



May 8-9 2024

Space Weather Tabletop Exercise (SWx TTX)

NASEM Space Weather Roundtable

8 July 2024

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The Johns Hopkins Applied Physics Laboratory




FEMA

Two Space Hazards, Two National Strategy & Action Plans



SPACE WEATHER
TABLETOP EXERCISE



**NATIONAL SPACE WEATHER
STRATEGY AND ACTION PLAN**

Product of the
SPACE WEATHER OPERATIONS, RESEARCH, and MITIGATION
WORKING GROUP
SPACE WEATHER, SECURITY, and HAZARDS SUBCOMMITTEE
COMMITTEE ON HOMELAND and NATIONAL SECURITY
of the
NATIONAL SCIENCE & TECHNOLOGY COUNCIL


March 2019

§3.5 Exercise Federal response, recovery, and operations plans and procedures for space weather events. [Ongoing; DHS, DOC, DOD, DOE, DOS, DOT, and NRC]

PLANETARY DEFENSE INTERAGENCY TABLETOP EXERCISE 4



§5.1 Develop a set of real-world scenarios based on credible impact threats with observable parameters to inform planning and procedure development. [Short term; FEMA, DHS, NASA]



**NATIONAL PREPAREDNESS
STRATEGY & ACTION
PLAN FOR NEAR-EARTH
OBJECT HAZARDS AND
PLANETARY DEFENSE**

Earth
A PRODUCT OF THE
PLANETARY DEFENSE INTERAGENCY WORKING GROUP
OF THE
NATIONAL SCIENCE & TECHNOLOGY COUNCIL
APRIL 2023

Space Weather TTX



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- Approaching Solar Max
- Unprecedented level of susceptibility
- Need for speed – get the word out fast



