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Analogue field study in the Sahara

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Abstract: Between 01st-28th. of February 2013, the Austrian Space Forum (Österreichisches Weltraum Forum, Innsbruck) – in partnership with the Ibn Battuta Center in Marrakesh - conducted an integrated Mars analog field simulation in the northern Sahara, in Morocco. Directed by a Mission Support Center in Austria, the field crew conducted experiments preparing for future human Mars missions in the fields of engineering, planetary surface operations, astrobiology, geophysics/geology, life sciences and others.
We participated to the study with the HUNVEYOR-4 educational space probe. During this terrestrial analogue field study our aim was testing the Hunveyor-4 in various, real working situations, testing our concepts and the mainly student-built equipments.

Key words: HUNVEYOR, field study, physics, space probe, robotics

1. Introduction

We are living in the 21th century, in the so called Space Age. We are more and more technology dependent (computers, smart phones, etc.), basically our everyday life hangs on electricity. At the same time the interest is going downhill about the science and engineering among the younger generation. The HUNVEYOR project is our answer to this challenge.

The name HUNVEYOR is an acronym for Hungarian UNiversity SurVEYOR. The HUNVEYOR-4 itself is an advanced environment monitoring robotic lander with remote access. The robot has been engineered and built by the students at the Alba Regia Technical Faculty, a campus of the Óbuda University, located in Székesfehérvár, Hungary.

Figure 1. The HUNVEYOR-4 robotic lander

In 2012 the Austrian Space Forum announced an integrated Martian analogue field study, codename MARS2013, conducted in northern Sahara, near Erfoud, Morocco. The aims of the MARS2013 field campaign was the preparation for future human Mars missions by testing scientific instruments, concepts for human-robotic partnerships as well as engineering and operations trials.

The program committee accepted our proposal for testing our HUNVEYOR-4 educational space probe. The aim of the participation was testing the Hunveyor-4 in various real working situations, and study equipment behavior involving the simultaneous usage of various instruments. This includes withstanding for vibrations (e.g. transportability), withstand for meteorological situations, like daily temperature changes, dew and dust accumulation, continuous working and collecting data about its environment and climate. Our goal was further more testing our data collecting concepts via distributed sensor network and the mainly students built equipments, but we did not intended to worry too much about the calibrated values. We also wanted to take the opportunity of serving as an outreach platform to enhance the international visibility of planetary sciences in Hungary as well.

2. The MARS2013 campaign setup

Conducting field research in a representative environment is an excellent tool to gain operational experience and understand the advantages and limitations of remote science operations on other planetary bodies.

2.1 The location of the martian analogue field study

The area near Erfoud is considered as a relevant proxy for various types of geological features of Mars, as well as a diversity of paleo (micro)biological signatures, terrain topographies similar to the Martian deserts and a test site area size which requires a diligent exploration mission design.

Figure 2. The MARS2013 campaign site

2.2 Connection between "Earth" and "Mars"

The organizers established an infrastructure and roadmaps which was implemented during the MARS2013. The activities were scheduled through a "flight plan" [Fig. 4.] managed by the Mission Support Center (MSC) in Innsbruck, Austria ("Earth") [Fig. 3.], the field operations were conducted in the desert ("Mars"). The "Earth" and "Mars" communicated with via a dedicated broadband satellite connection. [Fig. 5.] Occasionally they inserted an extra 15 minutes delay in the communication channel in order to make the experiment more realistic.

