GOES-R Program Status

Briefing to
MTG Mission Team Meeting
17 – 18 June 2008
ESA/ESTEC
Noordwijk, The Netherlands
• Weather sentinel
  – Hurricanes
  – Severe storms
  – Flash floods
• Input to weather models, forecasts and warnings
• Fire and smoke products for air quality monitoring and forecasting and fire fighting
• Sea surface temperature monitoring for fisheries and climate
• Winds for aviation
• Solar imagery for communication satellites, utility companies, and astronaut safety
• Environmental data collection–buoys, rain gauges…
• Search and Rescue
• GOES data shared within the western hemisphere
Current GOES Constellation

• GOES mission requires two on-orbit operational satellites and one on-orbit spare

• GOES-West location in GOES-R series to be 137°W instead of current 135°W
  – Eliminates conflicts with other satellite systems in X-band frequency at 135°W

* Note: Satellites are labeled with letters on the ground and changed to numbers on-orbit
GOES-R Program Guidance from IRT

- Split Flight and Ground Segments to provide more of an opportunity to industry leaders
- NOAA to retain overall program management responsibility and procure the ground segment
- NASA to procure the space segment
- Government to perform the System Engineering and Integration (SE&I) activities required to integrate the space and ground segments
Current Program Status

- Key program documents signed
  - Level 1 Requirements Documents – June 10, 2007
  - NOAA/NASA Memorandum of Understanding - June 15, 2007

- Spacecraft acquisition
  - The Government is evaluating S/C proposal and expects the award before the start of 2nd quarter FY09

- Ground acquisition
  - Final RFP released May 2008

- GOES-R Launch Readiness Date
  - April 2015

  - Spacecraft: NNG07193033J, NNG08193033R
  - Ground: DG133E-08-RP-0068
Satellite is operational beyond design life

On-orbit GOES storage

Continuity of GOES Operational Satellite Program

Calendar Year


GOES 10 Backup

GOES 11 GOES West

GOES 12 GOES East

GOES 13 On-orbit Spare

GOES O

GOES R

GOES S

Satellite is operational beyond design life

On-orbit GOES storage

Operational

Approved __________________ 3/19/2008

GOES P
• Advanced Baseline Imager (ABI)
  – Implementation phase
  – Contractor: ITT Corporation

• Space Weather
  – **Space Environmental In-Situ Suite (SEISS)**
    • Implementation phase
    • Contractor: Assurance Technology Corporation (ATC)
  – **Solar Ultra Violet Imager (SUVI)**
    • Implementation phase
    • Contractor: Lockheed Martin Advanced Technology Center
  – **Extreme Ultra Violet/X-Ray Irradiance Sensor (EXIS)**
    • Implementation phase
    • Contractor: Laboratory for Atmospheric and Space Physics (LASP)
  – **Magnetometer**
    • Procured as part of spacecraft contract

• **Geostationary Lightning Mapper (GLM)**
  – Implementation contract awarded in December 2007
  – Contractor: Lockheed Martin Space Systems Company
### Increased Performance

<table>
<thead>
<tr>
<th>Performance Capability</th>
<th>GOES I-M</th>
<th>GOES N-P</th>
<th>GOES R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible Resolution</td>
<td>1 km</td>
<td>1 km</td>
<td>0.5 km</td>
</tr>
<tr>
<td>IR Resolution</td>
<td>4-8 km</td>
<td>4-8 km N</td>
<td>1-2 km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 km O/P</td>
<td></td>
</tr>
<tr>
<td>Full Disk Coverage Rate</td>
<td>30 min</td>
<td>30 min</td>
<td>5 min</td>
</tr>
<tr>
<td># of Channels</td>
<td>5</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Solar Monitoring</td>
<td>GOES-M only</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lightning Detection</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Operate through Eclipse</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ground System Backup</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>Archive and Access</td>
<td>Limited</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Raw Data Volume per spacecraft</td>
<td>2.6 Mbps</td>
<td>2.6 Mbps</td>
<td>75 Mbps</td>
</tr>
</tbody>
</table>

- GOES-R maintains continuity of the GOES mission
- GOES-R also provides significant increases in spatial, spectral, and temporal resolution of products
Corresponding Simulated GOES Imager Spectral Bands:

Simulated “ABI” Spectral Bands:

... over a wider spectrum
## Advanced Baseline Imager (ABI) spectral bands and their associated products

