MULTI-MISSION SPACE EXPLORATION VEHICLE (MMSEV): AN EVA AND ROBOTICS WORK-SYSTEM FOR MULTIPLE DESTINATIONS. A. F. J. Abercromby[1], S. P. Chappell[1], and M. L. Gernhardt[2], [1] Wyle Science, Technology, and Engineering, Houston, TX 77058, USA, (andrew.abercromby-1@nasa.gov), [2] National Aeronautics and Space Administration, NASA Johnson Space Center, Houston, TX 77058, USA.

Vision: The Multi-Mission Space Exploration Vehicle (MMSEV) is an EVA and robotics work system optimized at the level of astronaut performance and safety rather than at the subsystem level with key features including: EVA-equivalent visibility, low-overhead EVA, and protection against solar particle events. The MMSEV uses a modular approach with a low-volume, high-function core cabin that is kitted with different mobility and work packages making it extensible to multiple mission destinations and applications.

Originally developed as a small pressurized rover for human lunar exploration missions, MMSEV prototypes have been developed for multiple destinations and applications using the same core cabin design outfitted differently for each case. A small multi-center team rapidly designed, built, and tested two prototype planetary MMSEVs from 2007–2010 [1-3]. A third MMSEV prototype incorporates a cabin module modified from the planetary MMSEVs and a modular reaction control system sled designed for free-flying microgravity missions to ISS, satellite servicing, or near-Earth asteroids [4]. A fourth prototype is being developed for use as a habitable airlock for an in-space habitat and a fifth was recently built and evaluated for use as a two-person or four-person lunar lander.

Extensibility & Affordability: Multi-mission applicability provides flexibility in response to changes in programmatic direction as well as potentially significant cost reductions through utilization of an extensible core design for multiple vehicles rather than developing optimal point solutions for every potential destination and mission application. The commercial offshore remotely operated vehicle (ROV) industry uses a common propulsion and telemetry bus outfitted for different work applications as a much more cost effective approach than developing entirely unique ROVs for every different work application. NASA Air Force Cost Model (NAFCOM) estimates suggest significant cost savings are also achievable through the MMSEV project's lean development approach of iterative design and build of increasingly flight-like prototype vehicles combined with frequent and rigorous operational testing at analog test sites and using high-fidelity integrated software simulations. This testing provides high confidence in design requirements for flight vehicles and enables informed decision making when trading multi-mission applicability against optimization for each destination and application.

MMSEV Features: MMSEVs optimize astronaut safety and performance during exploration by combining a comfortable shirtsleeve environment for habitation, gross translations, and geological observations, with the ability to rapidly place suited astronauts outside the vehicle to take full advantage of the perception, judgment, and dexterity of EVA astronauts. Low-overhead EVA capability is achieved via "step-in" space suits and suit ports, which allow crewmembers to egress or ingress the vehicle in 15 minutes or less with minimal consumables or energy usage [5], improving productivity and ensuring rapid EVA ingress and egress to and from the shelter of the MMSEV in response to solar particle events, suit malfunctions, medical emergencies, or cabin depressurization. Compared with unpressurized astronaut mobility systems, this combination of features could more than double the productivity of human exploration while requiring less than half the suited crew time and eliminating the overhead of returning to a habitat at the end of each day [1].

MMSEVs are envisioned as relatively small, simple, and low cost vehicles combining elements of the EVA suits' life support systems, with additional consumables tankage, cabin circulation fans, passive radiators, and an ice block heat sink for removal of cabin avionics and crew metabolic heat loads that also doubles as radiation protection. MMSEV cabins (12 m^3) are sized to support 2 astronauts in a shirtsleeve environment for up to 14 days of exploration, but provide contingency support for 4 crewmembers for 24 hours; testing of prototype MMSEVs in integrated mission simulations has demonstrated that the MMSEV cabin design meets these requirements [2, 3].

Exploring Beyond Apollo: A low-cost lunar exploration architecture could begin with 1–2 day missions using a simple 2-person MMSEV-lander (estimated cabin wet mass: 2,207 kg) with EVAs performed on foot. Subsequent delivery of a single MMSEV-rover (estimated 6,075 kg) would provide long-range exploration and 14-day habitation capability, representing meaningful progression beyond Apollo.

References: [1] Abercromby, A.F.J., et al, *NASA/TP 216136*. 2010. [2] Abercromby, A.F.J., et al. *Acta Astro*, 2012. [3] Abercromby, A.F.J., et al., *NASA/TP 217360*. 2012. [4] Abercromby, A.F.J., et al., *43rd ICES*. *RATS*. 2013. [5] Abercromby, A.F.J., et al., *43rd ICES*. *Exploration Prebreathe*. 2013