Prepared by NOAA
Agenda Item: D.1
For information to Plenary

STATUS OF NOAA CURRENT AND FUTURE SATELLITE PROGRAMS – REPORT TO CGMS-44

This document summarizes the status of NOAA current and future LEO and GEO satellite systems. The reporting period for the current satellite operations is 1 April 2015 to 30 April 2016. For future satellites, progress to date at the time of writing is included.

Current satellite programs cover the status of the spacecraft, ground segment, space weather effects, and data transmission.

Future satellite programs cover the mission objectives “(spacecraft, payload, instruments, products) and program status (space, system and ground segments).

CGMS is invited to take note.

Status of NOAA current and future satellite programs – report to CGMS-44

1 INTRODUCTION

This paper reports on the status of NOAA current and future satellite systems. The reporting period for current satellite operation is 1 April 2015 to 30 April 2016. For future satellites, progress to date at the time of writing is included.

2 STATUS OF CURRENT GEO SATELLITE SYSTEMS

Sector	Satellites in orbit P= pre-operational Op=operational B=back-up L=limited availability	Location	Launch date	Details on near real time access to L0-L1 data (links)	Environmental payload and status
GOES East	GOES-13 (Op)	75ºW	05/24/2006	http://www.ospo.noaa.gov/Organization/About/access.html	Imager only, Sounder not currently operational
Standby	GOES-14 (B)	105ºW	06/27/2009	http://www.ospo.noaa.gov/Organization/About/access.html	Backup for GOES-East and GOES-West
GOES West	GOES-15 (Op)	135ºW	03/04/2010	http://www.ospo.noaa.gov/Organization/About/access.html	All payloads are operational

2.1 Mission objectives, payload/instruments, products

The goals of the Geostationary Operational Environmental Satellite (GOES) system program are to:

- Maintain continuous, reliable, operational, environmental, and storm warning systems to protect life and property
- Monitor the earth's surface and space environmental conditions
- Introduce improved atmospheric and oceanic observations as well as data dissemination
- Develop and provide new and improved applications and products for a wide range of federal agencies, state and local governments, and private users

The GOES system functions to accomplish an environmental mission serving the needs of operational meteorological, space environmental, and research users.

- **Warnings to U.S. public –detect, track and characterize -** hurricanes, severe storms including flash floods, winter cyclones
- **Imagery for weather forecasting**
- **Derived products for analysis and forecasting** – surface temperatures, wind for aviation and NWS numerical models, sounding and radiances for NWS models, air quality, rainfall estimates
- **Environmental data collection** – platforms including buoys, rain gauges, river levels, ecosystem monitoring
- **Space weather monitoring and forecasting**
- **Search and Rescue**

2.2 Status of spacecraft

GOES-13

GOES-13, launched on May 24, 2006 has been on station at 75°W as GOES-East since April 14, 2010. 9 rows out of 512 Solar X-ray Imager (SXI) detectors were damaged due to 2006 flare. GOES-13 SXI provides data coverage for Space Weather prediction Center (SWPC) while the primary SXI is in eclipse. X-ray Sensor (XRS) measurements are functioning but may invert unexpectedly. The Sounder filter wheel has stalled in November 2015. GOES-13 Imager is functioning nominally.

GOES-14

GOES-14, launched on June 27, 2009 is located at 105°W as standby spacecraft. GOES-14 had provided short term GOES-East services while GOES-13 was recovering from anomalies. GOES-14 is in normal configuration, instead of storage mode configuration, to provide quick services as a backup. GOES-14 provides 1-minute Super Rapid Scan Operations for GOES-R (SRSOR) algorithm developers, research partners, and forecasters periodically. All of the GOES-14 payload instruments are nominal.

GOES-15

GOES-15, launched on March 4, 2010 has been on station at 135°W as GOES-West since December 14, 2011. Yaw-flip maneuver is required at equinox to mitigate Sounder temperature control blanket anomaly. Star tracker 1 failed in 2014 and star tracker 2 failed in 2015 so that GOES-15 is operating with single star tracker. GOES-15 SXI and XRS are primary instruments for SWPC.

2.3 Impact on spacecraft due to space weather

Space weather related spacecraft anomalies (Items in bold are required)

Source: Recommendations for Contents of Anomaly Database for Correlation with Space Weather Phenomena, P. O'Brien, J.E. Mazur, T. Guild, November 2011, AEROSPACE Report No.TOR-2011(3903)-5.

1. Date and Universal Time of the anomaly	**2. Fully specified location of the anomaly (spacecraft location)**	**3. Velocity or orbital elements at time of the anomaly**	4. Eclipse state of the vehicle (full, penumbra, partial, none)	5. Vector to Sun in spacecraft coordinates	6. Velocity vector of spacecraft in spacecraft coordinates	7. Initial guess at type of anomaly (See taxonomy below)	8. Estimated confidence of that guess	9. Anomaly category (e.g., affected system or kind of disruption)	10. Vehicle identity	11. Notes (e.g. unusual operational states or recent changes to operations (recent commands, attitude scheme, etc.)
May 22, 2013 at 0327z	75o West	Geo	No eclipse			Micrometeoroid/space debris	High	Satellite safe mode	GOES-13	

Taxonomy of Satellite Anomalies Caused by In Situ Charged Particle Environment (to be used for column 7):

1. Electrostatic discharge (charging)
    - 1.1 Surface charging
        - 1.1.1 Plasma sheet (subauroral)
        - 1.1.2 Auroral
    - 1.2 Internal charging
        - 1.2.1 Subsurface charging (e.g., beneath blanket)
        - 1.2.2 Deep charging (e.g., inside a box)
2. Single-Event Effects
    - 2.1 Protons
        - 2.1.1 Solar proton event
        - 2.1.2 Geomagnetically trapped protons
    - 2.2 Heavy ions
        - 2.2.1 Galactic Cosmic Rays
        - 2.2.2 Solar energetic particles
        - 2.2.3 Geomagnetically trapped heavy ions
3. Total Dose
    - 3.1 Long-term dose accumulation (multiple causes combined)
    - 3.2 Short-term (days or less) dose accumulation
        - 3.2.1 Solar protons
        - 3.2.2 Geomagnetically trapped protons
        - 3.2.3 Geomagnetically trapped electrons

2.4 Ground segment matters

The availability of the GOES ground systems was nominal in the reporting period. Two new GOES-R antennas in Wallops CDA have been tested and certified for GOES NOP operations. Four GVAR antennas in NSOF had been upgraded to serve both GOES NOP and GOES R series satellites.

