Air Force Space-Based Environmental Monitoring (SBEM) Update

HQ USAF Directorate of Weather (AF/A3W)

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Space-Based Environmental Monitoring (SBEM) Overview

- **The Air Force, and now the Space Force, is responsible for providing the Joint forces with SBEM capabilities (atmospheric, ocean, and space weather)**

- To provide global coverage, we rely on a Family of Systems (FoS) from civil, international and military satellites

- We own and operate a LEO constellation called Meteorological Satellite Program (DMSP) providing imagery (Vis/IR/microwave) and a space weather capability

- Recently procured a GEO satellite (GOES-13) from NOAA

- We ingest a myriad of satellite data into the 557th Weather Wing
  - Feeds into our global model & various cloud, land surface, and space weather models
  - Shared with weather forecasters that support global military operations

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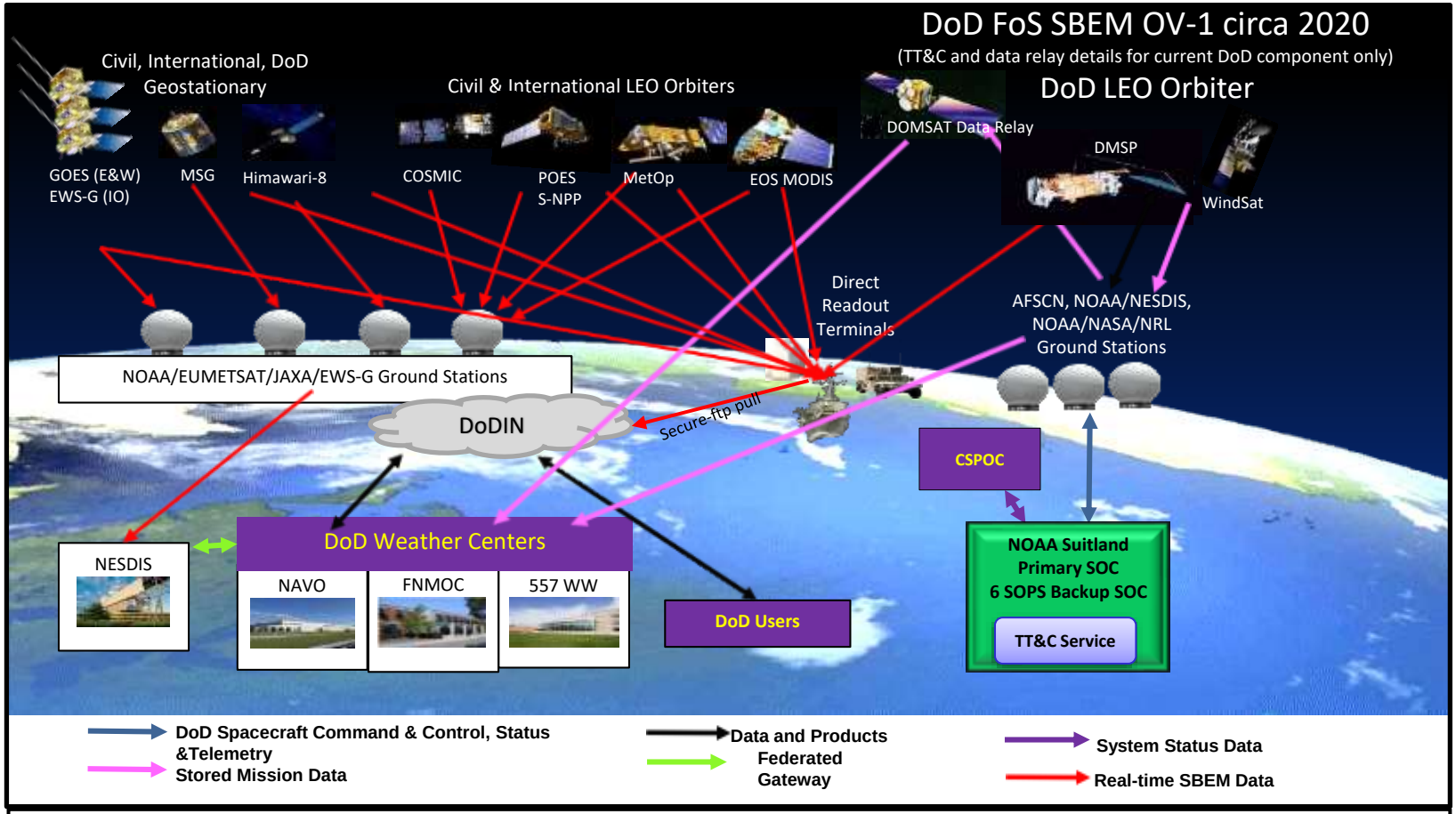
Family of Systems (FoS) Operational View 2020



