National Aeronautics and Space Administration

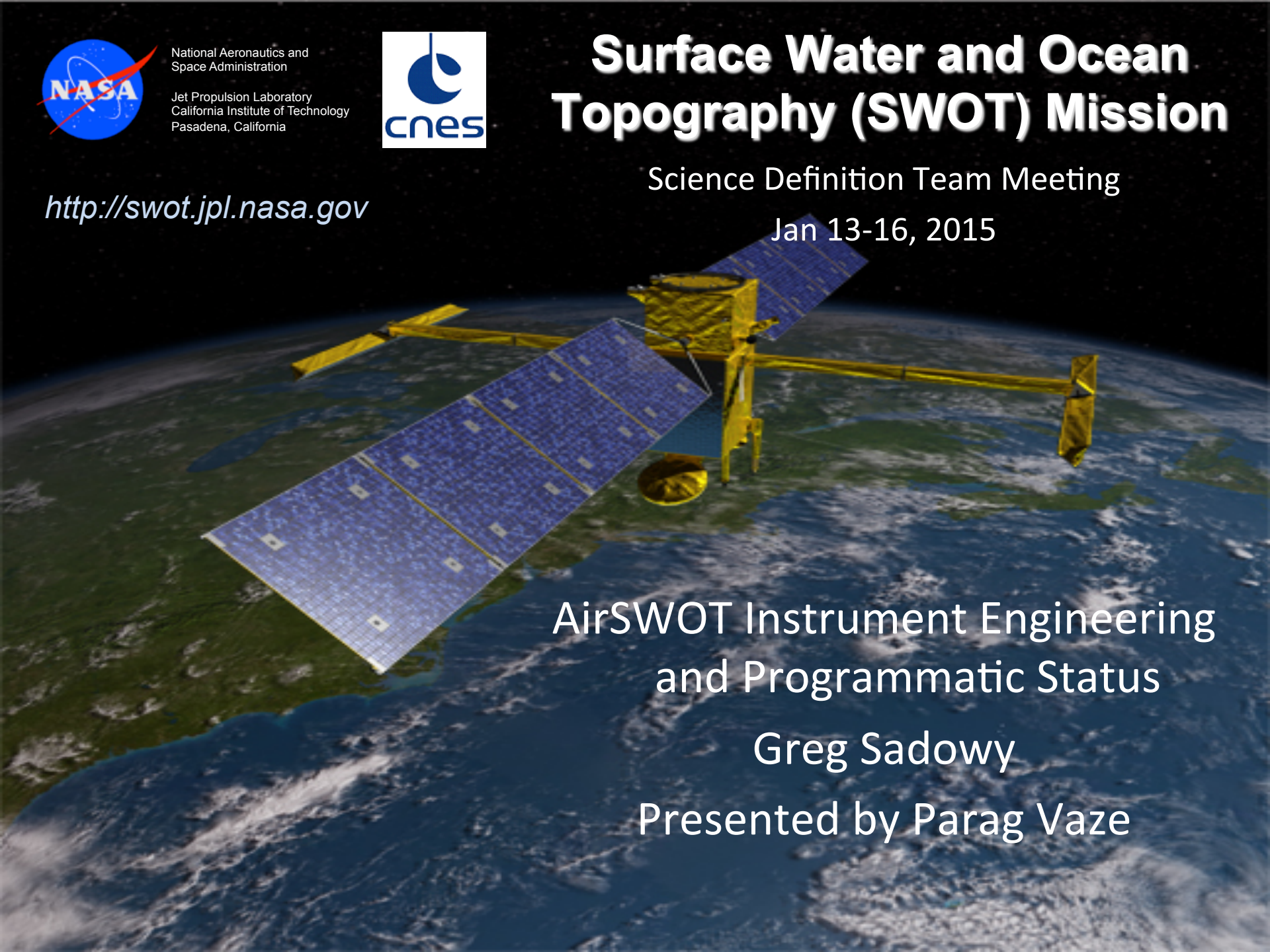
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

