J1 CrIS Mission Readiness

Lawrence Suwinski, Clayton Buttles, Rebecca Malloy (Frain),
Don Ripplinger, Steve Wells

Harris Corporation
Space and Intelligence Systems*
Fort Wayne, IN

STAR JPSS Science Team Annual Meeting
August 24-28, 2015
College Park, MD

*formerly Exelis Geospatial Systems

Agenda

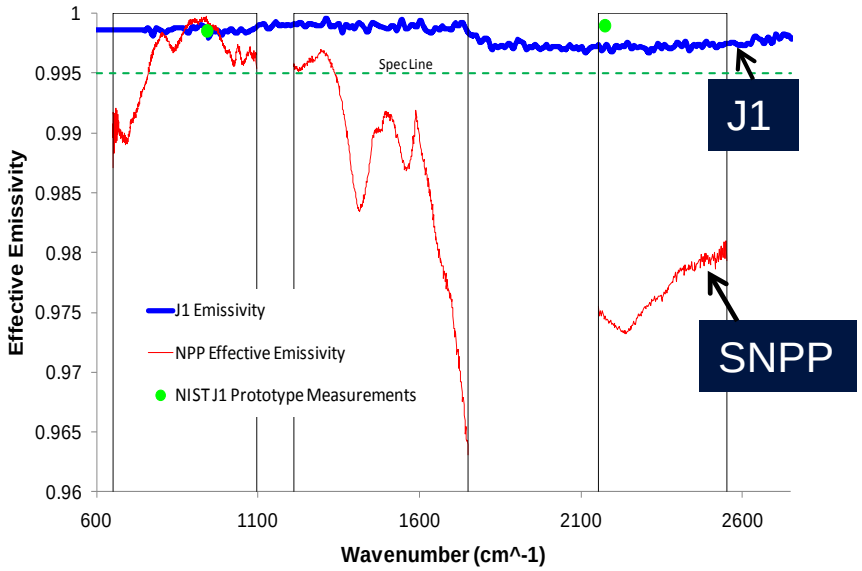
- J1 Design Improvements
- System Test Summary
- Spacecraft Level Testing
- J1 Launch Readiness
- Summary

J1 DESIGN IMPROVEMENTS

J1 CrIS ICT Performance Greatly Improved From SNPP

- J1 Internal Calibration Target (ICT) redesigned to improve performance
  - Specular coating provides increased emissivity and better stray light rejection
  - Cavity wedge design helps eliminate views to other optical surfaces within instrument
  - Additional PRT provides increased temperature and gradient knowledge
  - Results in simplified SDR processing and more accurate calibration performance
- Other J1 design improvements include frame and FPGA robustness enhancements

Improved Emissivity



Stray Light Views Eliminated

View From	To	Fractional View to Environment (NPP)	Fractional View to Environment (J1 and up)
ICT Base	ICT Walls	0.000	0.000
ICT Base	ICT Base	0.000	0.000
ICT Base	ICT Baffle	0.175	0.000
ICT Base	Scan Baffle	0.508	0.000
ICT Base	Scan Mirror		
ICT Base	Frame	0.214	0.000
ICT Base	Opto-Mechanical Assembly (OMA)		
ICT Base	Warm Beamsplitter	0.086	0.000
ICT Base	Cold Beamsplitter	0.008	1.000
ICT Base	Space	0.009	0.000

SYSTEM TEST SUMMARY

J1 CrIS Successfully Completed Comprehensive Test Program

- EMI testing
- Vibration testing
- TVAC testing
  - Noise Equivalent Spectral Radiance (NEdN)
  - Radiometric Performance
    - Radiometric Uncertainty
    - Repeatability
    - Detector Linearity
  - Instrument Line Shape (ILS) / Spectral Accuracy
  - Day in the Life
  - Field of View (FOV) Shape / Coregistration
  - Dynamic Interaction
  - Electrical Performance

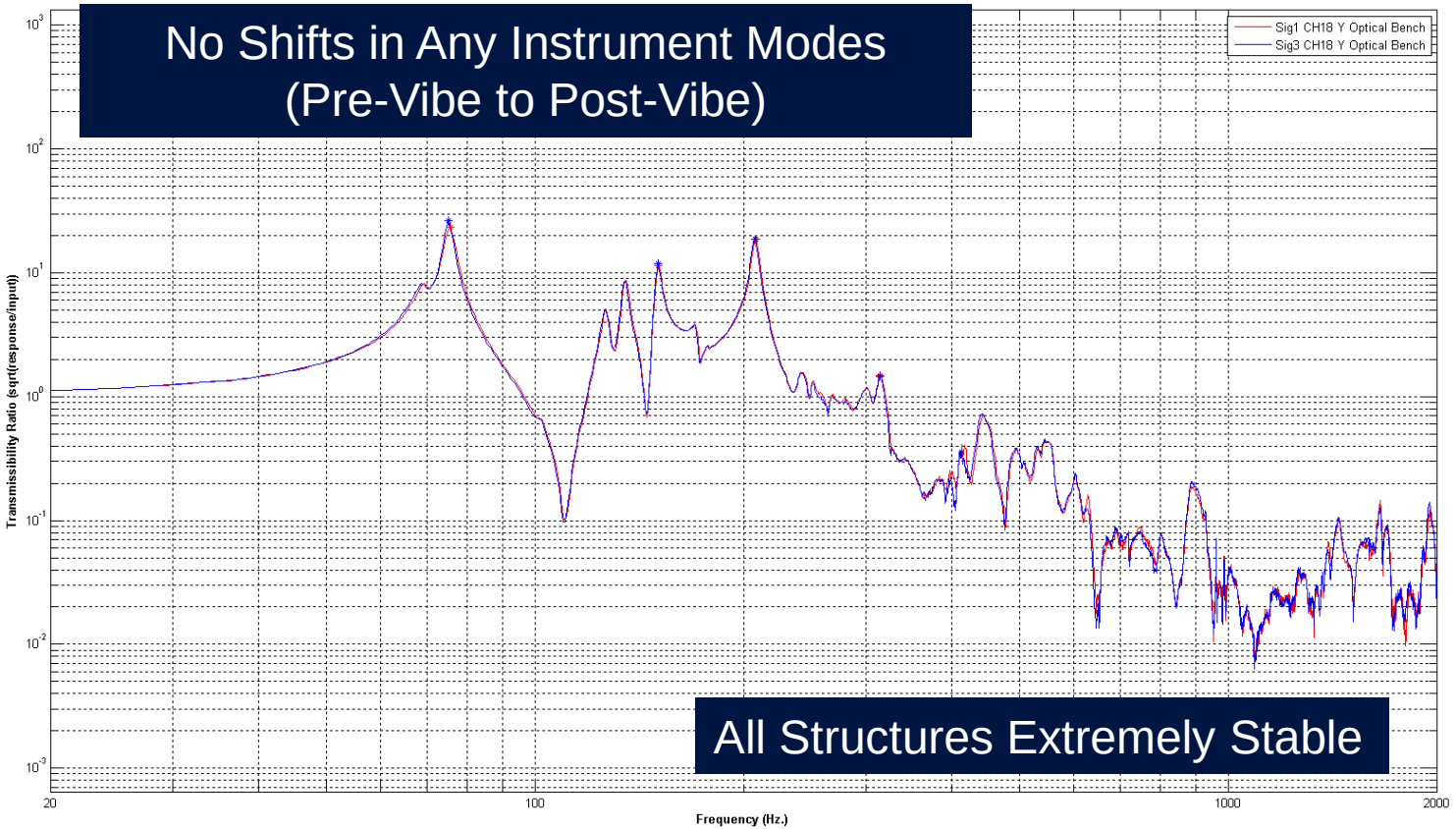
EMI Testing Very Successful

- Testing covered large range of frequencies while carefully examining instrument data
  - >5000 Excitation frequencies
  - >2200 Spectral channels monitored
  - All telemetry affecting science data monitored

