

Appendix 1 to Annex K to Emergency Support Function #15 External Affairs **Space Weather Activity Prior to Possible Power Outage**

References:

- A. National Planning Frameworks (NRF)
- B. NOAA Space Weather Scales

1.0 Purpose

The annex captures the roles and responsibilities of a space weather incident leading up to an impending extreme space weather event and the resulting threat of prolonged power outage that impacts critical infrastructure, the private sector, state, local, tribal, and territorial governments, communities, and individuals and families.

2.0 Space Weather Incidents

The sun is the main source of space weather. Sudden bursts of plasma and magnetic field structures from the sun's atmosphere called coronal mass ejections (CME) together with sudden bursts of radiation, or solar flares, all cause space weather effects on Earth. Space weather can produce electromagnetic fields that induce extreme currents in wires, disrupting power lines, and even causing prolonged, wide-spread blackouts. Severe space weather also produces solar energetic particles, which can damage satellites used for commercial communications, global positioning, intelligence gathering, and weather forecasting.

2.1 Geomagnetic Storms

Geomagnetic storms, strong disturbances to Earth's magnetic field, pose problems for many activities, technological systems, and critical infrastructure. The Earth's magnetic field changes in the course of a storm as the near-Earth system attempts to adjust to the jolt of energy from the sun carried in the solar wind, known as Coronal Mass Ejections (CMEs). Their effects can disturb the geomagnetic field for days at a time.

The most visible attribute of a geomagnetic storm is the aurora, which becomes brighter and moves closer to the equator. This heightened aurora signals the vigorous electrodynamic processes at play as they respond to the burst of energy. Geomagnetic storms usually last a few hours to days. The strongest storms may persist for up to a week.

A string of CMEs may cause prolonged disturbed periods related to the additional energy being pumped into Earth's magnetic field. The frequency of geomagnetic storms depends on where Earth is in the solar cycle—with most storms occurring near solar maximum; however, these storms are also common in the declining phase due to high-speed solar wind streams. Geomagnetic storms induce currents that can have significant impact on electrical transmission equipment. Electric power companies have procedures in place to mitigate the impact of geomagnetic storms.

3.0 Space Weather Research

NASA's Space Weather Research Center provides routine experimental research forecasts, notification, space weather analysis, and spacecraft anomaly resolution assistance in support of NASA robotic missions and human spaceflight. Data from NASA missions provide initial views of space weather activities from different vantage points, and these observations are cornerstones of NASA space weather research. NASA's Community Coordinated Modeling Center (CCMC) is a multi-agency partnership that tests and evaluates models and provides, to the international research community, access to modern space science simulations. In addition, the CCMC supports the transition of modern space research models to space weather operations.

The Department of Defense (DoD) maintains organic space weather research capabilities in support of DoD-wide and service-specific operational requirements. The Air Force Research Laboratory, the Air Force Office of Scientific Research, the Naval Research Laboratory, the Office of Naval Research, and the Army Research Laboratory coordinate, execute, and promote science and technology programs internally or through schools, universities, government laboratories, and non-profit and for-profit organizations.

4.0 Space Weather Prediction

Space weather prediction services in the United States are provided primarily by [NOAA's Space Weather Prediction Center \(SWPC\)](#) and the [U.S. Air Force's \(USAF\) 557th Weather Wing](#) Space Weather Operations Center (SpaceWOC), which work closely together to address the needs of their civilian and military user communities. The SWPC draws on a variety of data sources, both space and ground-based, to provide forecasts, watches, warnings, alerts, and summaries as well as operational space weather products to civilian and commercial users. The USAF SpaceWOC exploits data openly available to the community as well as military-unique data sources to provide summaries, analyses, forecasts, alerts, warnings and other products at multiple security classification levels to meet DoD requirements in support of global joint operations.

