ANNEX C TO THE LONG-TERM POWER OUTAGE PLAN
ELECTROMAGNETIC INCIDENTS

I. INTRODUCTION

A. Electromagnetic incidents fall under the umbrella of long-term power outages (LTPOs) and thus are subject to the same state and federal planning and preparedness requirements laid out in the LTPO Base Plan.

B. Electromagnetic incidents include both intentional man-made electromagnetic pulse (EMP) attacks and naturally occurring geomagnetic disturbances (GMD) caused by space weather.

C. While the effects of an electromagnetic incident may be similar to other LTPO hazards, the causes, impacts, and response and recovery actions may differ and be more extensive.

1. Electromagnetic incidents can disrupt or damage significant portions of the electrical grid, communications equipment, water and wastewater systems, and transportation modes. The impacts are likely to cascade, impacting additional lifeline sectors, and impacts could expand beyond the initial geographic regions.

2. Electromagnetic incidents have a different damage footprint than other hazards causing an LTPO. There will be greater compromise of any unprotected electronic equipment, devices, and systems, and electronic infrastructure and equipment may need to be repaired or replaced, leading to longer response and recovery time.

3. Much of the physical damage will be internal and not immediately obvious. In some cases, systems and equipment may have been merely tripped off-line and shut down but remain undamaged.

II. SCOPE

A. This annex provides specific electromagnetic incident material to the framework established in the LTPO Base Plan.

B. This annex pertains specifically to state-level response to LTPOs caused by electromagnetic incidents under the authority and responsibility of the South Carolina State Emergency Response Team (SERT).

III. FACTS AND ASSUMPTIONS

A. Facts

1. Electromagnetic incidents are considered low probability/high consequence events.

2. Any electronics system that is not protected against extreme EMP or GMD events may be subject to either the direct impact of the pulse itself or to the damage that is inflicted on the systems and controls upon which they were dependent.

3. Electromagnetic incidents do not have any direct negative health or safety effects on humans and do not directly interfere with radio communications; those impacts occur from indirect cascading effects.

4. The majority of all electrical infrastructure, equipment, and devices (government, commercial, and private) are unprotected against electromagnetic incidents and are at risk of impacts from an event.

B. Assumptions

1. The potential for simultaneous disruptions over large areas of the country could limit or eliminate mutual aid as a response option.

2. Response to a widespread electromagnetic event will require significant federal assistance and the regional impacts of such an event may hinder the availability to provide or receive state mutual aid through the Emergency Management Assistance Compact (EMAC).

3. Due to the severe impacts caused by a high impact electromagnetic incident, the SEOC may be operating under the South Carolina Continuity of Operations (COOP) Plan.

IV. SITUATION

A. EMP incidents are considered to be more intense, but the same protection, mitigation, and response measures generally apply to all electromagnetic incidents.

B. There are two types of electromagnetic events, EMPs and GMDs:

1. EMPs are associated with intentional attacks using high-altitude nuclear detonations, specialized conventional munitions, or non-nuclear directed energy devices.

a. A high-altitude electromagnetic pulse (HEMP) attack is the detonation of a nuclear weapon at high altitude or in space (~ 30 km or more above the earth's surface). A HEMP can generate an intense EMP. HEMP propagates to the earth and can impact various ground-based technological systems such as the electric power grid. The resulting HEMP, which is generally characterized by three hazard fields, E1, E2 and E3, is a function of the location of the explosion above the earth's surface and weapon yield (See table 1 below). HEMPs are of most concern because they may permanently damage or disable large sections of the national electric grid and other critical infrastructure control systems.

b. Non-nuclear directed energy devices create the effects of an EMP without a nuclear explosion. They can disrupt electronics over a limited range.

2. GMD events are associated with solar coronal mass ejections. Plasma from the sun, with its embedded magnetic field, arrives at Earth and can cause widespread, long-lasting damage to electrical power systems, satellites, electronic navigation systems, and undersea cables.

a. GMD events are considered to be less intense and unlike a single high-intensity EMP pulse, will rather feature multiple lower-intensity pulses with varying amplitudes over hours or days. Also, unlike EMPs, GMDs are a natural hazard that occur with some regularity at lower intensities.

b. The National Oceanic and Atmospheric Administrations (NOAA) Space Weather Prediction Center (SWPC) can issue warnings for GMDs.

C. The National Cybersecurity and Communications Integration Center defines four levels of protection for EMPs and GMDs (See table 2 below):

1. Level 1 begins with low-cost methods and best practices to help protect critical infrastructure from severe damage.

2. Level 2 guidelines are based on using EMP-capable filters and surge arresters on power cords, antenna lines, data cables, as well as installing fiber optics and ferrites, where possible, to protect critical equipment.

3. Level 3 guidelines are appropriate for organizations, facilities, and systems that cannot tolerate more than a few minutes of mission outage due to EMP, in order to effectively protect life, health, and security.

4. Level 4 guidelines are for organizations/missions/systems that cannot tolerate more than a few seconds of outage and where immediate life and safety are at stake.

