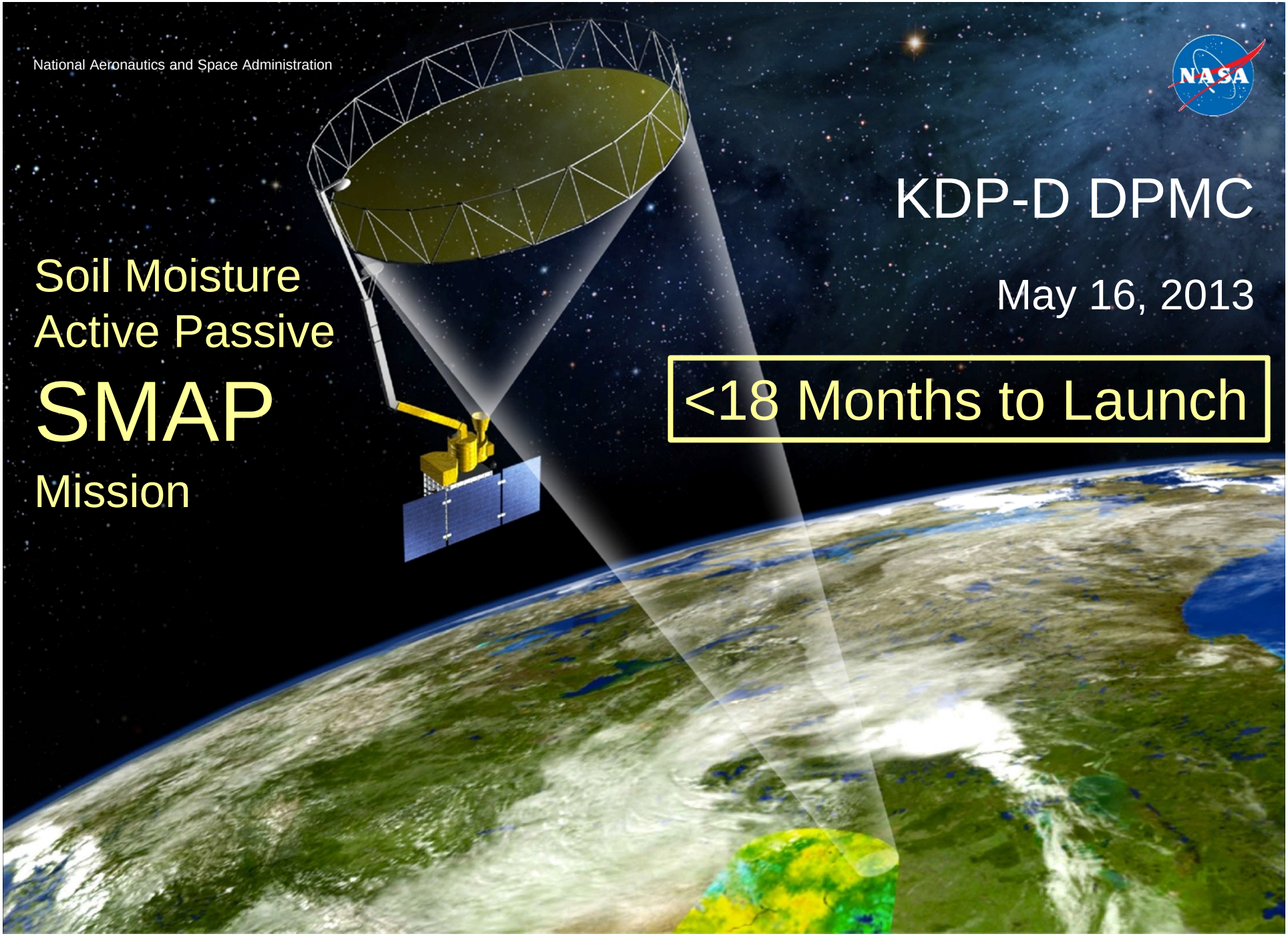
National Aeronautics and Space Administration