2.5 Data transmission

Data transmission for GOES is handled through the Processed Data Relay (PDR) direct broadcast service in the GOES Variable (GVAR) transmission format. The Environmental Satellite Processing Center (ESPC) collocated with the NOAA Satellite Operations Facility at Suitland, Maryland, also provide data directly to users, including the National Weather Service and field users.

3 STATUS OF CURRENT LEO SATELLITE SYSTEMS

Orbit Type ECT=Equator Crossing Time (for sun-synchronous orbits)	Satellites in orbit P= pre-operational Op=operational B=back-up L=limited availability	Equator Crossing Time (ECT) Ascending	Mean altitude	Launch Date	Details on near real time access to L0/L1 data (links)	Instrument payload and status
Polar, non-SSO	JASON-2 (Op)	N/A	1336 km	Jun 20, 2008	http://www.ospo.noaa.gov/Organization/About/access.html	Poseidon-3 Altimeter, DORIS, AMR, GPSP, LRA, CARMEN-2, T2L2, LPT
Polar, non-SSO	JASON-3 (P)	N/A	1336 km	Jan 17, 2016	http://www.ospo.noaa.gov/Organization/About/access.html	Poseidon-3B Altimeter, DORIS, AMR-2, GPSP, LRA, CARMEN-3, LPT
Polar, SSO	NOAA-15 (Op)	17:46	813 km	May 13, 1998	http://www.ospo.noaa.gov/Organization/About/access.html	AVHPR, HIRS, AMSU A &B, SEM
Polar, SSO	NOAA-18 (Op)	17:53	854 km	May 20, 2005	http://www.ospo.noaa.gov/Organization/About/access.html	AVHPR, HIRS, AMSU A, MHS, SBUV/2, SEM
Polar, SSO	NOAA-19 (Op)	14:36	870 km	February 6, 2009	http://www.ospo.noaa.gov/Organization/About/access.html	AVHPR, HIRS, AMSU A, MHS, SBUV/2, SEM
Polar, SSO	DMSP-17 (Op)	18:20	848 km	Nov 4, 2006	http://www.ospo.noaa.gov/Organization/About/access.html	OLS, SSMIS, SSULI, SSUSI, SSJ
Polar, SSO	DMSP-18 (Op)	19:08	850 km	Oct 18, 2009	http://www.ospo.noaa.gov/Organization/About/access.html	OLS, SSMIS, SSULI, SSUSI

Polar, SSO, Afternoon	Suomi-NPP (Op)	13:29	833 km	Oct 28, 2011	http://www.ospo.noaa.gov/Organization/About/access.html	VIIRS, ATMS, CrIS, CERES, OMPS

3.1 Mission objectives, payload/instruments, products

The POES spacecraft constellation includes one primary for mission services and two secondary spacecraft. These spacecraft are in circular orbits inclined at approximately 98 degrees (retrograde), allowing them to maintain a constant sun angle as they pass a point on earth (making detection of changed conditions easier). NOAA's primary afternoon operational spacecraft, Suomi-National Polar Partnership (S-NPP), was launched on Oct 28, 2011, declared operational in Jan 2013 and became the primary PM weather satellite in May of 2014. NOAA's previous primary satellite, NOAA-19 (launched in Feb 2009), remains the primary PM satellite for services such as SARSAT and the Argos Data Collection System (collecting data from small remote environmental transponders worldwide). Two secondary spacecraft, NOAA-18 and NOAA-15 provide additional payload operational data. As of Apr 2013, NOAA declared EUMETSAT's Metop-B as NOAA's mid-morning primary operational spacecraft.

3.2 Status of spacecraft

Jason-2

Jason-2 was launched in June of 2008 and declared operational in December of 2008. This satellite altimetry mission provides sea surface heights for determining ocean circulation, climate change and sea-level rise. It is operating the Poseidon-3 Radar Altimeter (Poseidon-3), Advanced Microwave Radiometer (AMR), Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS), Global Positioning System Payload (GPSP), Laser Retroreflector Array (LRA), Environment Characterization and Modelization-2 (Carmen-2), Time Tranfser by Laser Link (T2L2), and Light Particle Telescope (LPT). All instruments are operational.

Jason-3

Jason-3 was launched in January of 2016 and is currently undergoing commissioning activities. Jason-3 will make highly detailed measurements of sea-level on Earth to gain insight into ocean circulation and climate change. It is operating the Poseidon-3B Radar Altimeter (Poseidon-3B), Advanced Microwave Radiometer-2 (AMR-2), Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS), Global Positioning System Payload (GPSP), Laser Retroreflector Array (LRA), Environment Characterization and Modelization-3 (Carmen-3), and Light Particle Telescope (LPT).

NOAA-15

NOAA-15 was launched in May 1998, and declared operational in December of the same year. It is currently a secondary AM polar environmental satellite, along with

Metop-A. Along with Metop satellites, it is operating the Advanced Very-High-Resolution Radiometer (AVHRR), the High-resolution Infrared Radiation Sounder (HIRS), the Advanced Microwave Sounding Unit (AMSU) A and B, and the Space Environment Monitor (SEM). Most of the instruments are operating in a degraded mode, with the HIRS and AMSU-B non-operational and the SEM and AMSU-A2 units remaining fully operational. At 18 years old, it is the oldest of the NOAA satellites. NOAA-15 also carries a SARSAT payload, as well as a Data Collection System payload that allows remote transponders to feed information back to NOAA from equipment all over the world. The SAR unit on NOAA-15 is operating in a degraded mode, and the DCS payload is fully operational.

NOAA-18

NOAA-18 was launched in May 2005, and declared operational in August of the same year. It is currently a secondary PM polar environmental satellite. Along with Metop satellites, it is operating the Advanced Very-High-Resolution Radiometer (AVHRR), the High-resolution Infrared Radiation Sounder (HIRS), the Advanced Microwave Sounding Unit (AMSU) A, the Microwave Humidity Sounder (MHS, in place of the AMSU-B), the Solar Backscatter Ultraviolet Instrument (SBUV/2), and the Space Environment Monitor (SEM), as well as SARSAT and the Data Collection System (DCS) payloads of NOAA-15. In contrast to its older sister, NOAA-18's instruments are mostly fully operational, with the SBU-V/2 inoperative and the HIRS operating in a degraded mode. SAR and DCS payloads are both fully functional.

