

## ATK-Goleta Solar Array Technical Papers

Murphy, D., “MegaFlex - The Scaling Potential of UltraFlex Technology”, AIAA-2012-tbd, *53rd AIAA Structures, Structural Dynamics, & Materials Conference, 6th Gossamer Spacecraft Forum*, Honolulu, HI, April 23-26, 2012.

**ABSTRACT:** NASA has near-term needs for solar electric propulsion (SEP) power sources from 5 to 30 kW and longer term goals for SEP tugs as large as 300 kW and beyond. UltraFlex is a high-TRL solar array technology that spans the initial range of power levels with unmatched performance in specific power, stiffness, and strength. This technology has been to Mars, and is the baseline for the Multi-Purpose Crew Vehicle (MPCV) NASA currently has under development. MegaFlex is UltraFlex technology, with two enhancements to the compaction of stowage to allow a two-wing configuration to provide power levels up to 350 kW with near-term multi-junction cell efficiencies. This technology elegantly meets the SEP technology development need for true scalability, with a high-performance solution that uniquely allows for complete ground test and validation of the entire wing in existing facilities. Given the compaction capabilities of MegaFlex, it is an enabling technology for any kilowatt level where the power needed is more than the stowage volume allows with standard UltraFlex or alternate approaches. MegaFlex achieves similar performance characteristics as UltraFlex with specific power up to 200 W/kg (versus 30-70 W/kg) and also higher stiffness (>3x) and strength (>5x) than conventional arrays.

Eskenazi, M., Hoang, B., and MacDonald, K., “Seven Years of Performance Data for the CellSaver Concentrator in Geosynchronous Earth Orbit”, ATK SPW 2011, *29<sup>th</sup> Space Power Workshop*, Los Angeles, CA, April 18-21, 2011.

**ABSTRACT:** CellSaver is an on-panel reflector that replaces every other row of cells. The modest 2x concentration is an ideal compromise to provide significant mass and cost benefits, without incurring unique thermal management or array pointing challenges posed by competing concentrator technologies. CellSaver has successfully withstood a complete ground-based qualification test regime, demonstrating minimal degradation from the full gamut of environmental exposure: thermal, dynamic/loading and stowage. Also, flight data of a test sample in GEO orbit is presented, which validates basic performance predictions, as well as provides important lessons learned to apply to future designs.

Eskenazi, M., “Status of Several Different Multi-Junction Solar Cell Arrays in Geosynchronous and Low Earth Orbit”, SPW 2007, *2007 Space Power Workshop*, Los Angeles, CA, April 23-26, 2007

**ABSTRACT:** The on-orbit performance of several ATK solar arrays are presented. ATK solar arrays are in orbit in LEO, GEO, HEO, and inter-planetary. A variety of wing technologies are represented: classic planar, electrostatically clean arrays, and Fresnel and reflective concentrator arrays. All ATK solar array systems have achieved 100% on-orbit success with nominal operation.

Eskenazi, M., Jones, A., Jain, R., Hoang, B., MacDonald, K., Wong, Y., Kesapradist, J., & van Ommering, G “Preliminary Test Results for the CellSaver Concentrator in Geosynchronous Earth Orbit” 2005 PVSC, *31st IEEE Photovoltaic Specialists Conference*, Orlando, Florida, January 2005

**ABSTRACT:** CellSaver concentrator solar array technology was launched into geosynchronous earth Orbit (GEO) in the beginning of 2004 on a Space Systems Loral satellite. This paper presents the experiment design, the ground test qualification program and preliminary on-orbit test results. The on-orbit data includes both temperature and power measurements from the first 9 months of the successful experiment.

Eskenazi, M., White, S., Spence, B., Douglas, M., Glick, M., Pavlick, A., Murphy D., O’Neill M., McDanal A.J., and Piszczor , M., “Promising Results From Three NASA SBIR Solar Array Technology

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Development Programs,” NASACP-2005-213431, *Proceedings of the Space Photovoltaic Research and Technology Conference*, Cleveland, OH, September 16-18, 2003.