557 WW: 557th Weather Wing CSpOC: Combined Space Operations Center DoDIN: Department of Defense Information Network EWS: Electro Optical/Infrared Weather System ESBMC2: Enterprise Space Battle Management Command and Control EUMETSAT: European Organization for the Exploitation of Meteorological Satellites FNMOC: Fleet Numerical Meteorology and Oceanography Center JAXA: Japanese Aerospace Exploration Agency MUS: Mission Unique Software NASA: National Aeronautics and Space Agency NAVO: Naval Oceanographic Office NESDIS: National Environmental Satellite, Data, and Information Service NSDC: National Space Defense Center SAAS: SBEM As A Service SOC: Satellite Operations Center SpEAR: Space Environment Anomaly Resolution TT&C; Telemetry, Tracking, & Commanding WSF-M: Weather System Follow-on, Microwave

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Space-Based Environmental Monitoring (SBEM) Future

- **The AF is restructuring its SBEM architecture and acquisition strategy to focus on resilient constellations vs single point of failure**

- **Initial focus on Electro-Optical/Infrared (EO/IR) – Cloud Characterization (CC) & Theater Weather Imagery (TWI) – Our top sensing priority**
  - Replaces current Defense Meteorological Satellite Program (DMSP) capabilities
  - Increases resiliency & scalability
  - Better balances DoD reliance on civil & international partnership architecture (Family of Systems (FoS))
  - Potential to grow into other SBEM capabilities (*e.g.;* ocean surface vector winds & tropical cyclone intensity)
  - Aligns with congressional interest in promoting commercial capabilities for space and weather services

- **This distributed LEO Strategy has associated risk**
  - Key DMSP sensors projected to reach end of life (EoL) prior to IOC
  - Smaller sensors for distributed LEO (d-LEO) architecture need to be matured
  - d-LEO risk to be mitigated w/ high TRL sensor into legacy architecture (if required)

