VENERA-D: A POTENTIAL LONG-LIVED MISSION TO EXPLORE VENUS' SURFACE, ATMOSPHERE AND PLASMA ENVIRONMENT. T.K.P. Gregg[1], L. Zasova[2], T. Economou[3], N. Eismont[2], M. Gerasimov[2], D. Gorinov[2], N. Ignatiev[2], M. Ivanov[4], I. Khatuntsev[2], O. Korablev[2], T. Kremic[5], K. Jessup[6], S. Limaye[7], I. Lomakin[8], A. Martynov[8], and A. Ocampo[9]; [1]Affiliation Dept. of Geology, University at Buffalo, Buffalo NY 14260 (tgregg@buffalo.edu), [2]Space Research Institute RAS, Moscow, Russia, [3]Enrico Fermi Institute, Chicago, USA, [4]Vernadsky Institute RAS, Moscow, Russia, [5]Glenn Research Center, Cleveland, USA, [6]Southwest Research Institute, Boulder, USA, [7]University of Wisconsin-Madison, Madison, USA, [8]Lavochkin Association, Moscow, Russia, [9]NASA Headquarters, Washington DC, USA.

Introduction: Venus and Earth were formed at almost the same distance from the Sun, and have similar masses and volumes: they should be the most alike pair of planets in our Solar System. How and when did these two planets diverge in their evolutions? Significantly, recent investigations [1] reveal that Venus may have had oceans early in its history. Studies based on the similarity of "unknown ultraviolet (UV) absorbers" with some bacteria are consistent with the presence today of microbial life in Venus' clouds [2]. Venus presents us with fundamental questions about the origin and evolution of planetary bodies and of life in our Solar System.

Venera-D ("D" here stands for "long-lived:" dolgozhivushaya) is a potential mission that combines simultaneous observations of Venus' atmosphere, plasma environment, and surface to try to answer these essential questions. The Venera-D Joint Science Definition Team (VDJSDT) has been working to characterize a long-lived, Russian-led mission to Venus that would further our understanding of Venus as a system. It is being developed based on knowledge obtained by early Russian and American missions, and would build on data collected by JAXA's Akatsuki spacecraft and ESA's Venus Express, as well as the upcoming Indian Space Research Organization Venus orbiter [3].

The Venera-D JSDT Phase 2 report will be completed in early 2019.

Venera-D Baseline Architecture: Based on the initial report from the Venera-D Joint Science Definition Team (composed of scientists from both Russia and the USA) [4], a baseline Venera-D mission would include an orbiter and a VEGA-style lander with an attached Long-lived In-Situ Solar System Explorer (LLISSE) [5] on the surface. In addition, the VDJSDT identified additional science objectives (relying on the NASA Planetary Decadal Survey [6] and VEXAG [7]) that could be addressed by incorporating additional potential elements (e.g., additional long-lived stations, an aerial platform or subsatellites).

Orbiter Science Goals: Despite the fact that Venus is the planet nearest to Earth, it remains a planet of mysteries; one of the most intriguing is the atmospheric dynamics. In the troposphere and mesosphere, the main circulation mode is retrograde zonal superrotation (RZS) while in the thermosphere the mode is subsolar – antisolar circulation (SS-AS) [8].

Although recent investigations, using data collected by ESA's Venus Express and JAXA's Akatsuki spacecraft showed that the determining factors influencing atmospheric dynamics are insolation (particularly solar tides [9, 10]) and Venus' topography [10, 11], possibly through the generation of gravity waves [12, 13]. An orbiter associated with the Venera-D mission would need to examine the thermal tides, atmospheric composition and structure, examine the atmosphere in the ultraviolet, visible, and infrared wavelengths, study the possible surface thermal activity on the night side, and look at the interaction between the upper atmosphere, ionosphere, and magnetosphere with the solar wind. Ideally, the orbiter would take measurements for a minimum of 3 years.

Lander Science Goals: During descent, the lander would investigate the physical structure and chemical composition of the atmosphere down to the surface, including composition and distribution of atmospheric aerosols and sampling of the region thought to contain the "unknown absorber(s)" [2]. Below the clouds, cameras would image the surface to provide a geologic context for the landing site; on the surface, soil sampling and rock drilling (to study both weathered and unaltered materials) will be performed, the chemical composition of the atmosphere and ground would be measured and additional cameras would image the near- and far-field. Combining measurements of the surface (both elemental and mineralogical) and the adjacent atmosphere would allow us to constrain the chemical interactions occurring at that interface. A VEGA-style lander would likely live on the surface for 2 – 3 hours.

LLISSE Science Goals: A LLISSE attached to the lander would measure surface winds (velocity and direction), pressure, temperature, and atmospheric chemical composition over a lifetime of 2 – 3 months on the Venusian surface, continuing long after the lander analyses have ended. Ideally, the LLISSE would transition from the dayside to the nightside during this time.

The Glenn Extreme Environments Rig (GEER) at the NASA Glenn Research Center (GRC) can reproduce Venus surface temperature, pressure, and atmospheric composition and has been used to test the behavior of potential lander materials for a long-lived Venus surface experiment [14]. LLISSE is being developed at NASA GRC [5] and can take advantage of the GEER capabilities.

Potential Elements: The Joint Science Definition Team is examining the science return from potential additional elements, depending on the mass and volume available, which in turn are controlled at least partly by the precise launch date.

Additional contributed augmentations being discussed include: additional LLISSEs or a long-lived seismic instrument such as the Seismic and Atmospheric Exploration of Venus (SAEVe) package [15]; a variable-altitude balloon; subsatellite(s) placed at the Lagrange point L1 and / or L2.

Preliminary calculations from THE VDJSDT and Lavochkin Association show that there are sufficient resources to launch the baseline Venera-D mission using an Angara-A5 rocket, with mass and volume available for possible augmentations, for any of the considered launch windows (in 2026, 2028, 2029 and 2031) from the Vostochny launch site.

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