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Mitigating extreme environments for long-lived Venus in-situ missions

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NASA's 2006 Solar System Exploration Roadmap identified a long-lived Venus Mobile Explorer (VME) concept as the recommended third Flagship class mission, with a proposed launch date around 2025. In support of this, NASA is funding a Flagship class mission study in this fiscal year, which is expected to build upon the findings of last year's Extreme Environments Technologies report. The extreme environments (EE) of Venus present a unique challenge to in-situ exploration missions not only at high altitudes – where the conditions can be near Earth-like – but even more so near the surface, where temperature and pressure can reach 460˚C and 92 bars, respectively. Furthermore, at these conditions the predominantly carbon dioxide atmosphere becomes supercritical, while getting to the surface requires descent though sulfuric acid droplets of the high altitude clouds. Both of these constituents can be highly corrosive. Extreme environments due to mission operations are also a consideration, for example aeroshell thermal heating during planetary entry. Although some of the technologies for EE mitigation are currently available and planned for use on short lived small and medium class missions, long-lived in-situ missions require technologies which are not currently available. These include a suitable air mobility system, such as metallic bellows recommended in earlier studies, and an internal power source, likely in the form of a Radioisotope Power System, combined with active cooling to the payload to maintain a quasi-steady state condition throughout the lifetime of the mission. In this paper we will describe protection systems; component hardening for electronics, mechanisms and energy storage under high temperature conditions; and mobility operations, as part of an ongoing effort to prioritize technologies for a long-lived in-situ Venus mission near the surface, which may lead to a related technology

development program.