

Community Coordinated Modeling Center Workshop

Maui HPCC, October 29 - November 1, 2001

RELEVANCE & IMPORTANCE OF THE COMMUNITY COORDINATED MODELING CENTER TO THE AIR FORCE



Col Michael Jamilkowski

*Asst. for Environmental
Monitoring*

*HQ USAF Directorate of
Weather*

U.S. AIR FORCE

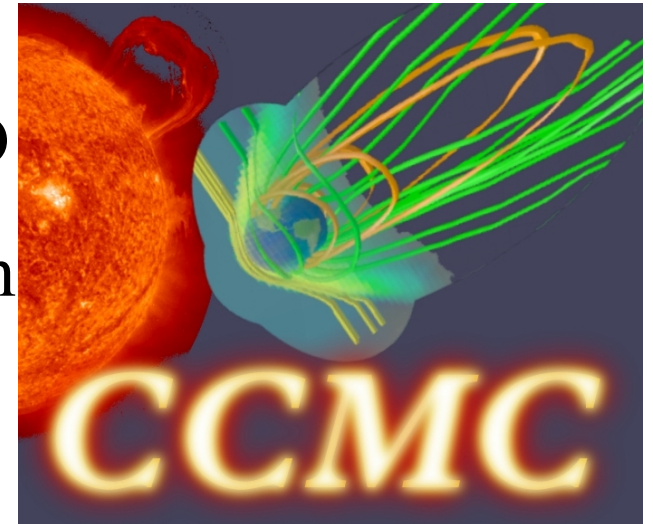
Integrity - Service - Excellence



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Overview

- Background
 - Space Weather Importance to DoD
 - Current DoD SWx Support System
 - Requirements - Present & Future
 - Directions and Strategy
- Top Reasons CCMC is Important to USAF
- Summary/Conclusion

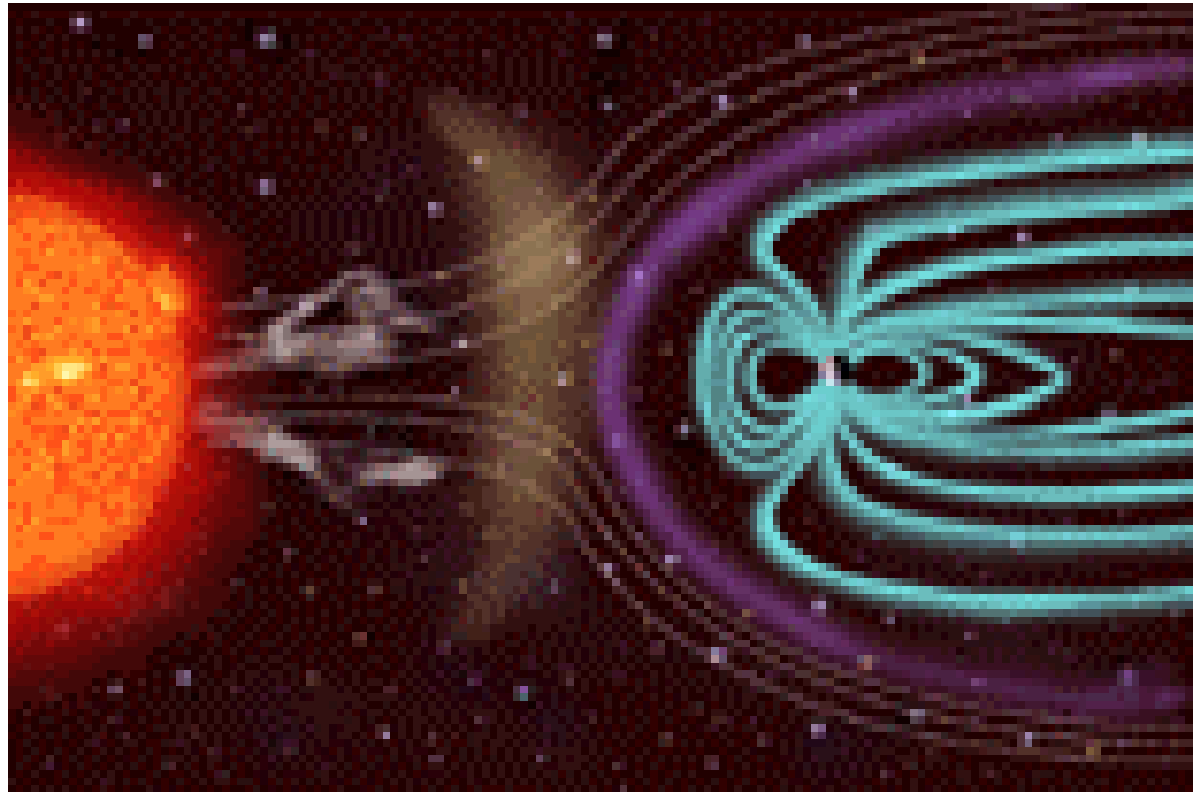




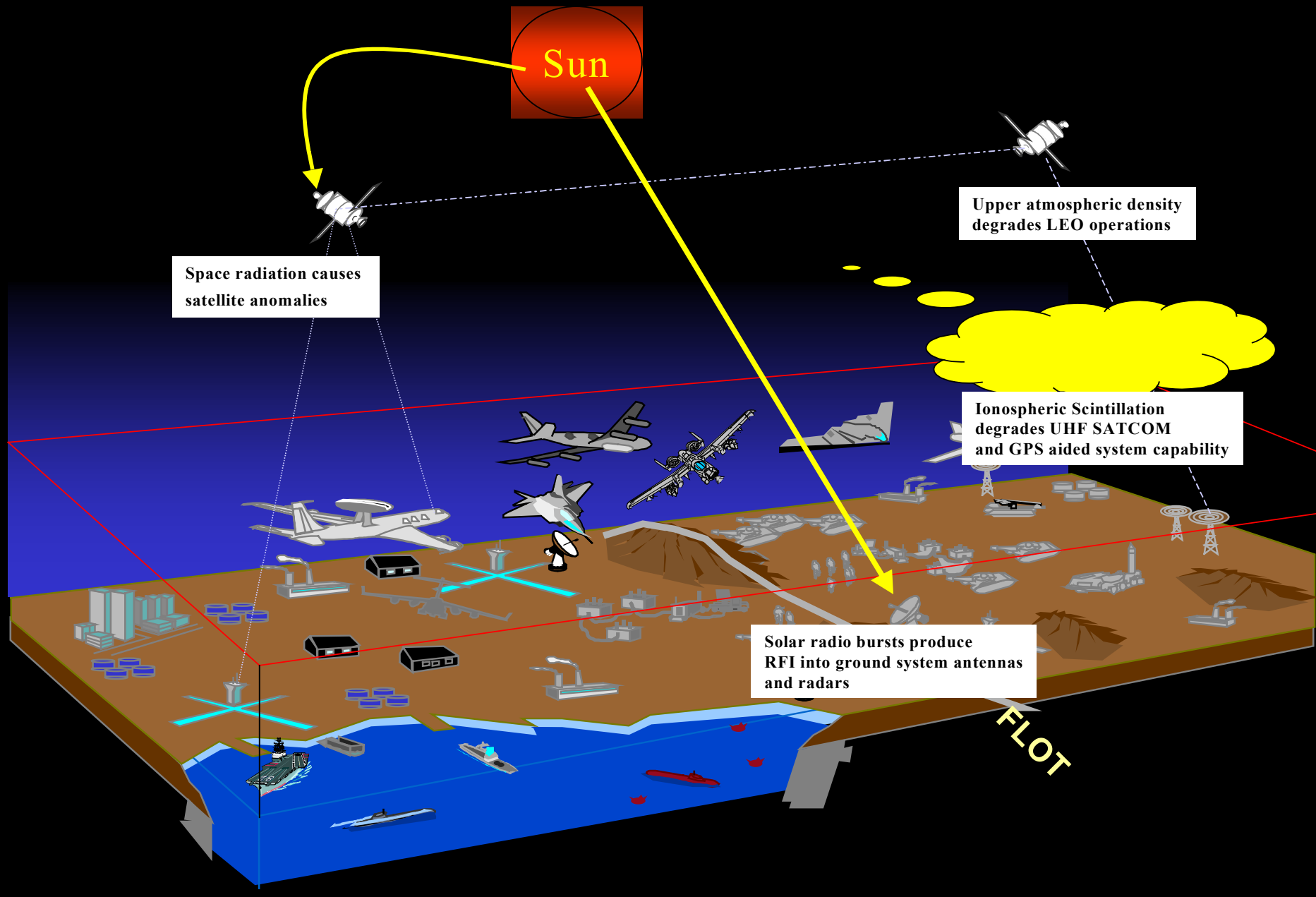
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CCMC Importance to DoD

Space
Weather
(Operational)
Importance to
Department
of Defense



Today's Space Environment Impacts to DoD Operations



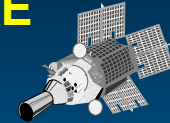


DoD Space Environment



MAGNETOSPHERE

30+ Satellites



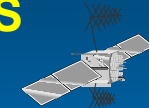
DSP
MILSTAR
DSCS

Geomagnetic Storm



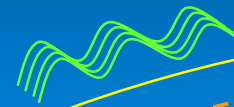
RADIATION BELTS

25+ Satellites



GPS

Scintillation



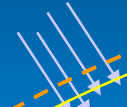
THERMOSPHERE

25+ Satellites



DMSP

Electromagnetic Radiation



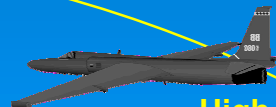
SHUTTLE



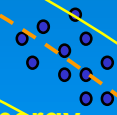
MESOSPHERE

STRATOSPHERE

U-2



High Energy Particles



TROPOSPHERE

Solar Radio Burst



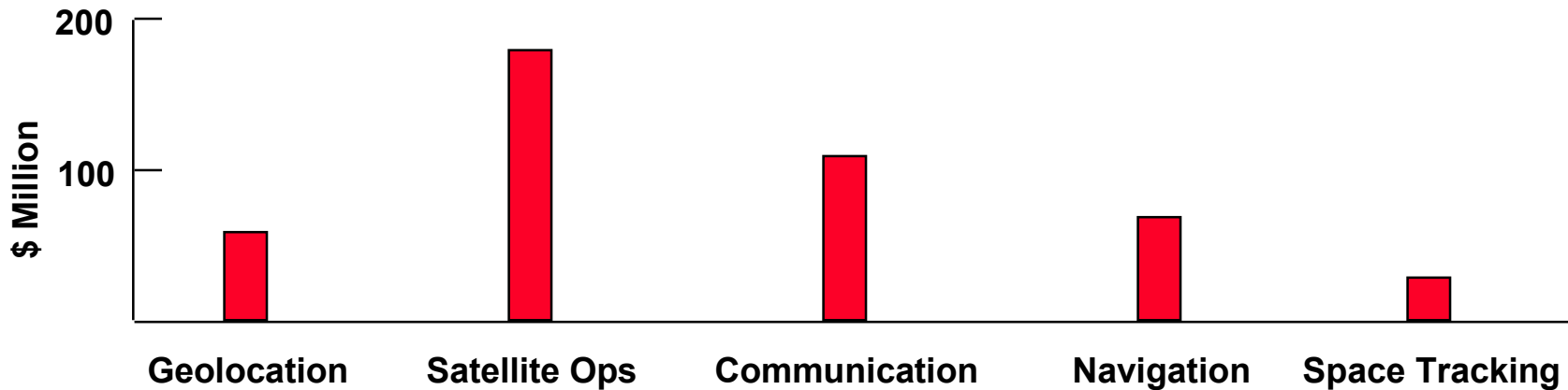


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SWx Significance: Costs

Mission-Impacting Effects of Space Weather

- Degrades Target Geolocation
- Disrupts Satellite Operations
- Interrupts Communications
- Impedes Navigation
- Affects Space Tracking
- Damages Power Grids