NOAA-19

NOAA-19, launched in Feb 2009, is the youngest NOAA/TIROS satellite, and was declared operational in June of the same year. It is currently the primary PM polar environmental satellite for services such as SARSAT and ARGOS Data Collection System (S-NPP is the primary environmental data satellite in the PM orbit). Along with Metop satellites, it operates the Advanced Very-High-Resolution Radiometer (AVHRR), the High-resolution Infrared Radiation Sounder (HIRS), the Advanced Microwave Sounding Unit (AMSU) A, the Microwave Humidity Sounder (MHS, in place of the AMSU-B), the Solar Backscatter Ultraviolet Instrument (SBUV/2), and the Space Environment Monitor (SEM), as well as SARSAT and the Advanced Data Collection System (ADCS), improved over the version in older satellites, allowing two-way communication with remote transponders. NOAA-19's instruments are fully functional, with the exception of its HIRS and MHS payloads, which are operating in a degraded mode.

DMSP F-17

DMSP F17 was launched on Nov 4, 2006. It had been a hot backup and providing direct-user support, up until February of 2016. DMSP F17 then took over as a Primary satellite following an anomaly aboard DMSP F19. All primary instruments are fully functional, with some degradation of secondary SSI-ES2/3, SSULI and SSUSI instruments. It provides meteorological data to the US Military.

DMSP F18

DMSP F18 was launched from Vandenberg AFB on Oct 18, 2009. It has been operating as a primary satellite, providing data to the US Military. All of its instruments are healthy, with the exception of a degraded Magnetometer.

DMSP F19

DMSP-F19 has stopped responding to commands on 11 February 2016 for reasons unknown. It remains unclear if the satellite can be recovered.

S-NPP

Suomi National Polar-orbiting Partnership (S-NPP) was launched on Oct 28, 2011, and has been operating as the Primary PM Weather satellite since May 1, 2014. S-NPP is the precursor of the Joint Polar Satellite System, the next generation of weather satellites. It is operating advanced instruments such as the Visible Infrared Imaging Radiometer Suite (VIIRS), the Advanced Technology Microwave Sounder (ATMS), the Cross-track Infrared Sounder (CrIS), the Clouds and the Earth's Radiant Energy System (CERES), and the Ozone Mapping and Profiler Suite (OMPS), which have revolutionized forecasters' ability to make longer range forecasts. The vehicle and instruments are all operating within specifications, though the ATMS instrument's scan drive motor is starting to show signs of aging. A program of drive motor reversals was undertaken this year in order to extend the life of the motor.

3.3 Impact on spacecraft due to space weather

Space weather related spacecraft anomalies (Items in bold are required)

Source: Recommendations for Contents of Anomaly Database for Correlation with Space Weather Phenomena, P. O'Brien, J.E. Mazur, T. Guild, November 2011, AEROSPACE Report No.TOR-2011(3903)-5.

1. Date and Universal Time of the anomaly	**2. Fully specified location of the anomaly** (spacecraft location)	**3. Velocity or orbital elements at time of the anomaly**	4. Eclipse state of the vehicle (full, penumbra, partial, none)	5. Vector to Sun in spacecraft coordinates	6. Velocity vector of spacecraft in spacecraft coordinates	7. Initial guess at type of anomaly (See taxonomy below)	8. Estimated confidence of that guess	9. Anomaly category (e.g., affected system or kind of disruption)	10. Vehicle identity	11. Notes (e.g. unusual operational states or recent changes to operations (recent commands, attitude scheme, etc.)
11/19/15 0135z	**804.297255 -6669.264008 -2701.665864 km**	**-0.905329 -2.843352 6.789637 km/s**	None	**-123535546.804261 64831983.107027 -48972594.177757 km**		2.2	Confident	SEU interrupted instrument operation	S-NPP	
01/17/16 0438z	**2820.604051 -2553.183136 6149.249063 km**	**-5.945346 2.410849 3.729121 km/sec**	None	**-63930505.447293 121754865.795060**		2.2	Confident	SEU interrupted instrument operation	S-NPP	

				- 5239614 6.06812 3 km						
02/24/16 16:19z	**- 7077.6004 96 - 1440.5041 51 90.939078 km**	**-0.331975 1.124880 -7.342283 Km/sec**	Umbra	**6981163 1.548716 - 1282457 21.31643 2 - 2442780 8.019089 km**		2.2	Confident	SEU interrupted instrument operation	S-NPP	

1. Electrostatic discharge (charging)
    1.1 Surface charging
        1.1.1 Plasma sheet (subauroral)
        1.1.2 Auroral
    1.2 Internal charging
        1.2.1 Subsurface charging (e.g., beneath blanket)
        1.2.2 Deep charging (e.g., inside a box)
2. Single-Event Effects
    2.1 Protons
        2.1.1 Solar proton event
        2.1.2 Geomagnetically trapped protons
    2.2 Heavy ions
        2.2.1 Galactic Cosmic Rays
        2.2.2 Solar energetic particles
        2.2.3 Geomagnetically trapped heavy ions
3. Total Dose
    3.1 Long-term dose accumulation (multiple causes combined)
    3.2 Short-term (days or less) dose accumulation
        3.2.1 Solar protons
        3.2.2 Geomagnetically trapped protons
        3.2.3 Geomagnetically trapped electrons

3.4 Ground segment matters

The Polar Ground systems continue to perform well. The NOAA Jason Ground System (NJGS) was installed, tested, and activated over the course of the year and is performing as expected handling a two-spacecraft (Jason-2/3) constellation. The S-NPP/JPSS ground system is undergoing a Block upgrade, which is to be delivered later this year, allowing the operation of the JPSS-1 satellite to be launched early in CY 2017. The JPSS ground system is also providing data collection support at McMurdo Station in Antarctica in order to decrease data latency. JPSS-1 will utilize a similar scheme to increase the speed at which environmental data is ingested into weather-forecasting systems worldwide.

3.5 Data transmission

Data transmission for POES and Jason is handled through the Environmental Satellite Processing Center (ESPC) collocated with the NOAA Satellite Operations Facility at Suitland, Maryland. Data is provided to users, including the National Weather Service, through the ESPC, and to field users directly through the High Resolution Picture Transmission (HRPT) direct broadcast service. S-NPP utilizes the NPP Data Exploitation (NDE) and the Interface Data Processing Segment to ingest and distribute products to users worldwide.