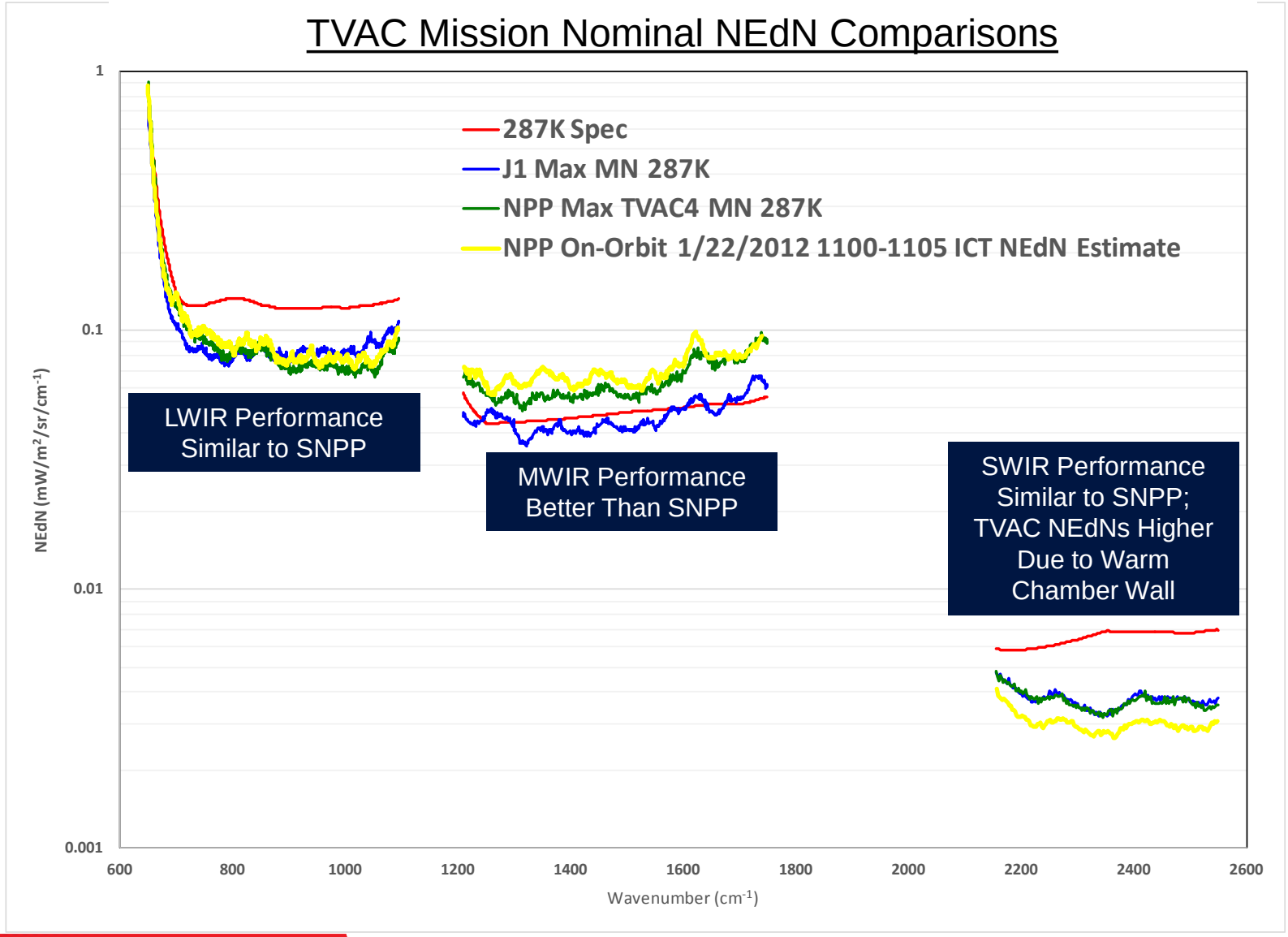
- Testing was highly successful
  - Nearly all conditions fully compliant
  - Less than 20 minor discrete outages out of >50 million test conditions and/or telemetry points monitored
    - All reviewed by SMEs / user communities and deemed to be acceptable for flight
    - Minor outages at frequencies/levels not seen on spacecraft

