Planetary Construction 3D Printing Using In-situ Resources and Mission Recyclables. I. Giwa[1], D. Moore[1], M. Fiske[2], A. Kazemian[1], [1] Louisiana State University, 3319 Patrick F. Taylor Hall, Baton Rouge, LA 70803, [2]Jacobs Space Exploration Group, Huntsville, AL, 35806. (Contact: kazemian1@lsu.edu)

Abstract: Space exploration is a key aspect of human colonization of the Moon and Mars in the future. In preparation for the NASA Artemis mission and a subsequent challenging journey to Mars, temporary or permanent structures like habitats, research labs, landing pads, hangars, and shield structures are necessary for the survival of astronauts and protection of assets and equipment. Such supporting infrastructure are central to the successful coordination and completion of space exploration missions in extreme environments such as the Moon and Mars. Lack of atmosphere, microgravity, cosmic radiations, micrometeorites, dusty terrains, and significant thermal fluctuations present a high risk to unprotected humans and a variety of exploration and research equipment which are needed for comprehensive Lunar and Martian exploration. Construction 3D printing (C3DP) is large-scale additive manufacturing technique which could be used for fabricating habitats and other infrastructure needed to support these manned or unmanned missions on the celestial bodies. Extrusion-based C3DP is a robotic construction technology that holds great potential for automated planetary construction using in-situ resource utilization (ISRU) based materials. Constraints associated with the cargo payload of Space Launch Systems (SLS) limit the number of terrestrial construction materials that can be transported to the Moon and Mars. Therefore, ISRU offers a viable solution for manufacturing construction materials out of indigenous raw materials. The scarcity of readily available construction materials or the high-energy demand for processing extraterrestrial resources into needed construction materials highlight the importance of investigating the use of mission recyclables as another possible option for space construction. Materials like metals and polymers can provide the possibility of recycling and being reused as construction materials for sustained planetary construction. This paper presents a review of the performance, potentials, and challenges of ISRU based materials that can be harnessed and processed as the printing material for extrusion-based construction 3D printing. Furthermore, this paper also explores the prospect of using recycled and recovered ISRU based materials for a sustainable extraterrestrial construction process. Finally, some preliminary results and experimental results are presented on the characterization of ISRU-based printing materials to assess their flowability and extrudability, printability, and buildability.