AIRS Operations, Calibration, and Extended Mission Status

Steve Broberg

NASA Sounder Science Team Meeting
October 6th, 2020

AIRS Cal Team:
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AIRS Operations Team:
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Jet Propulsion Laboratory, California Institute of Technology, *Millenium

Aqua status courtesy of the EOS Aqua FOT/FDT

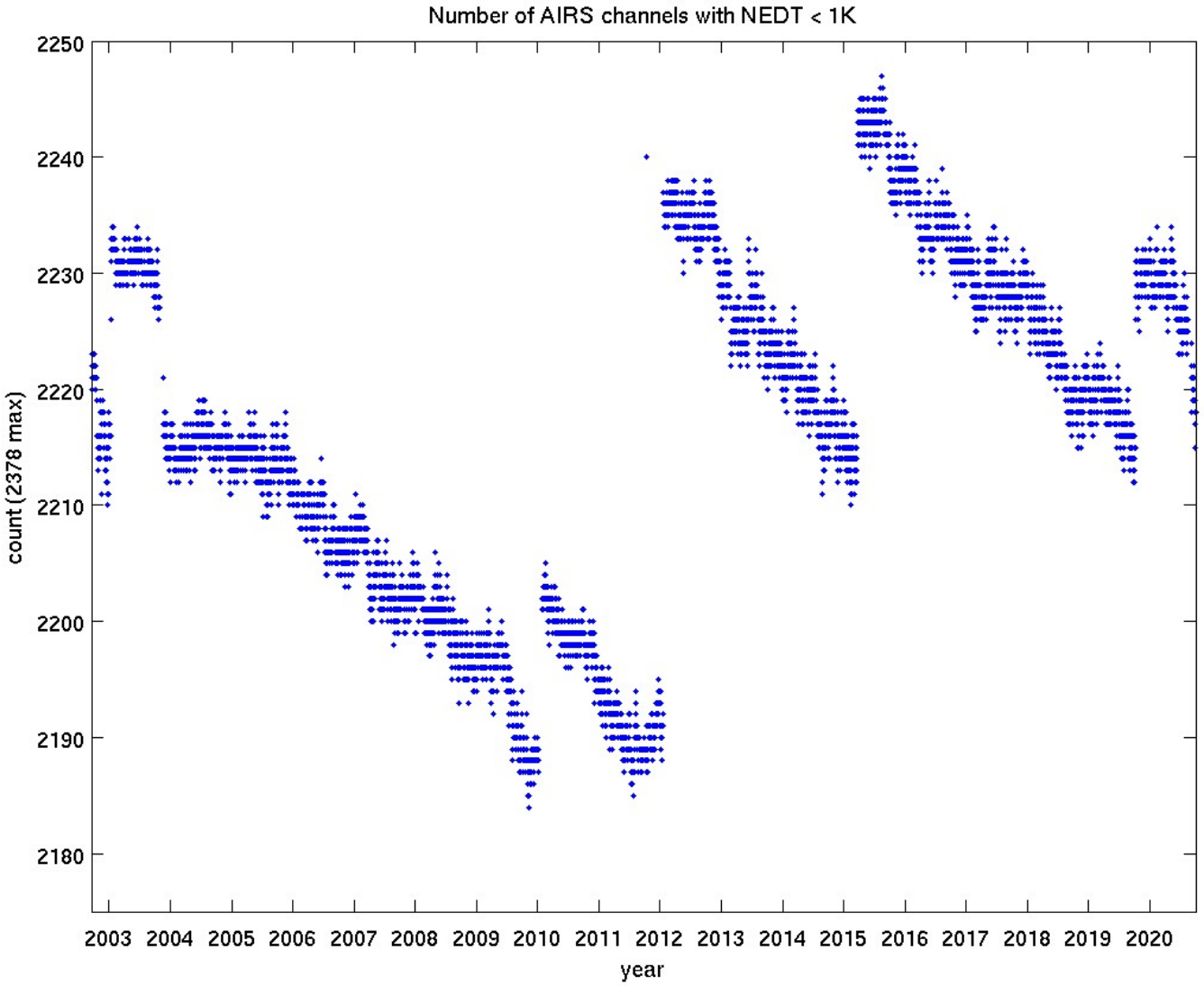
AIRS Operations Status

Image an image of the lonely Maytag repairmen here. Removed for copyright concerns.

- Nothing to see here. For AIRS. Last anomaly 2016-09-25 .
- Wait! Aqua FMU/SSR Anomaly 8/16-9/2. Data lost, but no impact instrument health.

AIRS Health

Number of AIRS channels with NEΔT < 1K



- There are no health issues indicated in engineering telemetry
- AIRS channel health remains good, at/near launch levels with periodic table update

Gain Table loads

2003-01-10
2003-11-18
2012-01-21
2013-06-10
2015-03-23
2019-10-07

Instrument Events

2003-10-29 Solar Flare safety shutdown
2010-01-09 28V SEU
2014-03-22 Cooler A 58K-> >107K
2016-09-25 Cooler A 58K-> 68K

Aqua Operating Margins (time/lifetime)

The Aqua spacecraft is in very good condition (expected subsystem life/reserve in parens).

