Mission Space Lab - Phase 4: cos(π) Report

Team Name: cos(π) – Coding of Space

Chosen theme: Life on Earth

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Figure 1 – cos(π) Logotype

Introduction

The main objective of the experiment is to study the relativity of the movement between a two-body system.
It is intended to accomplish this by exploring the relation between the Earth's rotation and ISS translation movements. This experiment is expected to provide answers to the following questions: *What is the value of the relative velocity of the ISS-Earth system? Is the relative velocity constant? Is it relevant to consider the Galileo's Relativity Theory when studying systems with two distinct velocities?*
In order to guarantee the validity of the results, a security measure was put in place as a secondary mission in which the AstroPi was programmed to be a human presence detector.
It is expected the identification of a relative velocity (that is predicted to be constant), duo to the existance of two different movements in a two-bodies system, thus evidencing the importance of the Galileo's Relativity Theory in this type of studies.

Method

The team wrote an algorithm to execute the experiment divided into two purposes. For the main objective it took photographs of the Earth, in time intervals of 5 seconds, and then added the coordinates to the EXIF fields within each image. For the security measure the AstroPi used humidity, pressure and temperature sensors to compare their variation values to the referenced ones and saved them in a CSV file.

The photographs were charted on a globe using *digiKam* software, in order to determine the distance between a pair of consecutive photographs (figures 2 and 3) and use that measures to approach the relative velocity (verifying Earth's rotation movement). Meanwhile, the data concerning temperature, pressure and humidity, was analysed in *Apple Numbers*. Some of the experiment method advantages lie on the approximations taken to simplify the model: the ISS trajectory was considered to be circular, the axis of the Earth's rotation and ISS orbit were considered parallel and the values of the Earth rotation velocity and ISS height (considered constant) were considered as set values. The data collection in short time intervals resulted in a high number of tests and, therefore, in an increase of the accuracy of the scientific results.

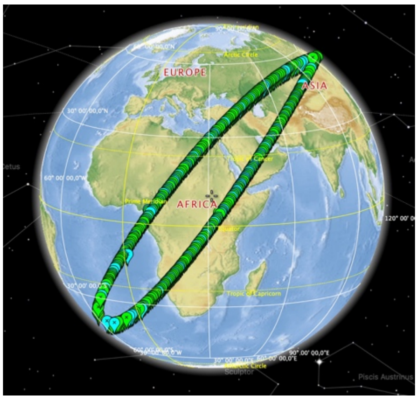


Figure 2 – Coordinates charted on a globe (*digiKam*)

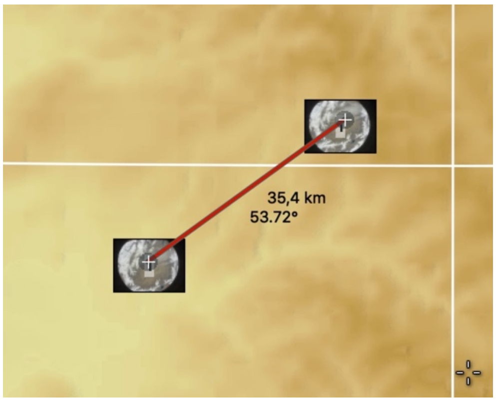
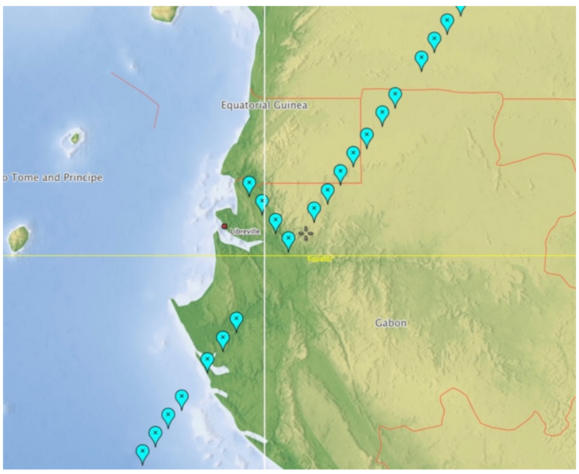