- Time
- Right people & organizations
- Right discussions



- Policy gaps
- Technology gaps
- Communications gaps



SWx TTX participants at APL

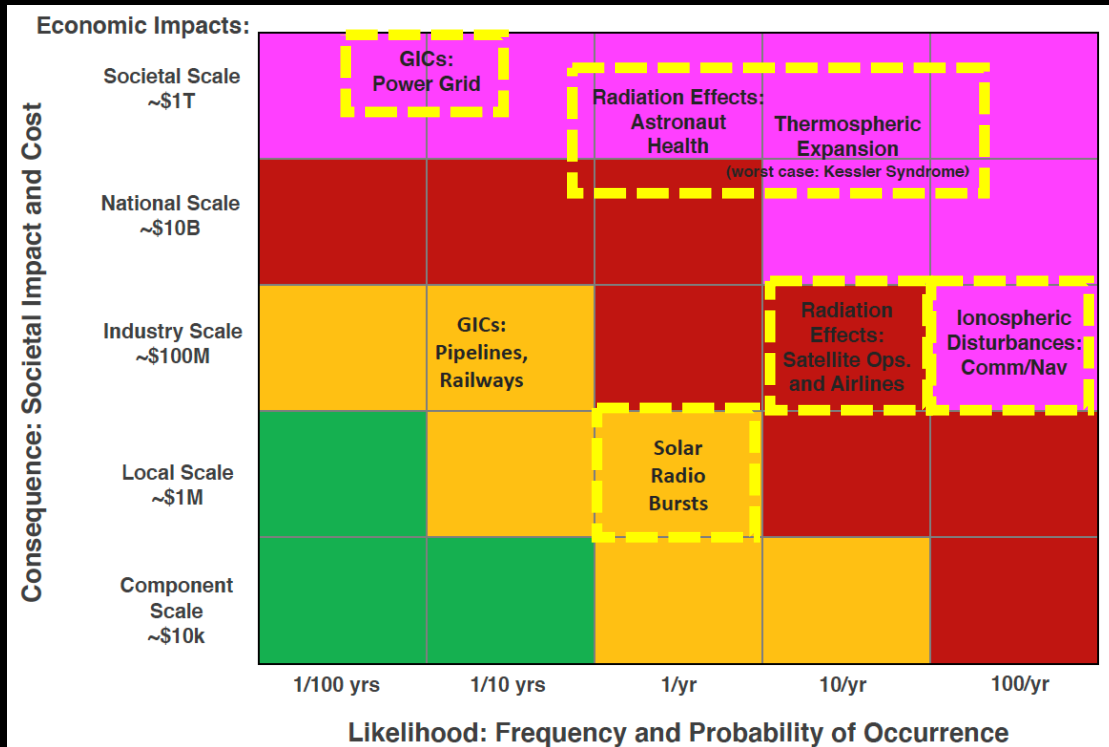


PDTTX4 After Action Report has helped define future investments

Exercising the Major Aspects of SWx



Likelihood v. Consequence chart for critical space weather hazards



TTX scenario incorporates each of the major SWx hazards identified in the NASA 2021 SWx Gap Analysis

Space weather hazards and vulnerabilities for different space weather drivers

SWx Vulnerability	SWx Driver:			
	CME-triggered Geomag. Storm	Fast-stream-triggered Geomag. Storm	Solar Energetic Particle Event	Solar Flare Event (incl. Solar Radio Bursts)
Power Grid Damage	Possible	Unlikely	N/A	N/A
Satellite Comm/Nav Degradation or Outage	Likely	Likely	Possible	Likely
Satellite Drag and Collision Avoidance/Debris	Likely	Possible	Unlikely	Possible
Radiation Effects on Spacecraft and Aviation	Possible	Likely	Likely	Possible
Astronaut Health and Safety	Possible	Unlikely	Likely	Possible

TTX scenario incorporates several of the most impactful solar, solar wind, and geomagnetic drivers of SWx plus engages the full range of vested end-user communities

Exercise Planning Team

Many organizations helped to plan and execute this event



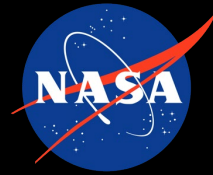
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- **NOAA's Space Weather Prediction Center:** Sponsor, provided direction, space weather expertise and planning oversight.
- **National Science Foundation:** Sponsor, provided direction and expertise.
- **NASA:** Sponsor, provided direction and expertise.
- **FEMA:** Sponsor, provided guidance, operational expertise, and liaison for state, local and tribal partners.
- **White House Office of Science and Technology Policy (OSTP):** Advisor and planning partner.
- **DoD US Air Force:** Advisor and planning partner.
- **Johns Hopkins Applied Physics Laboratory (APL):** Lead for planning, execution, evaluation, and provided expertise in space weather, critical infrastructure and emergency management.

Government Participants



SPACE WEATHER
TABLETOP EXERCISE



FEMA



U.S. AIR FORCE

55th

WEATHER
WING



UNITED STATES
SPACE FORCE



COLORADO
Department of Transportation



Background



- On May 8-9 2024, APL hosted the first ever end-to-end Space Weather (SWx) Tabletop Exercise (TTX). The hypothetical scenario presented a series of solar events involving a range of impacts on Earth and in cislunar space.
- The TTX was concurrently held in two locations:
 - APL in Laurel, MD for federal participants
 - FEMA Region 8 in Denver, CO for Federal, state, local and tribal participants
- The SWx TTX was designed to provide a low-stress, no-fault environment for generating dialogue about the challenges of preparing for and responding to an impending SWx event.

By chance, the largest solar-geomagnetic disturbance in ~20 years occurred during the TTX. These extraordinary events required key participants to divide their time between the TTX and real-world needs.

Active Space Weather Conditions Through Weekend
WHAT: Large Sunspot Groups and Flares Lead to First G4 Watch Since 2005

- On Thursday, May 9, the NOAA Space Weather Prediction Center issued a Severe (G4) Geomagnetic Storm Watch – the first since January 2005.
- At least five earth-directed coronal mass ejections (CMEs) were observed and expected to arrive as early as midday Friday, May 10, 2024, and persist through Sunday, May 12, 2024. This is an unusual event.
- Several strong flares have been observed over the past few days and were associated with a large and magnetically complex sunspot cluster (NOAA region 3664), which is 16 times the diameter of Earth. Additional solar activity is expected from the region.
- Only three Severe geomagnetic storms have been observed during this solar cycle which began in December 2019. The last G4 (Severe) was on March 23, 2024, and the last G5 (Extreme) was the Halloween Storms in October 2003. That G5 resulted in power outages in Sweden and damaged power transformers in South Africa.