Fuel is the limiting factor, as constrained by the 25 year re-entry requirement:

- Fuel (2022):
  - there is sufficient fuel to maintain the A-Train constellation orbit until early 2022 (maintain mean local time (MLT) at ascending node of 13:35:45 ±45 seconds).
  - After exit, the orbit drifts until power becomes the operating constraint.
- Power (2025):
  - At the current pace of solar string degradation (20 of 132 strings lost) and current spacecraft load, predictions show power margins will reach a limit in ~9/2025.
  - Spacecraft load management schemes could be altered to reduce the required power necessary.
- Batteries (2031):
  - No lost battery cells at this point, predictions have shown that the capacity of the cells will be able to support the max depth-of-discharge limit until ~2031.

Cal Team New and Ongoing Tasks

- L1B characterization
  - -> coefficient and implementation updates
- Optical model updated (Yuri Beregovski) – viewing geometry exploration
- Scattering investigation (Chris Wilson, this session)
- PSF reconstruction (Igor Yanovsky, this session)
- AIRS instrument descripition update for the web (Brian Sutin)

Cal Team Recent/forthcoming Publications

SPIE Annual Meeting (Aug. 2020)

- Understanding the possible effect of scan mirror contamination (Wilson et al.) (this session)
- Causes and effects of AIRS optics temperature cycles (Manning et al.)

Remote Sens. 2020, Volume 12

- “Evaluating the Absolute Calibration Accuracy and Stability of AIRS Using the CMC SST” (Aumann et al.) (Aug. 2020) doi:10.3390/rs12172743
- “SI-Traceability and Measurement Uncertainty of the Atmospheric Infrared Sounder Version 5 Level 1B Radiances” (Pagano et al.) (April 2020) doi:10.3390/rs12081338

TGRS (under review)

- “Evaluation of bias and trends in AIRS and CrIS SST measurements relative to globally gridded SST products.” (2020)

AIRS L1 Products - Level 1C

- AIRS v6.1 L1C was released 2015
  - Based on v5 L1B
  - Cleans noisy and known bad detectors, fills spectral gaps with synthetic values
  - 2645 frequencies vs. 2378 in L1B
  - Has been available at the GES DISC as a 1 month rolling window
- AIRS v6.7 L1C released March 18, 2020, adds:
  - spectral model from Strow
  - spectral resampling (to fixed grid)
  - The entire mission isavailable at GES DISC DAAC
  - Supports Larrabee Strow's CHIRP product
  - Enables use of new RTA
- AIRS v7.1 L1C (2021)
  - Improved v7.1 L1B input
  - New netCDF4 format
  - Other potential improvements – e.g., synthetic channel replacement

AIRS L1 Products - Level 1B V7 changes/status

New coefficients – “Version 7 Level 1B Radiometric Calibration Updates” (Pagano et al.) (this session)

- New calibration coefficients handling (A/B independent, time dependent polarization) – done
- New space view polarization handling (4 SVs treated independently) - done
- Increase precision of radiances - done
- Spectral estimate per granule (Bob Deen version) - done
- Spectral estimate per scan (newer Strow model – include in L1B, or ancillary file?)
- Non-gaussian noise characterization - eliminated
- Pop/moon detection dynamic thresholds (desired, but TBD)
- Clear, SO_2, and dust flags (new algorithms, include in L1B? L2-like, but popular)
- Scene homogeneity (“C_{ij}”) - improve metrics – eliminated (“good enough”)
- New output formats (netcdf) – in process
- L1B Vis – gain updates - planned