KDP-D DPMC

May 16, 2013

Soil Moisture
Active Passive

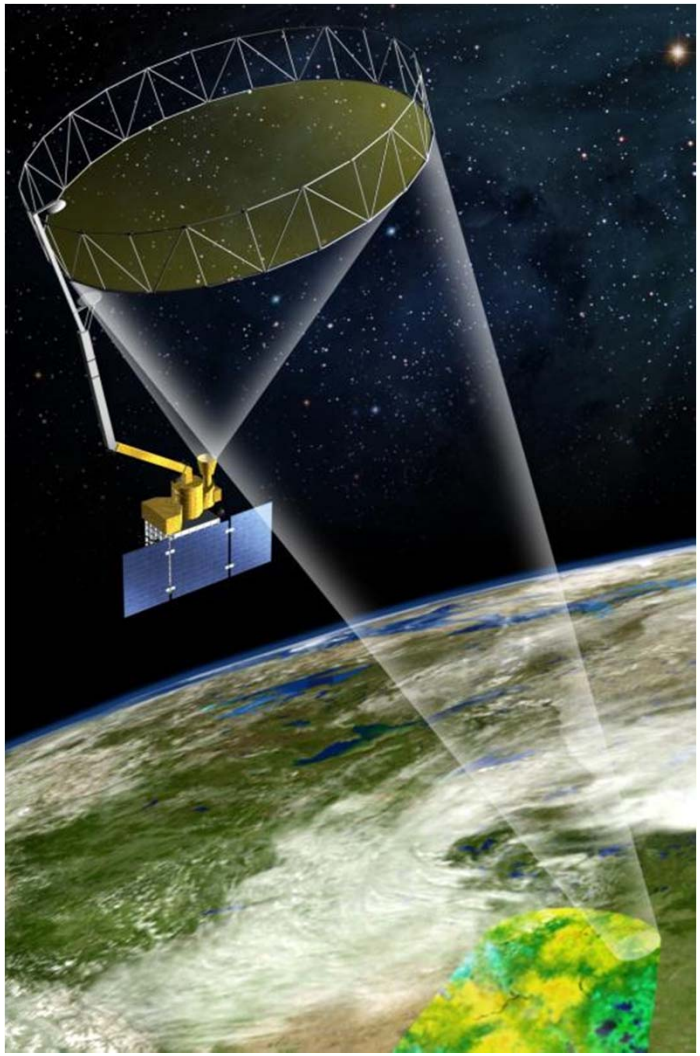
SMAP

Mission

<18 Months to Launch

Jet Propulsion Laboratory
California Institute of Technology

Project Overview



http://smap.jpl.nasa.gov/

Primary Science Objectives

- Global, high-resolution mapping of soil moisture and its freeze/thaw state to
  - Link terrestrial water, energy, and carbon-cycle processes
  - Estimate global water and energy fluxes at the land surface
  - Quantify net carbon flux in boreal landscapes
  - Extend weather and climate forecast skill
  - Develop improved flood and drought prediction capability

Mission Implementation

Partners	• JPL (project & payload management, science, spacecraft, radar, mission operations, science processing) • GSFC (science, radiometer, science processing)
Risk	• 7120.5E Category 2; 8705.4 Payload Risk Class C
Launch	• October 31, 2014 on Delta 7320-10C Launch System
Orbit	• Polar Sun-synchronous; 685 km altitude
Duration	• 3 years
Payload	• L-band (non-imaging) synthetic aperture radar (JPL) • L-band radiometer (GSFC) • Shared 6-m rotating (13 to 14.6 rpm) antenna (JPL)

NRC Earth Science Decadal Survey (2007) recommended SMAP as a Tier 1 mission

Mission Overview: Now Complete with Delta II Selection!

Jet Propulsion Laboratory
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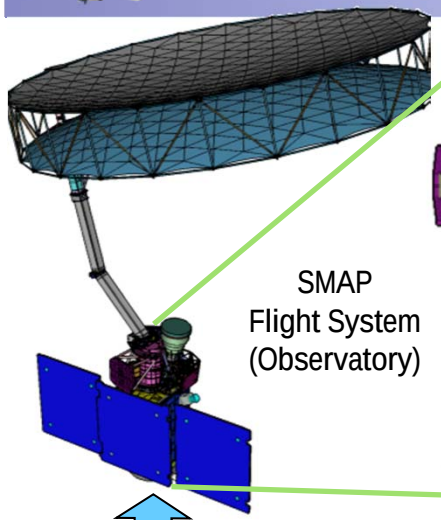


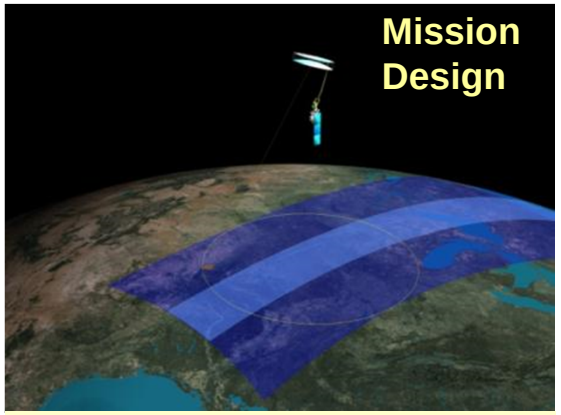
SMAP
Flight System
(Observatory)

INSTRUMENT

- L-band (1.3-GHz) radar (JPL)
- L-band (1.4-GHz) radiometer (GSFC)
- Shared antenna (6-m diameter)
- Conical scan: 13–14.6 rpm; 40° incidence
- Contiguous 1,000-km swath width

SPACECRAFT (& RADAR ELECTRONICS)

- JPL developed & built using MSAP/MSL avionics, power assemblies with small number of new mission-unique cards
- Commercial space electronics elsewhere
- 1450-W generation (Observatory-level)
- 1150-kg wet mass (Observatory-level)
- 80-kg propellant capacity



- 685-km polar 6 PM orbit (Sun-sync)
- 8-day repeat ground track
- Continuous instrument operation
- 2- to 3-day global coverage
- 3-year mission duration

Delta II 7320-10C

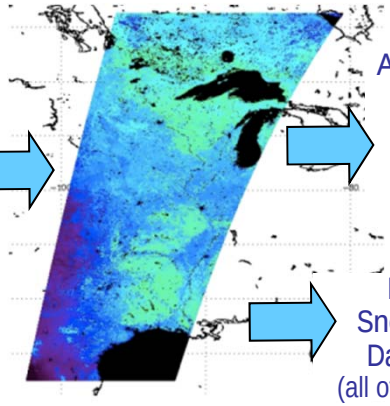
Target Launch:
Oct 31, 2014

Near-Earth Network

Surface Validation

SMAP Mission Operations &
Data Processing
(JPL, GSFC)

SCIENCE DATA PRODUCTS
Soil Moisture & Freeze/Thaw State Data Products



Alaska Satellite
Facility
Data Center
(radar
L1 products)

National
Snow and Ice
Data Center
(all other products)

Instrument Hardware Nearly Complete— On Track to Start Instrument I&T (II&T) in May