Vibration Testing Highlights Exceptional Structural Stability

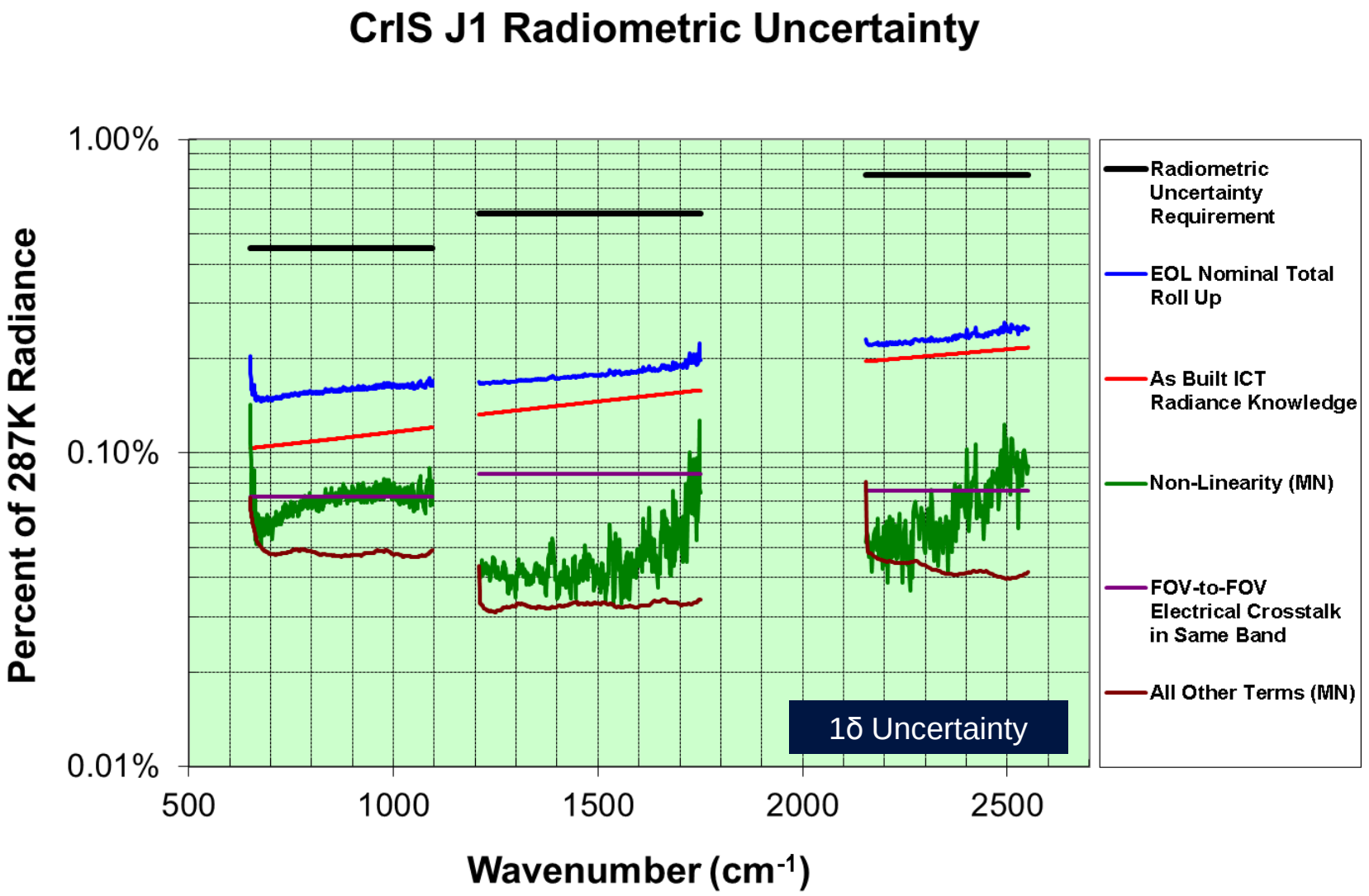
EXELIS



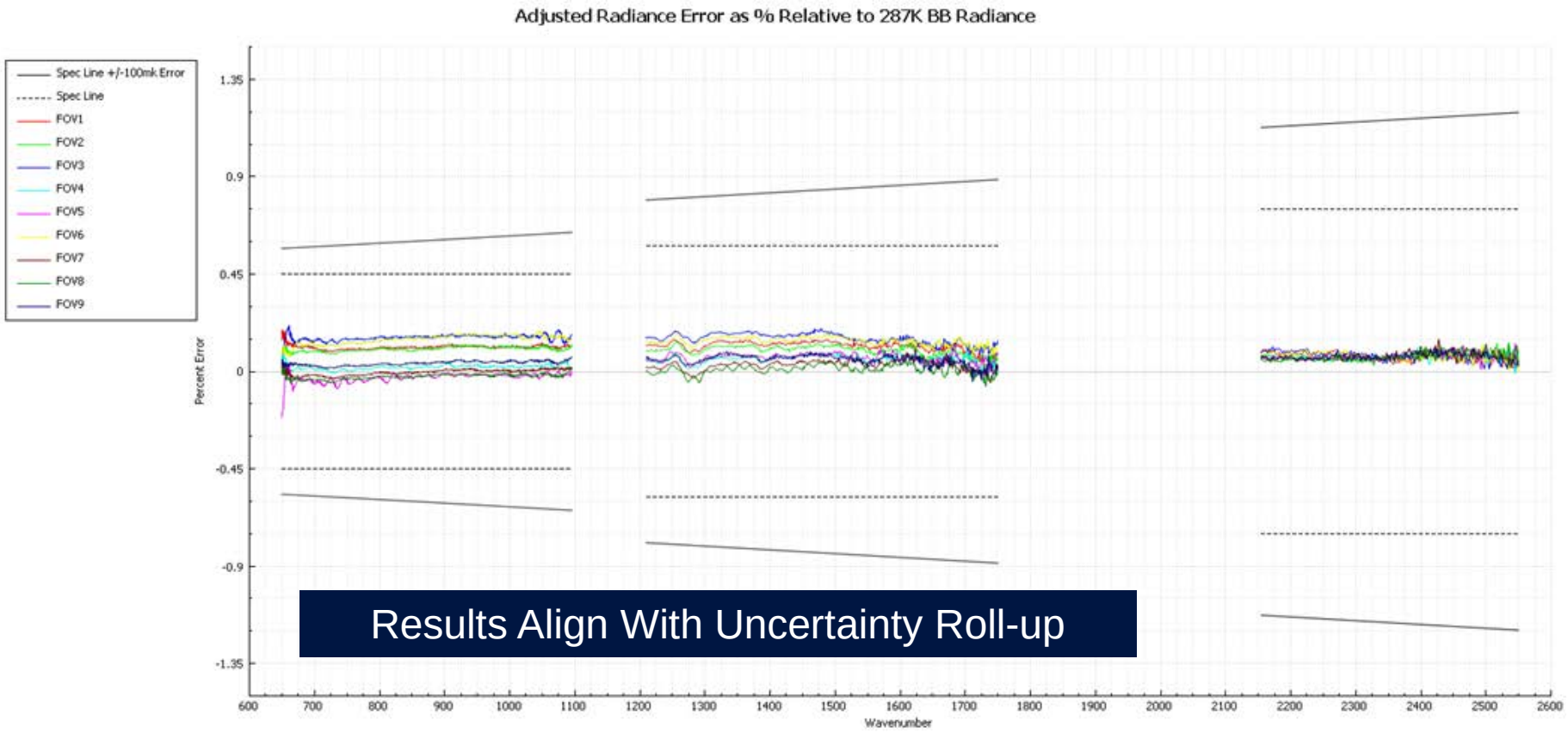
J1 NEdN Performance Equal to or Better Than SNPP



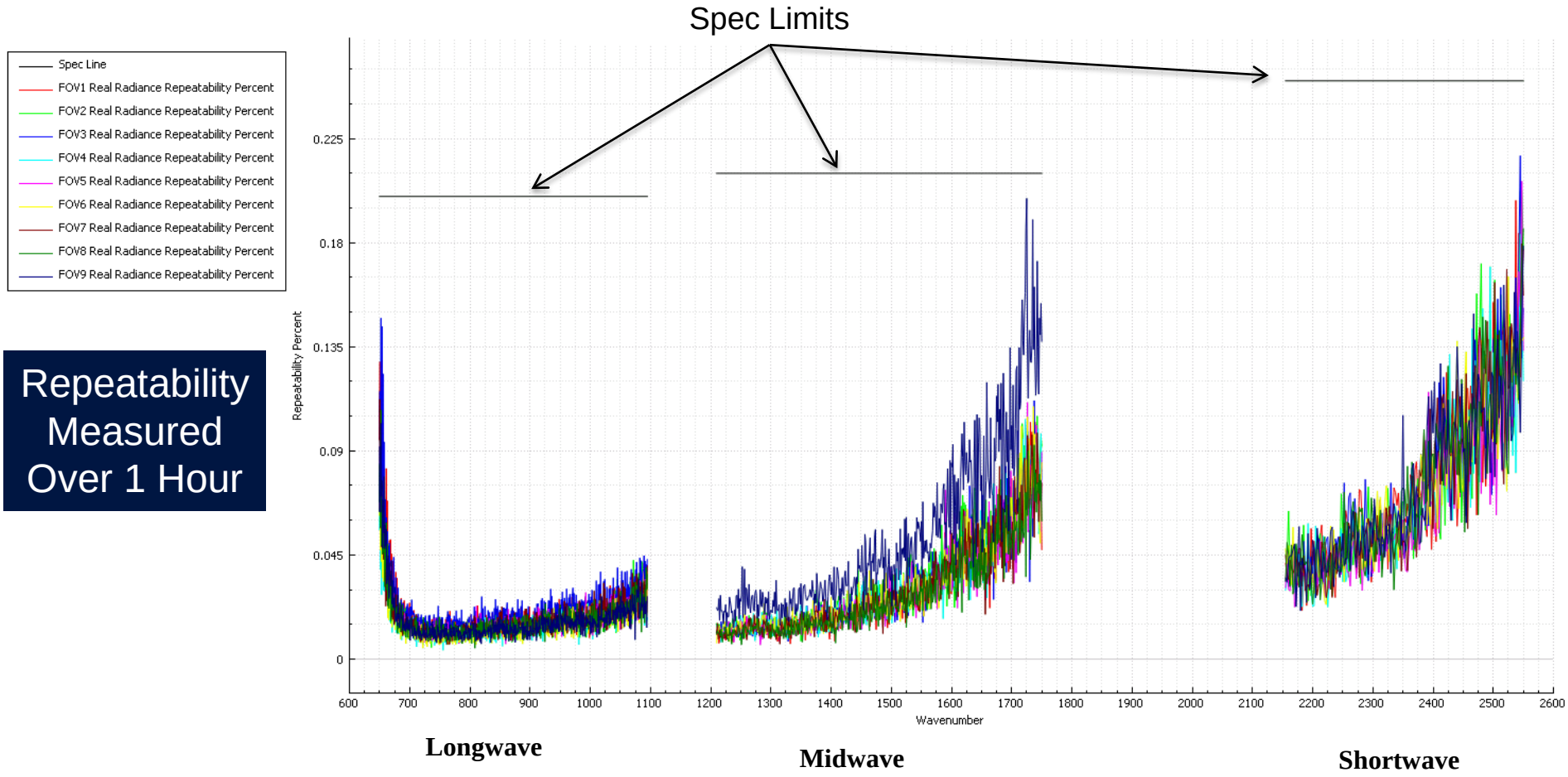
J1 Radiometric Uncertainty Performance is Excellent



