# Hybrid Power Management Program Continued

*E-Bike used in the Hybrid Power Management (HPM) program--Bike, Bus, and Beyond.* Photograph of an E-Bike mounted on a test stand. The bicycle frame carries a housing containing an electric motor drive and the energy storage devices, including the ultracapacitor.

Hybrid Power Management (HPM) is the innovative integration of diverse, state-of-the-art power devices in an optimal configuration for space and terrestrial applications. The appropriate application and control of the various power devices significantly improves overall system performance and efficiency. The advanced power devices include ultracapacitors and photovoltaics. HPM has extremely wide potential with applications including power-generation, transportation, biotechnology, and space power systems. It may significantly alleviate global energy concerns, improve the environment, and stimulate the economy.

One of the unique power devices being employed by HPM for energy storage is the ultracapacitor. A capacitor is an electrical energy storage device consisting of two or more conducting electrodes separated from one another by an insulating dielectric. An ultracapacitor is an electrochemical energy storage device that has extremely high volumetric capacitance energy because of its high-surface-area electrodes and very small electrode separation. Ultracapacitors have many advantages over batteries:

1. Batteries can be charged and discharged only about 300 times and then must be replaced. Ultracapacitors can be charged and discharged over 1 million times. The long cycle life of ultracapacitors greatly improves system reliability, and it reduces life-of-system costs.

2. Long ultracapacitor life significantly reduces environmental impact because ultracapacitors will probably never need to be replaced and disposed of in most applications.

3. The environmentally safe, recyclable components of ultracapacitors greatly reduce disposal concerns.

4. The ultracapacitor's high-power density provides high power during surges and the ability to absorb high power during recharging. Ultracapacitors are extremely efficient in capturing recharging energy.

5. Ultracapacitors are extremely rugged, reliable, and maintenance free.

6. Ultracapacitors have excellent low-temperature characteristics.

7. Ultracapacitors provide consistent performance over time.

8. Ultracapacitors promote safety because they can be discharged easily and then left indefinitely in a safe discharged state.

HPM has been used in several applications at the NASA Glenn Research Center. One successful application was the NASA Hybrid Electric Transit Bus (HETB)--a 40-ft transit bus with a unique hybrid drive. At over 37,000-lb gross weight, this is the largest vehicle to ever use ultracapacitor energy storage. The ultracapacitor technology utilized for this bus is being applied to satellite actuation to replace unreliable hydraulic systems. The motor and control technology utilized for the bus is being applied to flywheel dynamometer systems.

HPM also has been applied to the E-Bike--a state-of-the-art, built-from-the-ground-up, hybrid electric bicycle that was tested and documented in fiscal year 2001. The E-Bike is an inexpensive, practical way to advance the state of the art in hybrid technology.

HPM has been utilized to provide safe, long-life energy storage systems for drop tower research. In addition, it is being considered for providing reliable, long-life energy storage systems for space missions (such as the exploration of Mars) and deep space missions (such as the exploration of Europa).

Through Glenn's Commercial Technology Office, HPM is being applied to power-generation, transportation, safety, and biotechnology systems. Some specific examples include photovoltaic power generation, safety flashers, water pumping for irrigation and human consumption, and hearing aids. In fiscal year 2001, an ultracapacitor-powered highway safety flasher and an ultracapacitor-enhanced photovoltaic power station were designed, developed, and tested successfully.

# Bibliography

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