the overall programme, including the next steps beyond involvement in Luna-27.

4 PROSPECT PROJECT HIGH LEVEL REQUIREMENTS

In order to achieve the objectives in section 3 the PROSPECT project must meet a number of high level requirements. These requirements are given below. The products and set up of the PROSPECT project shall be derived such as to ensure that these programmatic requirements are met, and the project shall be continually verified against these requirements.

PR-RQ-01. A project shall be established to develop a drilling and sampling product, to be known as the PROSPECT package, in the context of the Luna-27 flight opportunity

PR-RQ-02. The project shall ensure the PROSPECT package delivers samples which meet the Russian requirements

PR-RQ-03. The project shall provide a drilling, sampling, sample handling and analysis end to end chain (referred to as the sample chain)

PR-RQ-04. The functionality, performance and eventual data products from the sample chain shall allow unknowns relating to resource utilisation and fundamental scientific questions to be addressed

PR-RQ-05. The project shall generate documented lessons learned and experience products that can be used to ensure knowledge transfer to future missions

PR-RQ-06. The project shall generate communication products that engage the public and other stakeholders

PR-RQ-07. The project's data products shall be utilised and the results of this documented and communicated

5 PROSPECT PROJECT HIGH LEVEL ELEMENTS

In order to meet these requirements a project called PROSPECT shall be initiated.

The PROSPECT project shall create an end to end sampling & analysis chain that meets the above requirements.

A PROSPECT User Group shall be set up to ensure that a trained and informed user community exists to utilise the data generated by PROSPECT and to ensure that the initial requirements are representative of the user community's interests and needs.

A web platform and other communication tools shall be established to enable engagement with potential users, the general public and other stakeholders.

All project elements shall be described and elaborated in dedicated documents.