DoD Funding Targeted to Help Mitigate Space Weather Effects

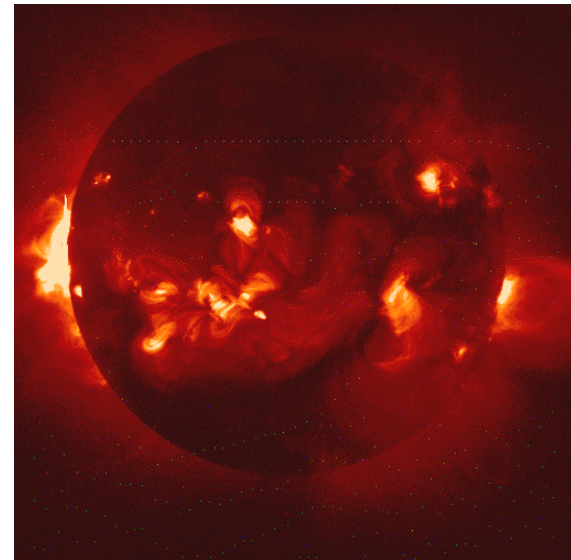
- Improvement in Space Weather Operations Could Decrease These Costs By ~10%
- Additional Savings During A Conflict: Better INTEL, Comm, Bombs on Target
- Potential to Save A Satellite During The Most Severe Space Weather



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AF Space Environment Interests

- AF Weather has mission to provide space weather analyses, forecasts, and warnings to DoD operators and decision makers
- Continued reliance on X-ray and energetic particle sensors for real-time warnings
- Solar X-Ray Imager (SXI) will improve AFW capabilities for monitoring and forecasting solar events

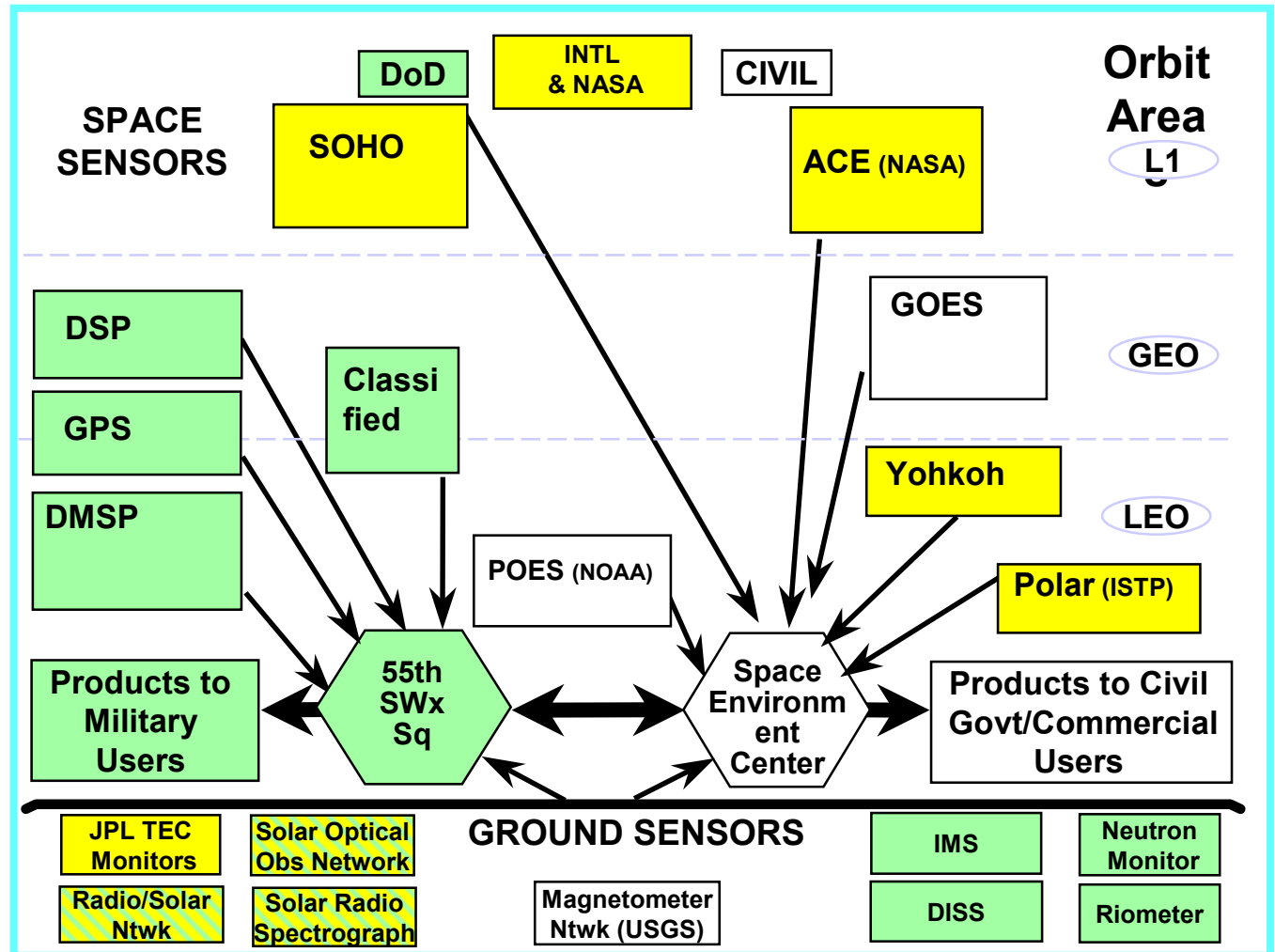




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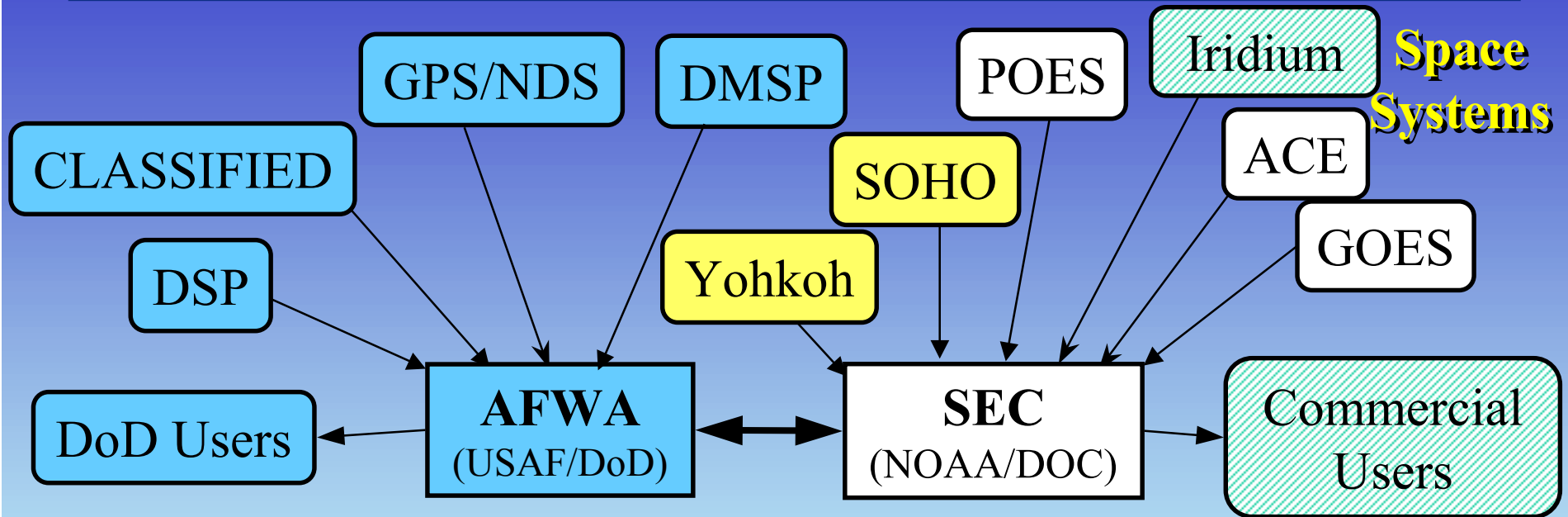
CCMC Importance to DoD

Current DoD Space Weather (SWx) Support System





Current Space Weather Support System



Ground Stations

- Solar Optical Observing Network (4)
- Radio Solar Telescope Network (4)
- Digital Ionospheric Sounding Sys (16)
- Ionospheric Measuring System (5)
- Neutron Monitor (1)
- Riometer (1)

- Canadian Radio Observatory
- Australian Observatory
- Australian Ionospheric Network (5)

- National Solar Observatories (2)
- JPL TEC Monitors (25)
- Archival Center
- USGS Magnetometer Network (13)