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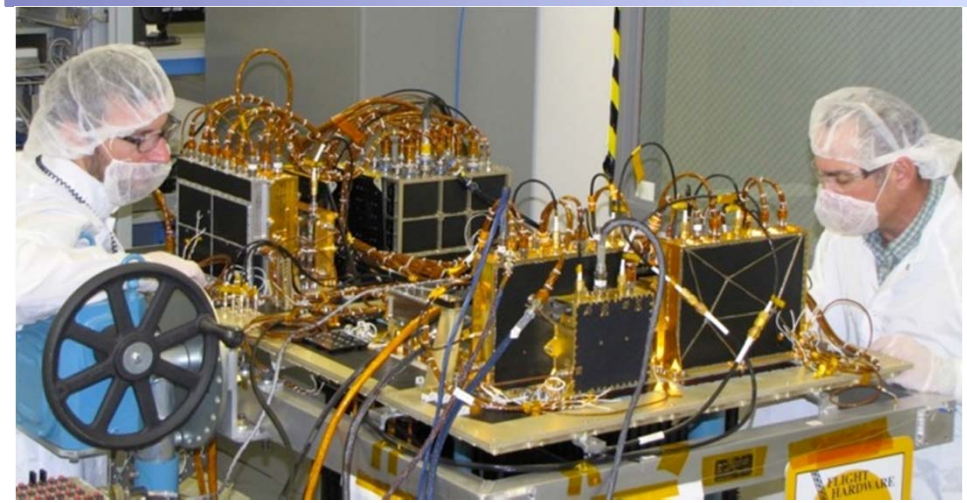
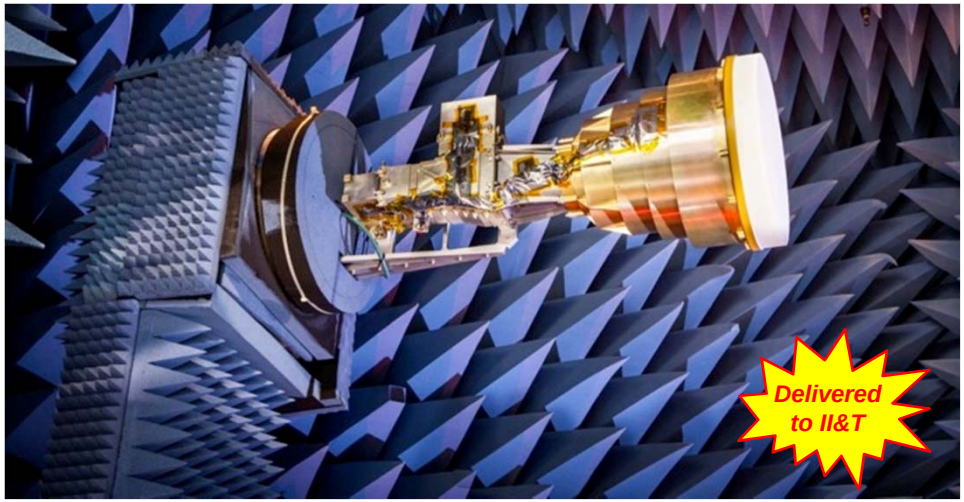
California Institute of Technology

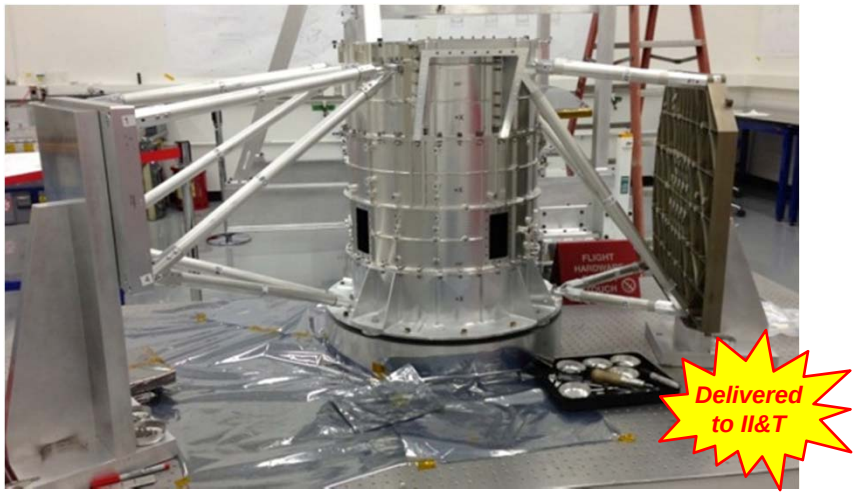


Radar fully integrated on its flight spacecraft bus panel; completed ambient performance testing (almost!) successfully

Radiometer has successfully completed all planned testing at GSFC and has been delivered to JPL/II&T



Feed Assembly has successfully completed all planned assembly-level testing and has been delivered to II&T (photo courtesy NSI)



Spun Structure static load testing was successfully completed; structure has been delivered to II&T

Spacecraft Hardware Nearly Complete—On Track for Spacecraft I&T in August

Jet Propulsion Laboratory
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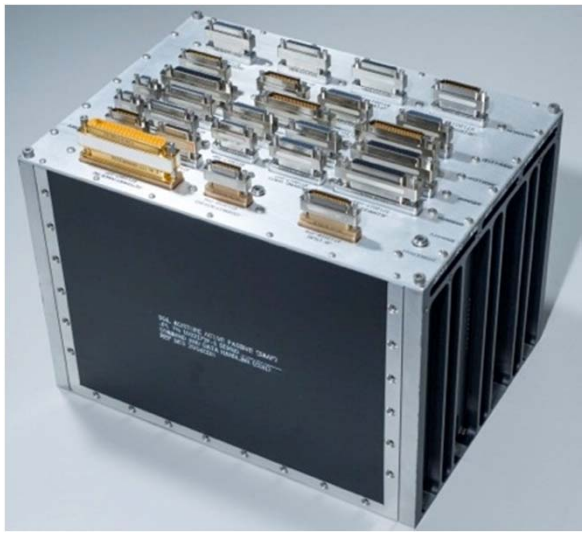
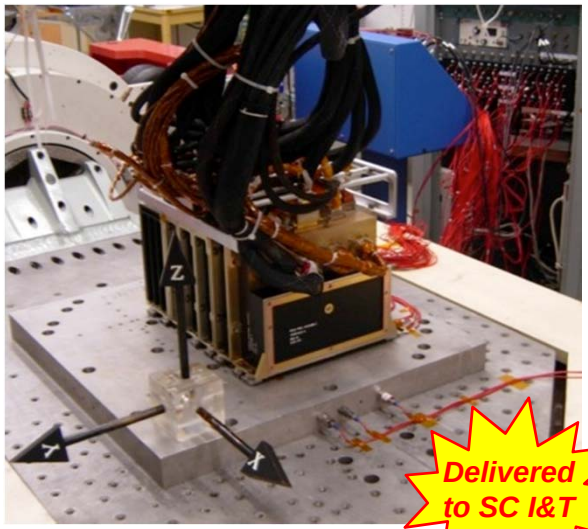
Spacecraft bus structure is assembled and static load tested; final bus panel surface preparations are now being completed