Uncertainty Roll-up Confirmed With Test Data

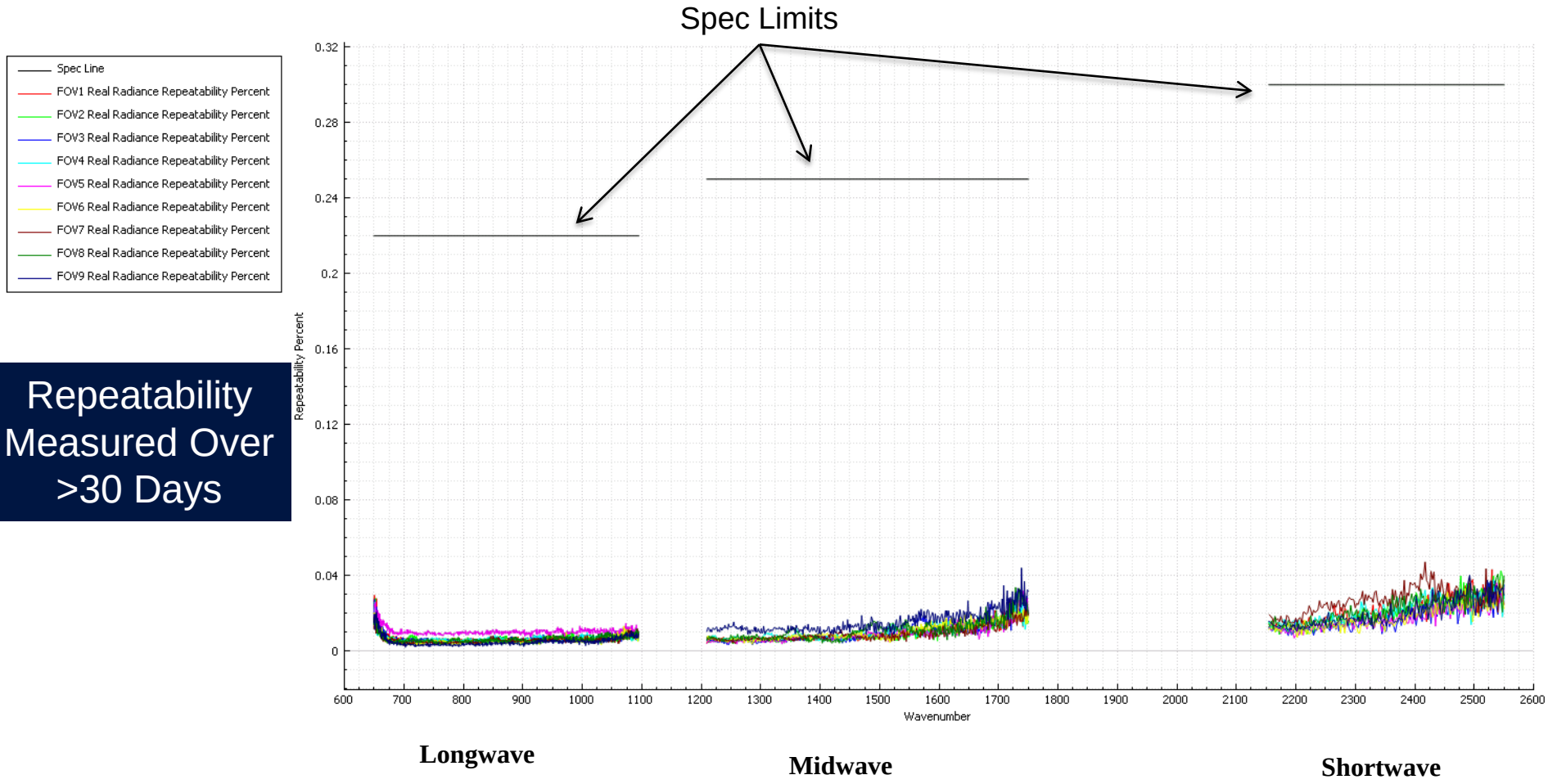


Short Term Repeatability Performance Within Specification



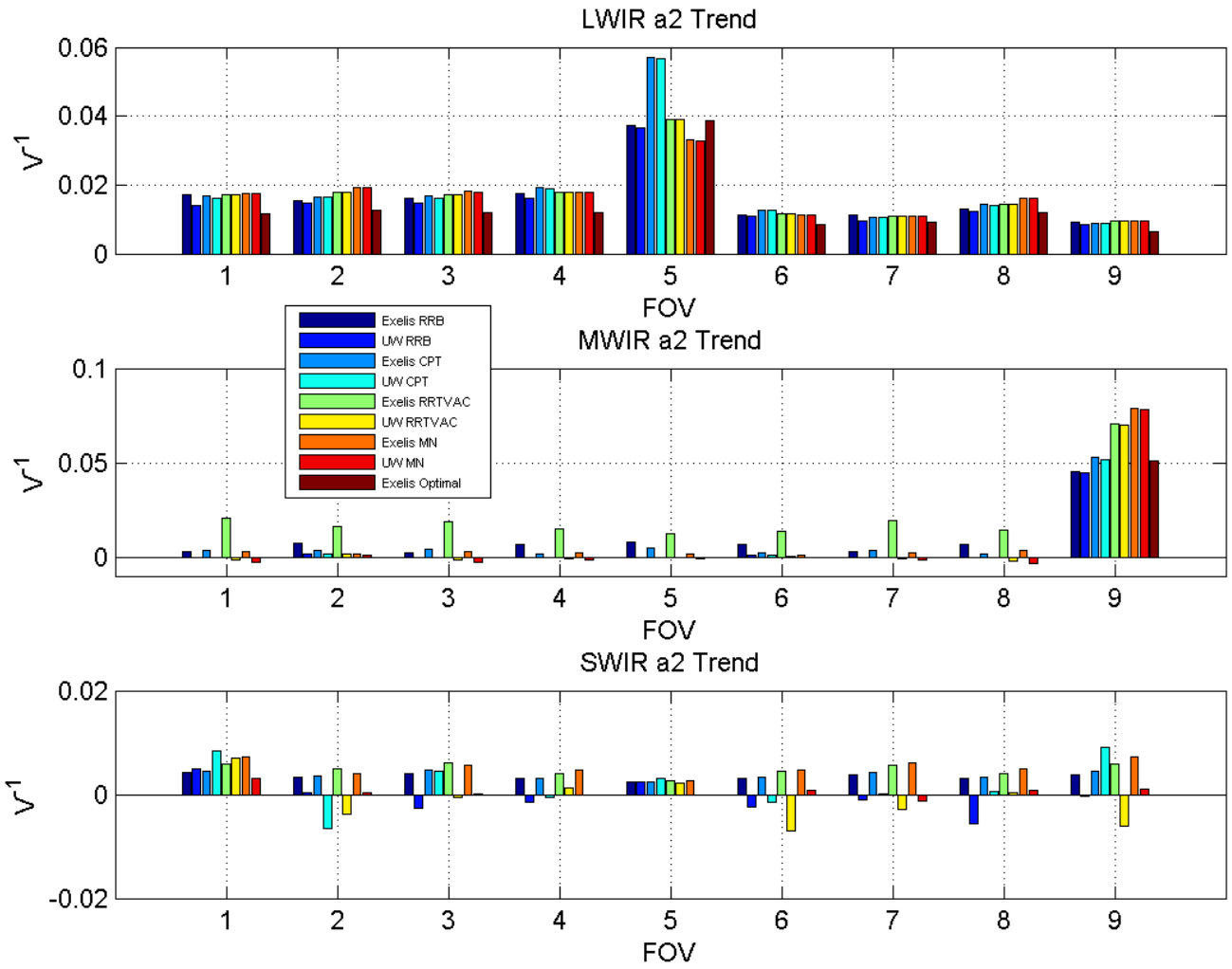
Repeatability Measured Over 1 Hour

Long Term Repeatability Performance is Outstanding



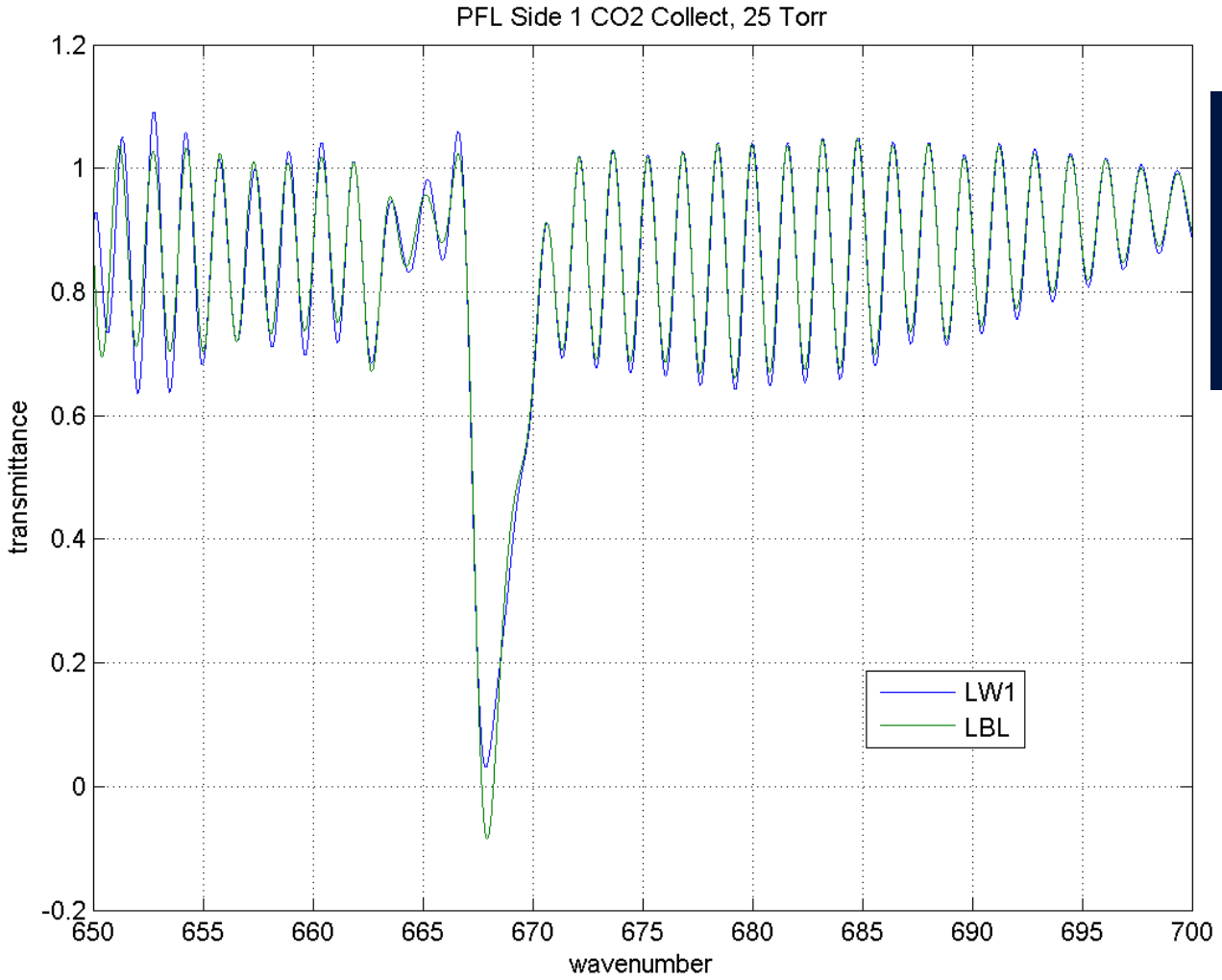
Repeatability Measured Over >30 Days

Detector Nonlinearity Levels Stable Over System Test



