Prepared by NOAA
Agenda Item: D.5
For information to Plenary

STATUS OF NOAA CURRENT AND FUTURE SATELLITE PROGRAMS – REPORT TO CGMS-46

This document summarizes the status of NOAA current and future LEO and GEO satellite systems. The reporting period for the current satellite operations is 30 April 2017 to 30 April 2018. 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.

1 INTRODUCTION

This paper reports on the status of NOAA current and future satellite systems. The reporting period for current satellite operation is 30 April 2016 to 30 April 2017. 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
Spare	GOES-13 (B)	60ºW	05/24/2006		Backup for GOES-East and West
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
GOES East	GOES-16 (Op)	75.2ºW	11/19/2016	http://www.ospo.noaa.gov/Organization/About/access.html	All payloads are operational
Pre-operational Checkout	GOES-17 (P)	89.5ºW	03/01/2018		Currently undergoing pre-operational checkout.

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, and 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, and rainfall estimates
- **Environmental data collection** – platforms including buoys, rain gauges, river levels, and ecosystem monitoring
- **Space weather monitoring and forecasting**
- **Search and Rescue**

2.2 Status of spacecraft

GOES-13

GOES-13, launched on May 24, 2006 and was stationed at 75ºW as GOES-East from April 14, 2010 until December 18, 2017. It was moved to its current station at 60ºW in January 2018. 9 rows out of 512 Solar X-ray Imager (SXI) detectors were damaged due to a 2006 flare. 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. Star tracker 3 failed in 2015. GOES-13 was commanded to storage mode configuration in February 2018.

GOES-14

GOES-14, launched on June 27, 2009, is located at 105ºW 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. All of the GOES-14 payload instruments are nominal. GOES-14 SXI and XRS are primary instruments for SWPC.

GOES-15

GOES-15, launched on March 4, 2010, has been on station at 135ºW as GOES-West since December 14, 2011. Yaw-flip manoeuvre 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 backup instruments for SWPC.

GOES-16

GOES-16 was launched on November 19, 2016. It has been located at 75.2ºW as GOES-East since December 18, 2017. All of the GOES-16 payload instruments are nominal.

GOES-17

GOES-17, launched on March 1, 2018, is located at 89.5^{o}W. GOES-17 will be relocated to 137^{o}W to replace GOES-15 as GOES West after 6 months of Post Launch Testing and drift.

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)

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 partic
        - 2.2.3 Geomagnetically trap
3. Total Dose
    - 3.1 Long-term dose accumulation (
    - 3.2 Short-term (days or less) dose a
        - 3.2.1 Solar protons
        - 3.2.2 Geomagnetically trap
        - 3.2.3 Geomagnetically trap

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 NOP is handled through the Processed Data Relay (PDR) direct broadcast service in the GOES Variable (GVAR) transmission format. The GOES-R series GOES Rebroadcast is primary relay of full resolution, calibrated, near-real-time direct broadcast space relay of Level 1b data from each instrument and Level 2 data from the Geostationary Lightning Mapper (GLM). 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 Mean Local TimeFirst 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-2 (B)	N/A	1309.5 km	Jun 20, 2008	http://www.ospo.noaa.gov/Organization/About/access.html	CARMEN-2 off, all others Green: Altimeter, DORIS, AMR, GPSP, LRA, , Poseidon-3, T2L2, LPT
Polar, non-SSO	JASON-3 (OP)	N/A	1336 km	Jan 17, 2016	http://www.ospo.noaa.gov/Organization/About/access.html	All Green: Poseidon-3B Altimeter, DORIS, AMR-2, GPSP, LRA, CARMEN-3, LPT
Polar, SSO	NOAA-15 (Op)	18:33 as of 4/10/2018	813 km	May 13, 1998	http://www.ospo.noaa.gov/Organization/About/access.html	HIRS and AMSU-B are red, AVHRR, AMSU-A1, SARR, SEM are Yellow, and AMSU-B, and DCS, and APT are Green.
Polar, SSO	NOAA-18 (Op)	19:44 as of 4/10/2018	854 km	May 20, 2005	http://www.ospo.noaa.gov/Organization/About/access.html	HIRS, and SBUV are Red, SEM is yellow, and AVHRR, AMSU-A1/2, MHS, APT, DCS are Green