Flight C&DH is integrated; successfully functionally & dynamically tested (shock, random vibe – powered-on)

Environmental & dynamic testing completed; includes testing of recommended mitigation features from RAD750 Tiger Team

Delivery to I&T planned for end of May (2 months earlier than baseline plan…)

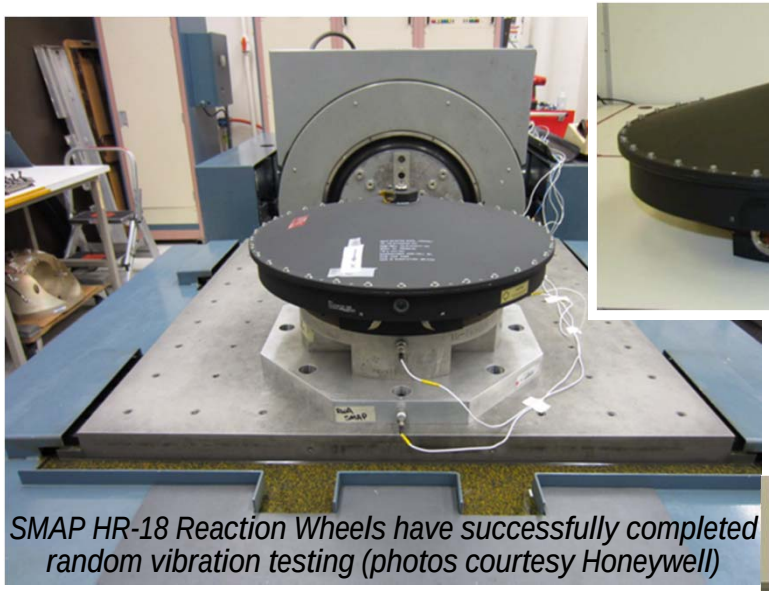


PC/DA assembly is now delivered to Project (delivery completed with no open issues)

Delivered to SC I&T

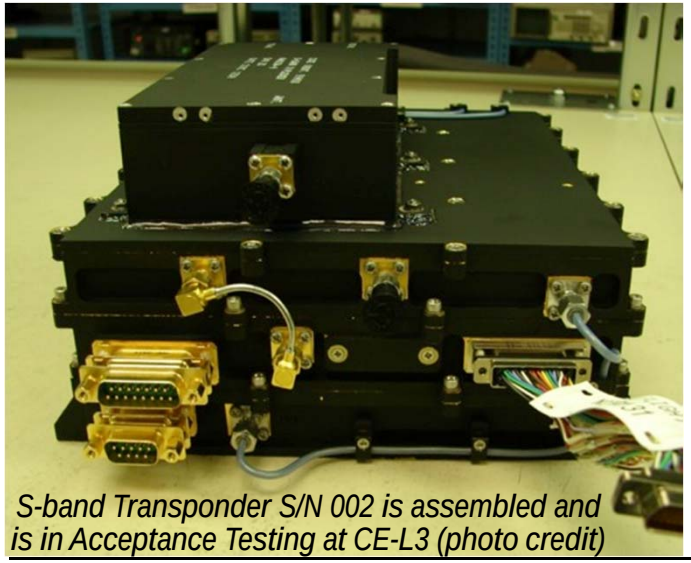
More Spacecraft Hardware Nearly Complete— On Track for Spacecraft I&T in August

Jet Propulsion Laboratory
California Institute of Technology



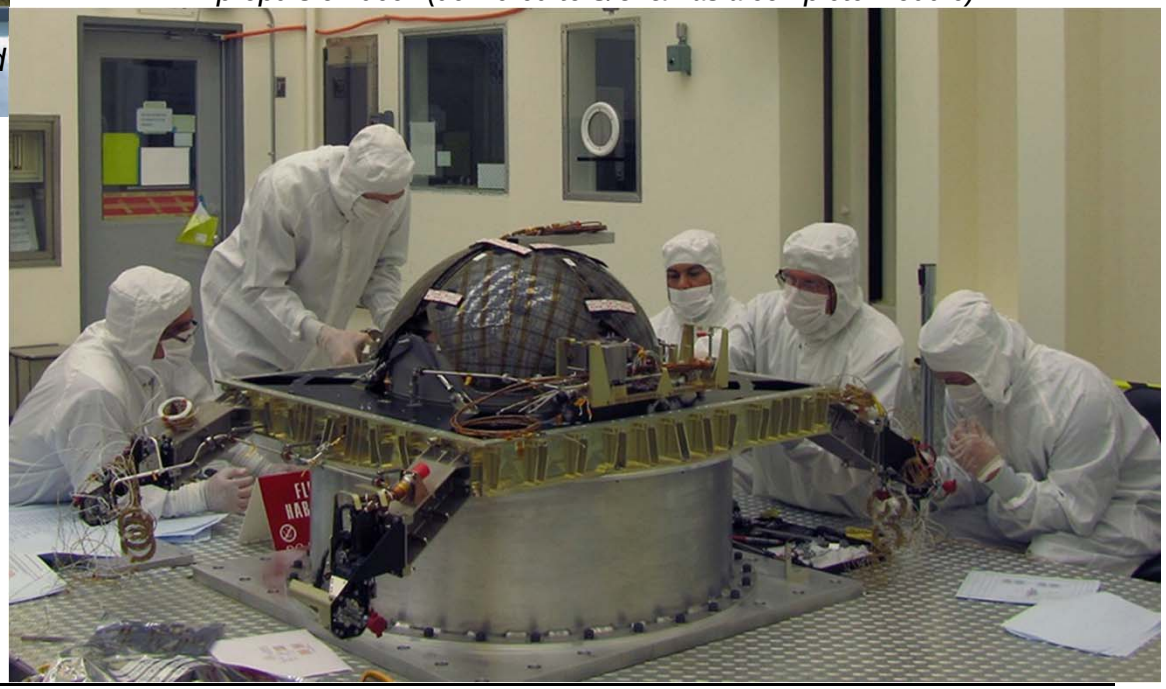
SMAP HR-18 Reaction Wheels have successfully completed random vibration testing (photos courtesy Honeywell)