Harris and UW Values Match Very Closely; Parameters Tuned Further On-Orbit

Spectral Uncertainty Results Show Excellent Agreement With Truth

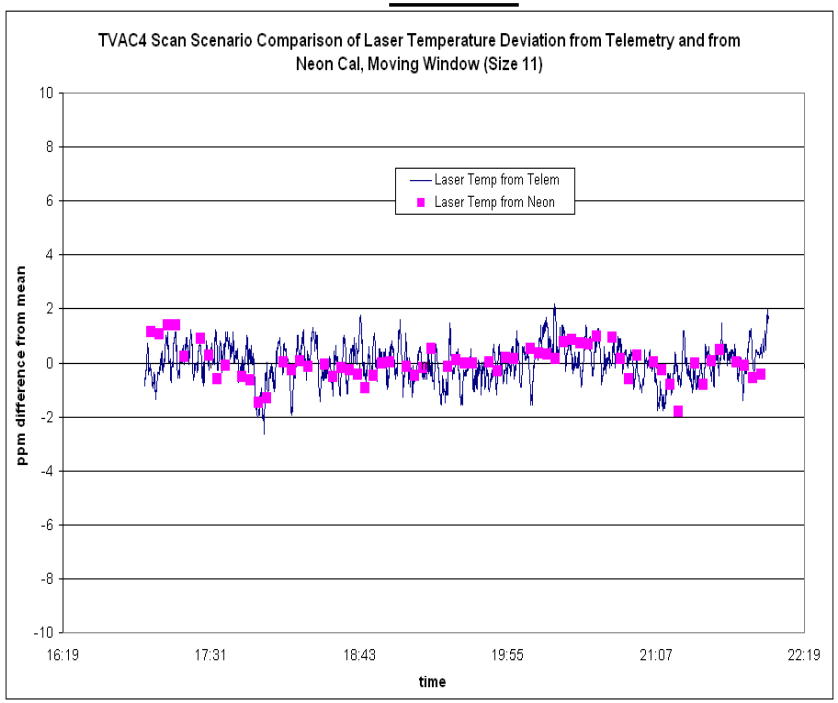


TVAC Spectral Uncertainties Better Than 4.6 ppm at Expected On-Orbit Conditions

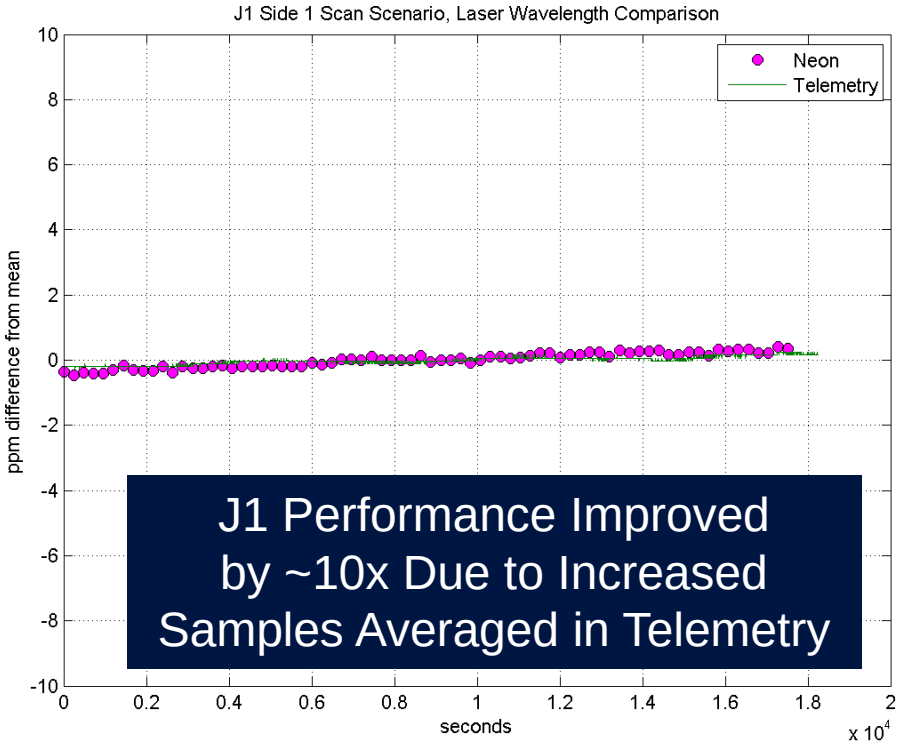
On-Orbit Uncertainties Expected to Match or Exceed SNPP 3 ppm Levels

