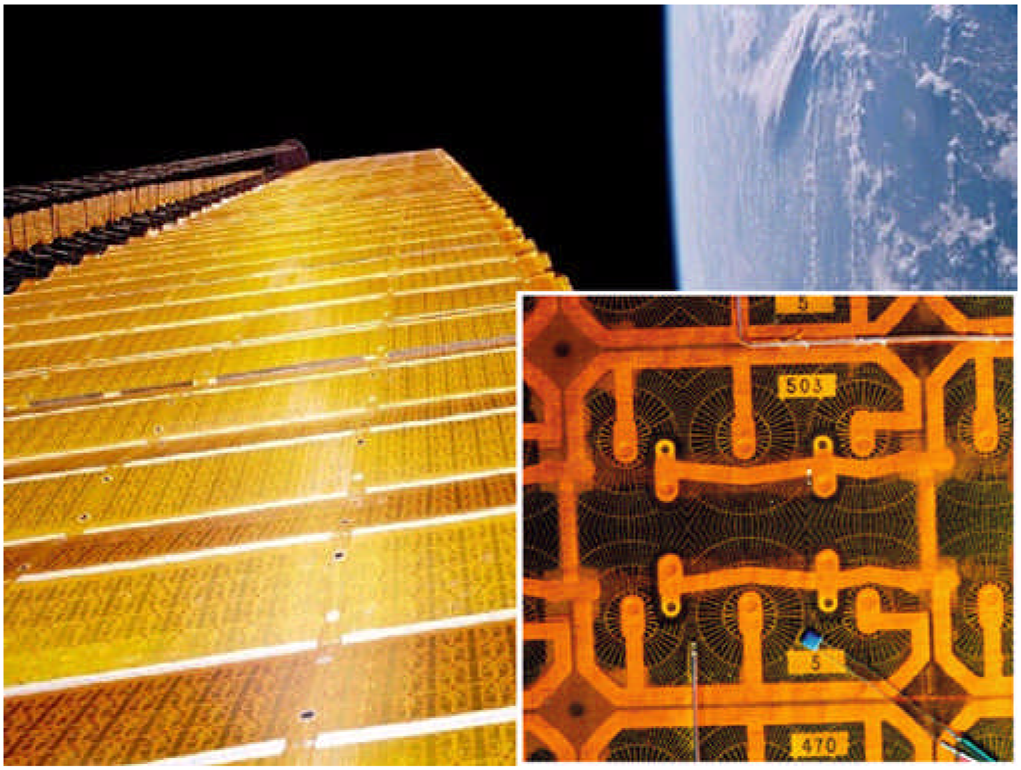
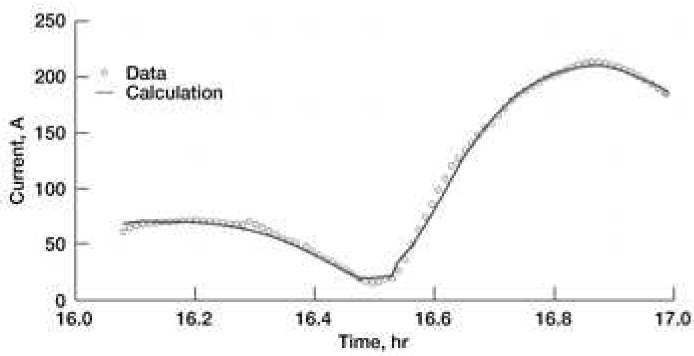
International Space Station Solar Array Bifacial Electrical Performance Model Developed



Backside of U.S. PVA showing series-connected, 8- by 8-cm crystalline silicon solar cells with gridded back contacts and copper flat printed circuit.

The first U.S. photovoltaic array (PVA) was activated on the International Space Station (ISS) in December 2000. Though normally Sun-tracking, U.S. ISS arrays are held stationary to minimize plume impingement from the space shuttle during docking and undocking, as well as during ISS assembly operations. Because of these operational constraints, it is not always possible to point the front side of the arrays at the Sun. In these cases, sunlight directly illuminates the backside of the PVA as well as albedo illumination on either the front or the back. Since the solar cells are mounted on a thin, solar transparent substrate, appreciable backside power (about one-third of the front-side power) is produced. To provide a more detailed assessment of the ISS power production capability, researchers at the NASA Glenn Research Center developed a PVA electrical performance model applicable to generalized bifacial illumination conditions. The model validation was done using on-orbit PVA performance.

For generalized PVA illumination, there is a direct solar component from the front or the back, and albedo components on the PVA front and/or back. The solar cell bifacial current-voltage, *IV*, values were calculated by superposing currents and scaling voltages with currents. Once the bifacial solar cell *IV* curve was obtained, the solar cell string *IV* curve was calculated by summing the voltage contribution of the individual series-connected cells and subtracting the voltage drop in the cell interconnects, harness and cabling, blocking diode, and sequential shunt unit. String current was iteratively determined such that the cell voltage generation minus the line voltage loss satisfied the sequential shunt unit output voltage set point. In the presence of string shadowing, separate *IV* curves were calculated for shadowed and unshadowed string sections. Total PVA current capability was obtained by summing the current contribution of the individual strings. On the basis of the uncertainties in the analysis methods, data input, Earth albedo, and infrared emission, the estimated total root-sum-square uncertainty in the predicted current is ±6 percent for a Sun-tracking PVA.



Comparison of predicted and measured PVA current for a sample orbit selected on December 10, 2001. (Extravehicular activity to install BGA thermal blankets.)

This graph compares predicted and measured PVA current for a sample orbit selected on December 10, 2001. The qualitative comparison between measured and calculated PVA currents through the orbit Sun period is excellent. Quantitatively, the root-mean-square difference between measured and calculated values was 3.0 A on the back and 4.4 A on the front. This is equivalent to approximately 2 percent of PVA front-side current capability or 4 percent of PVA backside current capability. Front-illuminated current data are smooth and in good agreement with calculated values.

This bifacial PVA performance model developed by Glenn has further improved the correlation between predictions and on-orbit data. With this more accurate modeling capability, improved power predictions that support on-orbit operations, certification for flight readiness, and mission planning can be made. The code has been incorporated into the SPACE (System Power Analysis for Capability) power systems software and into software used by the NASA Johnson Space Center Mission Operations Directorate for day-to-day on-orbit ISS operations planning. Recently, the Space Station Program Office began relying on the power produced from the PVA backside for on-orbit operations and planning.

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