Wheel Unit



S-band Transponder S/N 002 is assembled and is in Acceptance Testing at CE-L3 (photo credit)

All propulsion components have been delivered and are being integrated onto propulsion deck (delivered to S/C I&T as a complete module)



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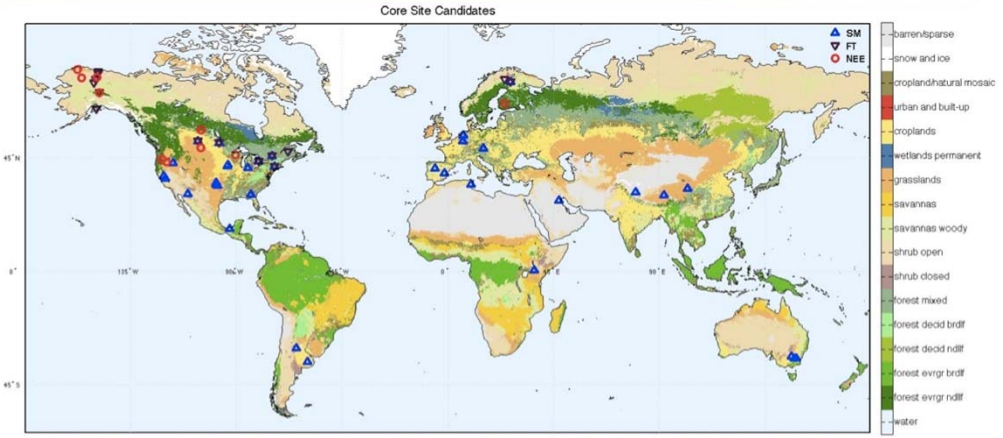
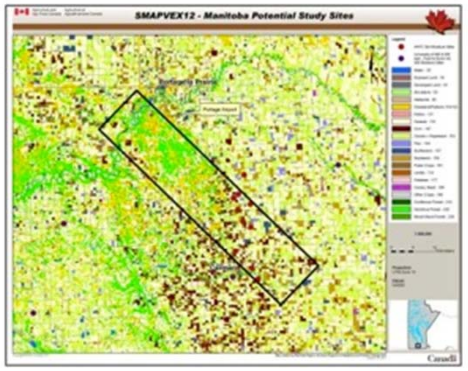
California Institute of Technology

Calibration/Validation Status and Plans

- Cal/Val sites selected in response to no-exchange-of-funds ROSES call
  - Globally-distributed; varied terrain & ecosystems for robust cal/val
  - In-situ data acquisition & processing tested in Cal/Val rehearsals
  - Agreements with partners are in approval





- SMAPVEX12 US-Canadian field campaign in June ’12 near Winnipeg, Manitoba
  - Varied terrain & soil; agriculture, forest, pasture
  - In situ, UAVSAR, and PALS radiometer data have been preprocessed and calibrated
  - Data being used for algorithm refinement

- Algorithm performance review in Sept ’13 will confirm baseline algorithms for “D4” delivery (at-launch algorithm drop) to Science Data System
- Cal/Val Rehearsal 1: Summer ’13 – to identify refinements to Cal/Val plans & tools and to test of core site/sparse network data collection, QC, and match-up analysis
- Cal/Val Rehearsal 2: Summer ’14 – expanded rehearsal based on lessons learned and updated tools and to test SDS in operational environment

Spin on Track for II&T Delivery Plan with Low–Moderate Risk (Mitigations Available)

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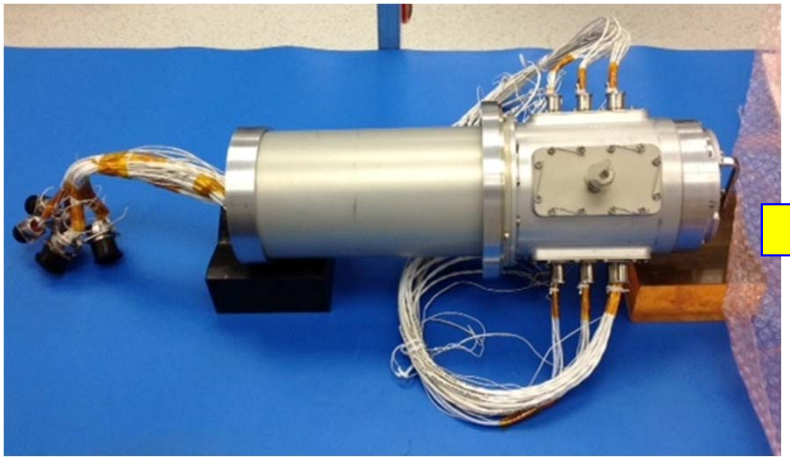
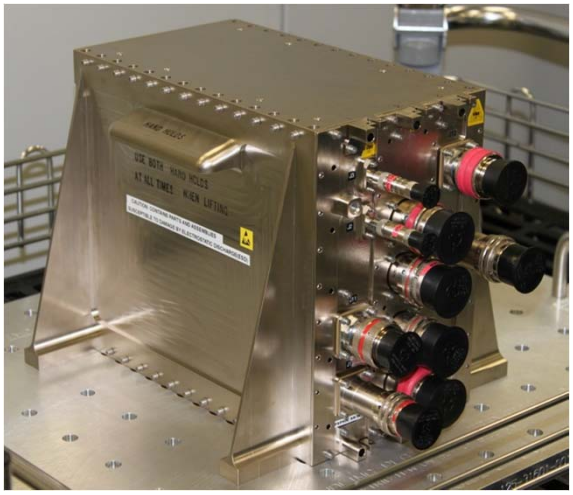