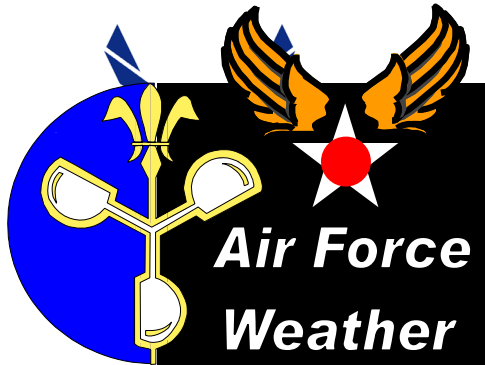
DoD

Commercial

Civil

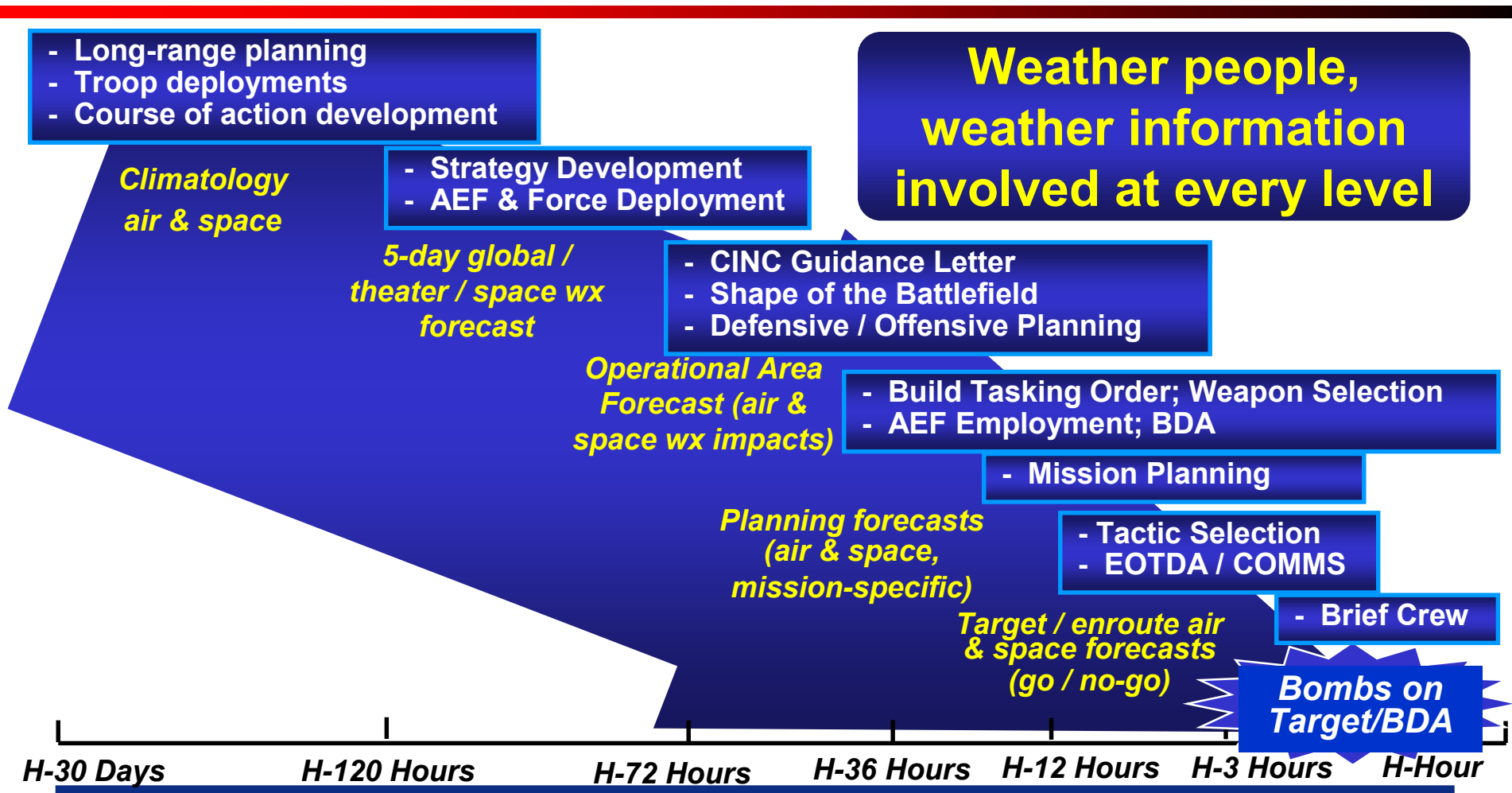
International/NASA

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WEATHER SUPPORT

Real-Time Accurate Relevant



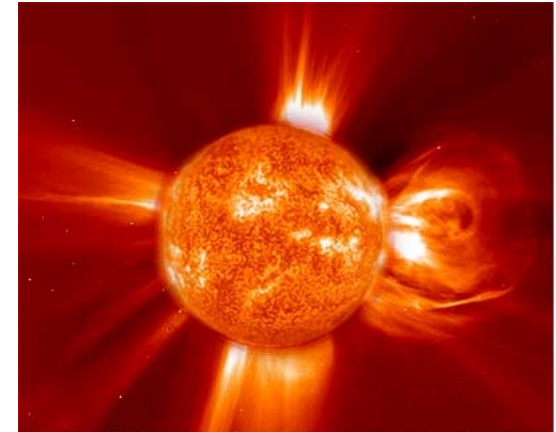


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AF Space Environment Services

- **RAPID EVENT WARNINGS**

- SOLAR FLARES
 - (X-RAY & RADIO BURSTS)
- PROTON EVENTS
- GEOMAGNETIC STORMS



A combination of two images from SOHO, showing Monday's solar flare at approximately 6 PM EDT.

- **SHORT OR LONG RANGE FORECASTS**

- GENERAL LEVEL OF SOLAR/GEOMAGNETIC ACTIVITY
- SPECIFIC NUMERICAL DATA OR INDICES
- STANDARDIZED OR TAILORED PRODUCTS
- ON-GOING OR ONE-TIME PRODUCTS

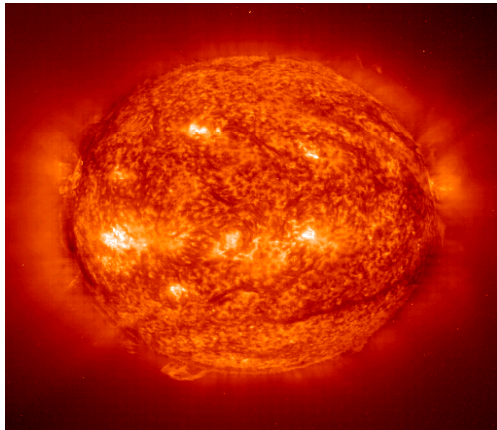
- **POST-ANALYSIS ANOMALY ASSESSMENTS**

- RADAR, COMMUNICATIONS, & SATELLITES



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Ongoing Efforts/Products



Space Environment

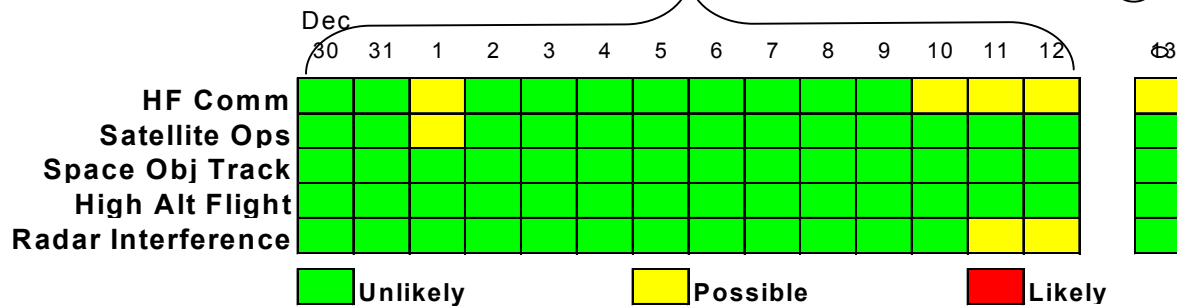
Valid: 13/0600Z Jan 00

History

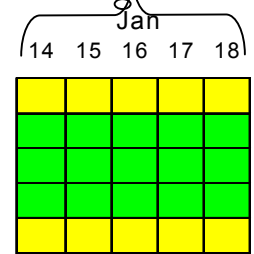
Nowcast

Forecast

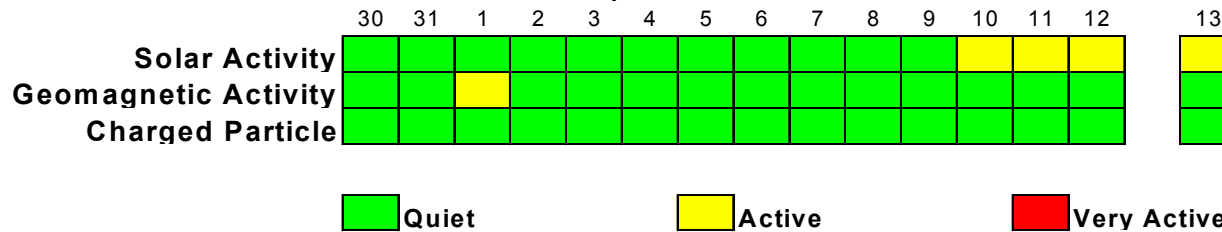
Past Space Environmental EFFECTS



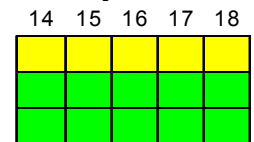
5 - Day Forecast



Past Space Environmental EVENTS



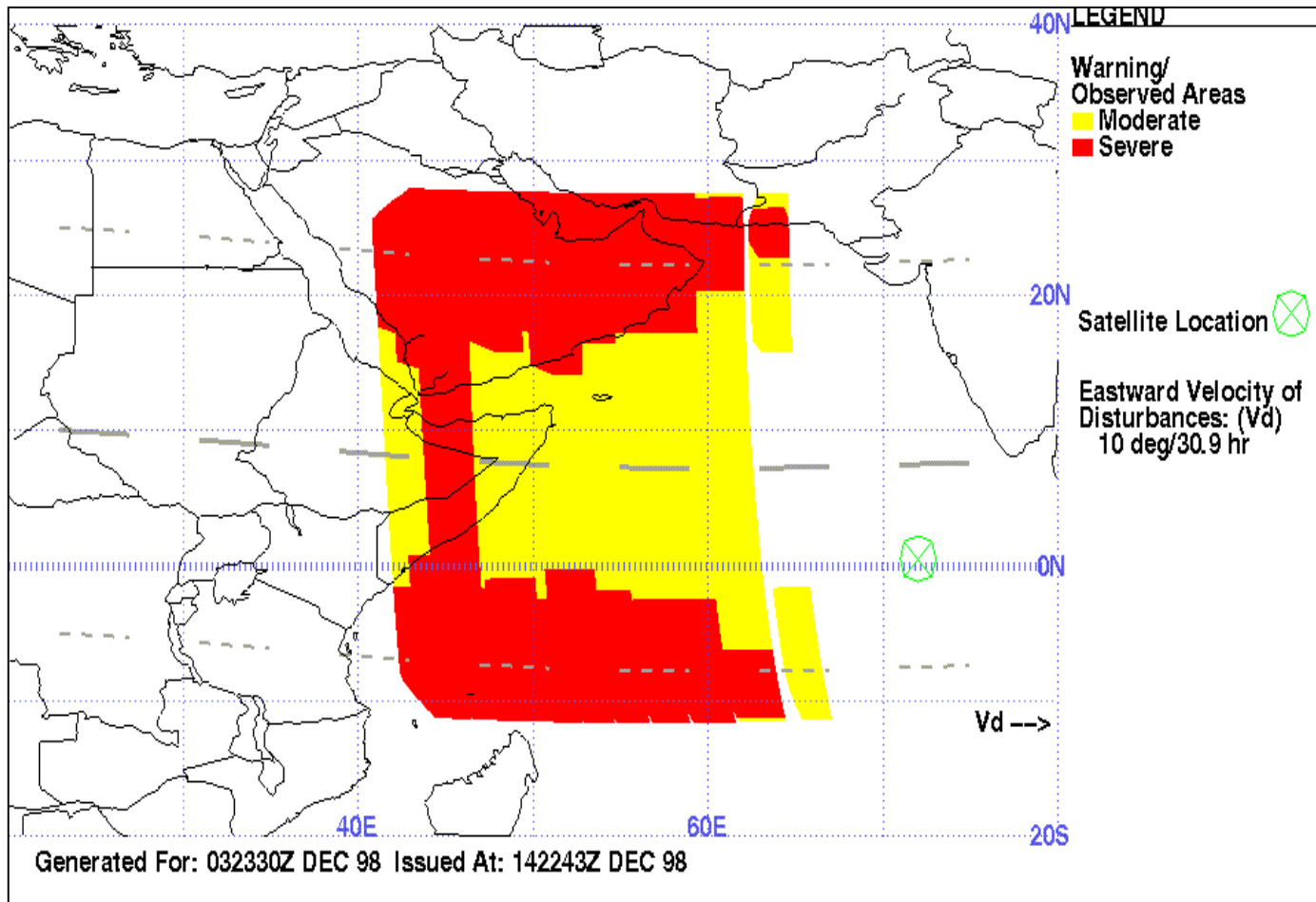
5 - Day Forecast





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Transition to Operations



**Simple
products
such as
this aid
SATCOM
use.**

Scintillation Network Decision Aid (SCINDA)

