



# Nanosats for Radar Altimetry SSC15-XII-7

**Austin Mroczek**  
**PEO Space Systems**  
**[austin.mroczek@navy.mil](mailto:austin.mroczek@navy.mil)**

**Gregg Jacobs**  
**Naval Research Laboratory**  
**[gregg.jacobs@nrlssc.navy.mil](mailto:gregg.jacobs@nrlssc.navy.mil)**

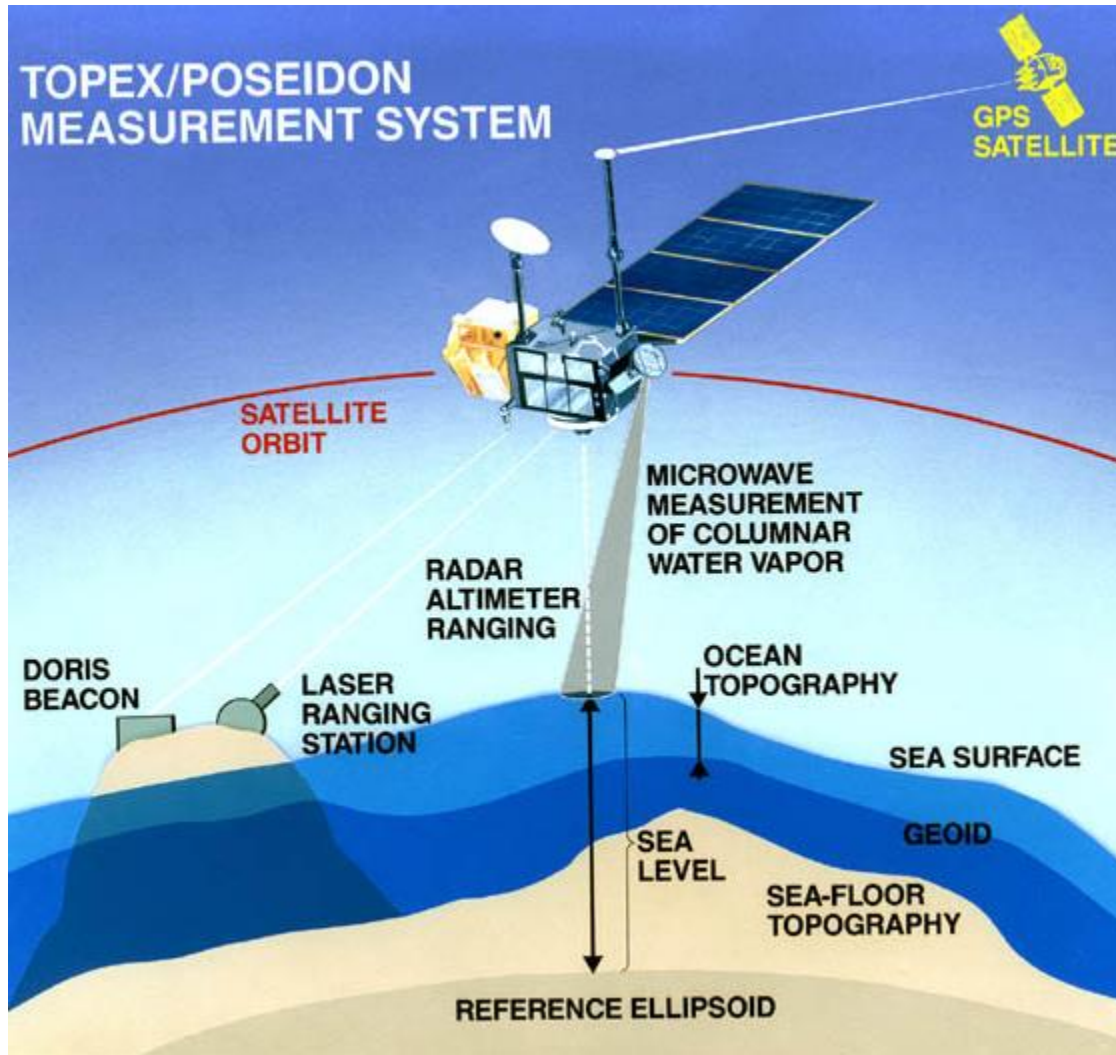
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SPAWAR security and policy review tracking number SR-2015-302.