Electrical Contract Ring Assy (ECRA, aka slip rings) have been delivered to Boeing and are being installed into the flight BAPTA

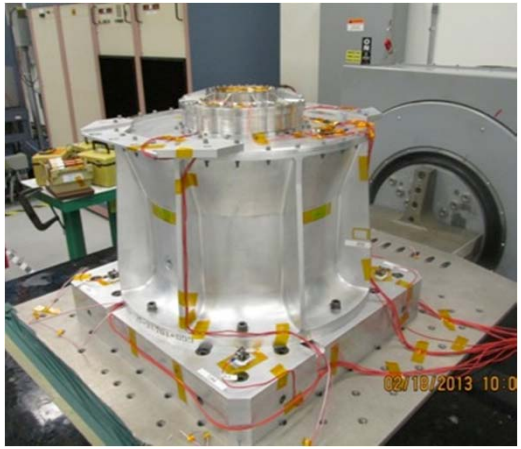
Flight BAPTA Motor Bearing Assy is complete and functionally tested

Flight RF Rotary Joint is ready for installation too!



Integrated Control Electronics in Flight Acceptance Testing

“Hardware in the Loop” aka “HITL” enables closed-loop simulation of spinning Observatory dynamics



Brassboard BAPTA bearing retest successfully completed (fixture now ready for Flight BAPTA testing)

RBA Progressing with Significant Schedule & Cost Risk from V&V Activities (Mitigations Available)

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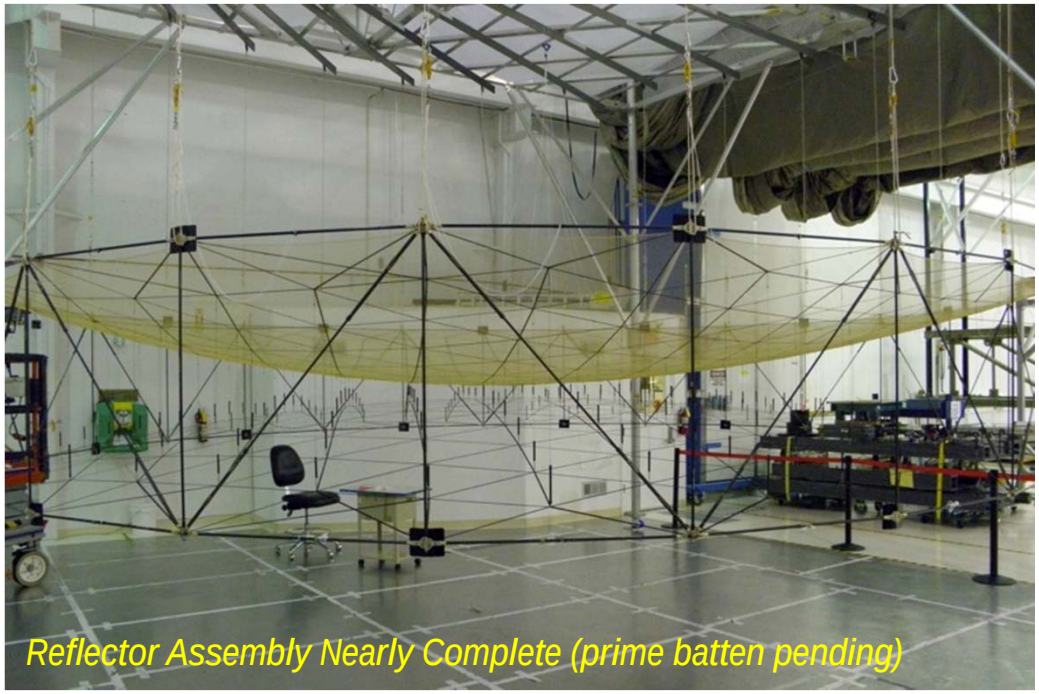
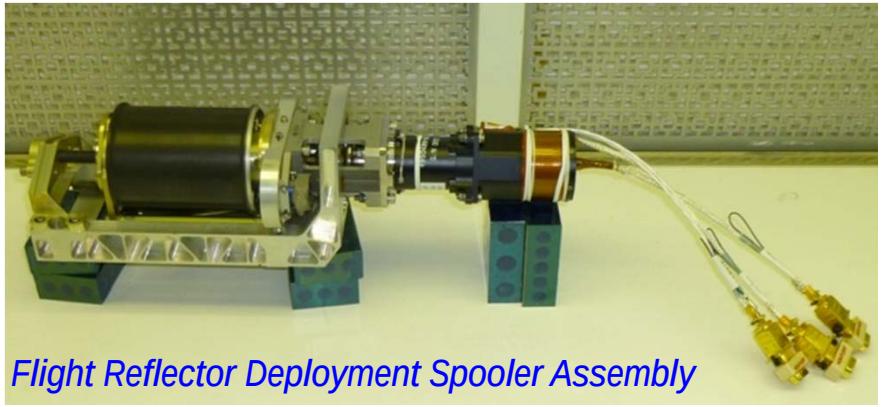
NORTHROP GRUMMAN



Reflector Assembly Nearly Complete (prime batten pending)



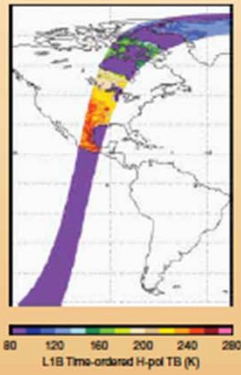
Flight Reflector Deployment Spooler Assembly

Boom Assembly in Alignment and Bonding Fixture (bonding now completed)

SMAP Data Products (Global Simulations)

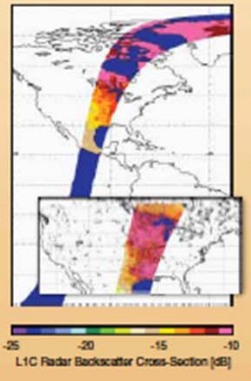
Jet Propulsion Laboratory
California Institute of Technology

