The Global Positioning System

By Anne G. K. Solomon

On March 29, 1996, President Bill Clinton issued PDD NSTC-6, shorthand for *Global Positioning System, Presidential Decision Directive, National Science and Technology Council #6.* This directive outlined a national policy on the management and use of the Global Positioning System (GPS). At the White House public announcement, or "roll out," the new policy was described as "opening the door for rapid

growth in aburgeoning civil and commercial GPS market." First conceived in the 1970s as a navigational means to enhance the effectiveness of U.S. and allied military forces, by the mid-1990s GPS had become an integral component of the emerging global information infrastructure. GPS applications range from mapping and surveying, to international air traffic management, to global climate change research. Accordingly, PDD NSTC-6 was intended to ensure that U.S. economic and other civilian aims for GPS were well served, while protecting the nation's national security interests.

In initiating the GPS interagency policy review that culminated in PDD NSTC-6, the President designated the Office of Science and Technology Policy (OSTP) to coordinate with the National Science and Technology Council (NSTC) and the National Security Council (NSC). The President's charge to OSTP and NSC was to review GPS policy issues and to provide "a strategic vision" for GPS management and use. The working group's final conclusions and recommendations on GPS policy goals and policy guidelines, and agency roles and responsibilities, reflected the complexities of managing a powerful dual-use technological system, as well as the intricacies of brokering competing interagency interests.

The Technology, Its Origins, and Development

The Global Positioning System is arranged in three distinct segments that together provide users with highly accurate position, time, and velocity information:

1. The space segment with a constellation of 24 orbiting satellites that broadcast precise time signals;
2. The ground-based control segment that includes a control center and access to overseas command stations; and
3. The user segment that consists of GPS receivers and associated equipment.

Simply explained, the satellites transmit radio signals giving each satellite's position and the time it transmitted the signal. A user's receiver calculates the distance between the receiver and the satellite by subtracting the time the signal left the satellite from the time that it arrived at the receiver. The user's exact location—a three-dimensional position with longitude, latitude, and altitude—is determined by coordinating the distance from the user's receiver to four or more satellites. Additional calculations can provide the velocity at which the user may be moving.

The GPS is regarded as a science and engineering triumph integrating knowledge and capabilities in areas including the fundamental infrastructure of rockets, atomic clocks, integrated circuits, and bandwidth compression.[1] The Department of Defense (DOD) developed the system to increase the precision of weapons delivery and to guide strategic aircraft more accurately. The cost to U.S. taxpayers was more than $10 billion.

From the start, DOD considered GPS to be inherently dual-use with potential civilian applications for navigation, surveying, and time transfer. DOD recognized, however, that potential adversaries could use this powerful satellite-based system as well. To mitigate the danger of hostile use, DOD provided positioning capability at two levels of accuracy—the highly accurate Precise Positioning Service (PPS), encrypted and restricted for use only by the U.S. military and its allies, and the less accurate Standard Positioning System (SPS), provided at no cost to civilian and commercial users worldwide. The DOD additionally degraded the accuracy of the civilian SPS through a technical means called "selective availability."

Two events were pivotal in shaping the perceptions of the value and potential of GPS that led up to the 1996 PDD NSTC-6 policy review. The first was the September 1983 Soviet shoot down of the Korean airliner, KAL-007, which had ventured into Soviet airspace. In response, President Ronald Reagan committed the United States to making GPS internationally available to improve civilian aviation safety. The second event a decade later was Operation Desert Storm—where in a featureless, sand-blown desert, GPS guided U.S. and allied assaults on Iraqi forces, and thus dramatically demonstrated the system's military value. By the mid-1990s GPS was considered to be a vital element in the basic infrastructure of the world's economy—for air, sea, and land transportation systems; and for the Internet, scientific research, and a range of other activities requiring precise positioning and timing data. Simultaneously, GPS was a key instrument serving the U.S. armed forces.

Policy Challenges

The fundamental policy challenge posed by GPS was similar to those posed by many dual-use technologies. That is, the government needed to determine which U.S. policy strategies would achieve the desirable balance among national objectives (1) to enhance U.S. economic competitiveness and productivity, (2) to protect national security and foreign policy interests, and (3) to ensure continued progress in scientific and technological research and innovation.

To help illuminate specific issues relevant to GPS, Congress asked two public policy research entities, the National Academy of Public Administration (NAPA) and the National Research Council (NRC), to conduct independent studies of future GPS management and funding. These studies, and an additional review that OSTP requested of the RAND Corporation's Critical Technologies Institute, provided research and analysis, policy conclusions, and recommendations that informed the subsequent White House policy review.[2] In addition, the GPS Industry Association worked constructively with the White House, Executive Branch agencies, and Congressional players to convey private sector views.