L1 current and near-future versions

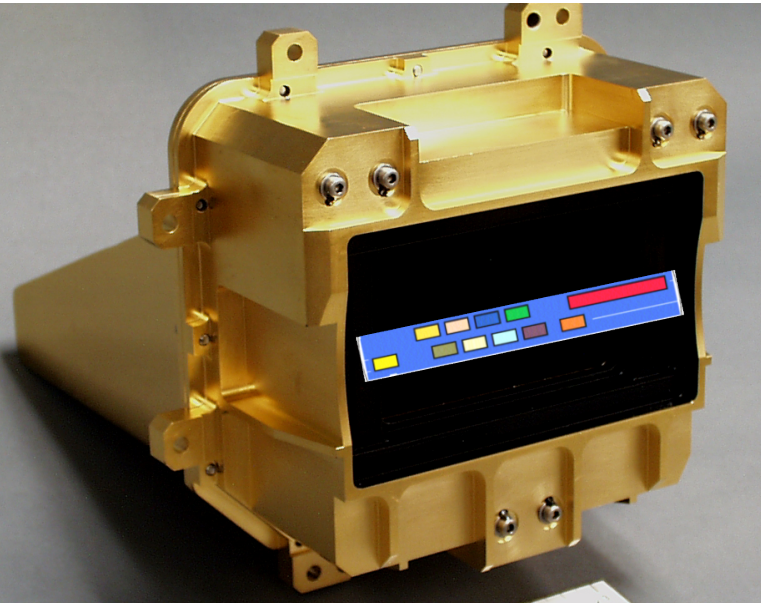
	Level-1B		Level-1C		
	v5 L1B	v7.1 L1B	v6.1 L1C	v6.7 L1C	V7.1 L1C
Release date	2007	Expected 2021	2015	3/18/2020	Expected 2021
Availability	Full record	Full record	Rolling 1 month archive	Full record	Full record
Channel set	Non-monotonic 2378 channels with 10 gaps and 6 overlap regions		Monotonic 2645 channels with one gap 1615-2180 cm^{-1}		
User quality control	Users must check QC flags, and channel properties for bad channels. Also check noise levels and flags within the L1B for calibration problems.	Simplified problem flagging.	Always usable unless an entire spectrum is missing. Optionally check noise and flags to exclude synthesized values or second-order issues. v6 versions based on v5 L1B. v7 based on v7 L1B.		
Spectral stability	Unstable with orbital cycle and long-term change each about 1% of SRF width		Stabilized within 0.2% of SRF width		
Format	HDF-EOS	netCDF4	HDF-EOS	HDF-EOS	netCDF4

Bucket list (pre A-train exit) tests

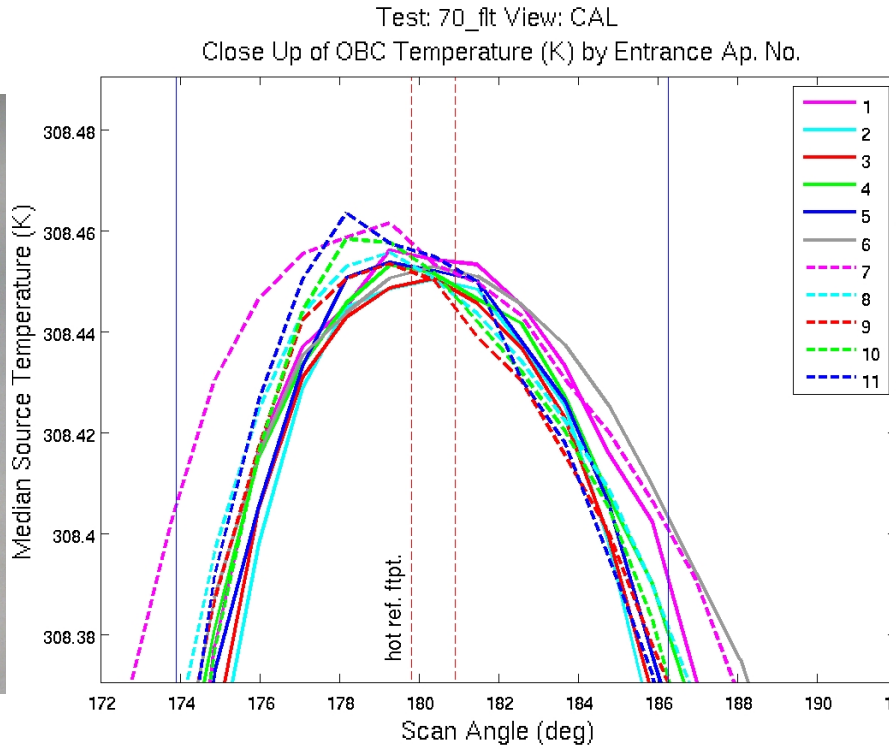
- Deep Space Maneuver – Aqua will try to fit it in before the Constellation Exit Maneuver
- A/B data extended data sets (one day or more)
- Cal sequences
  - Baseline cal test suite – C6, C7, C8, C9, C10
    - C5 = OBC Float – perform last – before or after deep space maneuver?
    - C6 = Variable Integration Time
    - C7 = Space View/OBC Noise
    - C8 = Radiation Circumvention
    - C9 = Scan Profile: Space, OBC (optimize space view for glint)
    - C10 = VIS / NIR Radiometric test
  - C3 (channel spectra phase test)? – requites adjusting choke point heater temperature
- After constellation exit
  - Repeat cal tests – C6 - 10