***Space-enabled capabilities for  
Naval, Joint and Allied Operations***





# Radar Altimetry Basics



- Precise orbit determination
- Radar measures distance to surface
- Calculates sea surface height



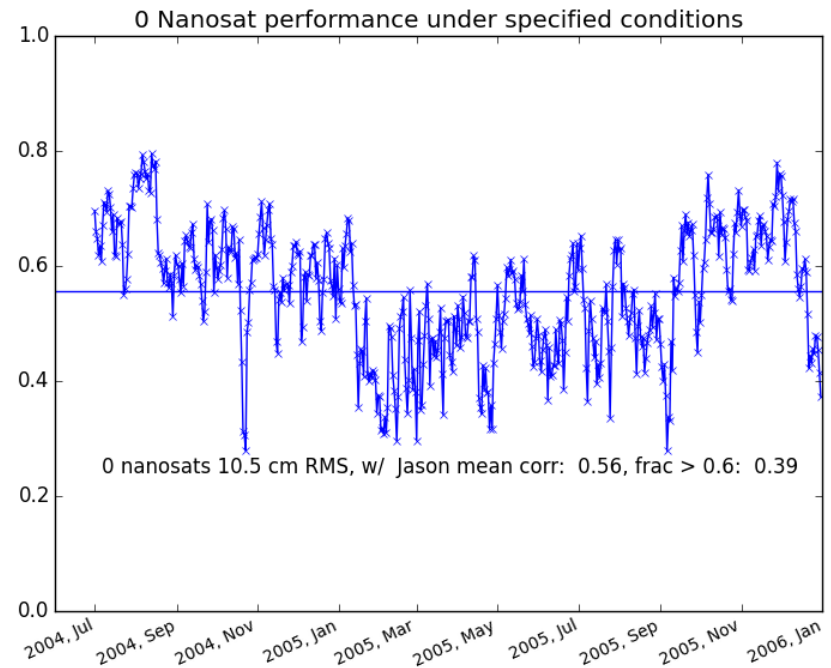
# Why is Altimetry Important?

- Predicting the ocean environment requires continual observations
- Space based altimeter-observed sea surface height remains the critical source that enables ocean prediction
- Crucial to Navy battlespace awareness and Meteorological and Oceanographic (METOC) forecasting
- U.S. Navy spends a lot on altimetry



