***American Meteorological Society***
***Policy Program***
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# Policy Research on Space Weather & GPS

## Overview

Dependence on new technologies many times leads to a growing corresponding vulnerability and can lead to risks that were not anticipated. When the Global Positioning System (GPS) became fully operational in the mid 1990s and declared by the U.S. government to be a dual-use system for both military and civilian purposes, it was unknown just how much our daily lives and the economy would become reliant on position, navigation, and timing (PNT) services. To the non-military user, GPS has transitioned from just a new interesting leisure technology to becoming critical infrastructure. Today, GPS is so entrenched into the daily activities of individuals, businesses, and government that the absence of satellite navigation services would be seen as an unmitigated disaster.

In other fields, it has been shown that when new technologies are introduced, overdependence leads to vulnerabilities that were not foreseeable and it takes time for the unintended consequences to show up. For example, ubiquitous use of cell phones and the internet means that when connectivity is down, most individuals and businesses are basically paralyzed. In New Orleans, the use of levees allowed most people to dismiss the warnings that one day the city would experience a catastrophe. Over reliance on our power grid was evident during the 2003 New York blackout demonstrating that while high connectivity in the power grid allows power to be transmitted over long distances, it also creates a major vulnerability, allowing local disturbances to propagate across the grid. Just as society takes for granted that electricity, heat, and clean water will be available, they also take for granted that GPS will be available, reliable, and accurate.

Space weather is a dramatic example of how technology advances create unforeseen vulnerability. The solar-terrestrial environment was not considered important until it was discovered in the mid-1800s it could disrupt the telegraph service, or during World War II jam HF radio communications, or even in more recent years cause the collapse of the Hydro-Quebec power network.

The vulnerabilities of GPS are well categorized[1] and it is understood that space weather is the single largest contributor to single-frequency GPS errors and a significant factor for differential GPS.[2] The 2008 Federal Radionavigation Plan states that the only practical way to mitigate errors in GPS accuracy due to space weather is to utilize models to predict the magnitude of these events and provide correctors for real-time high accuracy positioning and navigation applications.[3] However, several scientific challenges remain to keep up with the pace of the GPS industry and users: how to better predict of the state of the ionosphere (including forecasts of a few days ahead) and how to better predict the magnitude of the next solar cycle.

However, the policy issues have not been examined as thoroughly and are essential to understanding how to mitigate risks due to space weather and make informed decisions. During the last Solar Max in 2001, GPS equipment revenue was less than $10 billion. In 2008, just the GPS-enabled handset market revenues are expected to generate more than $50 billion, rising up to $100 billion in 2012, during the next Solar Max.[4] This is just one example of how our reliance on GPS has put us more at risk this solar cycle compared to the last one.

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[1] Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System, 2001, prepared by the John A. Volpe National Transportation Systems Center for the Office of the Assistant Secretary for Transportation Policy.
[2] Kunches, Joseph, "GNSS and Space Weather: Making the Least out of Solar Max," InsideGNSS, November/December 2007.
[3] The 2008 Federal Radionavigation Plan is prepared by Departments of Defense, Homeland Security, and Transportation.
[4] ABI Research, 2007

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During the last solar cycle there were documented errors and losses in GPS signals. Basically a decade later, with our over reliance on GPS, what will be the impact of this Solar Max? By better understanding the risks and preparing the GPS community with strategies for mitigation, potential disasters can be avoided.

## American Meteorological Policy Study

Therefore, the American Meteorological Society (AMS), with funding by the National Science Foundation, is conducting policy research leading to recommendations that will increase the reliability and accuracy of GPS, and thereby the Global Navigation Satellite System (GNSS), through more effective use of space weather forecasts and information.

The goal of the study is to examine policy issues in how to effectively apply space weather forecasts to GPS usage and services to reduce PNT errors or disruption. This research will lead to a better understanding of 1) the impact that space weather has on GPS technologies, services, and policies; 2) to what extent an improved understanding and usage of space weather information will have on GPS technologies, services, and policies; and 3) strategies and plans to effectively respond to space weather information.

The study will include discussion with GPS government and industry leaders, space weather scientists and information providers, and policymakers. A report will provide options to resolve policy issues facing the GPS community, better equipping government and industry leaders to make effective decisions with respect to space weather research and services. While space weather can impact the entire GNSS and this project will address national and international issues, the primary focus will be on developing a U.S. perspective.

## AMS Background

The AMS, a scientific and professional society, promotes the development and dissemination of information and education on the atmospheric and related oceanic and hydrologic sciences. Founded in 1919, The AMS has a membership of more than 13,000 academic, government and private sector professionals, students, and weather enthusiasts. The AMS publishes 11 atmospheric and related oceanic and hydrologic journals, sponsors more than 12 conferences annually, and offers numerous programs and services. The AMS Policy Program, founded in 1999, has experience in policy research and educational activities, along with educating scientists and policy makers on national policy issues. Through its Policy Study Series, the Program has succeeded in bringing together providers of science and services; the community of end users of weather, space weather, climate, and water information; the policy officials at all levels of government responsible for the issues; and the media. AMS is involved in a number of space weather related activities, including policy research and a symposium held at the Annual Meeting. In 2008, the AMS Council released a policy statement on space weather (http://www.ametsoc.org/policy/2008spaceweather_amsstatement.html).

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