Figure 3 – Distance between photographs (procedure for all the 1802 pair of photographs)

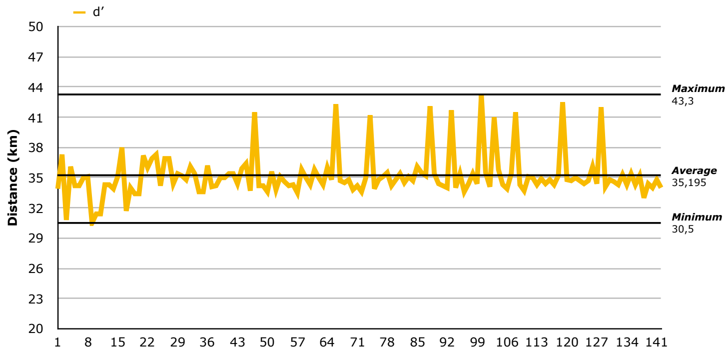
Results

The procedure started with the calculation of distances between all the pairs of consecutive photographs (1-2, 2-3, […], 1802-1803). During that phase one of the most notable events was verified in Figure 3, where it is observed a deviation of the expected flow of photographs. An explanation for this lies on a program error, once it is not verified periodically. Another notable event was that in every six photographs a 70 km distance was verified (Graphic 1), however, these values were not considered since they are not coherent with the other six measures. Hence, in order to reduce the experimental error, distances from these events were not considered.

Figure 4 – Flow deviation



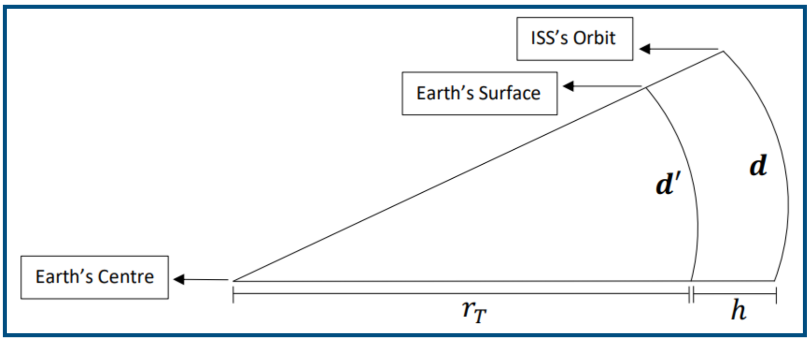
In order for a better understanding, these distances were plotted in Graphic 1:



Graphic 1 – d' variation

It is now important to relate the distance between two photographs, d', with the corresponding distance on the ISS orbit, d (Figure 4):

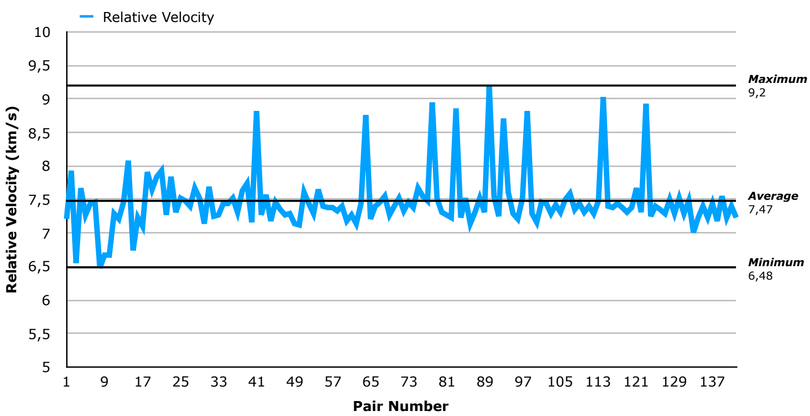
Figure 5 – Demonstration of the relative velocity



From this figure comes: $\frac{r_t}{d'} = \frac{r_t+h}{d} \Leftrightarrow d = d'\frac{(r_t+h)}{r_t}$

Considering that the relative velocity is $V'=\frac{d}{\Delta t}$, and: $\begin{cases} r_t = 6{,}37 \times 10^3\ km \\ h = 3{,}50 \times 10^2\ km \\ d' = 3{,}47 \times 10\ km \\ \Delta t = 5{,}00\ s \end{cases}$,

it is possible to calculate V' for each 1802 pairs of photographs (Graphic 2).