4 STATUS OF ADDITIONAL CURRENT LEO SATELLITE SYSTEMS

Orbit Type ECT=Equator Crossing Time (for sun-synchronous orbits)	Satellites in orbit P= pre-operational Op=operational B=back-up L=limited availability	Equator Crossing Time (ECT) Ascending	Mean altitude	Launch Date	Details on near real time access to L0/L1 data (links)	Instrument payload and status
Low-orbit (72º inclination), non-SSO?	COSMIC-1 (FM1 – 6) (Op)	Varies	700-800 km	Apr 15, 2006	http://www.ospo.noaa.gov/Organization/About/access.html	Integrated GPS Occultation Receiver (IGOR), the Tiny Ionosphere Photometer (TIP), the Coherent Electromagnetic Radio Tomography/Triband Beacon Transmitter (CERTO/TBB)

4.1 Mission objectives, payload/instruments, products

This joint U.S.-Taiwan program is called COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) in the United States and FORMOSAT-3 in Taiwan. The low-orbiting satellites are the first to provide atmospheric data daily in real time over thousands of points on Earth for both research and operational weather forecasting by measuring the bending of radio signals from the U.S. Global Positioning System (GPS) as the signals pass through Earth's atmosphere. Temperature and water vapor profiles derived from the GPS data will help meteorologists observe, research, and forecast hurricanes, typhoons, and other storm patterns over the oceans and improve many areas of weather prediction.

COSMIC relies on a technology known as radio occultation. Just as the water molecules in a glass change the path of visible light waves so that a pencil appears bent, molecules in the air bend GPS radio signals as they pass through (are occulted by) the atmosphere. By measuring the amount of this bending, scientists can determine underlying atmospheric conditions, such as air density, temperature, moisture, and electron density.

The six identical satellites host the Integrated GPS Occultation Receiver (IGOR), the Tiny Ionosphere Photometer (TIP), and the Coherent Electromagnetic Radio Tomography/Triband Beacon Transmitter (CERTO/TBB) sensors.

4.2 Status of spacecraft

FM1 – Fully Operational; IGOR operational, TIP and TBB instruments operating during low sun angle periods

FM2 – Degraded Power System (battery degradation), IGOR operating on reduced duty cycle, TIP and TBB instruments are powered off due to power situation

FM3 – Degraded Solar Array Drive and Battery degradation, remains in somewhat lower orbit IGOR operating on reduced duty cycle, TIP and TBB instruments are powered off due to power situation

FM4 – Degraded power system causes payload turn off at high battery state of charge TIP and TBB instruments operating during low sun angle periods

FM5 –Operational; IGOR operating with low Signal-to-Noise Ratio, TIP and TBB instruments operating during low sun angle periods

FM6 – Degraded power system causes payload turn off at high battery state of charge IGOR operating with low Signal-to-Noise Ratio, TIP and TBB instruments operating during low sun angle periods

4.3 Impact on spacecraft due to space weather

Space weather related spacecraft anomalies (Items in bold are required)

Source: Recommendations for Contents of Anomaly Database for Correlation with Space Weather Phenomena, P. O'Brien, J.E. Mazur, T. Guild, November 2011, AEROSPACE Report No.TOR-2011(3903)-5.

1. Date and Universal Time of the anomaly	**2. Fully specified location of the anomaly** (spacecraft location)	**3. Velocity or orbital elements at time of the anomaly**	4. Eclipse state of the vehicle (full, penumbra, partial, none)	5. Vector to Sun in spacecraft coordinates	6. Velocity vector of spacecraft in spacecraft coordinates	7. Initial guess at type of anomaly (See taxonomy below)	8. Estimated confidence of that guess	9. Anomaly category (e.g., affected system or kind of disruption)	10. Vehicle identity	11. Notes (e.g. unusual operational states or recent changes to operations (recent commands, attitude scheme, etc.)

Taxonomy of Satellite Anomalies Caused by In Situ Charged Particle Environment (to be used for column 7):

1. Electrostatic discharge (charging)
    - 1.1 Surface charging
        - 1.1.1 Plasma sheet (subauroral)
        - 1.1.2 Auroral
    - 1.2 Internal charging
        - 1.2.1 Subsurface charging (e.g., beneath blanket)
        - 1.2.2 Deep charging (e.g., inside a box)
2. Single-Event Effects
    - 2.1 Protons
        - 2.1.1 Solar proton event
        - 2.1.2 Geomagnetically trapped protons
    - 2.2 Heavy ions
        - 2.2.1 Galactic Cosmic Rays
        - 2.2.2 Solar energetic particles
        - 2.2.3 Geomagnetically trapped heavy ions
3. Total Dose
    - 3.1 Long-term dose accumulation (multiple causes combined)
    - 3.2 Short-term (days or less) dose accumulation
        - 3.2.1 Solar protons
        - 3.2.2 Geomagnetically trapped protons
        - 3.2.3 Geomagnetically trapped electrons

4.4 Ground segment matters

Ground Segment support for COSMIC is provided by the Fairbanks Command and Data Acquisition Station (FCDAS) as well as the Wallops Command and Data Acquisition Station (WCDAS), and services were contracted with Kongsberg Satellite Services (KSAT) at their Tromsø Satellite Station through NOAA agreements with the Norwegian Space Center. Since April 2008, NOAA stations have been providing both uplink and downlink services and Tromsø has been providing downlink services only. Ground station support availability for FS-3/C was required to perform at 90% or better. Over the course of FS-3/C operations, ground stations services have performed at 95% or better with only minor interruptions due to occasional equipment issues (hung servers or processors, for example). The MOC (Mission Operations Center) is located at NSPO (National Space Organization) in Taiwan. The MOC is embedded into NSPO's MMC (Multi-Mission Center). The MOC performs all S/C operations.

4.5 Data transmission

All science and some telemetry data is being sent to CDAAC (COSMIC Data Analysis and Archive Center) at the University Corporation for Atmospheric Research (UCAR) in Boulder, CO, and to TACC (Taiwan Analysis Center for COSMIC), a mirror site of CDAAC in Taiwan, located at CWB (Central Weather Bureau) in Taipei. The centers also receive data from a global network of ground GPS and TBB (Tri-Band Beacon Transmitter) receiving sites (the so-called fiducial network). The centers analyze the received data and distribute it to the principal investigators and to the science community for operational evaluation and research. COSMIC data are distributed by NOAA to be used operationally by weather forecast centers globally and also for space weather prediction services. COSMIC data have demonstrated significant positive impact on medium range forecasts.

4.6 Projects, services

The COSMIC-2/Formosat-7 follow-on project will launch six satellites into low-inclination orbits in the first quarter of 2017, and another six satellites are planned for launch into high-inclination orbits in 2020.

