THE JUPITER SYSTEM OBSERVER: A MISSION TO PROBE THE FOUNDATIONS OF PLANETARY SYSTEMS. D. A. Senske[1], L. Prockter[2] J. Kwok[1], and the JSO Science Definition and Technical Teams. [1] Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA, 91109, dsenske@jpl.nasa.gov. [2]JHU/Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, Louise.Prockter@jhuapl.edu.

Introduction: The Jupiter system is a natural laboratory to study diverse and dynamic planetary processes. Its set of planet-sized moons serves as a solar system in miniature. In addition, Jupiter itself is an analog for the majority of extra-solar planets discovered to date. The Galilean moons, from volcanic Io to ancient icy Callisto, embody a variety of geological and geophysical processes, providing a window into solar system history by preserving in their cratering records a chronology dating from the present time back nearly 4.5 billion years. The presence of potential subsurface oceans in the icy satellites has profound implications for habitability. The magnetosphere of Jupiter intimately interacts with its system of moons, transferring material throughout the system. Study of the internally generated magnetic field of Ganymede with comparison to the Earth and Mercury provides a basis to better understand planetary dynamos. Gaining insight into the composition and volatile inventory of Jupiter will shed light on how planets accrete from solar nebulae. Hence, a system-level investigation of the Jovian system will illuminate the question of how planetary systems form and evolve.

Study Approach: In January 2007, NASA commissioned JPL to conduct a Jupiter System Observer (JSO) study [1]. A Science Definition Team (SDT) consisting of twelve member of the science community was formed to define the goals, objectives, investigations and measurements for this mission. Guidelines governing this study included: (1) The mission should last about 5 years after arriving at Jupiter; (2) It must address five primary science targets: Jupiter, Io, Europa, Ganymede, and Callisto; and (3) The final destination should be in orbit around Ganymede, or in its immediate vicinity. Ganymede is a logical target for a long–lived observer of the Jovian system because of its diverse geological features, its potential possession of a liquid ocean, because it is one of only three terrestrial bodies in our solar system known to possess an intrinsic magnetic field, and because its radiation environment is less harsh than that of Europa.

Science Definition: The SDT was divided into 4 thematic groups focusing on Jovian atmosphere, magnetosphere, satellite science, and interiors. Other subject matter experts were invited to lead discussions on Jupiter rings, the Io torus, and Jupiter system science from New Horizons. The four groups developed the following science goals:

1) *Jovian Atmosphere:* Understand the processes that maintain the composition, structure and dynamics of the Jovian atmosphere as a typical example of a Gas Giant Planet [2, 3, 4, 5]
2) *Magnetosphere*: Understand the magnetospheric environments of Jupiter, its moons and their interactions [6, 7, 8]
3) *Satellite Science:*
   a) Understand the mechanisms responsible for formation of surface features and implications for geological history, evolution, and levels of current activity [9, 10, 11, 12]
   b) Determine the surface compositions and implications for the origin, evolution and transport of surface materials [13, 14]
   c) Determine the compositions, origins, and evolution of the atmosphere, including transport of material throughout the Jovian system [15, 16]
   d) Determine how the components of the Jovian system operate and interact [17]
4) *Interiors*: Determine the interior structures and processes operating in the Galilean Satellites in relation to the formation and history of the Jupiter system and potential habitability of the moons [18, 19, 20, 21].

From these goals, the SDT developed a hierarchical flow-down of science objectives, investigations, and a comprehensive set of measurements. In all, there are 46 objectives that lead to 140 investigations involving 334 measurements

Mission Concept: The baseline mission that emerged is a single spacecraft comprised of a bus and a nine-instrument (plus two radio science investigations) payload that launches in January 2017 on a Delta IV-H launch vehicle. A VEEGA interplanetary trajectory with a flight time to Jupiter of 5½ years is used, along with a conventional chemical propulsion system for trajectory adjustments. Upon arrival at Jupiter in September 2022, a close flyby of Io and a large propulsion system burn will establish JSO as only the third artificial satellite of Jupiter (after Galileo and Juno). The mission will conduct a 3-year tour of the Jovian system, using Io, Europa, Ganymede, and Callisto for gravity-assists to reduce JSO's orbital energy, leading

to Ganymede Orbit Insertion (GOI) in September 2025. This initial orbit around Ganymede will have a period of 24 hours, an inclination of about 60°, and an eccentricity that brings its periapsis to as low as 200-km altitude. This novel orbit is stable for at least tens of years. Due to Jupiter's gravity effects, the orbit will oscillate between the initial eccentric orbit and a near-circular orbit every 42 days while the periapsis location will vary in latitude and longitude. This novel orbit is ideally suited for long-term characterization of Ganymede's magnetic field while the many low-altitude passages afford important remote sensing, radar, altimetry, and gravity field observations. After approximately one year, a set of orbit transfer maneuvers will place the spacecraft in a 200-km altitude, circular, near-polar orbit. This orbit is ideal for geological, geophysical, and gravity science investigations, while continuing to afford campaigns of remote sensing of Jupiter and its other moons as well as field and particles measurements.

The study included a concept for a descoped mission where the spacecraft will remain in the elliptical orbit for two years (or more) until the end of mission rather than transfer to a low-altitude, circular orbit. The savings in propellant enables the use of the Atlas V 551 rocket.

At the end of the primary mission, the JSO mission will be extended, or the spacecraft will be disposed of onto the surface of Ganymede.

Planning Payload: The set of measurement requirements recommended by the JSO SDT provided the basis for developing a set of notional science instruments and radio science investigations known as the planning payload that includes, (1) a high-resolution camera; (2) a visible-near IR hyperspectral imager—both this and the high resolution camera share a 50-cm optic; (3) a medium resolution stereo camera; (4) a UV spectrometer; (5) a thermal spectrometer; (6) a ground penetrating radar; (7) a laser altimeter; (8) a magnetometer; (9) a plasma spectrometer/energetic particle detector. The high-resolution camera and the hyperspectral imager share a 50-cm front optic.

Conclusions: The JSO mission is a long-term science platform for studying the Jovian system that addresses nearly fifty unique science objectives. It will advance the understanding of fundamental processes of planetary systems, their formation, and evolution. Specifically, it will provide new insight into planetary dynamo processes and lead to a fuller understanding of subsurface oceans. As conceived, JSO will return a wealth of data to provide significant advancement in understanding the foundations of planetary systems.

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