<table>
<thead>
<tr>
<th>Aerosols</th>
<th>Clouds, etc</th>
<th>Vegetation</th>
<th>Cirrus Clouds</th>
</tr>
</thead>
<tbody>
<tr>
<td>“0.47 μm”</td>
<td>“0.64 μm”</td>
<td>“0.86 μm”</td>
<td>“1.38 μm”</td>
</tr>
<tr>
<td>Snow, Cloud Phase</td>
<td>Particle size</td>
<td>Fog, Fires, Clouds, etc</td>
<td>Water Vapor, Precipitation</td>
</tr>
<tr>
<td>“1.61 μm”</td>
<td>“2.26 μm”</td>
<td>“3.9 μm”</td>
<td>“6.19 μm”</td>
</tr>
<tr>
<td>Water Vapor</td>
<td>WV, Upper-level SO2</td>
<td>Volcanic Ash, Cloud Phase</td>
<td>Total Ozone</td>
</tr>
<tr>
<td>“6.95 μm”</td>
<td>“7.34 μm”</td>
<td>“8.5 μm”</td>
<td>“9.61 μm”</td>
</tr>
<tr>
<td>Surface features, clouds</td>
<td>Clouds, SST, Precipitation</td>
<td>Low-level Moisture</td>
<td>Cloud Heights</td>
</tr>
<tr>
<td>“10.35 μm”</td>
<td>“11.2 μm”</td>
<td>“12.3 μm”</td>
<td>“13.3 μm”</td>
</tr>
</tbody>
</table>
Space Weather Instruments

- Essential for the NOAA Space Weather Prediction Center’s real-time monitoring, forecasting and warnings of solar and geophysical events and disturbances
- Provide key measurements for the Radio Blackout Space Weather Scale
- GOES-R improvements
  - Multi-band "color" images at the same rate as GOES N-P produces single band images
  - Solar X-ray image dynamic range, resolution, and sensitivity
  - EUV measurements for improved modeling of ionosphere and thermosphere
  - Medium energy radiation environment responsible for spacecraft charging

Solar flares travel towards Earth at about 600,000 to 2 million MPH
Geostationary Lightning Mapper (GLM)

- Detects total strikes: in cloud, cloud to cloud, and cloud to ground
  - Compliments today’s land based systems that only measures cloud to ground (about 15% of the total lightning)

- Increased coverage over oceans and land
  - Currently no ocean coverage, and limited land coverage in dead zones
GOES-R Communications Payload

- Communications
  - GOES Rebroadcast (GRB)
    - Replacement of today’s GVAR
    - Data rate of 31 Mbps in L-band
      - GVAR - 2.11 Mbps
        - Previous GRB specifications - 17 Mbps
  - Low Rate Information Transmissions (LRIT)
  - Emergency Managers Weather Information Network (EMWIN)
  - Search and Rescue (SAR)
  - Data Collection System (DCS)

- EGVAR (Emulated GVAR)
  - Transmission between GOES-N/O/P and GOES-R series
  - GVAR like data set consisting of GOES-R data
  - For transmission through existing GOES-N/O/P legacy system
Advanced Sounding

• Hyperspectral Environmental Suite (HES) instrument removed from GOES-R program – August 2006

• NOAA continues to have strong requirements for measurements from advanced hyperspectral sounder in Geo orbit

• Subsequent efforts included:
  – Assessment of ABI data for derived sounder products
  – NOAA Analysis of Alternatives (AOA) study
    • Advanced sounding
    • Coastal waters imaging
  – Contractor studies of advanced sounding concepts for later GOES spacecraft

• Conclusions
  – ABI can approximate current GOES sounder capabilities
  – A geostationary high capability sounder (GHS) demonstration mission should be funded as soon as possible
Lifted Index

3 hr changes in T and T_d

Associated Synthetic GHS T_b Spectrum
simulated GHS winds field from IHOP
NRC Decadal Survey Recommendation for Advanced Sounding (January 2007)

• “The National Research Council committee … recommends that NOAA, working with NASA, develop a strategy to restore the previously planned capability to make high temporal- and vertical-resolution measurements of temperature and water vapor from geo orbit.”

• “Recognizing the technological challenges and accompanying potential for growth in acquisition costs for HES, the committee recommends consideration of the following approaches:
  – 1. Complete the GIFTS instrument, deliver it to orbit via a cost-effective launch and spacecraft opportunity, and evaluate its potential to be a prototype for the HES instrument, and/or
  – 2. Extend the HES study contracts focusing on cost-effective approaches to achieving essential sounding capabilities to be flown in the GOES-R time frame.”

Follow-on NRC recommendations are being formulated based on discussions held 7 June 2007 to discuss climate and GOES-R capabilities lost during the original NRC study period
The Way Forward
(guidance from the GOES-R Sounding AWG)

* A GIFTS Demonstration should be pursued in coordination with NASA. This prototype mission would provide experience with a large volume of high temporal and spectral resolution data.