In-flight calibration sequences – rotated scan profile

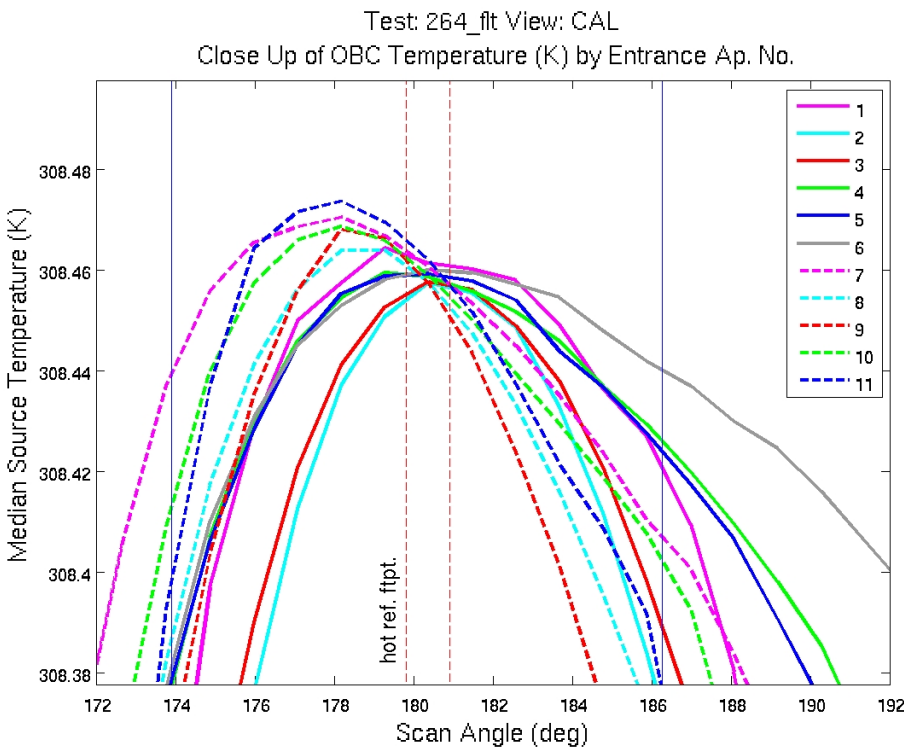
- In-flight cal sequences will be run more frequently towards end of main mission to better/ characterize calibration, quantify/explain trends
- Rotated scan profile test – the scan is rotated so the slow portion of scan is centered on the calibration sources (OBC or SV). Changes observed, but are small (< 19 mK over 12 years)