# Navy Altimetry Study

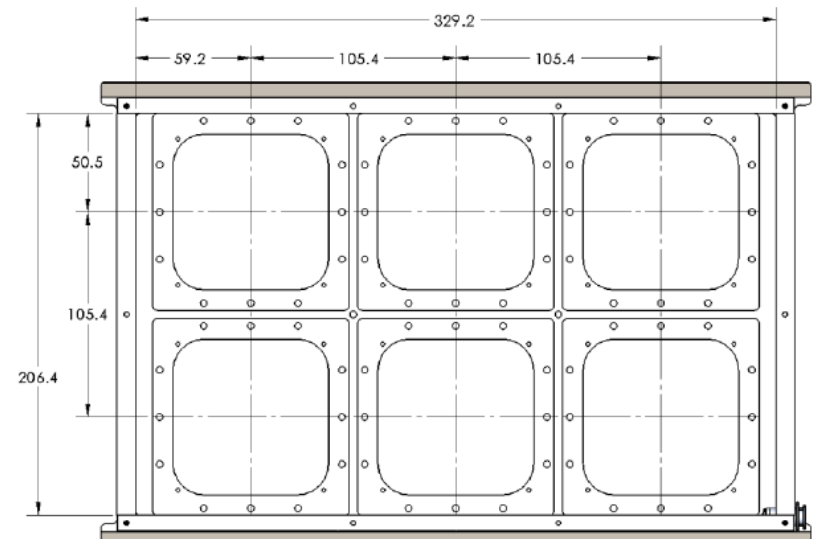
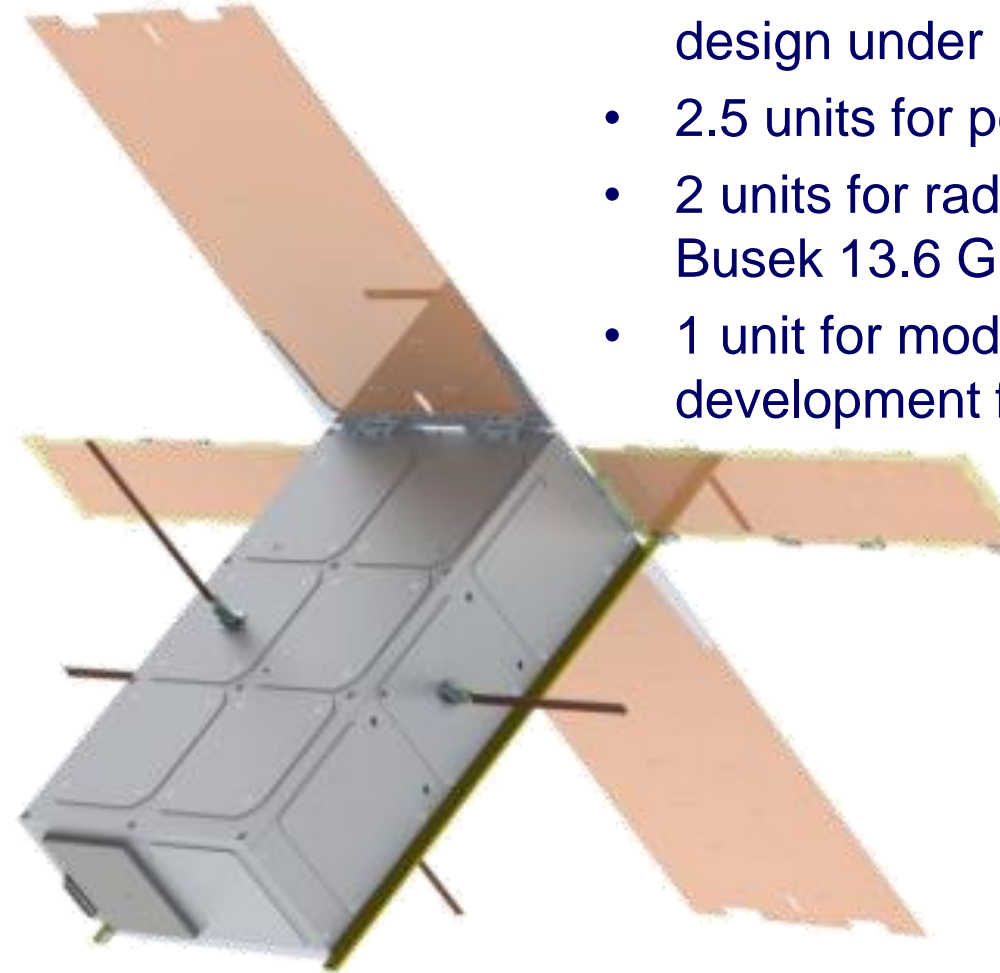
- Purpose: understand nanosat performance when augmenting larger mission
- Methodology:
  - Estimate reference design performance
  - Simulate the output of the ocean model
  - Tentative demo plan
  - Cost-effectiveness
- Using Navy Coastal Ocean Model
- Comparing to Jason missions





# Reference Design

- Based on Pumpkin 6 unit “SUPERNOVA” design under FY 13 Rapid Innovation Fund
- 2.5 units for power/comm/attitude/GPS
- 2 units for radar altimeter payload based on Busek 13.6 GHz design for SBIR N122-146
- 1 unit for modulated laser retro-reflector in development from SSC Pacific