5 STATUS OF CURRENT OTHER SATELLITE SYSTEMS

Sector	Satellites in orbit P=pre-operational Op=operational B=back-up L=limited availability	Location	Launch date	Details on near real time access to L0/L1 data (links)	Instruments and payload status
L-1	DSCOVR (P)	L-1, Lagrangian Point	2/11/2015	http://www.ospo .noaa.gov/Orga	All instruments operational.

				nization/About/access.html	

5.1 Mission objectives, payload/instruments, products

Primary mission is to monitor the solar wind activity from L1 in order to provide early warning for Earth orbiting satellites and ground-based systems that are susceptible to disturbances in solar wind. The PlasMag instrument, which includes a Magnetometer, Faraday Cup (FC), and Electrostatic Analyzer (ESA), collects the solar wind data for downlink to Space Weather Prediction Center (SWPC). The data is downlinked 24/7 through NOAA's ground stations (WCDA, FCDA) and Real Time Solar Wind Network (RTSWNet) around the globe.

Additionally, DSCOVR collects Earth observations from a pair of Earth-pointing instruments; the Earth Polychromatic Imaging Camera (EPIC) and National Institute of Standards and Technology (NIST) Advanced Radiometer (NISTAR).

5.2 Status of spacecraft

DSCOVR spacecraft is in its final orbit and operational with all instruments operating as designed. However, SWPC is still utilizing ACE for solar wind measurements due to final Faraday Cup calibrations and algorithm formulations still in progress. Switch from ACE observatory to DSCOVR is expected in mid-CY2016.

5.3 Impact on spacecraft due to space weather

Space weather related spacecraft anomalies (Items in bold are required)

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5.4 Ground segment matters

There have been some tracking issues with the Wallops (WCDA) 18-meter antenna which has been corrected temporarily with a software fix. We expect to have a permanent repair sometime in May 2016.

5.5 Data transmission

DSCOVR Space weather data are collected through NOAA's CDAS (Command and Data Acquisition System) and RTSWNet (Real Time Solar Wind Network) and distributed to U.S. and international users by SWPC (Space Weather Prediction Center). Terrestrial data and images are distributed by NASA's DSOC (DSCOVR Science Operations Center).

5.6 Projects, services

EPIC images are provided to public through the following web link: http://epic.gsfc.nasa.gov/

6 STATUS OF FUTURE GEO SATELLITE SYSTEMS

Sector	Satellites in orbit P= pre-operational Op=operational B=back-up L=limited availability	Location	Launch date	Details on near real time access to L0/L1 data (links)	Environmental payload and status
TBD	GOES-R (P)	TBD	13 October 2016	http://www.goes-r.gov/resources/docs.html	ABI, EXIS, SUVI, SEISS, MAG, GLM
TBD	GOES-S (P)	TBD	LCD 4th Qtr FY2018	http://www.goes-r.gov/resources/docs.html	ABI, EXIS, SUVI, SEISS, MAG, GLM
TBD	GOES-T (P)	TBD	LCD 3rd Qtr FY2019	http://www.goes-r.gov/resources/docs.html	ABI, EXIS, SUVI, SEISS, MAG, GLM
TBD	GOES-U (P)	TBD	LCD 1st Qtr FY2025	http://www.goes-r.gov/resources/docs.html	ABI, EXIS, SUVI, SEISS, MAG, GLM

6.1 Mission objectives, spacecraft, payload/instruments, products

The GOES-R series is NOAA's next generation of satellites within the GOES Mission. The GOES-R series will significantly improve the detection and observation of environmental phenomena that directly affect public safety and the protection of property. The satellites will provide advanced imaging with increased spatial resolution and faster coverage for more accurate forecasts, real-time mapping of lightning activity, and improved monitoring of solar activity.

The GOES-R series is a four-satellite program (GOES-R/S/T/U) that will extend the availability of the operational GOES satellite system through 2036. When operational, the GOES-R series will consist of two satellites at 75 degrees west and 137 degrees west longitude, respectively. The on-orbit storage location for GOES-R will be at 105 degrees W.

The Space Segment consists of the spacecraft, instruments, auxiliary communications payloads, and launch vehicle. The primary instrument is the Advanced Baseline Imager (ABI) that will provide hemispheric, synoptic, and mesoscale imagery for global and CONUS forecasting and severe weather warning. Secondary instruments include the Extreme ultraviolet and X-ray Irradiance Sensor (EXIS), Solar Ultraviolet Imager (SUVI), Space Environment In-Situ Suite (SEISS), Magnetometer (MAG), and Geostationary Lightning Mapper (GLM). Additionally, GOES-R will provide a set of communications services (Unique Payload Services) in support of the Data Collection System (DCS), High-Rate Information Transmission (HRIT), Search-and-Rescue Satellite Aided Tracking (SARSAT), and Emergency Managers Weather Information Network (EMWIN).

GOES-R will make available 34 meteorological, solar and space weather products. Additional products will be made available over time. Additional information about the baseline and planned future products is available at: http://www.goes-r.gov/products/overview.html

As of May 2016, the GOES-R satellite has completed all mechanical environmental testing and is currently preparing for Electro-Magnetic Interference (EMI) testing. GOES-R will then ship to Kennedy Space Center in the summer to begin processing for a currently scheduled 13 October 2016.

Work on the GOES-S continues with all instruments integrated as of May 2016. In addition, the GOES-T satellite core structure is in development with two of the six instruments (EXIS and ABI) complete.

6.2 Ground segment matters

The GOES-R ground system will receive the raw data from GOES-R series spacecraft and generate Level 1b and Level 2+ products. The ground system will also make these products available to users in a timely manner consistent with the GOES-R latency requirements. Level 1b data from each instrument and Level 2+ data from the Geostationary Lightning Mapper (GLM) will be distributed to direct readout users with antenna receivers by means of spacecraft relay as GOES Rebroadcast (GRB). Level 1b products and Level 2+ products will be provided to the Product Distribution & Access (PDA) System for users.

The Ground Segment (GS) will operate from three sites. The NOAA Satellite Operations Facility (NSOF) in Suitland, MD will house the: primary Mission Management (MM) functions of Tracking, Telemetry and Command (TT&C), and operations the Product Generation (PG) functions of Level 2+ product generation; and the Product Distribution (PD) of Level 2+ products. The Wallops Command and Data Acquisition Station (WCDAS) in Wallops Island Virginia will provide space communications services and Level 1b product generation. The third site is a geographically isolated Consolidated Backup Facility (CBU) located at Fairmont, WV. It will function as a completely independent backup for designated MM, PG and PD functions for the production and delivery of Level 1b, Key Performance Parameters (KPPs), and GOES Rebroadcast (GRB) data and will be capable of remote operation from the NSOF and WCDAS. The RBU will have visibility to all operational and on-orbit spare satellites. The Enterprise Management (EM) function lies over all ground segment components and locations.