The Space Radiation Analysis Group (SRAG) at the Johnson Space Center is responsible for ensuring that the radiation exposure received by astronauts remains below established safety limits. To fulfill this responsibility, the group uses a comprehensive crew exposure modeling capability and provides radiation exposure projections for astronauts prior to flight and prior to extra-vehicular activity (EVA).

4.1 Watch

A Watch is issued when the risk of a potentially hazardous space weather event has increased significantly, but its occurrence or timing is still uncertain. It is intended to provide enough advanced notice so those who need to set their plans in motion can do so. The purpose of a Watch is to give preliminary notification of possible space weather activity with a lead-time of hours to days. A Watch can be upgraded to a higher-level Watch. Example:

WATCH: Geomagnetic Storm Category G3 Predicted

Highest Storm Level Predicted by Day:

Dec 30: G3 (Strong) Dec 31: G1 (Minor) Jan 01: None (Below G1)

THIS SUPERSEDES ANY/ALL PRIOR WATCHES IN EFFECT

*NOAA Space Weather Scale descriptions can be found at
www.swpc.noaa.gov/noaa-scales-explanation*

*Potential Impacts: Area of impact primarily poleward of 50 degrees
Geomagnetic Latitude.*

*Induced Currents - Power system voltage irregularities possible, false alarms
may be triggered on some protection devices.*

*Spacecraft - Systems may experience surface charging; increased drag on
low Earth-orbit satellites and orientation problems may occur.*

*Navigation - Intermittent satellite navigation (GPS) problems, including loss-
of-lock and increased range error may occur.*

Radio - HF (high frequency) radio may be intermittent.

Aurora - Aurora may be seen as low as Pennsylvania to Iowa to Oregon.

4.2 Warning

A Warning is issued when a significant space weather event is occurring, imminent or likely. A Warning is a short-term, high confidence prediction of imminent activity. The purpose of a Warning is notification of impending space weather activity with a lead-time of minutes to a few hours. A Warning can be upgraded to a higher Warning if space weather conditions are expected to change sufficiently enough to warrant the upgrade. Example:

WARNING: Geomagnetic K-index of 7 or greater expected

Warning Condition: Onset

NOAA Scale: G3 or greater - Strong to Extreme

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*Potential Impacts: Area of impact primarily poleward of 50 degrees
Geomagnetic Latitude.*

*Induced Currents - Power system voltage irregularities possible, false alarms
may be triggered on some protection devices.*

*Spacecraft - Systems may experience surface charging; increased drag on
low Earth-orbit satellites and orientation problems may occur.*

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of-lock and increased range error may occur.*

Radio - HF (high frequency) radio may be intermittent.

Aurora - Aurora may be seen as low as Pennsylvania to Iowa to Oregon.

4.3 Alert

Alerts indicate that the observed conditions, highlighted by the warnings, have crossed a preset threshold or that a space weather event has already started.

Example:

ALERT: Geomagnetic K-index of 7

Active Warning: Yes

NOAA Scale: G3 - Strong

NOAA Space Weather Scale descriptions can be found at

www.swpc.noaa.gov/noaa-scales-explanation

*Potential Impacts: Area of impact primarily poleward of 50 degrees
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*Induced Currents - Power system voltage irregularities possible, false alarms
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of-lock and increased range error may occur.*

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Aurora - Aurora may be seen as low as Pennsylvania to Iowa to Oregon.

5.0 Space Weather Scales

The NOAA Space Weather Scales communicate current and future space weather conditions, and their possible effects on people and systems. NOAA space weather scales correlate space weather events with their likely effects on technological systems. The scales have numbered levels, analogous to hurricanes, tornadoes, and earthquakes, that convey severity.