Table 1: EMP and GMD Characteristics

Attribute	EMP	GMD
Cause	Adversarial threat	Natural hazard
Warning	Strategic: unknown Tactical: none to several minutes	Strategic: 18 to 72 hours Tactical: 20 to 45 minutes
Effects	*E1:* High peak field – quick rise time *E2:* Medium peak field *E3:* low peak field, but quicker rise time and higher field than for GMD (possibly 3 times higher)	No comparable E1 wave forms No comparable E2 wave forms *E3:* low peak field – fluctuating magnitude and direction
Duration	*E1:* less than a 1 microsecond *E2:* less than 10 millisecond *E3 Blast:* ~10 seconds *E3 Heave:* ~1 – 2 minutes	No comparable E1 wave forms No comparable E2 wave forms *E3:* hours
Equipment at Risk	*E1:* telecommunications, electronics and control systems, relays, lightning arrestors *E2:* lightning: power lines and tower structures – "flashover", telecommunications, electronics, controls systems, transformers. *E3:* transformers and protective relays – long run transmission and communication - generator step-up transformers	*E3:* transformers and protective relays – long-haul transmission and communications – generator step-up transformers
Footprint	Regional to continental depending on height of burst	Regional to worldwide, depending upon magnitude
Geographic Variability	Can maximize coverage for E1 or E3 *E3:* intensity increases at the lower latitudes and as distance from ground zero is decreased or as yield is increased	*E3:* intensity increases near large bodies of water and generally at higher latitudes although events have been seen in southern latitudes

Source: U.S. Department of Energy, "Electromagnetic Pulse Resilience Action Plan," p.4

Table 2: Four EMP Protection Levels for Infrastructure and Equipment

Level 1: Lowest cost; longer mission outages permitted	Level 2: Only hours of mission outages are permitted	Level 3: Only minutes of mission outages are permitted	Level 4: Only seconds of mission outages permitted
• Unplug power, data, and antenna lines from spare equipment where feasible. • Turn off equipment that cannot be unplugged and is not actively being used. • Use at least a lightning rated surge protection device (SPD) on power cords, antenna lines, and data cables; maintain spare SPDs. • Have either EMP protected backup power or a generation source that is not connected to the grid with one (1) week of on-site fuel or equivalent (e.g., renewable source). • Wrap spare electronics with aluminum foil or put in Faraday containers. • Use priority phone services like GETS, WPS (for cell phones), and TSP; join SHARES if applicable (see Appendix C).	In addition to Level 1: • Use EMP-rated SPDs on power cords, antenna lines, and data cables to protect critical equipment. • Use on-line/double-conversion uninterruptible power supplies (UPS) or a high quality line interactive UPS. • Use fiber optic cables (with no metal); otherwise use shielded cables, ferrites, and SPDs. Note: shielded racks, rooms or facilities may be more cost-effective than hardening numerous cables. • Use EMP protected backup power that is not vulnerable to EMP coupled through the power grid. • Implement EMP protected, high frequency (HF) voice and email for long-distance communications. • Consider geosynchronous (GEO) orbit satellite	In addition to Level 2: • Use International Electrotechnical Commission (IEC) EMP and IEMI protection standards (IEC SC 77C series, see Appendix F). • Shielding should be 30+ dB of protection through 10 GHz. • Use EMP shielded racks, rooms, or facilities to protect critical computers, data centers, phone switches, industrial and substation controls and other electronics. • Use "Recommended E3 HEMP Heave Electric Field Waveform for the Critical Infrastructures" from EMP Commission for grid and undersea cable protection planning. Use 85 V/km for CONUS E3 threat. • Use EMP tested SPDs and equipment. • Institute IEC level hardness maintenance &	In addition to Level 3: • Use Military EMP Standards (like MIL-STD-188-125-1 and MIL-HDBK-423), and 80+ dB hardening through 10 GHz. • Use EMP shielding in rooms, racks, and buildings as needed to protect critical equipment. • Use EMP protected double-door entryways. • Validate per Military guidelines, like Test Operations Procedure (TOP) 01-2-620 HEMP. • Have 30+ days of Military Standard protected power and fuel, plus alternate generation source (renewables preferred). • Consider double surge protection on critical external lines entering EMP protected areas. • Consider using communications systems/networks that are designed to meet Military EMP standards, like:

• Consider land mobile radios with standalone capabilities, HF radios, and FirstNet. • Store one week of food, water, and other supplies for personnel. • Use battery operated AM/FM/NOAA radios to receive Emergency Alerts.	services, like BGAN. Avoid low-earth orbit (LEO) satellite services. Use terminals that are EMP resilient. • Consider shortwave radio for situational awareness.	surveillance (HM/HS). • Have 30 days of EMP protected power/fuel. • Store 30 days of food, water, and critical supplies and spares. • Use time-urgent EMP resilient comms, like X, Ku and Ka satellite, and either HF groundwave or Automatic Link Establishment (ALE) HF.	Advanced EHF (AEHF) satellite, EMP protected fiber optic networks, and EMP protected radios. • Institute ongoing Military Standard HM/HS programs.