On-ramps affordable, resilient capabilities for SBEM Joint users

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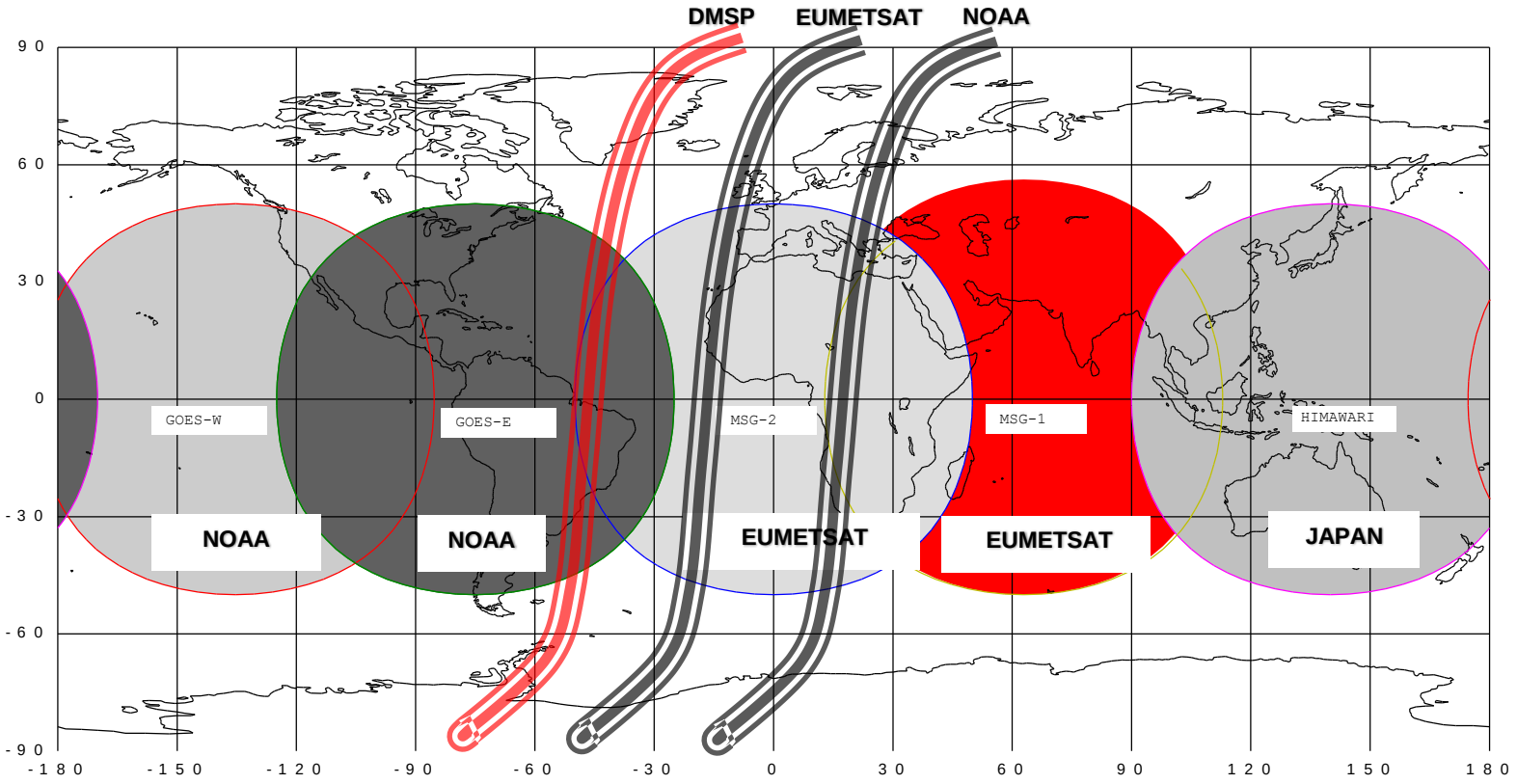
Family of Systems (FoS) Potential Gaps

- DMSP Operational Line Scanner (OLS) sensor Projected End of Life (EoL) 4Q2023
- MET-8 Projected EoL mid 2022



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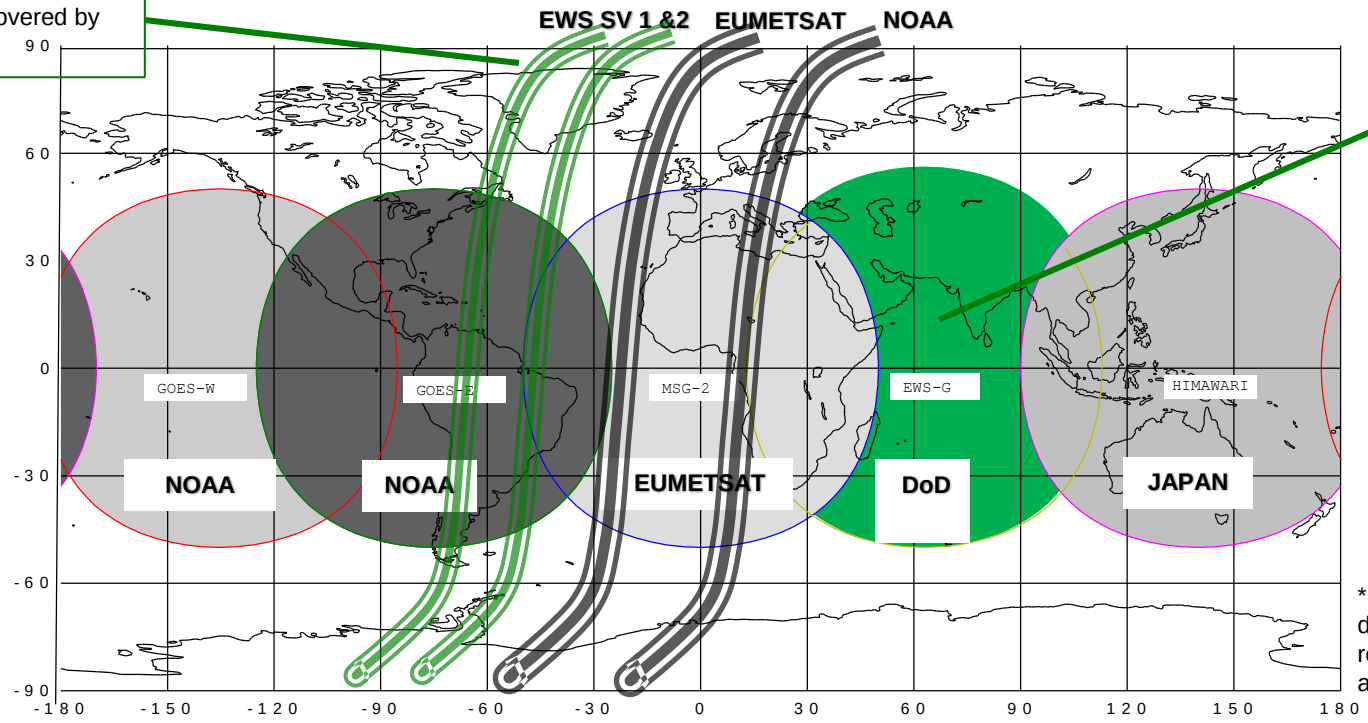
EO/IR Weather System – Geostationary (EWS-G) and EO/IR Weather System (EWS)

