



## GOES-R Satellite Program Set to Meet the Needs of Future Users

**T**he Geostationary Operational Environmental Satellite (GOES) program has provided operational environmental observations of the earth's surface and atmosphere for more than 30 years. From the vantage point of geostationary orbits, two GOES satellites provide continuous monitoring of the western hemisphere on a 24-hour per day basis. This unique observing perspective allows the GOES satellites to identify, locate and monitor severe weather events such as thunderstorms, tropical disturbances and hurricanes in near real time.

▶ *System improvements include enhanced weather forecasting and ecosystems management.*

The first generation of GOES operational satellites (GOES 1-7) was first launched in 1974. These were spin-stabilized spacecraft, utilizing the spacecraft's spinning motion for

scanning across the Earth while generating images of the Earth's full disk. Later in the first generation series, a 12-channel filter wheel spectrometer was added to provide additional details of the atmospheric vertical structure as a separate sounding mode of the instrument.

The second GOES generation satellites (GOES 8-12 series) transitioned to a three-axis stabilized spacecraft with separate Imager and Sounder instruments to allow for simultaneous imaging and atmospheric sounding observations of the same or different regional areas. The first of the GOES-I series (GOES 8) was launched in 1994. The GOES-N series maintains the same instruments on a new spacecraft bus for improved operations during eclipse and image navigation/registration capabilities. The first satellite of the GOES-N series (GOES 13) was launched in 2006 and is currently an on-orbit spare. There are two additional N-series satellites awaiting launch.

### GOES-R Program

Although the current GOES system provides critical weather information, improvements over the current capabilities are required to meet future users' needs for enhanced observations, improved weather forecasting, ecosystems management, and monitoring changing climatic conditions. The user community is not only looking for improvements in instrument capabilities, but also seeks new products and applications, along with faster data



The GOES-R Satellite



GOES 12 1KM visible imagery of Hurricane Katrina. (Photo: NOAA.)

dissemination techniques and reduced product latencies.

GOES-R is the next satellite series in the GOES program and represents a generational improvement in environmental observations to meet these needs. The GOES-R system is a joint development between NOAA and NASA that includes the development of new instruments, spacecraft, ground system, and the product generation/distribution infrastructure necessary to

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## MPAR in BAMS

The November 2007 issue of the *Bulletin of the American Meteorological Society* (Volume 88, Issue 11) features two articles on the technology of the Multifunction Phased Array Radar (MPAR) program of which Lockheed Martin is a key contributor.

The articles, "The Next-Generation Multimission U.S. Surveillance Radar Network" (Weber, et al) and "Agile-Beam Phased Array Radar for Weather Observations" (Zrnich et al), can be viewed at <http://ams.allenpress.com/perlserv/?request=get-toc&issn=1520-0477&volume=88&issue=11>.



## GOES-R (continued from page 1)

meet the emerging needs of a diverse user community.

### Instrument Suite

The instrument suite defined for the GOES-R mission provides the following:

*Improved Imaging Instrument Capabilities:* The GOES-R multi-spectral Advanced Baseline Imager (ABI) provides greater spectral coverage (16 bands), a 4X improvement in spatial resolution (2Km IR, several at 1Km and 0.5Km at 0.64 microns) and 6X faster image scanning (5 minute Full Disk, 30-second Mesoscale) over the current GOES Imager.

*Continued Legacy Sounding Products from ABI:* The increased spectral coverage provided by ABI, especially with the additional water vapor channels, will provide many of the legacy Sounder products alone or in combination with other remote sensing or model-derived information. These products will have increased spatial coverage (full disk) and faster refresh rates (5 minutes) over the current Sounder capability (CONUS area in one hour). Improvements in vertical resolution of sounder products await the development of an operational hyperspectral sounder for the GOES program.

► *All GOES-R instruments will be integrated in a cost-effective and timely manner.*

*Improved Space Weather Observations:* The GOES-R sensors for monitoring space weather include the Space Environment In-Situ Suite (SEISS), and a new solar imaging instrument suite: Solar Ultraviolet Imager (SUVI) and Extreme Ultraviolet and X-ray Irradiance Suite (EXIS). SEISS will provide insight into the effects of space weather on earth's environment and help track natural radiation in and around the earth. SUVI, another GOES-R instrument to be built by Lockheed Martin, will image the solar disk in multiple UV spectral bands with increased resolution, sensitivity and dynamic range over the SXI instrument currently on GOES-N. EXIS will provide significant improvement to specification and forecast models of the thermosphere and ionosphere.

