VIIRS OCEAN STATUS

Wayne E. Esaias

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MODIS Science Team Ocean Discipline

National Polar-orbiting Operational Environmental Satellite System

Topics

- **Instrument**
  - EDU
  - FU-1
  - Ocean Concerns Summary
- **Algorithms**
- **Calibration/Validation**

Background Reminders

- **NPOESS Preparatory Project (NPP) is risk reduction activity for NPOESS**
  - NPP is joint NPOESS-IPO and NASA mission
  - NPP can **not** be used in formal NPOESS System-level requirements sell-off
  - NASA NPP mission objectives are data continuity and Climate Data Records
- **VIIRS Engineering Development Unit (EDU) is risk reduction for NPOESS and NPP**
- **Sensor Data Records performance requirements defined as worst-case, end of life and end of scan**

EDU Status

- **Sensor completely built**
- **Thermal Vacuum (TV) testing complete**
  - Some post TV root- and contributory-cause testing continues (X-talk, e.g.)
- **EDU design primarily flight-like**
  - Differences in cooled focal plane read-out designs and Dewar configuration
  - Slower focal length (but also has been tested in ambient with flight like focal length)
- **EDU testing for proof of concepts**

On-board Calibrators

- **Solar Diffuser (SD) and SD Stability Monitor (SDSM) for Reflective Solar Bands (RSB)**
  - SD screen to reject Earthshine in fabrication
  - SDSM not installed in EDU
  - No end to end testing of SD-path in EDU program, under study with NIST for FU1 and beyond
- **Black-body and Space View primarily for Thermal Emissive Bands (TEB)**
- **Lunar views through Space View**

EDU Test Date Summary

- **Performance generally as expected, but with some differences**
- **Differences described as the "Big 3 EFRs"**
  - EFR essentially an anomaly report
  - LSF/IFOV, BBR and Cross-talk [Line Spread Function/Instantaneous Field of View, Band-to-Band Registration]
  - Concerns present in both ambient and TV test results
- **Root-cause and path-forward plans are component of FU1 integration and testing agreements**

Data Analysis Teams

SBRS

Todd Hurt, leader

Early Analysis
Test Reports
Anomaly Reporting
Formal Test Reports
- Leads to FU1 Compliance Determinations

NGST

Jim McCarthy, leader

Primary science interface to SBRS and NGST
Cal/Val efforts by Lushalan Liao

Systems Engineering

NASA

H. Oudrari, coordinator

NICST - Xiong
Oceans – Turpie
U. Wisc. – LaPorte
Land Team - Wolfe

IPO

F. DeLuccia, leader

Aerospace team
MIT/LL – Fischer
NRL, DC - Lucke

> 100 Data Reports written on EDU tests

IFOV/LSF

- **Effects mapped for single pixel resolution, reported in context of 1 pixel requirements**
- **Ambient IFOV**
  - DNB pixels (some, not all) small
  - I Bands
    - I1, I2 large (scan)
    - I3, I4, I5 large (track)
    - I5 small (scan)
- **Thermal Vacuum IFOV**
  - I1 – I4 large temperature sensitivity (scan)
- **M-Band effects relatively smaller due to lower spatial resolution**

Band – to – Band Registration (BBR)

- **EDU had larger-than-expected BBR shifts:**
  - Shift between ambient and thermal vacuum ("warm-to-cold")
    - VisNIR vs LWIR scan direction of 0.25 M band HSR
    - FU1 performance prediction better than this due to Dewar redesign
  - Shift over temperature
    - VisNIR vs LWIR scan direction of 0.25 M band HSR
    - VisNIR vs LWIR track direction of 0.15 M band HSR
    - FU1 performance prediction better than this due to Dewar redesign
  - Pre-TVAC to post TVAC offset
    - May be hysteresis up to 7% M band HSR
    - Alternatively may be uncertainty in alignment response to bench test cooler, use-to-use

Cross-talk

- **Distinguishing optical from electronic effects still underway**
- **Analyses suggest potential for optical effects within Dewar, still under investigation**
- **Common description of various test results still being developed**
- **Magnitude of effects TBD**
  - Potential remains for significant impact to radiometric stability/accuracy
  - Concern is with the Vis/NIR ROIC
  - FU-1 LWIR ROIC is improved over EDU version based on component tests