- **EWS-G in-place, Full Operational Capability (FOC) expected mid-2020, EoL 2023-2025**
- **EWS Initial Operational Capability (IOC) ~2025**

High latitude Refresh Gap to be covered by EWS IOC



EWS-G to cover Indian Ocean Gap, discussion w/ NOAA beginning for Space Vehicle-2 (potentially GOES-14/15)

*Notional EWS IOC design that may not represent final architecture

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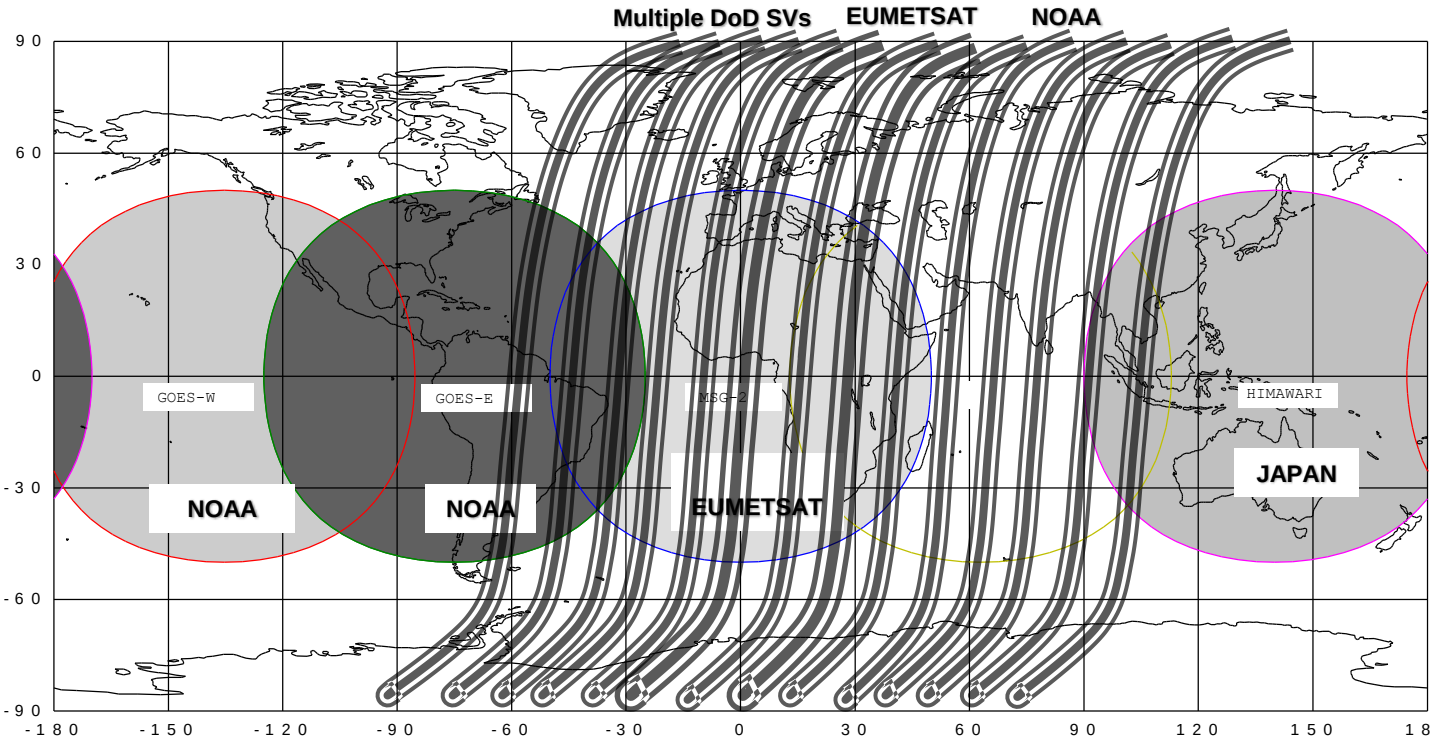
EO/IR Weather System (EWS) Full Operational Capability