The PD functionality will provide for direct distribution of GOES-R product data to the National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS) and the Environmental Satellite Processing Center (ESPC). The Environmental Satellite Processing and Distribution System (ESPDS), Product Distribution and Access (PDA) will receive GOES-R data and distribute the data to users and to the Comprehensive Large Array-data Stewardship System (CLASS). ESPDS and CLASS are co-located at the Environmental Satellite Processing Center (ESPC) at NSOF. CLASS will provide long-term archive and access services to retrospective users of GOES-R data. The CLASS system is considered external to the GOES-R Ground Segment and is part of the NOAA infrastructure interface.

As of May 2016, the Ground System has finished development and is currently undergoing testing.

6.3 Data transmission

The GOES-R communication system will support the higher volume of data and services by using X-band communication links. Data handling efficiency will be improved over current missions by using Consultative Committee for Space Data Systems (CCSDS) encoding for raw instrument, telemetry, and command links. CCSDS will permit diverse data types to be routed to appropriate applications without intermediate processing and delays associated with unpacking packet contents, while taking advantage of error detection and correction properties inherent in CCSDS design. A precision pointing bus is needed to meet instrument pointing and stability requirements. The GOES-R series will further improve on the attitude control and image navigation capability of the current missions. Image Navigation and Registration (INR) on GOES–R will differ from the previous two series in a number of ways. GOES–R will have a new allocation of INR responsibility, tighter INR performance requirements, and a new approach to achieving those requirements.

To support the large increase in spatial, spectral, and temporal resolution of the ABI and other instruments, the raw data rate will increase to 75Mbps, over 30 times the current rate. GOES-R data volume drives a large increase in processing requirements for product generation and for distribution of the products to users. Product processing will account for a much greater part of the GOES-R life cycle cost than the current system.

The GOES-R system will have a much greater product distribution capability over the legacy missions. The full set of Level 1b instrument data will be provided in real time through the GRB link and the Level 2+ products will be provided via network services. The Ground Segment is being designed with open and expandable architecture so that additional instrument management and data processing requirements may be accommodated without affecting existing capabilities.

GOES-R data and products will be distributed by two primary categories, internal and external interfaces. There are two primary internal (internal to the GOES-R System) data transport mechanisms: space-based relay through the GRB rebroadcast service, and telecommunications networks. There are two types of external (external to the GOES-R System) interfaces, which are the GOES-R Access Subsystem (ESPDS PDA) and the National Weather Service interface which allow external user access to the GOES-R System data. ESPDS PDA will also distribute GOES-R data to the CLASS system for external long-term storage, archival, and access.

7 STATUS OF FUTURE LEO SATELLITE SYSTEMS

Orbit Type ECT=Equator Crossing time (for sun-synchronous orbits)	Satellites in orbit P= pre-operational Op=operational B=back-up L=limited availability	Equator Crossing Time (ECT) ascending node	Mean altitude	Launch date	Details on near real time access to L0/L1 data (links)	Instrument payload and status
1330	JPSS-1 (P)	1330	824 km	01/20/17	http://www.ospo.noaa.gov/Organization/About/access.html	ATMS, CrIS, VIIRS, OMPS, RBI
1330	JPSS-2 (P)	1330	824	2021	http://www.ospo.noaa.gov/Organization/About/access.html	ATMS, CrIS, VIIRS, OMPS, RBI
1330	JPSS-3 (P)	1330	824	2026	http://www.ospo.noaa.gov/Organization/About/access.html	ATMS, CrIS, VIIRS, OMPS, RBI
1330	JPSS-4 (P)	1330	824	2031	http://www.ospo.noaa.gov/Organization/About/access.html	ATMS, CrIS, VIIRS, OMPS, RBI

7.1 Mission objectives, spacecraft, payload/instruments, products

The Joint Polar Satellite System (JPSS) is the new generation of United States' Polar-orbiting Operational Environmental Satellites in the afternoon sun-synchronous orbit. JPSS is part of the infrastructure of the U.S. National Oceanic and Atmospheric Administration (NOAA), a bureau of the U.S. Department of Commerce, to support NOAA's missions to enable a weather ready nation; healthy oceans; climate adaptation and mitigation; and resilient coastal communities and economies. Polar orbiting environmental satellites provide timely and global space based observations of weather and environmental phenomena for forecasts, monitoring, and impact assessment.

The most important function of polar operational weather satellites is to feed Numerical Weather Prediction (NWP) models with global three dimensional structure of atmospheric temperature, moisture, and other parameters that enable forecast skill to produce three to seven day-ahead forecasts of impending severe weather, critical to the protection of life, property, and economic efficiency. Data from satellites in polar orbits constitutes approximately 85% of all the input data used in NWP global and regional models. The polar orbiters also provide visible, infrared, and microwave imagery, which is the primary situational awareness observation for Alaska and the Arctic. The polar-orbiting capabilities are also important for a wide variety of specialty forecast and monitoring functions such as ozone, aerosols, ice, volcanic ash, wildfires, floods, droughts, vegetation health, algal blooms, and sea surface temperature.

