



# Federal Operating Concept for Impending Space Weather Events

May 2019



Homeland  
Security

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The Federal Operating Concept for Impending Space Weather Events was directed by Presidential Executive Order (EO) 13744, “Coordinating Efforts to Prepare the Nation for Space Weather Events,” and supports the National Space Weather Strategy. This Federal operating concept provides guidance to departments and agencies (D/As), to be used in the development of their operational plans to prepare for, protect against, and mitigate the effects of impending space weather events. It focuses on the operational and crisis planning functions, reporting structure, and reporting requirements of D/As in response to notification of a forecasted event.

D/As are responsible for identifying and developing processes and procedures within their organization to receive and monitor space weather notifications from the National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center (SWPC) daily. Other relevant notification systems may also be used, such as the United States Air Force (USAF) Space Weather Operations Center (SpaceWOC). The designated representatives at D/As will be responsible for:

- Engaging with internal and external scientific and engineering experts to analyze, identify, and mitigate equipment or system vulnerabilities;
- Communicating elevated space weather hazard status to their respective agency leadership; and
- Upon notification of a potential space weather incident, commence reactive protective actions and communicate operating status to the Department of Homeland Security (DHS) National Operations Center (NOC).

### Space Weather Incidents - Warning Times, Duration and Potential Effects

Incident	Notification Time	Duration	Impact
Radiation Event (S4-5)	Minimum = 30 minutes Maximum = several hours	Minimum = Few hours Maximum = Few days	Satellite operations degraded/lost Increased radiation exposure to aircraft at high altitudes Increased radiation to aircraft at high latitudes HF blackout in polar regions
Geomagnetic Disturbance (G4-5)	Minimum = 16 hours Maximum = 90 hours	Minimum = 1 day Maximum = 2 days	Possible bulk power grid collapse (in only the most intense G5 events) Degradation/loss of satellite and sky wave radio communication Degradation/loss of GPS navigation and timing Degradation of satellite operations

## Key Activities and Considerations

**Risk Analysis:** Each D/A will evaluate vulnerabilities to infrastructure and operations – including operational continuity and across the 16 critical infrastructure sectors – and assess their potential consequences to:

- Command, control, and communications;
- Delivery of Essential Services;
- Potential for cascading risk to human life;
- Potential for long-term or irreversible loss of property; and
- Potential for risk to national security.

**Alerts and Notifications:** NOAA SWPC Space Weather Prediction Center and USAF SpaceWOC will disseminate notifications of conditions that may pose an elevated threat of an incident and the occurrence of a radio blackout, radiation storm, or geomagnetic storm.

**Protective Actions:** Each D/A shall develop and disseminate to its programs, personnel, customers, sector representatives, and stakeholders:

- Messaging on expectations regarding the duration of impact and appropriate protective measures;
- Advice on the prioritization of resources for life sustain or national security purposes;
- Protection procedures for infrastructure or critical assets;
- Notification of impacts to essential goods and services; and
- Prioritization of back-up systems, critical supplies, and enabling resources.

**Operational Adaptations:** Each D/A may employ backup systems and crisis action planning to ascertain and execute infrastructure restoration, continuity of mission essential functions, and support to infrastructure sectors.

**Operational Coordination for Response:** FEMA will initiate incident management coordination among federal, state, territory, and non-governmental organizations at the National Response Coordination Center.

Coordination actions include:

- Departments and agencies evaluate their systems for damage or degradation and restore systems;
- Activate, mobilize, and employ response and recovery mission capabilities pursuant to the Federal Interagency Operations Plans and their associated incident annexes; and
- Establishment of a Joint Information Center in concert with the National Infrastructure Coordination Center and Space Weather Prediction Center.

## Infrastructure and Lifeline Coordination

**Sector Risk Mitigation:** Each Sector Specific Agency (SSA) shall coordinate with industry partners to:

- Conduct continuous inquiries with sector partners to monitor the onset and scale of impacts
- Disseminate messaging on expected duration and scale of impact; and appropriate protective measures
- Prioritize resources for emergency, life sustaining, or national security goals
- Execute precautionary critical infrastructure protection plans as appropriate
- Notify customers of potential impacts to essential goods and services
- Prioritize and supply of critical backup systems and enabling resources (e.g., generation, fuel)



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## INTRODUCTION

Space weather<sup>1</sup> events such as solar flares, solar energetic particles, and geomagnetic disturbances occur regularly and could have measurable effects on critical Earth-based infrastructure, such as the Global Positioning System (GPS), satellite operations, communications, aviation, and the electrical power grid. Space weather events of extreme intensity have the potential to disable large portions of the electrical power grid, resulting in cascading failures that would affect key services such as water supply, healthcare, and transportation. Successfully preparing for space weather events is a whole community endeavor that requires partnerships across governments, emergency managers, academia, the media, the insurance industry, non-profits, and the private sector.

In recognition of this threat, the President issued Executive Order (EO) 13744, “Coordinating Efforts to Prepare the Nation for Space Weather Events.” Creation of this document, the *Federal Operating Concept for Impending Space Weather Events*, was directed by section 5f of EO 13744 to coordinate federal assets and activities to respond to notification of, and protect against, impending space weather events. Departments and agencies (D/As) shall develop their own operational plans that document their procedures and responsibilities to prepare for, protect against, and mitigate the effects of impending space weather events. Such operational plans will be developed to support the Federal operating concept, be compatible with the National Preparedness System, and ensure continuity of D/A’s Mission Essential Functions (MEF).

### Purpose

This document outlines the necessary actions departments and agencies should take to prepare for, and respond to, a notification of an *impending* space weather event. The information in this document is based on current science regarding space weather and is intended as general guidance. It does not include all potential impacts from space weather or all actions required to maintain continuity of operations; D/As should use this information as it applies to their agency and consider additional actions as required by their unique needs.

### Scope

The guidance in this document applies to all D/As; each should create an operational plan that addresses the space weather hazard and create necessary protective actions<sup>2</sup> to minimize its impact on the nation’s critical infrastructure, systems, and operations. D/A operational planning should address pre-incident preparation and mitigation, actions taken upon notification of a forecasted event, and the process for reporting actions taken and ensure continuity of operations in a communications and power challenged environment.

This Federal operating concept focuses on the actions taken by the federal government during steady state operation and upon notification of a forecasted extreme space weather event. The following is a brief

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<sup>1</sup> Space weather refers to variations in the space environment between the Sun and Earth (and throughout the solar system) that can impact human health and technologies in space and on Earth.

<sup>2</sup> As D/As receive SWPC notifications of escalating threat, they are encouraged to consider executing protective actions where applicable. D/As must balance the potential for minimizing damage against the disruption to essential services that may be caused by a protective action, such as shutting down a system. Planners are encouraged to work with their leadership, the science and engineering communities, and their public and private sector stakeholders to understand the potential benefits as well as undesirable consequences of any proactive attempts to minimize the impacts of significant space weather events.

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summary of movement through the emergency management phases; a more detailed description is provided in the Federal operating concept chapter of this document. During Phase 1A (Normal Operations), the primary goal for each D/A is the execution of preparation and mitigation actions in anticipation of a space weather incident. During phases 1B (Elevated Threat) and 1C (Credible Threat), the focuses are on implementing protective actions and ensuring communication/reporting systems are established. Although phase 2A (Initial Response) is briefly described in this document, specifically the unique areas that should be of concern in a space weather incident, it is not intended to function as D/A operational planning guidance. Its inclusion is to illustrate the transition from space weather pre-impact to post-impact. D/As shall create their own operational plans to ensure MEFs remain viable and their continuity of operations (COOP) and continuity of government (COG) plans shall take into consideration the space weather hazard. D/As are also responsible for providing assistance to other entities and will coordinate interagency efforts as described in the Federal Interagency Operational Plan (FIOP).

### **Authorities**

The creation of this operating concept is authorized in EO 13744. This guidance does not supersede existing emergency plans or guidance, nor does it alter or impede the ability of D/As to carry out their statutory authorities and specific responsibilities. Details regarding specific D/A authorities are further detailed in Appendix D.

## **BACKGROUND**

Space weather forecasters can quickly identify and characterize incidents on the Sun that may cause impacts on Earth, but precise measurements of incident strength and specific location may not be available. The difficulty in predicting the damage associated with any space weather incident is compounded by the inherent uncertainty in vulnerabilities across the wide variety of technology and infrastructure systems used by D/As. These systems have unique vulnerabilities to communication and/or power disruptions; therefore, universal predictions regarding the extent of post-incident damage are not currently possible.

### **Space Weather Events**

The National Oceanic and Atmospheric Administration (NOAA) has developed metrics to classify the intensity of space weather events. The intensity is quantized into five levels: minor (level one), moderate (level two), strong (level three), severe (level four), and extreme (level five). Radiation event are designated by the prefix “S”, while geomagnetic disturbances use the prefix “G”. The scope of this document is restricted only to severe and extreme geomagnetic disturbances or radiation events (i.e. G4, G5, S4, and S5).

The following is a brief summary of space weather event types. A more in-depth explanation is provided in Appendix B.

#### **Radiation Event (S-scale)**

Eruptions on the Sun can generate storms of energetic solar particles that can penetrate Earth’s magnetic field. Once inside Earth’s magnetic field, the particles are channeled down Earth’s magnetic field lines,



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penetrating the atmosphere near the North and South Poles. Solar radiation storms arrive in tens of minutes from the solar eruption and can build in intensity over several hours with total event durations of hours to days. Intense radiation storms (i.e., those labeled S4 and S5 on the S-scale) can result in damage to satellites and significantly increase operational anomalies that could create a challenging environment for aviation and satellite operations. Satellite-based navigation services, such as the Global Positioning System (GPS), and HF radio communications in Polar Regions may be degraded or lost. Passengers and crew in aircraft flying at high altitudes and high latitudes may be exposed to increased radiation.

### Geomagnetic Disturbance (G-scale)

A geomagnetic disturbance is a disturbance of Earth's magnetic field that occurs when enhanced solar wind buffets the space environment surrounding Earth. There is an exchange of energy from the Sun's solar wind into Earth's environment. The strongest geomagnetic disturbances are associated with coronal mass ejections (CMEs). CMEs are large eruptions of magnetized plasma from the outer solar atmosphere or corona. Some of the most intense geomagnetic disturbances have been observed to begin as soon as 16 hours after the CME erupts on the sun.

Although geomagnetic events create visible aurora, but they can also create geomagnetically induced currents (GICs) in the electric power grid, which can result in widespread voltage control problems and even blackouts (in only the most severe and rare events). Geomagnetic disturbances also cause variations in the ionosphere, which can modify the path of both ground-based HF radio signals and satellite signals. This can result in degraded or lost signals from communication satellites and can produce errors in position and timing information provided by GPS. The vulnerability of communications, global navigation satellite systems, and electric power to an extreme geomagnetic disturbance are the primary areas of concerns for a space weather event.

Space weather occurrences differ in scope, strength and type, however, for the purposes of planning, the events that are most threatening to communication and power infrastructures are the G4, G5 and S4, S5 events. The following table details the space weather phenomena that pose the greatest hazard to critical infrastructure on Earth.

**Table 1: Critical Information Requirements**

Space Weather Incidents - Warning Times, Duration and Potential Effects			
Incident	Notification Time	Duration	Impact
Radiation Event (S4-5)	Minimum = 30 minutes Maximum = several hours	Minimum = Few hours Maximum = Few days	Satellite operations degraded/lost Increased radiation exposure to aircraft at high altitudes Increased radiation to aircraft at high latitudes HF blackout in polar regions
Geomagnetic Disturbance (G4-5)	Minimum = 16 hours Maximum = 90 hours	Minimum = 1 day Maximum = 2 days	Possible bulk power grid collapse (in only the most intense G5 events) Degradation/loss of satellite and sky wave radio communication Degradation/loss of GPS navigation and timing Degradation of satellite operations

## Operational Planning Guidance

In accordance with EO 13744, heads of all D/As that support NEFs must ensure that space weather incidents are adequately addressed in their all-hazards preparedness programs. Further, all D/As are tasked with the development of operational plans that document their procedures and responsibilities to prepare for, protect against, respond to, and mitigate the effects of space weather events. Those plans should be compatible with the National Preparedness System described in PPD-8 and should also be informed by the guidance provided in this document.

The descriptions of operational phases within this Federal operating concept contain guidance for three kinds of actions: 1) pre-incident preparation, 2) actions in response to notification of a predicted event, and 3) the process of reporting pre-incident preparatory actions taken. Incident response and recovery is covered in the respective FIOPs and it not covered in this document. As extreme space weather incidents occur infrequently, the exact nature of the consequences is not well established; however, it shall be assumed that consequences may be severe with cascading impacts across interdependent sectors, as described in Appendix C. This Federal operating concept reflects the current scientific understanding and seeks to prepare each agency ideas for intense space weather incidents. It should be noted that a space weather event could last as little as a couple of hours or as long as a few days.

D/As are responsible for identifying and developing processes and procedures within their organization to receive and monitor space weather notifications from NOAA SWPC daily. Other relevant notification sources may also be used, such as the USAF SpaceWOC. The designated representatives at D/As will be responsible for:

- Engaging with internal and external scientific and engineering experts to analyze, identify, protect, and mitigate equipment and/or system vulnerabilities;
- Communicating elevated space weather hazard status to their respective agency leadership; and
- Upon notification of a potential space weather incident, commencing reactive protective actions, and communicating operating status to the Department of Homeland Security (DHS) National Operations Center (NOC).

D/As shall work together, consistent with their ongoing activities, to develop models, observation systems, technologies, and approaches that inform and enhance national preparedness for the effects of space weather incidents, including how space weather incidents may affect critical infrastructure and change the threat landscape with respect to other hazards. In addition to the planning guidance provided in this document, D/As should consult with available scientific and engineering experts to better understand potential impacts to systems and equipment used to deliver mission essential functions.

## FEDERAL OPERATING CONCEPT

This Federal operating concept focuses on the actions taken by the federal government during steady state operations, actions taken upon notification of an impending space weather events, and briefly discusses the unique characteristics of a space weather event for response. The goal for planning in each phase of an event should be for the D/A to continue to operate and perform MEFs. This planning includes preparation, mitigation, and reaction to notification of an event. Each D/A should also ensure their continuity plans reflect the unique challenges of a communication and energy restrained environment which could occur during a space weather event. Post-impact governmental coordination for phase 2A (initial response) is covered in the FIOPs and should be addressed in the D/As operational plans. The following guidance outlines planning considerations and required actions overlaid against a standard response timeline. Planners are encouraged to incorporate this format in their operational plan.

