THE SPACE LAUNCH SYSTEM FOR EXPLORATION AND SCIENCE. K. Klaus[1], M. S. Elsperman[1], B. B. Donahue[1], K. E. Post[1], M. L. Raftery[1], and D. B. Smith[1], [1]The Boeing Company, 13100 Space Center Blvd, Houston TX 77059, kurt.k.klaus@boeing.com, michael.s.elsperman@boeing.com, benjmin.b.donahue@boeing.com, michael.l.raftery@boeing.com, kevin.e.post@boeing.com, david.b.smith8@boeing.com.

Introduction: The Space Launch System (SLS) is the most powerful rocket ever built and provides a critical heavy-lift launch capability enabling diverse deep space missions. This exploration class vehicle launches larger payloads farther in our solar system and faster than ever before. Available fairing diameters range from 5 m to 10 m; these allow utilization of existing systems which reduces development risks, size limitations and cost. SLS injection capacity shortens mission travel time. Enhanced capabilities enable a variety of missions including human exploration, planetary science, astrophysics, heliophysics, planetary defense, Earth observaton and commercial space endeavors. [1]

Human Exploration: SLS is the first heavy-lift launch vehicle capable of transporting crews beyond low Earth orbit in over four decades. Its design maximizes use of common elements and heritage hardware to provide a low-risk, affordable system that meets Orion mission requirements. SLS provides a safe and sustainable deep space pathway to Mars in support of NASA's human spaceflight (HSF) mission objectives. SLS enables the launch of large Earth-Moon Lagrange Point (EMLP) gateway elements. Our analysis include an architecture for Cislunar Development that facilitates early deployment of an Exploration Platform. [2] The Platform provides a flexible basis for future exploration, since it reduces cost through reuse of expensive in-space transfer stages and crew habitaits, while reducing the number of launches needed to accomplish missions. International Space Station (ISS) industry partners have been cooperating for the past two years on concepts for using ISS development methods and residual assets to support a broad range of exploration missions. These concepts have matured along with planning details for NASA's SLS and Orion Multi-Purpose Crew Vehicle (MPCV) to allow consideration for a platform located at an EMLP. Leveraging a low-energy transfer that reduces propellant, components are brought back to a desired cislunar destination. [3] SLS lowers risks for the Asteroid Retrieval Mission (ARM) by reducing mission time and improving mass margin. SLS lift capacity allows for additional propellant for this mission, enabling a shorter return or the delivery of a secondary payload, such as gateway component, to cislunar space. SLS capacity enables human return to the moon. The intermediate SLS capability allows both crew and cargo to fly to translunar orbit at the same time which will simplify mission design and reduce launch costs. One of the key features of the SLS in cislunar space is performance to provide "dual-use", i.e. Orion plus 15t of any other payload.

An opportunity exists to deliver payload to the lunar surface or lunar orbit on the unmanned 2017 MPCV/ SLS test flight (~4.5t of mass margin exists for this flight). Concepts of this nature can be done for less than Discovery class mission budgets (~$450M) and may be done as a joint venture by the NASA Science Mission Directorate and Human Exploration Operations Mission Directorate using the successful Lunar Reconnaissance Orbiter as a program model.

Science Missions: A single SLS launch to Mars will enable sample collection at multiple, geographically dispersed locations and a lower-risk, direct return of Martian material.

For the *Europa Clipper* mission, the SLS eliminates Venus and Earth flybys, via a direct injection to the Jovian system, arriving four years earlier than missions utilizing existing launch vehicles. This architecture allows increased mass for radiation shielding and expansion of the science payload.

A direct launch to the Uranus system with the SLS, also reduces travel time by two years when compared to existing launch capabilities.

SLS can launch the Advanced Technology Large-Aperture Space Telescope (ATLAST 16 m) to SEL2, providing 10 times the resolution of the James Webb Space Telescope and up to 300 times the sensitivity of the Hubble Telescope. SLS is the only vehicle capable of deploying telescopes of this mass and size in a single launch–greatly simplifying mission design and reducing risks by eliminating multiple launches and in-space assembly.

SLS greatly shortens interstellar travel time, delivering the Interstellar Explorer to 200 AU in about 15 years.

SLS Upgrades: The added payload to destination that can be provided by the SLS upgraded with a new Large Upper Stage (LUS) would be an enhancement for future science, astronomy and human spaceflight missions. The LUS can be built at the NASA Michoud Assembly Facility on the same 8.4m tooling as the SLS Core stage and achieve the economic benefits that come with commonality of subsystems, processes and personnel.[4]

Conclusions: The SLS in its evolving configurations will enable a broad range of exploration missions which may serve to recapture the enthusiasm and commitment that permeated the planetary exploration community during the early years of robotic exploration.[5] Multiple missions beyond Mars are possible with advances in power, propulsion, and materials, flying smaller focused missions, taking on some additional risk, utilizing international collaboration, and launching on SLS. NASA and the International Exploration Community should explore ways to utilize the SLS for Planetary Science Missions. The world needs a launch vehicle with the performance that today only the SLS will provide.

References: [1] Klaus K. (2013) *AGU FM-13, #P51G, 1818.* [2] Klaus K. and Post K. E. (1997) LPSC 44, Abstract #1231. [3] Raftery M. L. and Shireman K. (2013) *IAC-13, B.3.7.* [4] Donahue B. B. and Sigmon S. (2013) *AIAA 2013-5421*. [5] Elsperman M. S. and Klaus K. (2014) *IAA WAS0210.*