NASA SBIR 2019 Phase I Solicitation

Z4.02 In-Space Sub-Modular Assembly

Lead Center: LaRC

Participating Center(s): MSFC

Technology Area: TA12 Materials, Structures, Mechanical Systems and Manufacturing

NASA envisions that persistent (very long duration) assets in space will require modular assembly architectures and interfaces to facilitate routine expansion, upgrade and refurbishment at the module and submodule level. This subtopic seeks novel approaches to three classes of module interface systems.Â

The first assembly need isÂ autonomous (and highly automated) approaches and hardware concepts that support the interconnection of modules in the 100 â€“ 5,000 kg range using some form of space robotics. (Note: The robotic manipulation systems are not the subject of this solicitation.) The objective of this first subtopic area is to minimize the parasitic mass from the joints and modularity features that are required for inter-module assembly. The lightweight connections between modules must include both electrical (power and data) and structural connections. Joining strategies that support fluid connections are of interest but not necessary to be responsive to this subtopic area. The structural connection should occur at a minimum of 3 discrete locations fixing the rigid body motion of the 2 modules in all 6 degrees of freedom while isolating (minimizing) forces resulting from thermal induced strain between the modules consistent with a LEO orbit. The three (or more) connections do not have to occur simultaneously.

The second assembly need is the development of a lightweight modular, palletizing system to support transport, emplacement and exchange of sub-modules in the 1-100 kg range. The palletizing system must support power and structural connections between the pallet and supporting backbone structure (fluid connections are a plus). Important considerations for the system are structurally efficient approaches that minimize parasitic mass, volume and power necessary to operate the palletizing system while minimizing forces resulting from temperature induced strain consistent with a LEO orbit.Â

The third assembly need is the development of assembly strategies that enable individual small spacecraft to support structural connects with suitable rigidity to form superstructures of small spacecraft (for the listed applications and other proposed science and exploration applications).Â Structural systems formed with assembled dimensions approximately 20x the size of the individual spacecraft are desired.Â Important consideration for the system are structurally efficient approaches that minimize parasitic mass, volume and power necessary to form assemblies utilizing approaches appropriate for small spacecraft, while minimizing forces resulting from temperature induced strain consistent with a LEO orbit.Â Â

NASA has plans to purchase services for delivery of payloads to the Moon through the Commercial Lunar Payload Services (CLPS) contract.Â Under this subtopic, proposals may include efforts to develop payloads for flight demonstration of relevant technologies in the lunar environment.Â The CLPS payload accommodations are yet to be precisely defined, however at least for early missions, proposed payloads should not exceed 15 kilograms in mass and not require more than 8 watts of continuous power.Â Smaller, simpler, and more self-sufficient payloads are more likely to be accommodated.Â Commercial payload delivery services may begin as early as 2020 and flight opportunities are expected to continue well into the future. Â In future years it is expected that payloads of higher mass and with higher power requirements might be accommodated. Â Selection for award under this solicitation will not guarantee selection for a lunar flight opportunity.Â

Relevance to NASAÂ

Fundamental to this work is the cross-cutting nature of the technologies to all NASA missions that benefit from multiple visits to an asset, both zero-g and planetary surface assets. The technologies developed under this topic have the potential to radically change the way missions and in-space capabilities are conceived and developed. Rapid emplacement of initial capability followed by systematic upgrade and expansion will increase investment value while simultaneously improving return on investment.Â

References:Â

- Dorsey, J. T., Collins, T. J., Doggett, W. R., and Moe, R. V., â€œFramework for Defining and Assessing Benefits of a Modular Assembly Design Approach for Exploration Systems,â€ Presented at the Space Technology and applications International Forum â€“ STAIF 2006, Albuquerque, NM, 12 â€“ 16 February 2006, AIP Conference Proceedings Volume 813, Editor Mohamed S. El-Genk, 2006 American Institute of Physics.
- Belvin, W. Keith, Dorsey, John T., and Watson, Judith J., â€œTechnology Challenges and Opportunities for Very Large In-Space Structural Systems,â€ Presented at the International Symposium on Solar Energy from Space, Toronto, Canada, Sept. 8 â€“ 10, 2009.
- Dorsey, John T., Doggett, William R., Hafley, Robert A., Komendera, Erik, Correll, Nikolaus, and King, Bruce, â€œAn Efficient and Versatile Means for Assembling and Manufacturing Systems in Space,â€ Presented at the AIAA Space 2012 Conference and Exposition, 11 â€“ 13 September 2012, Pasadena, CA, Available as AIAA-2012-5115.
- Dorsey, J., and Watson, J., â€œSpace Assembly of Large Structural System Architectures (SALSSA),â€ Presented at the AIAA Space 2016 Conference, 13 â€“ 16 September 2016, Long Beach, CA, Available as AIAA-2016-5481.
- Belvin, W. Keith, Doggett, Bill R., Watson, Judith J., Dorsey, John T., Warren, Jay, Jones, Thomas C., Komendera, Erik E., Mann, Troy O., and Bowman, Lynn, â€œIn-Space Structural Assembly, â€œApplications and Technology,â€ Presented at the AIAA SciTech Conference, 4-8 January 2016, San Diego, CA.
- Lymer, J., Doggett, W., Dorsey, J., Bowman, L, et. al., â€œCommercial Application of In-Space Assembly,â€ Presented at the AIAA Space 2016 Conference, 13 â€“ 16 September 2016, Long Beach, CA, Available as AIAA-2016-5236.
- Dorsey, J. T., Doggett, W. R., Moe, R. V., Ambrose, R. O., and Trevino, R. C., â€œTechnology Validation for On-Orbit Assembled, Large Aperture Modular Space Telescopes,â€ Presented at the Space Technology and Applications Forum (STAIF-2004), February 8 â€“ 12, 2004, Albuquerque, New Mexico.
- Komendera, E., and Dorsey, J., â€œInitial Validation of Robotic Operations for In-Space Assembly of a Large Solar Electric Propulsion Transport Vehicle,â€ (Not Presented due to Hurricane) AIAA Space and Astronautics Forum, 2017, 12 â€“ 14 September 2017, Orlando, FL, Available as AIAA-2017-5248.
- Williams, L., Dorsey, J., and Foust, J., â€œGEO Communications Transponder Park: A New Concept for Direct Broadcast Services,â€ Presented at the AIAA Space 2003 Conference and Exhibition, 23 â€“ 25 September 2003, Long Beach, California, Available as AIAA 2003-6316.
- Doggett, William R., Dorsey, John T., Collins, Timothy J., King, Bruce, and Mikulas, Martin M., â€œA Versatile Lifting Device for Lunar Surface Payload Handling, Inspection and Regolith Transport Operations,â€ Presented at the Space Technology and applications International Forum â€“ STAIF 2008, Albuquerque, NM, 10 â€“ 14 February 2008, AIP Conference Proceedings Volume 969, Editor Mohamed S. El-Genk, 2008 American Institute of Physics.