Figure 3. The Mission Support Center

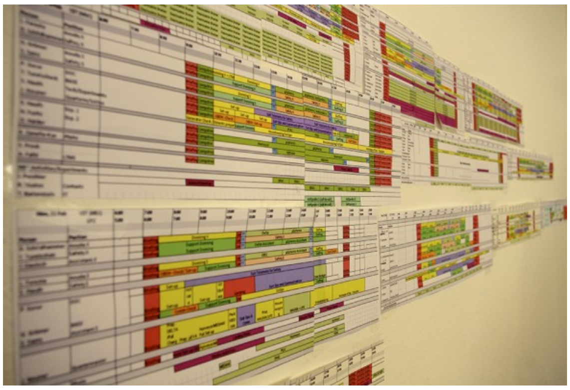


Figure 4. Part of the flight plan

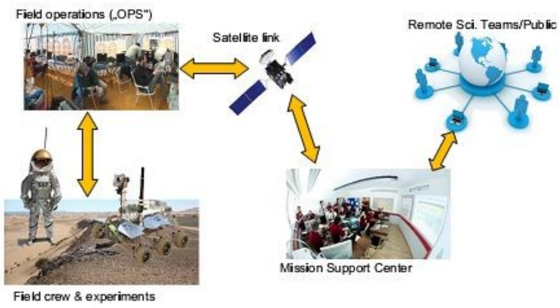


Figure 5. The communication schema

2.3 The main characteristics of HUNVEYOR-4

The HUNVEYOR-4 is an internet controllable explorer robot. This educational space probe was designed for a long term operation on a remote field, with little or no human presence, low power consumption/dissipation using a single 12V battery/solar panel combination and with minimal moving components. The on-board computer, the so called “Space Probe Control Unit” runs Debian Linux from a CF card.

The main building elements of the HUNVEYOR-4 are the followings: frame, environment monitoring units such as stereo web-camera, temperature, humidity, air pressure, noise, spectral illumination, lightning, and particle radiation devices. We developed a rover for small soil sample collection purposes.

Power requirements: the power consumption is in idle about 20 watts. Each equipment (like access point, camera movements, lights, etc.) add about 3 more watts, but they can be used one by one, so the total energy need at maximum load does not exceed the 30 watts.

Power supply: We supply the energy using four, 12V batteries in parallel, the type which are common in UPS devices. The batteries are charged by a 55 W solar panel during the day, and they keep the HUNVEYOR-4 alive during the night.

Communication: The HUNVEYOR-4 is equipped with a 2.4 GHz access point and can communicate wirelessly with a correctly set up other access point for a few hundred meters. If still the probe has the original piece of rod antenna, but we provide the parabolic dish to the internet connection side, the range can go up to a few kilometers. We planned to take snapshots in every 15 minutes automatically.

Figure 6. The solar panel and the dish for radio communication, and the sample collecting rover.

2.4 The proposed experiments

The following measurements and instrument tests were planned:

Testing and observing:

-Hunveyor-4 portability and ability for continuous work
-testing the soil collecting rover: mobility, range, radio communication
-testing our concept for data collection using an experimental dynamic configurable sensor network
-camera observations of the quality of surface events and forms
-camera observation of the rock surface textures
-camera observations of the windswept sandy surface and wind transport (dunes, lee forms)
-camera observation of dust devils
-monitoring the magnetic particle content of the precipitating dust
-robotic arm observation in working: sand, smaller clast and pebble manipulations
-stereo-camera observations for guiding the sample collecting rover

Instrumental measurements:

-monitoring insolation
-analyzing spectral composition of the light and its daily changes
-monitoring noise level
-monitoring humidity
-monitoring temperature in different places (outside, under the hood, processor)
-monitoring wind speed and direction changes
-monitoring high energy particle radiation
-rough spectral analysis of the soil
-data collection, transmission and storage in a data base for later retrieval and analysis

3. Results and Discussion

3.1 Changes in the final setup

We had to change the actual set up at the time of the dress rehearsal:

#1, Our 2.4 GHz wifi connection did not work correctly, so we removed from the set up. The investigation (at home) revealed that a PCMCIA card was loose in one of the Access Points.

#2, Due to an accidental shortcut the Sun tracking electronics was damaged, so we removed from the solar panel stand. As it turned out we could collect enough power without tracking.

#3, We did not install the LED spectrometer for the rough spectral analysis of the soil.

3.2 Result of the field operation

The HUNVEYOR survived the transportation.

We could successfully connect to the device and could retrieve some data.

Unfortunately the connection was interrupted many times. The interrupts was due to power outages (e.g. oil change in the generators, everything shut down at night see fig. 4.), harsh weather conditions (e.g. sand storm), relocation or other network related problems.