*New Observation Capabilities:* The

## GLM Contract Awarded to Lockheed Martin

The Lockheed Martin Space Systems Company was awarded a \$96.7 million contract by NASA Goddard Space Flight Center to provide the Geostationary Lightning Mapper (GLM) instrument that will fly on the National Oceanic and Atmospheric Administration (NOAA) GOES-R Series environmental satellites.

GLM's ability to monitor lightning on a global scale will provide new insight into the formation, distribution, morphology and evolution of storms. Data from GLM will help protect communities by increasing severe storm and tornado warning times. GLM also enables investigations into the mechanisms at the core of the global water and energy cycle.

### Partnership Program

"Along with our teammates from the University of Alabama-Huntsville, we are enormously gratified to be selected to design and build the Geostationary Lightning Mapper," said Joe Mobilia, Lockheed Martin GLM program manager at the Space Systems Advanced Technology Center (ATC) in Palo Alto.

"Our team has worked together since 1992 on successful lightning imaging missions, and this extensive spaceflight heritage is directly applicable to GLM," added Earl Aamodt, Lockheed Martin GLM deputy program manager. "The combination of this team's experience and knowledge of GLM requirements, and our proven systems engineering approach will move this instrument successfully from drawing board to orbit."

### Storm Solution

GLM's lightning observations will penetrate cloud tops and detect

GOES-R instrument suite includes a new instrument, the Geostationary Lightning Mapper (GLM). (See sidebar this page.)

### Benefits of GOES-R

The development of the GOES-R system is being driven by the mission needs "pull" to improve the overall system's capabilities to not only accurately observe the earth/atmosphere/ ecosystems



*Since intense and increasing in-cloud flashes are known to precede severe weather by tens of minutes, the real-time transmission of GLM data will improve warning times for severe storms.*

convective activity continuously over whole continents and adjacent oceans. This lightning characteristic of clouds is inadequately measured, both temporally and spatially, by current observing systems.

With improved insight into the dynamics and life cycles of storms and weather systems, GLM will greatly improve understanding of the fast time scale elements of atmospheric convection. This will lead to a better understanding of the Earth's climate system, which, combined with long-term GLM observations, will lead to significant improvements in monitoring changes in storm climatology. In addition, since intense and increasing in-cloud flashes are known to precede severe weather by tens of minutes, the real-time transmission and distribution of GLM data will improve warning times for severe storms, particularly tornadoes.

environment but also process and deliver the information content to users and decision makers in a timely manner.

GOES-R will provide improved capabilities that benefit society in several areas, including severe weather monitoring and forecasting, disaster observations, overall climate monitoring, and enhanced severe weather warnings for air and ground transportation systems. ↻

# GOES-R: A Winning Approach to Capturing Key Weather Data

## GOES-R Ground Segment

Early in 2008, the NOAA is expected to release a draft request for proposal (DRFP) for the next GOES ground segment. Industry will be given time to comment, and the final RFP is expected soon thereafter. Contract award is targeted for late 2008 for the next generation ground segment that will fly the GOES-R series of spacecraft starting in 2014.

Lockheed Martin IS&GS and Raytheon IIS have partnered and are leveraging both companies extensive expertise in systems engineering and integration, algorithm development, software engineering, meteorology and remote sensing to develop an innovative and low-risk ground solution to meet NOAA's mission requirements for the next generation GOES-R satellites.

The evolution of the GOES-R series poses many challenges in developing the next generation in GOES ground systems. The Ground Segment provides Enterprise Management (EM), Mission Management (MM), Product Generation (PG), and Product Distribution (PD) capabilities beyond what's currently done today. More than 150 Earth and space products will be processed and delivered to a diverse user

community in the U.S. and the world.

The Ground Segment will operate from three sites. The NOAA Satellite Operations Facility (NSOF) in Suitland, MD, will house the primary Mission Management, Product Generation and Product Distribution functions. The Wallops Command and Data Acquisition Station (WCDAS) will provide space communications services and selected Ground Segment functions. The third site is a geographically isolated Remote Backup Facility. It will function as a completely independent backup for the MM, PG, and PD functions for the production and delivery of products through Level 1b, and will be concurrently and remotely operated from the NSOF.

## GOES-R Space Segment

The GOES-R Space Segment consists of the government-contracted instruments (ABI, GLM, SUVI, EXIS, SEISS), the spacecraft bus, and auxiliary communication services (DCS, SARSAT, LRIT, EMWIN).

Some of the major driving requirements for the GOES-R spacecraft design over the current system are: 1) accommodating

the GOES-R instrument suites' increased mass, volume, power and data rate requirements; 2) meeting the more challenging pointing and image navigation and registration requirements of the instruments; and 3) achieving the increased requirements for data availability and reliability/lifetime. Lockheed Martin has been working with NOAA and NASA to develop a conceptual spacecraft design to meet these requirements, while performing risk mitigation activities to ensure the first GOES-R satellite launch in 2014.