- EWS FOC ~ 2030 depending on investment
- Fills both Indian Ocean and High Latitude Gaps with d-LEO solution



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Weather System Follow-on – Microwave (WSF-M)

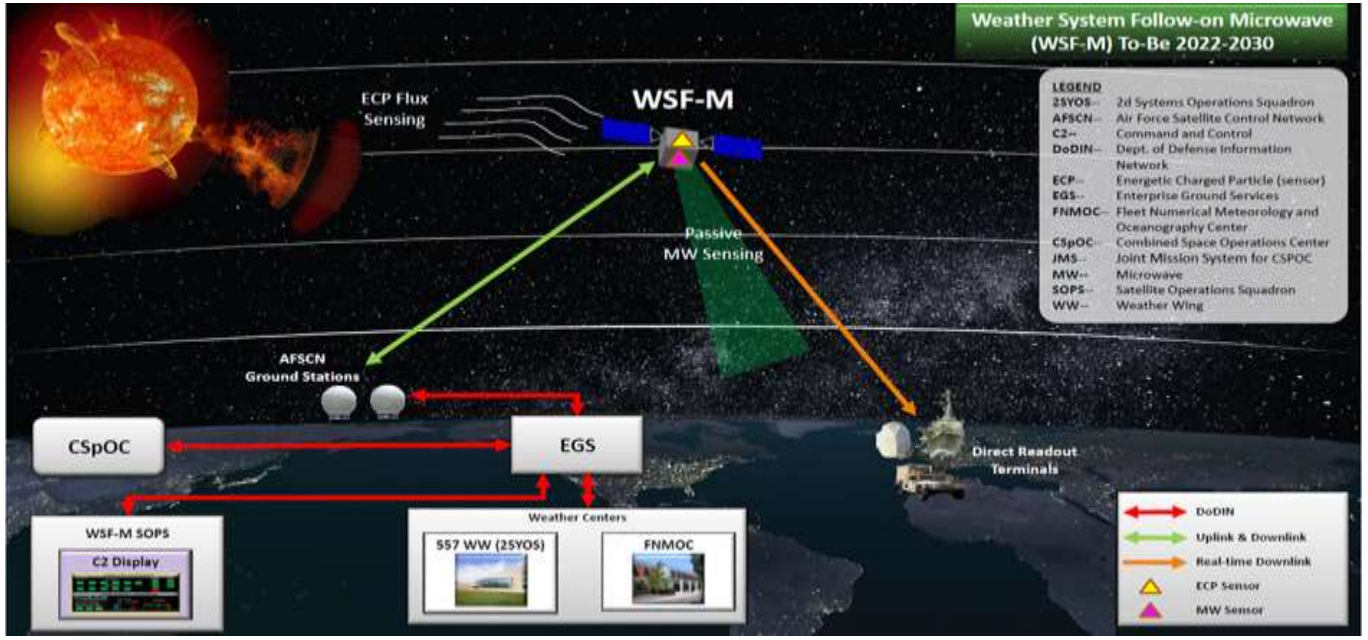
What:

- Joint Requirements Oversight Council directed a material solution to address Ocean Surface Vector Winds & Tropical Cyclone Intensity
  - Addresses SECAF hosted-sensor mandate for SBEM Energetic Charged Particles
- Low Earth Orbit (LEO), Sun-synchronous
- Ball Aerospace awarded design/build contract (Dec 17)