This chapter begins by discussing D/A roles and responsibilities with respect to space weather events, with a focus on pre-event responsibilities. Some responsibilities for the response and recovery operational phases are mentioned for completeness, but the list is not exhaustive because not all responsibilities are within the scope of this Federal operating concept. The operational phases are discussed in depth, including the actions that D/As are advised to take in response to impending space weather events. Many of the actions that D/As will take in each operational phase are focused on communication and coordination of their actions. The chapter concludes with a brief discussion of the types of information that should be communicated if possible.

### D/A Roles and Responsibilities

Impacts of a space weather event may require coordination across many federal agencies to respond in an effective and timely manner. The primary responsibility of each D/A is to ensure viability of their MEFs in a communications and energy degraded environment which may be caused by a space weather event. Secondly, each D/A should also strive to facilitate interagency communication and cooperation to increase protective and response capabilities at the national level.

Although not exhaustive, the following D/As have direct responsibilities concerning the space weather hazard and should be consulted as necessary in creating operational plans.

### Monitoring and Communication of Space Weather Events

**National Oceanic and Atmospheric Administration (NOAA):** The Space Weather Prediction Center (SWPC) is the center within NOAA whose mission is to provide timely and accurate space weather forecasting.

*SWPC is the official source of space weather forecasts, alerts, and warnings in the United States, exclusive of the Department of Defense (DoD).* D/As are advised to subscribe to SWPC notifications and to utilize these products to inform their planning and preparedness activities. The link to subscribe to SWPC notifications is <http://www.swpc.noaa.gov/content/subscription-services>

**Department of Defense (DoD):** The Air Force is the department responsible for ensuring the timely provision of operational space weather observations, analyses, forecasts, and other products to support the mission of the DOD. The Space Weather Flight, 2nd Weather Squadron, 2nd Weather Group, 557th

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Weather Wing (USAF SpaceWOC), based at Offutt Air Force Base, Nebraska, is the primary source for space weather prediction, modeling, alerts, and warnings for DoD, the intelligence community, and coalition partners.

### Research and Development

Led by the Department of Commerce's NOAA, the DOD, and the National Aeronautics and Space Administration (NASA), the federal D/As with science and technology components perform research to advance understanding of space weather phenomena, improve predictive modeling, develop mitigation and protection strategies designed to shield infrastructure from harm, and communicate their findings to all federal D/As. When developing operational plans, D/As can leverage the scientific and engineering expertise of the following key agencies to analyze, identify, and mitigate equipment or system vulnerabilities.

**National Aeronautics and Space Administration (NASA):** Implements a national research program to understand the Sun and its interactions with the solar system, especially Earth, to advance space weather modeling and prediction capabilities. NASA also develops and operates space weather research missions, instrument capabilities, and models for space weather events. It also supports the transition of space weather models and technology from research to operations and from operations to research.

**National Science Foundation (NSF):** Supports fundamental research linked to societal needs for space weather information through investments and partnerships, as appropriate.

**Department of Energy (DOE):** Analyzes potential impacts to grid reliability, identifies vulnerabilities, and evaluates technology that can protect or mitigate against space weather effects. During warning of a very intense G-5 storm, DOE may contact members of the energy sector to offer assistance. If damage occurs, DOE may employ the Defense Production Act (DPA) as necessary to expedite production and delivery of damaged critical components. DOE will also remain prepared to issue a grid security emergency after consulting with stakeholders.

### Federal Emergency Operations

**Department of Homeland Security (DHS):** Federal Emergency Management Agency (FEMA) leads the development of this Federal operating concept and associated checklist to provide guidance to federal D/As developing operational plans to respond to notifications of and protect against disruptions caused by space weather events. If required, FEMA will coordinate federal emergency management response post-impact in accordance with its authorities under the Stafford Act and per established all-hazards plans.

**Department of State:** In consultation with the heads of relevant D/As, carries out diplomatic and public diplomacy efforts to strengthen global capacity to prepare for and respond to space weather events.

**Department of the Interior (DOI):** Sustains the existing ground-based geomagnetic monitoring network and enhances the network through the installation of new observatories.

**D/As with NEFs:** Ensure timely reporting to FEMA's National Continuity Programs Directorate of potential and realized impacts to MEFs using existing plans, procedures, and processes.

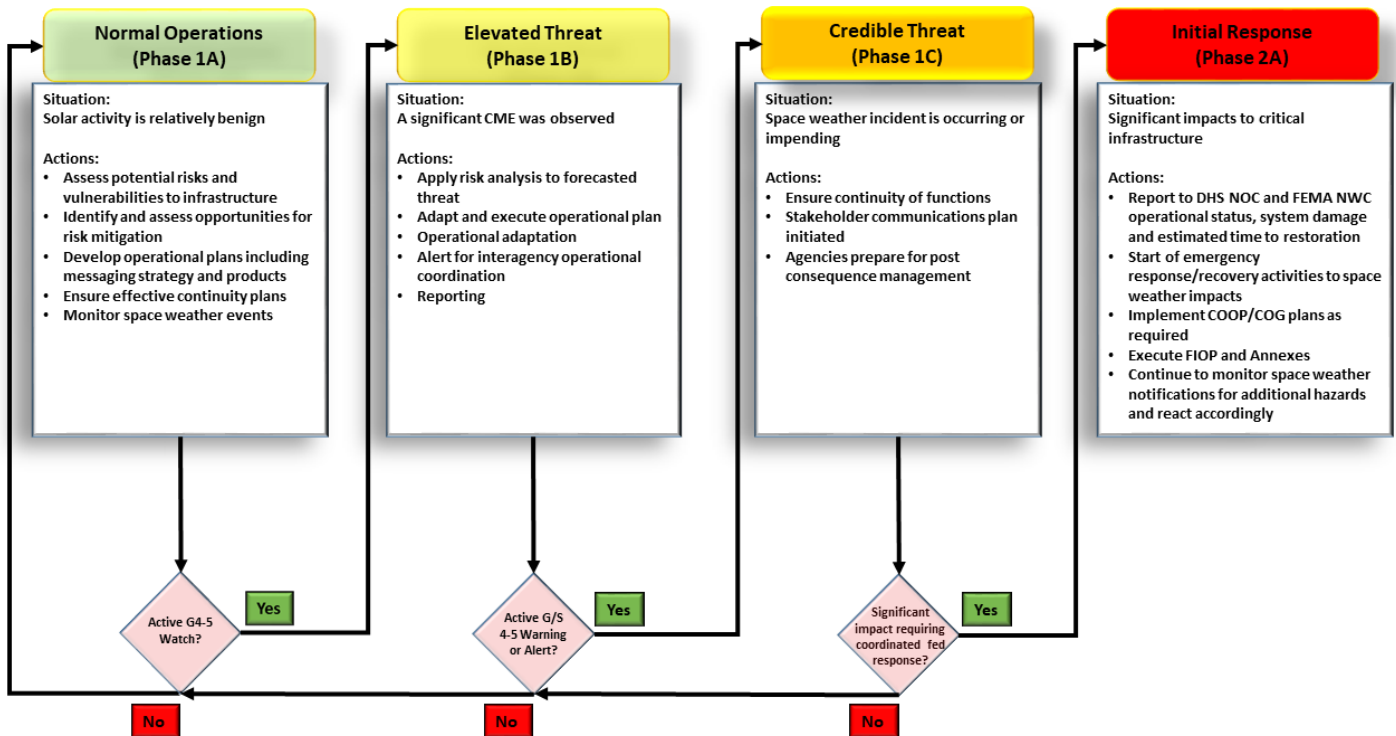
## Operational Phases

The following section describes the emergency management operational phases and details the actions D/As should take within each phase in preparation for, or in reaction to, the notification of an impending space weather incident. The escalation from one operational phase to another occurs upon notification of a potential hazard to Earth through a notification from SWPC. D/As will familiarize themselves with SWPC and USAF SpaceWOC notifications, as appropriate; more detailed information is supplied in Appendix D.

Protective actions may be taken at any time. These are any efforts taken to reduce or eliminate the impacts of space weather. Protective action planning includes mitigation strategies for minimizing risks and enhancing resilience, and protection procedures designed to minimize damage to existing systems and infrastructure.

The following graphic visually depicts the triggers, actions, and flow through the emergency management phases:

**Figure 1 Graphic of Emergency Management Operational Phases**



### Normal Operations (Phase 1A)

During normal operations, the space weather environment does not pose an emergency hazard to society. There is no observable activity to indicate potential disruptions to communication or energy infrastructure. Similarly, there is no active warning, watch, or alert notification from SWPC concerning level 4-5 space weather events.

During this phase, D/As perform an agency-specific analysis of threats and vulnerabilities, conduct risk

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management planning, create an operational plan, and ensure their COOP/COG plans are effective and complete. In preparing their operational plans, D/As, in consultation with their scientific and technical experts, should identify all potential impacts to Mission Essential Functions (MEFs) and should describe appropriate actions to ensure mission continuity in the event of a consequential space weather incident. The operational plan should describe preparatory actions to minimize potential damage, describe agency response to prediction of potential space weather incidents, and provide guidance for initial responses following the incident. Further, D/As charged with coordinating and supporting the federal emergency response will monitor for threats, prepare and disseminate notifications and warnings, and prepare to provide consequence management and response coordination in the incident of significant space weather-related disruptions.

The checklist of essential actions for this phase is as follows:

### 1. Risk Analysis:

- a. Federal Infrastructure Impact Analysis: All D/As should assess the expected vulnerability of the hazard to infrastructure
- b. Federal Operational Continuity: Appropriate D/As should assess the expected direct and indirect impacts on the performance of mission essential functions, including ongoing operations and services. Areas of focus include:
  - i. Command, control, and communications;
  - ii. Delivery of essential services;
  - iii. Potential for cascading risk to human life;
  - iv. Potential for long-term or irreversible loss of property; and
  - v. Potential for risk to national security.
- c. Critical Infrastructure Sector: SSAs and supporting D/As responsible for the protection of the Nation's critical infrastructure should assess their sectors' vulnerability, assess projected impacts, and identify opportunities for risk mitigation. (See Appendix A Sector-Specific Agency Roles and Crisis Planning Considerations.)

### 2. Develop Operational Plans: Where applicable, in their planning efforts, D/As should develop and communicate to their personnel, customers, sector representatives, and stakeholders:

- a. An internal/external messaging plan to inform leadership, personnel, and other stakeholders of the space weather hazard and the unique challenges it could present.
- b. Advise on the prioritization of resources and sharing of protocols for emergency, life sustaining, or national security use in a communications and energy constrained environment;
- c. Protections and procedures for mitigating the effects of a space weather event on critical infrastructure;
- d. Communication of potential impacts to essential goods and services; and
- e. Prioritization plan of back-up systems, fuel, and other key supplies.

3. **Monitor for Space Weather Notifications:** D/As are responsible for identifying and developing processes and procedures within their organization to receive and monitor space weather notifications from NOAA SWPC. Notifications from other relevant organizations, such as the USAF SpaceWOC, may also be considered, as appropriate.

### **Elevated Threat (Phase 1B)**

Phase 1B is associated with an *increased likelihood* of a space weather event creating physical impacts on Earth due to an observed coronal mass ejection (CME), and the need for expanding situational awareness of the space environment. This phase indicates that the CME is predicted – though not certain – to affect the Earth. The time from the prediction of a *geomagnetic* disturbance to its onset typically varies between 16 and 90 hours. Alternatively, a *radiation* event may begin within tens of minutes of the observed sunspot eruption.

During this phase, D/As will update their risk analyses and protective action plans as appropriate. They will also initiate crisis action planning within their agencies and across the interagency. Selected teams and personnel may be alerted and could be activated and deployed to assist in the collection and monitoring of the evolving space weather hazard.

#### Trigger to enter Phase 1B:

SWPC issues a G4 or G5 Geomagnetic Disturbance Watch.

#### The checklist of essential actions for this phase is as follows:

1. **Apply Risk Analysis to Impending Space Weather Event:** All D/As will increase the fidelity of their Phase 1A risk analysis by incorporating the specific information available about the forecasted event. Such information may include the event type, intensity, geographic extent, time of onset, and time duration. Specific actions include:
  - a. Federal Infrastructure Impact Analysis: All D/As will assess the expected vulnerability of their physical infrastructure to the actual hazard, as outlined in Appendix A: Sector Specific Agency Roles and Crisis Planning Considerations.
  - b. Federal Operational Continuity: All D/As will assess the expected direct and indirect impacts to the performance of mission essential functions, including ongoing operations and services. Areas of focus include
    - i. Command, control, communications
    - ii. Delivery of essential services
    - iii. Potential for cascading risk to human life
    - iv. Potential for long-term or irreversible loss of property
    - v. Potential for risk to national security
  - c. Critical Infrastructure Sector: When deemed necessary, Sector Specific Agencies (SSAs), and supporting agencies responsible for guiding the voluntary participation of industry and other partners in the protection of the Nation’s infrastructure, must consider their sectors’ vulnerability, assess possible impacts, and work with partners to implement risk mitigation for the *actual* hazard being reported.
2. **Execute Operational Plan for the Potential Events:** All D/As should coordinate with their partners to disseminate guidance to their personnel, customers, sector representatives, and

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stakeholders to:

- a. Initiate continuous inquiries with sector partners to monitor the onset and scale of impacts;
  - b. Execute coordination, information analysis, information sharing, protective action guidance, and operational continuity actions relevant for the specific sector as outlined in Appendix A: Sector Specific Agency Roles and Crisis Planning Considerations;
  - c. Distribute messaging on expectations regarding duration of impact and appropriate protective measures;
  - d. Advise on the prioritization of resources for emergency, life sustaining, or national security uses;
  - e. Protect infrastructure or critical assets;
  - f. Notify of impacts on essential goods and services; and
  - g. Prioritize back-up systems, fuel, and other key supplies.
3. **Initiate Crisis Action Planning:** All D/As shall initiate crisis action planning to ascertain and execute priority actions and phasing for:
- a. Agency infrastructure restoration;
  - b. Continuity of mission essential functions; and
  - c. Support to sectors and associated infrastructure.
4. **Alert for Interagency Operational Coordination:** For events likely to cause physical impacts, FEMA will initiate event management coordination among Federal, State, Territory, and non-governmental organizations (NGOs) at the National Response Coordination Center (NRCC) and relevant Regional Response Coordination Centers regarding projected impacts pursuant to the National Response Framework, National Disaster Recovery Framework, and their corresponding FIOPs. The following list describes the various levels of FEMA NRCC activity:
- a. Alert: FEMA, through its National Watch Center (NWC), will issue operation orders (OPORDs) to NRCC staff and other federal agencies (OFA) liaison officers (LNOs). An OPORD will contain instructions to monitor communications from the NWC regarding changes to reporting time or cancellation of activation.
  - b. Activation: In the event of a communications or power outage preventing additional OPORDs from being communicated, all NRCC staff and LNOs will report to the NRCC at the assigned time.
  - c. Public Information and Warning: FEMA will establish a Joint Information Center (JIC) through the activation of Emergency Support Function (ESF) #15 External Affairs to coordinate and synchronize messaging while retaining SWPC and SpaceWOC as the lead subject matter experts on space weather information.
5. **Reporting:** All D/As will report the status of the Phase 1B actions addressing the essential elements of this concept of operations stated above to the following:
- a. DHS NOC for monitoring Federal D/A response to an impending space weather event; and
  - b. FEMA NWC to facilitate FEMA's role in coordinating the Federal operational response to manage the consequences of a space weather event.



