Detection of Earthquakes through a STratospheric INfrasound studY

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Introduction

Investigating Venus is key to understanding our solar system history. However, harsh surface conditions prevent the use of landers. An alternative is to measure ground seismic events from a high altitude (∼55 km) where Venus presents earthly conditions via stratospheric infrasound measurements using balloons [1]. Conservation of energy and decrease in air density allow infrasound signals to be amplified making their detection easier at high altitude.

DESTINY - Detection of Earthquakes through a STratospheric InfrasoundstudY - flew on the BEXUS 28 balloon in October 2019. Its aim was to use stratospheric infrasound measurements to locate ground seismic events, as a proof of a concept to study the seismic activity of Venus.

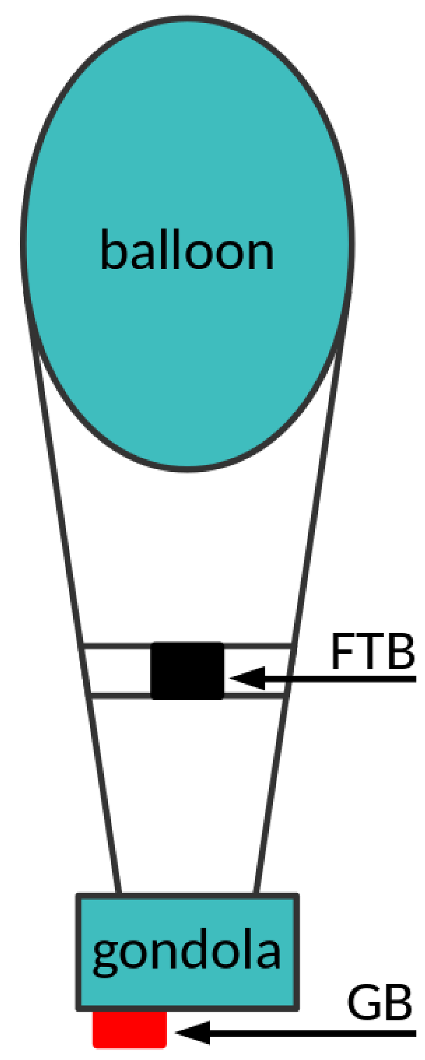
Mission

Objectives :

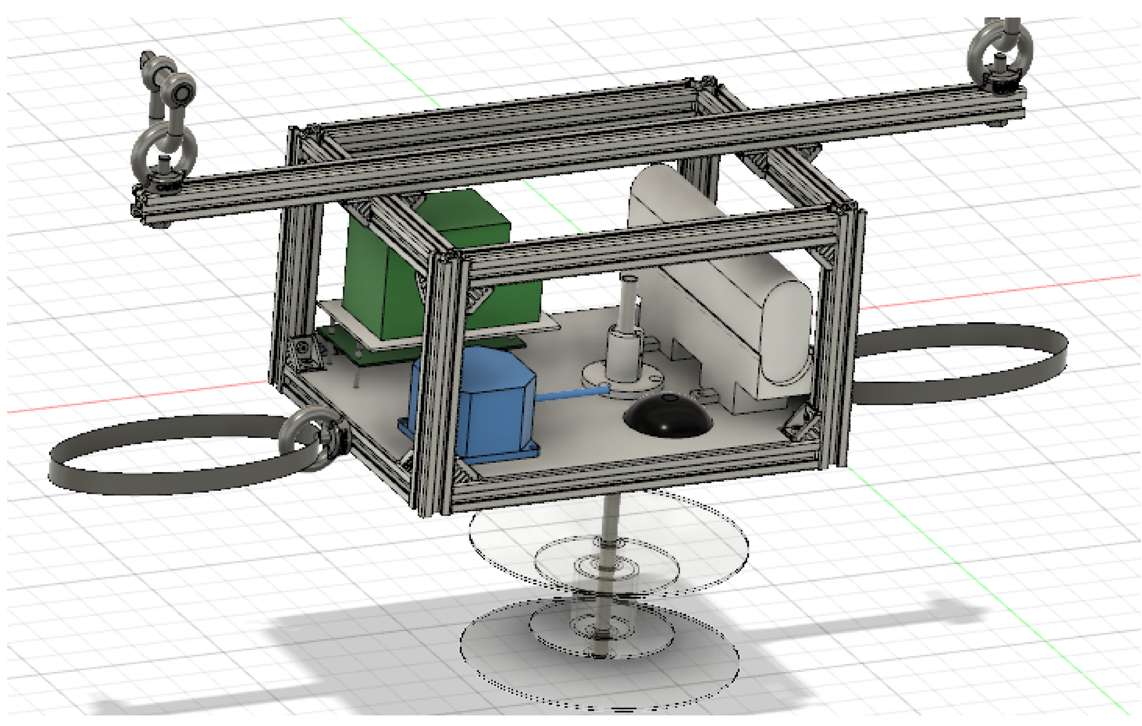
- to characterize the infrasonic background noise during the stratospheric flight.
- to extract signals related to geophysical processes from infrasound measurements and to identify them.
- to locate the infrasound sources.

