AMADEE-24: Pushing the Limits of Mars Missions

Laia López Llobet[1] and Soumyajit Mandal[2]

[1]Austrian Space Forum, Remote Science Support, Austria (laia.lopez.llobet@gmail.com)

[2]Austrian Space Forum, Flight Plan, Austria (soumya.pzs2010@gmail.com)

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1. Mission Aim and Structure

Planetary analog missions are the mechanism to prepare human space exploration for upcoming missions to other planetary bodies. The AMADEE program, managed by the Austrian Space Forum (OeWF), is one of the largest Mars analog simulations. In March 2024, the 4-week AMADEE-24 Mars analog organised by the Austrian Space Forum was hosted by the Armenian Space Agency. Experiments in the fields of geosciences, physics, biology and psychology, have been performed in order to study the environmental conditions of the site. All of these are crucial to understanding the mission architecture, scope and limitations of the future human planetary missions. Especially, considering the development of remote science operations, helping to understand the constraints and opportunities of the technology and workflows.

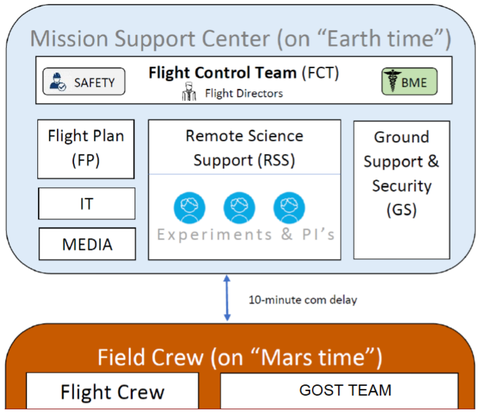
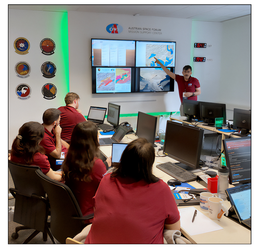


Fig 1. Mission architecture



Mission Support Center (Vienna, Austria)

Mars Habitat (Armenia)

Fig 2. AMADEE 24

Fig 1. shows the mission architecture of the AMADEE 24 mission. Primarily, it consists of the Mission Support Center (MSC, on "Earth time") and the Field Crew (FC, on "Mars time"). For this mission, a 10-minute communication delay is introduced. In reality the delay time varies between 3 to 22 minutes, hence the choice of 10 minutes is realistic.

Fig 2. represents snapshots of the MSC and the field during the mission and their activities.

2. Pre-Mission

Fligth Plan

The Flight Plan (FP) team is responsible for the creation of strategic Mission Plans (MP), tactical Activity Plans and as well as the Traverse Plans (TP) for the field crew. FP is the link between the RSS (and external experiment teams) on one side, and the Flight Control Team (FCT) on the other side.

In the Pre-mission phase, tasks include:

- Implement the mission architecture, that is developed by the mission management: namely developing MP based on the preliminary data
- Support the PIs (in collaboration with RSS) in the creation of Standard Experiment Information Form (SEIF) and definition of experiment locations (such as points of interest, WiFi locations etc.)

Remote Science Support

The Remote Science Support (RSS) team are the representatives of the PIs and research teams in the MSC. Once the call for mission experiments is announced to the scientific community, RSS is responsible for reviewing the proposals and selecting the experiments. Per each experiment selected, a prime coordinator and deputy is designated.

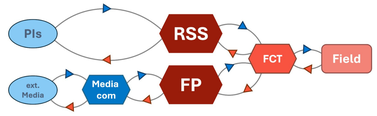


Fig 3. Link between Science, Media and FCT/Field

During the pre-mission phase:

- RSS (deputy) coordinators meet regularly with the research teams to ensure that the experiment objectives are well understood, questions are solved and the relevant documentation (such as procedures and SEIF) is filled
- Regions of interest of the site based on the experiments' objectives are defined and the first maps are provided to the teams

Experiment

After the mission experiments have been selected, the experiment teams meet with the RSS and FP coordinators to clarify the experiment requirements and objectives. It is in this phase when the research teams write the procedures and participate in the dress rehearsals in order to practise in a simulation environment the setup and procedure execution of their experiments.