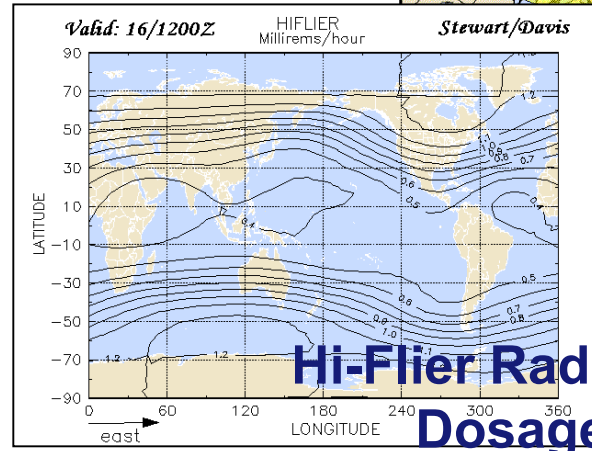
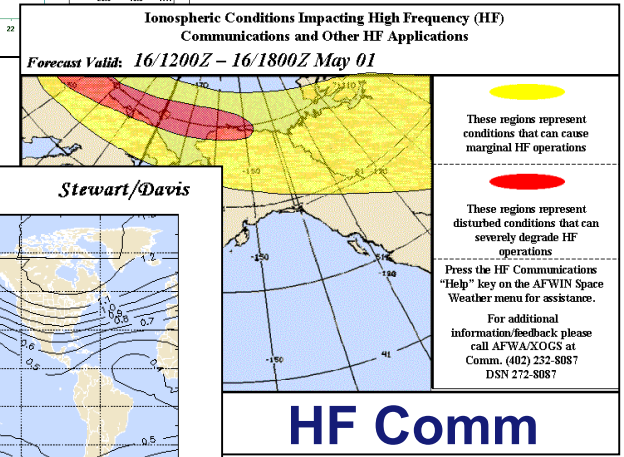
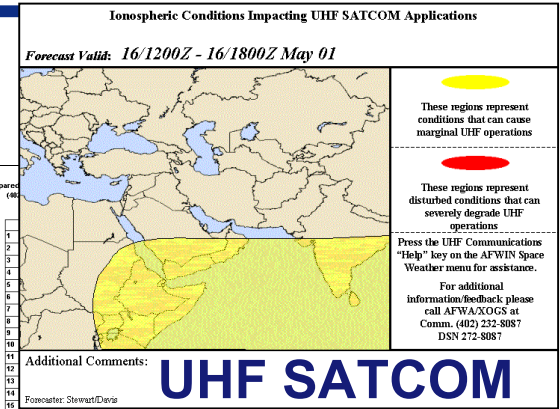
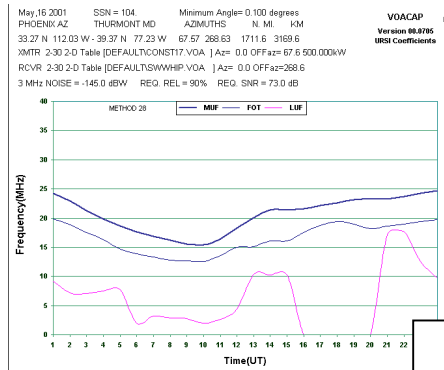
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Operational Military Applications Today

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- Applications of Environmental Aps will only be as good as the validity of the environmental info
- Some current capabilities shown here
 - Scintillation (WBMOD)
 - HF
 - Radiation Dosage

HF Point to Point

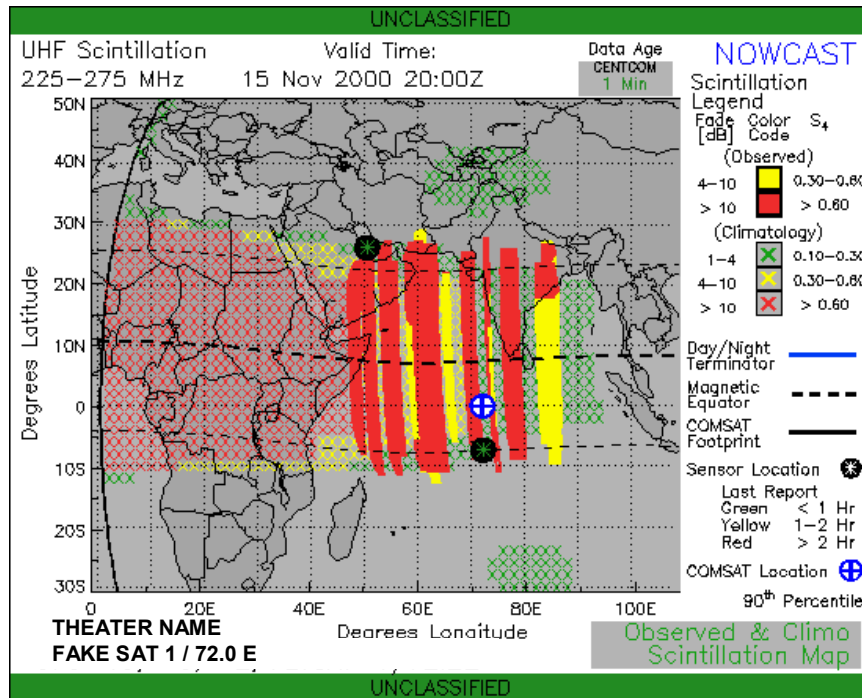




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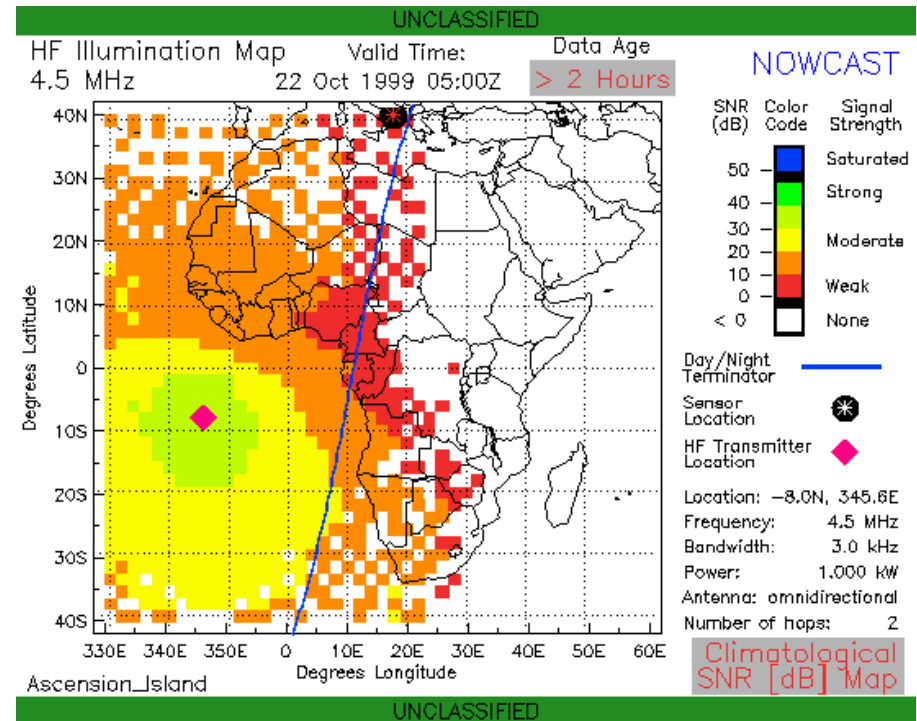
OPSEND Products

**OPSEND products are nowcasts;
forecasts are required**



UHF Scintillation Maps

**AFRL-AFMC Det 11
Rapid Prototyping Center
(RPC)**



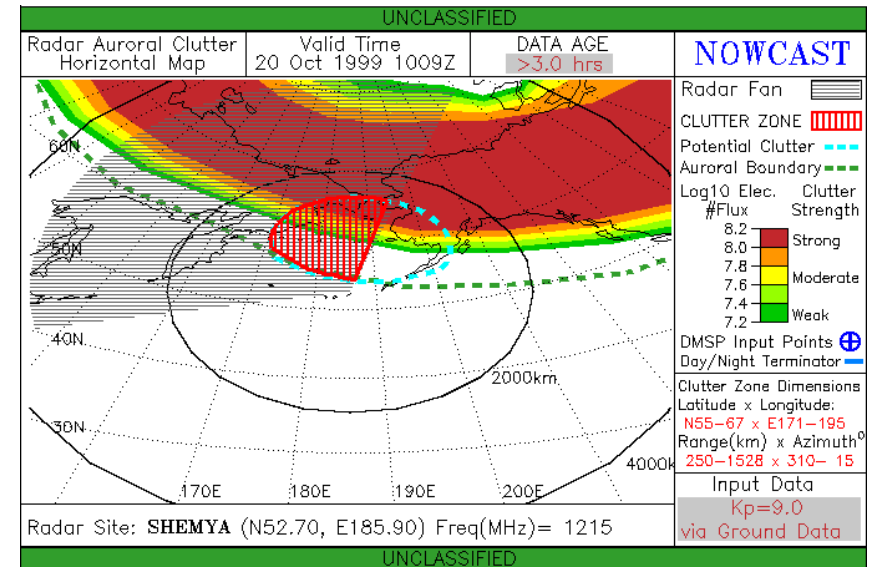
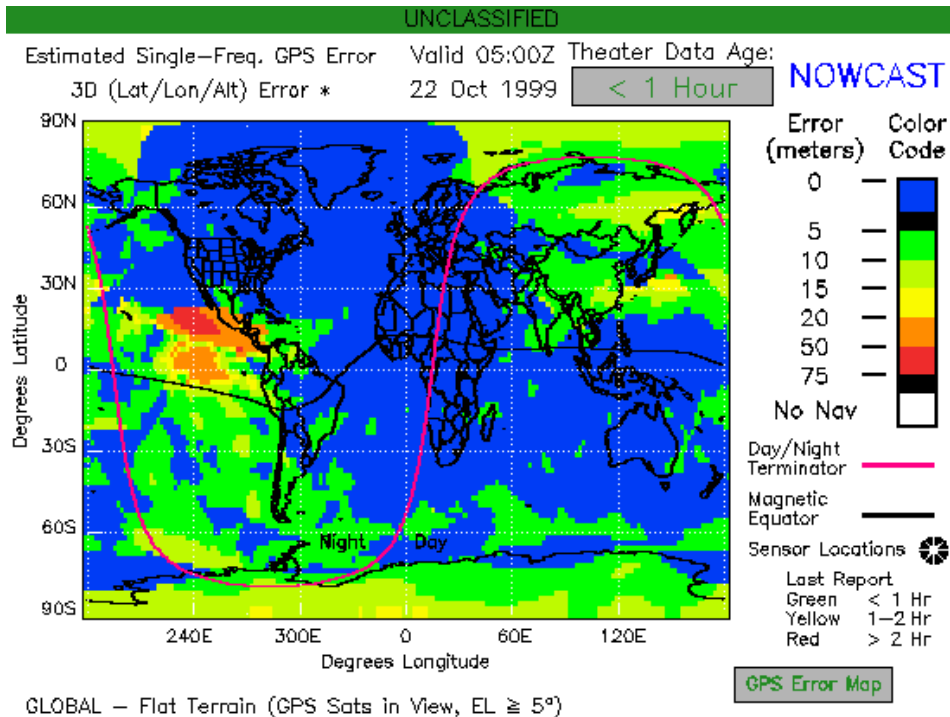
HF Illumination Map