### **Credible Threat (Phase 1C)**

Phase 1C is entered when the space weather event is observed, and its impacts are impending. After the event begins, it may still take hours or days to reach its maximum. Due to limitations in forecasting *radiation* events, confirmation and notification of the S4 or S5 levels will likely occur within minutes of the initial event notification.

During this phase, D/As begin executing their emergency protective measures and communicating their activities to the relevant stakeholders.

#### Trigger to enter Phase 1C:

SWPC issues one of the following:

- G4 or G5 Geomagnetic Disturbance Warning;
- S4 or S5 Radiation Event Warning;
- G4 or G5 Geomagnetic Disturbance Alert; or
- S4 or S5 Radiation Event Alert;

#### The checklist of essential actions for this phase is as follows:

1. **Modified Alert/Warning Receipt and Dissemination:** All D/As should immediately disseminate updated hazard notices received from SWPC and USAF SpaceWOC to their stakeholders.
2. **D/A Plan Execution:** D/As should continue plan execution and implement emergency protective and continuity measures as appropriate.
3. **Reporting:** D/As will continue to report preparation activities and operating status to DHS NOC and FEMA NWC.
4. **Public Notification:** D/As should use public notification plans as appropriate.

### **Initial Response (Phase 2A)**

Phase 2A begins when the space weather event develops (for notice events) or occurs (for no-notice events) and has caused measurable degradation or failure of critical infrastructure. This phase is characterized by seizing the initiative in response to the event through the mobilization, deployment, and/or employment of appropriate capabilities required to counter or lessen the impacts of the space weather event. Initial efforts are focused on the retaining of MEF capabilities including life-saving and life-sustaining actions, and systems recovery through the employment of D/As operational plans. If warranted and directed, D/As could activate continuity plans in response. Post-impact governmental coordination for phase 2A is covered in the FIOP and should be addressed in the D/As operational plans.

#### Trigger to enter Phase 2A:

Measurable degradation or failure of critical infrastructure that requires a coordinated Federal response.

#### The checklist of essential actions for this phase is as follows:

- **Evaluate Status of Systems:** D/As should evaluate their systems for damage or degradation, communicate status and estimated time of full restoration or return to steady state operations, and if

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required, implement alternative service delivery options. If significant impacts are reported, agencies charged with emergency management response and recovery will mobilize using the existing consequence management structure and activate operations as described in the FIOPs, applicable Regional all-hazard plans, and associated annexes as appropriate. The FIOP is an all-hazards federal communication and coordination plan, therefore not every annex will be applicable to a space weather event. The following is a list of FIOP products that are most applicable to a space weather event affecting communications and energy infrastructure:

- Power Outage Restoration – See Power Outage Incident Annex
- Public Health/Medical Impact Response – Response FIOP (Annex C; Appendix 2: Public Health, Healthcare, and Emergency Medical Service)
- Nuclear Radiological Impacts – See Nuclear/Radiological Incident Annex
- Oil/Chemical Impact Response – See Oil/Chemical Incident Annex
- Evacuation support requirements – See Federal Evacuation Support Annex (draft)
- **Reporting:** All D/As will continue to investigate, analyze, plan, and report on their respective actions as set forth in phases 1B and 1C.

### Critical Information Requirements Post Impact

The unique nature of a space weather event creates several Critical Information Requirements (CIRs) that are not usually used in the collection and processing of information in other emergency management events. For the purpose of assisting D/As in creating operational and continuity plans for their organization, the CIRs necessary for a space weather initial response are offered below.

CIRs comprise information requirements identified by leadership as being critical in facilitating timely decision making in response to the space weather event. They provide insight into important details that response personnel need to effectively manage and execute their operations. CIRs can be developed through the acquisition and assembly of one or more essential elements of information. Senior-level decision-makers responsible for implementing this plan will require the information presented in Table 2.

**Table 2: Critical Information Requirements**

Critical Information Requirements
• The space weather event’s geographic area of impact, magnitude, intensity, and preliminary damage assessments
• Status of federal and state coordination centers
• Ability of government organizations to continue Primary Mission Essential Functions and other critical services
• Potential impacts or risks to national security
• Impacts on community populations requiring emergency critical lifeline and life sustainment support

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<ul style="list-style-type: none"><li>• Potential chemical, physical, natural, and biological hazards resulting from an extreme space weather event that may affect the safety and health of Federal employees</li></ul>
<ul style="list-style-type: none"><li>• Status of critical infrastructure sectors, cascading impacts, and interdependent requirements</li></ul>
<ul style="list-style-type: none"><li>• Space weather information, both current and forecasted</li></ul>
<ul style="list-style-type: none"><li>• Possible resource shortages</li></ul>
<ul style="list-style-type: none"><li>• Economic impacts and long-term recovery requirements</li></ul>
<ul style="list-style-type: none"><li>• Legal and statutory impediments</li></ul>
<ul style="list-style-type: none"><li>• Potential international impacts (especially key international partners)</li></ul>

## APPENDIX A: SECTOR SPECIFIC AGENCY ROLES AND CRISIS PLANNING CONSIDERATIONS

This appendix provides D/A’s with examples of Sector Specific responsibilities and potential planning considerations for inclusion in their operational plan, as described in the emergency management phases. This table is provided as a planning aid and should not be considered exhaustive or conclusive. D/A’s should carefully consider all their statutory and regulatory authorities and areas of responsibility when developing operational plans in responding to an impending space weather event.

<b>Sector / Lead Agency</b>	<b>Risk Analysis Considerations (including cascading impacts to other sectors)</b>	<b>Risk Mitigation Opportunities</b>
All Sectors	<ul style="list-style-type: none"> <li>• Command, control, communications</li> <li>• Delivery of essential services</li> <li>• Potential for cascading risk to human life</li> <li>• Potential for long-term or irreversible loss of property</li> <li>• Potential for risk to national security</li> </ul>	<ul style="list-style-type: none"> <li>• Conduct continuous inquiries with sector partners to monitor the onset and scale of impacts</li> <li>• Appropriate messaging on expected duration of impact and appropriate protective measures</li> <li>• Prioritization or resource sharing protocols for emergency, life sustaining, or national security uses</li> <li>• Precautionary shut-downs or critical asset protections</li> <li>• Customer notifications of essential goods and services</li> <li>• Prioritization and supply of backup generators and fuel</li> <li>• Secure supervisory control and data acquisition</li> </ul>
Energy – Department of Energy (DOE)	<ul style="list-style-type: none"> <li>• Electricity</li> <li>• Oil and Natural Gas</li> </ul>	<ul style="list-style-type: none"> <li>• Initiate private and public sector utility communication</li> <li>• Discuss the potential need for a Grid Security Emergency order (following the President’s declaration of a Grid Security Emergency) under section 215A(b) of the Federal Power Act</li> </ul>

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Sector / Lead Agency	Risk Analysis Considerations (including cascading impacts to other sectors)	Risk Mitigation Opportunities
<p>Communications – DHS National Protection and Programs Directorate (NPPD)/ Federal Communications Commission (FCC)</p>	<ul style="list-style-type: none"> <li>• Communications networks (wireline, wireless, cable, satellite, broadcast)</li> <li>• Communications facilities</li> <li>• Cyber infrastructure</li> <li>• Activate Disaster Information Reporting System (DIRS) for significant outages</li> <li>• Issue waivers, Special Temporary Authorities (STAs) for communications recovery operations</li> </ul>	<ul style="list-style-type: none"> <li>• Identification and prioritization of facilities to prepare initiation of “black start”</li> <li>• Backup communications systems</li> <li>• Adjust to communications routing</li> </ul>
<p>Transportation Systems – Department of Transportation</p>	<ul style="list-style-type: none"> <li>• Aviation</li> <li>• Highway and motor carrier</li> </ul>	<ul style="list-style-type: none"> <li>• Suspension of at-risk modes of transportation</li> </ul>
<p>(DOT) Office of Intelligence Security and Emergency Response DHS Transportation Security Administration and United States Coast Guard</p>	<ul style="list-style-type: none"> <li>• Maritime</li> <li>• Mass transit and passenger rail</li> <li>• Pipeline systems</li> <li>• Freight rail</li> <li>• Postal and shipping</li> </ul>	<ul style="list-style-type: none"> <li>• Personnel evacuations</li> </ul>
<p>Water and Wastewater – Environmental Protection Agency Water Security Division</p>	<ul style="list-style-type: none"> <li>• Drinking water systems</li> <li>• Wastewater treatment systems</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust facility/pump operational capacity</li> </ul>
<p>Chemical – DHS NPPD</p>	<ul style="list-style-type: none"> <li>• Basic chemicals</li> <li>• Specialty chemicals</li> <li>• Agricultural chemicals</li> <li>• Pharmaceuticals</li> <li>• Consumer products</li> </ul>	

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<b>Sector / Lead Agency</b>	<b>Risk Analysis Considerations (including cascading impacts to other sectors)</b>	<b>Risk Mitigation Opportunities</b>
Commercial Facilities – DHS NPPD	<ul style="list-style-type: none"> <li>• Entertainment and media</li> <li>• Gaming</li> <li>• Lodging</li> <li>• Outdoor events</li> <li>• Public assembly</li> <li>• Real estate</li> <li>• Retail</li> <li>• Sports leagues</li> </ul>	
Critical Manufacturing – DHS NPPD	<ul style="list-style-type: none"> <li>• Primary metals</li> <li>• Machinery</li> <li>• Electrical equipment, appliance, and components</li> <li>• Transportation equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Identify and prioritize critical assets to be manufactured to enable cross-sector restoration requirements</li> </ul>
Federal Dams –  Department of the Interior – Bureau of Reclamation USACE	<ul style="list-style-type: none"> <li>• Water storage and irrigation</li> <li>• Sediment and flood control</li> <li>• Electricity generation</li> <li>• “Black start” capabilities</li> <li>• Peaking Power</li> </ul>	<ul style="list-style-type: none"> <li>• Identify and prioritize facilities to prepare initiation of “black start”</li> <li>• Adjust water holding capacity and initiate Dam Safety Emergency Protocols</li> </ul>
Defense Industrial Policy – DoD Office of the Secretary of Defense	<ul style="list-style-type: none"> <li>• Weapon system platforms</li> <li>• Military components</li> <li>• Military expendables</li> </ul>	<ul style="list-style-type: none"> <li>• Initiate priority service protocols with other infrastructure owners and operators (e.g., fuel, power)</li> </ul>
Emergency Services – DHS NPPD	<ul style="list-style-type: none"> <li>• Law enforcement</li> <li>• Fire and rescue services</li> <li>• Emergency management</li> <li>• Emergency medical services</li> <li>• Public works</li> </ul>	<ul style="list-style-type: none"> <li>• Critical asset movements</li> <li>• Arrange for the access, security, and safety of restoration operations in affected regions</li> <li>• Message public on individual protective measures, expectations on impact, duration of impact, and opportunities to assist in their community</li> </ul>

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<b>Sector / Lead Agency</b>	<b>Key Impact Assessments (including cascading impacts to other sectors)</b>	<b>Risk Mitigation Opportunities</b>
Financial Services – Department of the Treasury Office of Critical	<ul style="list-style-type: none"> <li>• Deposit, consumer credit, and payment systems products</li> <li>• Credit and liquidity products</li> <li>• Investment products</li> </ul>	<ul style="list-style-type: none"> <li>• Ration available resources across sectors or communities</li> </ul>
Infrastructure Protection and Compliance Policy	<ul style="list-style-type: none"> <li>• Risk transfer products</li> </ul>	<ul style="list-style-type: none"> <li>• Preserve information, accessibility, and routing of major equities exchanges</li> <li>• Adjust available supplies of cash</li> </ul>
Food and Agriculture – U.S. Department of Agriculture Office of Homeland Security ; Department of Health and Human Services (HHS) Food and Drug Administration	<ul style="list-style-type: none"> <li>• Food supply</li> <li>• Processing, packaging, and production</li> <li>• Agricultural and food product processing, storage, transportation, and distribution</li> <li>• Agricultural and food supporting facilities</li> <li>• Regulatory, oversight, and industry organizations</li> <li>• Other agriculture and food</li> </ul>	<ul style="list-style-type: none"> <li>• Authorization of Disaster Supplemental Nutrition Assistance</li> <li>• Industry messaging on expectations duration of impact</li> </ul>

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<b>Sector / Lead Agency</b>	<b>Key Impact Assessments (including cascading impacts to other sectors)</b>	<b>Risk Mitigation Opportunities</b>
Healthcare and Public Health – HHS	<ul style="list-style-type: none"> <li>• Direct patient care</li> <li>• Healthcare information technology</li> <li>• Health plans and payers</li> <li>• Mass fatality management services</li> <li>• Medical materials</li> <li>• Laboratories, blood, and pharmaceuticals</li> <li>• Public health</li> <li>• Health care services impacts</li> <li>• Behavioral health impacts</li> <li>• Environmental health impacts</li> <li>• Food safety and regulated medical products</li> <li>• Long-term health issues specific to responders</li> <li>• Social services impact</li> <li>• School impact</li> <li>• Referral to social service/disaster case management</li> </ul>	<ul style="list-style-type: none"> <li>• Mass patient movement</li> <li>• Blood supply adjustments</li> <li>• Medication and medical supply adjustments</li> <li>• Owner/operator messaging on expectations for duration of impact and cascading impacts from other sectors (e.g., water, fuel) to inform emergency continuity measures</li> <li>• Food and safety and medical regulation</li> <li>• Provision of technical assistance, regulated biologics, device, drug, animal feed, and human food establishments to protect public health</li> <li>• Evaluate disaster-related structural, functional and operational impacts to social services</li> <li>• Facilitation of a supportive educational environment for students in impacted communities</li> </ul>



