



New NOAA data, products, and research safeguarding the satellite infrastructure from space weather

Green, J.C, W. Denig, J. Rodriguez, T. Onsager, W. Murtagh, R. Rutledge, J. Stankiewicz, J. Kunches, D. Wilkinson



Abstract: Satellites operating in near Earth space are subjected to intense electron and proton radiation that can degrade spacecraft performance or cause complete failure. The radiation intensity near Earth fluctuates dramatically depending on the current space weather conditions. In response to this environmental threat to this aspect of the world's technological infrastructure, NOAA is enhancing its support for understanding and resolving satellite anomalies caused by space weather. The NOAA Space Weather Prediction Center provides real time measurements of the space radiation intensity and issues alerts, warnings and watches when warranted by the current threat conditions. Now, the NOAA National Geophysical Data Center is complementing this effort by providing additional data, products, and expertise for post- satellite anomaly assessment, resolution, and improved satellite design. We report on NOAA's plans for providing data, products and services to protect the worlds satellite infrastructure from space weather effects.

1.0 Introduction

Space weather impacts much of our society's critical technology and infrastructure including satellites in Earth orbit. Energetic charged particles streaming from the sun as well as those trapped within Earth's magnetosphere field can temporarily or permanently disable satellite electronics and severely limit performance and lifetimes. Space weather effects drive satellite design and daily space operations. To mitigate this hazard, NOAA assesses the needs of the satellite community and provides a suite of data and other services for understanding and coping with space weather related anomalies.

2.1 Assessing the Needs of the Satellite Community

NOAA brought together government and commercial satellite designers and operators for a **Satellite Anomaly Mitigation Stakeholders Meeting** in April 2012 to

- Review issues space weather poses for satellites today
- Discuss current and future products and services
- Identify what else is needed
- Discuss issues presented by large events and level of preparedness

Highlights of the meeting

- From the insurance perspective the risk posed by space weather is being controlled to a reasonable degree with some room for improvement.
- However, the magnitude and expected impact of a large space weather event on the overall satellite infrastructure is difficult to quantify
 - Each satellite is unique, information is proprietary, and large margins are included in design
 - Environmental data is sparse and physics based model parameters are not well constrained
 - The interdependencies on satellite services are not well known