Ongoing Activities

- Milestone B approved – 5 Sep 19
- CDD JS Approved - Feb 20
- WSF-M Design/Build contract with Ball Aerospace
  - Multiple design reviews (Aug 19 - Mar 20)
  - System CDR - Mar 20

Initial Launch Capability - Nov 23
IOC/FOC – 2024/2025



Family of Systems (FoS) Operational View 2030

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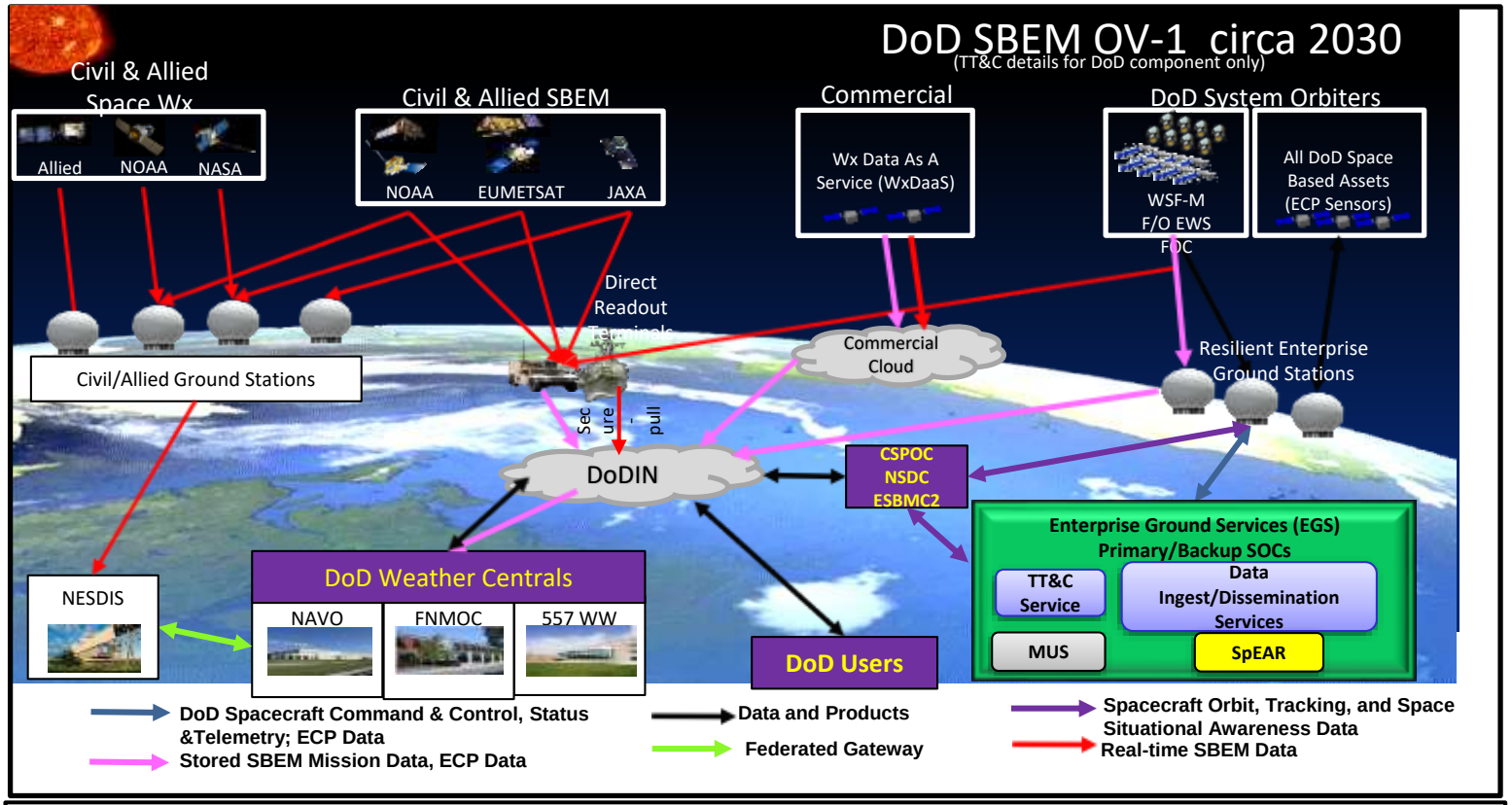