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Sector / Lead Agency	Key Impact Assessments (including cascading impacts to other sectors)	Risk Mitigation Opportunities
		<ul style="list-style-type: none"> <li>Assessment disaster-related impacts to at-risk individuals (e.g., children, people living with disabilities and others who may have additional access and functional needs, people with pre- existing mental disorders, people with limited English proficiency and other underserved populations), in order to use a hazard mitigation plan and shelters.</li> </ul>
Information Technology – DHS NPPD	<ul style="list-style-type: none"> <li>IT products and services</li> <li>Event management capabilities</li> <li>Domain name resolution services</li> <li>Identity management and associated trust support services</li> <li>Internet-based content, information, and communications services</li> <li>Internet routing, access, and connection services</li> <li>Telemetry and telemedicine</li> </ul>	<ul style="list-style-type: none"> <li>Adjust cyber security resiliency protocols</li> <li>Identify additional hazards, intrusion methods and network vulnerabilities</li> <li>Adjust internet routing and resilience</li> </ul>
Nuclear Reactors, Materials, and Waste – DHS NPPD and the Nuclear Regulatory Commission (NRC)	<ul style="list-style-type: none"> <li>Commercial nuclear power plants</li> <li>Non-power reactors (research, training, and radioisotope production)</li> <li>Fuel cycle facilities</li> <li>Nuclear and radioactive materials used in medical, industrial, and academic settings</li> </ul>	<ul style="list-style-type: none"> <li>Initiate communications with nuclear power plants, non-power reactors, fuel cycle facilities, and nuclear and radioactive material users</li> <li>Reactor operators prepare to implement controlled down power or shutdown procedures, if required</li> <li>Materials facility and reactor operators prepare to implement security protocols</li> </ul>

## APPENDIX B: THE SPACE WEATHER HAZARD

This appendix provides more depth on the two main space weather hazards that are the subject of this Federal operating concept. It will discuss the relationship of space weather to the solar cycle, the science and infrastructure impacts of geomagnetic disturbances and radiation events, and the NOAA event intensity scale. Finally, an example of a space weather notification from SWPC will be given.

### Space Weather and the Solar Cycle

The number of sunspots on the surface of the Sun increases and decreases in solar cycles of approximately 11 years. Solar Minimum refers to the several years when the number of sunspots is lowest; Solar Maximum occurs in the years when sunspots are most numerous. The Sun is usually very active when sunspot counts are high; however, extreme space weather can occur anytime during the solar cycle. Sunspots are darker, cooler areas on the solar surface that contain strong, constantly shifting magnetic fields. A moderate-sized sunspot is many times larger than the size of the Earth. Sunspots represent areas where the Sun's magnetic field energy is building up and places from which it could release to cause solar flares and CMEs. Sunspots form over periods lasting from days to weeks and can persist for weeks and even months before erupting or dissipating. Most space weather originates from sunspot clusters.

### Geomagnetic Disturbances

Geomagnetic 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 an event as the near-Earth environment attempts to adjust to the jolt of energy from the Sun. The strongest geomagnetic disturbances are associated with CMEs. A CME is a large eruption of magnetized plasma from the outer solar atmosphere (the corona) that can disturb the geomagnetic field for days at a time. Though CMEs can take several days to arrive at Earth, some of the most intense CMEs have been observed to arrive in as little as 17 hours. The most visible attribute of a geomagnetic disturbance is the aurora, which becomes brighter and moves closer to the equator during event periods. This heightened aurora signals the vigorous electrodynamic processes at play as they respond to the burst of energy from the Sun.

Geomagnetic disturbances usually last from a few hours to days, though the strongest events 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. In general, the frequency of geomagnetic disturbances depends on the stage in the solar cycle—with most events occurring near solar maximum; however, these are also common in the declining phase of the solar cycle.

Geomagnetic disturbances induce currents that can have significant impact on electrical transmission equipment and electric power companies have procedures in place to mitigate the impact of geomagnetic disturbances. The vulnerabilities of communications, GPS, satellites, and electric power to an extreme geomagnetic disturbance are the primary areas of concerns for a space weather event due to possibilities of widespread disruptions.

Should an extreme space weather event occur, all levels of government, as well as citizens and the private sector, should plan appropriately to prepare for, respond to, and recover from such an occurrence. Depending on its size, a G5 disturbance could cause significant issues. An event on the

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low end of the G5 scale could include widespread voltage instability: many protective systems may trip offline and some transformers may experience hot spots but are not expected to fail. Some minor customer outages may occur.

The table below details the Geomagnetic Disturbance Scale

**Table 3: Geomagnetic Disturbance Scale**

Scale	Description	Effect
<b>G5</b>	<b>Extreme</b>	<p><b>Power systems:</b> 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><b>Spacecraft operations:</b> May experience extensive surface charging and problems with orientation, uplink/downlink, and tracking satellites</p> <p><b>Other systems:</b> Pipeline currents can reach hundreds of amps, HF 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 latitude).</p>
<b>G4</b>	<b>Severe</b>	<p><b>Power systems:</b> Possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid.</p> <p><b>Spacecraft operations:</b> May experience surface charging and tracking problems; corrections may be needed for orientation problems.</p> <p><b>Other systems:</b> 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 latitude).</p>
<b>G3</b>	<b>Strong</b>	<p><b>Power systems:</b> Voltage corrections may be required; false alarms triggered on some protection devices.</p> <p><b>Spacecraft operations:</b> 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><b>Other systems:</b> HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic latitude).</p>
<b>G2</b>	<b>Moderate</b>	<p><b>Power systems:</b> High-latitude power systems may experience voltage alarms.</p> <p><b>Spacecraft operations:</b> Corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions.</p> <p><b>Other systems:</b> HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic latitude).</p>
<b>G1</b>	<b>Minor</b>	<p><b>Power systems:</b> Weak power grid fluctuations can occur</p> <p><b>Spacecraft operations:</b> Minor impact on satellite operations possible</p> <p><b>Other systems:</b> Migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).</p>

Source: [NOAA Space Weather Prediction Center](https://www.noaa.gov/forecast/space-weather-predictions)

## Radiation Event

Radiation events occur when large quantities of charged particles, protons and electrons, are accelerated by processes at or near the Sun. When these processes occur, the near-Earth satellite environment is bathed with high-energy particles. Earth's magnetic field and atmosphere offer some protection from this radiation, but the amount of protection afforded a given geographic region is a function of its altitude, latitude, and magnetic field strength. The Polar Regions are most affected by energetic particles because the magnetic field lines at the poles extend vertically downwards, allowing the particles to spiral down the field lines and penetrate the atmosphere.

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Energetic protons reach Earth a half hour to several hours after a solar eruption. Solar radiation events can last from a few hours to days, depending on the magnitude of the eruption.

Radiation events can occur at any time during the solar cycle but tend to be most common around solar maximum. Impacts of a solar radiation event include loss of HF radio communications through the polar regions, navigation position errors, elevated radiation exposure to astronauts as well as to passengers and crew in aircraft at high altitudes and latitudes, and damage to satellite systems. The table below details the Radiation Event Scale:

**Table 4: Radiation Event Scale**

Scale	Description	Effect
<b>G5</b>	<b>Extreme</b>	<p><b>Biological:</b> Unavoidable high radiation hazard to astronauts on extra-vehicular activity (EVA); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.</p> <p><b>Satellite operations:</b> Satellites may be rendered useless; memory impacts can cause loss of control; may cause serious noise in image data; star-trackers may be unable to locate sources; permanent damage to solar panels possible.</p> <p><b>Other systems:</b> Complete blackout of HF communications possible through the polar regions, and position errors make navigation operations extremely difficult.</p>
<b>G4</b>	<b>Severe</b>	<p><b>Biological:</b> Unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.</p> <p><b>Satellite operations:</b> May experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded.</p> <p><b>Other systems:</b> Blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.</p>
<b>G3</b>	<b>Strong</b>	<p><b>Biological:</b> Radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.</p> <p><b>Satellite operations:</b> Single-incident upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely</p> <p><b>Other systems:</b> Degraded HF radio propagation through the Polar Regions and navigation position errors likely.</p>
<b>G2</b>	<b>Moderate</b>	<p><b>Biological:</b> Passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk.</p> <p><b>Satellite operations:</b> Infrequent single-incident upsets possible.</p> <p><b>Other systems:</b> Small effects on HF propagation through the Polar Regions and navigation at Polar Cap locations possibly affected.</p>
<b>G1</b>	<b>Minor</b>	<p><b>Biological:</b> None</p> <p><b>Satellite operations:</b> None</p> <p><b>Other systems:</b> Minor impacts on HF radio in the polar regions</p>

Source: [NOAA Space Weather Prediction Center](#)

## Example of a Space Weather Event Notification

Figure 2: Screenshot of a geomagnetic disturbance watch notification (SWPC website)

Space Weather Message Code: ALTK08

Serial Number: 25

Issue Time: 2017 Sep 08 1306 UTC

**ALERT:** Geomagnetic K-index of 8

Threshold Reached: 2017 Sep 08 1304 UTC

Active Warning: Yes

NOAA Scale: G4 - Severe

NOAA Space Weather Scale descriptions can be found at

[www.swpc.noaa.gov/noaa-scales-explanation](http://www.swpc.noaa.gov/noaa-scales-explanation)

Potential Impacts: Area of impact primarily poleward of 45 degrees Geomagnetic Latitude.

**Induced Currents** - Possible widespread voltage control problems and some protective systems may mistakenly trip out key assets from the power grid. Induced pipeline currents intensify.

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

**Navigation** - Satellite navigation (GPS) degraded or inoperable for hours.

**Radio** - HF (high frequency) radio propagation sporadic or blacked out.

**Aurora** - Aurora may be seen as low as Alabama and northern California.

## APPENDIX C: CASCADING IMPACTS TO INFRASTRUCTURE AND COMMUNITY

D/As must understand and prepare for cascading effects across critical infrastructure systems from space weather events to ensure the effects on their MEFs are minimized. The downstream effects of communication and energy infrastructure degradation are *cascading impacts* and could cause severe disruption to the D/A's capability to perform MEFs. It is projected that if a space weather event occurs, the greatest impact will be to communications, messaging, and information management systems. Although less likely, it is also possible for the nation's power grid to suffer significant disruption. For example, an extreme space weather event *would* result in severe communications disruptions and, if large enough, *could* result in widespread power grid blackouts that may persist. To support the stabilization and restoration of basic services and community functionality, agencies must be prepared for these possible scenarios and any downstream effects on their systems and personnel. This portion of the document describes the potential effect on communication and power grid systems, and the cascading effects that may result from long-term failures of these two critical systems.

### Communications and Messaging

Technologies and infrastructure supporting communication networks are at the highest risk of experiencing degradation from a space weather event. In addition to the obvious vulnerability of radio and satellite communications, the physical backbone that supports communication is susceptible to damage and disruption. Even minor disturbances could have significant impacts on the ability to communicate critical information during and after an event. The following areas should be researched with the goal of understanding their vulnerabilities and how these systems can be protected when an event is impending. Wherever appropriate, planners should consult engineers or information technology professionals to better understand the strengths and vulnerabilities of each of these systems:

- Satellite-reliant communication
- Global positioning technology
- Radar systems
- HF radio communications
- Sky wave radio technology
- Interconnected computer networks

Because of the potential degradation of communication systems, both internal and external messaging may be difficult during a long-term power outage. This poses a number of problems that may affect both the operational capability of an agency as well as communication to the public in a timely and accurate manner. The consequences of the degradation of internal and external messaging may have severe impacts on the ability to complete mission tasks effectively and communicate with the D/A customers.

The ability to continue effective communications should be addressed in an organizational emergency operations plan, such as an occupant emergency plan or organizational crisis action plan that describes employee actions required during an extended period of communications

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failure or degradation. It is the purpose of the D/A leadership and supporting crisis action team (or equivalent) to ensure employees remain safe but able to provide continued service to their customers. Each D/A should develop alternative communication strategies and techniques in the event of a messaging failure and should provide pre-event training and education to both employees and customers to increase the likelihood of maintaining communication and therefore contribute to mission success.

The following table details the various types and methods of communication that may be available for messaging inside and outside the agency and could be affected by a severe space weather event. It is strongly recommended that D/As develop plans for communication that reach beyond what is normally used daily.

**Table 4: Communication Planning Considerations**

Mass Media	Government, NGO, and Private Sector	Special Communications and Nontraditional Methods
Emergency Alert System (EAS)	Federal Websites (FEMA, NOAA, USA.gov)	Cable television outlets
Wireless Emergency Alerts (WEA)	Corporate intranet sites and employee email distribution lists	Social media
NOAA Weather Radio All-Hazards	Organizational alerting and notification systems	Questions and answers with the public
NOAA Emergency Manager’s Weather Information Network	State, local, and tribal governments and associated websites	Really Simple Syndication feeds
Nationally broadcast public service announcements (PSA) on commercial stations and networks	Faith-based, community, and disability organizations	Wikis
National news and wire service releases	Professional associations and emergency management organizations	Texts
Press conferences (Headquarters, Joint Field Offices) – live, video, and phone	Schools	GETs
Multi-language media	Foreign media	
Federal department and agency Internet and web postings	Conference calls with stakeholders	
E-mail alerts to subscribers	Utility and transportation industries	
Satellite and radar imagery	Local building community	
Public advisories on rebuilding strategies and risk and hazards		
Information in accessible formats		

To convey messages to audiences, the normal channels of communication (e.g., nationally broadcast PSAs, live-read radio PSAs on commercial stations and networks, news and wire releases, multi-language media, the EAS) will be used. In the case of an event, [www.usa.gov](http://www.usa.gov), which links to every federal website, will be used as the federal information portal for the U.S. Government. In addition, personal preparedness information for the public will be posted on [www.ready.gov](http://www.ready.gov). Interagency communicators will leverage community networks to expand the reach of key messaging through established and trusted structures within affected communities. D/As are encouraged to develop messaging that does not rely on these traditional methods.