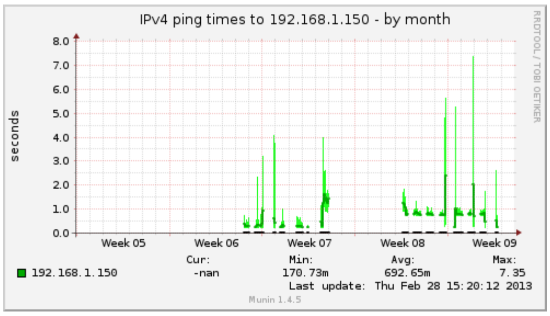


Figure 7. A long interruption, and sometimes extremely long ping times.

The solar panel and the battery pack worked excellent, so the HUNVEYOR-4 could have been continuously up more than 24 hours (fig. 8.). Despite of our assumption all the devices, including ours were shut down for the nights. Only once the HUNVEYOR-4 was not shut down for the night, so we could test the performance of the energy module – the solar panel, the intelligent charger and the battery pack.

```
login as: root
root@192.168.1.150's password:
Linux hunveyor 2.6.32-5-486 #1 Sun Sep 23 09:17:35 UTC 2012 i686

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Feb 20 16:36:58 2013 from 192.168.0.2
root@hunveyor:~# uptime
 17:26:58 up 1 day, 51 min,  1 user,  load average: 0.08, 0.02, 0.01
root@hunveyor:~#
```

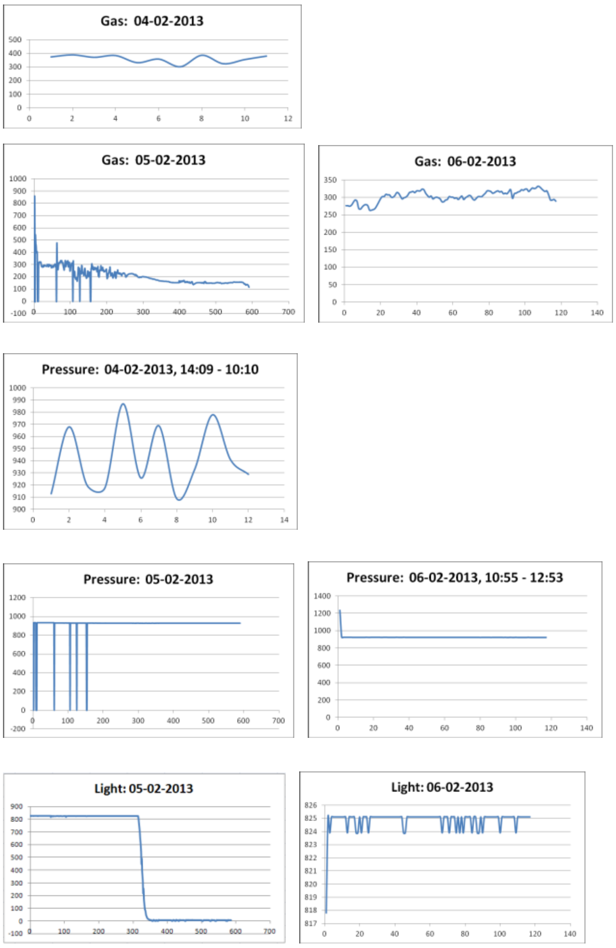
Figure 8. The HUNVEYOR worked overnight (uptime: 1 day 51 min)

We have 619 data sets from the meteorological station for the following days:

04-02-2013 14:09 - 14:10 every 2 seconds, 11 measurements

05-02-2013 11:42 - 23:46 every minutes, 591 measurements, 10 drop outs

06-02-2013 10:55 - 12:53 every minutes, 117 measurements (the first data may invalid)



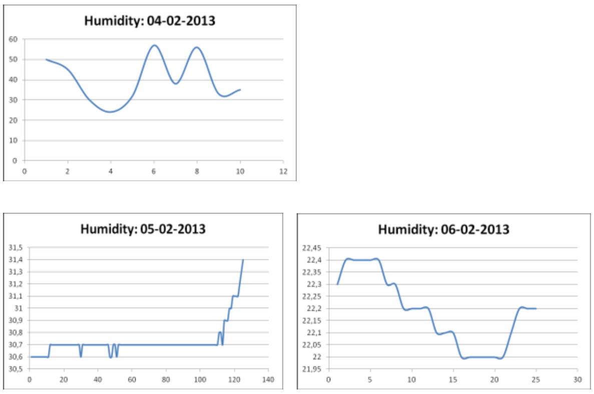


Figure 9. Data collected from the meteorological station for gas, pressure, light and humidity.