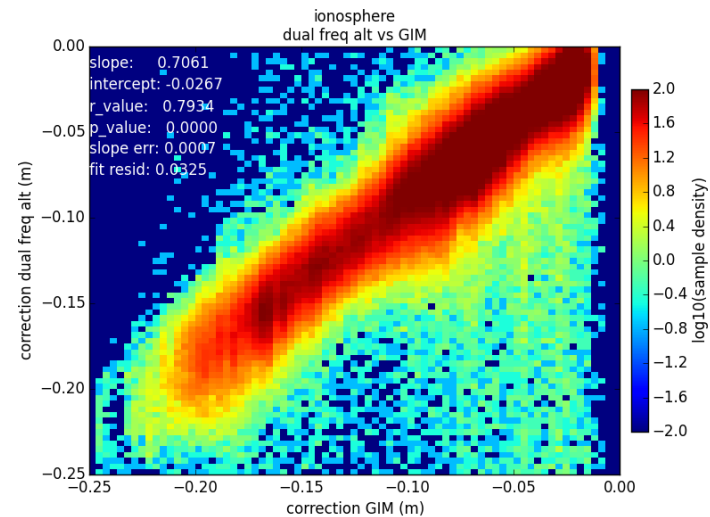
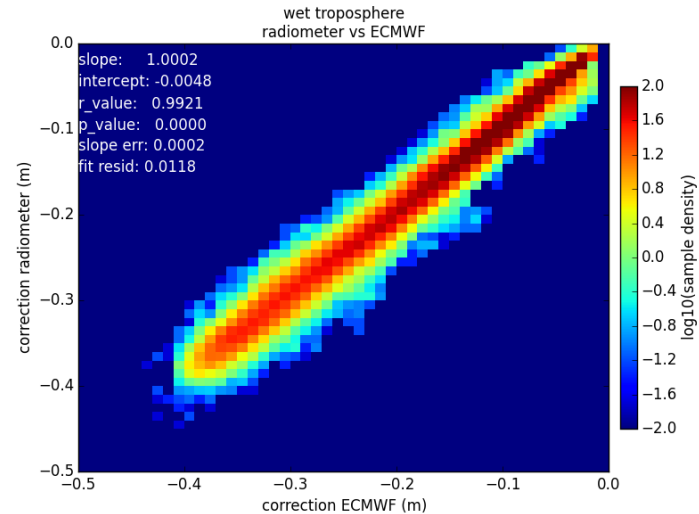


Note: dimensions shown in millimeters



# Traditional Altimetry Concerns

- No radiometer for water vapor?
  - European Center for Medium-range Weather Forecasting (ECMWF) shows good correlation with Jason-2 data
  - Result: ECMWF forecast can be used in place of a radiometer for 1.2 cm error
- No dual frequency for ionosphere?
  - JPL's Global Ionospheric Maps (GIM) model shows good correlation with Jason-2 data
  - Result: GIM can be used in place of second frequency for 3.25 cm error





# Sea Surface Height Anomaly Correlation

	Number of nanosats	2	4	6
Error level	With Jason ?			
10.5 cm	Y	0.65	0.71	0.73
22.5 cm	Y	0.59	0.65	0.68
22.5 cm	N	0.47	0.57	0.62
40.5 cm	Y	0.48	0.54	0.56

Green indicates the constellation and error levels are better than Jason only, yellow indicates similar performance, and red indicates worse performance.

***Nanosat augmentation increases ocean model performance***



# Outcome of Study

- Nanosat sea surface height anomaly likely between 6.7cm and 16.1cm RMS
- Two nanosats increase performance 51-73% for cost increase of 22%
- Four nanosats increase performance 80-109% for cost increase of 37%
- Navy to consider nanosat demonstration to meet future altimetry requirements

***Significant performance increase for small cost increase  
Nanosats are a cost-effective augmentation of altimetry data***





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sustain, and influence  
space-based capabilities  
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Operations**