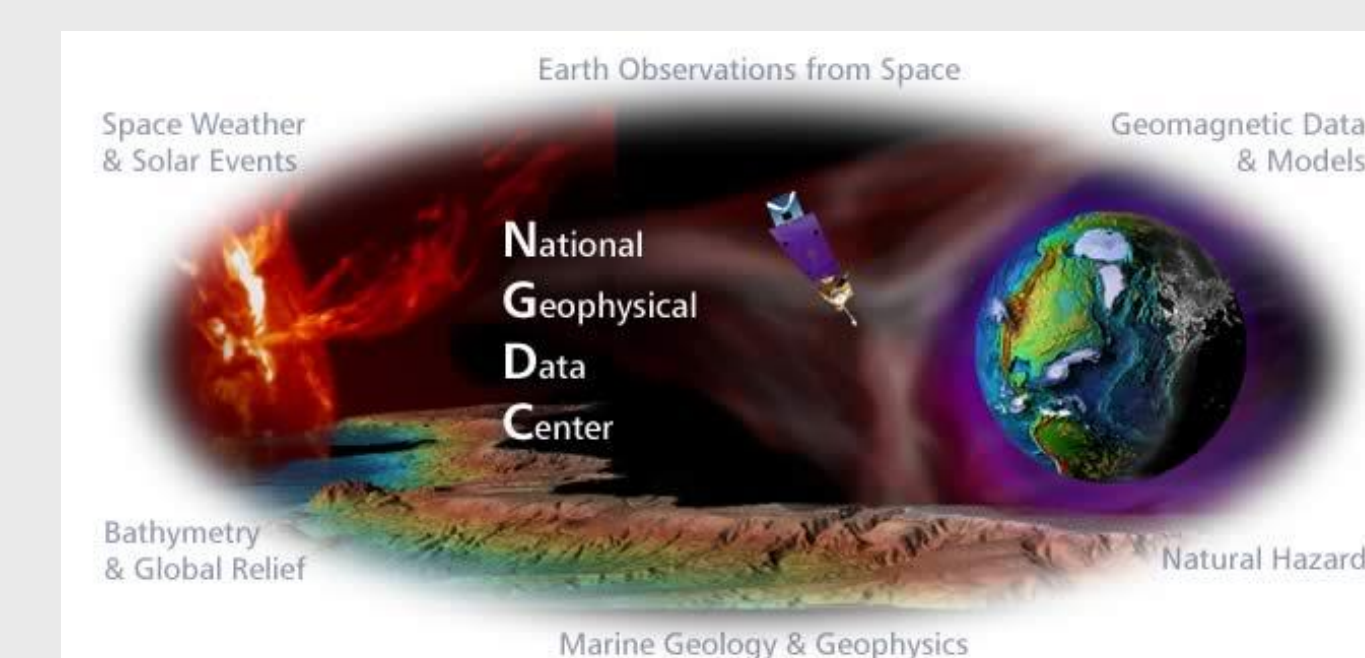
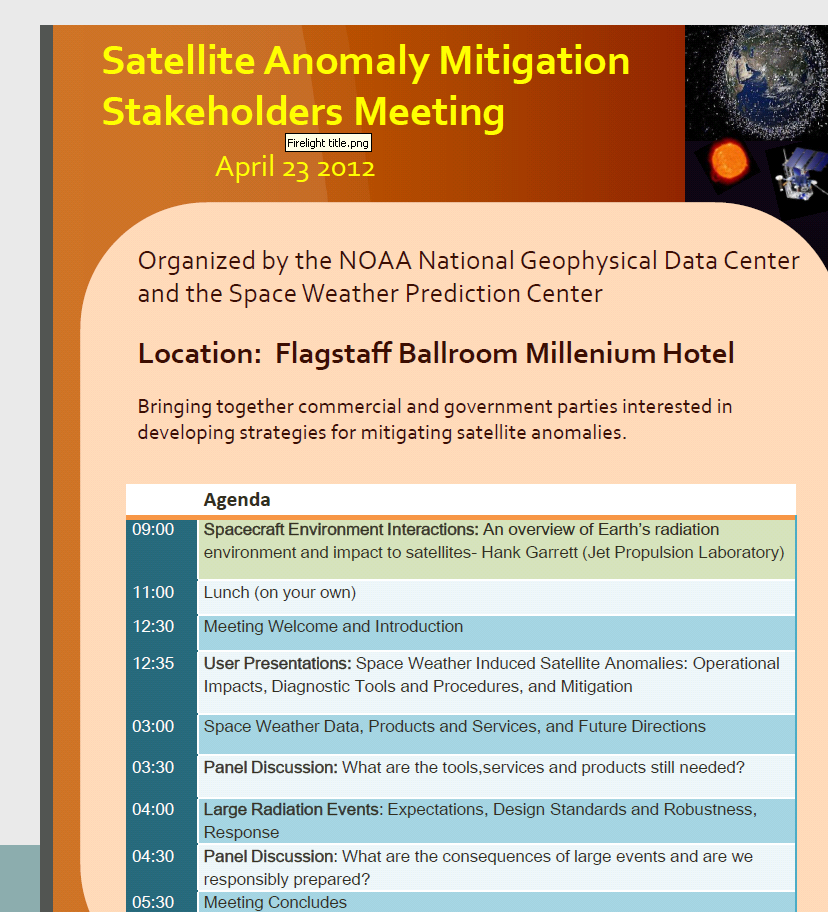
2.2 Needs of the Satellite Community

Suggestions for coping with large space weather events

- Create extreme event alerts based on comparisons of real-time space particle radiation measurements to worst case environments commonly used for design
- Perform a 'day without satellites' study to assess the impact of many satellites lost temporarily or permanently due to space weather
- Have a plan ready to deal with the aftermath because there is no effective means for safeguarding satellites just before or during an extreme event