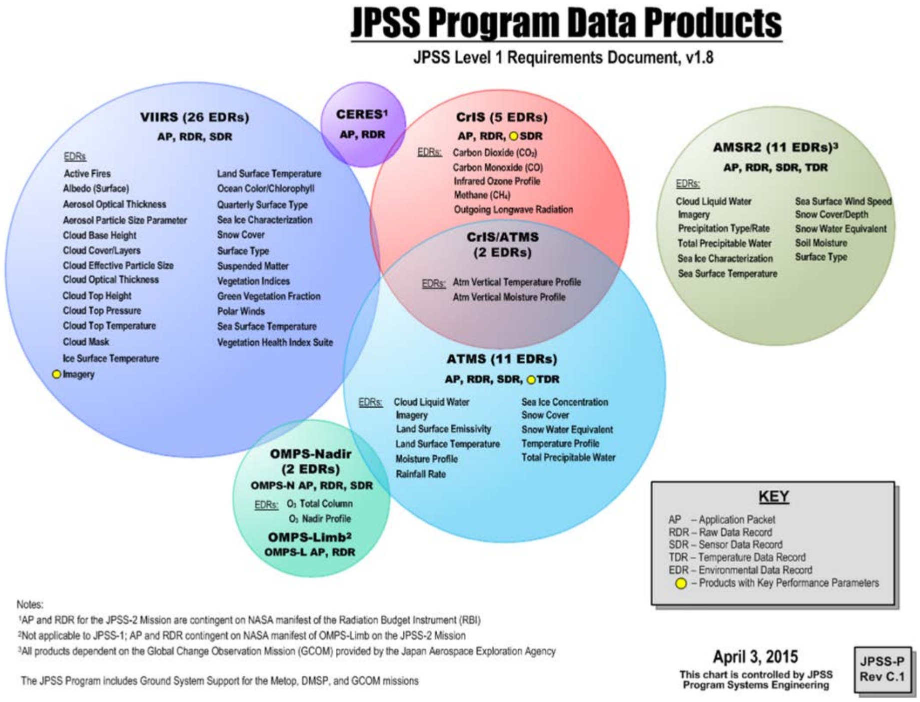
Data from instruments in polar sun-synchronous instruments have provided more than 35 years of continuous observations that have allowed scientists to monitor the climate. These data support modellers, scientists and decision makers concerned with advancing understanding of climate change, prediction, mitigation, and adaptation strategies and policies.

The primary drivers for NOAA's polar orbiting environmental satellites are conveyed in the *National Space Policy of the United States of America* as well as international treaties; protocols and agreements governed by specialized agencies of the United Nations and coordination groups.

JPSS was announced in February 2010 as part of the President's Fiscal Year 2011 President's budget request to be the civilian successor to the National Polar-orbiting Operational Environmental Satellite System (NPOESS). JPSS program completed formulation in July 2013 with a formal baseline establishing requirements, budget, and top level schedules, to include continued operations and sustainment of the Suomi-National Polar-orbiting Partnership (S-NPP); development operations and sustainment of JPSS-1 and JPSS-2 missions through September 2025, and sustainment of ground segment capabilities necessary to perform the missions. JPSS-3 and JPSS-4 missions were approved in 2016 to extend capabilities to at least 2038.

JPSS hosts five instruments, the Advanced Technology Microwave Sounder (ATMS), the Cross Track Infrared Sounder (CrIS), the Visible -Infrared Imaging Radiometer Suite (VIIRS), the Ozone Monitoring and Profiler Suite (OMPS), and an earth radiation budget instrument. The ATMS, CrIS, VIIRS, and OMPS Nadir comprise the NOAA provided weather instrument complement. NASA provides the OMPS Limb sensor and Radiation Budget Instrument (RBI) for JPSS-2. S-NPP was developed as a partnership between NASA and NOAA, with NASA providing the spacecraft, ATMS, Clouds and Earth's Radiant Energy Sensor (CERES) radiation budget instrument, and launch; while NOAA provided the CrIS, VIIRS, OMPS Nadir, and Limb, the ground and operations. JPSS-1 does not include the OMPS limb, and hosts a NOAA provided CERES radiation budget instrument.

Below figure provides a list of data products:



7.2 Ground segment matters

NOAA implements JPSS through and with several essential partnerships. The U.S. National Aeronautics and Space Administration, primarily through the Goddard Space Flight Center in Greenbelt Maryland, is responsible for the acquisition of the flight elements and the ground segment development for processing the sensor data records (SDRs). NOAA is responsible for the development of the processing systems needed to derive Environmental Data Records (EDRs) from the SDRs. NOAA is responsible for the top-level requirements, the data product algorithm science, operations, the partnerships, and ground sustainment after transition to NOAA. NASA also provides services to the program through its Space Communications and Networking Program. EUMETSAT and NOAA cooperate through close partnership to provide two-orbit polar coverage with EUMETSAT covering the mid-morning orbit, and NOAA covering the afternoon orbit. The U.S. National Science Foundation provides access to McMurdo station for data down link and communications services. The Norwegian Space Center provides access to Svalbard and the commercial provider KSAT for data downlink and communications services. The Japanese Aerospace Exploration Agency provides data from the Global Climate Observing Mission-Water (GCOM-W) in exchange for JPSS data services. JPSS also cooperates with the U.S. Air Force, which provides coverage in the early morning orbit with Defence Meteorological Satellites Program (DMSP), and the U.S. Navy, which shares data and modelling.

7.3 Data transmission

The ground segment architecture consists of the NOAA Satellite Operations Facility (NSOF) in Suitland, Maryland as the primary center for JPSS control, telemetry, and data processing. JPSS will establish a remote backup center in Fairmont, West Virginia; and has interim capability at the ground system prime contractor site in Aurora, Colorado. JPSS also supports data processing at the United States Air Force (USAF) 557th Weather Wind headquartered at Offutt Air Force Base in Omaha, Nebraska; and the 557th Weather Wing provides JPSS data to two primary sites for the U.S. Navy. Primary data reception resides at the KSAT site in Svalbard, Norway and McMurdo Station, Antarctica. JPSS also has backup reception at Fairbanks, Alaska. The JPSS ground system provides data reception and routing services for the European Organization for the Exploitation of Metrological Satellites (EUMETSAT) Metop series; the USAF Defense Meteorological Satellite Program (DMSP) Series from McMurdo Station; and provides data routing services for the Japanese Aerospace Exploration Agency (JAXA) Global Climate Monitoring Mission Water-1 (GCOM W-1) and the U.S. Navy WindSat/Coriolis mission from Svalbard. The JPSS ground system provides data processing for all the JPSS series spacecraft, and for NOAA GCOM W-1 data products. The SNPP spacecraft transmits stored mission data once per orbit using X band to Svalbard. JPSS-1 and JPSS-2 are planned to transmit stored mission data using Ka band twice per orbit to both Svalbard and McMurdo. JPSS-1 and JPSS-2 will also have a secondary capability to transmit stored mission data through NASA's Tracking and Data Relay Satellite System (TDRSS) and Space Network. Data are routed through commercial network services back to Suitland and Fairmont. JPSS data can also be accessed through direct readout antennas.