2024-05-09 19:28:00 UTC

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce
Safeguarding Society with Actionable Space Weather Information
Space Weather Prediction Center: Boulder, CO

<https://www.swpc.noaa.gov/news/swpc-issues-its-first-g4-watch-2005>

Dual Exercise Locations

- Senior leaders participating and interacting via two locations in Laurel, MD (ET) & Denver, CO (MT)
- Allowed for opportunities to explore the many challenges associated with preparing for, protecting against, and mitigating the effects of impending space weather events at the federal, state, local and tribal levels.



**Two locations
interacting virtually,
simulating real-
world coordination**



Participants in Laurel MD from federal departments and agencies.

Participants in Denver from Region 8 departments & agencies

FEMA Region 8 (R8) Role



As FEMA's designated **Center of Excellence for Space Weather Prediction**, FEMA Region 8 is a critical partner as they serve as a use case opportunity via this TTX for the nation for developing and sharing best practices, as well as lessons learned.

FOCAL POINT
for the purposes of this TTX

REGION 8

The mission of the Cybersecurity and Infrastructure Security Agency (CISA) is to lead the national effort to understand and manage cyber and physical risks to our critical infrastructure.

Because roughly 85% of American infrastructure is privately owned, CISA acts as a central coordinator of analysis, planning, and response working with partners to defend against today's threats and collaborating to build more secure and resilient infrastructure for the future.

R8 AT-A-GLANCE

Serving: Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming, and 28 Tribal Nations

Regional Office: Lakewood, Colo.
Coverage Area: 573,259 square miles
Estimated Population: 11,435,332

Key Facts:

- Lead nation in coal production
- Significant products: natural gas, crude oil, and barley

Primary Industries:

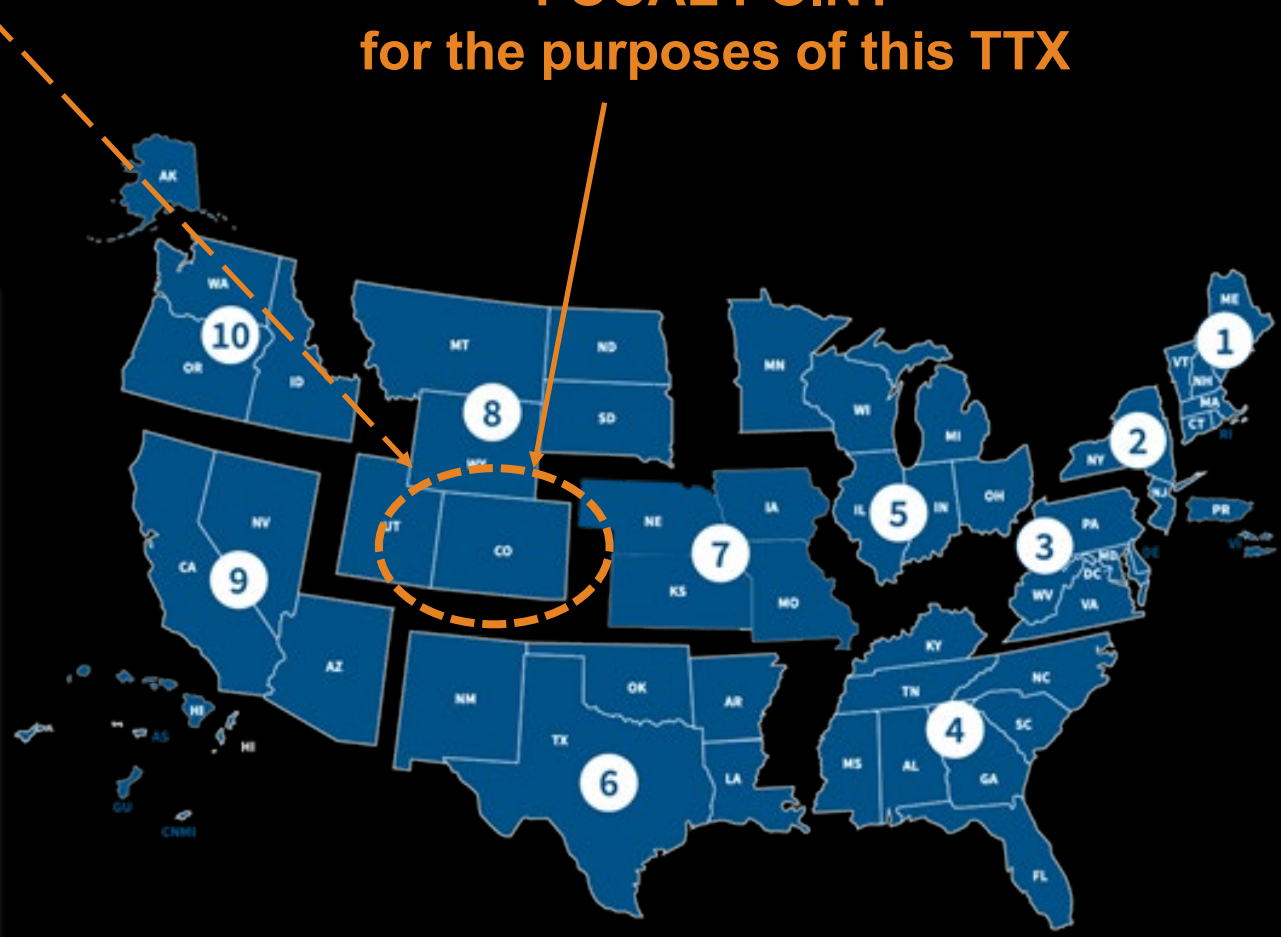
- Food & Agriculture
- Energy
- Mining
- Recreation and Tourism

CISA Priority Areas:

- Elections security
- K-12 Education
- Water and Wastewater
- Health Care and Hospitals

Contact us:

- Email: CISARegion8@hq.dhs.gov



APL Collaborative Analysis Center, Laurel MD



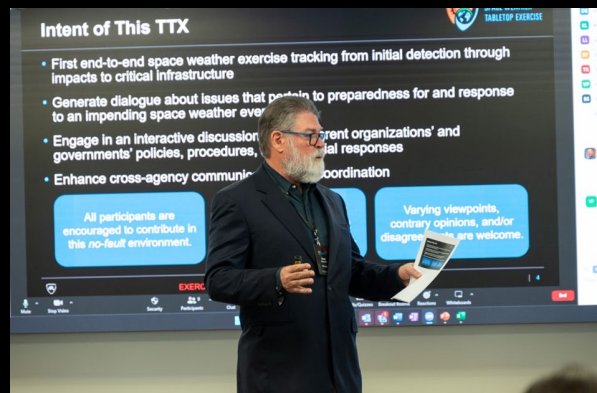
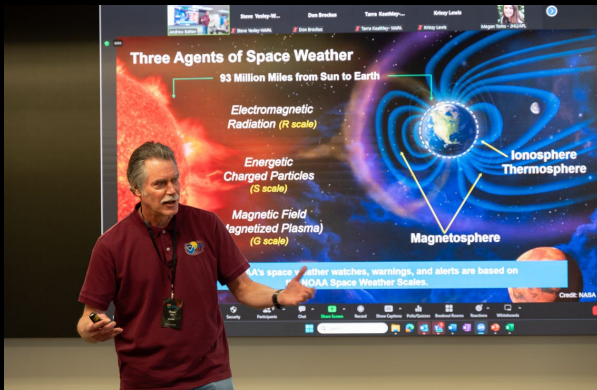
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FEMA Region 8, Denver CO