NOAA Space Weather Scales



Category		Effect	Physical measure	Average Frequency (1 cycle = 11 years)
Scale	Descriptor	Duration of event will influence severity of effects		
Geomagnetic Storms				
G 5	Extreme	<p>Power systems: widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage.</p> <p>Spacecraft operations: may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites.</p> <p>Other systems: pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.).**</p>	Kp=9	Number of storm events when Kp level was met; (number of storm days) 4 per cycle (4 days per cycle)
G 4	Severe	<p>Power systems: possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid.</p> <p>Spacecraft operations: may experience surface charging and tracking problems, corrections may be needed for orientation problems.</p> <p>Other systems: induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.).**</p>	Kp=8	100 per cycle (60 days per cycle)
G 3	Strong	<p>Power systems: voltage corrections may be required, false alarms triggered on some protection devices.</p> <p>Spacecraft operations: surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems.</p> <p>Other systems: intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.).**</p>	Kp=7	200 per cycle (130 days per cycle)
G 2	Moderate	<p>Power systems: high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage.</p> <p>Spacecraft operations: corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions.</p> <p>Other systems: HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.).**</p>	Kp=6	600 per cycle (360 days per cycle)
G 1	Minor	<p>Power systems: weak power grid fluctuations can occur.</p> <p>Spacecraft operations: minor impact on satellite operations possible.</p> <p>Other systems: migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).**</p>	Kp=5	1700 per cycle (900 days per cycle)

* Based on this measure, but other physical measures are also considered.

** For specific locations around the globe, use geomagnetic latitude to determine likely sightings (see www.swpc.noaa.gov/Aurora)

6.0 Roles and Responsibilities

6.1 NOAA/SWPC

NOAA SWPC continually monitors and forecasts the Earth's space environment. It is also primary federal authority of space weather alerts and warnings for the United States.

- **Space Weather Alerts and Warnings**

Similar to the bulletins put out by the NWS local forecast offices, SWPC provides Alerts, Watches and Warnings to the public at large about what to expect from Space Weather. These bulletins are levels of severity of the solar activity that can be expected to impact the Earth's environment.

6.2 NASA

NASA's Space Weather Research Center addresses the space weather needs of NASA's robotic missions and human spaceflight through routine experimental research forecasts, notification, space weather analysis, and spacecraft anomaly resolution support.

6.3 DHS/FEMA

DHS/FEMA tools can support NOAA SWPC Alerts, Watches and Warnings through its coordination platforms to reach key emergency management communications teams at the Federal, state, local, tribal and private sector level to align communication messages to provide timely public information.

- **National Incident Communications Conference Line (NICCL)**
The NICCL is used for the transmission and exchange of critical and timely incident information among Federal and affected state, local, tribal and territorial authorities.
- **State Incident Communications Conference Line (SICCL)**
The SICCL is a dedicated Federal-state-tribal incident communication conference line similar to the NICCL.
- **Private Sector Incident Communications Conference Line (PICCL)**
The PICCL is a standing line and distribution list that may be used to provide timely public information to private sector communicators in Critical Infrastructure industries.

6.4 DOD

The USAF SpaceWOC is the DoD's only operations center, providing 24/7 space environmental monitoring and forecasting at multiple security classification levels in support of global joint operations. It is the primary source of space environment information at classified levels for the National Security Council, informing the formulation and implementation of national security policy.

- **Space Weather Product Dissemination**
The SpaceWOC provides summaries, analyses, forecasts, alerts, warnings and other products through a mixture of subscription service (automatic send) and via the AF Weather-Web Services (AFW-WEBS) (individual retrieve) internet capability. Both services are available at multiple security enclaves. The SpaceWOC coordinates specific alerts, warnings, and forecasts with SWPC to ensure horizontal consistency of information being disseminated to the space weather community.

6.5 DOE

Department of Energy works with the energy asset owners and operators to advise state, local, tribal and territorial authorities and the private sector to develop procedures and products that improve situational awareness to effectively response to disruptions to the energy sector.

7.0 Federal Space Weather Resources

Power Outage Incident Annex (currently in draft)

NASA Research: http://www.nasa.gov/mission_pages/sunearth/index.html

NOAA SWPC Forecasting: <http://www.swpc.noaa.gov/forecasts>

NOAA SWPC Reporting: <http://www.swpc.noaa.gov/reports>