Data Distribution and Analyses Approaches

- **All test data sets delivered to CasaNOSA**
- **Primary delivery mechanism is via circulation of hard drives**
- **Some data over Internet connection**
  - Data users identify highest priority files
- **Sensor builder (SB) holds daily table-top discussions including in-plant customer community**
- **Customer community holds daily teleconferences**
- **Monthly SB driven Data Review and release meetings**
- **Government Team and shoulder-to-shoulder omnibus data reviews at completion of testing.**
- **NASA wants to capture all data for FU-1 testing.**

Test and Test Fixture Status

- **Polarization Source Assembly (PSA)**
  - Being rebuilt, need significant improvement in performance over EDU capability
- **Spectral Measurement Assembly (SpMA)**
  - Need better stability, uniformity behavior
  - Need two runs in track each band (non-centric optical design leads to intrinsic sensor spectral smile in RSR, ~3 nm at 1000 nm); centered on both odd and even detectors, and correction for atmospheric effects M13
- **SIS-100 monitoring needed, but expect this will be ready for FU1 testing**
- **Maturity of fixture certification before use in FU1 testing may be problem**

Results from EDU Test Data analyses

- **Review processes improved relationships among Government Team, SBRS and NGST**
- **Recommendations for improvements in fixtures, testing and analyses**
  - Will evaluate as high, medium and low for program impact (cost and schedule) and benefit
  - Develop consensus with SBRS list at CVWG in November
- **CVWG outputs and NGST/SBRS responses will be evaluated at FU1 Consent to Proceed (NET December 2006)**
- **Government Team X-talk Tiger Team still active as well, including Data Analysis Working Group (DAWG)**

INSTRUMENT CONCERNS (OCEAN COLOR)

- Cross Talk
- Within Band and Total Band Spectral Response
- Polarization (not tested on EDU, Waluschka team instru. model)
- Radiometric Stability (between cals, between bands)
- Reflectivity vs Scan (HAM)
- Radiometric Characterization
- Stray Light
- System Level Calibration Verification
- SDR look-up table verification

Instrument Summary

- **Risk reduction with EDU testing a success**
- **Some significant work remains**
  - Cross-talk and fixture verification
- **Formal determination for "use-as-is" or changes for FU1 Decision ~ 12/14**
- **FU1 will be delivered from SBRS**
- **Other**
  - 1394 Interface
  - Cryoradiator performance
  - EMI/EMC

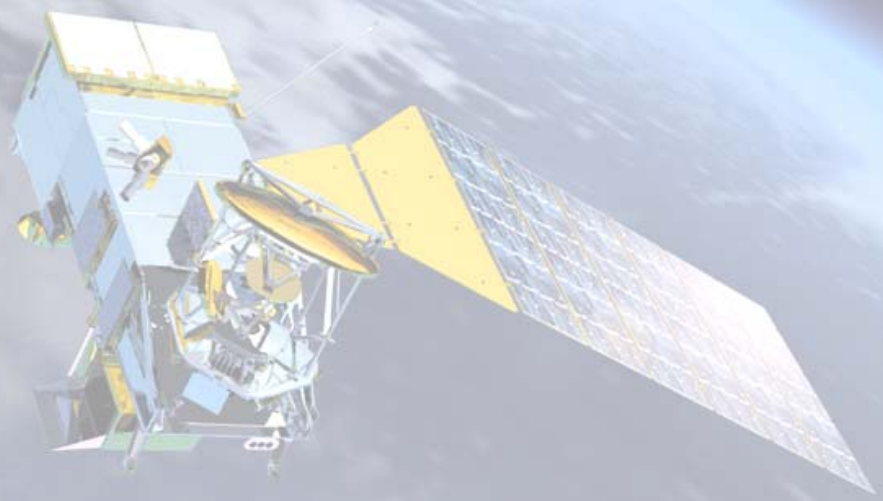
OCEAN ATMOSPHERIC CORRECTION, OCEAN COLOR OPERATIONAL ALGORITHMS

- **PEATE - Product Evaluation Analysis Tool Element**
- **NPP Science Data Segment CDR**
  - Ocean PEATE given very good marks
  - Concern re staying compatible with Operational System (IDPS)
  - Concern re interproduct dependency of SDR, Atmospheric Correction during early mission
- **Ocean PEATE is an evaluation effort, not CDR production.**
- **NGST-led Error Budget (Instrument-SDR-EDR) analyses indicates ocean color product performance requirements exceed performance of heritage sensors and algorithms.**
  - VOST group in general agreement.
  - Good instrument characterization is essential.

Ocean Product Validation

- **Early draft Validation Plan(s) have been written with Government and Academic input.**
- **NGST (SSPR) is responsible to IPO for Cal/Val**
  - demonstrate level of performance relative to contract for the operational EDR and customer needs.
- **Unlikely that the NGST validation plan will be as extensive as that required for NASA Climate Data needs.**
- **Validation Plan development approach is being formulated.**
  - One hopes that it will foster productive coordination among the three ocean partners and NGST.