Polar, SSO	NOAA-19 (Op)	15:55 as of 4/10/2018	870 km	February 6, 2009	http://www.ospo.noaa.gov/Organization/About/access.html	MHS, ADCS, SEM and HIRS are Yellow, AVHRR, AMSU-A1/2, , SBUV, APT are Green
Polar, SSO	DMSP-17 (Op)	18:20	848 km	Nov 4, 2006	http://www.ospo.noaa.gov/Organization/About/access.html	OLS, SSMIS, SSIES, SSUSI, SSM, SSJ
Polar, SSO	DMSP-18 (Op)	19:08	850 km	Oct 18, 2009	http://www.ospo.noaa.gov/Organization/About/access.html	OLS, SSMIS, SSIES, SSULI, SSUSI, SSM, SSJ
Polar, SSO, Afternoon	Suomi-NPP (Op)	13:25 as of 4/10/2018	833 km	Oct 28, 2011	http://www.ospo.noaa.gov/Organization/About/access.html	VIIRS, ATMS, CrIS, CERES, OMPS
Polar, SSO, Afternoon	NOAA-20	13:24 as of 4/10/2018	834 km	Nov 18, 2017	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 spacecraft 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. In April 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, declared operational in December of 2008, and became the backup spacecraft when Jason-3 was declared operational in July of 2016. In July 2017 Jason-2 was maneuvered to a new orbit, 27km below the reference orbit (i.e. at 1309.5km altitude), with the same inclination. This orbit is known as the LRO (Long Repeat Orbit), and is also the graveyard orbit for Jason-2. On this orbit, the cycle is no longer 9.9 days, but approximately 368 days (4736 revs). In order to simplify the continuation of data production, the numbering of cycles and passes stays artificially the same at processing level (254 passes – 9.9 days cycle). Cycles are restarted from cycle 500 on July 10, 2017 at 04:43:08 UTC.

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 Transfer by Laser Link (T2L2), and Light Particle Telescope (LPT). All instruments are operational with the exception of Carman which is off.

Jason-3

Jason-3 was launched in January of 2016, declared operational in July of 2016 and became the primary Jason mission spacecraft in July of 2016. 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). The LPT status is degraded and under investigation.

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/B. Along with the 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 19 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 SBUV/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 F17

DMSP F17 was launched from Vandenberg AFB on Nov 4, 2006. All primary instruments are fully functional, with some degradation of secondary SSMIS, SSI-ES2/3, and SSUSI instruments. The SSULI instrument is non-operational. It provides meteorological data to the US Military.

DMSP F18

DMSP F18 was launched from Vandenberg AFB on Oct 18, 2009. All primary instruments are fully functional, with some degradation of secondary SSMIS, SSI-ES2/3, and SSULI instruments. It provides meteorological data to the US Military.

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.

NOAA-20

The Joint Polar Satellite System-1 (JPSS-1) was successfully launched and reached polar orbit on November 18, 2017, resulting in its re-designation as NOAA-20. A successful Post-Launch Acceptance Review and Handover Readiness Review were conducted by NASA and NOAA on Mar 6 and 7, so the spacecraft and its operations were transferred to NOAA's Office of Satellite and Product Operations. Provisional critical data products are being produced and this set of products is expected to be declared operational in the May/June timeframe, which will result in NOAA-20 replacing S-NPP as the Primary PM Weather satellite.

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)

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 partic
        - 2.2.3 Geomagnetically trap
3. Total Dose
    - 3.1 Long-term dose accumulation (r
    - 3.2 Short-term (days or less) dose a
        - 3.2.1 Solar protons
        - 3.2.2 Geomagnetically trap
        - 3.2.3 Geomagnetically trap

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 JPSS Common Ground System completed its Block 2.0 upgrade and transitioned to operations in August 2017, to support the November 2017 JPSS-1 launch.

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 and NOAA-20 utilize 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 – Degraded Power System (battery degradation), IGOR is powered off, TIP and TBB instruments are powered off due to power situation, currently not providing any downlink data. The spacecraft may provide data in the future in more favourable sun conditions.

FM2 – Degraded Power System (battery degradation), IGOR is powered off, TIP and TBB instruments are powered off due to power situation, currently not providing any downlink data. The spacecraft is not expected to provide any data in the future.

FM3 – Degraded Power System (battery degradation), IGOR is powered off, TIP and TBB instruments are powered off due to power situation, currently not providing any downlink data. The spacecraft is not expected to provide any data in the future.

FM4 – Degraded Power System (battery degradation), IGOR is powered off, TIP and TBB instruments are powered off due to power situation, currently not providing any downlink data. The spacecraft is not expected to provide any data in the future.

FM5 – Degraded Power System (battery degradation), IGOR is powered off, TIP and TBB instruments are powered off due to power situation, currently providing some state of health downlink data only. The spacecraft may provide IGOR data in the future in more favourable sun conditions.