Experimental Design :

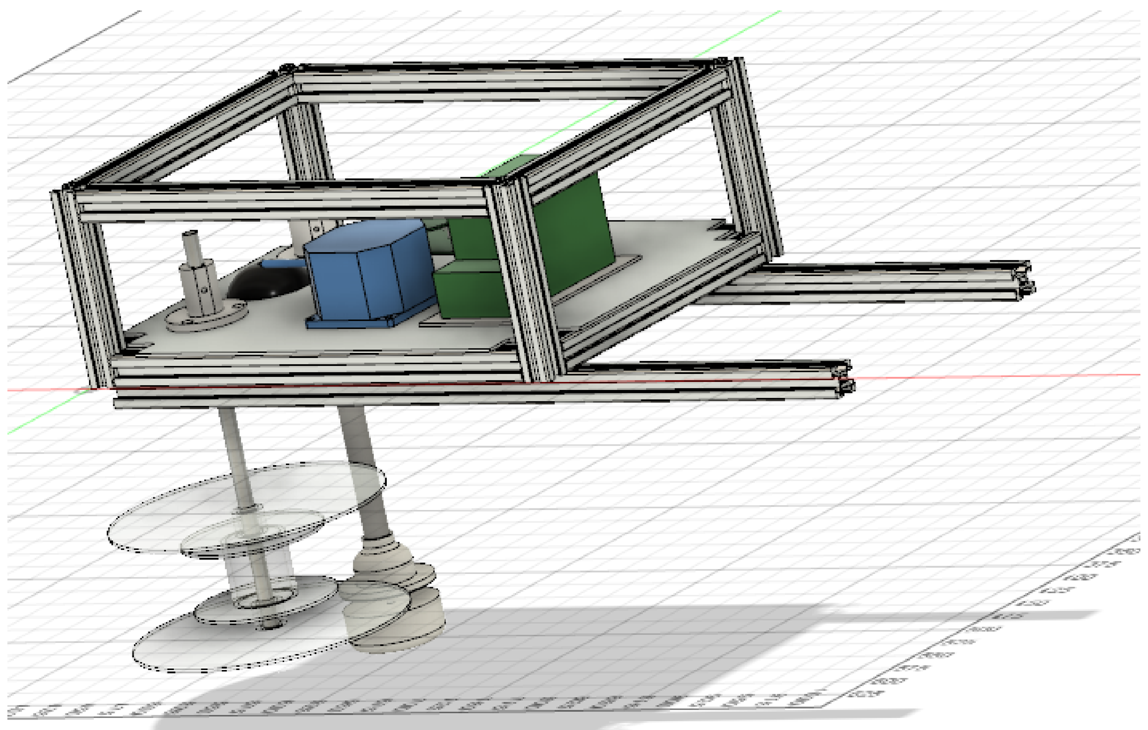
- **Seismic event**: 800kg TNT equivalent ground explosion used as a mock earthquake near launch site (Kiruna).
- **Infrasound Sensors**: Paroscientific 2000 Barometer, with ∼ 0.01 Pa resolution to enable detection (calculated expected amplitude of blast ∼ 0.3 Pa).
- **Configuration**: Multiple sensors in separate positions to enable localization using phase shifts between sensors.



