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WEGENER: Solid Body Dynamics Investigation of Venus. Results from Summer School Alpbach 2014.

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Abstract

The work presented in this paper was performed by the Orange Team during Summer School Alpbach 2014, which mainly concerns about geophysics of terrestrial planets. A mission is designed to investigate the past and current tectonic and volcanic activity on Venus. During the mission, a simultaneous observations from topographic, magnetic and gravitational measurements will be performed and the combination of the information has the potential to provide an improved understanding of the formation and evolution of the planet.

1. Introduction

The presence of tectonic features and related surface movements has yet to be identified on Venus' surface and is still an unsolved question. Understanding which bodies in the solar system have plate tectonics tells us more about the evolution of young terrestrial planets, more about Earth during its earlier years, and potentially constrain formation and evolution scenarios for exoplanets.

The Solid Body Dynamics Investigation of Venus, also known as Wegener, is a mission proposed to search for evidence of tectonic and volcanic activity, and to provide insight into geomorphological processes modifying Venus' crust. Therefore, Wegener shall enhance the knowledge in the field of tectonics, volcanics and surface activity on the planet.

2. Science objectives

The aim of the Wegener mission is summarized in the list of its scientific objectives:

SO1. Search for evidence of tectonic activity.
- SO1.1. Search for evidence of resurfacing.
- SO1.2. Search for crust movement.

SO2. Search for evidence of volcanic activity.
- SO2.1. Search for evidence of eruptions.
- SO2.2. Search for inflation in volcanic edifices.

SO3. Understand geomorphological processes modifying the surface.
- SO3.1. Identify geomorphological processes modifying the surface by searching for landslides and dunes.

These objectives will be achieved by allowing the spacecraft to be in an orbit of 91.5° inclination ~400 km above the planet's surface and using sophisticated instruments, described in the payload section.

This low-cost mission is designed to be launched on a Soyuz rocket to drive the spacecraft to its end-destination, where it will be operating for five years and increase our knowledge of young and active planets.

3. Payload

To satisfy the science objectives of the mission, the Wegener spacecraft will carry the following

instruments: an altimeter, a magnetometer and a gradiometer. An altimeter with SAR mode and SARIn mode, i.e. two 1.7 m in diameter antennas will operate at a frequency of 6 GHz. A Double Star like magnetometer instrument (fluxgate) and a dark state magnetometer (absolute) will be used in combination to detect magnetic fields and potentially trace their origin. And lastly, a Cold Atom Gradiometer will be used onboard to enhance the position determination for orbital tracking and to improve existing gravity field models for Venus, which is imperative for detecting subtle changes in surface features.

4. Spacecraft design

The preliminary design of the spacecraft is shown on figure 1.

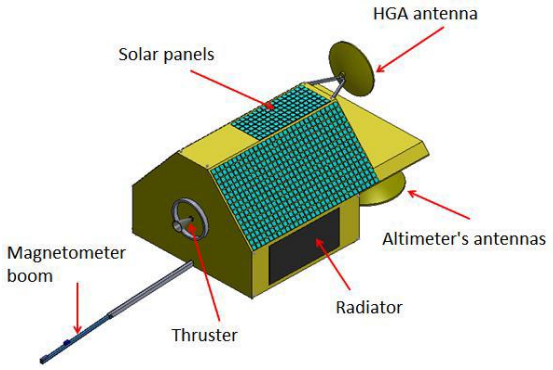

Figure 1: Preliminary Wegener spacecraft design.

The spacecraft consists of the main bus on top of which the solar panels are mounted. On the front side of the spacecraft the HGA antenna of about 1.2 m in diameter is mounted and the bench holds two altimeter antennas each 1.7 m in diameter. On the rear side of the spacecraft the thrusters and the magnetometer boom are located. The flanks are reserved for the radiators. The interior of the spacecraft houses all of the electronics, power supply, batteries and fuel tanks.

The power budget for the spacecraft is estimated at around 1300 W, where ~400 W is dedicated to the payload. The spacecraft's total mass is estimated at about 570 kg as a dry mass and with propellant around 940 kg.

5. Mission overview

The Wegener spacecraft is going to operate on a polar orbit around Venus at about 400 km altitude.

The timeline including the satellite design, launching, transfer and science operation is presented in figure 2.

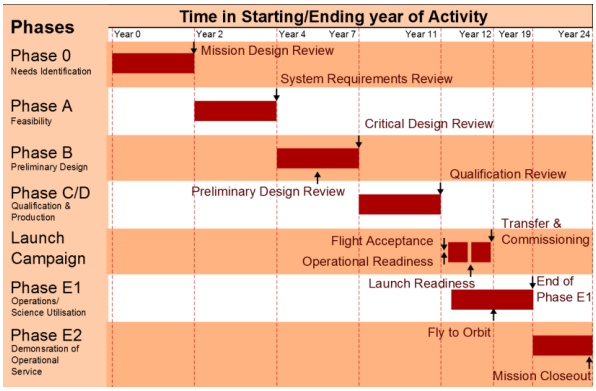

Figure 2: Wegener mission phases.

Wegener is a M-class (Medium size) mission and its overall budget is estimated at around 750 M€ for a 5 year long mission. The total cost excluding the payload is estimated at around 570 M€.

6. Summary and Conclusions

The Wegener mission will provide a unique opportunity to study the surface activity of Venus and its solid body dynamics. The ideal combination of topographic, magnetic, and gravity measurements will lead to a significant improvement of understanding plate tectonics, volcanism, and crustal structure of an Earth-like planet. The improved knowledge of the solid body dynamics of Venus will also enhance the general understanding of planetary geophysics and evolution of terrestrial planets.

Acknowledgements

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