

# The Private Journals of William C. Brown

## Father of Microwave Power Transmission (MPT)

One of the 20<sup>th</sup> century's finest engineers, Bill Brown answered two crucial questions in his journals: *How* would power satellites bring reliable 24/7 solar power to our grids? And *how* does a great high-tech engineer live, work, think and pioneer new technology for industry? Bill's astonishing autobiography chronicles the high tech world of 1964 to 1999. His MPT is essential for Space Solar Power (SSP) - the key to our contentious environmental energy economics. The cover of Vol I celebrates Bill's Amplitrons. Two were carried on every Apollo mission, providing live television coverage to earth from the moon. Also among Bill's 50+ inventions and patents were practical wireless power transmission - demonstrated in the lab and on national TV. Bill Brown first demonstrated practical wireless power transmission on May 23, 1963 at Raytheon's Spencer Laboratory with 25% power transmission efficiency. In 1964 he publicly demonstrated a small helicopter powered wirelessly by microwave beam on Walter Cronkite's national TV newscast. In 1975 at NASA/JPL's historic Goldstone MPT demonstration, Bill set power transfer efficiency records that are still unbroken: 92% RF-DC efficiency, DC-RF-DC efficiency of 54% at 1 KW, and later 34 kW transferred *one mile* with a collection efficiency of 82.5%.



<b>Author:</b> William C. Brown	<b>Deceased:</b> (1916 - 1999)
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**Testimonials:** “Bill Brown was a great engineer. He knew how to produce practical results in the many developments he supervised, including mine. He was a true visionary. Brown dared to investigate the promising future of Microwave Power Transmission (MPT)—the key to Solar Power Satellites (SPS), which will one day provide most of our energy. As such he was greatly respected and honored by his peers with the IEEE Society’s Microwave Theory and Techniques’ Pioneer *and* Career awards. This book is his saga. His strong foundation will be the bedrock for Space Solar Power (SSP).

- Dr. John M. Osepchuk, Raytheon Company employee from 1950-1995; past president of IMPI; editor of the Journal of Microwave Power; chair of the IEEE International Committee on Electromagnetic Safety; and a Fellow of IMPI and IEEE.

“Bill Brown provides a cogent chronology of MPT. However, without Bill's being aware of it, what also comes through as his friends and colleagues have always known is his dedication to the realization of a technically challenging idea, his courage in taking risks, and his courtliness. Bill is an engineer of the old school: a gentle, soft-spoken man who had a powerful vision of what could be and the technical capability and personal discipline to realize his goal. People like Bill give technology a good name. They see it not as an end in itself but as a way to give people an opportunity to live better lives. The editors acknowledge Bill's pioneering contribution to obtaining and utilizing the unlimited resources of solar power from space. We gratefully dedicate this book to him.

- Dedication page of “Solar Power Satellites”, 2<sup>nd</sup> ed. by Peter Glaser, F. Davidson, K. Csigi, 1998, Wiley-Praxis Space Science and Technology, 694 pages, **ISBN-13: 9780471968177**

### **Sample Book Excerpts:**

**First entry: “May 10th, 1964** - Two weeks ago I felt compelled to keep a journal of my activities and some commentaries on the new technology of power transfer by microwave beam. This is the 1st entry. ... The 1st meeting, devoted solely to power transfer by microwave beam, was held in Clearwater Florida, Wednesday, May 6 under sponsorship of the IEEE conference on energy sources. Ernie Okress was chairman of the session and Paul Hausel was chairman of the overall technical program. ... I gave two papers—one on the state of the art of microwave power generation and detection, and one reviewing our May 23, 1963 demonstration at Raytheon on the efficient transmission of meaningful amounts of power by microwave beam. These papers were made part of the meeting’s general record. Neil Heenan also gave a paper. It was a very impressive review of what had been done in the antenna area.

**October 12th, 1967** - “These are red-letter days for the helicopter project. The day before yesterday the helicopter operated in five degrees of freedom, each servo controlled and using the microwave beam as a reference. Today Hunter Chilton visited from Rome Air Development Center (RADC) and we were able to give him a good demonstration.

