Embedded Recording Interface for EVA

Aim

The main purpose of this project is to design a system to improve EVAs and post-EVA debriefing on different aspects: speed, ease, security…

To do so, a micro-computer would be connected to different sensors and carried with the spacesuit. In the final version, many add-ons can be imagined such as tools to measure the characteristics of the environment as well as physiological sensors. Then a screen on the wrist will allow interacting with an interface to get all the information necessary to the marsonaut during an EVA (navigation, software tools, audio report, etc.). However, preliminary work has to be done before being able to design this tool as efficiently as possible.

This proposal aims at acquiring data during EVA for the development, in short term, of electronics add-ons to MDRS spacesuit.It is searched for real data in an analog environment to develop a user-friendly interface. For now, the material list is composed of a micro-computer Raspberry Piconnected to a GPS chip, humidity and temperature sensor and sunlight exposure sensor to be brought on the top of the backpack during EVAs.

The data that will be collected will be: GPS positioning, external humidity and temperature, and sunlight exposition (UV, visible, IR). All this information that can help to contextualize the events that happen during an EVA will be stored on the SD card that contains the software and will help to build an embedded graphic interface to be used for future missions.

Relevance to Mars

The spacesuit is a kind of personal spacecraft that shall provide the astronaut with everything needed to work efficiently, while ensuring security. From Mercury spacesuits to current EMU or Orlan spacesuits, they have kept evolving and they will also have to adapt to Mars environment.

The embedded system that this experiment would help to design could contribute building the next generation of spacesuits. Indeed, it would for sure help the astronaut to work on a more autonomous basis, while optimizing the presentation of the data collected by all the instruments that are part of this embedded system.

Being equipped with such a system, the marsonaut wouldn't have to worry about a lot of details and could be automatically notified when environmental and/or physiological conditions require him/her to take a decision, to adapt a different behavior and even to go back to the Hab.

On Mars surface, there would be a lot of parameters to measure for safety purposes, but also for scientific purposes. The described system could help better understand the environment where marsonauts are operating and contextualize some events that can occur during an EVA, for example: “What was the temperature and humidity when these sample have been collected?”.

Finally, it is very important to try to reduce as much as possible the weight of the spacesuit and this system could help to do so. Indeed, gravity on Mars is more than one third of that on Earth. Knowing the fact that the total weight of the current EMUs that are used during an EVA on ISS is 55,3kg, they would seem like 21kg on Mars surface. No need to explain that it would be far more tiring to conduct long EVAs in this situation than aboard the ISS.

However, a battery of tests is necessary to take all the parameters into account and optimize the whole while trying to find new features. It is also important to keep in mind, that all these add-ons should not jeopardize the gains of the previous spacesuits, particularly their security.

Relevance to MDRS

One of the main goals of this embedded recording device is to improve the efficiency of extra-vehicular activities and the quality of data recorded during EVAs. In its final form, it will consist in an embedded graphical interface: a nano-computer (RaspBerry Pi) will be connected to different sensors (a lot more than the above cited thermo-, hygro- and luminometer) to help the Marsonaut in his tasks during the EVA or during its debrief. Besides, it will also help monitoring the efficiency of the Marsonaut, his bio and physiological data and his environment.

Alexandre Mangeot, a member of Association Planète Mars (the French chapter of the Mars Society) is currently working on this project and now needs data recorded from a Mars-analog environment to improve its efficiency and user-friendliness. He acquired and connected hardware parts (the Raspberry Pi computer, and the temperature, hygrometry and luminosity sensors) and developed the software (Python routines) to acquire and stock data. To improve the interface software and test its usability, he used to take the system with him and have it recording data on his way to work, for instance: he would therefore check the usability of the system and check the quality of recorded measurements afterwards. But, according to him, data should now be recorded in an environment that looks like EVA environmental conditions, i.e. during a Mars-analog simulation, to allow for further tests and improvements.

It is thus of extreme relevance to test the system in analog conditions, not only to record data for software improvements, but also to test the usability and robustness of hardware during EVAs. It will have to resist the tough conditions of the Utah desert, and to be manipulated in uncomfortable positions. Especially, bringing it with us at the MDRS would allow us to test :

-the solidity of the fixation with backpack and its battery ;

-its resilience and ability to keep track of data despite heat, dust, shock, etc.

-its usability wearing a spacesuit, and especially heavy gloves, making its activation difficult.

It comes within the scope of previous experiments aiming at recording data from Marsonauts, in the Hab (NEEMO project) as well as during EVAs (personal assistant currently developed at the CNES). Alexandre Mangeot expects to have the final system, with a functional graphical interface, to be operational for the Mars Arctic 365 mission. Tests in Mars-analog conditions at the MDRS are thus greatly needed for efficiency and usability assessments.

Protocole

This project will use a Raspberry Pi connected to a GPS chip (https://www.adafruit.com/products/746), humidity and temperature sensor (https://www.adafruit.com/products/1899) and sunlight exposure sensor (https://www.adafruit.com/products/1777).
The overall package (expected size: 10x7x5cm for less than a kg of mass) will be powered by the backpack battery through a voltage regulator. The voltage used is 5V and the power draw should be around 750mA. The package will be placed on top of the backpack.

For each selected EVA, a randomly selected crew member will, during the time of the EVA, have the system linked to his backpack. The organization of the experiment will thus be dependent on other experiments and on the EVA schedules, as it will take place in the same time as other experiments. However, we estimated that at least 4 EVAs are required by this experiment to reach a reasonable validity: they can take place anytime during the mission.

In the Hab, Alexandre Mangeot will have provided us with a protective case containing the Raspberry Pi chip and the sensors, that we will have to non intrusively fix on the backpack and to link to its batteries. During the EVA, the system, depending on the development stage of the software, will either start automatically recording data as soon as backpack batteries are connected, or when the Marsonaut presses a manual switch. The collected data are stored during EVA on the SD card that contains the software.

After each EVA, the data can be used for reporting, and are analyzed offline. Back in the Hab, we will have to assess the integrity of the system, and the quality of recorded data. They will be stocked for further software improvements after the mission, jointly with a precise description (weather measurements recorded independently, time, precise description of the activities conducted) of the EVA.

Finally, we will also make the most of available time in the Hab to conduct exploratory analyses after each EVA :
- depending on the position of the luminosity sensor, data can be used to improve further human factors experiment. Previous work conducted by one of the member of the MDRS Supaéro Crew (‘*Detection of mind wandering using eye tracking*’ : Camille Gontier & Charlotte Dietrich, 2014) has confirmed the hypothesis according to which pupil diameter online monitoring using an eye-tracking device could be an effective mean to detect the apparition of mind-wandering, as an increase in pupil size is detected prior to an error during a supervision task. It could be interesting to replicate these results during an EVA,

but recording eye-tracking measurements outside of a laboratory leads to strong variations in pupil diameter due to environment luminosity variations. Having luminosity recorded thanks to the interface could alleviate this problem by normalizing pupil diameter by luminosity measurements.

- We will also check the possibility to record the interface to other systems we will use during the mission, such as the EMUI glasses.