General Suggestions/requirements from the community

- Create a satellite anomaly database for reporting satellite issues
 - A database would highlight connections between the environment and satellite problems enabling products that would predict anomalies based on the space environmental conditions
 - Inform satellite designers of potential design vulnerabilities to space weather
 - Could be used as a real time validation of predictive models
- List of desired data and products including
 - Integrated total proton event fluences for estimating the degree to which individual large events decrease expected lifetimes and performance
 - Internal charge accumulation based on high energy electrons for understanding when a satellite might experience a large damaging discharge
- Provide a comprehensive list of simple inexpensive radiation monitors that could be included as payloads on many satellites



3.0 New NOAA Products and Services

In response to suggestions from the Satellite Anomaly Mitigation Stakeholders meeting as well as other input NOAA has created a satellite anomaly mitigation team sam@noaa.gov

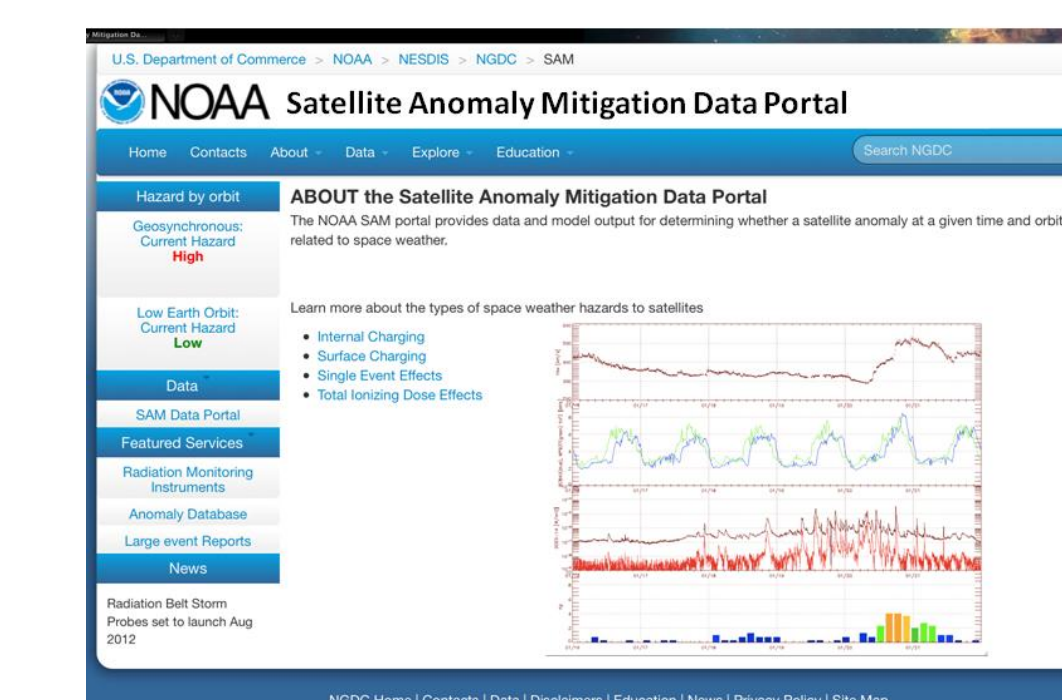
Environmental Assessments for Significant Events

The team generates reports on the space weather environment during time where significant problems have been reported.

Examples: Galaxy 15 anomaly (ftp://ftp.ngdc.noaa.gov/STP/publications/stp_presentations/presentations-oral/2011/WDenigEtAl_BSA_2011.pdf), disruption of service from Skyterra-1, and recent space weather issues with the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on the Suomi National Polar-orbiting Partnership (NPP) satellite.

Satellite Anomaly Mitigation Data Portal

- Provides a gateway for real time and archive data needed to determine whether satellite anomalies are related to the space environment
- Data are presented along with a decision tree for determining the likelihood of 4 types of anomalies
- Provides mechanism for reporting anomalies and accessing anomaly database



- Available 2013
- Space Environmental Anomalies Expert System Real Time [O'Brien et al., 2009]

- Provides hazard quotients for 4 types of anomalies
 - Internal charging
 - Surface charging
 - Single event upsets
 - Total dose events
- Available 2013

