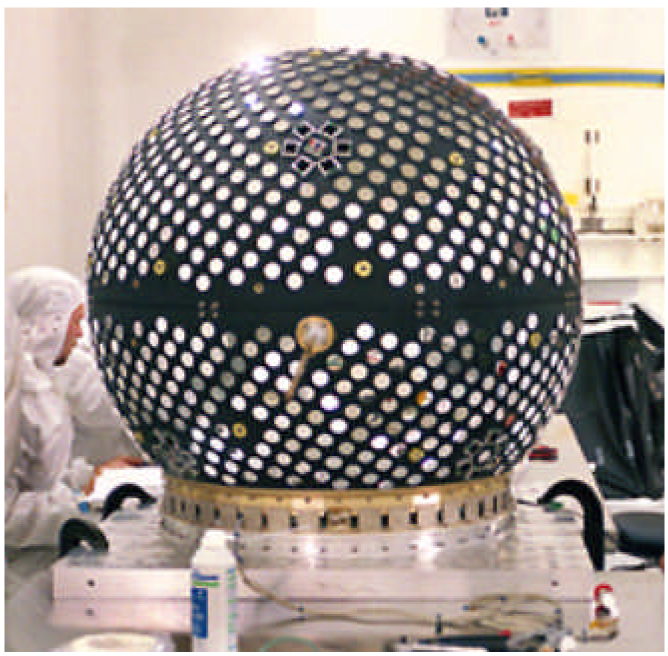
Advanced Power Technologies Developed for the Starshine 3 Satellite

The need for smaller, lightweight, autonomous power systems has recently increased with the increasing focus on microsatellites and nanosatellites. The NASA Glenn Research Center has been working on the development of such systems and recently developed several power technology demonstrations in conjunction with Project Starshine (ref. 1). The Starshine 3 microsatellite is designed to measure the density of the Earth's upper atmosphere as a function of solar activity and is primarily a passive experiment. Therefore, it did not need electrical power to successfully complete its primary mission, although a power system for future Starshine satellites was desired that could be used to power additional instruments to enhance the data collected. This created an excellent opportunity to test new power technologies capable of supplying this future need. Several Government and commercial interests teamed up with Glenn to provide Starshine 3 with a small power system using state-of-the-art components. Starshine 3 is also the inaugural flight of a novel integrated microelectronic power supply (IMPS) developed at Glenn.



Starshine 3 satellite.

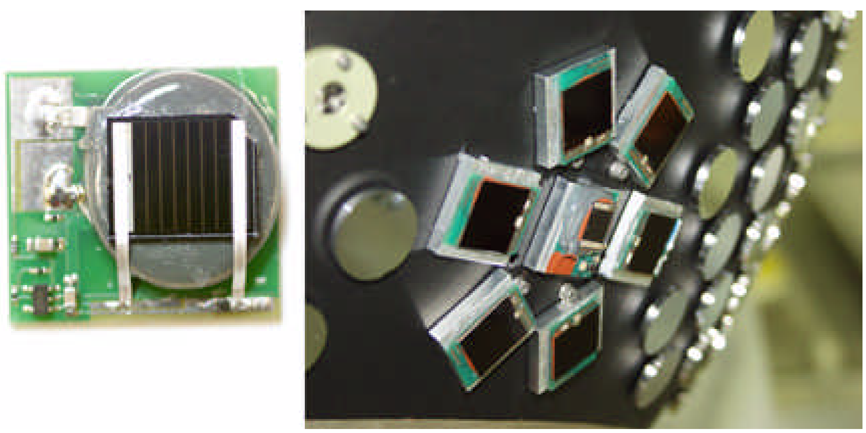
Starshine 3 is 1.0 m in diameter and has a mass of 88 kg (see the preceding figure). Its surface is covered with 1500 student-polished mirrors, 31 laser retroreflectors, 48 2- by 2-cm triple-junction solar cells manufactured by Emcore Corporation, and 5 IMPS's developed at Glenn. The Starshine 3 flight marks the first time Emcore triple-junction cells have flown in space. Emcore is currently producing triple-junction cells that are 26-percent efficient at air mass zero (AM0) (ref. 2).

The Starshine 3 microsatellite was launched on a Lockheed Martin Athena I rocket from

Kodiak, Alaska, on September 29, 2001. It was deployed into a 470-km orbit by a Lightband separator system developed by Planetary Systems Corp. (Washington, DC). The spacecraft has a 67° inclination, with a fixed rotational velocity of 5°/sec and an orbital period of 92 min. Data from the onboard sensors are being downloaded with a transmitter operating at a frequency of 145.825 MHz.

The power system rechargeable battery, used for powering the satellite during the eclipse portion of the orbit, comprises three Sony 18650 lithium-ion rechargeable cells. NASA has qualified these cells for one-time (primary cells) use aboard the space shuttles, making this technology an excellent candidate for a rechargeable application. The main advantage of lithium-ion technology is its high-energy density. Lithium-ion cells weigh approximately one-fourth of what nickel-cadmium cells weigh for a given watt-hour rating.

The IMPS developed for Starshine 3 combines the generation, storage, and conditioning of power for microelectronic applications using a microphotovoltaic array, a rechargeable battery, and power management and distribution (PMAD) electronics combined into a small autonomous package. These supplies can be integrated with individual satellite components and can provide continuous power in a variety of illumination schemes. It is a technological goal of IMPS development to have all components seamlessly integrated on a common substrate. The Starshine 3 IMPS's, which are just the first step toward this goal, will provide valuable experience in the design and operation of an IMPS in a space environment. Starshine 3 is flying the five experimental IMPS's pictured in the following figure. The 5-gram IMPS's are providing power for temperature sensors located around the spacecraft.



Left: Starshine 3 IMPS prototype with Panasonic battery. Right: IMPS surrounded by the Emcore triple-junction solar cells mounted on the Starshine 3 microsatellite.

Ideally, to minimize the control electronics associated with an IMPS, researchers designed the microphotovoltaic array such that its output voltage matches the voltage needs of the battery and its current output is sufficient to charge the battery while simultaneously providing power to the load. The precise sizing of the array and battery will also depend on the anticipated illumination scheme. For example, in a typical 90-min low-Earth-orbit period, the battery will have to support the electrical load for 35 min of eclipse. During the 55-min insolation (daylight) period, the solar array will have to provide load power while fully recharging the battery. The IMPS we developed combines a seven-cell, 1-cm^2 gallium arsenide (GaAs) microphotovoltaic array produced at Glenn, with a Panasonic ML2020 rechargeable manganese dioxide lithium-ion battery (see the preceding figure) (ref. 3). This 3.0-V "coin cell" battery has a diameter of 2.0 cm, a thickness of 2.0 mm, a mass of 2.2 g, and a nominal capacity of 45.0 mA-hr.

References

1. Project Starshine. http://www.azinet.com/starshine/ (accessed Sept. 2001).

2. Solar Cells. http://www.emcore.com/html_documents/Photovoltaics.htm (accessed Sept. 2001).

3. Raffaelle, R.P., et al.: Integrated Microelectronic Power Supply (IMPS). 36th Intersociety Energy Conversion Engineering Conference, vol. 1, 2001.

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