July 2002

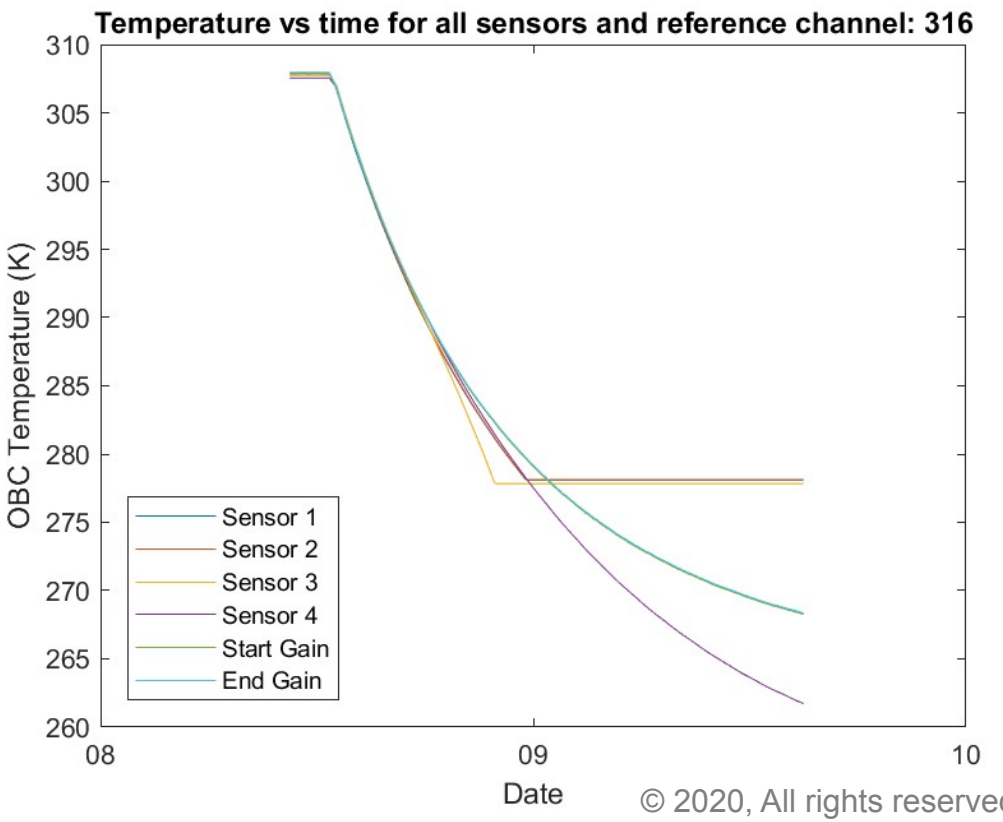


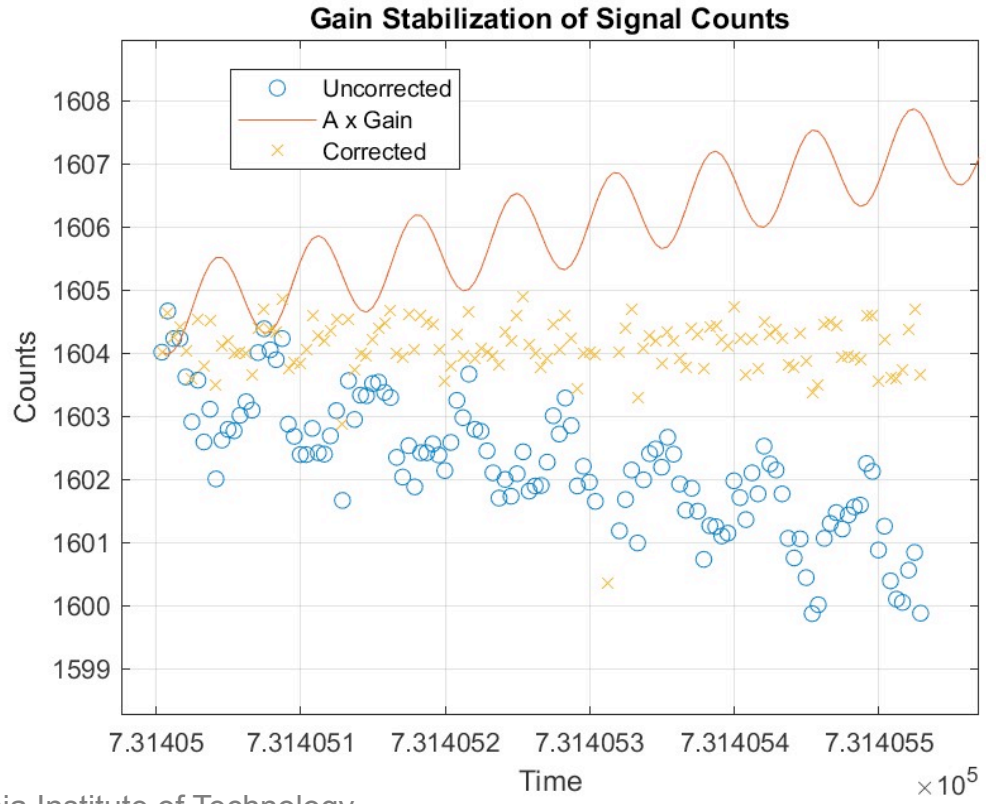
April 2014



In-flight calibration sequences – OBC Float

- The OBC float test is where the OBC temperature control is turned off and the temperature allowed to fall to evaluate non-linearity.
- Originally discontinued because of temperature uncertainty. Resolved with analysis using stable reference channel and gain stabilization/compensation. (Pagano, SPIE 2019)
- OBC float (planned as part of pre-exit bucket list)