‘Day in the Life’ Test Demonstrates Improved Spectral Stability from SNPP

SNPP

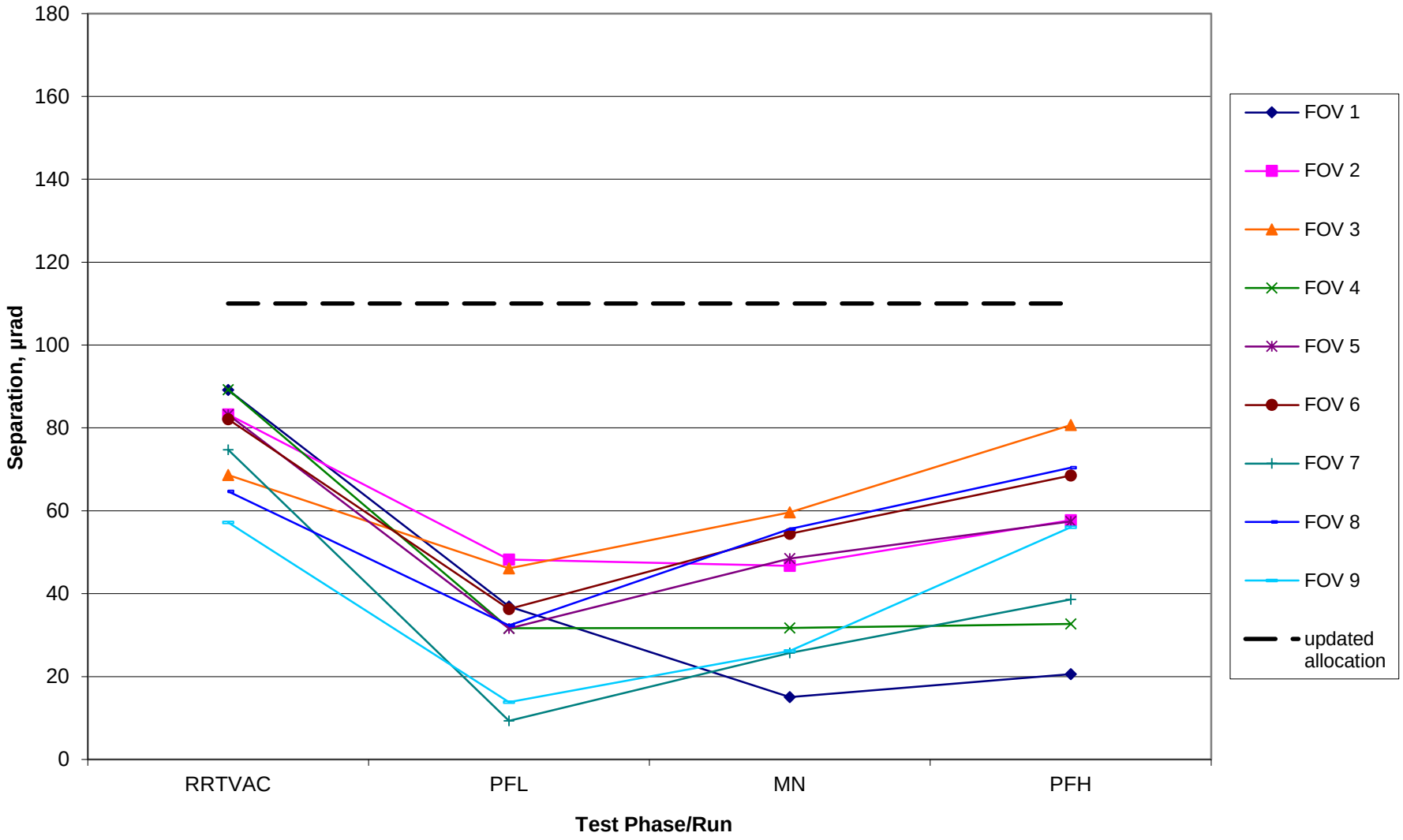


J1

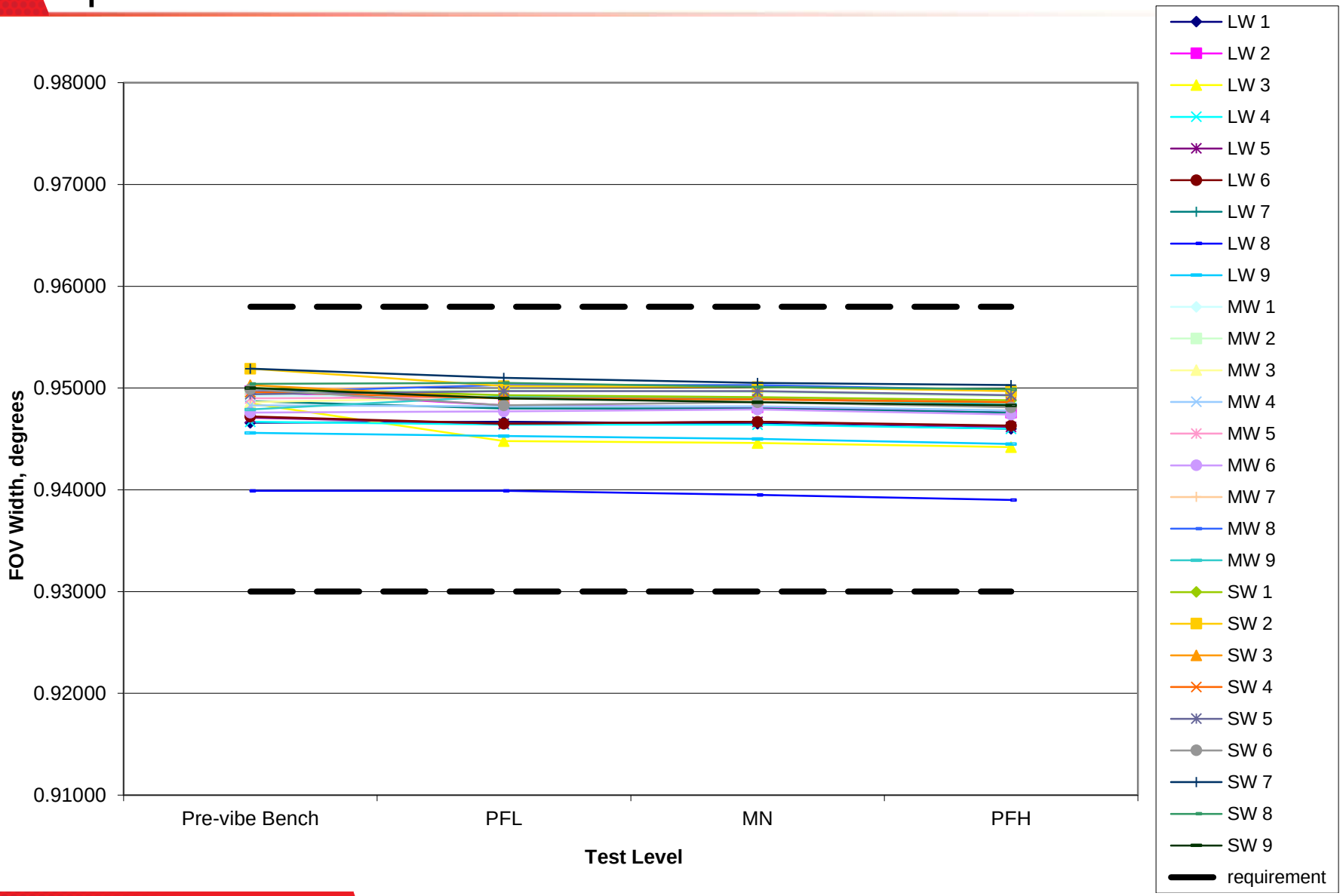


J1 Performance Improved by ~10x Due to Increased Samples Averaged in Telemetry

Coregistration Stable Over Thermal Plateaus



FOV Sizes Very Stable and Within Specifications



Dynamic Interaction Testing Verified Performance in Presence of Jitter

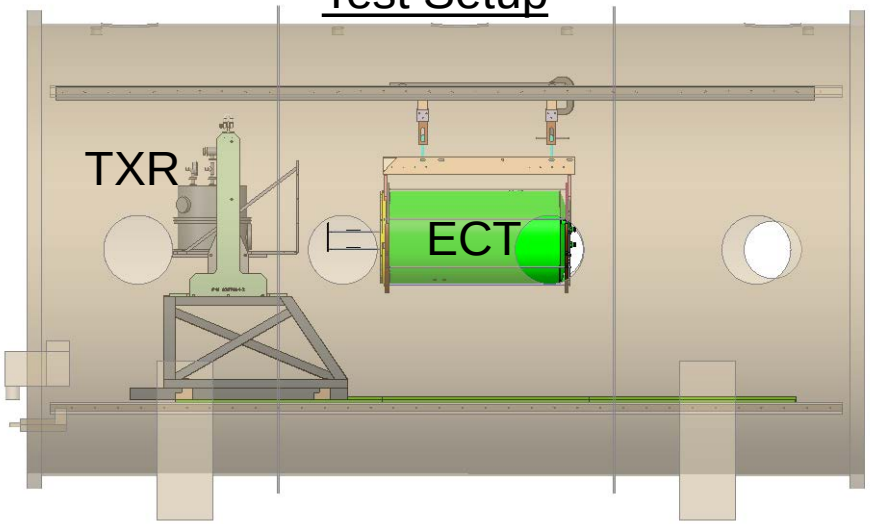
- Ka band gimbal antenna added to J1 spacecraft
  - Resulted in concern that 6 Hz jitter might impact NEdN
  - Further concerns regarding ICD jitter specification and reaction wheels
- Request made by NASA to characterize NEdN in presence of jitter
  - Jitter introduced to instrument during NEdN collections
  - Vibration Isolation System (VIS) not deployed
    - Transfer function applied analytically to results
- Threshold limits for jitter disturbance levels determined
- Jitter specification updated for J1 and J2 based on test results

TVAC Testing Highly Successful

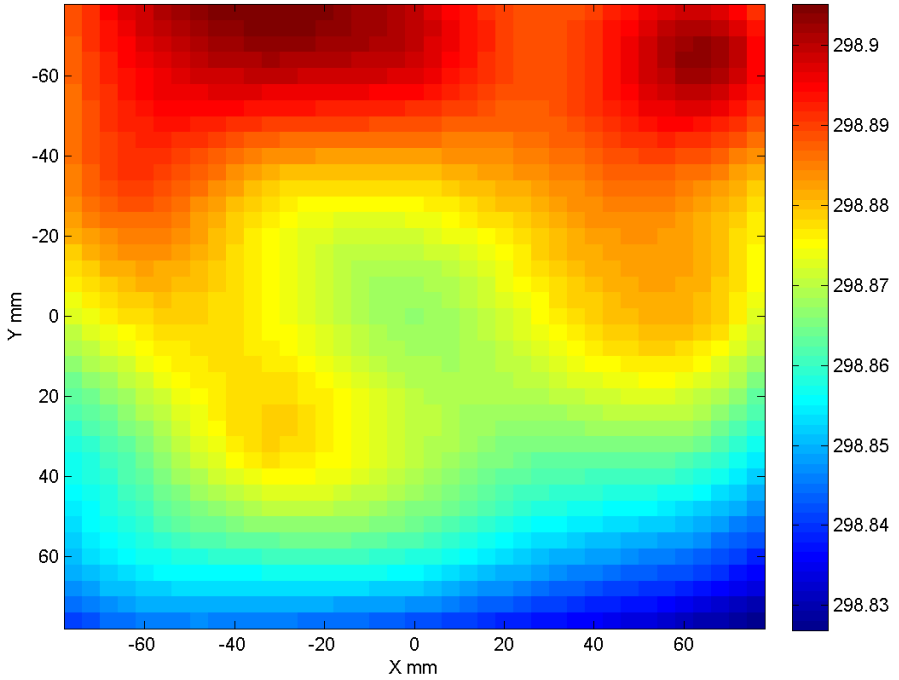
- Electrical Performance tests all meet requirements
- Mapping uncertainty performance met with margin
  - Further optimized on-orbit
- Successful Pre-Ship Review held on 2/10/2015
- J1 CrIS shipped to Ball on 2/12/2015
  - Mechanically integrated to spacecraft on 3/17/2015
  - Fully integrated on 4/14/2015