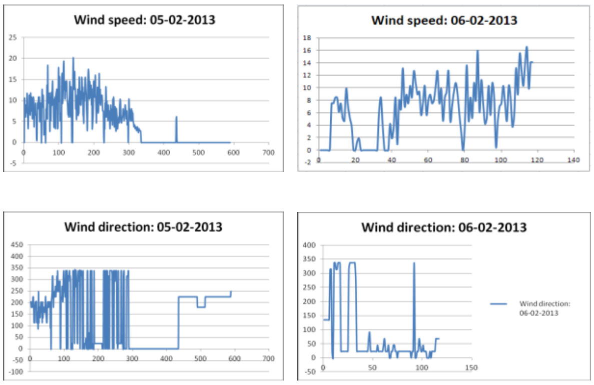


Figure 10. Data collected from the meteorological station for wind speed and direction.

We successfully tested our sensor network, consisted of an USB data collecting device which communicated wirelessly with three small sensor units, called MOTs, each containing light, humidity and two temperature sensors.

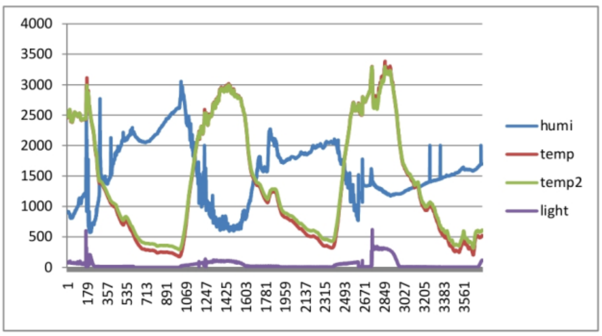


Figure 11. Data sets retrieved from one of the MOTs (the little blue boxes/mobile sensors). The data spans from 04-02-2013 14:37 until 07-02-2013 07:01. The measurements were taken in every minute.

Unfortunately, a couple of days into the campaign we lost the control to our devices. The loss was due to the USB to IIC controller failure for one group of devices (we lost the complete meteorological station) and battery source to others (MOTs). After returning home we analyzed the devices, and we found that the culprit was the controller's memory.

Because of the USB failure, we could not use the cameras, so the camera observations of the quality of surface events and forms were cancelled.

Because we had no pictures from the stereo camera, we could not test the sample collecting rover as well.

Analyzing the returned device we found enormous amount of dust accumulations on the component side of the PCB-s over the soldering points. We concluded that the soldering resin on the PCB was electro statically charged by the wind. Despite the resin side facing downward, the PCB collected tremendous amount of dust particles on the top side.
This could be the source of many serious problems.

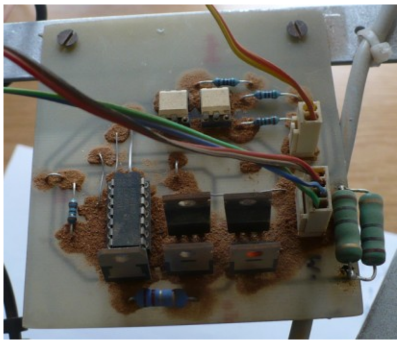


Figure 12. Dust accumulation on the component side over the soldering points.

4. Conclusions

During the 28 days of the field simulation program, scientist from 10 nations collected and sent more than 15 Gigabyte data per day of the twenty experiments to MSC in Innsbruck to store and analyze. The whole setup in Morocco weighted about 2 tons, and more than hundred persons from five continents participated into the campaign, partly as researchers, executives, managers, organizers, security service, or even contact persons with the media. Our participation to such a project was a big step toward the international visibility of our work.

Figure 13. The HUNVEYOR-4 in the desert Sahara participating to the MARS2013 analogue field study day and night.

Despite of the hardware failure, we consider the field test as a success, because the HUNVEYOR-4 space probe was not designed to operate in harsh environment, and performed better, than we expected.

For a more robust solution we plan to redesign the space probe for Raspberry PI. Because the RPI has a built in IIC interface programmatically implemented on the GPIO pins, we will not need the faulty USB/IIC interface any more.

Acknowledgment

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