AGROMARS, SPACE MISSION CONCEPT STUDY TO EXPLORE MARTIAN SOIL AND ATOMOSPHERE TO SEARCH FOR POSSIBILITY OF AGRICULTURE ON MARS. M. Duarte dos Santos[1,2], M. Salpetrier[1,2], R. Monnier[1,2] and B.H. Foing[1,2,3] [1]IPSA, [2]EuroSpaceHub Academy, [3]LUNEX EuroMoonMars and Leiden Observatory

Summary: We show the preliminary design of AGROMARS, to explore and monitor Martian soil and atmosphere to search for possibility of agriculture on Mars, developed as IPSA/EuroSpaceHub/LUNEX EuroMoonMars study project.

Introduction: We describe the concept and basic design of a space mission, developed in the frame of a course between IPSA and EuroSpaceHub Academy.

Space Mission Description

The purpose of AGROMARS is to capture Martian soil samples, analyze it on site and send the collected data to biology laboratory partners. The goal is to study the following parameters [3]:

1-Mineralogical Composition
2-Soil Texture
3-Soil pH
4-Presence of Organic Compounds
5-Water retention capacity, soil porosity

The rover must possess advanced capabilities for capturing and analyzing Martian soil samples. The primary customers for AGROMARS are biology laboratories on Earth, which eagerly await the rover's transmitted data. These laboratories play a pivotal role in receiving, interpreting, and leveraging the insights gained from the Martian soil analyses. The collaboration between the mission and these laboratories underscores the interdisciplinary nature of AGROMARS, where the rover's findings also directly inform potential advancements in astrobiology and future agricultural exploration on Mars.

AGROMARS primarily focus on assessing the potential for agriculture on Mars, expanding the already existing geological and astro biological research of Perseverance, Curiosity, and others. The mission aims to capture Martian soil samples and conduct on-site analyses, providing data transmission to biology laboratories on Earth.

The heritage from the previous endeavors plays a key role in shaping the trajectory of our upcoming mission. The technological advancements from the design, operation, and analysis of past rovers, including Sojourner, Spirit, Opportunity, Curiosity, and Perseverance, form the cornerstone of our approach. This encompasses refined rover systems, enhanced sampling and analysis capabilities, robust communication protocols and optimized operational planning processes. Drawing on the experiences of our predecessors, we will integrate these lessons into the development of new instruments and autonomous functionalities to ensure the efficiency of AGROMARS.

Launch, orbit, propulsion.

As said before, AGROMARS will be launched with the same technology as rovers gone on Mars like Perseverance or Curiosity. With an approximated weight of 950 kg (including all the instruments), it must be launched by a technology which can send more than 20 tons of payload to carry on the rover. The last two missions on Mars were launched by Atlas V, but for this mission, we decided to use the Falcon 9 by Space X, which be part more of an ecological approach, by recycling the different levels of the launcher.

On-Board Instruments.

Using the conception of rover Curiosity, we concluded that we would provide to the rover the following instruments:

1-An X-ray spectrometer and an infrared spectrometer to detect spectral signatures of minerals.

2-High-resolution cameras, to provide visual images of the soil to assess its texture. However, a more in-depth analysis will likely require direct physical measurements, such as using drilling tools and texture sensors.

3-pH sensors integrated into the rover can directly measure the soil's acid-base reaction.

4-Mass spectrometers and gas chromatographs to detect and analyze organic compounds.

5-Drilling tools, thermal and moisture sensors can help to measure the soil's porosity and capacity to retain water

Mass and Power Budget.

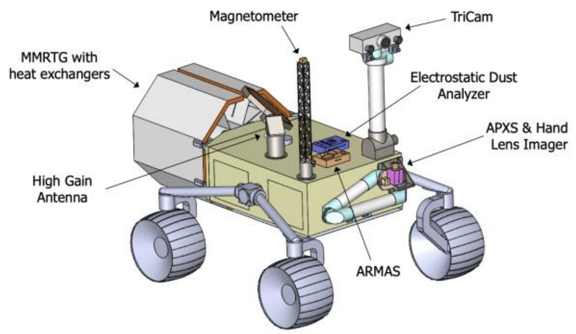
Using Curiosity and Perseverance rovers as references, and with the integrations of the instruments mentioned previously, we estimated that the total dry mass of the AGROMARS rover equals 950kg, including about 100kg of scientific instruments. To supply these systems with power, the rover carries a Multi-Mission Radioisotope Thermoelectric Generator like its predecessors. The output of this generator has a maximum of 100W.

System	Mass (kg)	Power (W)	Ratio (W/kg)
Instruments	100	204	2.04
Communication	40	116	2.9
Power	42.5	102	2.4
Navigation	142	300	2.11
Structure	332.5	0	0

Table of mass/power for main subsystems

The total cost of the mission is estimated to be around $2.7 billion, which includes $2.2 billion for the development and launch of the rover and $500 million for its exploitation during the entirety of the mission.

Mechanical layout.



Here, we can distinguish the different main systems that compose a spatial rover. We can see: all terrain wheel, to explore the rocky surface of Mars, different instruments like a magnetometer, an electrostatic dust analyzer, to and analyze samples that the rovers will collect by using its digging and drilling tools.

Operations. Landing site: Eberswalde

The rover will travel a surface with a radius of 30 km around the site and will provide:

1-Precise identification of minerals present in the soil

2-Relative proportion of sand, silt, and clay in the soil.

3-pH value to assess soil acidity or alkalinity.

4-Identification and quantification of potentially present organic compounds.

5-Percentage of water in the soil. This is crucial for evaluating the soil's ability to retain water necessary for plant growth.

Development plan.

This mission will be developed in 5 main steps.

1. Preparation stage, where we will define the mission's objectives with more details and specifications. Preparation stage: We will define the mission's objectives with more details and specifications.
2. Launch Stage: Extensive testing phase to ensure component reliability and functionality and launch of the rover with Falcon9.
3. Landing Stage: Safe and precise touchdown on Mars and start of the exploration mission and soil collection.
4. Data Transmission to Laboratories on Earth: Once the analysis is done and the data is collected, the information is transmitted from Mars to Earth efficiently.
5. Data Analysis on Earth: Laboratories on Earth receive the data and extract valuable insights into Martian soil, allowing them to evaluate the agricultural potential of the chosen Martian region.

Summary and perspectives.

To summarize, this mission aims to explore the Martian soil and atmosphere to search for possibility to exploit agriculture on Mars.

This mission could be an interesting preparative project for the next missions on Mars, and more especially for inhabited missions. Indeed, if humans wish to live on Mars, we would have to know if the Martian soil is conducive to agriculture.

Acknowledgments: We thank IPSA and EuroSpaceHub academy for opportunity with this space system preliminary design study.

References:

[1] Electrical power, NASA. Available at: https://mars.nasa.gov/mars2020/spacecraft/rover/electrical-power

[2] Van Leeuwen, C. and Chery, P. Quelles méthodes pour caractériser et étudier le terroir viticole ANALYSE DE SOL, CARTOGRAPHIE PEDOLOGIQUE OU ETUDE ECOPHYSIOLOGIQUE ?

[3] Baize D. et Jabiol B., 1995. Guide pour la description des sols. INRA Editions, Paris, 375p.

[4] IPSA, 2023, https://www.ipsa.fr/en/

[5] Perseverance Landing Sites Selection, NASA. Available at: https://mars.nasa.gov/mars2020/timeline/prelaunch/landing-site-selection/eight-potential-sites/