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)

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 partic
        - 2.2.3 Geomagnetically trap
3. Total Dose
    - 3.1 Long-term dose accumulation (r
    - 3.2 Short-term (days or less) dose a
        - 3.2.1 Solar protons
        - 3.2.2 Geomagnetically trap
        - 3.2.3 Geomagnetically trap

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 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 science and research. COSMIC data are also distributed by NOAA for operational use by weather forecast centers globally, and also for space weather prediction services. COSMIC data have demonstrated significant positive impact on medium range weather forecasts.

4.6 Projects, services

The COSMIC-2/Formosat-7 follow-on project will launch six satellites into low-inclination orbits later in 2018.

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/Org	All instruments operational.

				anization/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. SWPC switched operations from ACE to DSCOVR on July 27, 2016. ACE is still being utilized as back-up.

5.3 Impact on spacecraft due to space weather

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

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    - 3.2 Short-term (days or less) dose a
        - 3.2.1 Solar protons
        - 3.2.2 Geomagnetically trap
        - 3.2.3 Geomagnetically trap

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-T (P)	TBD	LCD 4th Qtr FY2020	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 significantly improves the detection and observation of environmental phenomena that directly affect public safety and the protection of property. The satellites 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 fully operational, the GOES-R series will consist of two satellites at 75 degrees west and 137 degrees west longitude and a spare satellites.

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

The first GOES-R series satellite (GOES-16) has been operational at the 75.2 degrees west longitude location since December 2017 and is now designated GOES-East. The second GOES-R series satellite (GOES-17), which was launched on March 1, 2018, is currently undergoing post-launch testing (PLT) and will be relocated to the GOES-West location of 137 degrees west longitude in late 2018 after successful completion of PLT and drift.

Work on GOES-T continues. The mate of the core and system modules has been completed and the satellite is currently undergoing post-mate integration testing. Environmental testing is scheduled to begin in the summer of 2018. GOES-U mechanical subassemblies and other components remain on schedule. The Manufacturing Readiness Review was completed for the System Module, and integration of this module has begun. In addition, acceptance testing was completed on the GOES-U Liquid Apogee Engine at IHI in Japan.

6.2 Ground segment

The GOES-R ground system receives the raw data from GOES-R series spacecraft and generates Level 1b and Level 2+ products. The ground system also makes 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) is distributed to direct readout users with antenna receivers by means of spacecraft relay as GOES Rebroadcast (GRB). Level 1b products and Level 2+ products are provided to the Product Distribution & Access (PDA) System for users.

The Ground Segment (GS) operates from three sites. The first is the NOAA Satellite Operations Facility (NSOF). NSOF is responsible for the primary Mission Management (MM) functions which include: Tracking, Telemetry, and Command (TT&C), Product Generation (PG), and Product Distribution (PD) functions of Level 2+ products. The Wallops Command and Data Acquisition Station (WCDAS) in Wallops Island Virginia provides space communications services and Level 1b product generation. The third site is a geographically isolated Consolidated Backup Facility (CBU) located at Fairmont, WV. It functions 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 is capable of remote operation from 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 provides 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) receives GOES-R data and distributes 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.

The Ground System supported the GOES-16 post launch testing and has been supporting GOES-East (GOES-16) day-to-day operations since December 2017. In addition, the Ground System is simultaneously supporting GOES-17 post launch testing. The responsibility for operation of GOES-16 was handed over from the GOES-R Series Program to the Office of Satellite and Product Operations in June of 2017.

6.3 Data Transmission

The GOES-R communication system supports the higher volume of data and services by using X-band communication links. Data handling efficiency is improved over current missions by using Consultative Committee for Space Data Systems (CCSDS) encoding for raw instrument, telemetry, and command links. CCSDS permits 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 used to meet instrument pointing and stability requirements. The GOES-R series further improves on the altitude control and image navigation capability of the current missions. Image Navigation and Registration (INR) on GOES–R differs from the previous 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 has been increased to 75Mbps, over 30 times the legacy 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 has a much greater product distribution capability over the legacy missions. The full set of Level 1b instrument data is provided in real time through the GRB link and the Level 2+ products are 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 are distributed by two primary categories, internal and external interfaces. There are two primary internal data transport mechanisms: space-based relay through the GRB rebroadcast service, and telecommunications networks. There are two types of external 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 also distributes GOES-R data to the CLASS system for external long-term storage, archival, and access.