# Surface Water and Ocean Topography (SWOT) Mission

Science Definition Team Meeting

Jan 13-16, 2015

http://swot.jpl.nasa.gov



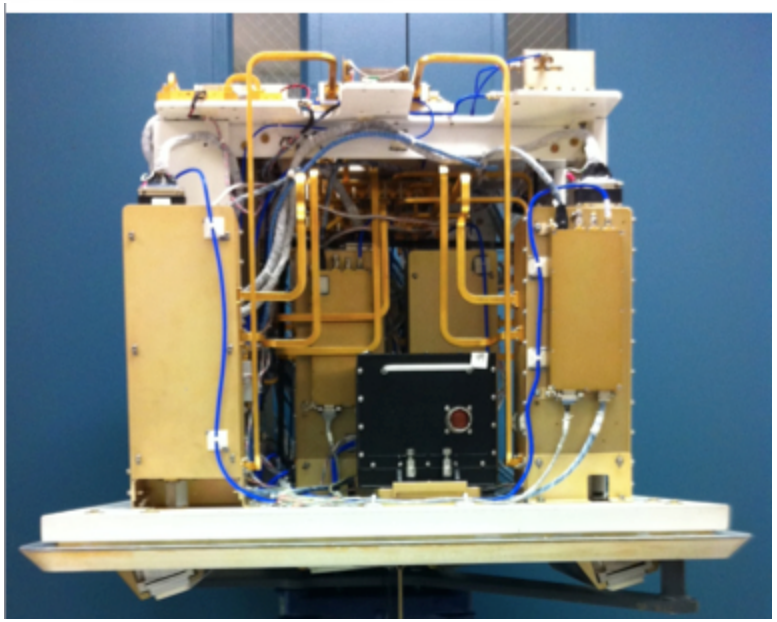
## AirSWOT Instrument Engineering and Programmatic Status

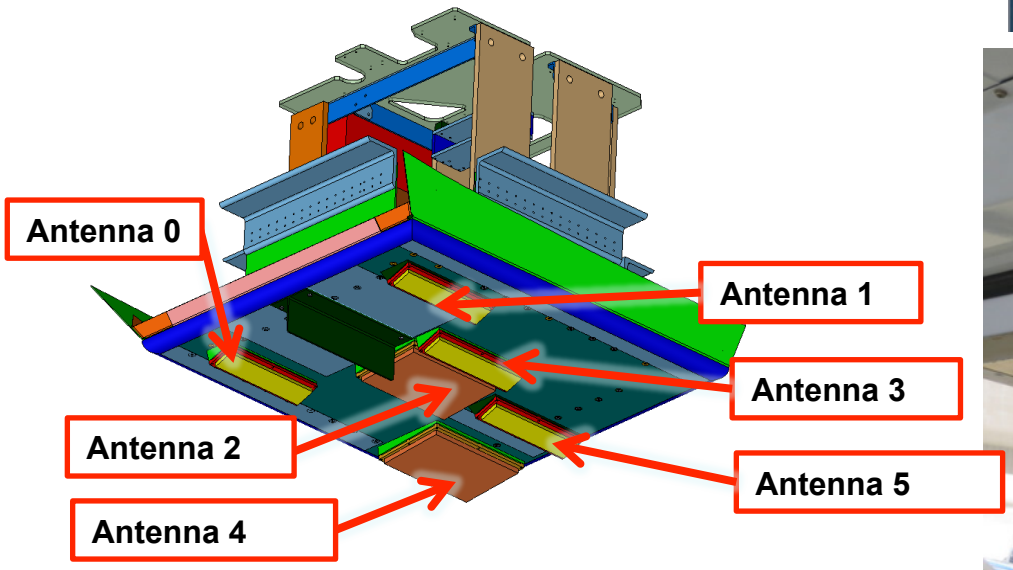
Greg Sadowy

Presented by Parag Vaze

# AirSWOT Ka-band Radar Interferometer

- Ka-band (35.75 GHz)
- 40 W peak transmitter power
- 6 antennas:
  - 3 transmit-receive (0,1,2)
  - 3 receive only (3,4,5)
- Integrated on Beechcraft King Air B-200 (based at Armstrong FRC, Edwards, CA)
- Will also be compatible with IGN B200, Creil, France






