SPACE LOGISTICS AND MOBILITY

AN MPOWER TECHNOLOGY WHITE PAPER

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POWERING THE NEXT GENERATION OF SPACE

Space logistics plays a pivotal role in the next generation of Space 2.0 missions, enabling the intricate coordination and management of resources, transportation, and infrastructure in space. By streamlining operations, reducing costs, and enhancing overall mission success, space logistics is essential to establishing a robust space economy and a sustained presence in space.

Space logistics encompasses a wide range of activities, notably space mobility, in-space manufacturing, in situ resource utilization (ISRU) and space habitation. All these activities share one thing in common – they require a tremendous amount of reliable and sustainable power.

DragonSCALES™, developed by mPower Technology, is uniquely positioned to meet the broad needs of space logistics missions, offering several distinct benefits that make it the ideal choice, specifically:

- Low cost
- Ultra-scalable to high volumes
- Lightweight
- Resilient and reliable
- Capable of high voltages
- Highly customizable and flexible

Let's review the powerful advantages of DragonSCALES for each of the key space logistics activities and missions.

SPACE MOBILITY AND SEP

Mobility in space is a critical element of space logistics. Mobility operations such as station keeping, orbit raising, deorbiting, salvage operations, and space tugs all require a form of efficient propulsion. Traditionally, space missions have relied on chemical propulsion systems ; however, these systems are limited by the amount of propellant that can be carried. Moreover, the environmental impact of chemical propulsion and the constraints of propellant availability restrict the duration and scope of space missions.

Solar electric propulsion (SEP) systems like the one shown below are rapidly emerging as the choice for many of these space mobility operations, providing a low-thrust, high-specific impulse propulsion capability that enables efficient and precise control over spacecraft maneuvers. By using solar power, SEP systems optimize the amount of propellant needed for propulsion, thereby reducing spacecraft mass, launch costs, and mission constraints. SEP engines generally require high voltage input and consequently expensive and complex power electronics.

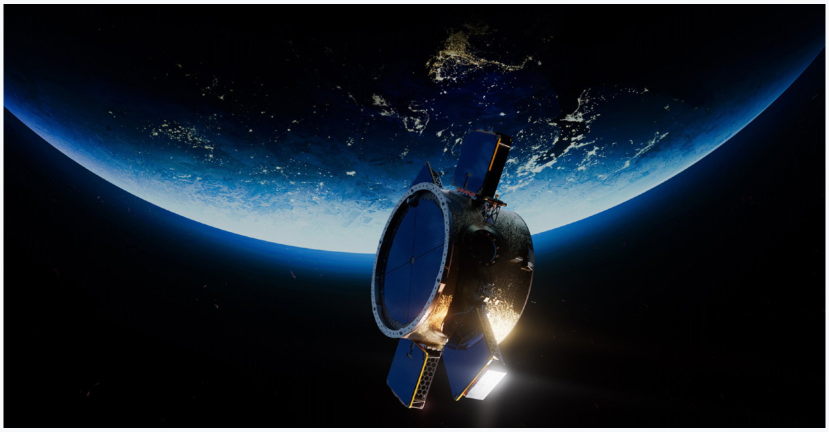

Image: Firefly Aerospace

A key benefit of in-space mobility enabled by solar electric propulsion is the ability to refuel and "maneuver-without-regret". New satellite configurations and logistical support vehicles with solar electric propulsion can replenish their fuel in orbit, allowing new ways of operating in space. This also enables in space assembly and manufacturing described in following section.

DragonSCALES provides an exceptional power solution for SEP systems due to its high-voltage capability and flexible design. DragonSCALES cells are connected in both series and parallel and can thus be designed to reach very high voltages in relatively small areas. With proper design, this allows the solar array to be directly coupled to the propulsion system, thereby simplifying power management and control systems, potentially saving both cost and weight. In addition, the size, shape, and layout of DragonSCALES can be customized to enable nearly complete coverage of any surface area, resulting in extremely high packing factors and optimized power output. As an example, mPower has been selected by Firefly Aerospace, Inc., an emerging leader in economical launch vehicles, spacecraft, and in-space services, to provide solar power for its latest space utility vehicle (SUV).

IN-SPACE ASSEMBLY AND MANUFACTURING (ISAM)

In-space assembly and manufacturing has the potential to revolutionize space logistics and exploration. Traditionally, space missions have relied on launching prefabricated equipment and materials from Earth. With in-space assembly and manufacturing, components, structures, and even entire spacecraft can be produced directly in space or repurposed from materials already in orbit (such as spent second stages, etc.), reducing reliance on Earth-based supplies and transportation costs.

Solar arrays can provide a sustainable and abundant energy source for driving in-space manufacturing processes, powering robotic systems, additive manufacturing devices, and other machinery. This eliminates the need for heavy onboard energy storage or reliance on limited fuel cells or nuclear power, enabling continuous and efficient manufacturing operations.