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Strategy Opens Spectrum of Commercialization Opportunities

Legacy Approach, Single System

Gov't-Built, Gov't-Operated, Distributed Smallsats

Gov't Sensors on Commercially-Produced Satellites

Gov't Sensors Embedded in Commercial Constellations

Weather Data As A Service

Increasingly Commercialized

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Summary

- **The AF ensures all services receive their meteorological and oceanography satellite needs through a combination of civil, international and military capabilities.**

- **Our future environment and our way forward**
  - VIIRS path produced unaffordable, single platform system that does not progress toward JROC-directed objective or Congressional interests
  - Move now to path that balances cost, performance, and schedule; on-ramps commercial capabilities & adds resiliency through proliferation

- **Key Attributes**
  - Introduces a pipeline of sensor maturation
  - Integration of commercial capability
  - Leveraged opportunities presented by SpaceX constellations

- **AF Global Weather Vision & NDS**
  - Lethality: Drive to reduced revisit rates to meet true warfighter needs
  - Balances alliances & partnering: multiple sources reduces mission risk

Questions?

Back-up

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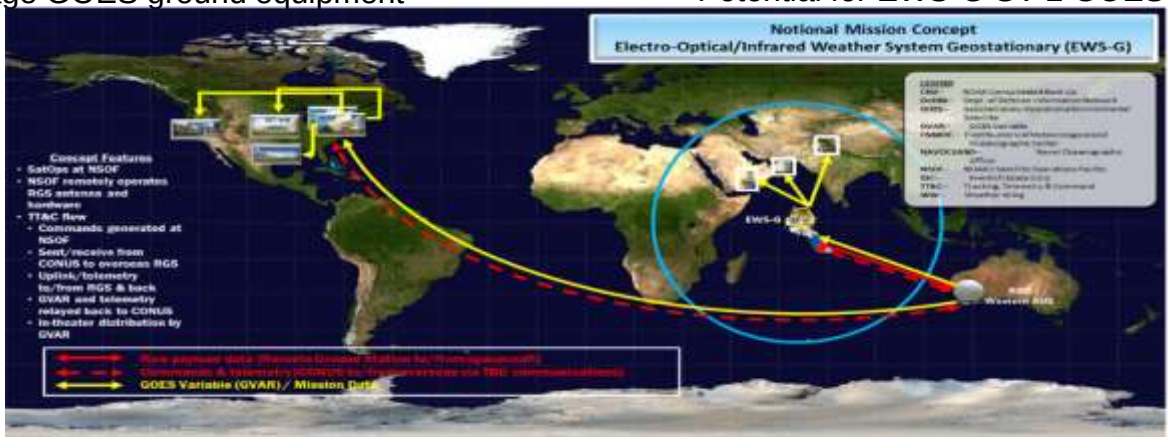
EO/IR Weather System-Geostationary (EWS-G)

What:

- JROC directed a temporary non-material solution for Cloud Characterization & Theater Weather Imagery over the Indian Ocean
  - Based on projected EUMETSAT MET-8 End-of-Life
- Moving a legacy National Oceanic and Atmospheric Administration (NOAA) Geostationary satellite (GOES-13)
- Leveraging NASA to establish remote ground station in Western Australia for operations and data relay
  - Using heritage GOES ground equipment

Ongoing Activities

- Satellite drift began - Jul 19
- Initial antenna transport to AUS began - Jul 19
- Nov 19 - Remote ground station reconstruction complete
- Nov/Dec 19 – Ground Station testing w/GOES-13
- Satellite arrived at final location (61.5 E) – 18 Feb 20
- IOC - Apr 2020, FOC - ~Jun/Jul 2020
- EOL ~ 2023 based on fuel for station-keeping, w/ potential to extend to 2025 w/ software mods
- Potential for EWS-G SV-2 GOES transfer



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USAF Commercial Weather Data Pilot

- USAF provided CWDP funds via Congressional adds starting in FY2017
- First contract focused on GPS-RO given availability of multiple vendors with more mature capabilities
- New BAA established to fund multiple smaller projects to address multiple SBEM gaps
- Future challenges:
  - Sustain CWDP efforts outside congressional adds
  - Transition of prototypes to ops + data buys
  - Evolve modeling system to exploit data from multiple data paths, including ability to rapidly assimilate new data into NWP models