Level 1B Radiometer



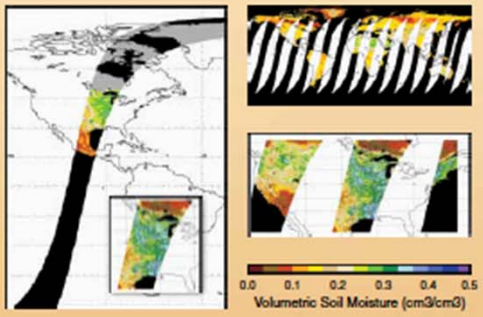
- L1B radiometer coverage is continuous (AM or PM, fore/aft scans) over all surface types
- Contains Earth-located, calibrated brightness temperatures at H, V, and 3rd & 4th Stokes polarizations for each FOV footprint, in time-order
- FOV footprint resolution is approximately 40 km
- 3rd Stokes measurements are used to infer Faraday rotation corrections to the H & V T_B measurements
- EASE grid coordinates for global & polar 36 km grid for each footprint

Level 1C High Resolution Radar



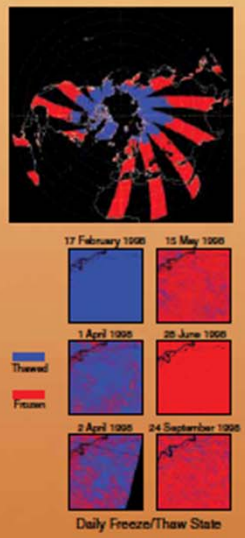
- Has coverage over land and coastal oceans, on the AM orbit pass (AM and PM for regions above 45° N), and uses the forward and aft parts of the scan for the AM pass
- Allows SAR processing to enable high-resolution single-look measurements; has varied resolution from ~400 m at the swath edge to about 1.2 km within 150 km of the nadir subtrack; has nadir looks that are thin slices as wide as the beam footprint
- Contains Earth-located and calibrated radar backscatter measurements for HH, VV and HV

Level 2 and 3 Soil Moisture Active/Passive



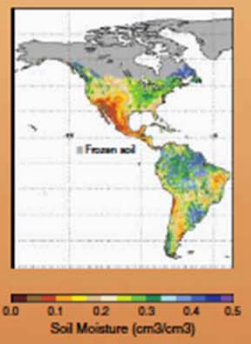
- Merges active (radar HH and VV) with passive (radiometer H and V) channels using a time-series algorithm and spatial heterogeneity of L1C radar products to retrieve ~9 km soil moisture product over land with 0.04 $cm^3\ cm^{-3}$ accuracy for low-to-moderately vegetated areas (VWC ≤ 5 kg/m^2)
- Depends on transient water body and freeze-thaw state retrievals from HiRes radar
- Level 3 daily composite made from Level 2 half-orbits
- Provides global coverage in 3 days

Level 3 Freeze/Thaw



- Quantifies daily land surface freeze/thaw state as a binary condition of land surface
- Uses the 1 km L1C radar HiRes data with a time-series change detection algorithm to infer freeze/thaw state
- 80% F/T spatial classification accuracy
- Results in the posting of output data at 1-3 km spatial resolution with 2 day average temporal intervals for regions above 45° N

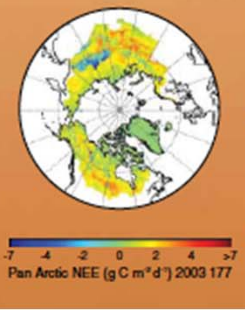
Level 4 Surface and Root Zone Soil Moisture (L4_SM)



- Merges SMAP observations with soil moisture estimates from a land surface model in a land data assimilation system, yielding a product that is superior to satellite or land model estimates alone
- Provides global surface (top 5 cm) and root zone (top 1 m) soil moisture estimates at ~9 km and 3-hourly resolution that are spatially and temporally complete and consistent with SMAP observations
- Includes surface meteorological forcing fields, land surface fluxes, soil temperature and snow states, runoff, and error estimates as research output (validated on a best effort basis)

Level 4 Carbon Net Ecosystem Exchange (L4_C)

- Constrains carbon flux estimates from a soil respiration model and satellite observations of gross primary productivity with SMAP observations



- Provides enhanced global estimates of carbon fluxes at ~3 km and daily resolution
- Uses L3_F/T and L4_SM based soil moisture and temperature with ancillary land cover and vegetation productivity inputs to predict net ecosystem CO_2 exchange (NEE) with the atmosphere
- L4_C accuracy (RMSE) commensurate with in situ tower measurements (NEE <30 g C $m^{-2}\ yr^{-1}$ or 1.6 g C $m^{-2}\ d^{-1}$)
- Results posted to 9-km global grid with daily temporal fidelity

Science Planning is Ready for Implementation

- Science algorithms are in good shape and have been successfully reviewed by NASA HQ appointed science algorithm review panel
  - Algorithm Theoretical Basis Documents are mature and will be released to public in Fall 2012
- Cal/Val plans are maturing
  - CSA partnership is in place to contribute Cal/Val site and science support
  - Several experiments have been completed; a major field campaign (SMAPVEX12) is on track to start on June 6 with PALS and UAVSAR
  - Post-launch planning is maturing – A major Cal/Val review is planned for Oct 2012
- Science Definition Team have been active participants throughout Formulation
  - No issues with instrument performance, missions systems performance and concept of operations
  - Extensive algorithm testing using field experiment & simulation data
  - No issues with Cal-Val plans