Lockheed Martin's GOES-R spacecraft solution is based upon a proven A2100 geostationary spacecraft bus tailored to meet the GOES-R mission requirements. The A2100 spacecraft has been identified by Frost & Sullivan as the commercial GEO bus with the highest reliability. Currently, there are more than 34 spacecraft operating in orbit and the A2100 has accumulated over 194 years of reliable on-orbit operations – a record unequalled in industry. The A2100 has also won accolades for its ease of operations.

Lockheed Martin has more than 40 years of partnership with NASA and NOAA in developing remote sensing satellites, and this experience will ensure the successful integration of GOES-R instruments onto the spacecraft in a cost-effective and timely manner. ↻



The new NOAA Satellite Operations Facility in Suitland, MD. (Photo: NOAA.)

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## IS&GS Participates in Assessment of Atmospheric Science Facilities

**L**ockheed Martin was an active participant in the 2007 National Science Foundation (NSF) Facilities Assessment effort. The NSF Facilities Assessment was charged with reviewing atmospheric science instrumentation across the community. The assessment looked at facilities across government agencies, universities, national laboratories, international organizations, private companies, as well as those systems still under development.

Dr. North Larsen, Lockheed Martin Information Systems and Global Services (IS&GS) Chief Scientist for the GOES-R Ground Segment, is part of the subcommittee on satellites and remote sensing. He is contributing knowledge of currently active sensors, past instruments and satellites, and future planned satellite programs and instruments. Lockheed Martin IS&GS is one of two invited industry participants in the NSF assessment, along with Vaisala, a Finnish company that develops atmospheric measurement instrumentation.

In addition to the satellite data subcommittee, six other subcommittees contributed to the Facilities Assessment:

- Airborne Measurement Resources
- Airborne Platform Resources
- Emerging Technologies Resources
- In Situ and Surface Atmosphere Exchange
- Solar Measurement Data
- Surface-Based Remote Sensing

### Assessment Objectives

NSF initiated the assessment to examine emerging instrument technologies in

atmospheric science that offer improving capabilities for new discoveries and knowledge. Innovative technologies for intensive observational field experiments and longer-term climate studies benefit from instrument miniaturization, greater portability, and autonomous operations, but also place an increasing demand on current atmospheric science facilities and instrumentation.



*This December 20, 2007, image of Tropical Cyclone Melanie in the Indian Ocean, off the coast of Western Australia, was captured by the MODIS satellite. The MODIS on NASA's Aqua satellite is one of more than 70 satellite instruments that were part of the NSF assessment exercise. (Photo: NASA MODIS Land Rapid Response Team)*

With limited funding available, strategic planning and community partnerships become vital to target appropriate investments in new capabilities and to facilitate the sharing of resources. The assessment identified gaps in scientific measurement capabilities.

The NSF-led assessment provided a forum to development community partnerships. The NSF University Corporation of Atmospheric Research (UCAR) and Lower Atmospheric Observing Facilities program office and the Earth Observing Laboratory (EOL) of the National Center for Atmospheric Research (NCAR) conducted a community-wide assessment of

atmospheric science instrumentation.

### Input From Key Sources

Needed expertise within the atmospheric science community was drawn on broadly to assist with the assessment. This expansive community participation facilitated the identification of potential partnerships for sharing multi-purpose facilities and instrumentation. Emerging technologies for new observation capabilities, miniaturization, or autonomous operation were also a major element of the assessment.

In addition to conducting the assessment study, the assessment committee was tasked with outreach efforts to the community. This included completing the following activities:

- Establishing a website ([www.eol.ucar.edu/fadb/resource](http://www.eol.ucar.edu/fadb/resource)) to provide descriptive information of atmospheric science facilities and instrumentation in a consistent, easy-to-read format.
- Develop an overview paper for submission to the *Bulletin of the American Meteorology Society* (BAMS) or other journal of equal stature.
- Develop a workshop to provide an additional opportunity to augment the facilities assessment study with overlooked measurement facilities or gaps in capabilities.
- Outcomes of the committee work, including input from the workshop, will be widely distributed to enhance community awareness both of the existing atmospheric facilities as well as the new and emerging facilities.

These activities have been done in order to assist NSF in strategic planning and budgeting for future instrumentation and facility development for use in field experiments and long-term field observations. Emerging technologies that could benefit from strategic investments will be identified. The overview and web-based resource will also serve as a valuable reference document for other governmental agencies and community partners who have the need to utilize or share atmospheric science facilities. ↻

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