Graphic 2 – Relative Velocity variation

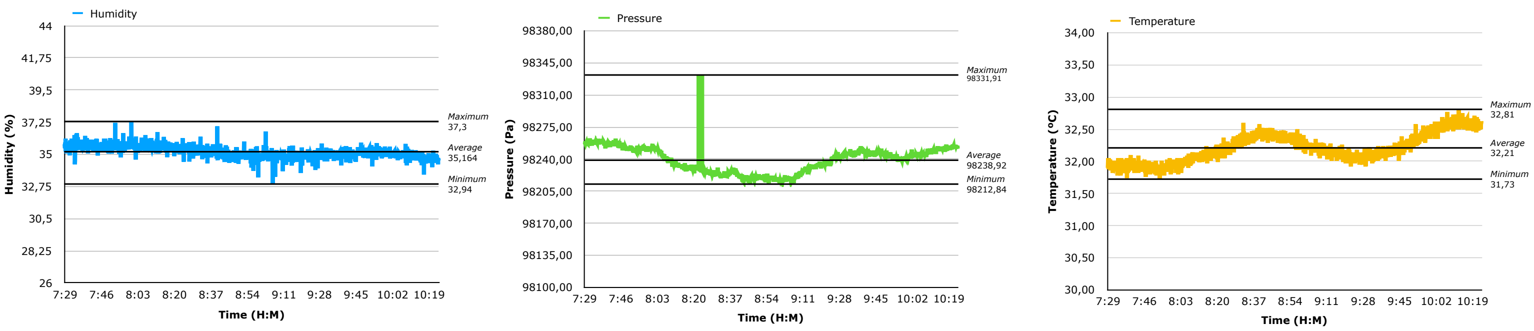
It is now possible to aproach Earth's rotation speed, V_{earth} , since: $V' \approx |V_{ISS} - V_{Earth}| \Leftrightarrow V_{Earth} \approx |V_{ISS} - V'|$. Finally, comparing the set value V_{earth} with the calculated, an experimental error is determined. Note that this is an indirect meausurement once it uses V_{earth} instead of V' (because there is no set value for V').

The following table presents the values of velocities and experimental error:

Table 1 – Velocities and Experimental Error

V_{ISS} (km/s) (set value)	V_{Earth} (km/s) (set value)	V' (km/s) (average)	V_{Earth} (km/s) (experimental)	E_r (%)
8,00	0,48	7,47	0,53	10,42

For the secondary mission the collected data was plotted into three time-graphics. No significant variation was observed; therefore, it is possible to claim that no human presence was detected. This allows to verify the validity of the collected data (the peak in the pressure graphic is considered to be a high-voltage disruption).



Graphics 3, 4 and 5 – Humidity, Pressure and Temperature variations

Conclusion

In the conclusion, the team considers that the experiment was partially successful, according to the limitations of the used mathematical model. In that way, the questions presented in *Introduction* were also partially answered.

It is concluded that the value of the relative velocity is 7,47 km/s, as displayed in Table 2. This value was expected to vary, but according to Graphic 2, the variation was not observed. It is believed that with more time and a better mathematical model this would be possible to verify. Comparing the translation velocity of the ISS (8,00 km/s) with the relative velocity calculated (7,47 km/s) it is evident that ignoring the Relativity of Galileo would not conduce to viable results, which means that it must be considered, in the system of movements presented.

The team recognizes that all the approaches considered in the mathematical model contribute to the simplicity of the calculations, and were responsible for the reasonable value of the experimental error (10,42%).

Although in a future experiment, with more tests and a more accurate model, it would be possible for cos(п) to achieve better results.