GLOBAL POSITIONING SYSTEM'S HIDDEN HISTORY

In his Reference Frame colum "Where I Stand" (January 1994, page 9) Daniel Kleppner uses the Global Positioning System as an example of applying the fruits of research to technology, to the benefit of humanity. In so doing, he extols the virtues of the GPS as indeed they were recognized by the National Aeronautical Association in February 1993 when it bestowed the coveted Collier Trophy to the GPS team "for the greatest achievement in aeronautics in America . . . the most significant development for safe and efficient surveillance of air and spacecraft since the introduction of radio navigation 50 years ago."

However, Kleppner's column also illustrates the errors that creep in when the path to such successful contributions come by the route of sponsorship by the military. For example, in the 1930s scientists and engineers in the Navy (at the Naval Research Laboratory) and in the Army (at the Signal Corps Red Bank and Fort Hancock Laboratories) independently "invented" and developed radar, but secrecy prevented acknowledgment of this work till well after 1945. Prior to the 20th century, military information security was generally applied to the size and location of military forces. However, with the recognition in this century of technological superiority as a critical element in the "balance of power," security classifications have been applied even to basic science as soon as the potential military value was recognized, and certainly to engineered military systems. So too the early history of the GPS was largely hidden behind the walls of security.

Radio-navigation system development in the United States was stimulated in 1940 by the onset of World War II. Since then radio-navigation systems, in general, have been developed by the military and classified during development and first use; the GPS followed the same evolution.

The Johns Hopkins Applied Physics Laboratory, sponsored by the Navy, was the first to study and develop a satellite navigation system, TRANSIT. The system met the Navy's requirements for an intermittent all-weather surface navigation system to be used by strategic submarines (and later all surface ships). TRANSIT did not, however, meet the needs of fast military aircraft for three-dimensional, accurate, continuous navigation.

The Aerospace Corporation, of which I am president emeritus, was established in 1960 to apply "the full resources of modern science and technology to the problem of achieving those continued advances in ballistic missiles and space systems which are basic to national security," in the words of its mission statement as expressed by then-Undersecretary of the Air Force Joseph Charyk. Hence among the first space systems studies initiated at the Aerospace Corporation was the design of a satellite navigation system that would meet the above-mentioned needs and would employ nonradiating, inexpensive and compact "user receiver" equipment. The GPS concept was the immediate result. In 1963 it was adopted and supported by the Air Force's space division as project 621B. By 1965 the GPS basic system had been well defined; in 1968 the Air Force placed contracts with industry for user receivers. (See reference 1 for more detailed accounts of the evolution.)

As the decade wore on, the Air Force with GPS, the Navy with improved TRANSIT concepts and the Naval Research Laboratory's Timation concepts, and the Army with SECOR competed for the role of the Department of Defense's navigation system. Finally, on 17 August 1974, Malcolm Currie, director of Defense research and engineering, determined that a joint three-service program based on the GPS concept would be established, with the Air Force as program manager. This history is at odds with Kleppner's statement that "the GPS was initiated by the Navy in the 1970s and taken over by the Air Force in the early 1980s." In fact, when my retirement as president of the Aero-

space Corporation was being continually delayed, I used to say, "I will retire only when I am convinced that the DOD could not stop its support of the GPS even if it wanted to!" I did retire in 1977.

In the meantime strong support for the GPS had been given by many civilian leaders in the DOD and military leaders of the Air Force, among them Gene Fubini, Al Flax, Gerald Dinneen and General Lew Allen. As the system evolved, compromises in satellite orbits were made, working relations with the NRL established, and so forth. Some of NRL atomic (rubidium) clocks were flown side by side with Air Force (cesium) clocks. Use was made, at first, of the Navy's TRANSIT computing facility. The Aerospace Corporation continues to supply the Air Force with systems engineering for the GPS. Many scientists and engineers from government, academia and industry, here and abroad, have applied ingenuity to improved user equipment for various applications.

The DOD has declassified the elements of the GPS applicable to civilian use; Congress and the President have assured continued and reliable access to the GPS by all nations for peaceful uses. The Department of Transportation and the Department of Defense have issued a joint plan to terminate various other radio-navigation aids and in the future rely on the GPS as the principal global positioning system and radio-navigation aid.[2] The GPS will also serve in establishing an accurate worldwide mapping grid and accurate worldwide time synchronization system.

References

1. I. A. Getting, *All in A Lifetime*, Vantage, New York (1989); IEEE Spectrum, December 1993, p. 36. *The Aerospace Corporation, Vol. 1: Its Work, 1960–1980*, Aerospace Corp., El Segundo, Calif. (1980), Library of Congress no. 80-67774. B. W. Parkinson, GPS World, September 1994, p. 32.
2. US Dept. of Transportation and Dept. of Defense, 1992 Federal Radionavigation Plan, January 1993.

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2/94

KLEPPNER REPLIES: I thank Ivan Getting for describing the early history of the Global Positioning System and regret not having known about the role of the Aerospace Corporation.

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9/94

Reassigning Blame for the SSC's Demise

The February 1994 Washington Reports story by Irwin Goodwin (page 87) is an excellent review of the history of the Superconducting Super Collider project and the causes and consequences of its demise. In Goodwin's discussion of the "SSC as a procurement" former Energy Secretary James Watkins, SSC general manager Edward Siskin and DOE project director Joseph Cipriano come out as the villains of the piece in cutting the physicists out of the management loop. In point of fact the high-energy physicists were cut out of the loop long before, when Maury Tigner and his colleagues in the Central Design Group were dropped as the SSC design team and a controlling role was ceded by the Universities Research Association to aerospace and defense-related industries under alleged pressure from elements in DOE and Congress. This restructuring, which was facilitated by structural changes within DOE to remove the project from the normal Office of Energy Research chain, is noted by Wolfgang K. H. Panofsky in a letter to PHYSICS TODAY (March 1994, page 13). Edward Knapp, who was a principal in arranging the marriage, was removed as president of URA for his part. Subsequently Doug Pewitt, who also was an architect of the arrangement with these industries, tried to rein them in and became a victim of his own creation.

While Siskin and Cipriano certainly contributed to the debacle, it is easy to forget that they were brought in because the project was already in deep trouble as a result of these prior arrangements. Before Siskin arrived on the scene the original project manager had long since been removed because the project was in trouble, to be followed by a series of acting project managers, none of whom had experience in accelerator building. Technical focus and leadership were lacking. There had been multiple turnovers of the leadership of the administrative and conventional construction divisions. And there was no budget or schedule, in spite of the fact that Tigner had already had a cost-and-schedule system in place at CDG. But that system was discarded to make way for the defense-related industries to assume that aspect of the project.

There is indeed "enough blame for the death of the project for many people to share," as Will Happer, for-

continued on page 90