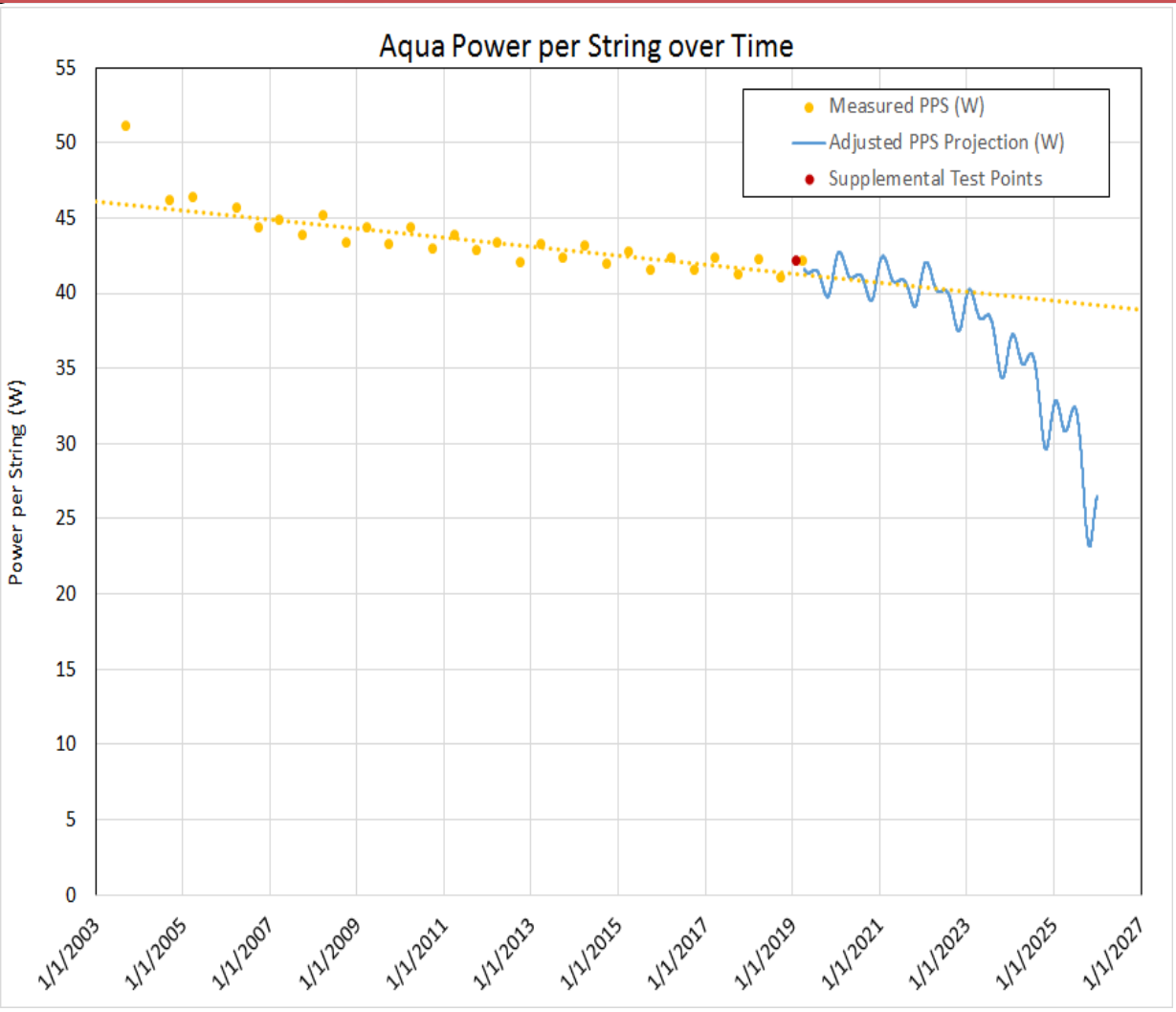


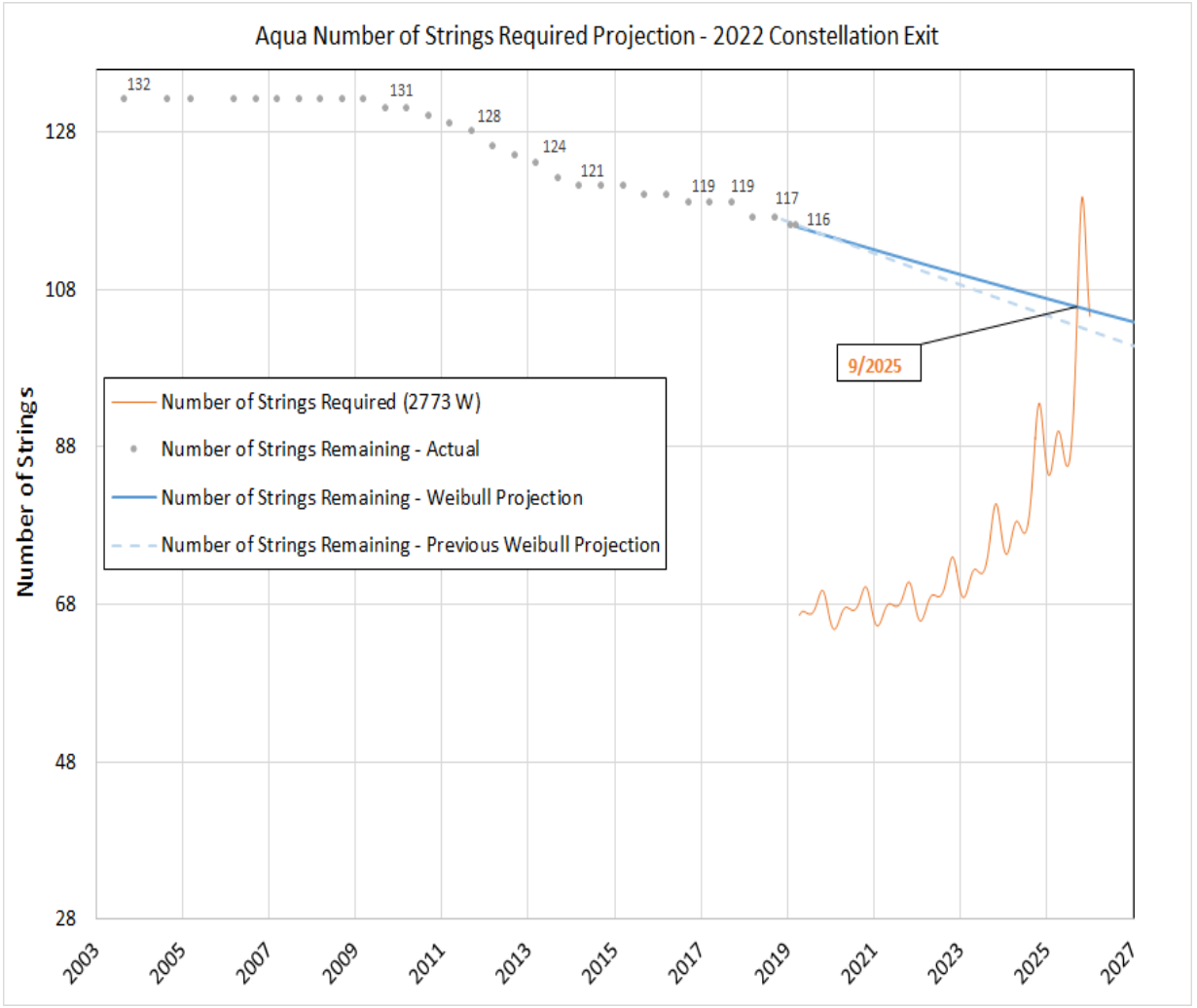


Aqua Extended Mission Plans

- Exit the A train by lowering Aqua's orbit in Spring 2022 (Jan-Feb timeframe).
- From that point, sun synchronicity will not be maintained.
  - MLT will drift, reaching 15:00 by 1/1/2025 and 15:30 by 9/2025.
- The Aqua spacecraft is expected to be able to support the science mission for several years beyond the orbit-lowering maneuver, with power being the limiting factor, ~9/2025 currently, perhaps 2026 and beyond with TBD power management schemes.
- Roughly 3.5 years post A-train exit currently projected