8 STATUS OF ADDITIONAL FUTURE LEO SATELLITE SYSTEMS

Orbit Type	Satellites in orbit P= pre-operational Op=operational B=back-up L=limited availability	Right Ascension of Ascending Node (RAAN)	Mean altitude	Launch date	Details on near real time access to L0/L1 data (links)	Instrument payload and status
Equatorial, 24º Inclination	COSMIC-2A; 6 satellites (P)	0º, 60º, 120º, 180º, 240º. 300º	520 km	1Q CY 2017	http://www.ospo.noaa.gov/Organization/About/access.html	TGRS* IVM** RFB***
Polar, 72º Inclination	COSMIC-2B; 6 satellites (P)	0º, 30º, 60º, 90º, 120º, 150º	750 km	Estimated FY 2020	http://www.ospo.noaa.gov/Organization/About/access.html	TGRS* NSPO-provided secondary payloads

8.1 Mission objectives, spacecraft, payload/instruments, products

FORMOSAT-7/COSMIC-2 is a joint U.S.-Taiwan satellite mission being conducted under an agreement between the American Institute in Taiwan (AIT) and the Taipei Economic and Cultural Representative Office in the United States (TECRO). NOAA is AIT's designated representative, and the National Space Organization (NSPO) is TECRO's designated representative. The objective is to continue collecting data similar to the current FORMOSAT-3/COSMIC mission with important technology advances. The objective of the FORMOSAT-7/COSMIC-2 mission is to demonstrate an operational constellation for the continuous and uniform collection of atmospheric and ionospheric data as inputs to daily near-real-time weather forecasts, space weather research, and climate change studies. For operational numerical weather prediction and space weather monitoring, the Radio Occultation (RO) data profiles from the reliable global constellation system will number approximately 8,000 profiles on average per day.

The 12 FORMOSAT-7/COSMIC-2 satellites will be launched and transferred into two sets of low earth mission orbits with altitude of 520 km and 750 km and inclination of 24º and 72º, respectively. Each FORMOSAT-7/COSMIC-2 will carry one primary mission payload, called the TriG Global Navigation Satellite System (GNSS) Radio Occultation (RO) Receiver System (TGRS) which tracks GNSS signals and infers the deviations in each signal's straight-line path caused by temperature, pressure, moisture and electron density gradients.

The six equatorial satellites will also each carry two U.S. secondary science payloads. The Ion Velocity Meter (IVM) measures in-situ plasma properties using a series of apertures mounted on the ram-facing side of the low-inclination satellites. The IVM also measures the background ionospheric density, ion composition, and ion temperature for ionospheric modelling research. The Radio Frequency Beacon (RFB) measures the ionospheric scintillation by transmitting phase coherent signals in UHF, L-Band and S-Band RF which are received by ground-based receivers. The ground receivers will also measure the ionospheric total electron content (TEC) along the ground receiver-satellite line of sight during satellite contacts. The RFB ground receivers will be established by the USAF and may be established by NSPO at ancillary sites. Secondary payloads on the polar satellites will be provided by NSPO and are not yet defined.

The six equatorial satellites are fully integrated with instruments and are planned for launch in the first quarter of CY 2017. The polar satellites are planned for launch in 2020.

8.2 Ground segment matters

For satellites in the low-inclination orbit, 8-9 receiving stations are planned to be strategically placed around the equator. Current locations are Taiwan, Honduras, Hawaii, Guam, Kuwait, Australia, and Brazil, with one to two additional locations to be determined. For satellites at high-inclination orbit, additional receiving stations located in the northern hemisphere and southern hemisphere will be utilized. The NSPO Satellite Operations Control Center (SOCC) will provide command and control of the COSMIC-2 constellation.

Mark IV-B antennas in Hawaii, Honduras, Guam, and Kuwait are being provided by the Air Force with signed letters of commitment in place. Testing is being carried out with the Honduras antenna in April 2016. The Australian Bureau of Meteorology (BoM) is providing an antenna in Darwin for which the Implementing Agreement (IA) was finalized March 29, 2016. The Brazil National Institute of Space Research (INPE) and NOAA concluded an arrangement on June 30, 2015 for the installation of an antenna at INPE’s expense at their facility in Cuiaba. NSPO provides antennas in Taiwan as part of the FORMOSAT-7/COSMIC-2 mission.

8.3 Data transmission

The data collected by FORMOSAT-7/COSMIC-2 will be downlinked to the tracking stations, then transferred to the U.S. Data Processing Center (USDPC) at UCAR as well as to the Taiwan Data Processing Center (TDPC). The TDPC is the mirror site of the USDPC to serve the users in Taiwan. USDPC Readiness Review (RR) #1 was carried out in December 2015, with RR#2 to be held in May 2016.

The main objective of the USDPC is to process all raw mission science data into Environmental Data Record (EDR) products and disseminate the data for operational use by weather and space weather forecast centers, and for research by the broad atmospheric science community. The USDPC processes the mission science data in a near real-time mode for operational applications, within 8 weeks of observation in a post-processing mode, and in a re-processing (re-analysis) mode every 2-3 years with consistent software algorithms. The USDPC serves as a complete mission data analysis center for the FORMOSAT-7/COSMIC-2 mission.

9 STATUS OF ADDITIONAL FUTURE LEO SATELLITE SYSTEMS

Orbit Type	Satellites in orbit P= pre-operational Op=operational B=back-up L=limited availability	Equator Crossing Time (ECT) ascending node	Mean altitude	Launch date	Details on near real time access to L0/L1 data (links)	Instrument payload and status
Polar, non-SSO	Jason-CS (P)	N/A		CY 2020	http://www.ospo.noaa.gov/Organization/About/access.html	

9.1 Mission objectives, spacecraft, payload/instruments, products

The Sentinel-6/Jason-CS primary mission objective is to provide continuity of ocean topography measurements beyond the TOPEX/Poseidon, Jason, OSTM/Jason-2, and

Jason-3 cooperative missions, for determining sea surface height, ocean circulation, and sea level. Accordingly, the Sentinel-6/Jason-CS Mission will utilize the legacy TOPEX/Poseidon precision altimetry orbit.

As a secondary mission objective, it will collect high-resolution vertical profiles of atmospheric temperature, using the GNSS-RO sounding technique, to assess temperature changes in the troposphere and the stratosphere and to support numerical weather prediction. The secondary mission objective will not become a driver of or in any way impede the development and implementation of the Sentinel-6/Jason-CS Mission, or delay the launches.

The Sentinel-6/Jason-CS cooperative mission will be implemented by two identical Sentinel-6/Jason-CS Satellites launched in sequence, each with a nominal 5.5 year lifetime. In order to provide continuity, the launch of the Sentinel-6/Jason-CS A satellite is planned for 2020 and the launch of the Sentinel-6/Jason-CS B satellite is planned for 2025.

10 ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY CGMS PLENARY SESSION

11 CONCLUSIONS

This document summarises the status of NOAA current and future satellite systems.

CGMS is invited to take note.