Fig 4. A few snapshots during the dress rehearsals (DR)

In the pre-mission phase, extensive preparation is carried out, including training such as AMBT and AMAT, as well as in-person dress rehearsals (DR). Fig. 4 *(left)* illustrates simulations conducted by some of the principal investigators (PIs), and *(right)* safety measures and precautions training.

3. In-Mission

Fligth Plan

During the mission, FP works on:

- the development of daily activity plans (DAP) and TP. Along with additional information (such as weather conditions, authorisation from the FD) these are combined in the Field Activity Plans (FAP)
- handling of Media requests with respect to available resources

Remote Science Support

RSS tasks in-mission are:

- keeping the PI updated about the FP and times when their experiment will be performed
- Through a chat between the analog astronauts and the FCT, the RSS team knows whether the experiment has been performed successfully or if there are questions/problems related to the experiments which the RSS needs to coordinate with the PIs for troubleshooting (an example in the **Experiment** section).

Experiment

During the bridging days, after the shipping containers arrive at the mission site, the mission preparations are performed. In this poster, the ALIX experiment will be used as an example since it has been coordinated from our perspective, focusing on both the RSS and FP angles.

ALIX is a radio interferometry-based location tracking experiment which uses antenna setups to investigate cm-scale tracking, as well as ground receiver stations for km-resolution. The objective of this experiment is to track the astronauts' location during Extravehicular activities (EVAs). During the EVA in the location (as shown in the bottom panel of Fig. 5), some of the ground stations would show their status as "unknown". In order to troubleshoot this, RSS contacted the PIs and clarified that this was not a showstopper as it would mean that the antennas have been measured since they were powered on but they are unable to receive the Wifi.

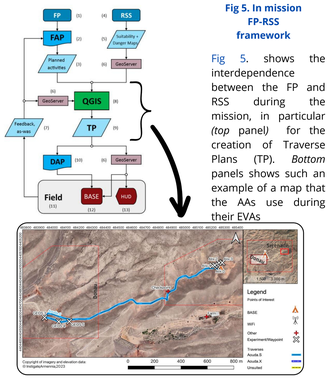


Fig 5. In mission FP-RSS framework

Fig 5. shows the interdependence between the FP and RSS during the mission, in particular *(top panel)* for the creation of Traverse Plans (TP). *Bottom* panels shows such an example of a map that the AAs use during their EVAs

4. Post-Mission

Fligth Plan

After the mission is concluded, FP works on:

- comparison between planned vs executed tasks (in terms of time)
- analysis of planned and actual experiment locations and traverses
- compilation of the results in a final report and publication

Remote Science Support

After the mission, RSS takes care of

- helping the PIs share their science results with the scientific community through conferences, workshops and publications.

As part of this effort, the OeWF hosts a session titled "PS7.1 – Terrestrial Field Analogues and Crewed Analog Missions" at the EGU (European Geosciences Union) conference in 2024.

Experiment

After the very preliminary data analysis, the ALIX team managed to localize the antennas using photogrammetry via the Agisoft Metashape software. In order to perform this, a series of pictures are taken at different angles of every antenna. In these pictures some recognizable points are selected. With the Agisoft Metashape software, a pointcloud of the terrain can be created to establish the locations of the antennas.

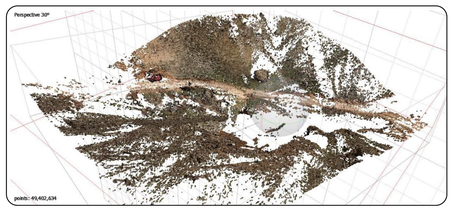


Fig 6. Antenna locations pointcloud

Fig 6. shows the terrain of the antenna locations using the Agisoft Metashape software. This terrain pointcloud has been obtained using the sets of images of the five antennas of the array.

5. Results

The AMADEE-24 mission contributed to our understanding on how future human missions would be developed on Mars. Key findings in this analog mission include advancements in habitat construction, life support systems, astronaut location technologies and communication protocols. Like real space missions, all teams faced and overcame challenges day by day but in the end, the AMADEE-24 mission in Armenia served to advance research and continued inspiring the next generation of space enthusiasts.

Fig 7. Various OeWF teams, a truly international family in various stages of the mission

Acknowledgements

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