JOURNAL OF SPACECRAFT AND ROCKETS
Vol. 40, No. 1, January–February 2003

Engineering Notes

ENGINEERING NOTES are short manuscripts describing new developments or important results of a preliminary nature. These Notes cannot exceed six manuscript pages and three figures; a page of text may be substituted for a figure and vice versa. After informal review by the editors, they may be published within a few months of the date of receipt. Style requirements are the same as for regular contributions (see inside back cover).

Solar Array Modeling for Space Station S-Band/Global Positioning System Communications Analysis

Shian U. Hwu,* Yin-Chung Loh,† and L. A. Johnson‡
Lockheed Martin Space Operations,
Houston, Texas 77258
and
R. J. Panneton§
NASA Johnson Space Center, Houston, Texas 77258

Introduction

THE International Space Station (ISS) solar arrays comprise the largest deployable space structure ever built and put into orbit, as shown in Fig. 1. The Space Station S-band communications system and global positioning system (GPS) antennas have to track satellites in a wide field of view region and will encounter blockage from the solar panels. Because the ISS is being assembled in space, a ground test for the communication and navigation antenna performance with ISS assembly complete is not possible. Computer simulation for assessing ISS communication and navigation system performance is important for mission planning and operations. To model the solar array panels properly in a computer simulation for assessing ISS communication system performance, the solar array blockage effects are investigated.

The solar array panel is a composite structure formed by closely spaced solar cells. The solar cells are silicon and are welded on the front surface of the solar array panel. A grid of copper strips that collect the current is on the back side of the solar array panel, as shown in Fig. 2.

Rigorous signal strength computations, including multipath effects from ISS structures, require considerable computing time. A detailed electromagnetic modeling of the solar array panels by composite conductors and dielectrics is very complicated and expensive with currently available numerical techniques and computer resources. This Note investigates whether the solar panel can be modeled approximately by a conducting plate for S-band communication and GPS signal strength prediction.

Received 6 March 2002; revision received 6 July 2002; accepted for publication 29 July 2002.

*Engineering Specialist, Avionics Systems Analysis Section, 2400 NASA Road 1. Senior Member AIAA.
†Engineering Specialist, Avionics Systems Analysis Section.
‡Engineering Specialist, Advanced Engineering Division.
§Acting Branch Chief, Systems Engineering Branch, MC: EV413, 2101 NASA Road 1. Senior Member AIAA.

Flight Data and Simulation Results

The flight data for the ISS S-band communications and GPS systems were recently obtained. Figures 3 and 4 show the flight data of the S-band communications system signal strength with solar array panel blockage at 2.0875 GHz. Figures 5 and 6 show the flight data of the GPS signal strength with solar array panel blockage at 1.575 GHz. The simulation data are computed using the geometrical theory of diffraction (GTD).[1] Reasonable agreement is achieved by modeling the solar array panel as a flat conducting plate (11.68 by 34.5 m). In the GTD computation, the reflected and diffracted field

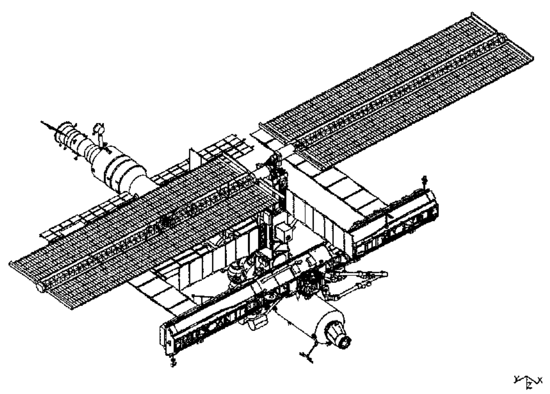

Fig. 1 Solar panels cause blockage to communications and navigation antennas.

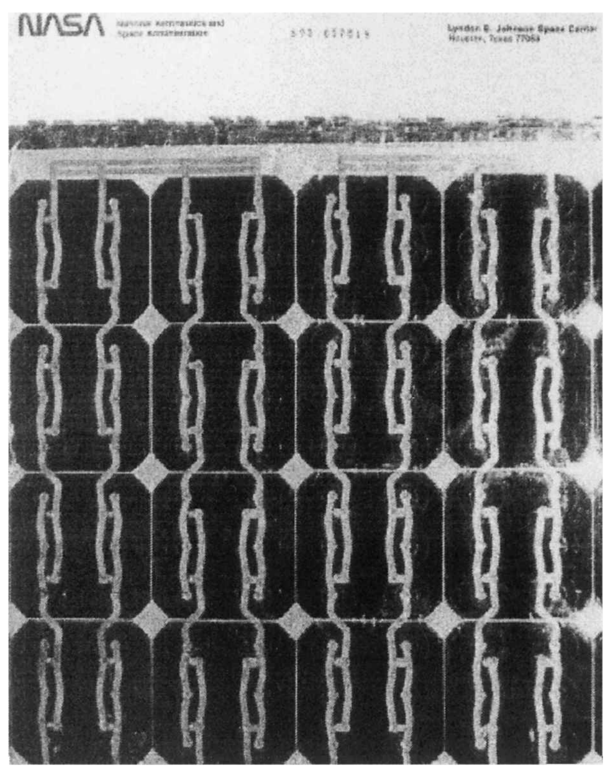

Fig. 2 Back side of the solar array panel.

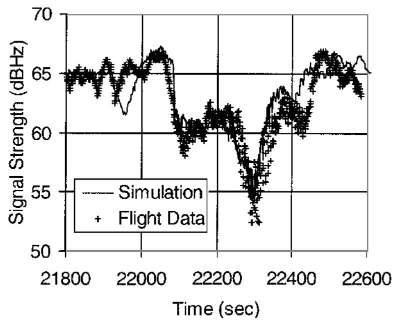

Fig. 3 GTD computed signal strength compared with flight data for S-band low data rate communication link.

