Centennial Missions: Conducting Planetary Science on Century Timescales. A. H. Parker[1], [1]Southwest Research Institute (aparker@boulder.swri.edu).

Introduction: How do we explore the evolution of surfaces, atmospheres, interiors, magnetospheres, and orbits of the worlds in our solar system over timescales stretching beyond a single human lifetime? Datasets collected in a consistent manner over very long timescales are crucial for identifying and characterizing processes operating over climatological, geological, and astronomical timescales. Reliable sunspot counts date back continuously to 1849 and consistently back to 1610, revealing long-term variations in solar activity. Meteorological stations have recorded land temperatures on Earth continuously for nearly 140 years at some sites, providing crucial input to models of weather, climate, and land-use effects. NASA's Landsat program has monitored the Earth's surface in a consistent and coherent manner from space for 44 years and counting, enabling unique studies of an enormous host of slow and fast terrestrial processes. Planetary science has implemented few of these types of coherent long-term experiments. For example, between the Lunar Laser Ranging Experiment [1] and the Apache Point Observatory Lunar Laser-ranging Operation [2], lunar laser ranging has been conducted continuously for 47 years. This long-term dataset has enabled not only direct and detailed characterization of the effects of tidal interaction between the Moon and the Earth, but also unparalleled tests of fundamental theories of gravity [3]. I will discuss several classes of planetary science endeavors enabled by extremely long-term planning. Together, they motivate the development of mission efforts that operate over multi-decade to century timescales. These Centennial Missions, if flown, will be missions of inheritance, built and launched for the benefit of future generations of explorers.

Baselines For Long-Term Predictions: Discovering potentially hazardous objects is only one component of effective planetary defense; another is characterizing their current orbits and their orbital evolution. Non-gravitational forces that act to slowly alter the orbits of small asteroids are difficult to characterize without concerted astrometric characterization over long timescales; predicting and mitigating impact hazards centuries into the future relies upon this characterization. LSST will enable the discovery of order 100,000 Near-Earth Asteroids [4]; no means have been established to guarantee that these objects will be tracked with high enough precision to determine their orbital evolution. Long-term, space-based, highly autonomous platforms can enable these measurements.

Processes With Long Timescales: Many processes active today in the solar system act over timescales longer than a human lifetime. Uranus and Neptune have orbital periods of 84 and 165 Earth-years, respectively, and these long periods coupled with their high obliquities drives extremely long-term seasonal variation in their deep and complex atmospheres. Orbital missions that could persist in their observing campaigns over these timescales would provide future generations with powerful tools to understand the structure and evolution of these worlds. Similarly, the magnetic fields of the giant planets may undergo quasi-periodic reversals on timescales of centuries [5]. This timescale is intermediate between the 11-year solar polarity reversal periodicity and the much longer timescale of the Earth's geomagnetic reversals. In-situ monitoring of Jupiter and Saturn's magnetospheres over century timescales would provide valuable insight into the complex behavior of planetary dynamos.

Mission Sustainability Through Autonomy: Long-term experiments must be robust to the vagaries of human support for them. Should human events transpire that lead to loss of contact from the Earth, these experiments should endure and their data remain recoverable. This coupled with the desire to reduce operation costs over long mission lifetimes, calls for both a high degree of autonomy and open-source communication standards. A truly autonomous platform can recognize and adapt to temporary termination of communications, and continue its operations while waiting for new communication to be initiated.

A Pathway To Interstellar Exploration: In the absence of a means to travel faster than light, robotic missions that cross the interstellar void to even the nearest stars will operate in transit for many decades or centuries. Many interstellar mission development efforts focus on propulsion and communication technologies; however, developing an understanding of *operational* procedures for extremely long-duration missions is also critical for successful interstellar exploration. This development can begin without waiting for solutions to be found for the other engineering challenges that beset interstellar flight. Multi-decadal and centennial planetary missions provide an ideal avenue for building this understanding.

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