DragonSCALES' unique attributes position it as a game-changing technology for in-space manufacturing applications. Cost-effective, reliable, large-scale power systems are required for any type of in-space manufacturing, such as material processing, material movement, manufacturing, and construction. DragonSCALES leverages the economies of scale of both the silicon photovoltaic industry and existing semiconductor fabrication tools and processes to enable low-cost, automated manufacturing of solar power systems at mega-scale. In addition, the combination of series and parallel connections in the DragonSCALES architecture creates resilience to damage and shading, thereby increasing system resiliency and reliability and reducing maintenance. With DragonSCALES, large scale, resilient power systems (10 -100 MW+) can be readily constructed at a reasonable cost.

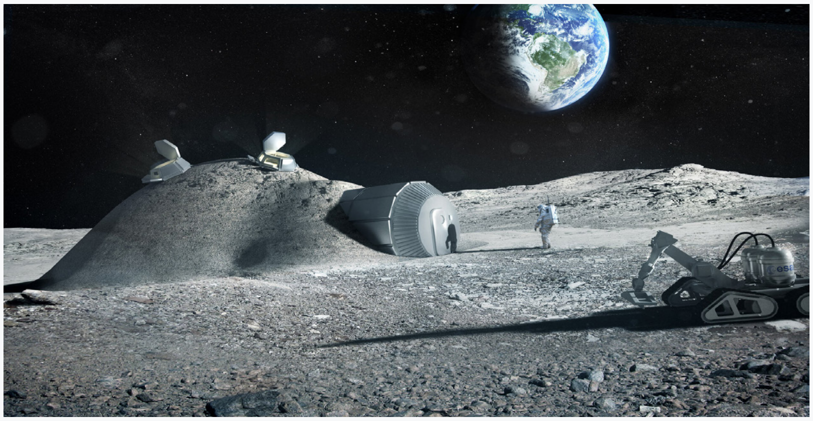

Image: European Space Agency

SPACE HABITATS

The establishment of sustainable space habitats, both orbital and landed, is a critical aspect of future space exploration and colonization. Landed habitats serve as self-sustaining outposts on celestial bodies such as the Moon or Mars. These habitats provide shelter, resources, and support systems for astronauts to conduct research, explore, and ultimately pave the way for future colonization efforts. Orbiting space habitats, commonly known as space stations, serve as long-term residences for astronauts and as laboratories for scientific experiments, technological advancements, and the testing of crucial systems for future deep space missions. Both landed and orbiting space habitats are instrumental in pushing the boundaries of human exploration.

Image: Gravitics

DragonSCALES offers significant advantages for powering space habitats, making them self-sufficient and enabling long-duration human habitation. This ensures a constant energy supply for life-support systems, communications, and other critical functions. The flexible and conformable nature of DragonSCALES facilitates seamless integration onto unique and curved habitat surfaces, maximizing power generation potential and enabling optimal thermal management. Further, the resilient nature of DragonSCALES enables power systems that can stow, deploy and reconfigure as needed. Finally, DragonSCALES' resilience to radiation, micrometeoroids, and extreme temperature variations ensures the durability and reliability required for long-term space habitation. In practical application, mPower is working with Gravitics as a key element of the solar power solution for the Gravitics StarMax™ space station modules.

IN SITU RESOURCE UTILIZATION (ISRU)

In situ resource utilization involves the extraction and utilization of resources available in space to support various aspects of space missions. ISRU plays a crucial role in enabling long-duration space exploration, colonization efforts, and sustainable space logistics. ISRU leverages resources found on celestial bodies such as the Moon, Mars, asteroids, or comets, to reduce payload mass and launch costs and enable more ambitious missions.

One of the key applications of ISRU is the production of propellants for spacecraft. For example, on the Moon or Mars, water ice can be extracted from lunar or Martian regolith, and through processes such as electrolysis, it can be separated into hydrogen and oxygen, the components of rocket propellant. By producing propellants in situ, ISRU enables the refueling of spacecraft, facilitating exploration, and reducing the reliance on Earth-based propellant resupply.
ISRU can also contribute to the production of life-support consumables such as oxygen and water, and can provide raw materials for manufacturing processes, including 3D printing. This allows for the production of structures, tools, spare parts, and other components directly in space, reducing the need for transportation from Earth and enabling on-site fabrication.

DragonSCALES' power solutions are highly suitable for powering ISRU processes. As with space manufacturing, ISRU at meaningful scale requires a large-scale power system capable of megawatts to tens of megawatts of power output (or more). With a modular, lightweight, stowable architecture, DragonSCALES enables these large-scale power systems to be rapidly, and cost-effectively developed and deployed as needed. Further, the nearly unlimited customization of DragonSCALES simplifies integration into ISRU systems, ensuring sustainable and cost-effective resource utilization in space. Finally, the resilience of DragonSCALES minimizes maintenance and downtime due to environmental impact and damage.

CONCLUSION

DragonSCALES, developed by mPower, offers a unique and ideal solution for powering a wide range of space logistics missions. Its low cost, scalability, lightweight design, resilience, high-voltage capability, and customizability make it the perfect choice for space mobility, in-space manufacturing, space habitats, and in-situ resource utilization. DragonSCALES simplifies power management and control systems, optimizes power output, enables large-scale power systems, and ensures self-sufficiency, durability, and reliability in space. With DragonSCALES, we can pave the way for a robust space economy and sustained presence in space.