7 The Joint 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-2 (P)	1330	824	2022	http://www.ospo.noaa.gov/Organization/About/access.html	ATMS, CrIS, VIIRS, OMPS-N, RBI
1330	JPSS-3 (P)	1330	824	2026	http://www.ospo.noaa.gov/Organization/About/access.html	ATMS, CrIS, VIIRS, OMPS-N, RBI
1330	JPSS-4 (P)	1330	824	2031	http://www.ospo.noaa.gov/Organization/About/access.html	ATMS, CrIS, VIIRS, OMPS-N, 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 (POES) in the early afternoon sun-synchronous orbit of 13:30. JPSS contributes to NOAA's missions to enable a weather ready nation; healthy oceans; climate adaptation and mitigation; and resilient coastal communities and economies by providing timely and global space based weather and environmental phenomena observations for forecasts, monitoring, and impact assessment. The Joint NOAA/National Aeronautics and Space Administration (NASA) Suomi-National Polar Partnership (S-NPP) mission is the first of the JPSS missions and was launched on October 28, 2011 with an inclination angle of 98.79 degrees and an altitude of about 833 km.

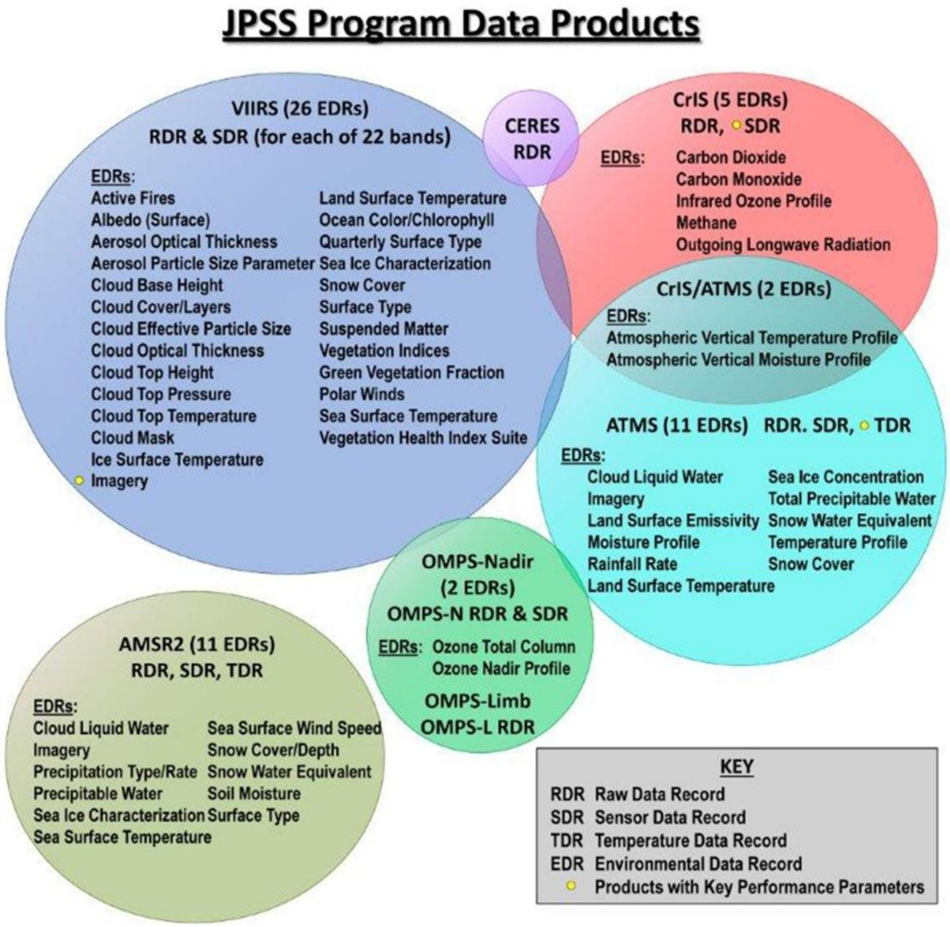
The most important function of polar orbiting operational weather satellites is to feed Numerical Weather Prediction (NWP) models with global three dimensional structures of atmospheric temperature and moisture and other parameters that enable increased forecast skill to produce three to seven day-ahead forecasts of impending severe weather, critical to the protection of life, property and economic efficiency. Approximately 85% of all the input data used in NWP global and regional models comes from polar orbiting satellites. Polar orbiters also provide visible, infrared, and microwave imagery, which are the primary observations for situational awareness for Alaska and other regions in proximity to the Arctic and Antarctic. 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 the understanding of global weather dynamics, prediction, mitigation and adaptation strategies, and policies.