**ABSTRACT:** Results from three NASA SBIR solar array technology programs are presented. The programs discussed are the 1) Thin Film Photovoltaic UltraFlex Solar Array; 2) Low Cost/Mass Electrostatically Clean Solar Array (ESCA); and 3) Stretched Lens Array SquareRigger (SLASR). The purpose of the Thin Film UltraFlex (TFUF) Program is to mature and validate the use of advanced flexible thin film photovoltaics blankets as the electrical subsystem element within an UltraFlex solar array structural system. In this program operational prototype flexible array segments, using United Solar amorphous silicon cells, are being manufactured and tested for the flight qualified UltraFlex structure. In addition, large size (e.g. 10 kW GEO) TFUF wing systems are being designed and analyzed. Thermal cycle and electrical test and analysis results from the TFUF program are presented. The purpose of the second program entitled, “Low Cost/Mass Electrostatically Clean Solar Array (ESCA) System,” is to develop an Electrostatically Clean Solar Array meeting NASA’s design requirements and ready this technology for commercialization and use on the NASA MMS and GED missions. The ESCA designs developed use flight proven materials and processes to create a ESCA system that yields low cost, low mass, high reliability, high power density, and is adaptable to any cell type and coverglass thickness. All program objectives, which included developing specifications, creating ESCA concepts, concept analysis and trade studies, producing detailed designs of the most promising ESCA treatments, manufacturing ESCA demonstration panels, and LEO (2,000 cycles) and GEO (1,350 cycles) thermal cycling testing of the down-selected designs were successfully achieved. The purpose of the third program entitled, “High Power Platform for the Stretched Lens Array,” is to develop an extremely lightweight, high efficiency, high power, high voltage, and low stowed volume solar array suitable for very high power (multi-kW to MW) applications. These objectives are achieved by combining two cutting edge technologies, the SquareRigger solar array structure and the Stretched Lens Array (SLA). The SLA SquareRigger solar array is termed SLASR. All program objectives, which included developing specifications, creating preliminary designs for a near-term SLASR, detailed structural, mass, power, and sizing analyses, fabrication and power testing of a functional flight-like SLASR solar blanket, were successfully achieved.

Adler, A., Hague, N., Spanjers, G., Engberg, B., Goodding, J., Murphy, D., Mikulas, M., “Powersail: The Challenges of Large, Planar, Surface Structures for Space Applications”, AIAA-2003-1823, *44th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics, and Materials Conference*, Norfolk, VA, Apr. 7-10, 2003.

**ABSTRACT:** Deployable surface structures, a subset of gossamer structures, are a near-term solution for producing large area surfaces in orbit. These surfaces have a variety of applications, high stowed packing efficiency, and mass properties that increase flexibility in the overall system design. ABLE Engineering’s *SquareRigger*, a major component of the Air Force Research Laboratory (AFRL) PowerSail program, is the first modular, large scale, planar deployable surface structure intended for space applications. In developing and studying the basic module of this class of structure, a number of new challenges have arisen in ground testing and modeling. These challenges have led to changes in the modeling and testing procedures, resulting in an approach that closely ties finite element modeling with ground testing of modules and components. The approach is intended to generate increasingly accurate simulations of on orbit behavior of surface structures unable to be completely tested on the ground

Murphy, D., “The Scarlet Solar Array: Technology Validation and Flight Results”, *Deep Space 1 Technology Validation Report (2000)*.

**ABSTRACT:** The Solar Concentrator Arrays with Refractive Linear Element Technology (SCARLET) system used on the Deep Space 1 (DS1) spacecraft has been validated through

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successful performance in flight. *Scarlet*<sup>TM</sup> is the first successful concentrator array ever used as primary power for a spacecraft.

Flight results to date show that performance projections were within 1% of measured results, making *Scarlet* one of the highest performance solar arrays ever used in space. The *Scarlet* array uses linear, arched Fresnel lens concentrators to focus sunlight onto narrow rows of multiple band gap solar cells to produce 2.5-kW of power. This paper describes the array technology, development process, array assembly and qualification, and flight operations of this novel system.