External Calibration Target Performance Verified by NIST Following TVAC

Test Setup



Example Results



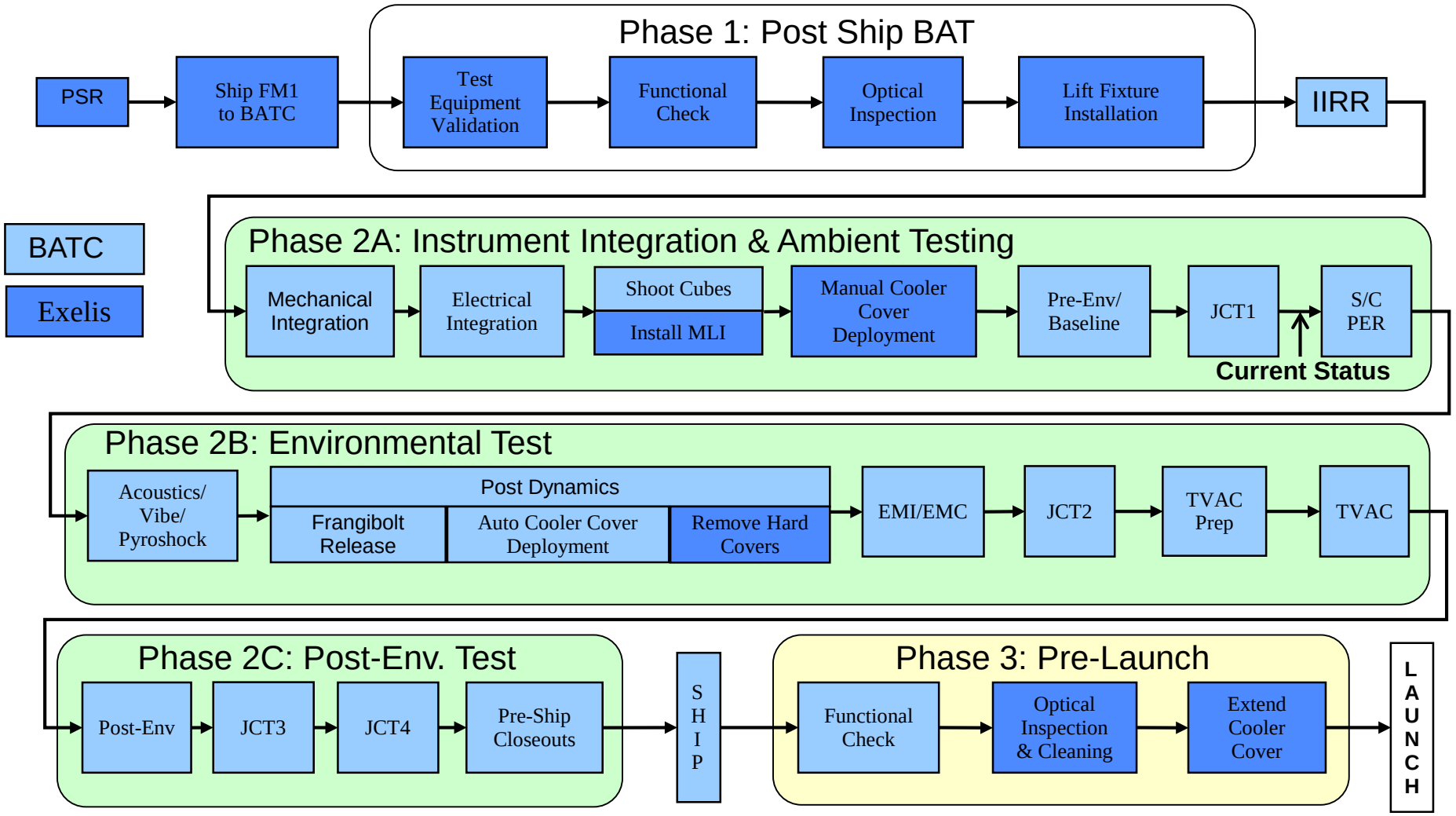
Testing Verified ECT Performance as Seen By Sensor During TVAC; ~80 mK Gradient Matches That Seen By CrIS

Parameters Needed for Early Orbit Activation Defined and Ready

- Bit trim and impulse noise masks ready
  - Same as used during ground testing
  - May change slightly on-orbit if extended interferogram configuration is desired for J1
- ILS parameters calculated
  - Will be further tuned on-orbit
  - Harris, UMBC and UW values agree closely
- Linearity correction parameters determined
  - Will be further tuned on-orbit
  - Harris and UW calculations match well
- Geolocation angles measured and ready
  - Can be further tuned post-launch

SPACECRAFT LEVEL TESTING

CrIS Proceeding Through Spacecraft Test Flow



Several Spacecraft Level Tests Evaluate Science Performance Data

- Reaction wheel jitter
  - Measured interferometer jitter performance with spacecraft reaction wheels activated
  - All other instruments unpowered
  - Results show there is no expected NEdN impact due to reaction wheels
- Spacecraft to sensor alignment measurements
  - Measure CrIS LOS to spacecraft cube alignment to ensure geolocation accuracy
  - Angles calculated and entered into SDR processing chain
- EMI
  - Measures interferometer and scan mirror performance during EMI injections
  - All telemetry that affects SDR production monitored during tests
- TVAC
  - First NEdN measurement with sensor integrated to spacecraft
  - Ensures CrIS compatibility with other on-board instruments

Satellite EMI Test Enhanced Relative to SNPP

- Susceptibility measurements of the digital portion of the signal processor CCAs planned for J1
  - J1 design modification allows the signal processors and detectors to be powered independently

- Balance of EMI tests are the same as SNPP
  - EMI testing will be performed at ambient in EMI chamber used for SNPP
    - Detectors will be warm and unpowered, NEdN will not be measured
    - Interferometer and scan mirror performance monitored during EMI injection
    - All telemetry affecting SDR production also monitored
  - EMI self compatibility test will be performed during TVAC
    - Detectors will be cold and powered, NEdN will be monitored
    - Susceptibility measurements will include both servo performance and NEdN