## **Power Systems**

Although communication networks are more susceptible to degradation from space weather events, the nation's power grid is also at risk. Planners should consider how they would operate in an environment without grid power for up to two weeks. The impacts of prolonged outages may present direct impacts to the performance of essential functions if contingency options or resilience features are not implemented.

## **Transportation**

Many types of transportation systems are vulnerable to power loss. All modes of transportation may be disrupted by power outages, from non-functioning traffic signals, to rail and air traffic control systems. In addition, while fuel distribution services are not technically part of the transportation infrastructure, the lack of availability of gasoline and diesel fuel for motorists, truckers, and emergency responders will cause significant disruption.

There may be a lack of detailed transportation assessments by Federal, State, and local officials due to inadequate resources and communication capabilities. Degradation of the normal transportation systems can even slow the ability of officials to assess transportation infrastructure. Assessments will be necessary to determine functionality of transportation resources (road, rail, air, and water) and to determine evacuation routes. Responders will need to know the safest modes with which to reach the impacted area and establish logistical lines of support. Per the ESF #1 annex to the National Response Framework, DOT is charged with monitoring and reporting status of and damage to the transportation system and infrastructure. Federal resources (e.g., DOT personnel) will likely be required to work alongside State and local resources to conduct assessments of transportation systems, provide technical assistance, and support repairs.

In the event of a significant space weather power outage event, the ability for agency personnel to use public or private transportation may be degraded to the point where it is difficult or impossible to safely commute to their official worksites.

## **Environmental Response/Health and Safety**

Long-term power outages can create various environmental hazards: public and private water and sewage treatment systems may release waste into a community's waterways; carbon monoxide poisoning can occur from the public's use of grills or generators indoors; electrical and gas conduits can be damaged, producing dangerous conditions when service is restored.

Long-term power outages can also cause destruction of food stores and medical supplies because of the failure of refrigeration systems.

Assessment, identification, and providing responders and the public with information about the environmental hazards and how to reduce them are essential, but mechanisms by which affected federal D/As agree upon and communicate environmental health and safety issues will be established as part of the response process.

## **Critical Infrastructure (CI) Systems**

Based on the size of the affected area, the timeline for restoration of CI will be unknown until the severity of the damage is assessed. Assessment of CI for stabilization and repair will require equipment, expertise, and resources to perform the necessary repairs. A shortage of resources to

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conduct assessments of infrastructure areas may delay overall response actions. Identifying private sector resources and vetting credentials, will expedite getting qualified individuals to the impact area to support infrastructure assessment and restoration.

Again, it must be reiterated that lack of power or other essential functions may have a severe adverse effect on personnel, including the desire to stay at their place of residence. Well established continuity plans, and alternative means of communication and work capability should be completed prior to an event and be executed should it become necessary.

### **Financial Systems**

Because of the overwhelming reliance on computer systems to track currency movement and account balances, financial systems are particularly exposed. It is commonplace for institutions and individuals to rely completely on digital means to pay bills, receive pay, and invest assets. The degradation of these capabilities may cause widespread hardship and public concern. Automated teller machines may also be inoperable. Although financial institutions have disaster recovery professionals who protect their systems from failures, planning for the impact to an agency's operations must be taken into consideration, as well as the impact on its employees.

### **Security**

Evacuations, loss of power, sheltering, and loss of transportation systems all create expanded law enforcement requirements to include additional requirements for traffic control. Large shelters will require a law enforcement presence to deter property crimes because evacuated citizens in the shelters may have their most valuable possessions and documents with them. Law enforcement may be needed at points of distribution (POD) to direct traffic and deter altercations over limited resources.

State and local law enforcement and security personnel may be employed during a space weather power outage event and will need relief to sustain operations during response and short-term recovery. Law enforcement personnel in impacted jurisdictions will be extended beyond existing capabilities, and normal mutual aid from surrounding jurisdictions also will not be available due to space weather impacts across the affected region. At the request of state and local governments, federal resources can provide some on-scene security and protection during a space weather response (e.g., law enforcement support for evacuations, shelters, PODs).

Under a Stafford Act emergency, when State and local resources are exhausted, the Governor may request assistance from the Federal Government, which could include certain DoD support.

### **Operational Communications**

Long-term power outages or CI damage related to an extreme space weather event can encumber communications capabilities within the affected area. Emergency communications towers and call centers may be without power and undamaged communications systems can be overloaded by increased traffic. Intermittent problems with satellite systems can cause additional difficulty. The ability to communicate to D/A personnel and interagency partners may be delayed when communications channels are not available. Federal assistance, including temporary communications systems and rapid restoration of critical systems, will be requested by State and local jurisdictions and may be available, but this is not assured. Without communication systems, citizens may be unable to receive emergency messages or other communications from the agency. D/A continuity programs ensure the performance of essential

functions and associated personnel, facilities, communications, and information systems, as well as processes involved in their performance. The communications and information systems requirements for the performance of essential functions are critical continuity planning focus areas due to the impact's outages present to those functions. Continuity planning should account for effective system contingencies and resilience to continue essential functions.

It is critical for agencies to create an alternative communication plan. A "PACE" plan consists of the following modes of communication among personnel and agencies:

- Primary
- Alternative
- Contingency
- Emergency

As each of these methods of communication fail, it is incumbent on the agency and personnel to use the next mode to attempt to remain in contact. For instance, if the "primary" mode of communication is issued work phones and it fails, then the "alternative" method of work/personal email may need to be employed. It is the responsibility of each agency to create a communications plan that best adheres to their mission and capabilities and ensures availability based on essential function task requirements.

### **Operational Coordination**

During a long-term power outage, affected areas may face diminished capacity to maintain operational control. Depending on the scale and location of an event, emergency personnel and resources from numerous different Federal, State, and local D/As could be operating simultaneously. The ability to establish a unity of effort will likely be delayed as will the time required to establish lines of communications and pathways for logistical support. The ability to mobilize and integrate whole community resources is also dependent on the ability to establish operational coordination and will be underutilized until this capability is set.

An already complex operation is further complicated by multiple reporting methodologies and statutory authorities across the event echelons and within multiple jurisdictions. Multiple reporting methodologies and statutory authorities require coordination to maintain a unity of effort and a common operating picture (COP) for efficient and effective response requests to support States. Any disruption in reporting will create a delay or loss of information contributing to the COP. Because this information ultimately informs decision makers and impacts possible resource allocation, a COP will improve overall response efforts.

### **Public and Private Sector Services and Resources**

During a long-term power outage due to an extreme space weather event, private sector resources beyond those provided by existing government contracts may need to be identified. The affected population will require items including bottled water, ready-to-eat meals, personal sanitary supplies, fuel, and generators. The number of emergency supplies required for a large, heavily populated area being affected by an extreme space weather event could surpass the capabilities of a single state or local government, or federal D/A. Private sector suppliers within the region may sustain damages, loss of power, or limited access to the affected area.

Establishing a COP with the levels of available resources in the impact area will require time for

evaluation. The resource requirements require all of the federal, state, and local response partners to work with the private sector in a coordinated operation to order, deliver, and manage the distribution of resources. The delivery of emergency resources must be sustained until the existing commercial distribution (e.g., gas stations, pharmacies, banks, grocery stores) in the affected area can be restored.

### **Public Health and Medical Services**

Geomagnetic disturbances may cause widespread power and communication outages across state and local jurisdictions. These outages will have significant impacts to the healthcare sector in these areas. Emergency medical services may be hampered due to communication loss. Emergency departments will operate at a reduced capacity due to damage or close due to power and communication outages. Other hospital services may be limited or unavailable due to power loss. Injured and ill citizens will seek healthcare at the few open medical facilities causing them to be overwhelmed. Sharing of state and local jurisdictions' resources will be delayed due to communication outages, and overwhelmed states may request federal public health and medical support to evacuate patients from hospitals or health care facilities that are adversely affected by power loss. The ability of federal support to reach the affected area will be dependent on the condition of CI and the condition of facilities providing medical services. Additionally, there will be significant public health concerns requiring increased health surveillance for vector borne illness due to the potential breakdown in sewage and sanitation. The loss of power will require that local jurisdictions set up recharging stations for individuals with power dependent medical devices and employ alternate mortuary storage strategies with possible requests for federal support. Any increase in the number of fatalities from the event may also cause additional requests for federal public health consultation, technical assistance, or mission scoping assessments to determine the full extent of public health impacts, the development of a recovery strategy, and implementation.

### **Situational Assessment**

An accurate and timely assessment and communication of impacts on an organization is critical in providing a Common Operating Picture (COP). A delay in developing a COP would have negative effects on the decision-making process at all levels of government. Initial reporting will overwhelm situational assessments during early response operations and potentially delay the deployment of resources until assessment information can be deconflicted.

## APPENDIX D: EXECUTIVE AND STATUTORY AUTHORITY

In line with EO 13744, Section 5(b), this appendix provides a summary of executive and statutory authority and limits of that authority to direct, suspend, or control CI operations; functions and services before, during, and after a space weather event. The text of this action is as follows:

Section 5(b): Within 120 days of the date of this order, the heads of Sector- Specific Agencies that oversee the lifeline critical infrastructure functions as defined by the National Infrastructure Protection Plan of 2013—including communications, energy, transportation, and water and wastewater systems shall assess their executive and statutory authority, and limits of that authority, to direct, suspend, or control critical infrastructure operations, functions, and services, before, during, and after a space weather event. The heads of each sector-specific agency shall provide a summary of these assessments to the Sub-committee.<sup>3</sup>

**Table 5: Statutory Authorities**

Statutory Authorities to Direct, Suspend, or Control Critical Infrastructure Operations, Functions, and Services Before, During, and After a Space Weather Event		
Sector	Authority	Summary
Transportation	Defense Production Act of 1950, 50 U.S.C. § 4501 <i>et seq.</i>	Under Title I of the DPA, the President has authority to require prioritization of performance under contracts and orders deemed necessary or appropriate to promote national defense -- and to allocate materials, services, and facilities – to promote the national defense.
Transportation	EO 13603; 49 CFR Part 33	Under Section 201 of E.O. 13603, the President delegated Defense Production Act prioritization and allocation authorities to the Secretary of Transportation for all forms of civil transportation. DOT’s procedures for implementing this authority, the Transportation Priorities and Allocations System, are found in 49 CFR Part 33.

<sup>3</sup> Executive Order (EO) 13744, “Coordinating Efforts to Prepare the Nation for Space Weather Events”

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Sector	Authority	Summary
Transportation	49 U.S.C. § 40101(c)	Requires the Federal Aviation Administration (FAA) Administrator, in carrying out subpart III of this part [Part A, Air Commerce and Safety, of Subtitle VII, Aviation Programs, of title 49, U.S. Code] and those provisions of subpart IV applicable in carrying out subpart III, to consider the following matters:(1) the requirements of national defense and commercial and general aviation, and (2) the public right of freedom of Transit through the navigable airspace. 49 U.S.C. § 40101(c).
Transportation	49 U.S.C § 40101	Requires the FAA Administrator, in carrying out subpart III of this part [Part A, Air Commerce and Safety, of Subtitle VII, Aviation Programs, of title 49, U.S. Code] and those provisions of subpart IV applicable in carrying out subpart III, to consider the following matters, among others, as being in the public interest:(1) assigning, maintaining, and enhancing safety and security as the highest priorities in air commerce; (2) regulating air commerce in a way that best promotes safety and fulfills national defense requirements; (3) encouraging and developing civil aeronautics, including new aviation technology; (4) controlling the use of the navigable airspace and regulating civil and military operations in that airspace in the interest of the safety and efficiency of both of those operations; (5) consolidating research and development for air navigation facilities and the installation and operation of those facilities; (6) developing and operating a common system of air traffic control and navigation for military and civil aircraft; and (7) providing assistance to law enforcement agencies in the enforcement of laws related to regulation of controlled substances, to the extent consistent with aviation safety. 49 U.S.C. § 40101(d).

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Sector	Authority	Summary
		<p>revoke an assignment when required in the public interest. 49 U.S.C. § 40103(b)(1).</p> <p>Directs the FAA Administrator to prescribe air traffic regulations on the flight of aircraft (including regulations on safe altitudes) for-- (A) navigating, protecting, and identifying aircraft;(B) protecting individuals and property on the ground;(C) using the navigable airspace efficiently; and (D) preventing collision between aircraft, between aircraft and land or water vehicles, and between aircraft and airborne objects. 49 U.S.C. § 40103(b)(2).</p> <ul style="list-style-type: none"> <li>• To establish security provisions that will encourage and allow maximum use of the navigable airspace by civil aircraft consistent with national security, the Administrator, in consultation with the Secretary of Defense, shall—(A) establish areas in the airspace the Administrator decides are necessary in the interest of national defense; and (B) by regulation or order, restrict or prohibit flight of civil aircraft that the Administrator cannot identify, locate, and control with available facilities in those areas. 49 U.S.C. § 40103(b)(3).</li> </ul>

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Sector	Authority	Summary
Transportation	49 U.S.C. § 40105(b)(1)	Requires the FAA Administrator, in carrying out this part [Part A, Air Commerce and Safety, of Subtitle VII, Aviation Programs, of Title 49, U.S. Code] (A) to act consistently with obligations of the United States Government under an international agreement; (B) to consider applicable laws and requirements of a foreign country; and (C) not limit compliance by an air carrier with obligations or liabilities imposed by the government of a foreign country when the Secretary takes any action related to a certificate of public convenience and necessity issued under Chapter 411 of Title 49.
Transportation	49 U.S.C § 40106(a)	Appropriate military authority may authorize aircraft of the armed forces of the United States to deviate from air traffic regulations prescribed under section 40103(b)(1) and (2) of this title when the authority decides the deviation is essential to the national defense because of a military emergency or urgent military necessity. The authority shall—(1) give the Administrator of the Federal Aviation Administration prior notice of the deviation at the earliest practicable time; and (2) to the extent time and circumstances allow, make every reasonable effort to consult with the Administrator and arrange for the deviation in advance on a mutually agreeable basis.