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OPSEND Products

GPS Single Frequency Error Maps



Radar Clutter Maps

- OPSEND Products are stand-alone today;
- Must be integrated into GPS accuracy maps and radar common operational picture

AFRL-AFMC Det 11
Rapid Prototyping Center (RPC)



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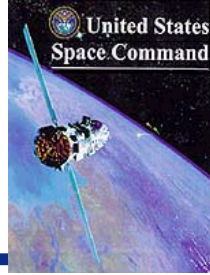
CCMC Importance to DoD

DoD Space
Weather
Requirements:
Present
and
Future





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USAF/DoD Space Weather Requirements Documents

- Ionospheric Sensing (IONS) SON 002-80, 21 Mar 80
- Space Envir Technology Transition (SETT) SON 005-86, 28 Mar 86
- MJCS 154-86, Mil Requirements for Defense Envir Satellites, 1 Aug 86
- Space Environmental Monitoring SON 001-83 (Clas), 24 Aug 87
- MNS for Environmental Sensing, AFSPC 035-92, 6 Jan 93
- Space Weather CRD, draft Nov 97, HQ USSPACE
- Space Weather Analysis and Forecast System (SWAFS) ORD, Jan 00
- MNS for Capability to Effectively Integrate Space Envir Info into DoD Operations, AFSPC 003-00 Draft
- AFSPC Mission Area Plan (Clas), Aug 01
- NPOESS IORD II, Oct 2001



SON: Statement of Operational Need
 MJCS: Memorandum of the Joint Chiefs of Staff
 MNS: Mission Need Statement
 CRD: Capstone Requirements Document

ORD: Operational Requirements Document
 IORD: Integrated Operational Requirements Document
 AFSPC: Air Force Space Command
 DoD: Department of Defense



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Requirements vs Current Capability

Requirements	Supported Mission Area	Current Support Capability
Scintillation	Comm, PNT, BMD, ISR	Specification (-) Warning Forecast
Electron Density	Comm, PNT, BMD, ISR	Specification Forecast (-)
Radiation and Charging	Spacecraft High Altitude Flight	Specification (-) Warning Forecast
Neutral Density	BMD, ISR	Forecast (-)
GIC	Electric Power	Specification (+) Warning
RFI	BMD, ISR	Specification (+) Warning Forecast
Aurora Clutter	ISR	Specification Warning



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DoD SWx Needs Evolution

Past

Present

Future

Surveillance & Comms

Weapons Support, Space Station, Power Grids

Space Control

Weapons Delivery

Increased Demands	Example System Impacts
•Coverage	Scintillation limits space-based radar coverage
•Timeliness	Radiation limits processing for direct downlink
•Accuracy	Electron density causes geolocation errors
•C ²	Scintillation breaks space-based cell phone links
•Situational Awareness	ISR satellite failures to charging

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Future Needs vs Architecture Vector

Future Needs	Supported Mission Area	Future Support Capability
Scintillation	Comm, PNT, BMD, ISR	Specification (+) Warning Forecast
Electron Density	Comm, PNT, BMD, ISR	Specification (+) Warning Forecast
Radiation and Charging	Spacecraft High Altitude Flight	Specification (+) Warning (+) Forecast (-)
Neutral Density	BMD, ISR	Specification (+) Warning Forecast
GIC	Electric Power	Specification (-) Warning Forecast (-)
RFI	BMD ISR	Specification Warning Forecast
Aurora Emissions	Comm, ISR	Specification (+)



Future DoD Space-Based Systems

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Space-Based Infrared System (SBIRS)

Space-Based Radar (SBR)

Space-Based Laser (SBL)

Space-Based NBC Detection System

GPS Block IIF/III

Advanced MILSATCOM Systems

Space X-Vehicle

Space-Based Range

SBIRS Low

Nanosatellites/Picosatellites

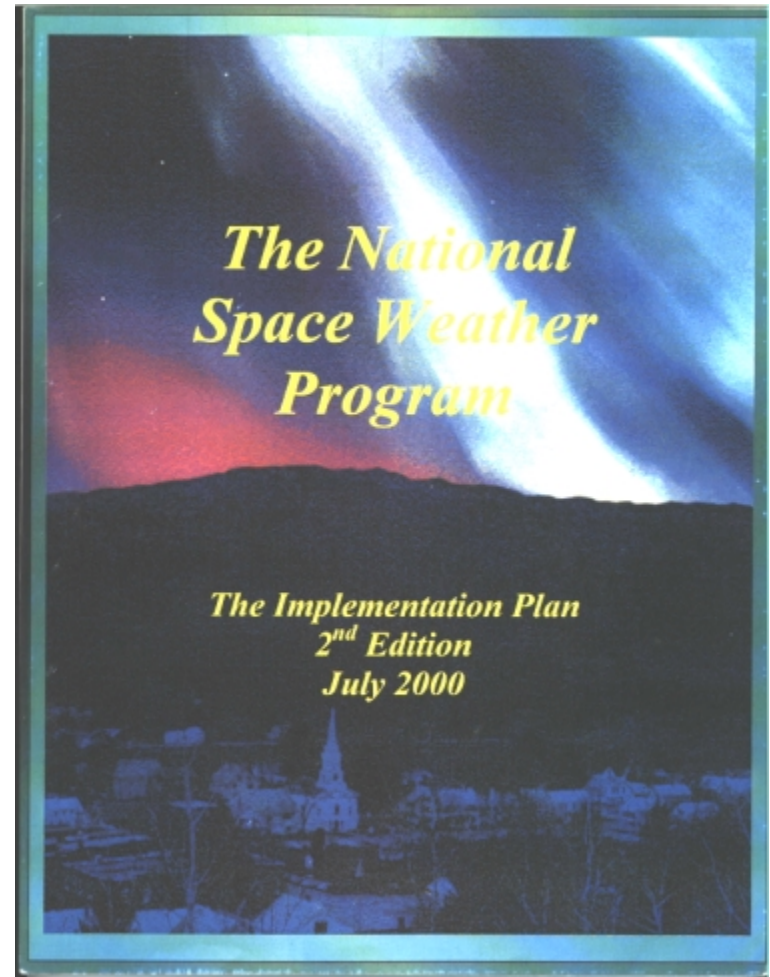
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Future Expanding Requirements

- DoD Requirements consistent with:
 - National Security Space Architect's (NSSA) Space Weather Architecture Study and
 - National Space Weather Program (NSWP) Implementation Plan

