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Joint IKI/ROSCOSMOS - NASA Science Definition Team and concept mission to Venus based on Venera-D

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Abstract

NASA and IKI/Roscosmos established in 2015 a Joint Science Definition Team (JSDT), a key task of which was to codify the synergy between the goals of Venera-D [1] with those of NASA [2,3]. In addition, the JSDT studied potential NASA provided mission augmentations (experiments /elements) that could to fill identified science gaps. The first report to NASA - IKI/Roscosmos was provided in January 2017. The baseline Venera-D concept includes two elements, and orbiter and a lander, with potential contributions consisting of an aerial platform/balloon, small long-lived surface stations or a sub-satellite.

1. Introduction

The Venera-D mission concept is devoted to the detailed study of the atmosphere, surface, and plasma environment of Venus [1]. Envisioned as launching in the post-2025 timeframe and consisting of an orbiter and lander with advanced, modern instrumentation, this mission would build upon the Venera, VEGA, Pioneer Venus, and Magellan missions carried out in the 1970's and 1990's [4,5,6] along with the more recent Venus Express [7].

2. Lure of Venus

Our knowledge of Venus' basic atmospheric properties (composition, thermal structure, clouds, winds, etc.), and how different this planet is from Earth has come through the success of the Soviet, US, ESA and now, JAXA missions to Venus as well the Earth-based observations of last decades. Venus was formed in the inner solar system out of the same proto-planetary material as Earth, and is considered Earth's twin. Although these siblings have nearly the same size, mass, and density, unlike Earth, which has a comfortable condition for the life, Venus' climate presents a "hellish" condition, fueled by a massive (90 atm) CO_2 atmosphere which is responsible for an enormous greenhouse effect and a near-surface temperature of 470°C, sulfuric acid clouds, lack of water. Its young surface is sculpted by volcanism and is deformed by folding and faulting resulting in belts of mountains and rifts. The lack of an intrinsic magnetic field suggests the planet's interior structure may also be different than that of the Earth. Why did Venus take an evolutionary path so different from that of the Earth, why and when did the evolutionary paths of these twin planets diverge? Were there ever favorable conditions for starting life on Venus?

3. The goals of Venera-D mission components

Specific areas of scientific investigation would focus on the dynamics of the atmosphere with emphasis on atmospheric superrotation, the origin and evolution of the atmosphere, and the geological processes that have formed and modified the surface with emphasis on the mineralogical and elemental composition of surface materials, the chemical processes related to the interaction of the surface and atmosphere, solar wind interaction and atmospheric losses.

Orbiter Goals consist of the following: study of the dynamics and nature of superrotation, radiative balance and greenhouse effect; investigation of the thermal structure of the atmosphere, winds, thermal tides and solar locked structures; measurement of the composition of the atmosphere; study of the clouds, their structure, composition, and chemistry;

evaluation of the nature of the 'unknown' UV-absorber; and investigation of the upper atmosphere, ionosphere, electrical activity, magnetosphere, and the escape rate.

Lander Goals focus on the detailed chemical analysis of the surface material; study of the elemental and mineralogical composition of the surface, including radiogenic elements; characterize of the geology of local landforms at different scales; study of the interaction between the surface and the atmosphere; investigation of the structure and chemical composition of the atmosphere down to the surface, including abundances and isotopic ratios of the trace and noble gases; and direct chemical analysis of the cloud aerosols.

To fill the "science gaps," where important VEXAG science may not be addressed by the baseline Venera-D concept, the JSDT generated a list of possible contributed options: from specific instruments such as a Raman Spectrometer and an Alpha-Particle X-Ray Spectrometer (APXS) to possible flight elements such as a maneuverable aerial platform, small long-lived surface stations, a balloon, and a small sub-satellite.

In situ measurements, both in the atmosphere and on the surface have not been carried out for more than 30 years. The Venera-D mission is proposed to correct this gap. Long-duration measurements in the atmosphere (from several weeks to several months) would aid in understanding the processes that drive the atmosphere. A well instrumented mobile platform or balloon that could maneuver to different altitudes in the clouds could help understand the 'puzzles' of the UV-absorber, its nature, composition, vertical and horizontal distribution as well as providing a platform to measure key trace and noble gases and their isotopes, meteorology and cloud properties, composition, etc., depending on scientific payload. Another high priority augmentations that are considered are small long-lived surface station (possibly 1-5 stations with an operation life time from 60 days to up to one year) and subsatellite.

4. JSDT recommendations

The JSDT identified priorities for the science goals and objectives for the comprehensive scientific exploration of Venus. Based on these priorities, a baseline Venera-D mission would consist of a single highly capable orbiter and a single highly capable lander. In addition to the baseline mission, the JSDT identified potential "contributed" augmentations that would enhance the science return.

In formulating a strategy for the development of Venera-D, the JSDT identified areas where investments would need to be made to bring the mission concept to fruition.

5. Future work

The next phase of development of the Venera-D concept would focus on a more detailed examination of the science measurements and potential instrumentation along with the specifications of the spacecraft requirements.

In its ongoing work, the JSDT will incorporate into its deliberations information from a set of science community modeling workshops (in May at GRC, Cleveland, USA and in October at IKI, Moscow) to identify additional key measurements (and corresponding instruments) that could be achieved by the planned Venera-D mission. In addition these workshops will identify needed high-value data that could be obtained by Venera-D that would advance future modeling work, specifically the development of new GCMs.

Acknowledgements

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