NPOESS: OBSERVING AND COMMUNICATING WEATHER, CLIMATE, AND ENVIRONMENTAL DATA FROM SPACE

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The National Oceanic and Atmospheric Administration (NOAA), Department of Defense (DoD), and National Aeronautics and Space Administration (NASA) are working with prime contractor Northrop Grumman Aerospace Systems (NGAS), principal teammate Raytheon, and instrument subcontractors to jointly develop the next-generation operational weather and environmental satellite system - the National Polar-orbiting Operational Environmental Satellite System (NPOESS). NPOESS will replace NOAA's Polar-orbiting Operational Environmental Satellites (POES) and DoD's Defense Meteorological Satellite Program (DMSP) spacecraft that have provided global data for weather forecasting and environmental monitoring for nearly 50 years. NPOESS will employ platforms and instruments that incorporate technological advances from NASA's Earth Observing System (EOS) satellites in an integrated mission serving the nation's civilian and military needs for space-based, remotely-sensed environmental data.

NPOESS will consist of four spacecraft (C1 – C4) and associated sensors in two orbits (1330 Equatorial Local Time of Ascending Node [LTAN] and 1730 LTAN) to meet the operational needs of NOAA and DoD. The afternoon NPOESS spacecraft will carry the following instruments: Visible/Infrared Imager Radiometer Suite (VIIRS); Cross-track Infrared Sounder (CrIS); Advanced Technology Microwave Sounder (ATMS); Ozone Mapping and Profiler Suite (OMPS); Microwave Imager/Sounder (MIS – C3 only), Space Environment Monitor-NPOESS (SEM-N), Clouds and the Earth's Radiant Energy System (CERES – C1 only) and Total Solar Irradiance Sensor (TSIS – C1 only). Atmospheric temperature and moisture profiles and surface data collected from imaging and atmospheric sounding instruments in the afternoon orbit are critical for global numerical weather prediction (NWP) models. The early morning NPOESS spacecraft (1730 LTAN) will carry VIIRS and MIS (C2 and C4) to provide visible, infrared, and microwave imagery for global cloud forecast models to support DoD's tactical decisions for air, sea, and ground operations. Both early-morning and afternoon spacecraft will also be equipped with the Advanced Data Collection System (A-DCS) and the Search and Rescue Satellite Aided Tracking System (SARSAT). The mid-morning orbit (2130 LTAN) will be occupied by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Meteorological Operational (MetOp) satellites series that carry advanced instruments similar to those that will fly on NPOESS. EUMETSAT successfully launched the first in the series of MetOp satellites in October 2006 [1] to permanently replace

NOAA's POES in the mid-morning orbit as part of the NOAA/EUMETSAT Initial Joint Polar-orbiting Operational Satellite System (IJPS). The joint constellation of NPOESS and MetOp polar-orbiting operational satellites will provide global coverage with a data refresh rate of approximately four hours for most observations.

As a precursor to NPOESS, the NPOESS Preparatory Project (NPP) [2] that is jointly managed by the NPOESS Integrated Program Office and NASA is scheduled for launch in 2011. NPP will: (1) test the on-orbit performance of NPOESS sensors (VIIRS, CrIS, ATMS, OMPS, and CERES) and validate the ground system design for receiving, processing, and distributing data and products; (2) provide continuity of the NASA EOS Terra, Aqua, and Aura global imaging and sounding observations; and (3) ensure early user access to data from NPOESS sensors for evaluation and operational use three years in advance of NPOESS. Flight units for ATMS, OMPS, and CERES have been delivered and integrated onto the NPP spacecraft. The flight unit for VIIRS has successfully completed testing, during which the instrument demonstrated very good radiometric performance [3]. The flight unit for CrIS is undergoing final testing, calibration, and characterization in preparation for shipment to Ball Aerospace and Technologies Corp. for integration onto the NPP spacecraft. The NPP spacecraft will be launched into the 1330 LTAN orbit to reduce the risk of an operational data gap between the last POES and the first NPOESS satellite. The first operational NPOESS spacecraft (C1) is now scheduled for launch in 2014. The final satellites (C3 and C4) in the two-orbit NPOESS constellation are expected to be operational well into the 2023-2026 time period.