Source: National Cybersecurity and Communications Integration Center, "Electromagnetic Pulse (EMP) Protection and Resilience Guidelines for Critical Infrastructure and Equipment", p.3

V. CONCEPT OF OPERATIONS

A. The operational phases align with the phases outlined in the LTPO Base Plan, though the following additional considerations are needed to account for the unique circumstances of electromagnetic impacts, protection, and repair.

B. Pre-Impact

1. Warning of an impending electromagnetic incident could offer utilities time to take operational actions that could significantly reduce harmful impacts to their systems.

2. Although these warning times may only be issued minutes before an event, there are emergency actions such as disconnecting, powering down, or rerouting lines, systems, and equipment that may mitigate impacts, ease response, and expedite recovery.

C. Post-Impact

1. Depending on the extent of the impacts and status of communication equipment, SCEMD and the SERT disseminate to the whole community, but especially utilities, first responders, and owners/operators of critical

infrastructure the unique nature of electromagnetic incident impacts could facilitate better informed, targeted and comprehensive post-incident diagnostic inspections, thereby ensuring more timely stability and continuity of operations and preventing wasted effort and funding to repair or replace equipment that was merely tripped off.

2. Because impacts from an electromagnetic incident may involve damage to small internal components that are not immediately visible, post-incident electronic diagnostics is essential to identify and discern which impacted components, equipment and devices are damaged and which may only have been tripped off and can be quickly and easily reset.

3. If the infrastructure and equipment used in normal operations is damaged or offline, the SEOC will operate under the conditions laid out in the SC COOP Plan.

4. Unique Challenges to Black Start Operations After an Electromagnetic Incident

   a. While many utilities have black start plans and capabilities, these are likely based on more typical hazards and events; the systems and equipment needed for black start capabilities may themselves have been impacted by the incident.

   b. It is probable that the communications capabilities needed to coordinate the carefully balanced restoration of the grid may also be inoperable.

   c. Much of the electrical equipment powered by the affected portion of the grid may similarly be damaged and will affect the availability of the load necessary to balance the system when restarting generation stations.

5. The substantial and widespread amount of damages to electronic equipment and devices will likely cause significant shortages and backlogs of replacement parts and skilled persons qualified to make such repairs.

6. Procurement may be the fastest way to restore critical command and control operability and continuity of government and operations and may need to be prioritized early along with lifesaving initiatives.

7. In the event of an LTPO caused by an electromagnetic incident, initial and intermediate recovery efforts have the potential to span for much longer than LTPOs caused by other hazards.

VI. DISASTER INTELLIGENCE AND COMMUNICATIONS

A. Lifeline Sector Analysis

1. All community lifeline impacts laid out in the LTPO Base Plan will be more prevalent, widespread, and longer lasting due to the additional potential loss of equipment and backup power systems, coupled with the additional repair and restoration time on the electrical grid.

2. Significantly more strain may be laid out on each community lifeline as the longevity and geographic scale of such an event would limit mutual aid and extend restoration time.

B. Communications

1. State and regional communication capabilities may be significantly impacted. The use of alternate, contingency, or emergency communication methods may be required.

2. The National Public Warning System ensures the President of the United States can communicate with Americans in the event of a national emergency. The FEMA IPAWS Program equips 77 private sector radio broadcast stations with EMP-protected backup transmitters, communications equipment, and power generators that would enable the station to broadcast national emergency information to the public in the event of an EMP incident.

VII. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. In addition to the responsibilities laid out in the LTPO Base Plan, the following responsibilities are unique to electromagnetic incidents.

B. Emergency Support Functions

1. ESF-2 (Communications)

a. South Carolina Department of Administration, Office of Technology and Information Services (Coordinating Agency)

(1) Facilitate information-sharing and readiness outreach to owners/operators of critical communications infrastructure regarding potential impacts of electromagnetic disturbances and long-term power outages; coordinate situational awareness and restoration priorities with providers, while

recognizing that identification, reset, and repair of provider networks remain owner/operator responsibilities.

2. ESF-3 (Public Works and Engineering)

   a. South Carolina National Guard (Coordinating Agency)

      (1) Educate utilities and owners/operators of critical water/wastewater infrastructure how to identify, repair, or reset elements impacted by an electromagnetic incident.

3. ESF-7 (Finance and Administration)

   a. South Carolina Emergency Management Division (Coordinating Agency)

      (1) Given the anticipated damage and destruction to electronic systems and equipment on a massive geographic scale, be prepared to procure replacement parts and equipment at unprecedented quantities.

      (2) Emergency, non-electronic procurement procedures will likely need to be incorporated given the impacts to traditional systems.

4. ESF-12 (Energy)

   a. South Carolina Office of Regulatory Staff (Coordinating Agency)

      (1) Immediately communicate the unique nature of electromagnetic incidents to utilities so they can direct their repair and restoration activities accordingly.

      (2) Work with utilities to facilitate their needs and resource gaps given that their traditional black-start systems may themselves have been impacted by the incident.

VIII. PLAN DEVELOPMENT AND MAINTENANCE

This annex complies with plan development and maintenance elements of the LTPO Base Plan.