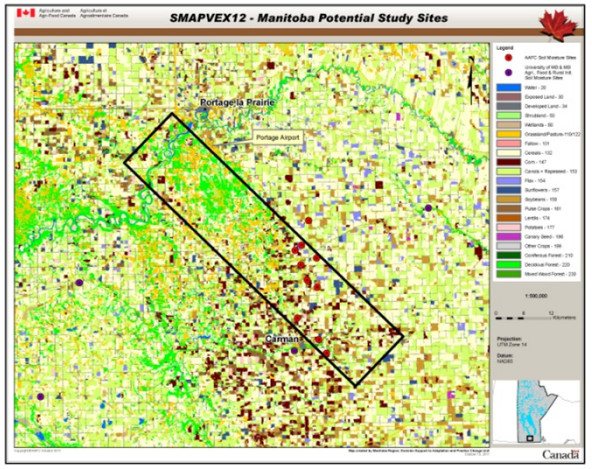
SMAPVEX12 Field Campaign Status

Jet Propulsion Laboratory
California Institute of Technology

- PALS (radar-radiometer) and UAVSAR (radar) sensors will take part in field campaign near Winnipeg, Canada, June 6-July 17, 2012
- Provides multi-resolution active-passive time-series data for pre-launch soil moisture algorithm development under range of soil moisture and vegetation conditions
- Ground conditions (soil, vegetation) sampled by Canadian and U.S. teams including significant graduate student participation
- Local GLOBE schools to be involved also in educational component

PALS on Twin Otter

UAVSAR on G-III



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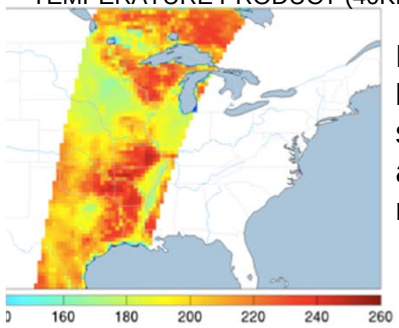
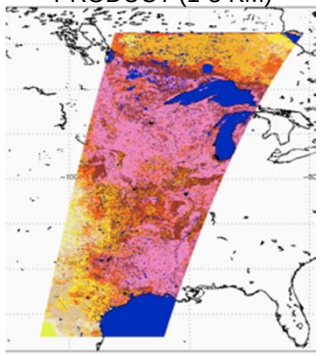
Instrument Overview

RADIOMETER BRIGHTNESS TEMPERATURE PRODUCT (40KM)

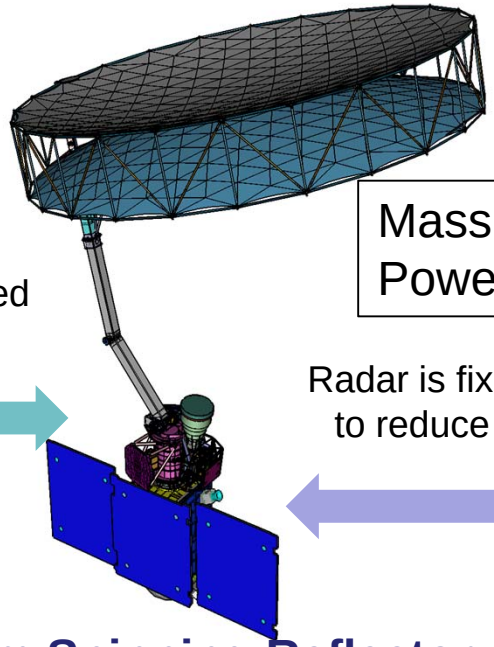


L-band (1.41 GHz)
Radiometer for high soil moisture accuracy at moderate spatial resolution

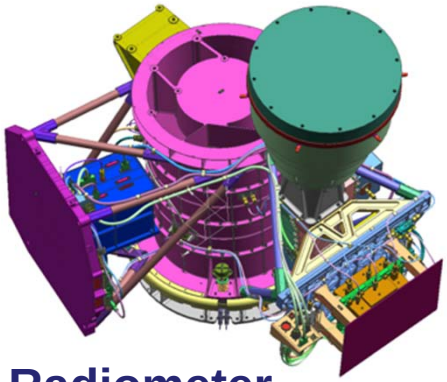
HI-RES RADAR BACKSCATTER PRODUCT (1-3 KM)



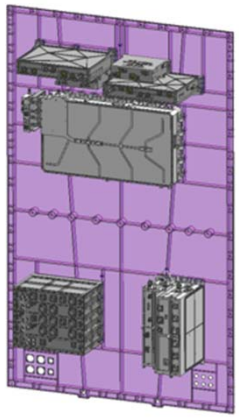
L-band (1.26 GHz)
Radar: Unfocused Synthetic Aperture for high spatial resolution & freeze/thaw detection



Mass: 378 kg
Power: 474W



Radiometer is spun-side-mounted to reduce losses



Radar is fixed-mounted to reduce spun inertia

Radiometer

- Provided by GSFC
- Leverages Aquarius design
- Includes RFI mitigation
- V, H, 3rd & 4th stokes
- 1.3-K accuracy
- 40-km resolution

Common 6-m Spinning Reflector

- Spin Assembly and Reflector/Boom Assembly derived from heritage designs
- Conically scanning at 13–14.6 rpm
- Constant incidence angle of 40-deg

Radar

- Provided by JPL
- Leverages JPL designs
- Includes RFI mitigation
- Polarizations: VV, HH, HV
- 500-W SSPA (9% duty cycle)
- 3-km spatial resolution

Public Engagement Plan Emphasizes Synergy with other Missions, Engagement with Key Partners

Jet Propulsion Laboratory
California Institute of Technology

- SMAP EPO Plan is approved
  - Compliant with SMD policy SPD-18
- JPL-led, with GSFC key support to lead Education component
- Exploiting linkages with other missions such as GPM, CARVE, OCO-2
- Partnerships:
  - Project Wet/Action Education Program
  - Nat'l Science Teachers Association
  - Goddard Education & Middle School
  - 4H Organization
  - GLOBE (Global Learning & Observations to Benefit the Environment)
- Website and social media engaged

SMAP's Project Scientist explains soil horizons and their importance

Students get a hands-on sense for varying soil moisture levels and the impact on surface temperature

A SMAP engineer explains to students how soil moisture is measured from space