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Sector	Authority	Summary
Transportation	49 U.S.C. § 40107	<p>(a) General authority.—The President may transfer to the Administrator of the Federal Aviation Administration a duty, power, activity, or facility of a department, agency, or instrumentality of the executive branch of the United States Government, or an officer or unit of a department, agency, or instrumentality of the executive branch, related primarily to selecting, developing, testing, evaluating, establishing, operating, or maintaining a system, procedure, facility, or device for safe and efficient air navigation and air traffic control. In making a transfer, the President may transfer records and property and make officers and employees from the department, agency, instrumentality, or unit available to the Administrator.</p> <p>(b) If war occurs, the President by executive order may transfer to the Secretary of Defense a duty, power, activity, or facility of the Administrator. In making the transfer, the President may transfer records, property, officers, and employees of the Administration to the Department of Defense.</p>
Transportation	49 U.S.C. §§ 40109(b), 44701(f)	<p>The FAA has broad exemption authority to grant exemptions from FAA regulations when doing so is in the public interest. In emergency conditions, the FAA may authorize deviations from the regulations that would normally apply to operations conducted under 14 C.F.R. Parts 121 or 135 if the emergency conditions necessitate the transportation of persons or supplies for the protection of life or property and the FAA finds that a deviation is necessary for the expeditious conduct of the operations. The FAA can authorize these deviations either as an amendment to the certificate holder’s operations specifications, or orally, if the nature of the emergency does not permit the timely amendment of the operations specifications.</p>

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Sector	Authority	Summary
Transportation	49 U.S.C. §§ 40113(a), 44701(a)(5)	The FAA can order U.S. air carriers and U.S. commercial operators, persons exercising the privileges of an airman certificate issued by the FAA, and operators of aircraft registered in the United States not to enter designated airspace in which the FAA does not provide air navigation services due to risks to U.S. civil aviation existing therein.
Transportation	49 U.S.C. § 44502	Provides the FAA Administrator with full authority to acquire, establish, improve, operate, and maintain air navigation facilities and to provide the facilities and personnel needed to regulate and protect air traffic.
Transportation	49 U.S.C. § 44701	Directs the FAA Administrator to promote safe flight of civil aircraft in air commerce by prescribing— (1) minimum standards required in the interest of safety for appliances and for the design, material, construction, quality of work, and performance of aircraft, aircraft engines, and propellers; (2) regulations and minimum standards in the interest of safety for (A) inspecting, servicing, and overhauling aircraft, aircraft engines, propellers, and appliances; (B) equipment and facilities for, and the timing and manner of, the inspecting, servicing, and overhauling; and (C) a qualified private person, instead of an officer or employee of the Administration, to examine and report on the inspecting, servicing, and overhauling; (3) regulations required in the interest of safety for the reserve supply of aircraft, aircraft engines, propellers, appliances, and aircraft fuel and oil, including the reserve supply of fuel and oil carried in flight; (4) regulations in the interest of safety for the maximum hours or periods of service of airmen and other employees of air carriers; and

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Sector	Authority	Summary
		<p>(5) regulations and minimum standards for other practices, methods, and procedure the Administrator finds necessary for safety in air commerce and national security. 49 U.S.C. § 44701(a)</p> <p>Directs the Administrator to carry out chapter 447 of title 49, U.S. C. in a way that best tends to reduce or eliminate the possibility or recurrence of accidents in air transportation. However, the Administrator is not required to give preference either to air transportation or to other air commerce in carrying out this chapter 49 U.S.C. § 44701(c).</p>
Transportation	49 U.S.C. § 46105(c)	<p>When the Administrator is of the opinion that an emergency exists related to safety in air commerce and requires immediate action, the Administrator, on the initiative of the Administrator or on complaint, may prescribe regulations and issue orders immediately to meet the emergency, with or without notice and without regard to this part and Subchapter II of Chapter 5 of Title 5. The Administrator shall begin a proceeding immediately about an emergency under this subsection and give preference, when practicable, to the proceeding.</p>
Transportation	51 U.S.C. § 50904	<p>(c)Preventing Launches and Reentries —The Secretary of Transportation shall establish whether all required licenses, authorizations, and permits required for a payload have been obtained. If no license, authorization, or permit is required, the Secretary may prevent the launch or reentry if the Secretary decides the launch or reentry would jeopardize the public health and safety, safety of property, or national security or foreign policy interest of the United States.</p>

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Sector	Authority	Summary
Transportation	51 U.S.C. § 50908(c)(2)	<p>(c) Suspensions and Revocations—The Secretary may suspend or revoke a license if the Secretary decides that—</p> <p style="text-align: center;">* * * *</p> <p>(2) the suspension or revocation is necessary to protect the public health and safety, the safety of property, or a national security or foreign policy interest of the United States.</p>
Transportation	51 U.S.C. § 50909	<p>(a) General Authority.—The Secretary of Transportation may prohibit, suspend, or end immediately the launch of a launch vehicle or the operation of a launch site or reentry site, or reentry of a reentry vehicle, licensed under this chapter if the Secretary decides the launch or operation or reentry is detrimental to the public health and safety, the safety of property, or a national security or foreign policy interest of the United States.</p> <p>(b) Effective Periods of Orders—An order under this section takes effect immediately and remains in effect during a review under section 50912 of this title.</p>
Transportation	14 C.F.R. § 91.3	<p>(a) The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft.</p> <p>(b) In an in-flight emergency requiring immediate action, the pilot in command may deviate from any rule of this part to the extent required to meet that emergency.</p> <p>(c) Each pilot in command who deviates from a rule under paragraph (b) of this section shall, upon the request of the Administrator, send a written report of that deviation to the Administrator.</p>

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Sector	Authority	Summary
Transportation	14 C.F.R. § 91.123	When an air traffic control (ATC) clearance has been obtained, no pilot in command may deviate from that clearance unless an amended clearance is obtained, an emergency exists, or the deviation is in response to a traffic alert and collision avoidance system resolution advisory. However, except in Class A airspace, a pilot may cancel an instrument flight rules (IFR) flight plan if the operation is being conducted in visual flight rules (VFR) weather conditions. When a pilot is uncertain of an ATC clearance, that pilot shall immediately request clarification from ATC. Except in an emergency, no person may operate an aircraft contrary to an ATC instruction in an area in which air traffic control is exercised.
Transportation	14 C.F.R. § 91.139	Whenever the FAA Administrator determines that an emergency condition exists, or will exist, relating to the FAA's ability to operate the air traffic control system and during which normal flight operations under this chapter cannot be conducted consistent with the required levels of safety and efficiency—(1) The Administrator issues an immediately effective air traffic rule or regulation in response to that emergency condition; and (2) The Administrator or the [Chief Operating Officer of the Air Traffic Organization] may utilize the Notices to Airmen (NOTAM) system to provide notification of the issuance of the rule or regulation. Those NOTAMs communicate information concerning the rules and regulations that govern flight operations, the use of navigation facilities, and designation of that airspace in which the rules and regulations apply. When a NOTAM has been issued under this section, no person may operate an aircraft, or other device governed by the regulation concerned, within the designated airspace except in accordance with the authorizations, terms, and conditions prescribed in the regulation covered by the NOTAM.

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Sector	Authority	Summary
Transportation	14 C.F.R. § 101.37	Unmanned free balloons being used for solar or cosmic disturbance investigations involving a time critical element are required to provide the following information to the FAA air traffic control (ATC) facility that is nearest to the intended place of operation within 30 minutes to 24 hours before beginning the operation: (1) The balloon identification; (2) The estimated date and time of launching, amended as necessary to remain within plus or minus 30 minutes; (3) The location of the launching site; (4) The cruising altitude; (5) The forecast trajectory and estimated time to cruising altitude or 60,000 feet standard pressure altitude, whichever is lower; (6) The length and diameter of the balloon, length of the suspension device, weight of the payload, and length of the trailing antenna; (7) The duration of flight; and (8) The forecast time and location of impact with the surface of the Earth.
Transportation	14 C.F.R. §§ 121.551 and 121.553	When a certificate holder conducting domestic or flag operations knows of conditions, including airport and runway conditions, that are a hazard to safe operations, it shall restrict or suspend operations until those conditions are corrected. When a certificate holder conducting supplemental operations or pilot in command knows of conditions, including airport and runway conditions, that are a hazard to safe operations, the certificate holder or pilot in command, as the case may be, shall restrict or suspend operations until those conditions are corrected.

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Sector	Authority	Summary
Transportation	14 C.F.R. §§ 121.557 and 121.559	In an emergency situation that requires immediate decision and action the pilot in command may take any action that he considers necessary under the circumstances. In such a case he may deviate from prescribed operations procedures and methods, weather minimums, and this chapter [Chapter I of title 14, Code of Federal Regulations], to the extent required in the interests of safety. For domestic and flag operations, in an emergency situation arising during flight that requires immediate decision and action by an aircraft dispatcher, and that is known to him, the aircraft dispatcher shall advise the pilot in command of the emergency, shall ascertain the decision of the pilot in command, and shall have the decision recorded. If the aircraft dispatcher cannot communicate with the pilot, he shall declare an emergency and take any action that he considers necessary under the circumstances. For supplemental operations, in an emergency situation arising during flight that requires immediate decision and action by appropriate management personnel in the case of operations conducted with a flight following service and which is known to them, those personnel shall advise the pilot in command of the emergency, shall ascertain the decision of the pilot in command, and shall have the decision recorded. If they cannot communicate with the pilot, they shall declare an emergency and take any action that they consider necessary under the circumstances.

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Sector	Authority	Summary
Transportation	Appendix P to Part 121 – Requirements for Extended-range Twin-engine Operational Performance Standards (ETOPS) and Polar Operations, Section III, Approvals for operations whose airplane routes are planned to traverse either the North Polar or South Polar Areas	Except for intrastate operations within the State of Alaska, no certificate holder may operate an aircraft in the North Polar Area or South Polar Area, unless authorized by the FAA. In addition to any of the applicable requirements of Sections I and II of this appendix, the certificate holder's operations specifications must contain, among other things, a plan for mitigating crew exposure to radiation during solar flare activity.
Transportation	14 C.F.R. § 135.19	In an emergency involving the safety of persons or property, the certificate holder may deviate from the rules of this part [part 135 of title 14, Code of Federal Regulations] relating to aircraft and equipment and weather minimums to the extent required to meet that emergency. In an emergency involving the safety of persons or property, the pilot in command may deviate from the rules of this part to the extent required to meet that emergency.
Transportation	14 C.F.R. § 135.69	(a) During operations under this part [Part 135 of title 14, Code of Federal Regulations], if a certificate holder or pilot in command knows of conditions, including airport and runway conditions, that are a hazard to safe operations, the certificate holder or pilot in command, as the case may be, shall restrict or suspend operations as necessary until those conditions are corrected.(b) No pilot in command may allow a flight to continue toward any airport of intended landing under the conditions set forth in paragraph (a)



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Sector	Authority	Summary
		of this section, unless, in the opinion of the pilot in command, the conditions that are a hazard to safe operations may reasonably be expected to be corrected by the estimated time of arrival or, unless there is no safer procedure. In the latter event, the continuation toward that airport is an emergency situation under § 135.19.
Transportation	14 C.F.R. § 135.98	After August 13, 2008, no certificate holder may operate an aircraft in the region north of 78° N latitude (“North Polar Area”), other than intrastate operations wholly within the State of Alaska, unless authorized by the FAA. The certificate holder's operation specifications must include, among other things, a plan for mitigating crew exposure to radiation during solar flare activity.
Transportation	49 U.S.C. § 20103(d); 49 CFR § 211.45	The Federal Railroad Administration (FRA) may issue waivers of certain safety regulations or orders during an emergency situation or event. Such waivers may include temporary postponement of required maintenance, repair, or inspection related to railroad equipment, track, and signals; temporary relief from certain recordkeeping or reporting requirements; or short-term relief from various operational requirements.
Transportation	49 U.S.C. § 20104; 49 CFR § 1.89	FRA may issue, without providing prior notice and an opportunity for comment, an emergency order imposing any restrictions or prohibitions necessary to abate what FRA determines is an emergency situation involving a hazard of death, personal injury, or significant harm to the environment caused by unsafe conditions or practices. While FRA may stop rail traffic it may not redirect the movement of the traffic.
Transportation	49 U.S.C. § 20702(b); 49 CFR §§ 216.13, 216.17	FRA safety inspectors may immediately order a locomotive out of service if it is not safe to operate without unnecessary danger of personal injury (e.g., non-compliance with FRA regulations) until either repair of the defect or further inspection and a finding of compliance.

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Sector	Authority	Summary
Transportation	49 U.S.C. §§ 20111(b), 20702(b); 49 CFR §§ 216.11, 216.15, 216.17	FRA safety inspectors may immediately order freight cars and railroad passenger equipment (both cars and locomotives) out of service if they violate certain FRA regulations and are unsafe to operate until repaired or found to be in compliance.
Transportation	49 U.S.C. § 20111(b) 49 CFR §§ 213.9, 216.15, 216.17	FRA safety inspectors may order a railroad to reduce the class of a segment of its track to as low as Class 1, which entails maximum operating speeds of 10 mph for freight trains and 15 mph for passenger trains, when the track segment does not comply with the requirements for the class at which the track is being operated.
Transportation	49 U.S.C § 5334	In general, DOT is forbidden from regulating the operation, routes, or schedules of public transportation system grantees of the Federal Transit Administration (FTA). However, 49 U.S.C § 5334 creates an express exception to the above prohibition when needed for national defense or in the event of a national or regional emergency, or for purposes of establishing and enforcing a program to improve the safety of U.S. public transportation systems. FTA may not regulate the rates, fares, tolls, rentals, or other charges prescribed by any provider of public transportation. When making a grant under FTA’s Public Transportation Emergency Relief Program, grants are subject to terms and conditions FTA considers are necessary. Therefore, FTA may choose not to apply requirements that would impair the ability of a public transportation agency to act quickly in response to an event.
Transportation	49 U.S.C. § 5323, 49 CFR Parts 604, 605	FTA’s charter rule provides that evacuations and emergency services are not considered charter service. Grantees may provide emergency services that might otherwise be considered charter to a community for up to 45 days before notifying FTA. In addition, FTA may waive the prohibition against use of FTA-funded assets for school bus service during or in the aftermath of an emergency.