Aqua Projected Power Generation



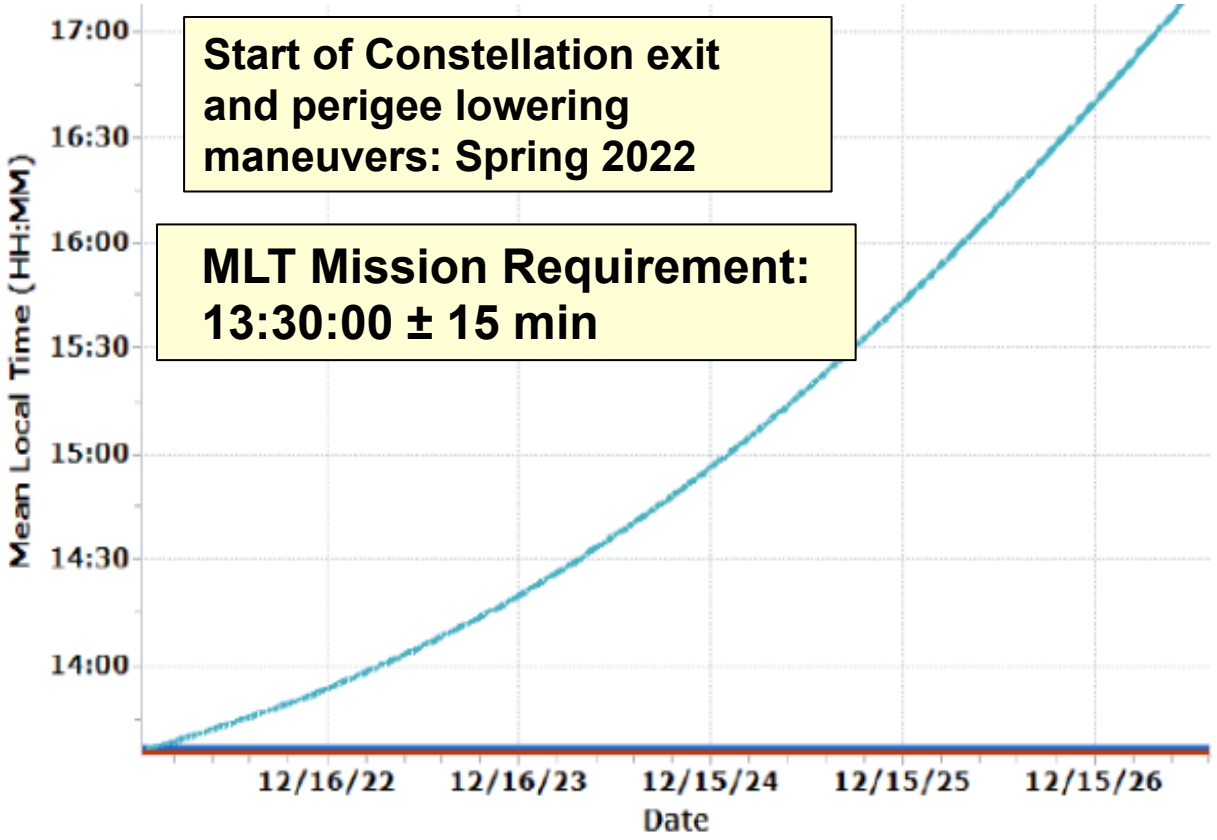


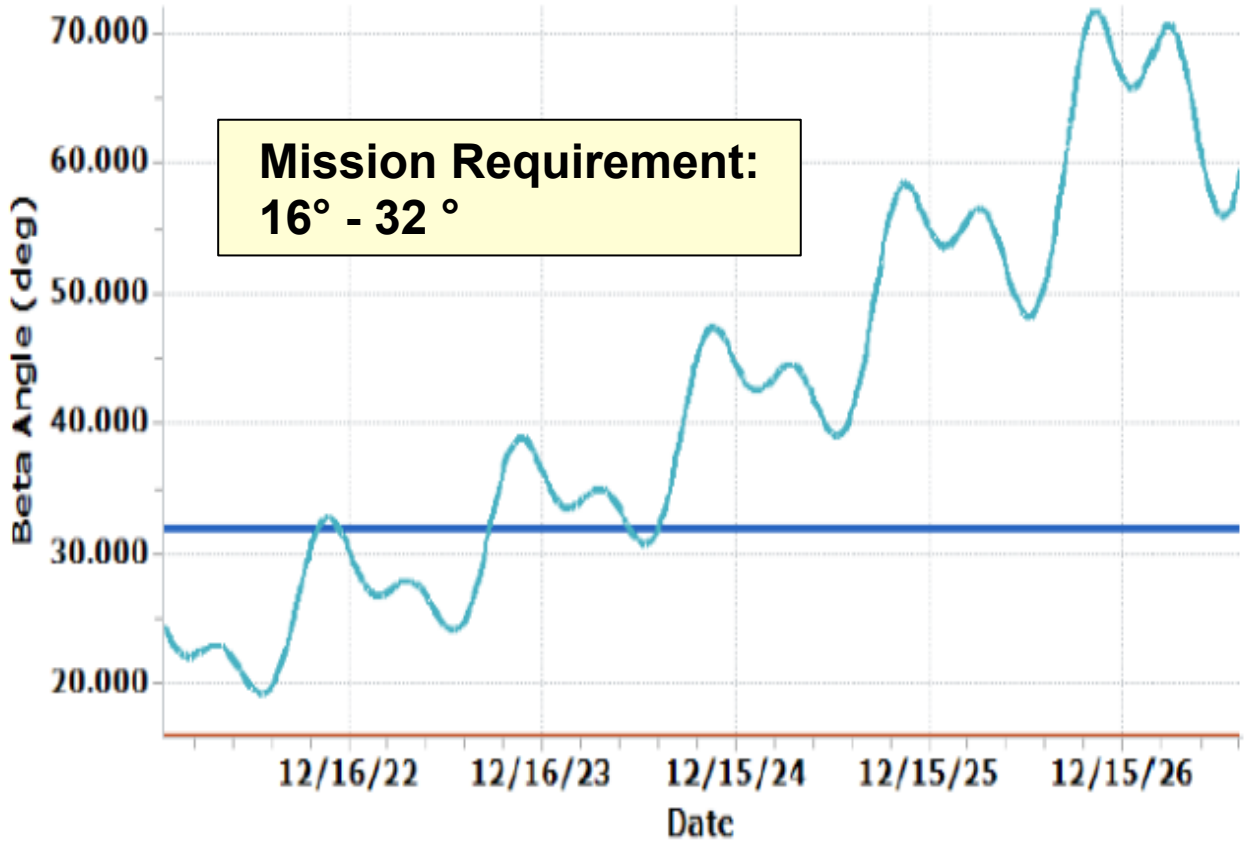
Current best estimates for the 2022 exit case predict the power margin threshold would be violated in approximately September 2025

(Charts courtesy of EOS Flight Dynamics Team)

Aqua and AIRS Expected to Function Beyond 2022 A-Train Exit

- Post-2022 orbit will have a thermal impact on AIRS – specifically, the 2nd stage heater will need to draw more power to maintain the spectrometer temperature set point
- Safety and thermal/calibration impact being assessed with spacecraft and instrument models
- Current modeling efforts show a +20k impact to the sensor (initial modeling was +65K),
- FPA temperature expected to hold.





- A-Train exit (lowering) maneuvers to 680 km: Jan-Feb 2022
- Actual fall to earth in mid 2040s

(Charts courtesy of EOS Flight Dynamics Team)

Summary

- AIRS is in good health, expected to function as long as Aqua can supply it power
- Calibration team focus - understand/characterize radiometric uncertainty and trends
  - Increased special in-flight testing/analysis as main mission draws to a close
- A-Train exit
  - Thermal analysis indicates small temperature excursion (20 K), instrument focal plane temperature can be maintained
  - Spectral knowledge will need to be assessed/updated more dynamically for L1C/L2.
- L1C v6.7 released
  - added interpolation to a fixed frequency grid – available for the entire mission
  - Enables use of new RTA
- V7 L1B and V7 L1C next on the delivery docket