The operation in five degrees of freedom was surprisingly easily achieved, and not expected when it was tried. After the not completely satisfactory operation in the roll-Y mode, so called for the rolling motion and translatory motion along the Y-axis, I decided to try operation in the other three degrees of freedom as well. These were yaw, pitching motion, and motion along the X-axis. However, when I put all of them together, and without turning on the microwave beam, there was interaction between the servo motor systems due to improper ground leads. This was corrected in part but there was still interaction between the yaw and the roll-Y servos. So with this difficulty, plus the dubious roll-Y performance, and the very possible interaction between the systems, I really did not expect any performance that could be called “stabilized.” So it was with great surprise that I observed relatively “smooth” stabilized performance when I turned on the microwave beam and applied power to the main rotor.

This is a real milestone and its achievement has caught me flat footed. Although I am pleased, I am also at loose ends. I feel restless, dissatisfied. There is still much to be done to improve the present performance, writing a final report, arranging for demonstrations for people within Raytheon and for people outside. But now I want to get started on the design of a new rectenna, and get along with the next phase. For the past two months I have scarcely given the new rectenna a passing thought.

Now there will be a large amount of time and effort consumed in attempting to affect some sort of interaction with the whole spectrum of Raytheon management on the project. There will be the corporate staff marketing and engineering personnel, and then the line types for two or three divisions, and the marketing groups in these divisions.

Then there will be the problem of what direction to go in should the helicopter be equipped with a gasoline motor as the next stage? Should something be done on the new rectenna? Where should the project be worked on? What kind of a building facility? Oh boy. It would not be simple to determine the direction even if only one person were involved, but infinitely easier than when so many are involved.

## **Space Solar Power (SSP):**

Global efforts to slow soaring CO<sub>2</sub> amid increasing economic and environmental problems have centered on subsidizing windmills and terrestrial solar. They have failed, wasting trillions. Such intermittent and mature technologies need no subsidy. Instead, they require expensive massive back-up to be reliable dispatchable generation. SSP must be added to our energy choices for any “Green New Deal” to work. All satellites now in space are *communications* satellites. SSP would add *power* satellites, to bring unlimited, zero CO<sub>2</sub>, clean, reliable power back to earth’s failing power grids (1).

Professor Jacobson’s plan, cited in many Green New Deals, to repower America with only hydro, windmills and terrestrial solar was submitted to the National Academy of Sciences several years ago, and then strongly rejected by expert review. Jacobson then sued those critics for \$10 million. The D.C. Superior court strongly rejected his lawsuit, upholding the rejection of his plan. His lawsuit was dropped and termed ridiculous. (2) SSP must be added to our global and national energy alternatives(2).

How should we proceed? A similar challenge, Sputnik, was faced by America in 1962, when President Kennedy signed the Comsat Act into existence. This legislation created the first communications satellite companies, Comsat and Intelsat; public/private corporations. They created the \$400 Billion communications satellite industry we now enjoy. Congress should charter the first “Sunsat Corp”, to create the first *power* satellite corporation to overcome the large initial R&D investment of Sunsat #1. Draft legislation based on the 1962 Comsat Act is available.

SSP is a simple idea. The sun does the hard work of nuclear fusion. Moving solar panels to high orbit provides 9.6 times more always on energy, Rooftop solar faces clouds, dust, rain, hail and night make it pseudo-random intermittent. Windmills provide most of their power when it is least needed; in the spring and fall when demand is lowest. Crops or pasture could be grown under SSP’s rectennas, providing revenue and taxes like windmills now provide.

In 1962 we knew virtually nothing about digital satellite communications, photovoltaics, tele-robotics, satellite operations, debris mitigation, and many other technologies. But now the technology SSP needs has been demonstrated already in *communications* satellites and continues to advance daily. Most rockets today are *expendable*, or thrown them away. But *Reusable Launch Vehicles* (RLV), essential to lower launch costs, are rapidly becoming mature.