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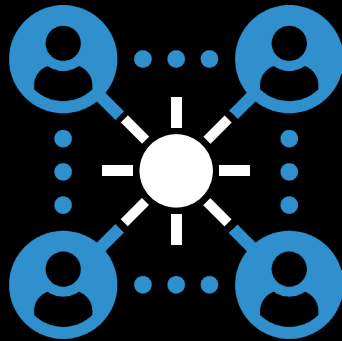
TTX was Organized around Four Objectives

Education & Awareness



Raise awareness of the nature of space weather and the challenges related to preparing an effective response

Space Weather Preparedness



Enhance whole-of-government preparedness for a multiregional disaster with impact on our nation's critical infrastructure

Information Sharing & Public Messaging



Assess the effectiveness of information and communication protocols and pathways

Cislunar Space Readiness

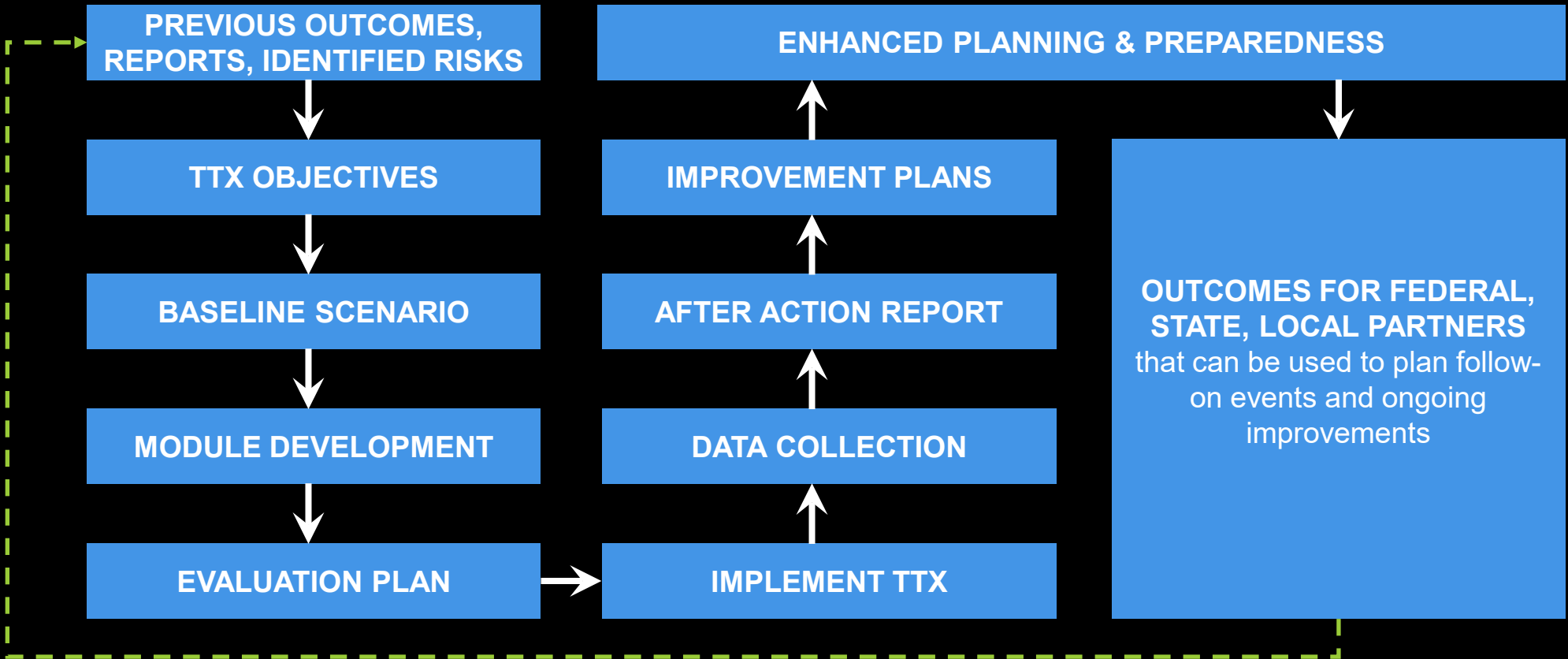


Assess our resiliency in the face of increasingly degraded space assets due to a space weather event

Approach is adapted from the Department of Homeland Security Exercise & Evaluation Program (HSEEP)



HSEEP provides a universal process that allows for tracking and comparison of capabilities, helps to assess overall preparedness, and builds upon outcomes through *ongoing improvement planning*.



