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Basic Mars Navigation System For Local Areas

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Introduction: This project has been first set up as a basic solution in navigation during EVA (extra-vehicular activities) in the Mars Society Desert Research Station in the desert of Utah. The main idea is to keep the system as simple as possible so that it can be easily adaptable and portable. The purpose of such a device is to tell the astronauts in EVA where they roughly are and then letting them reaching different points in avoiding any risky way. Thus the precision needed has not to be really high: even if it is about 50m, every astronaut can then look on a map and be able to design a way to another point. This navigation system will improve the safety of the EVA as it is an added reliable orientating tool.

Concept: To look at a simple way to localize oneself, one should have a look at what has been done by mankind on Earth. Today, everyone can think of the GPS because it's simple and very reliable. However the infrastructure for such a system is huge and will not be for sure available during the first missions. We can think of course of a basic GPS using the satellites being in orbit but this approach is not yet as simple as we would like.

If we want to keep the sky in sight, we can use the stars and the moons of Mars. Yet this would be a good solution and we can even have a star tracker that would give a good position according to the time of the picture. This solution has to be kept in mind but a star tracker is quite big for an astronaut without any rover nearby and using the sky may not be as precise as one should expect.

Another useful tool is the compass. It has been used for centuries by sailors but on Mars, without a good magnetic field for this purpose. But sailors also use lighthouses and some placemarks on the land to localize themselves. This is done with a compass, measuring the angle between a placemark and the magnetic North. With two angles, we can then have the position of the boat.

The idea here is the same: measuring the angles between different placemarks so that we can compute the position. But which placemarks? We have to think about something that can be installed on Mars and is light enough to be brought there. Balloons are really light, and in order to place them, we need a gas as helium (or hydrogen) and also some rope. Hydrogen is likely to be produced in situ and rope will be useful for astronauts. So we started on a concept with some balloons around the base, with different colors or patterns. The crew in EVA can thus know where the base is every time they are in sight of a balloon and with at least three balloons; they can compute their position according to the base.

Procedure of the test: During EVA, the astronauts will measure the angle between the different balloons. The balloons are high in the sky so they can be seen far from their location. This is particularly important on Mars where the horizon is nearer than on Earth. The balloons have different colors so they can be identified and we can even think of adding an autonomous colored light under so they can be observed during the night. With good quality balloons, we can keep them in the sky for a few days without maintenance.

Angle measurement is done thanks to a camera. A numeric camera can have a precision of less than 0.01°/pixel, which is enough for our application. The distance between the different balloons can easily be seen in a free

picture management software and a Matlab tool is under development for this. An algorithm is then run and it gives the positions that fit with the observations on a map. Simulation gave areas 20m width, which is enough for the astronaut who has a map. The exact precision will be investigated in situ, at the MDRS. For this first test bench, computations will be manually done on a computer in order to validate the concept without huge development. Afterwards, one can imagine an implementation on a PDA brought by the astronauts. This PDA would have its own camera so the process can be fully automatic. Such a system can also implement other navigation system as a Martian GPS or a radio localization system like a VOR in order to enhance the reliability of the system and use all the advantages of each method.

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References: [1] "ExoGeoLab Lander/Rover instruments and EuroGeoMars MDRS campaign", B.H. Foing, LPSC abstract 2009