SSP could also provide unlimited clean liquid fuel, anhydrous ammonia, which could be made from sea water, energy and air. Ammonia is the second most widely pumped liquid, after oil and gas. It powered the

X-15 rocket plane. Many major global energy companies, including Equinor (formerly Statoil), Saudi Aramco, Woodside Petroleum, Shenhua Group, Shell, and Total are all investing in, demonstrating and/or developing new technologies and/or business cases for ammonia energy in a low-carbon economy (3), especially for the maritime shipping industry.

We can add SSP to our energy mix. Global environmental energy economics demands it. We must soon plug into the sun directly gaining this new unlimited, zero CO<sub>2</sub>, zero water use, 24/7, low-cost, clean, reliable energy alternative. SSP industry could also open the High Frontier to greater space commercialization and innumerable exciting new jobs, professions, studies and endless horizons. We could ship parts and materials from the moon to SSP in GEO 22 times easier. It requires 22 times less energy to ship from the moon.

## **Editor:**

Darel Preble wrote white papers on key SSP technologies for industry in 1994, 1995 and 1996 while working at Southern Company. In 1997 he left Southern Company's strategic planning group and chartered the Space Solar Power Institute, an educational non-profit 501(c)3. Mr. Preble holds Masters Degrees in Systems management (R&D forecasting) (George Washington University) and Theoretical nuclear physics (Georgia State University, 1980). A answers to SSP Frequently Asked Questions are at <https://solarsat.org/faq.htm>

## **References**

1. Space Solar Power Institute <https://solarsat.org> has draft public/private legislation for SSP charter at <http://www.sspi.gatech.edu/sunsat-act.pdf>, “**PG&E’s Bankruptcy would mark the First Major Corporate Casualty of Climate Change**”, [www.wsj.com/articles/pg-e-wildfires-and-the-first-climate-change-bankruptcy-11547820006](http://www.wsj.com/articles/pg-e-wildfires-and-the-first-climate-change-bankruptcy-11547820006) ; Rebecca Smith, WSJ, Dec. 11, 2019, “**Northern California Power Outages Could Soar If Aging Lines Aren’t Replaced, PG&E Study Finds**”, <https://www.wsj.com/articles/northern-california-power-outages-could-soar-if-aging-lines-arent-replaced-pg-e-study-finds-11576082069> **Governors Tell Congress To Step Up To Climate Change Fight**, [www.wral.com/cooper-tells-congress-to-step-up-in-climate-change-fight/18171966/](http://www.wral.com/cooper-tells-congress-to-step-up-in-climate-change-fight/18171966/) ; **Once Powerful PG&E Has Few Friends Left in California Capital**, [www.wsj.com/articles/once-powerful-pg-e-has-few-friends-left-in-california-capital-11548844202](http://www.wsj.com/articles/once-powerful-pg-e-has-few-friends-left-in-california-capital-11548844202) ;
2. Experts debunked Jacobson’s 100% renewables decarbonization plan which argued that the U.S. can end carbon dioxide emissions using 100% wind, (terrestrial) solar, and hydro “between 2050 and 2055”. Christopher Clack, of the National Oceanic and Atmospheric Administration, lead author, and 21 prominent energy and climate experts, writing in the Proceedings of the National Academy of Sciences found that Jacobson’s work “has significant shortcomings in analysis. This work uses invalid modeling tools, contains modeling errors, and made implausible and inadequately supported assumptions...” <http://m.pnas.org/content/early/2017/06/16/1610381114> (*Jacobson claimed vast quantities of new hydro could be added anywhere needed, ignoring geologic and economic reality.- ed.*) Jacobson then sued Clack, the National Academy of Sciences and his critics. Jacobson then dropped his ridiculous defamation lawsuit against his scientific critics - LA Times, Michael Hiltzik, Feb 23, 2018, <http://www.latimes.com/business/hiltzik/la-fi-hiltzik-jacobson-lawsuit-20180223-story.html> and <http://www.sandiegouniontribune.com/business/energy-green/sd-sdfi-jacobson-withdraws-20180222-story.html>
3. <https://www.ammoniaenergy.org/articles/>