Scenario Overview

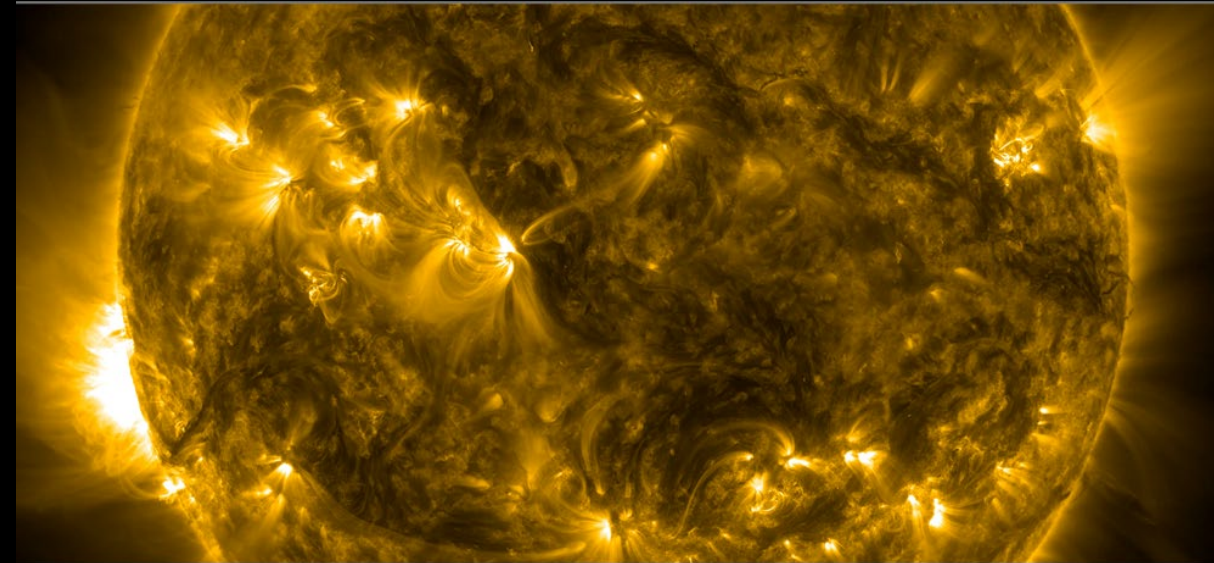


The SWx TTX scenario involved a series of solar events culminating in a range of adverse space weather effects on Earth and in cislunar space. Events took place over approximately 8 days of scenario time from late January to early February 2028.

The scenario began with NOAA's Space Weather Prediction Center (SWPC) tracking an evolving active region on the solar surface with the potential to result in space weather impacts on Earth. These effects could last for hours to days or even longer. The scenario also included an in-progress NASA Artemis IV mission with two astronauts in orbit around the Moon and two astronauts on the moon's surface preparing for a 7-day lunar exploration mission.