# AirSWOT System Objectives

- AirSWOT data are intended to support:
  - Phenomenology studies to inform KaRIn instrument and algorithm development
  - Calibration/Validation of SWOT
  - Science investigation
- Notable AirSWOT differences from SWOT:
  - Multiple baselines (along-track and cross-track) and reconfigurable radar characteristics (bandwidth, pulsewidth, etc.) for studying phenomenology
  - Narrower swath that spans wider range of incidence angles due to airborne altitude
  - Antennas are V polarized only (SWOT uses V and H for different swaths)
  - Generally higher SNR is possible due to shorter range
  - Hardware architecture and design are completely different from SWOT
  - Does not do on-board processing; all raw data are saved
  - Platform motion presents greater challenge for data processing

# Summary Update Since Last SDT

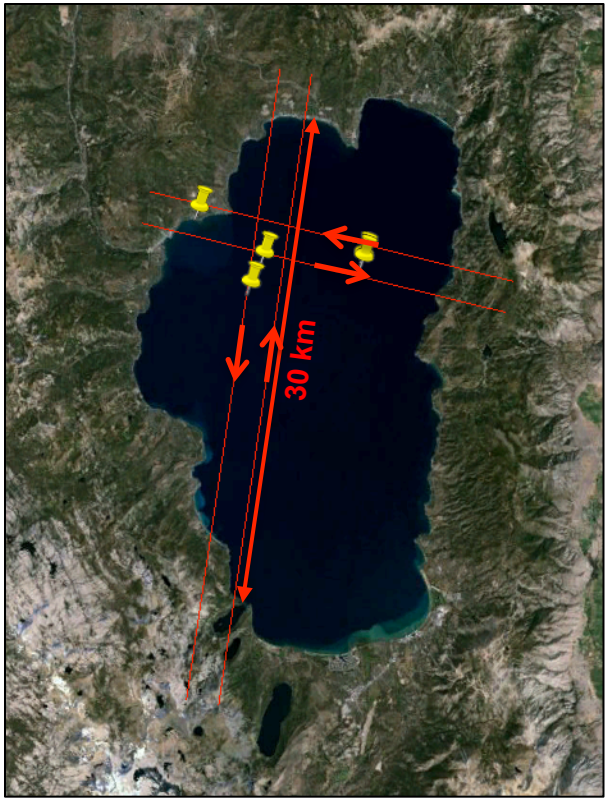
- At the last SDT (June 2014, Toulouse), we reported the resolution of previous issues with calibration leakage, but described issues still pending resolution
- The main outstanding issues were:
  - Instability in antenna pointing (Resolved)
  - Unexplained errors in interferometric height measurements
    - There are some initial theories that may explain and help apply corrections to significantly improve the performance.
    - Even so, as it is today, AirSWOT is capable of supporting many SWOT engineering and science objectives.
- Two intensive engineering test campaigns were conducted in August and November of 2014 in order to collect data to facilitate the analysis of these issues
- Test sites:
  - Rosamond lake corner reflector calibration site
  - Ocean (AltiKa tracks)
  - Lake Tahoe, Mono Lake, Lakes near Mammoth, June CA

# Fall 2014 AirSWOT Flight Summary

- Overall objective of Fall 2014 flights was continued engineering checkout and calibration:
  - 2014-08-21: Rosamond
  - 2014-08-27: Rosamond, Piute
  - 2014-08-31: Ocean (AltiKa underflight), Rosamond
  - *AirSWOT removed from aircraft in September (aircraft not available)*
  - 2014-10-21: Rosamond
  - 2014-10-28: Tahoe
  - 2014-11-12: Tahoe (flight 1); June, Saddlebag, Mono (flight 2)
  - 2014-11-13: Tahoe
  - 2014-11-17: June, Saddlebag, Mono
  - 2014-11-19: Tahoe
  - 2014-11-20: June, Saddlebag, Mono
  - 2014-11-24: Ocean (Jason-2 track), Rosamond