* A pre-operational GHS should be pursued for 2016 (on GOES-S). This prototype instrument would introduce the technology that will be used operationally and provide a testbed for operational data processing and utilization.

* GHS operations should be planned to begin in 2021 (on GOES-T). This allows adequate time for all phases of preparation – algorithm development, technology testing, and user familiarization.
NOAA Analysis of Alternatives

- Broad range of options considered, including
  - Several high spectral resolution imaging sounders
  - GEO microwave
  - Polar advanced sounders
  - COSMIC GPS
  - Ground-based RAOBS and NEXRAD
  ⇒ Advanced GEO Sounder needed to meet requirements

- Advanced high spectral resolution sounder trade included
  - HES: Original Hyperspectral Environmental Suite
  - FPCCR: High spectral resolution sounder with 5-km, rapid-coverage mesoscale mode (presented at GOES-R Formulation Phase Concept and Cost Review)
  - RCSC: High spectral resolution sounder specified with current GOES spatial (10 km) and temporal (70 min CONUS) capability
  - GIFTS: High spectral resolution sounder with 4 km imaging and rapid mesoscale coverage (12 minute CONUS)
  ⇒ FPCCR is lowest risk option for GOES-T operational sounder
  ⇒ GIFTS cost ranked high because of assumed cost of free-flyer spacecraft, but considered option for Demonstration
  ⇒ Path forward involves an earlier Demonstration

- Ground Processing Costs: Greatly reduced from original estimates! (Based on NOAA STAR and Cooperative Institutes playing major role)
## NOAA Analysis of Alternatives

### Final Advanced Sounder Results

#### Alternative versus Risk

<table>
<thead>
<tr>
<th>Alternative/Risk</th>
<th>HES on GOES</th>
<th>HES on GEO free flyer</th>
<th>FPCCR on GOES</th>
<th>FPCCR on GEO free flyer</th>
<th>RCSC on GOES</th>
<th>RCSC on GEO free flyer</th>
<th>GIFTS on GEO free flyer</th>
<th>GEO Microwave on free flyer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>High</td>
<td>High</td>
<td>(Demo mode)</td>
<td>(Demo mode)</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Performance</td>
<td>Meets</td>
<td>Meets (1 sat)</td>
<td>Meets (1 sat)</td>
<td>Medium Accuracy and spatial resolution</td>
<td>Medium Accuracy and spatial resolution</td>
<td>Meets</td>
<td>Does not meet</td>
<td></td>
</tr>
<tr>
<td>Space Development / Implementation Risk</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Schedule Risk for GOES-T (2019) or Free flyer (2014)</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Ground System Development / Implementation Risk</td>
<td>Medium</td>
<td>Medium</td>
<td>Low for Demo Mode</td>
<td>Low for Demo Mode</td>
<td>Low for Demo Mode</td>
<td>Low for Demo Mode</td>
<td>Low for Demo Mode</td>
<td>Medium</td>
</tr>
</tbody>
</table>

**HES Sounder is Low Risk as demo**
NOAA Analysis of Alternatives

Sounder Capability vs. Cost
Atmospheric Vertical Moisture Profile

C4: FPCCR on GOES-T
C4b: FPCCR demo on GOES-T
C5: RCSC on GOES-T
C5b: RCSC demo on GOES-T
C6: FPCCR Free flyer
C7: RCSC Free flyer
C8: GIFTS Free flyer
C9: GEO Microwave Free flyer

Reduced ground demo cases
Summary of Geo Sounder Status within NOAA
Jun 08

(1) GOES-R IRT recommended that the GOES-R program (imager, lightning mapper, space instruments) proceed into the acquisition and operations phase for two geos with sufficient spares and components to avoid lengthy schedule delays during integration and test.

(2) NRC decadal study recommended that the GOES have a capability for high temporal- and vertical-resolution measurements of temperature and water vapor.

(3) NOAA recapitalization plans call for a high capability geo sounder in 2020s.

(4) Cost Benefit Analysis of high capability sounder $4B+ beyond that of ABI.

(5) The AWG suggests GIFTS Demo with NASA or GHS Demo on GOES-S followed by GHS operational on GOES-T.

(6) NOAA AoA finds acceptable technical risk for HES-like sounder (sans CWI).

(7) There has been no visible progress for transferring GIFTS to geo orbit.

(8) There will need to be an attempt to get a new start ($) to develop high capability geo sounder in the coming year(s).
A new one-stop source for all GOES-R information.
http://www.GOES-R.gov
A joint web site of NOAA and NASA