DEVELOPMENT OF A LIGHTWEIGHT RADIOMETER FOR IN-SITU MEASUREMENTS IN EXTREME ENVIRONMENTS J. M. Newman[1], [1]Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI. newmanjm@umich.edu

Introduction: Our neighborhood solar system is teeming with interesting but sometimes mysterious moons and planets because they are surrounded by a dense atmosphere, creating a challenge for scientists and engineers that strive to understand them deeply. One approach to overcome this obstacle for studying them is to plunge into their atmospheres, and conduct in-situ measurements in these extreme environments. Previous missions have been limited in operational duration due to contemporary technological limitations for making measurements in high pressures and temperatures. For example, the Galileo probe to Jupiter was limited to 59 minutes of measurements, due to operation in an atmosphere with a pressure of 21 bars and a temperature of around 150 °C. Similarly, the Pioneer Venus Multiprobe operated on the surface of Venus for 1 hour before succumbing to its extreme temperature and pressure of 480 °C and 100 bars respectively. If robust instruments were available that could survive in these extreme environments to make long duration in-situ measurements, it would create a new realm of possibilities for science. Indeed, this opportunity has been recognized, and is highlighted in the NASA TA08 Technology Roadmap: “Future technology development of sensors, optics, electronics capable of operating in extreme environments, and sampling systems will make possible investigations of the Solar System currently thought to be impractical [1].” The proposed instrument will exceed past capabilities, and will enable further investigations. When engineering systems for space application, we account for worst-case scenarios to guarantee that our designs can surmount the most difficult obstacles and achieve mission success. Our sister planet Venus could be viewed as a “worst case” design driver for most destinations in our solar system, due to its extreme environment. As described in the 2013 planetary decadal survey, “To explore the surface of Venus for any period longer than a few hours requires engineering systems and science instruments that can withstand intense heat and pressure [2].” An instrument developed to operate under these conditions will be extensible for missions to a variety of destinations. Further, if it can be adapted to make application-specific measurements, the end result is an extremely flexible instrument package that is well-suited for exploration of many destinations throughout our solar system. A robust radiometer meets this requirement; through deliberate selection of optical bandpass filters, radiometers can take specific measurements of radiation ranging from UV to far IR wavelengths. The type of sensor(s) used in this radiometer will be the result of a trade study conducted after the instrument requirements have been reviewed and baselined. An example sensor option is a thermopile, which is robust and available in very small form factors (TO-5 package), permitting efficient, low mass packaging. Further, example single channel modules draw current on the order of 1 mA. This instrument is robust, and can make high value measurements at a low mass and power penalty, positioning it as an ideal candidate for development.

Upon review of the latest decadal survey, the far-reaching demand for measurements obtained by the proposed radiometer is clear. As one example, the survey raised a multitude of cross-cutting questions pertaining to water, on destinations throughout the solar system. These included calls for measurements at Venus, Saturn, Jupiter, Uranus, and Neptune. To facilitate development, and to serve as an example of a mission-specific application, wavelengths have been selected that are optimal for measurements of H_2O . The differences in the bulk absorption coefficient for liquid water and ice enables a distinction between these phases. With measurements near the 2.1 µm and 2.25 µm wavelengths, this distinction is manifested, and the phase can be determined [3]. With measurements near the 1.14 µm wavelength, columnar water vapor can be determined, providing insight into atmospheric water vapor abundance [4]. However, these wavelengths are notional, and final wavelengths will be determined with subsequent trade studies.

Due to the low mass, volume, and power characteristics of the proposed instrument, it is well-matched for missions utilizing a planetary probe to make in-situ descent profile measurements to extreme environments.

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