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# NOAA PLANNING FOR OPERATIONAL SOLAR WIND MONITORING AND CORONAL MASS EJECTION IMAGING


Solar wind data and coronal mass ejection (CME) imagery are critical for warnings and alerts of potential and impending geomagnetic storms, which are the most damaging form of space weather. NOAA currently receives all this data from NASA and ESA research missions which are, in some cases, well beyond their 2-year design lives. NOAA has studied how to follow these research missions with a continuing operational capability. At the direction of the White House Office of Science & Technology Policy (OSTP), NOAA and other federal agencies are developing a plan to address the long-term need for solar wind & CME data. Prior NOAA studies identified government smallsats, commercial data buys, and refurbishment of the NASA Deep Space Climate Observatory (DSCOVR) as options for meeting solar wind requirements. NOAA also studied new, smaller coronagraph designs for CME imaging. This work was brought to the interagency study for OSTP, whose study has been completed.

# NOAA PLANNING FOR OPERATIONAL SOLAR WIND MONITORING AND CORONAL MASS EJECTION IMAGING

## 1 INTRODUCTION

Solar wind data and coronal mass ejection (CME) imagery are critical for warnings and alerts of potential and impending geomagnetic storms, which are the most damaging form of space weather. Areas potentially affected by geomagnetic storms include electric power grids, communications, navigation, air transportation, human space flight, and spacecraft health. NOAA currently receives all this data from NASA and ESA research missions which are, in some cases, well beyond their 2-year design lives. NOAA has studied how to follow these research missions with a continuing operational capability. At the direction of the White House Office of Science & Technology Policy (OSTP), NOAA and other federal agencies are developing a plan to address the long-term need for solar wind & CME data. This paper describes the details of that planning which can be shared at this time.

## 2 MAIN TEXT

### 2.1 RESEARCH BACKGROUND

#### Solar Wind Data

The NASA International Sun-Earth Explorer 3 (ISEE3) mission launched in 1981 first demonstrated an orbit around the sun-Earth L1 Lagrange point, which is a gravitational equilibrium point located approximately 1.5 million km sunward of Earth. The space physics instruments on ISEE-3 measured various solar wind properties which, when sent back to Earth in real-time, were used to predict geomagnetic storms approximately 30-60 minutes before they reached Earth. The NASA WIND mission, launched in 1995, periodically makes similar measurements, but cannot return real-time data. The NASA Advanced Composition Explorer (ACE), launched in 1997, uses a beacon to deliver an operationally useful subset of its space physics data to various ground stations around the world in real-time. This is called the Real-Time Solar Wind (RTSW) Network. These data are sent to NOAA’s Space Weather Prediction Center (SWPC) to generate various space weather alerts and warnings, in conjunction space weather instruments on low-Earth orbit (LEO) and geostationary (GEO) environmental satellites. ACE is the sole source of data for 30-60 minutes warnings of impending geomagnetic storms.

#### Coronal Mass Ejection (CME) Imagery

The NASA/ESA Solar and Heliospheric Observatory (SOHO) and NASA Solar TErrestrial RElations Observatory (STEREO) provide CME imagery. SOHO was launched in 1995, while STEREO launched in 2006. These spacecraft use

coronagraphs to image the corona of the sun, observing coronal mass ejections (CME) leaving the sun. They can tell if CMEs are headed for the Earth. This imagery is used by SWPC for alerts of potential geomagnetic storms from <24 hours to 3 days warning time, depending on the speed of storms. SOHO orbits the L1 point like ACE. STEREO consists of two spacecraft in Earth-following and Earth-leading orbits around the sun that are gradually drifting apart. This arrangement, and a suite of solar imagers, coronagraphs, and heliospheric imagers, allows STEREO to image CMEs in 3 dimensions from the sun, through the corona, and through interplanetary space to the Earth.

## 2.2 PLANNING BACKGROUND

NOAA studies of operational solar wind and CME monitoring missions date back many years. More recently, in 2003, NOAA released a Request for Information (RFI) to industry soliciting information on how to execute a solar wind monitoring mission. This activity brought to our attention the potential for a commercial data buy approach to procuring solar wind data. Based on the positive results of the RFI, NOAA followed this with funded Broad Agency Announcement (BAA) studies into solar wind, communications, and coronal mass ejection imaging. This study awarded two companies, Space Services Inc. and Lockheed Martin, with solar wind studies. SSI Inc. further refined their commercial data buy approach, while Lockheed Martin examined government smallsats and the refurbishment of the NASA Deep Space Climate Observatory (DSCOVR), formerly known as Triana, which carries solar wind instruments and is built for L1 operations. The BAA study also awarded contracts to Southwest Research Institute (SwRI) and the Naval Research Lab (NRL) to study designs of small coronagraphs and heliospheric imagers optimized to meet our observing requirements. The results of these studies were very positive, leading NOAA to three leading candidates for operational solar wind and CME capabilities. These are:

- Refurbish DSCOVR
- Government smallsat
- Commercial data buy

## 2.3 DEEP SPACE CLIMATE OBSERVATORY (DSCOVR)

### DSCOVR Background

The Deep Space Climate Observatory (DSCOVR), formerly called Triana, was intended to be the first Earth science mission to observe the Earth from a sun-Earth L1 Lagrange orbit. The spacecraft was built by Goddard Space Flight Center (GSFC) and planned for launch on a space shuttle. DSCOVR was placed in storage and never remanifested after the space shuttle program was put on hold after the Columbia disaster. DSCOVR carries two Earth science instruments for its original primary mission, an imager and radiometer. DSCOVR also carries a magnetometer and plasma sensor for monitoring the solar wind, which meets the two highest priority NOAA solar wind requirements. The third highest priority requirement would be met by a low-energy charged particle detector.

### DSCOVR Studies

Lockheed Martin in their BAA study examined the documented state of the DSCOVR spacecraft and estimated the cost to refurbish it for flight as a solar wind mission, and to also carry out the original Earth science mission. Based on these results, NOAA solicited a refurbishment cost estimate from NASA GSFC. Following this study, NOAA and the U.S. Air Force (AF) funded NASA GSFC to pull DSCOVR out of storage and examine the spacecraft, including various powered tests of the spacecrafts subsystems. This test was completed and found that the spacecraft was in good health and could be refurbished for use in a solar wind mission. The Earth science instruments were not tested.

## 2.4 CURRENT PLANNING ACTIVITY

The White House Office of Science & Technology Policy (OSTP), recognizing the potential gap in solar wind and other space weather observations, asked the Office of the Federal Coordinator for Meteorology (OFCM) to lead an interagency assessment of the impact of losing the ability to perform geomagnetic storm warnings and forecasts, and assess options for mitigating this loss. The Committee for Space Environmental Sensor Mitigation Options (CSESMO) was formed to perform this assessment from members of several federal agencies, including NOAA, NASA, and the Department of Defense. NOAA brought our prior work to this effort. CSESMO concluded the study and reported their results to OSTP, who is responsible for releasing the information.

# 3 CONCLUSIONS

Prior work by NOAA and recent work by the interagency CSESMO has established a path forward for meeting near and long-term solar wind monitoring and CME imaging capabilities needed for the geomagnetic storm forecasts and warnings that are critical to maintaining our technological infrastructure.