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Sector	Authority	Summary
Transportation	49 U.S.C. § 5331; 49 CFR Part 655; 2 CFR Part 200, 49 U.S.C. § 5323; 49 CFR Part 661	FTA may waive requirements for driver drug and alcohol testing, competitive procurement and Buy America requirements, if drivers or assets need to be quickly obtained to respond to an emergency. A recipient may not assume such waivers will be granted and must seek approval from FTA in advance.
Transportation	49 U.S.C. § 60112	The Pipeline and Hazardous Materials Safety Administration (PHMSA) has authority to issue an administrative order suspending or restricting operation of a gas or hazardous liquid pipeline facility without prior notice and hearing if it determines that: (1) continued operation of the pipeline facility is or would be hazardous; and (2) failure to issue the order expeditiously will result in likely serious harm to life, property, or the environment.
Transportation	49 U.S.C. § 5117(a)(1)	PHMSA may issue special permits authorizing a variance of specified hazardous materials transportation safety regulations for transportation of hazardous materials in a way that achieves a safety level at least equal to that required under existing law; or that is consistent with the public interest and Chapter 51, Title 49, if a required safety level does not exist.
Transportation	49 U.S.C. § 5103(c)	The Secretary of Transportation may by order waive compliance with any part of an applicable standard prescribed under Chapter 51 of Title 49 U.S.C. when it is in the public interest, not inconsistent with the safety of transporting hazardous materials, and necessary to facilitate the safe movement of hazardous materials into, from, and within an area of major disaster or emergency under the Stafford Disaster Relief and Emergency Assistance Act. A waiver may be issued for a period of not more than 60 days and may be renewed upon application to the Secretary only after notice and an opportunity for a hearing on the waiver. The Secretary shall immediately revoke the waiver if continuation of the waiver would not be consistent with the goals and objectives of this chapter.

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Sector	Authority	Summary
Transportation	33 U.S.C. §§ 984, 1226	The Saint Lawrence Seaway Development Corporation (SLSDC) may halt traffic through those portions of the St. Lawrence Seaway subject to the jurisdiction of the United States, if required for safety or security of the seaway or for national
Transportation	The Ports and Waterways Safety Act of 1972 (Pub. L. 92-340, 86 Stat. 424), as amended by the Port and Tanker Safety Act of 1978 (Pub. L. 95-474, 92 Stat. 1471).	Provides the SLSDC authority over vessel operations in the St. Lawrence Seaway.
Transportation	46 U.S.C. § 56301 <i>et seq.</i> ; Emergency Foreign Vessels Acquisition Act, 50 U.S.C. §§ 196-198.	DOT does not have the authority to regulate other maritime transportation. However, during a national emergency declared by the President, DOT, through the Maritime Administration (MARAD), can enhance U.S. sealift capacity by taking control of certain vessels through requisitioning.
Transportation	50 U.S.C. § 4405.	MARAD operates and maintains the National Defense Reserve Fleet (NDRF). The NDRF is available, among other uses, to support the deployment of the armed forces of the United States and for civil contingency operations upon orders from the National Command Authority.
Transportation	46 U.S.C. § 57533	MARAD has authority to purchase, charter, operate, or otherwise acquire the use of any documented vessel.
Transportation	46 U.S.C § 501	Although the DHS, not DOT, issues waivers of the Merchant Marine Act of 1920 (the “Jones Act”), MARAD assists DHS in determining whether such waivers are necessary, as well as the extent and duration of such waivers, by identifying available U.S. flagged sealift capacity.

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Sector	Authority	Summary
Transportation	49 U.S.C. § 5122(b); 49 U.S.C. § 5102; 49 U.S.C. §	Any aspect of hazardous materials transportation by any mode that presents an “imminent hazard” may be halted by court order. An “imminent hazard” is a condition that presents a substantial likelihood that death, serious illness, severe personal injury, or a substantial endangerment to health, property, or the environment may occur before the reasonable foreseeable completion date of a formal proceeding begun to lessen the risk of that death, illness, injury, or endangerment (49 U.S.C. § 5102). DOT may issue or impose emergency restrictions, prohibitions, recalls, or out-of-service orders involving hazardous materials, without notice or an opportunity for a hearing, but only to the extent necessary to abate an imminent hazard (49 U.S.C. § 5121(d)).
Transportation	49 U.S.C. § 521(b)(5); 49 CFR § 386.72(b)	The Federal Motor Carrier Safety Administration (FMCSA) has authority to order out-of-service a driver, commercial motor vehicle or all or part of a motor carrier’s operations as an imminent hazard (49 U.S.C. § 521(b)(5) and 49 CFR § 386.72(b)). However, unlike 49 U.S.C. Chapter 51 authorities which may be based on an unsafe condition or practice involving the transportation of hazardous material and could arise from a significant outside event, an imminent hazard order under 49 U.S.C. § 521(b)(5) and 49 CFR § 386.72(b) must be based on violations of federal motor carrier safety statute or regulations which result in an imminent hazard.
Transportation	49 U.S.C. §§ 31315 and 31502(e); 49 CFR § 390.23	Upon declaration of a regional or local emergency by the President, designated FMCSA officials, or appropriate State or local officials, FMCSA regulations provide temporary relief from specific safety regulations to any motor carrier or driver operating a commercial motor vehicle to provide direct emergency assistance during the emergency.
Transportation	Note – Federal Highway Administration	DOT’s Federal Highway Administration possesses no authority to operate the Nation’s highway system during times of emergency. States, local governments, other federal agencies, and private parties own, control, and operate the Nation’s roads and bridges.

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Sector	Authority	Summary
Transportation	6 U.S.C. § 942	6 U.S.C. § 942 (Post-incident resumption of trade) directs the U.S. Coast Guard and Customs and Border Protection to develop and update, as necessary, protocols for the resumption of trade in the event of a transportation disruption or a transportation security incident. The protocols shall include: 1) the identification of the appropriate initial incident commander, if the Commandant of the Coast Guard is not the appropriate person, and lead departments, agencies, or offices to execute such protocols; 2) a plan to redeploy resources and personnel, as necessary to reestablish the flow of trade; 3) a plan to provide training for the periodic instruction of personnel of the United States Customs and Border Protection, the Coast Guard, and the Transportation Security Administration in trade resumption functions and responsibilities; and 4) appropriate factors for establishing prioritization of vessels and cargo determined by the President to be critical for response and recovery, including factors relating to public health, national security, and economic need.
Transportation	PPD-21 Critical Infrastructure Security and Resilience	Designates DHS and DOT as the co-SSAs for the Transportation Systems Sector.

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Statutory Authorities to Direct, Suspend, or Control Critical Infrastructure Operations, Functions, and Services Before, During, and After a Space Weather Event		
Sector	Authority	Summary
Water and Wastewater Systems	42 U.S.C. § 300f	Section 1431 of the Safe Drinking Water Act includes emergency powers: The Administrator, upon receipt of information that a contaminant which is present in or likely to enter a public water system or an underground source of drinking water may present an imminent and substantial endangerment to the health of persons, and that appropriate State and local authorities have not acted to protect the health of such persons, may take such actions as he may deem necessary in order to protect the health of such persons. The action which the Administrator may take may include (but shall not be limited to): 1) issuing such orders as may be necessary to protect the health of persons who are or may be users of such system (including travelers), including orders requiring the provision of alternative water supplies by persons who caused or contributed to the endangerment, and 2) commencing a civil action for appropriate relief, including a restraining order or permanent or temporary injunction.
Water and Wastewater Systems	33 U.S.C. §§ 1364 Sec. 504	Section 504 of the Clean Water Act includes emergency powers: Notwithstanding any other provision of this chapter, the Administrator upon receipt of evidence that a pollution source or combination of sources is presenting an imminent and substantial endangerment to the health of persons or to the welfare of persons where such endangerment is to the livelihood of such persons, such as the inability to market shellfish, may bring suit on behalf of the United States in the appropriate district court to immediately restrain any person causing or contributing to the alleged pollution to stop the discharge of pollutants causing or contributing to such pollution or to take such other action as may be necessary.
Water and Wastewater Systems	Presidential Policy Directive 21 (PPD-21)	The Environmental Protection Agency (EPA) is identified as the Sector-Specific Agency for Water and Wastewater Systems, per Presidential Policy Directive 21—Critical Infrastructure Security and Resilience.

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Sector	Authority	Summary
Communications	E.O. 13618	Federal Government must have ability to communicate at all times and under all circumstances. DHS shall incorporate, integrate, and ensure interoperability and the necessary (5.2.b) incorporate, integrate, and ensure interoperability, restorability, and security to obtain, to the maximum extent practicable, the survivability of NS/EP communications defined in section 5.2(a) of this order under all circumstances, including conditions of crisis or emergency; (5.2.f) maintain a joint industry-Government center that is capable of assisting in the initiation, coordination, restoration, and reconstitution of NS/EP communications services or facilities under all conditions of emerging hazards, crisis, or emergency; (5.2.g) serve as the federal lead for the prioritized restoration of communications infrastructure and coordinate the prioritization and restoration of communications, including resolution of any conflicts in or among priorities, in coordination with the Secretary of Defense when activities referenced in section 5.1(a) of this order are impacted, consistent with the National Response Framework. If conflicts in or among priorities cannot be resolved between the Departments of Defense and Homeland Security, they shall be referred for resolution in accordance with section 2.1 of this order.
Communications	47CFR 215.2	Space weather and electromagnetic pulse (EMP) are complimentary phenomenon. The Executive Agent, DHS Office of Emergency Communications (OEC), shall be the focal point within the federal Government for all EMP technical data and studies concerning telecommunications. It shall provide such data and the results of such studies to all appropriate agencies requesting them. It shall coordinate and approve EMP telecommunications tests and studies, and shall keep the National Security Advisor informed regarding such tests and studies being conducted and planned.



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Sector	Authority	Summary
Communications	Sec 706 [47U.S. Code 606]	Upon proclamation by the President that there exists war or a threat of war, or a state of public peril or disaster or other national emergency, or in order to preserve the neutrality of the United States, the President, if he deems it necessary in the interest of national security or defense, may suspend or amend, for such time as he may see fit, the rules and regulations applicable to any or all stations or devices capable of emitting electromagnetic radiations within the jurisdiction of the United States. Space weather event falls into public peril, disaster, national emergency considerations.
Communications	42 U.S.C. 5121-5207 Stafford Act	Governing document for organizing federal response.
Energy	Energy Supply and Environmental Coordination Act of 1974, as amended	Authority to obtain current information regarding emergency situations in the electric supply systems in the United States. DOE has established mandatory reporting requirements for electric power system incidents or possible incidents ( <i>see</i> Federal Energy Administration Act authority summary).
Energy	Federal Power Act, as amended	Authority to obtain current information regarding emergency situations in the electric supply systems in the United States. DOE has established mandatory reporting requirements for electric power system incidents or possible incidents ( <i>see</i> Federal Energy Administration Act authority summary).

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Statutory Authorities to Direct, Suspend, or Control Critical Infrastructure Operations, Functions, and Services Before, During, and After a Space Weather Event		
Sector	Authority	Summary
Energy	Fixing America’s Surface Transportation Act	<p>Authority to develop and adopt procedures to improve coordination between DOE energy response teams, federal partners, and industry to enhance emergency preparedness for natural disasters.</p> <p>As lead Sector-Specific Agency for cybersecurity for the energy sector, authority (in coordination and/or collaboration with other relevant agencies and entities) to “serve as a day-to-day Federal interface for the dynamic prioritization and coordination of sector-specific activities, carry out incident management responsibilities consistent with applicable law (including regulations) and other appropriate policies or directives, [help to] identify vulnerabilities and mitigate incidents, as appropriate, and support the reporting requirements of the Department of Homeland Security under applicable law by providing, on an annual basis, sector-specific critical electric infrastructure information and issues orders for emergency orders in the event of a grid security emergency.</p>
Energy	Bonneville Project Act of 1937, Reclamation Act of 1939, Flood Control Act of 1944, et al. (as amended)	DOE’s Power Marketing Administrations have general powers to manage multiple areas ranging from protection to response and restoration. The authorities cover generation, transmission, and related facilities.

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Statutory Authorities to Direct, Suspend, or Control Critical Infrastructure Operations, Functions, and Services Before, During, and After a Space Weather Event		
Sector	Authority	Summary
Energy	Defense Production Act of 1950, as amended	Secretary of Energy has delegated authority with respect to all forms of energy to require the priority performance of contracts or orders relating to materials (including energy sources), equipment, or services, including transportation, or to issue allocation orders, as necessary or appropriate for the national defense or to maximize domestic energy supplies.
Energy	Public Utility Regulatory Policies Act of 1978, and Power Plant and Industrial Fuel Use Act	Secretary of Energy authorized to request “appropriate persons” to examine and report to the President concerning any electric utility reliability issue.
Energy	Homeland Security Act of 2002	As the primary agency charged with implementing Emergency Support Function #12 – Energy, under the National Response Framework has responsibility to facilitate the reestablishment of damaged energy systems. This can include assessment and repair of energy infrastructure, coordination of energy industry utilities, and energy forecasting.
Energy	Federal Energy Administration Act of 1974	Authorizes the Secretary of Energy to order “all persons owning or operating facilities or business premises who are engaged in any phase of energy supply or major energy consumption” to make available energy-related information.
Energy	Executive Order 13744—Coordinating Efforts to Prepare the Nation for Space Weather Events	The Secretary of Energy shall facilitate the protection and restoration of the reliability of the electrical power grid during a Presidentially declared grid security emergency associated with a geomagnetic disturbance.
Energy	Presidential Policy Directive 21—Critical Infrastructure Security and Resilience	Designates DOE as the Sector-Specific Agency for the Energy Sector.

## APPENDIX E: D/A WATCH CENTER GUIDANCE

The following appendix provides concepts and samples for those in D/A watch centers who may need more detailed information about space weather notifications. Those D/As without a watch will also benefit from this guidance as it discusses the monitoring, analysis, application, and notification procedures necessary for space weather events. These duties may be performed by emergency management, continuity programs, and other personnel tasked with the duty to ensure the continuation of their mission in the event of a crisis. This guidance does not supplant internal D/A emergency management procedures, or continuity plans. It is intended to provide information unique to the space weather event that may be incorporated into these plans as the D/A deems fit. The two primary areas discussed are the pre-event awareness of an impending event and the necessary actions required should a response be required. Each representative given the responsibility for monitoring space weather conditions should use these tools as appropriate.