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). The 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 S-NPP development operations and sustainment of JPSS-1 and JPSS-2 missions through September 2028, and sustainment of ground segment capabilities necessary to perform these missions. Polar Follow-On Missions, JPSS-3 and JPSS-4, were approved in 2016 to extend JPSS' capabilities to at least 2038. Each satellite is launched approximately every 5 years with a design life of 7 years. JPSS-1, now designated NOAA-20, was successfully launched November 17, 2017, into the 1330 orbit, separated from S/NPP by one-half orbit (i.e. 50 minutes separation) to maximize the impact on applications.

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 starting with 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

The JPSS Common Ground System is a global, multi-mission enterprise network of receiving stations that acquires and routes satellite data to NOAA and its partners. This versatile enterprise controls multiple spacecraft, ingests and processes data from a variety of sources and distributes data products to end-users, like NOAA's National Weather Service. The JPSS ground system delivers timely satellite data and is capable of reducing data latency by acquiring and routing satellite data at both north and south latitudes. The JPSS ground system provides data acquisition and routing services for the European Organisation for the Exploitation of Metrological Satellites (EUMETSAT) Metop series; the USAF Defense Meteorological Satellite Program (DMSP) Series the U.S. Navy WindSat/Coriolis mission; and provides data routing services for the Japanese Aerospace Exploration Agency (JAXA) Global Climate Monitoring Mission Water-1 (GCOM W-1)

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	4Q CY 2017	http://www.ospo.noaa.gov/Organization/About/access.html	TGRS* IVM** RFB***

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 4,000 profiles on average per day.

The 6 FORMOSAT-7/COSMIC-2A satellites will be launched into low earth mission orbits with altitude of 520 km and inclination of 24º. Each FORMOSAT-7/COSMIC-2 satellite 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.

The six equatorial satellites are fully integrated with instruments and are planned for launch later in 2018.

8.2 Ground segment matters

For satellites in the low-inclination orbit, 9 receiving stations are planned to be strategically placed around the equator. The 9 receiving station are located in Taiwan, Hawaii, Honduras, Guam, Kuwait, Australia, Brazil, Ghana, and Mauritius Island. The NSPO Satellite Operations Control Center (SOCC) will provide command and control of the COSMIC-2 constellation as well.

The Mark IV-B antennas in Hawaii, Honduras, Guam, and Kuwait are being provided by the Air Force with signed letters of commitment in place. 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. NOAA concluded a Program Implementation Plan with the Norwegian Space Centre for antenna services from a site on Mauritius Island and awarded a contract to Atlas Space Operations, Inc. for antenna services from a site in Ghana. The Ghana and Mauritius Island ground sites now provide backup commanding capability.

8.3 Data transmission

The data collected by FORMOSAT-7/COSMIC-2 will be downlinked to the tracking stations and 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. Several "Day In The Life" (DITL) tests have been completed to demonstrate readiness of the various components of the ground system. These DITL tests have successfully verified the data transmission from the ground antenna sites through the USDPC to the end users at NOAA/NWS.

The main objective of the USDPC is to process all raw mission science data into Environmental Data Record (EDR) products, 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	Equator Crossing Time (ECT)	Mean altitude	Launch date	Details on near real time access to L0/L1 data (links)	Instrument payload and status

	Op=operational B=back-up L=limited availability	ascending node				
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 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.

The Sentinel-6/Jason-CS Project is currently in the development and continues with the Systems Engineering Working Group (SEWG), Radio Occultation Working Group (ROWG) and Mission Performance Working Group (MPWG) meetings and reviews.

Current status of Sentinel-6/Jason-CS Satellite Project is as follows: System Preliminary Design Review (PDR) completed April 2017, Satellite Critical Design Review (CDR) completed May 2017, Jason-CS Overall Ground System Preliminary Design Review (PDR) completed December 2017, with two System Check Point meetings at the mid-point between System PDR and System CDR with one scheduled in the spring of 2018 and the other in the fall of 2018..

Moreover the Mission Advisory Group (MAG) has begun meetings following these Reviews. Whereas it is the MAG's goal to deliver competent, independent, and unprejudiced advice to the Partners by addressing questions raised during implementations relating to any aspect of the Sentinel-6/Jason-CS Mission Performance.

The next step in the development work of this project is the System Check Point #1 meetings which is currently scheduled for May 2018 keeping the mission on track for its scheduled launch in 2020.

10 CONCLUSIONS

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

CGMS is invited to take note.