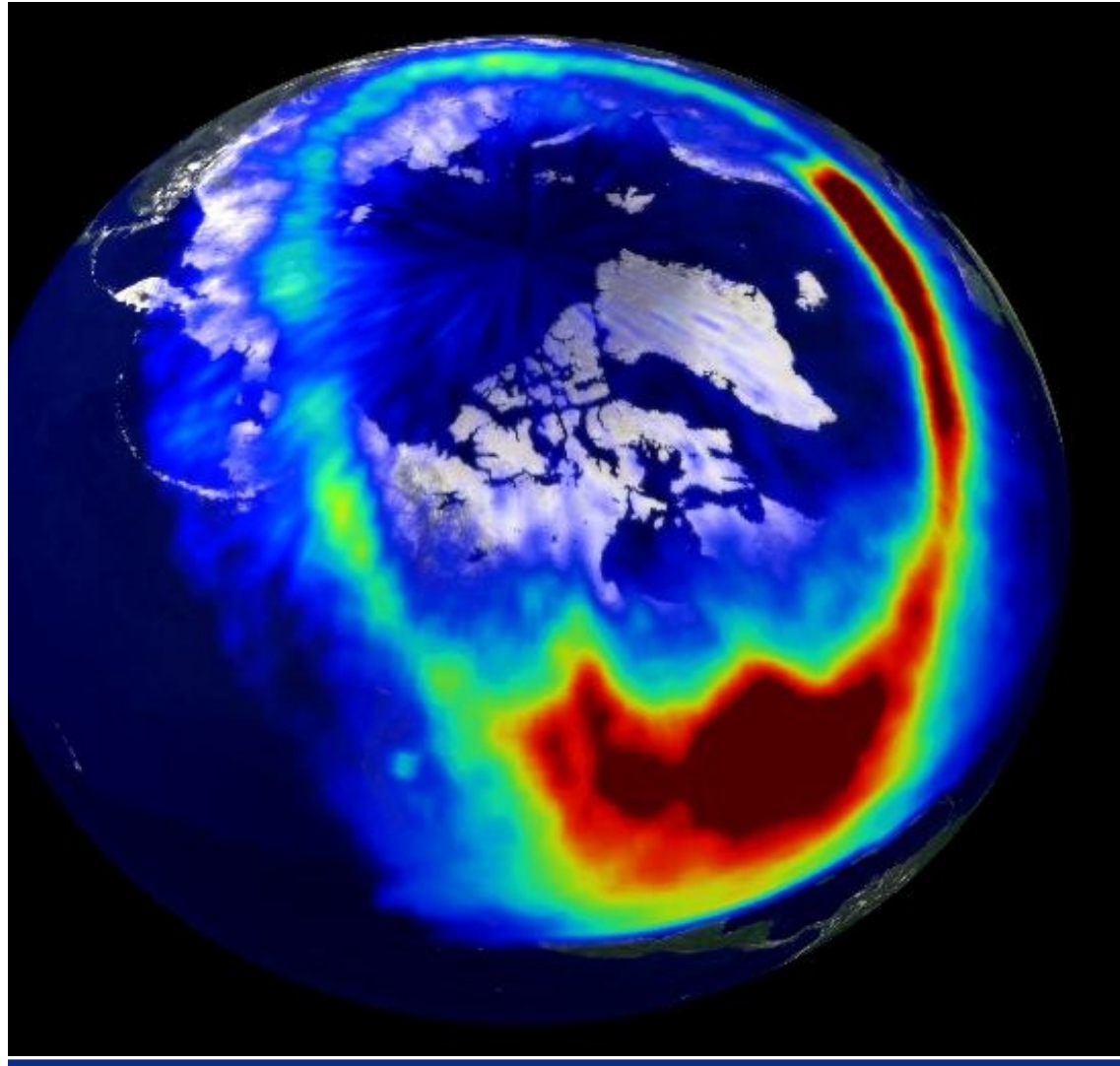




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CCMC Importance to DoD

DoD Space
Weather
Directions
and Strategy

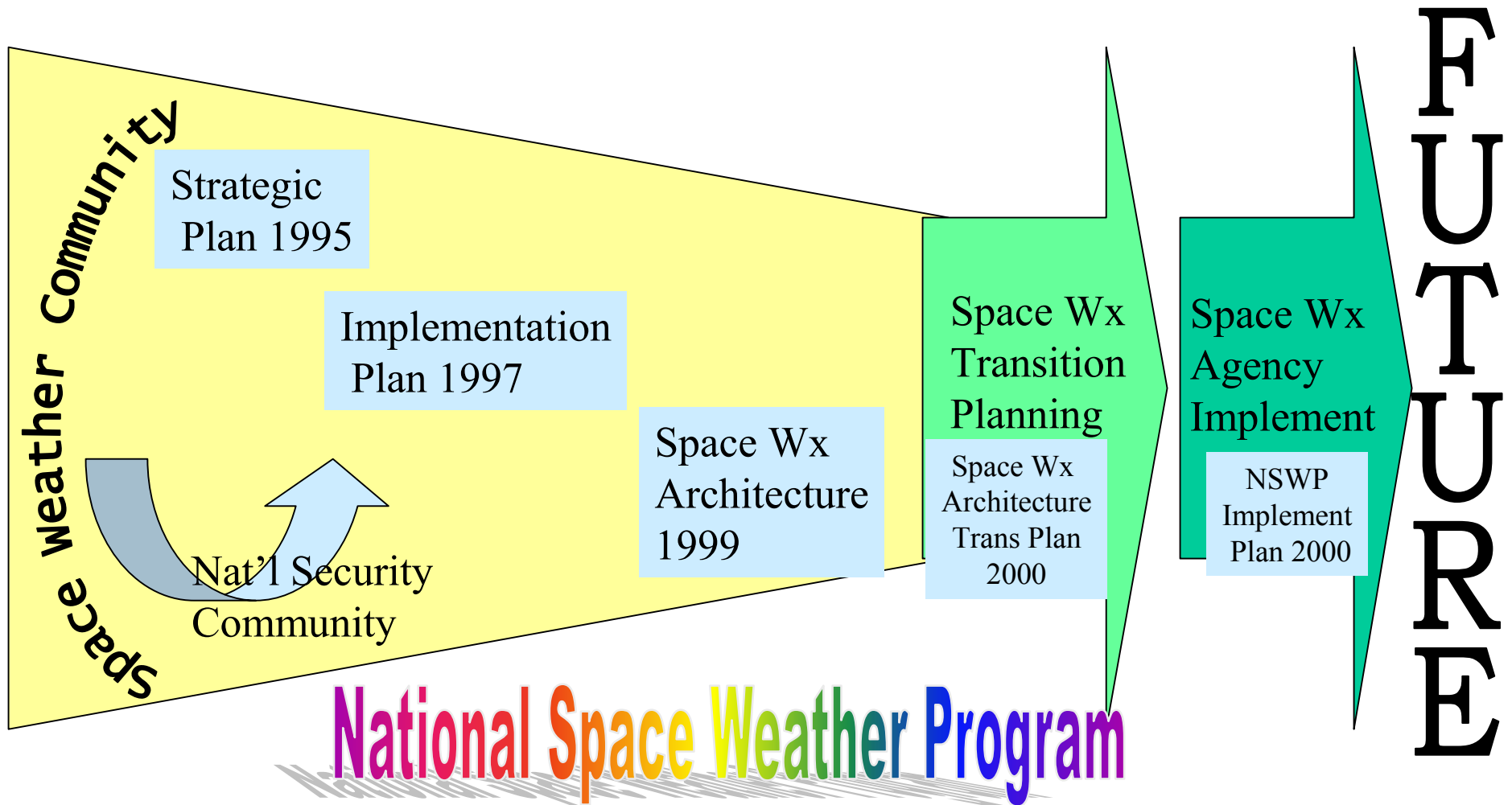


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USG Space Weather Roadmap





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NSSA SWx Architecture Study: Recommendations

1. Pursue the Space Weather Architecture Vector

2. Space Weather Importance Awareness

3. Develop and Update SWx Requirements

4. Coordinated Space Weather Architecture Acquisition

5. Consolidate and Expand Archival System

6. Integrated User Information

7. Evolve to an Integrated Space Weather Center

8a. Provide a Robust R&D to Develop operational Capabilities

8b. Leverage R&D Missions

9a. Provide Timely Data to Space Control Mission

9b. Incorporate Man-made Effects on SWx Architecture



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NSSA SWx Architecture Study: SWx Transition Plan Actions

Recommendation 1: Space Weather Architecture Vector

- **Increase emphasis on Operational Model development**
- **Ensure improved Operational Capabilities based on User Needs**
 - **National Security priorities include Ionospheric and Radiation Environment Specifications and Forecasts**
 - **Civil priorities also include Geomagnetic Warnings and Forecasts**
- **Evolve to Improved Forecast Capabilities, as phenomenology is better understood, models mature and user needs are better defined**

Main Actions

- **Sensors**: Design and deploy new/improved SWx space- and ground-based sensors
- **Models**: Develop and implement advanced SWx operational models
- **Funding**: Align funding with prioritized SWx project list



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NSSA SWx Architecture Study: SWx Transition Plan Actions

Recommendation 8: Space Weather Research & Development

- **Provide a Robust Space Weather Research and Development Program**
- **Develop and Implement Standardized Processes to rapidly and efficiently Transition R&D into needed Operational Products**
- **Continue to Leverage Research and Development Missions**
 - **Enhance Operational Products until Operational Systems are ready**

Main Actions

- Document space weather operational deficiencies and articulate to R&D community to facilitate leveraging opportunities
- Review NASA, DoD and commercial R&D missions for applicability to current operations
- Coordinate and plan R&D among all the stakeholders
- Conduct R&D for SWx Models and Sensors
- Integrate data/products from R&D missions into SWx support operations



Architecture Sensors

1 satellite @ "Stereo"

1 satellite at Sun-Earth Line
Interplanetary

Suite hosted on
3 NPOESS

Telescope package
hosted on HEO satellite

2 GEO satellites - Solar and Earth
Observations

10 Sensors (Polar)
SCINTILLATION

All-Sky Cameras (10)