# Lake Tahoe AirSWOT Calibration Site

- Lake Tahoe was selected as a calibration site for the following reasons:
  - Large enough to get lines of reasonable length (30 km)
  - Shape of surface known from both previous IceSAT measurements and new GPS towed buoy measurements
  - No need for tidal corrections as in ocean measurements on multi-hour time scales
  - No long-scale waves or currents
  - Buoys measure wind at surface (yellow pins in image)
- These factors simplify analysis and validation of measurements
- Tracks (shown in red) were chosen to provide four compass directions with overlapping swaths
  - North-South and East-West track overlap
  - At crossover, all four tracks overlap
- Tahoe site was flown four times under a variety of wind conditions

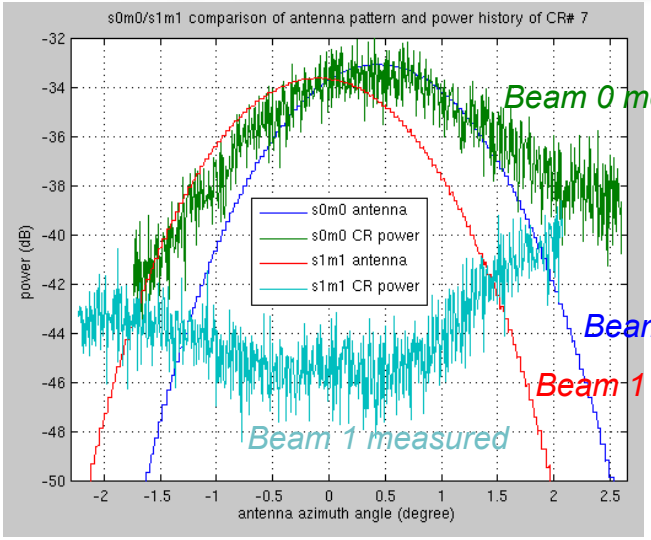



*Flight tracks over Tahoe*

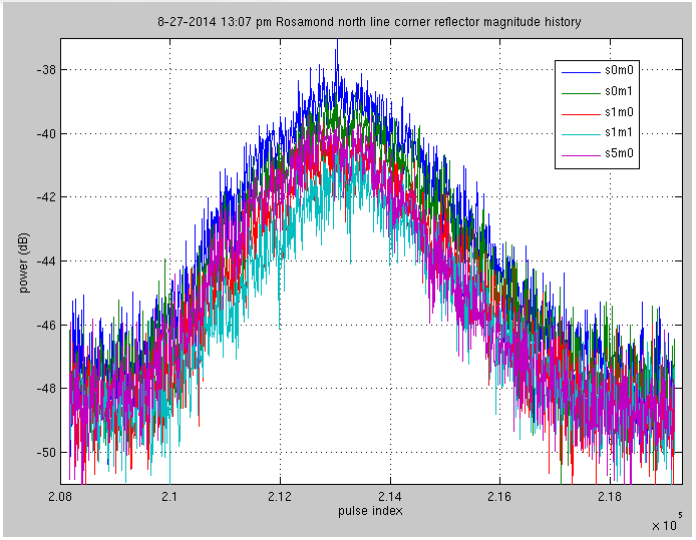
# Key Progress/Results from recent Engineering Flights