The monitoring of space weather should be conducted by frequently checking the SWPC website and notification emails. Once a notification of a potential space weather event, documenting actions taken, reporting the hazard to the appropriate D/A leadership should occur. The type, estimated time of impact, potential damage to critical infrastructure, and areas affected should be noted as they will determine which protective actions will be taken. The provided checklist also includes contact information for key personnel and organizations, which should be informed of the space weather hazard.

As the space weather situation evolves and more information is gathered, additional stakeholders may need to be contacted. It is essential that D/As with decentralized facilities and personnel maintain awareness of conditions throughout their organization. Should the space weather event affect D/A critical infrastructure, their reactions should reflect current emergency management and continuity SOPs. More detailed information is provided below.

### Key Space Weather Notifications

SWPC issues many notification products, such as watches, warnings, alerts, and summaries. A *watch* is a long lead-time prediction of a space weather event, which carries lower confidence in the timing and intensity of the predicted disturbance than a warning. *Warnings* are high-confidence predictions of a space weather event believed to create physical impact to CI, issued only minutes to hours in advance. *Alerts* indicate that the Earth is currently experiencing an event whose intensity has observed impacts on CI. SWPC issues many types of space weather summaries; however, only the *event summary* is relevant for disaster preparedness. Event summaries are issued after the event intensity has decreased below a previously exceeded threshold, though the danger may not have completely passed.

The following are the specific notifications that D/As will use to escalate through pre-event operational phases and into the initial response phase. Each watch and warning product may contain an expiration date, which will trigger entrance to a reduced phase. Further, watch and warning products may be modified by subsequent notifications that either extend the expiration date or to immediately cancel the prior product. These events will also trigger a de-escalation of the phase.

A **Geomagnetic Disturbance Watch** is driven by the *forecast* of an impending geomagnetic disturbance due to an *observed* coronal mass ejection (CME). The watch can cover the current day through the third day of the forecast period (or up to 90 hours lead time). Lead times vary significantly, with some of the historically fastest CMEs arriving within 16 hours. A Watch carries a lower degree of confidence both in intensity and in timing than the Warning product but is useful for longer-range notification of an

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expected geomagnetic disturbance.

A **Geomagnetic Disturbance Warning** is driven by the *observation* of the solar wind condition affecting Earth. Geomagnetic Disturbance Warnings carry a higher degree of confidence in both timing and intensity but are generally only issued minutes to a couple of hours in advance. SWPC only issues a single warning product for G3-5 events; thus, it is used to trigger phase escalation, despite G3 disturbances being outside the scope of the Federal operating concept.

A **Geomagnetic Disturbance Alert** is driven by ground-based magnetometer observations and is indicative of a specific disturbance threshold being reached. In other words, an Alert is a characterization of what is occurring now.

**Radiation Event Watch** indicates that solar activity is high, though the probability of a radiation event is unable to be predicted. Due to the difficulty of forecasting a radiation event, SWPC will use the geomagnetic disturbance watch product as a proxy for the radiation event watch. This is rational because a level 4-5 geomagnetic disturbance watch is the result of an observed CME; an S4 or S5 event can generally only be produced during a CME capable of also producing a G4 or G5 event.

**Radiation Event Warning** indicates a possible event on the tens of minutes to hours timescale. The amount of lead time possible is strongly influenced by how well-connected Earth is to the source region on the Sun. In some cases, well-connected events will exceed thresholds almost immediately, resulting in little to no warning lead time.

**Radiation Event Alerts** are issued when observed values at the NOAA GOES satellites exceed event thresholds. Alerts are issued for each NOAA Radiation Event Scale level, driven by measured intensity.

**Radiation Event Summaries** are issued post-event and will indicate peak intensity as well as the particulars of start, peak, and end times for each event level (e.g. the S5 Radiation Event Summary will be issued when event levels have subsided below the S5 event threshold but generally before the S4 Radiation Event has ended). Receipt of a Radiation Summary does not automatically trigger a phase de-escalation.

### Watch Center Decisions


The following flowcharts were created to give emergency managers and leaders an overall understanding of the flow in which a space weather event could evolve from an observable, potential event (phase 1B) to an event that is highly likely to impact critical infrastructure on Earth (phase 1C). Because G and S disturbances have different attributes, it may be beneficial for the watch centers to understand these differences, so they may incorporate them into their decision processes. The following graphics show the different triggers based upon the disturbance type.

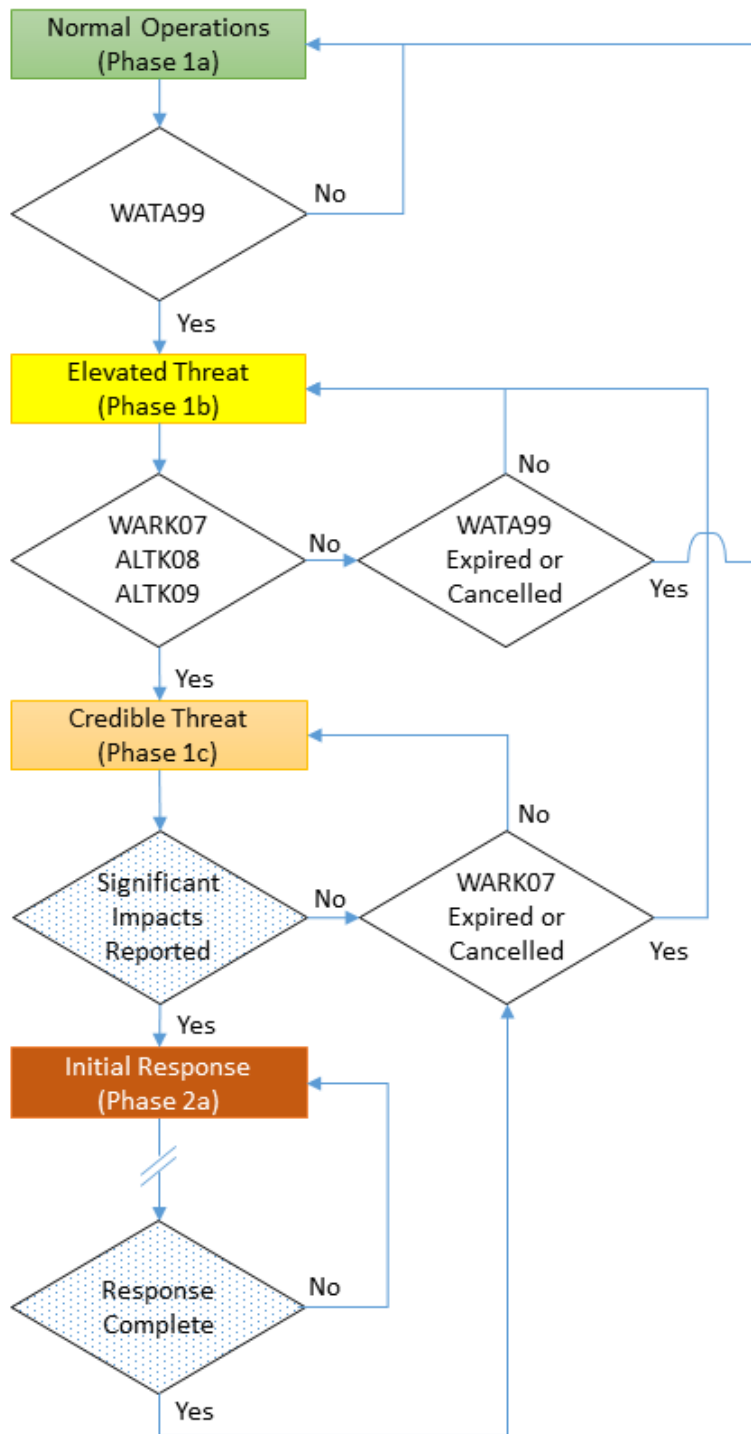
The following two graphics depicts the movement through the emergency management phases during a geomagnetic disturbance and radiation event, respectively.

## Geomagnetic Storm Phase Escalation Triggers: Watches, Warnings, and Alerts

### SWPC Notifications

Code	Product
WATA99	WATCH: Geomagnetic Storm Category G4 or Greater Predicted
WARK07	WARNING: Geomagnetic K-index of 7 or greater (G3)
ALTK08	ALERT: Geomagnetic K-index of 8 (G4)
ALTK09	ALERT: Geomagnetic K-index of 9 (G5)


 Not a SWPC Product

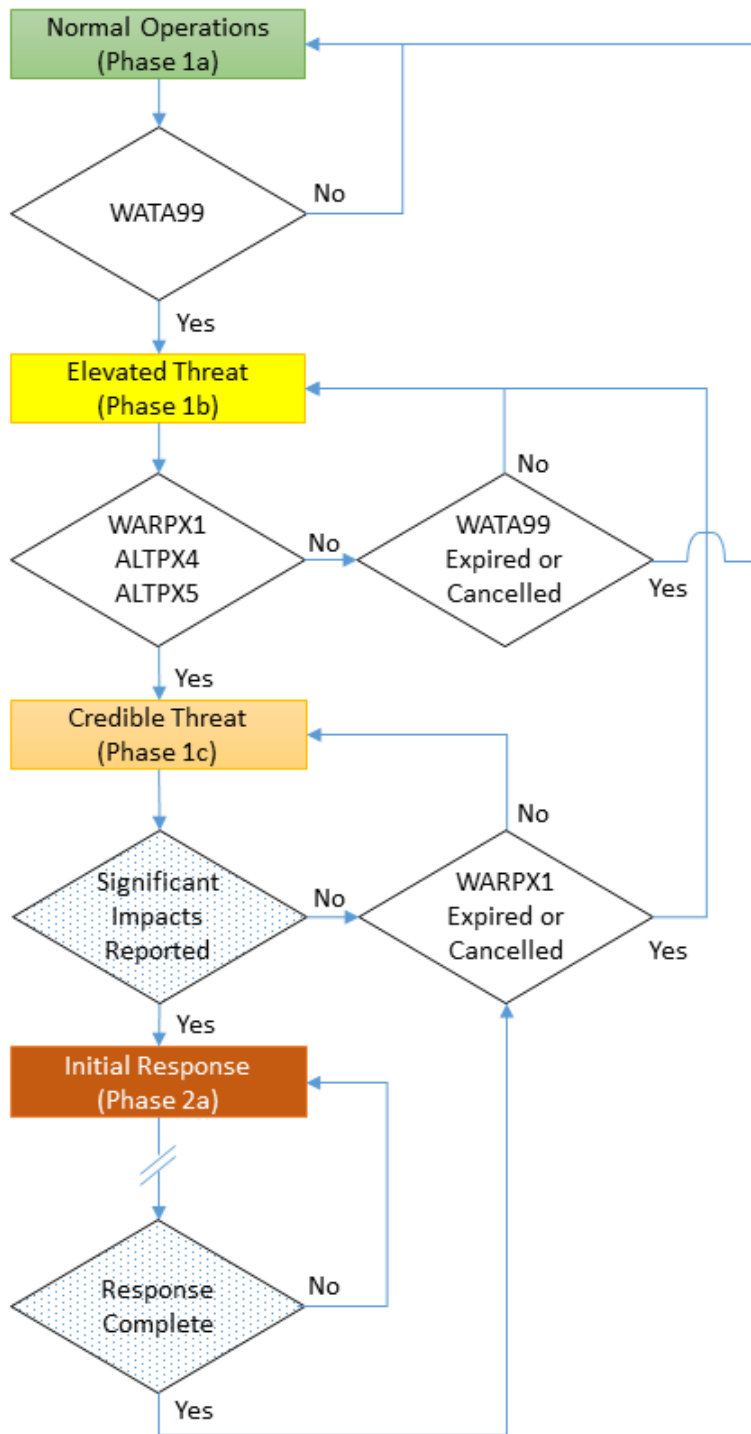


## Radiation Storm Phase Escalation Triggers: Watches, Warnings, and Alerts

### SWPC Notifications

Code	Product
WATA99	WATCH: Geomagnetic Storm Category G4 or Greater Predicted. This product will also serve as a severe radiation storm watch.
WARPX1	WARNING: Radiation storm S1 or Greater. See field 'NOAA Scale' for predicted intensity. Only advance if field 'NOAA Scale' indicates S4 or S5 intensity
ALTPX4	ALERT: Proton Event 10 MeV Integral Flux exceeded 10,000 pfu (S4)
ALTPX5	ALERT: Proton Event 10 MeV Integral Flux exceeded 100,000 pfu (S5)

 Not a SWPC Product



## Watch Center Processes

D/A watch centers must integrate potential space weather events into their existing watch center processes, taking into consideration the unique nature of this hazard. The following gives some sample checklists and decision tools that could be integrated into D/As watch center protocols.

A generic watch center checklist that systematically outlines the steps taken to prepare for, and respond to notification of an impending event is offered below. This checklist is offered as guidance and should be altered as necessary for each D/A.

### D/A National Watch Center Checklist

**Applicability:** Used when notified of a severe space weather event (G4/S4 or higher), an ongoing or predicted space weather event, or any significant space weather activity receiving National Media coverage.

Sequence of Events Overview:

05 Minutes: D/A Watch Center must notify appropriate executive leadership, emergency managers, and continuity managers

15 Minutes: D/A Watch Center alerts proper stakeholders of impending disturbance

15 Minutes: D/A Watch Center contacts FEMA Operations Center to advise status and precautions taken

Checklist:

\_\_\_ 1. Time checklist initiated

\_\_\_ 2. Confirm event with FEMA Operations Center (800-634-7084)

\_\_\_ 3. IDENTIFY

Type of Event(geomagnetic/radiation) \_\_\_\_\_

Estimated time of impact \_\_\_\_\_

Potential impacts \_\_\_\_\_

Areas impacted \_\_\_\_\_

D/A actions \_\_\_\_\_

\_\_\_ 4. Gather additional information, as required:

Contact DOE (202-586-8100), get impact/status on power grid: \_\_\_\_\_

Contact NOAA LNO (202-646-2817), obtain latest data from SWPC (303-497-7492)

Contact NICC Watch (202-646-2817), see if they have any impact data to provide

Is NCR in the potential impact zone? (*If yes, review QRC #4C, Devolution*)

\_\_\_ 5. Test comms/network availability if necessary

\_\_\_ 6. Scan applicable websites for situational awareness (SWPC, NWS, News sites, etc.)



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\_\_7. Transmit Initial SPOTREP with available information to distribution group

The contact information for the required persons notified are:

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\_\_8. Initiate pre-impact protection measures