NPOESS will provide an end-to-end system to acquire, process, and deliver data to NOAA and DoD central processing facilities through a global SafetyNet^{TM} communications network of 15 dedicated, unmanned ground stations that will provide significantly improved data latency. The NPOESS ground system architecture is expected to deliver 95% of the data within 28 minutes from the time of collection on orbit. NPOESS spacecraft will also simultaneously broadcast real-time data at X-band and L-band frequencies to suitably equipped ground stations. Key components of the NPP and NPOESS command, control, and communications system have already been installed and have passed tests at the Svalbard Satellite station (SvalSat) and at NOAA's Satellite Operations Facility. Communications capabilities from Antarctica are being upgraded to support NPOESS. NOAA and EUMETSAT are currently exploring opportunities to receive MetOp data from an Antarctic ground station, thereby substantially improving data latency in the mid-morning orbit.

High (spatial and spectral) resolution imaging and sounding instruments on NPP and NPOESS will support continuing advances in data assimilation systems and NWP models to improve short- to medium-range weather forecasts. Assimilation of high-spectral resolution radiance data from NASA's Atmospheric Infrared Sounder (AIRS) into NWP models has already resulted in a several hour increase in forecast skill/range at five to six days

in both northern and southern hemispheres, a significant improvement that normally takes several years to accomplish [4]. Advanced infrared (CrIS - similar to AIRS) and microwave (ATMS) sensors on NPP and NPOESS will provide excellent global coverage of the atmospheric temperature and moisture fields. A single platform carrying these two instruments will provide near-global coverage every 12 hours. When fully deployed, the joint constellation of NPOESS and MetOp will provide full global coverage of the temperature and moisture fields every 4-8 hours.

NPOESS is designed to deliver more than 35 essential measurements for operational weather and ocean nowcasting and forecasting, land use, and space weather while providing continuity of data for 14 of 26 essential climate variables. While supporting operational weather forecasting as a primary mission, NPOESS will also carry other instruments to continue and extend important legacy measurements of atmospheric ozone, Earth radiation budget, and solar irradiance that have been made from NOAA and NASA spacecraft over the last three decades. CERES, TSIS, and OMPS are important climate sensors that will now be flown on an operational platform to maintain continuity of Climate Data Records (CDR) for space-based measurements. Pre-flight characterization of instruments, enhanced onboard instrument calibration, and stable orbits will significantly contribute to high-quality CDRs from NPP and NPOESS.

To promote rapid use of data and products from NPP and NPOESS shortly after launch, the NPOESS program has been supporting the development of education and training modules that simulate NPOESS-era products well ahead of launch. Over the past six years, the Cooperative Program for Operational Meteorology, Education and Training (COMET) has developed satellite training on the capabilities, applications, and relevance of NPP and NPOESS to operational weather forecasters and other user communities [5]. Complementary training resources are hosted on the Naval Research Laboratory (NRL) Next Generation Weather Satellite Demonstration Project (NexSat) website that uses real-time imagery from current operational and research satellites to highlight the expected capabilities of comparable sensors on the future NPP and NPOESS spacecraft [6].

In the next decade, NPOESS will be the principal U.S. operational, polar-orbiting, space-based observing system for weather forecasting and climate monitoring. Consistency of radiometric measurements from NPOESS instruments will help improve present NWP weather forecasting capabilities and allow forecasters to extend the range of forecasts for the United States. The NPOESS architecture will enable high-quality, space-based, remotely-sensed data to be used faster and more frequently in numerical weather prediction models for improved environmental forecasts and warnings. Shortly after NPOESS becomes operational, NOAA will also be implementing the Geostationary Operational Environmental Satellite-R (GOES-R) program with the first satellite launch in ~2015. NPOESS and GOES-R will carry similar, advanced-technology, high-resolution visible/infrared

imagers to provide the weather forecasting community with highly complementary data. The synergy of NPOESS and GOES-R will provide opportunities to blend and fuse data from multiple sources into more useful, accurate, and timely products for forecasters and other users. NPOESS and GOES-R will provide essential real-time data to the international community to support weather forecasting, as well as continuity of critical data for monitoring, understanding, and predicting climate change and assessing the impacts of climate change on seasonal and longer time scales.

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