LLISSE: A long duration Venus surface probe, Tibor Kremic[1] (Tibor.Kremic@nasa.gov), Gary Hunter[1], Jennifer Rock[1], 1, NASA Glenn Research Center, Cleveland, OH

Exploration to better understand the deep Venus atmosphere and surface have been long standing objectives by the Venus science community as stated in Venus Exploration Analysis Group (VEXAG) documents [1] and the Planetary Decadal Survey Report [2]. The extreme environmental conditions at the surface of Venus, coupled with the thick clouds and dense atmosphere, have made achieving the science objectives very challenging. So challenging in fact that many have believed that our ability to survive on the surface of Venus and do in-situ science is limited to timeframes of hours, as seen with the former Soviet Venera and VEGA landers. Further, it was not clear that this situation will improve much in the foreseeable future. Recent technology advances in high-temperature electronics [3] and the addition of new capabilities to simulate Venus conditions, such as provided by the Glenn Extreme Environment Rig (GEER) [4], are changing this paradigm. One project in particular, known as the Long-Lived In-situ Solar System Explorer (LLISSE), is challenging these perceptions [5]. LLISSE has a goal of developing and demonstrating proof of concept probes that will function in Venus surface conditions and do so for long time periods (weeks to months) (Figure 1). These probes will be designed, fabricated, and demonstrated by test to operate in Venus conditions. To accomplish these goals, LLISSE leverages NASA Glenn Research Center (GRC) high-temp electronics, sensors, power, and communications in an innovative operations model to collect and transmit science data for 60 Earth days or longer in Venus conditions.

The key science questions targeted by LLISSE include: better knowledge of super-rotation of the atmosphere (Goal 1, Objective B), the climate and its evolution (Goal 1, Objective B), and surface – atmosphere interaction/weathering (Goal 3, Objective B). A significant contribution toward these questions will be the ability to take periodic measurements over a long-duration – Venus daylight period and a transition(s) at the end- or approximately 60 Earth days minimum. Science objectives include: estimating the moment exchange between the planet and its atmosphere, acquiring temporal weather data to update global circulation models and quantify near surface atmospheric chemistry variability. Anticipated instruments include: Wind speed/direction sensors, temperature sensors, pressure sensors, chemical multi-sensor array.

Given its small volume and expected low mass (10 kg), LLISSE could be delivered to the Venus and its surface as a ride along with an orbiter and then descend with a lander or probe or be dropped from an aerial platform, or a set of probes put in a dedicated capsule for entry and deployment. Once the probe is deployed into the Venus atmosphere, it decelerates in the thickening atmosphere with its drag plates to touchdown on the surface at under 8 m/s^2 or less. The probe then begins taking measurements and transmitting important parameters at or near the surface. At preset intervals, the probes acquire the science measurements and beams the data to the orbiting host spacecraft. LLISSE will not only acquire important science measurements but also pave the way for larger and more complex lander missions to explore Venus in the future.

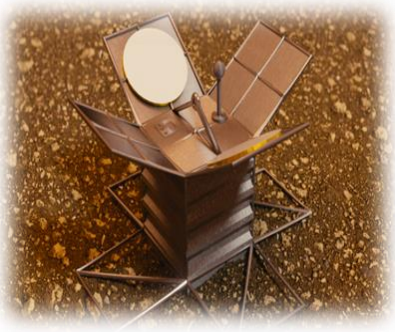

Figure 1. LLISSE probe concept

References:

[1] Venus Exploration Analysis Group. (2009-2011) *VEXAG reports located at http://www.lpi.usra.edu/vexag/reports /archive.*

[2] National Research Council. (2011) Vision and Voyages for Planetary Science in the Decade 2013-2022. Washington, DC: The National Academies Press. https://doi.org/10.17226/13117.

[3] Neudeck, P., et al. (2016) Prolonged silicon carbide integrated circuit operation in Venus surface atmospheric conditions. *AIP Advances*. http://aip.scitation.org/doi/10.1063/1.4973429.

[4] Kremic, T., (2016) GEER Status Update. *VEXAG presentation located at: http://www.lpi.usra.edu/vexag/meetings/archive/vexag_14/presentations/28-Kremic-GEER.pdf*

[5] Kremic, T., et al. (2016) Long-Lived In-Situ Solar System Explorer. *VEXAG presentation located at: http://www.lpi.usra.edu/vexag/meetings/archive/vexag_14/presentations/27-Kremic-Long-Lived%20Venus%20Station.pdf*