The scenario incorporated solar and geomagnetic activity that resulted in multiple hazards and disruptions, including:

- intense radiation exposure to satellites, astronauts, and commercial aviation
- communications disruptions and outages
- loss of functionality or degraded performance of GPS for precision navigation and timing
- satellite failures and on-orbit collisions
- local to regional-scale power outages



TTX Modules Based on the Scenario

MODULE 0
Introductory
Sessions

MODULE 1
Solar
Drivers

MODULE 2
Geomagnetic
Storm

MODULE 3
Extreme
Storm

MODULE 4
Response
& Recovery

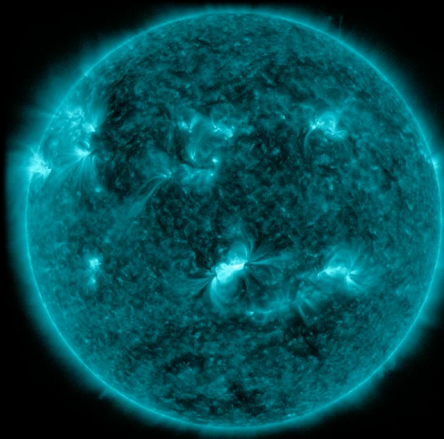
Space Weather 101
Space Weather
Prediction

Artemis Contingency
Planning

National Response
Framework

National Incident
Management Systems

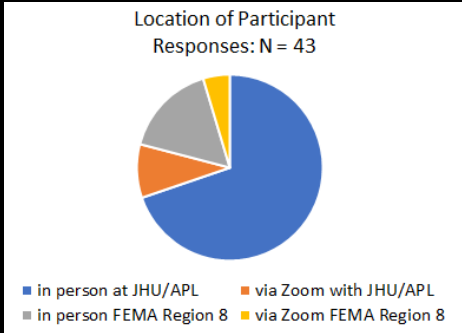
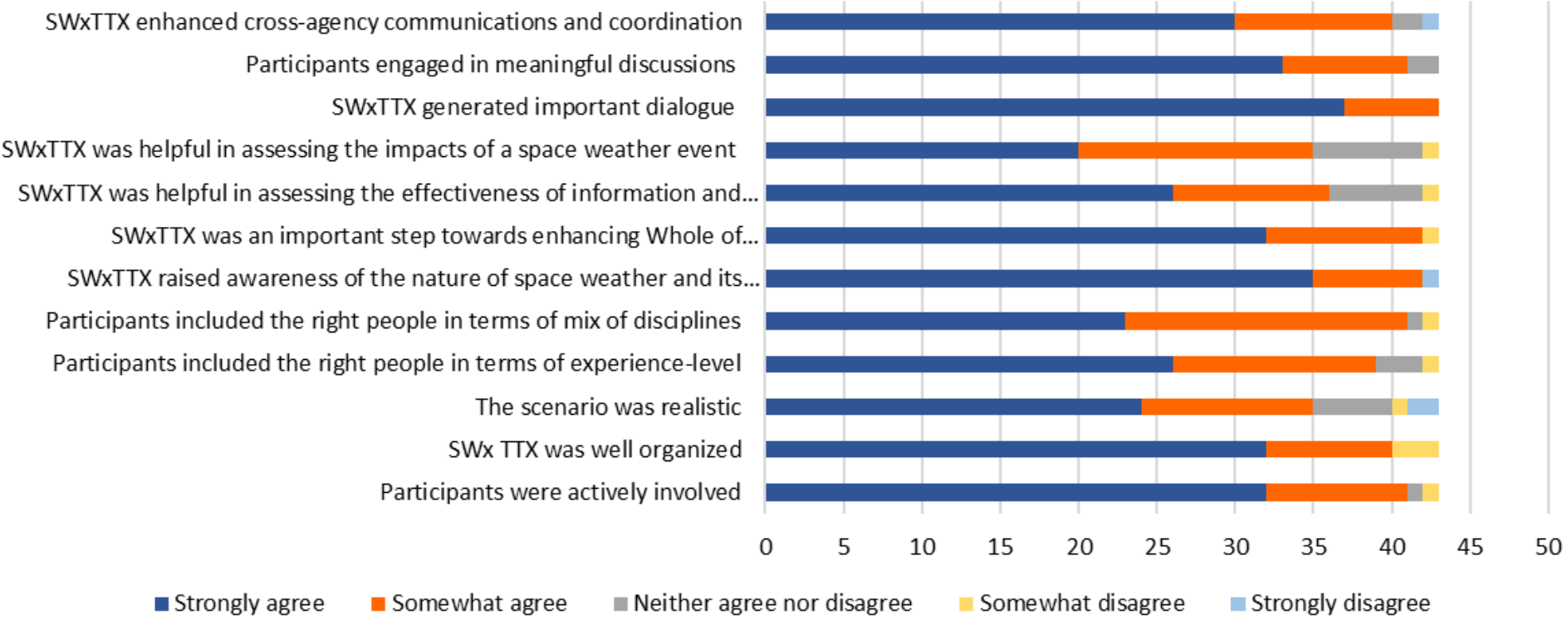
Federal Operating
Concept