Mechanical Design



Flight Train Box - FTB



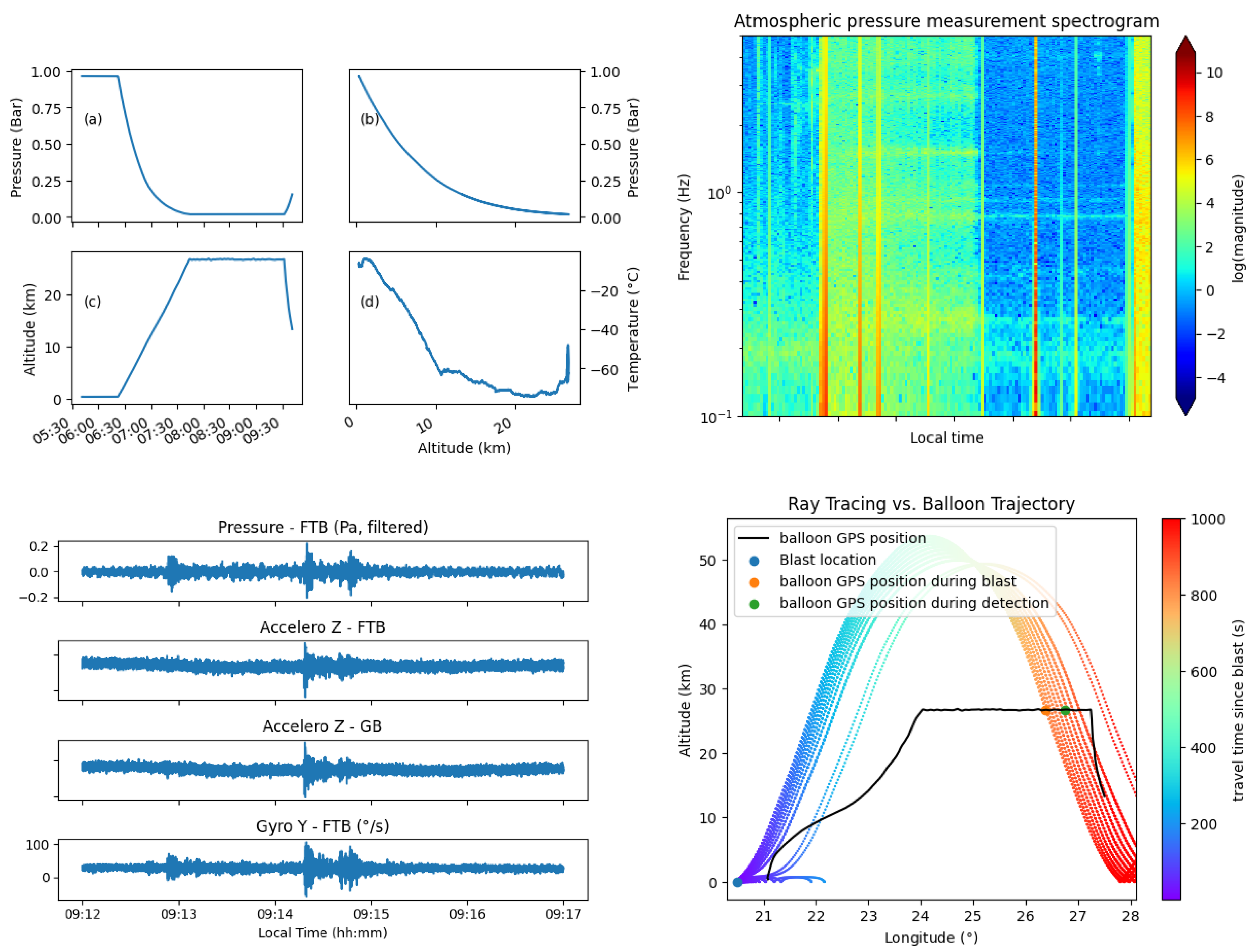
Gondola Box - GB

Mission Schedule

Major stages of the mission (2019):

- Selection: 27-29 NOV 2018
- Preliminary Design Review: 11-15 FEB
- Critical Design Review: 14-16 MAY
- Integration Process Review: 17-18 JUL
- Test campaign - CNES: 16-20 SEP
- Experiment Acceptance Review: 30 SEP
- Launch campaign - Esrange: 18-28 OCT
- Results analysis: to APR 2020

Results



Top Left: (a) Measured atmospheric pressure vs time. (b) Altitude vs time. (c) Measured atmospheric pressure profile (exponential law). (d) Measured atmospheric temperature profile. Top right: Spectrogram of measured atmospheric pressure vs time (x axis) and frequency (y axis) showing the properties of the infrasonic background in the ionosphere. Bottom left: Measurements of the signal associated to the blast from the FTB barometer (no detection from the GB barometer), but also from inertial sensors (accelerometers and Gyroscope). Bottom right: Simulated infrasound propagation from blast location vs Balloon trajectory as an alternate method for identifying the blast's location from the knowledge of the atmospheric profiles.

Conclusion

The experiment allowed us to characterize the infrasonic background noise during the floating phase. It also allowed us to extract and characterize the infrasound signal coming from our blast. However, we were not able to localise the position of the blast because the GB did not detect them, but also because we did not take properly into account the nonlinear nature of the propagation of the infrasound in the ionosphere. This issue is adressed by [2], which opens prospects for the exploration of Venus.

Acknowledgments

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References

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[2] Bowman & Albert 2018, doi: 10.1093/gji/ggy069

[3] Waxler et al. 2015, doi: 10.1121/1.4916718