NOAA Perspective
on
U Class Satellites

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Outline

• Key data and current studies
• Gap mitigation
• Reliability needs
• Summary
Key Polar Satellite Data

Microwave and infrared atmospheric sounders on polar orbiting satellites have a large positive impact on reducing numerical weather prediction forecast error.

Imagery from polar orbiting satellites provides enhanced coverage in high-latitudes where geosynchronous satellite coverage is diminished.

ATMS

CrIS
Current NESDIS U Class Studies

• MIT / LL U Class Design Studies
  – Provide design, analysis, and other support to inform future development and use of microwave radiometers hosted on small satellites.
  – Study provides risk reduction to the FY2017 President’s Budget Request for the Earth Observing Nanosatellite-Microwave (EON-MW) mission under the Polar Follow-on Program.

• JPL Sensor Studies
  – MidWave IR Sounder design and capabilities assessment versus a fully capable CriS – assessment of ability to meet NOAA sounder requirements.
• EON-MW will use miniaturized microwave sounder technology demonstration developed by MIT Lincoln Laboratory (MIT/LL)
• EON-MW uses innovative, proven CubeSat technology to greatly reduce cost of construction and launch compared to traditional space systems
• EON-MW is next evolutionary step to MIT/LL’s CubeSat microwave sounder series

### MicroMAS-1
3U cubesat with 118-GHz radiometer
8 channels for temperature measurements
July 2014 launch, March 2015 release; validation of spacecraft systems; eventual transmitter failure

### MicroMAS-2
3U cubesat scanning radiometer with channels near 90, 118, 183, and 206 GHz
12 channels for moisture and temperature profiling and precipitation imaging
Two launches, first in 2017

### MiRaTA
3U cubesat with 60, 183, and 206 GHz radiometers and GPS radio occultation
10 channels for temperature, moisture, and cloud ice measurements
Launch on JPSS-1

### EON-MW
12U satellite with 22 channels to replicate ATMS
High-performance, radiation tolerant design; 2-3 year mission life
Included in 2017 NOAA budget
30 month build and test
22x22x34 cm; 20 kg; 50 W
EON-MW: Investment in New Technology

- Demonstrating a low cost, small satellite alternative could lead to more sustainable and robust sources of microwave sounding data.
- Upon successful demonstration EON-MW can be transitioned to industry for production of a microwave sounding gap-filler or low-cost ATMS replacement.
- Implementation of EON-MW will be critical to furthering the design of a flexible and cost-efficient observing capability.
  - Provides for the government, national laboratories, academia and the commercial sector to work together to develop and demonstrate a critical capability that has the potential to reduce the out-year costs of sounding instruments.
EON-IR

NOAA is working with JPL to develop designs for EON-IR concept
• CubeSat-based mid-wave IR sounder (4.8 – 5.1 microns)
• Mitigate against the loss of CrIS on S-NPP and JPSS
• Leverages NASA/JPL CIRAS demonstration mission with design modified to meet NOAA’s observational and operational requirements
  – Scanning sensor head
  – High reliability components
  – Meet power and thermal requirements for operational duty cycle
• Current Work
  – Detailed design study to reduce risk on parts reliability, scanning mechanism, and thermal/mechanical interference
  – Study to determine impact of mid-wave IR only sounding
Data Impact Studies

Scope:

- Determine the quantitative value of MicroMAS and CIRAS in the reduction of forecast error in global and regional NWP models:
  - Impact of MicroMAS-2 in the absence of PM microwave sounder data
  - Impact of CIRAS in the absence of PM IR sounder data

Recent Work:

- Created simulated MicroMAS-2 and CIRAS data CubeSat Sounders for studying impact
- Created orbit simulator for MicroMAS-2 and CIRAS

Next Steps:

- Impact study on local severe storm forecast
## Strategy for Gap Mitigation

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### Microwave Sounding

Potential Enabling Technology: NASA investment in CubeSat based mid-wave IR sounders for the JPL CubSat Infrared Atmospheric Sounder (CIRAS) mission (Pictured)

### Infrared (IR) Sounding

Potential Enabling Technology: NOAA’s EON-MW concept is based on NASA funded MIT/LL CubeSat based microwave sounder technology demonstrations MiRaTA and MicroMAS-2/TROPICS (pictured).

### Visible / IR Imaging

Potential Enabling Technology: Department of Defense investment in low-light CubeSat based imagers such as AeroCube-4 (pictured)
SmallSat Constellations

- Flying identical satellites in a constellation can improve reliability
- Data from domestic and international research missions can be used to reduce error in numerical weather prediction models
  - NASA’s upcoming CYGNSS GNSS reflection mission and TROPICS microwave sounder constellation mission show promise for transition from research to operations

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<td>Time-Resolved Observation of Precipitation structures and storm intensity with a Constellation of SmallSats (TROPICS) operational demonstration mission. NOAA will study impact of TROPICS high-refresh temperature profile data on tropical cyclone forecasts</td>
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Small Satellites and Gap Mitigation

Small satellites are especially suitable for gap mitigation

- Low Cost
- Adaptable
- Short Lead Time
- Launch Flexibility
- Fast Tech Refresh

Affordable source of mitigation data with short, responsive call up time
Why U Class Satellites?

- Current satellites are expensive
  - No ability for spares
  - Long development cycle
  - Failure means lack of data availability
- U Class satellites could be the future for some observations
  - Lower cost alternatives
    - Use commercially available parts
    - Less weight means low launch costs
    - Can afford to have a spare for Gap Mitigation
  - Much shorter development time
  - Commercial launch availability
  - Loss of a single spacecraft does not result in the loss of all instruments
- U Class constellations can provide more key observations
  - Improved performance of Numerical Weather Prediction (NWP) models
NOAA Reliability Needs

• NOAA provides operational weather data
  – Initial SmallSat usage for gap mitigation
  – 2-3 yr mission life appears to be adequate
  – Affordability and lead time
  – Potential SmallSat usage as operational constellation
• NOAA 15, 18, and 19 satellites still in operation
  – Well beyond 2 yr engineering design life
• What reliability efforts are necessary for SmallSats?
• Create new models for SmallSat reliability?
• Which radiation tolerant parts are necessary for LEO missions?
Summary

• NOAA is interested in SmallSats as potential Gap Mitigation and for playing a role in future space architectures
• NOAA looking to leverage the investments of NASA, DoD and other partners to begin developing SmallSat capabilities
• NOAA envisions that SmallSats may play a role as an element in NOAA’s observation system
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