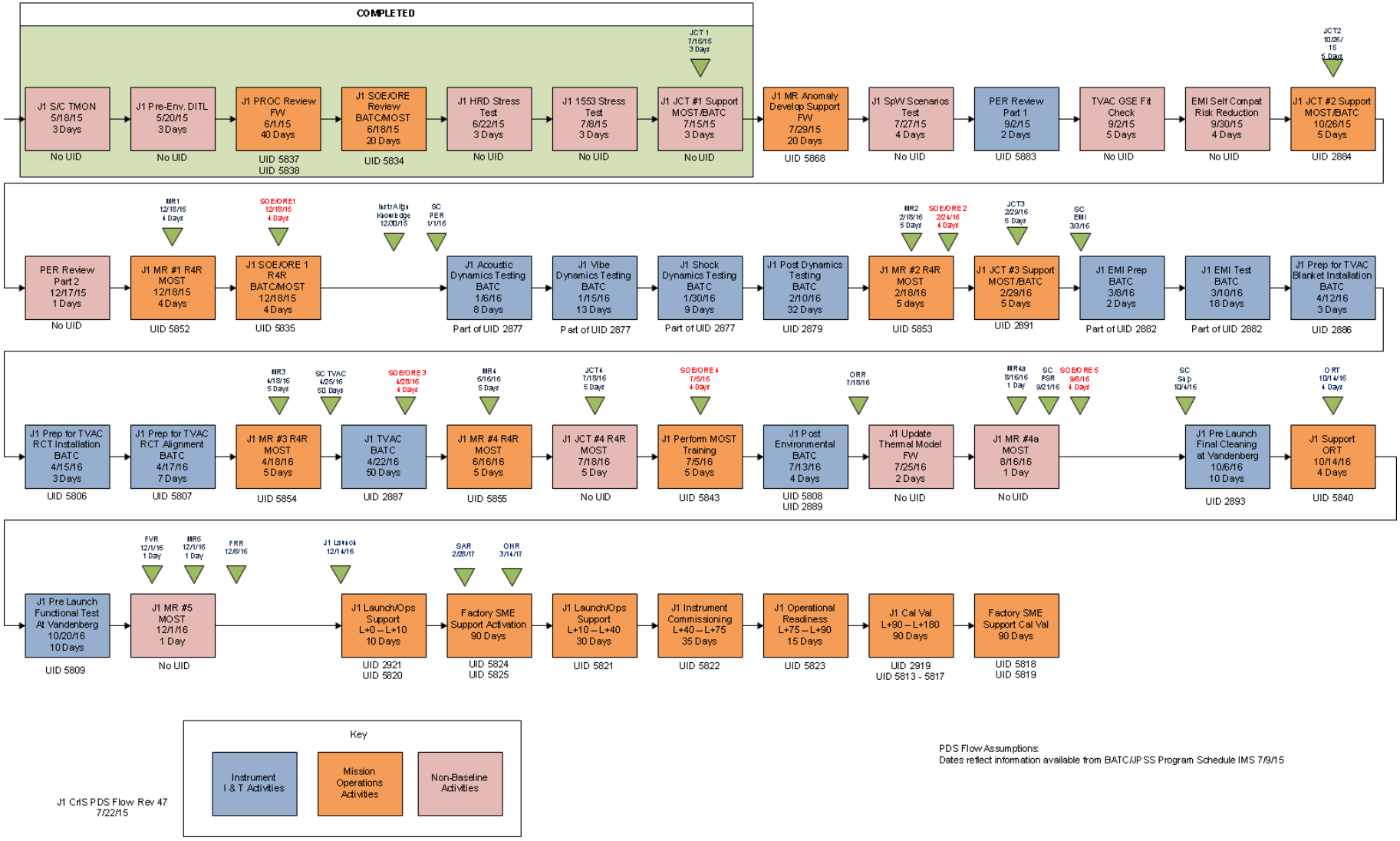
Spacecraft TVAC Approach Same as SNPP

- Same space target and radiant cooler target as used during system TVAC
  - Same targets used for SNPP
- External calibration target (ECT) supplied by Ball
  - Same target used for SNPP
- NEdN can be calculated using scanning or stare mode data collect
  - 2 point calibration (ICT and SCT) while scanning
  - 3 point uses the calibration targets and ECT plate
  - Compared to system level NEdN for self-compatibility evaluation
  - Same process used on SNPP
- Instrument temperatures monitored real-time to ensure sensor safety
  - Same as SNPP

J1 LAUNCH READINESS

Activity Flow Supports Launch Schedule

J1 CrIS PDS Integration & Test and Mission Operations Flow



MOST, Harris and Science Team Roles Clearly Defined

- Mission Operations Support Team (MOST) operates sensor and ensures instrument safety
  - Verifies and performs instrument commanding
  - Monitors sensor alarm limits and responds to anomalous behavior
  - Trends instrument critical telemetry and reviews for anomalies

- Harris supports MOST and Science team
  - Responsible for Early Orbit Activation (EOA) period following launch
    - Includes instrument calibration related activities
  - Supports science team during Intensive Cal Val (ICV)
  - Supports troubleshooting of instrument anomalies as needed
  - Develops/tests commanding as needed to support incremental performance improvements

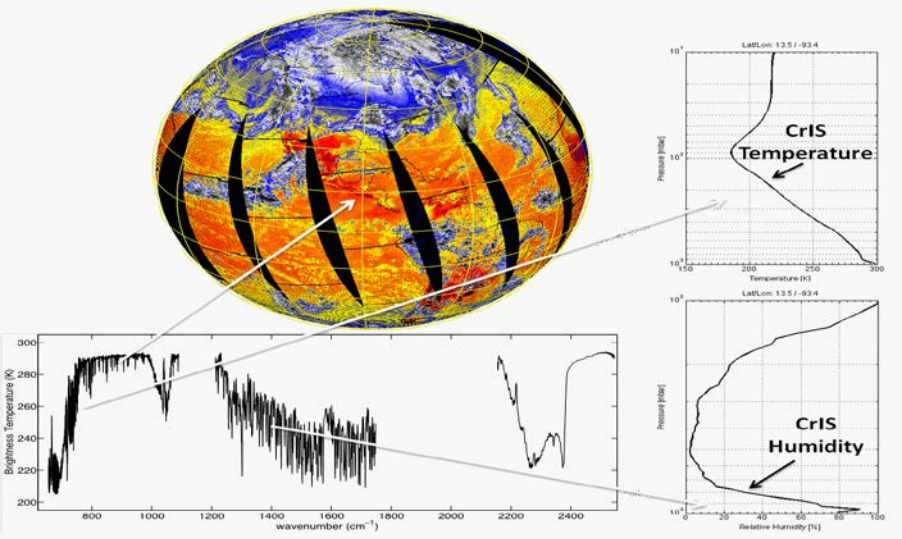
- Science team ensures optimal calibration of sensor
  - Independent assessment of TVAC data
  - Reviews data and provides input during EOA phase
  - Responsible for ICV and Long Term Monitoring activities

Cal/Val Procedures Ready to Support J1 Mission

Title	Purpose	Status
ROP CRIS-CV-001 - CrIS Bit Trim and Impulse Mask Checks	Checks bit trim and impulse noise masks and modifies as needed	Ready
ROP CRIS-CV-002 - CrIS Noise Equivalent Radiance Difference (NEDN)	Details collection and calculation of NEdN	Ready
ROP CRIS-CV-003 - CrIS IR Channel Programmable Amplifier Gain Check and Adjustment	Checks PGA gain and modifies settings as needed	Ready
ROP CRIS-CV-004 - CrIS Interferometer Optimization	Optimizes metrology laser temperature setpoint and optical ZPD location	Ready
ROP CRIS-CV-005 - CrIS Bias Tilt Offset Calibration	Optimizes interferometer dynamic alignment (DA) mirror bias tilts	Ready
ROP CRIS-CV-006 - CrIS Metrology Laser System Stability Check	Checks metrology laser for stability	Ready
ROP CRIS-CV-007 - CrIS Detector Linearity Check	Checks/trends detector nonlinearity performance	Ready
ROP CRIS-CV-008 - SSM In-Track Mechanism Rotation Compensation	Determines scan mirror null torque offset to optimize geolocation performance	Ready
ROP CRIS-CV-009 - Configure SPs for Truncated Mode or Full Spectral Mode	Configures CrIS to truncated or full resolution mode	Ready

ICV Analyses Leverage SNPP Experience

- Initial on-orbit checkouts
- NEdN evaluations
- Comparisons with other instruments
  - SNPP CrIS, VIIRS, IASI, AIRS
- Calibration optimization
  - EOA activities optimize instrument
    - Gain settings
    - Mask checks/tailoring
  - ICV activities optimize calibration
    - Linearity parameters
    - ILS parameters
    - Geolocation parameters
- Goal is high quality validated SDRs



Plot courtesy of University of Wisconsin

Lessons Learned Incorporated from SNPP

- J1 bit trim mask levels same as SNPP
  - Minimizes data rate while avoiding mask clipping
- J1 FIR filter same as updated SNPP filter
  - Mitigates sweep dependence bias observed in early SNPP data
- ROPs updated based on SNPP experience
  - Contingency ROPs developed to support anomaly troubleshooting
  - Several ROPs simplified based on SNPP execution
- Increased diagnostic data collections planned
  - Useful for SNPP troubleshooting
  - Truncated resolution diagnostic data collections for all FOVs
    - Only 3 FOVs collected during SNPP
  - Possible SWIR full resolution diagnostic collect to support impulse mask evaluation

SUMMARY

CrIS Ready for J1 Launch

- J1 CrIS completed comprehensive test program
  - Excellent performance during all phases
  - Performance as good or better than SNPP
- Spacecraft testing underway
  - CrIS integrated to J1
  - EMI and TVAC testing upcoming
- Launch readiness activities identified
  - EOA and ICV tasks defined
  - Lessons learned incorporated from SNPP

CrIS Ready to Support Successful J1 Mission