The complexities were many, as indicated by a NAPA/NRC list of "powerful forces" shaping the policy environment:[3]

- GPS as a potential weapon of war and terrorism. The United States, having developed GPS, must retain the technology's military advantages for its own and allied forces use and deny these advantages to enemies. As with other technologies,other nations will acquire GPS-like capabilities. How fast this hap pens depends, in part, on U.S. policies and actions.
- Rapidly growing commercial markets. Sales of GPS-related products and services are expected to grow to more than $30 billion annually after the year 2000.
- Use by much larger segments of the general public. As GPS becomes a key part of vehicular navigation systems and mobile communications, millions of people will come to know and depend on it.
- Further potential technological improvements. Technological improvements will be made to the basic GPS system to improve accuracy, integrity, and availability.
- International markets and influences. International markets are expanding and foreign firms and governments are pressing the United States for assurance of continued GPS signal avail ability, and for international participation in system governance and management. Foreign unease with reliance on a U.S. military-controlled system provides incentive for international development of competing global navigation systems.

Contending Players and Bureaucratic "Stovepiping"

Responsibility for managing U.S. interests associated with these "powerful forces" was split among several federal departments. These contending players were confined and restricted by a "stove piped" federal bureaucratic organization. For example, the Department of Transportation focused on air, sea, and land navigation; the Department of Defense on military considerations; and the Department of Commerce on productivity and competitiveness. There were misunderstandings and mistrust within and among mission agencies that stymied decision making on important issues of GPS governance, management, and budgets. The OSTP/NSTC and NSC policy review process brought together all of the relevant players to identify and resolve issues and to set policy guidelines—and did so successfully.

The entire process that led up to PDD NSTC-6 worked well—commissioning outside entities to identify and analyze issues, working closely with industry to understand the private sector perspective, and establishing within the White House a policy review process that facilitated debate and resolved differences among players. PDD NSTC-6 outlined a useful policy framework for an extraordinary technology with great potential.

Policy Outcome

The key components of PDD NSTC-6 were intended to reassure all American and friendly foreign stakeholders that the United States was committed to supporting their respective interests. The central element was assurance that America would keep the constellation of 24 GPS satellites and other components up and running—and available to scientists, consumers, businesses, and others around the world for their use, free of charge. This commitment was designed to assure all users, including foreign governments and international organizations, that they could depend on civil GPS services for their navigation and positioning needs. Such a commitment was necessary to ensure international acceptance of GPS as a global standard. Providing free access eliminated the economic incentives for others to invest the large sums that would be required to develop their own systems—systems that the United States feared could pose security threats.

The Presidential Decision Directive also committed the U.S. government to improving the quality of the civilian Standard Positioning System signal by eliminating "selective availability" as soon as the DOD developed the technical capability to selectively deny GPS to hostile entities. These steps together cleared the way for a revolution in international transportation by allowing unrestricted broadcast of enhanced GPS signals worldwide. Finally, the PDD established a permanent GPS executive board, co-chaired by the Departments of Defense and Transportation and including representatives from all relevant agencies, to coordinate GPS management and use.

Continued Policy Management

PDD NSTC-6 was a first step in a policy process that continued in the international arena. It provided the basis for a broad, coordinated U.S. government approach in negotiations with foreign governments and international organizations. A range of tough technical, commercial, and security issues required international resolution to make GPS an enduring component of the global transportation and communications infrastructure. Subsequent U.S.-international negotiations both addressed these important issues and also encouraged other governments to match the American integrated policy approach to reflect GPS policy complexities.

Lessons Learned

PDD NSTC-6 brought together the senior levels of government responsible for policies on national security, the economy and trade, and research and innovation. Such integrated policy initiatives and structures increasingly are required to adequately manage the complexities of advanced technological systems.

---

1 For an excellent discussion of some of the science and engineering accomplishments that made development of the GPS possible see The Global Positioning System: The Role of Atomic Clocks, part of the National Academy of Sciences "Beyond Discovery Series," http://www.nas.edu.

2 The Global Positioning System: Charting the Future. A report by a Panel of the National Academy of Public Administration (NAPA) and a Committee of the National Research Council (NRC) for the Congress of the United States and the Department of Defense, May 1995.

The Global Positioning System: A Shared National Asset. A report of the National Research Council, May 1995.

Pace, Scott, et. al., The Global Positioning System: Assessing National Policies. The RAND Corporation, MR-614-OSTP, 1995.

3 The Global Positioning System: Charting the Future, pp. xxiii-xxiv.