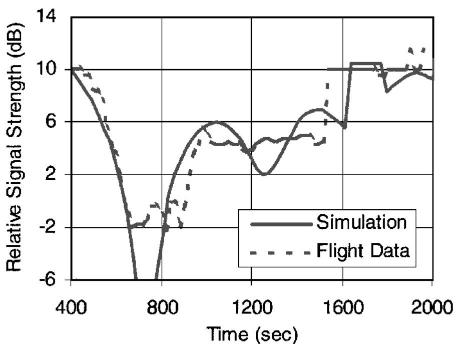

Fig. 4 GTD computed signal strength compared with flight data for S-band high data rate communication link.

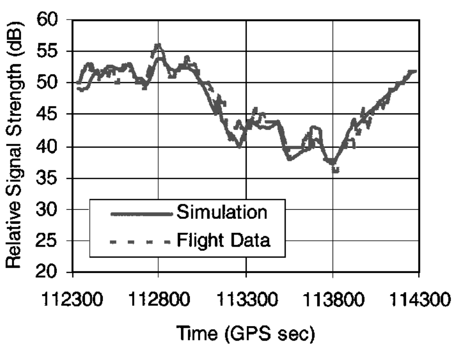

Fig. 5 GTD computed signal strength compared with flight data for selected GPS satellite pass 1.

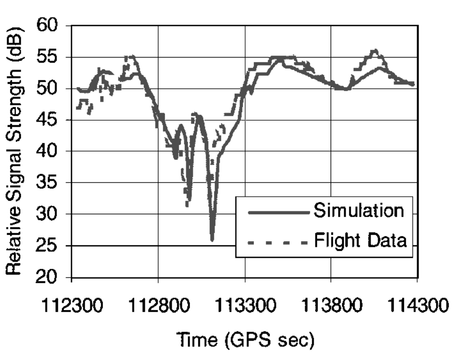

Fig. 6 GTD computed signal strength compared with flight data for selected GPS satellite pass 2.

at a field point r', $\boldsymbol{E}^{r,d}(r')$, can be computed as

$$\boldsymbol{E}^{r,d}(r') = \boldsymbol{E}^{i}(r)\boldsymbol{D}^{r,d}\boldsymbol{A}^{r,d}(s)e^{-jks} \tag{1}$$

where $E^i(r)$ is the field incident on the reflection or diffraction point r, $\boldsymbol{D}^{r,d}$ is a dyadic reflection or diffraction coefficient, $\boldsymbol{A}^{r,d}(s)$ is a spreading factor, and s is the distance from the reflection or diffraction point r to the field point r'. $\boldsymbol{D}^{r,d}$ and $\boldsymbol{A}^{r,d}$ can be found from the geometry of the structure at reflection or diffraction point r and the properties of the incident wave there.

Conclusions

The ISS is being assembled in space. Thus, conventional ground tests for communication and navigation system performance are not possible with the ISS completely assembled. Rigorous computer simulations are important for ISS communication and navigation system performance assessment. Both flight data and computer simulation results presented in this Note indicate the solar array panels may be modeled using perfect reflecting plates at S-band frequencies for communication and GPS signal strength predictions.

Reference

[1] Kouyoumijian, R. G., and Pathak, P. H., "A Uniform Geometrical Theory of Diffraction for an Edge in a Perfectly Conducting Surface," *Proceedings of the IEEE*, Vol. 62, No. 11, 1974, pp. 1448–1461.

D. L. Edwards
Associate Editor

Investigation of a Laser-Supported Directed-Energy "Air Spike" in Hypersonic Flow

M. A. S. Minucci,* P. G. P. Toro,† J. B. Chanes Jr.,†
A. G. Ramos,‡ and A. L. Pereira§
IEAv Centro Técnico Aeroespacial,
12228-840 São José dos Campos, São Paulo, Brazil
and
H. T. Nagamatsu¶ and L. N. Myrabo**
Rensselaer Polytechnic Institute,
Troy, New York 12180-3590

Introduction

It has been suggested by several authors[1–4] that aerodynamic drag and heating of a hypersonic transatmospheric vehicle (TAV) could be greatly reduced by adding energy to the air ahead of it. Such energy addition could be accomplished by focusing a powerful laser or microwave beam ahead of the TAV flight path, as it has been originally suggested by Myrabo and Raizer[2] in 1994.

Myrabo and Raizer called the effect of reducing aerodynamic drag and heating by electromagnetic radiation, the directed-energy "air spike" (DEAS). One of the first experimental confirmation of such an effect came in 1996 when a model of the Apollo reentry

Received 27 April 2001; revision received 30 September 2002; accepted for publication 4 October 2002.

*Major, Brazilian Air Force, Laboratory of Aerothermodynamics and Hypersonics. Senior Member AIAA.

†Research Engineer, Laboratory of Aerothermodynamics and Hypersonics.

‡Research Assistant, Laboratory of Aerothermodynamics and Hypersonics; currently Operational Engineer, Universidade do Vale do Paraíba (UNIVAP), Av. Shishima Hifumi, 2911, 122244-000 São José dos Campos, São Paulo, Brazil.

§Research Assistant, Laboratory of Aerothermodynamics and Hypersonics.

¶Active Professor Emeritus of Aeronautical Engineering, Department of Mechanical Engineering, Aeronautical Engineering, and Mechanics. Fellow AIAA.

**Assistant Professor of Aeronautical Engineering, Department of Mechanical Engineering, Aeronautical Engineering, and Mechanics. Senior Member AIAA.