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Introduction: Recent advances in high temperature electronics open the opportunity for significantly smaller and cheaper extended lifetime Venus landers. This paper describes a "Pathfinder Class" (i.e, a mission implemented mainly as a technology proof of concept, similar to Mars Pathfinder) lander/orbiter concept designed to obtain the first ever long term scientific data on the surface of Venus. The concept would demonstrate the capabilities of high temperature sensors and electronics and their ability to return the first *in situ* temporal data on the climate and geophysical activity of Venus.[1] This study builds on the Long-Life In-situ Solar System Explorer (LLISSE) concept.[2] Major modifications to LLISSE were investigated; additional scientific instruments were added as appropriate in order to maximize valuable science data return and a CubeSat orbital communication system was specified.

Methods: The COMPASS concurrent engineering facility at the NASA Glenn Research Center was utilized to perform a feasibility analysis of power and communication systems using technology likely to be mission ready by 2025. A mass analysis was also done to prove the feasibility of such technology for inclusion in "Pathfinder Class" missions as well as to assess the scalability of such a concept. The general idea of using simple, low cost devices in all aspects of the mission was at the core of the analysis. Many ride-along flight possibilities as well as deployment options were weighed. Landing locations, data acquisition sequences, and orbit paths were compared to allow for maximum data delivery time and therefore a maximum science return for the duration of the mission.

Results: This innovative mission concept consists of a maximum of 5 probes and 2 orbiters (dependent upon delivery mode). The probes will have the ability to obtain *in situ* measurements of the seismic, magnetic, radiometric, chemical, and thermal characteristics of Venus's atmosphere, surface, and interior as well as pressure, temperature, and wind velocity measurements. Ovda Regio was chosen as the landing site for optimal communication and scientific return. Two CubeSat orbiters are utilized to relay *in situ* measurements from the probes back to the Deep Space Network. CubeSats are chosen over SmallSats because they are less massive by a factor of ten. Two CubeSats out of phase could also be used to achieve 100% contact time with the probes, yielding the maximum possible science return. Preliminary analysis revealed that using green propellant AF-M315E for insertion into a 10 day orbit is most feasible of the options considered, but still poses a major challenge to such a mission. The drawback is a higher communication power requirement due to the higher apoapsis. A ride-along secondary payload package consisting of an orbiter-probe vehicle housed in a 27U CubeSat P-POD was suggested. Ongoing analyses of its feasibility need to be undertaken.

Conclusion: A method of executing small, inexpensive missions to Venus was proposed. This comprehensive mission concept details a packaging, delivery, deployment approach; with operation of a surface probe / orbital relay combination. An expanded instrument suite, data acquisition sequences, and a preliminary CubeSat communications system were designed. The result is a greatly enhanced ability to address high priority science questions. Based on the power analysis, data acquisition can be achieved with low power requirements while yielding more scientific measurements than previous studies. Improvements in high temperature memory and batteries with higher energy densities and or recharging capabilities would greatly increase science return. Further analyses into the delivery methods as well as instrument development are needed.

References: [1] Neudeck, P. G., et al., "Prolonged silicon carbide integrated circuit operation in Venus surface atmospheric conditions," *AIP Advances*, vol. 6, Dec. 2016, p. 125119. [2] Kremic, T., Hunter, G. W., Neudeck., P. G., et al, "Long-Life In-Situ Solar System Explorer (LLISSE) Probe Concept and Enabling High Temperature Electronics," *Lunar and Planetary Science XLVIII*, 2017.