Scenario spanned 26 January 2028 – 03 February 2028

Overall Summary: Participant Feedback Forms

Participants' Feedback for Overall SWx TTX Outcomes



Immediate Impact!



FEMA National Watch Center
Daily Operations Briefing

- FEMA and SWPC collaboration during the event led to an update of the NWC Daily Brief - the very next day after the TTX!
- Focus was on *IMPACT* rather than cause

Space Weather Summary/Outlook MAY 10 2024

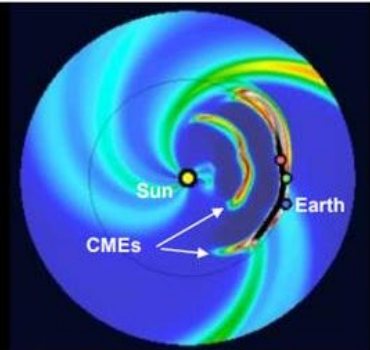
Space Weather Type	Past 48 Hours	Forecast: 10 May	Forecast: 11 May
Solar Flare (Radio Blackout) R Scale (R1-R2/R3)	R3	95% / 60%	95% / 60%
Solar Radiation Storms S Scale	None	50%	50%
Geomagnetic Storms G Scale	None	G1 - 70%	G4 - 70%

KEY MESSAGE: A Severe (G4) Geomagnetic Storm is **LIKELY** – possibly as early as later today and continuing through the weekend. At least five coronal mass ejections are in transit to our atmosphere.

IMPACTS: HF communication, GPS, power grids, and other technologies may be affected. Critical infrastructure operators have been notified.

CONTEXT: Only three Severe (G4) geomagnetic storms have occurred so far this solar cycle, the last being a brief occurrence on March 23rd, 2024.

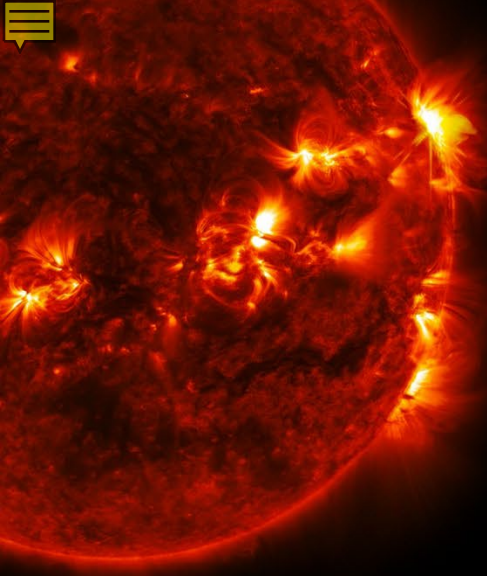
CAUSE: The source for most of this activity has been a large, complex sunspot cluster (NOAA Region 3664) that is 16 times the diameter of Earth. Additional solar activity from this region is still expected.



FROM FEMA DAILY OPERATIONS BRIEF (5/13/24)

Identified Impacts: ▪ Impacts thus far have been power irregularities, disruptions to navigation systems, and widespread auroras (SWPC)

FEMA/Federal Response: ▪ FEMA Response Operations conducted a series of ops coordination calls with SWPC, all 10 FEMA Regions, HQ leadership & program offices All FEMA regions continue to monitor for impacts; regional watches operating 24/7, all RRCCs are rostered.



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