- Project objective has been to systematically validate the end-to-end AirSWOT system to utilize the measurements and data products to meet long term project needs:
  - AirSWOT System: Aircraft, Instrument, complementary instruments (GPS, IMU, Camera's, **Data Processor**, In-situ instrumentation, ground calibration instruments)
  - All these elements need to work successfully for a successful campaign
- Doing a successful flight campaign requires a multi-faceted team effort:
  - ✓ Experiment Planning: Tools, matching capabilities to objectives
  - ✓ Team resources and coordination: Significant ramp-up of team and continuing to grow to develop depth to support long term support for the mission
  - ✓ Operations plan : Instrument configurations, tuning and ops procedures
  - ✓ Instrument function and performance: Basic functions verified
  - ✓ Logistic and programmatic planning: Instrument shipment, integration, Securing aircraft availability, obtaining proper clearances, funding
  - ✓ Data capture and processing:
    - ✓ Significant progress in capturing and processing the radar and complementary instrument data
- We've improved on all of these aspects and can execute campaign fairly regularly and systematically.

# Antenna Pointing Issue Resolved




***Before: Beam 1 pattern shifted (sometimes) by more than full beamwidth***




***Now: All patterns overlay (consistently), including Beam 5***

- Antenna #1 (one of two antennas used for wide-swath interferometry) previously had unacceptably large pointing variation
  - Issue occurred only in flight, and even then only intermittently
  - Internal fasteners re-torqued and staked for all antennas
  - Antennas in #1 and #5 positions swapped prior to August flights
  - Pointing has been stable for all subsequent flights
  - Probable root cause: temperature-induced mechanical distortion of antenna that allowed leakage in feed network that affected electrical pointing of antenna (fixed by torqueing fasteners)

# Remaining open items

- Verified fix for antenna stability problem
- Continuing to note some errors in the reported heights to consistently achieve centimetric performance:
  - It is possible that the observed height errors are caused by more than one issue (either independent or interacting).
  - Errors and mitigations will likely involve further adjustments and tuning of the instrument and data processing
- Results of our on-going study will be communicated regularly to the SDT
- In 2015, significant amounts of additional data will be collected to further characterize this effect and to demonstrate processor and calibration improvements.

# AirSWOT Objectives for 2015

- Each experiment will satisfy multiple objectives with a priority on collections supporting SWOT mission PDR:
  - Validation of the end-to-end AirSWOT system
  - Collect engineering and phenomenology data for support of SWOT mission analyses. Of particular importance are:
    - Surface radar cross-section
    - Surface decorrelation time
  - Collect science data for experiment PIs
  - Transition processor and processing infrastructure from experimental to operational status
    - Complete validation of processor using real and simulated data
    - Enhance robustness to minimize requirement for human intervention
    - Improve automation of product generation
    - Improve data quality control
    - Provide interface for data distribution
- Upgrade flight planning system to improve interfaces for experimenters
- Prepare for installation and flight test of AirSWOT on IGN B200 in Creil, France

# 2015 Plan

- A series of flights are planned for 2015 with the priority on resolving any remaining AirSWOT issues with synergy in meeting any specific campaign science objectives:

  - March: Hydrology Validation Experiment
    - Sacramento and Willamette Rivers
    - *In situ* data collected in both locations
  - April: Ocean Validation Experiment
    - Satellite underflights off of California coast
    - Wave current drifters, Lidar, towed probe measurements
  - Early May: Mississippi Delta Experiment
    - Cooperative with UAVSAR L-band radar
  - June: Alaska / Canada Experiment
    - Tanana River, Yukon Flats, Yukon River
    - Extensive ground campaign
    - Opportunities for data collection at Peace-Athabasca delta during transits (To be confirmed)


# Summary

- Since the last SDT, one of the two major outstanding issues has been resolved and the other issue has been identified and there is an active effort with some promising corrections and mitigations
- The system hardware is working without significant issues. However, calibration and processing improvements are ongoing.
- Upcoming campaigns will give us excellent opportunities improve our processing and calibration and validate the data products.
  - Improvement of calibration and processing is a continuous process – this is typical of a first-of-a-kind instrument.
- AirSWOT, as it is today, is capable of supporting many SWOT engineering and science objectives. More details regarding current results and capabilities will be given in other talks.
- Improvements to planning and processing automation will enable AirSWOT to efficiently support future campaigns both in the US and abroad

*Thank You*