18 SBIRS - LO

Riometer

Satellite Drag from
Tracking Network

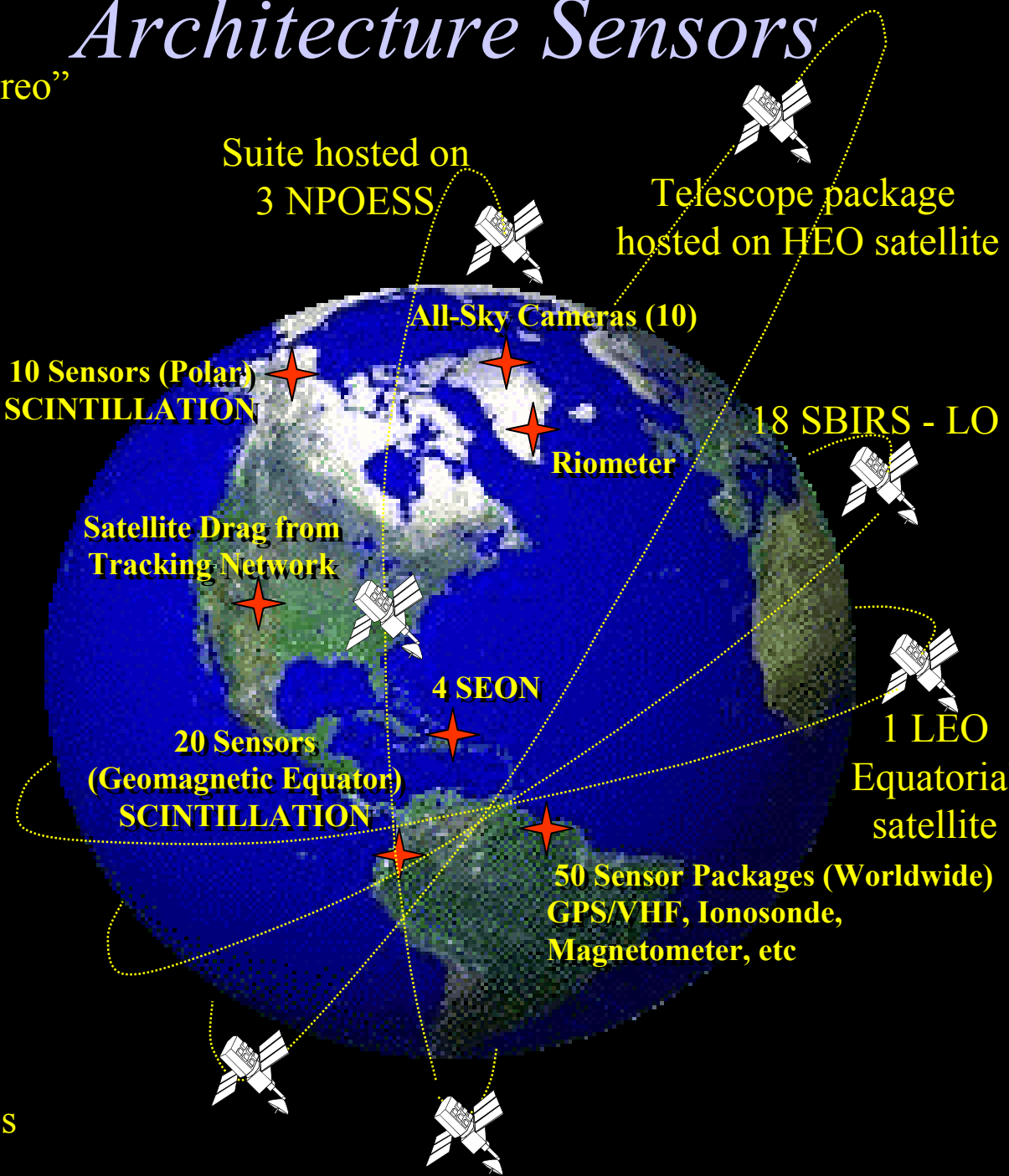
4 SEON

20 Sensors
(Geomagnetic Equator)
SCINTILLATION

1 LEO
Equatorial
satellite

50 Sensor Packages (Worldwide)
GPS/VHF, Ionosonde,
Magnetometer, etc

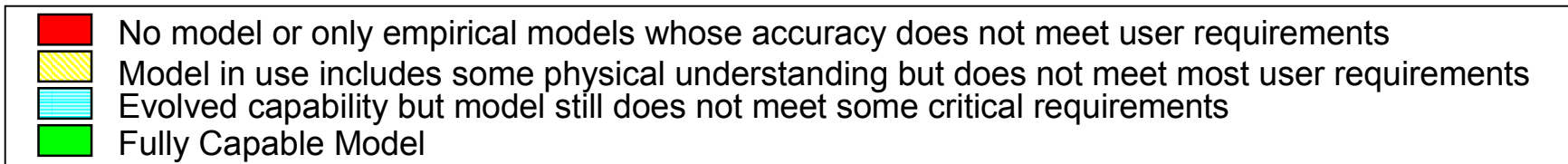
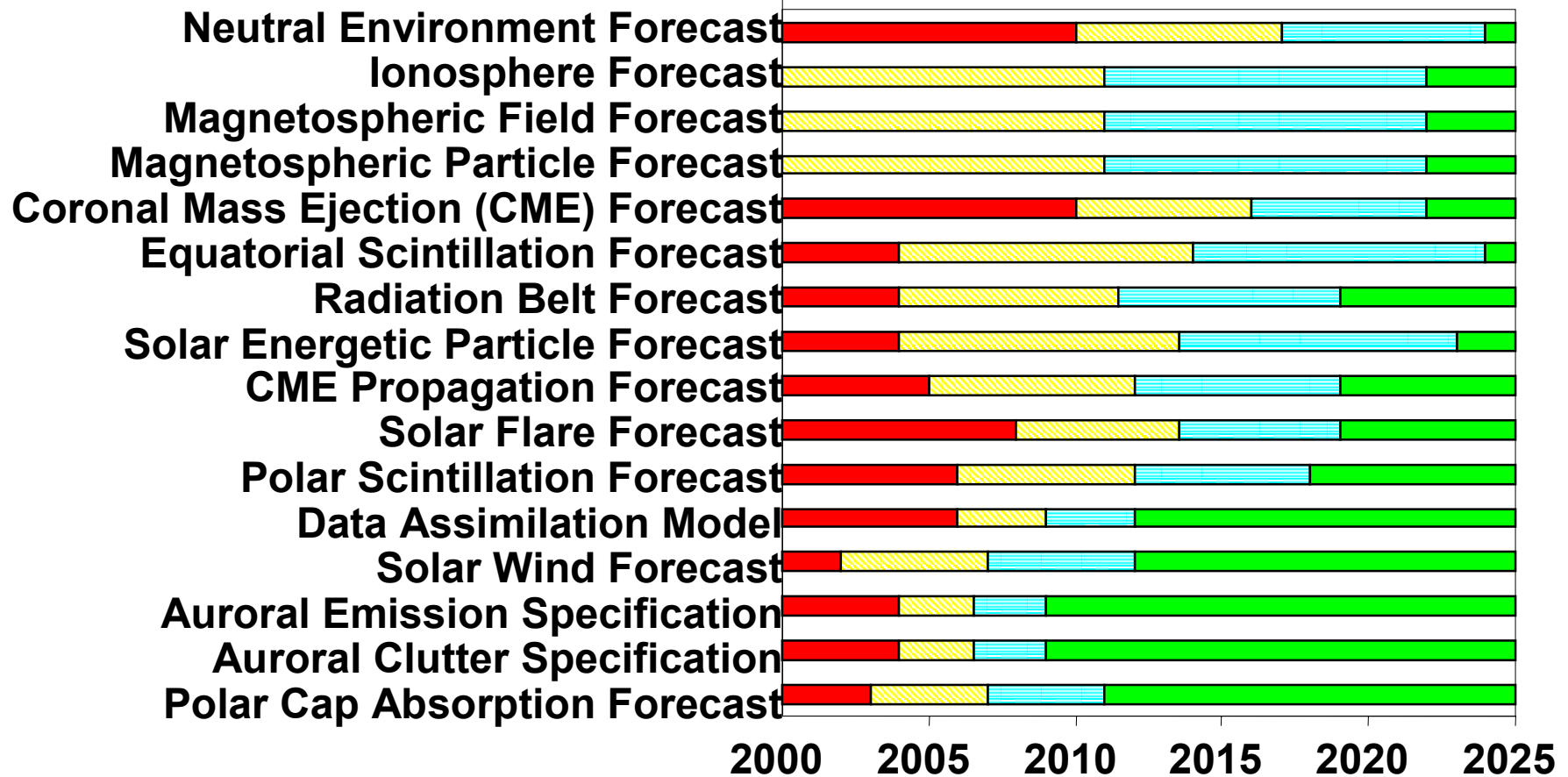
Piggy-back packages
of particle detectors
hosted on many satellites





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NSSA SWx Architecture Study: Operational Models Timelines

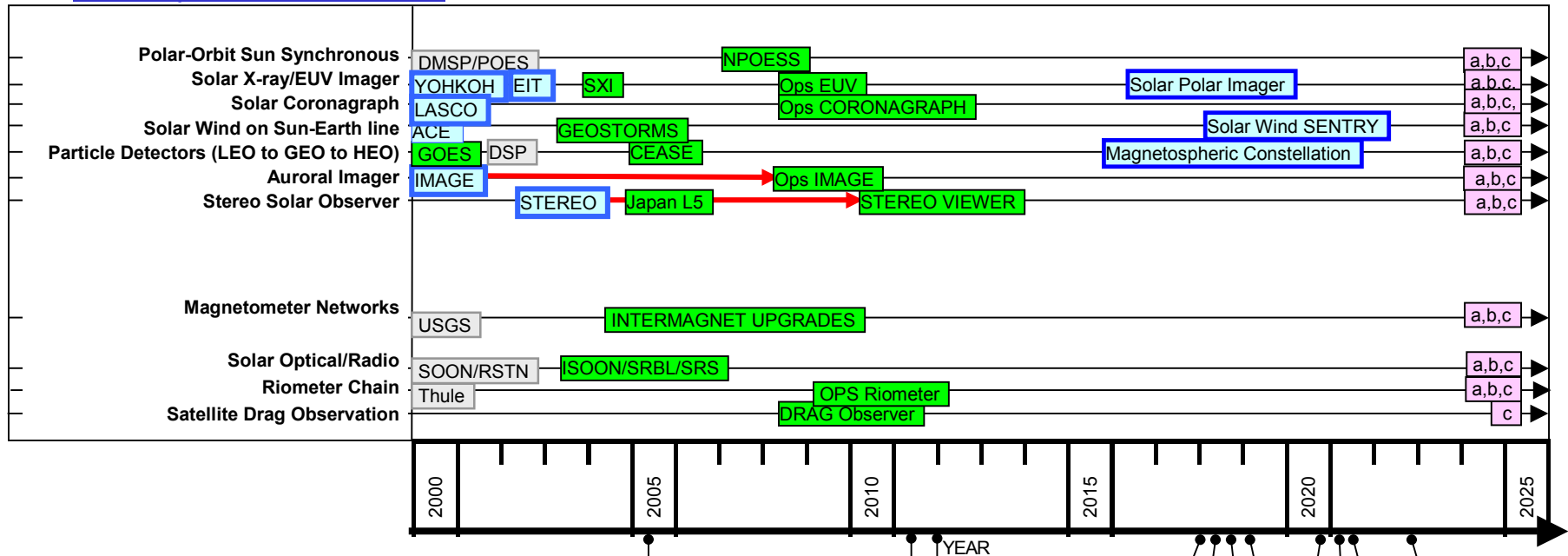




NSSA SWx Architecture Study: Sat Ops Implementation w/Models Timeline

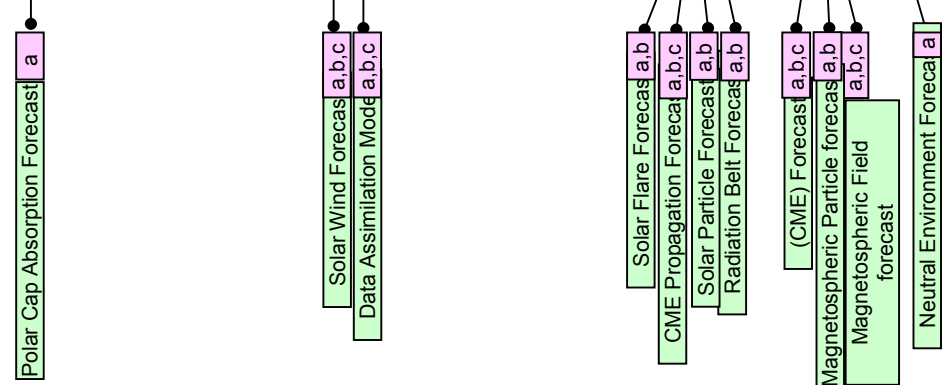
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SWx Operational Sensors



Radiation Dosage (a)
Charging and Single Event Upsets (b)
Natural Environment (c)

SWx Operational Models





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CCMC Importance to USAF

- Top Reasons CCMC Is Important To USAF:
 - Supports Space Weather Vision & Initiatives
 - Supports SWx Operationalization & Mainstreaming
 - Helps Bridge Science/Research-to-Operations Gap
 - Essential to NSSA SWx Architecture Capability Improvement Recommendations
 - Multi-Agency is Smart Way to Fulfill USG SWx Requirements



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*SPACE WEATHER
VISION*



“Relevant space weather observations and forecasts... provided to every DoD unit affected by space weather... with forward weather forces identifying support needs and tailoring products.”



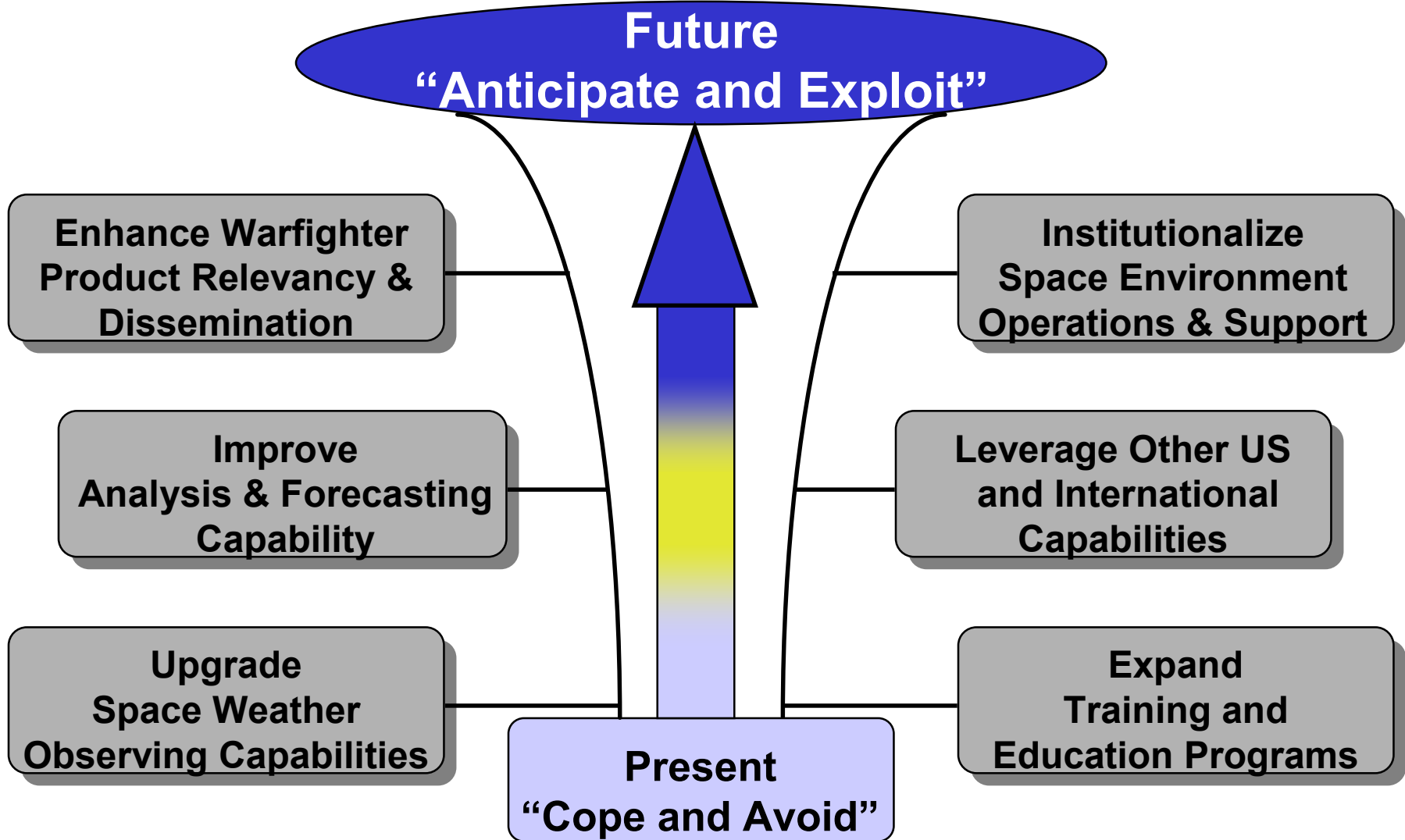


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USAF SW_x



Operationalization Summary



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AF SWx Program Initiatives

Near-to-Mid Term Acquisition Strategy

98 99 00 01 02 03 04 05

Solar Observing



GeoSpace Observing



Analysis/Forecast



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Bridging “Research-to-Ops” Gap:

CCMC Objectives and Potentials:

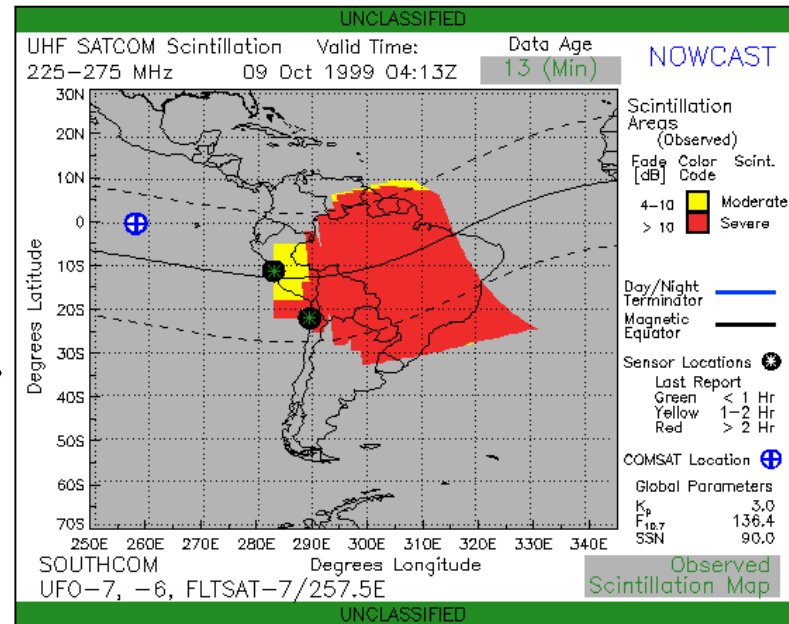
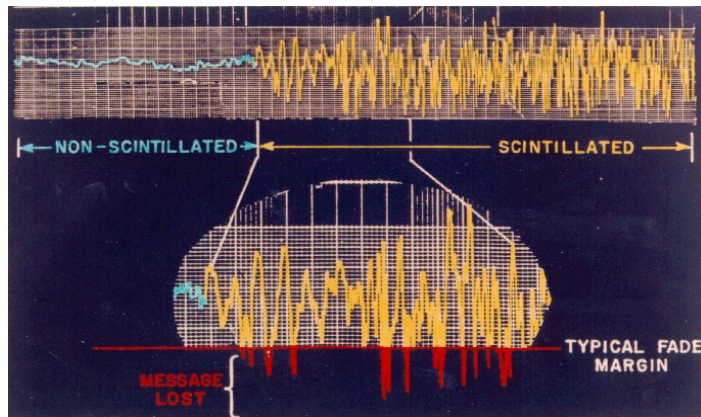
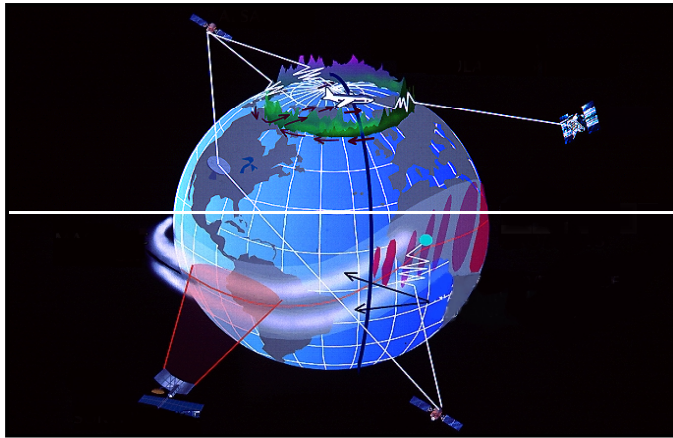
- Provide comprehensive process coordinating basic research, model development, and transition to operations
- Facilitate research coordination
- Couple space environment research domains
- Stimulate coordination among players & stakeholders
- Serve to align basic research strategies among agencies
- Catalyst for synergy between research and operations
- Provide comprehensive validation process for models
- Provide common development criteria for models
- Simplify effort required to make models operational



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Bridging "Research-to-Ops" Gap: Science-to-Ops Transition

Situational Awareness and Planning for Assured Access



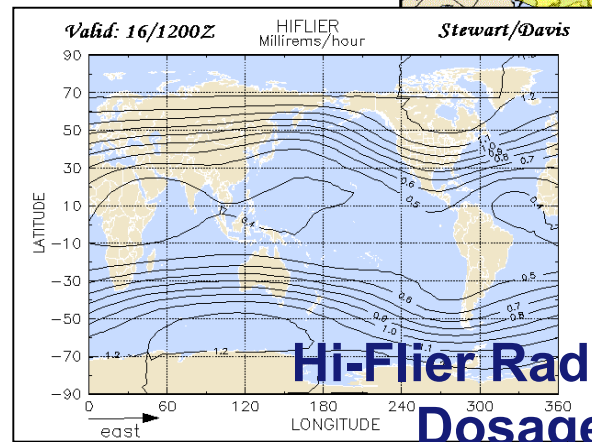
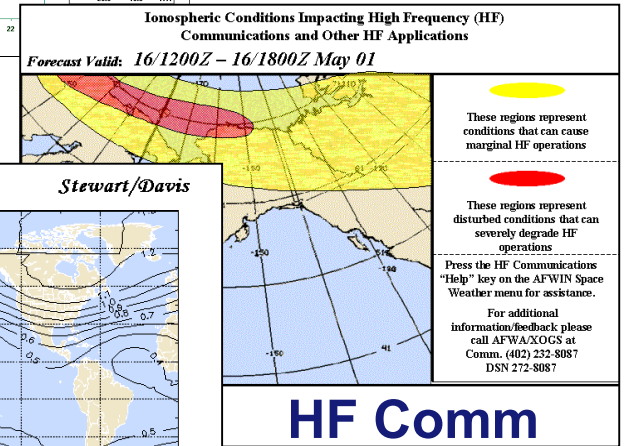
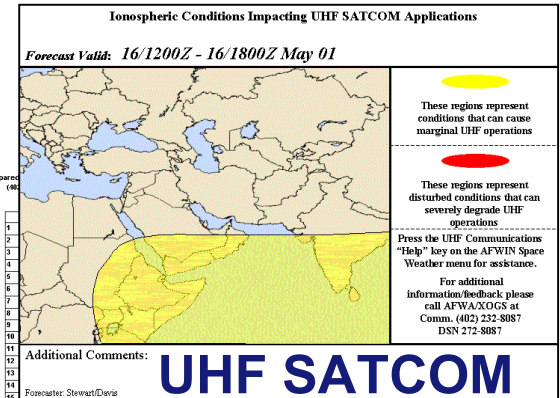
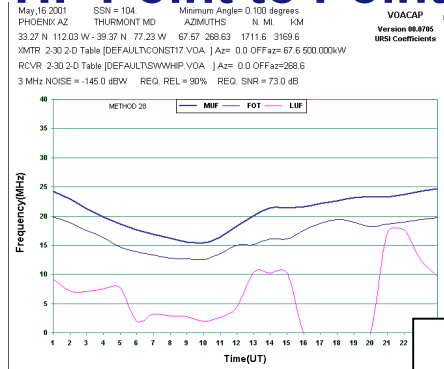


Mainstreaming SWx in AF & DoD

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- Validate space weather products
- Improve and tailor space weather products so customers can easily understand the message
- Integrate space weather information into warfighter systems

HF Point to Point



- Modeling and *Integrity - Service - Excellence*



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NSSA SWx Architecture Study: Architecture Vector Capabilities

Priority Domains	Current Capability	Essential Capability Adds:	Desired Capability Adds:
Ionosphere	<ul style="list-style-type: none"> Proxy Data Climatology 	<ul style="list-style-type: none"> TEC/EDP Spec. In Real Time Scintillation Forecasts Periodic Global Coverage 	<ul style="list-style-type: none"> Greater Confidence Long Term TEC/EDP Forecasts
CCMC	<ul style="list-style-type: none"> Sparse Real Data 	<ul style="list-style-type: none"> Some Forecast 	<ul style="list-style-type: none"> Greater Confidence Forecasts
Radiation	<ul style="list-style-type: none"> Climatology Post Event Data Sparse Coverage 	<ul style="list-style-type: none"> Real-time Data Full Coverage of All Orbits 	

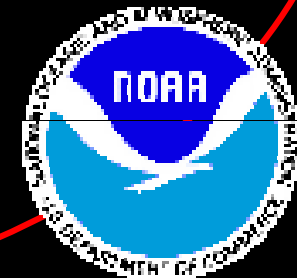
Multi-Agency: Smart Way to Fulfill USG Needs



CCMC



“A multi-agency partnership to enable, support, and perform the research and development for next generation space science and space weather models”





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Multi-Agency: Smart Way to Fulfill USG Needs

COMMUNITY COORDINATED MODELING CENTER

- Exploit scientific research models to accomplish Space Weather objectives
- Provide broad research community access to scientific model results (“open model policy”)
- Facilitate broad-based testing, combination and improvements of research models using government high-performance computing
- Deliver science-tested models to government sponsored Rapid Prototyping Centers for Space Weather Applications



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Multi-Agency Benefits

- Integrated SWx modeling approach from basic research (CCMC) thru prototyping (RPC's) to warfighter support
- Complies with documents calling for modernization of the nation's space weather forecast capability
- Leverages multi-agency funds and resources
- Synergy with other Science and Technology efforts
- Implements NSWP guidance and achieves NASA/AF partnership objectives
- Fosters and enhances basic science missions
- Develops next-generation science & forecasting tools
- Synergy with other ongoing activities



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CCMC Importance to DoD Summary & Conclusions

- CCMC is important to the USAF strategy to improve space weather capabilities & support to warfighters.
- Bottom Line:
 - CCMC will improve AFWA's operational tools/models since AF does not have a dedicated center to bridge the gap between universities, research orgs and operations.