Back-up



Potential NPP Mitigation Opportunities

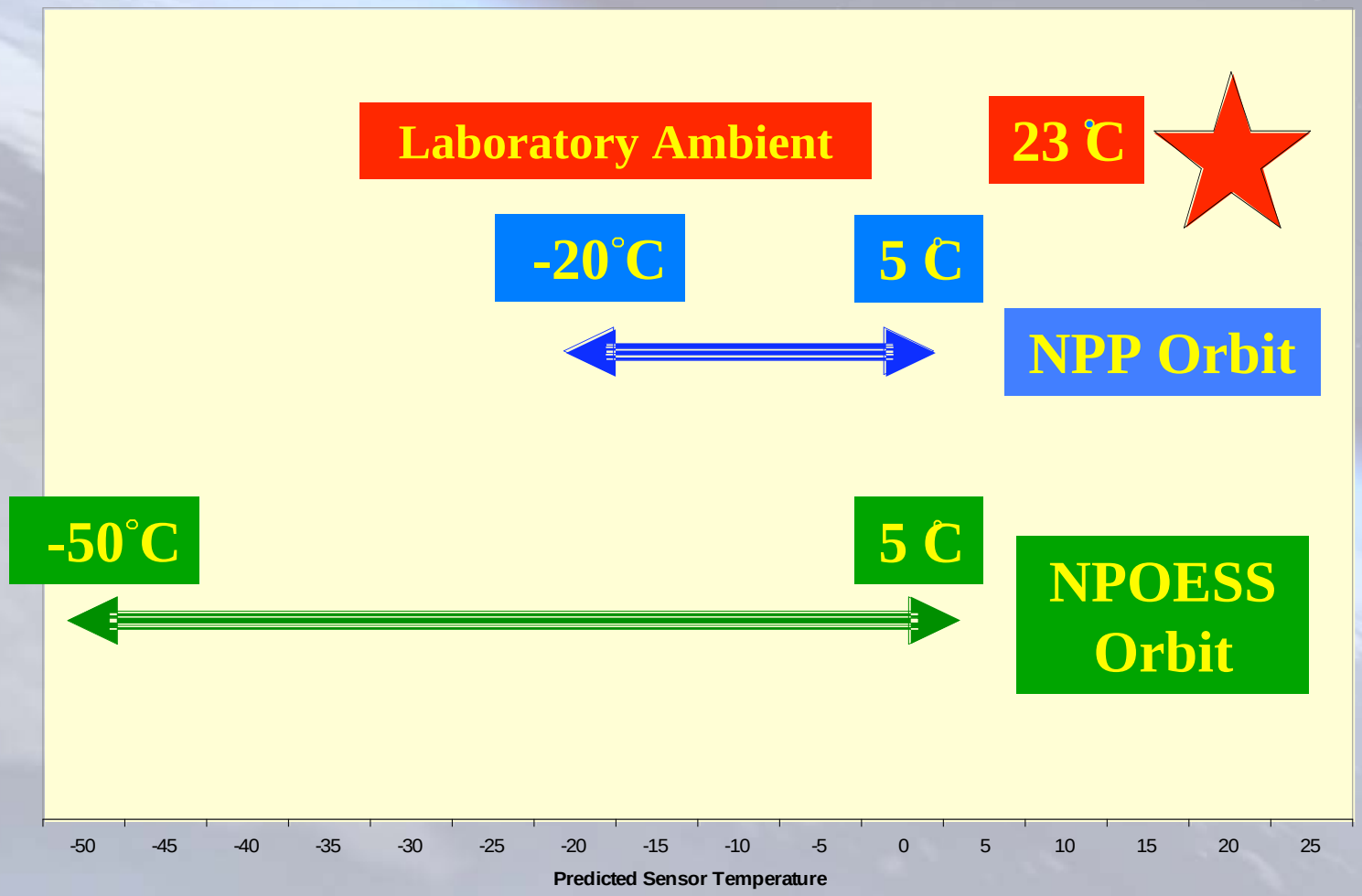
- **LSF/IFOV/BBR effects above for individual pixels**
  - 3-pixel aggregation within 31.59º of NADIR; 2-pixel aggregation extends to 44.82º of NADIR
- **Significantly smaller temperature ranges for NPP only orbit**
- **Significant mitigation of IFOV/BBR effects obtained in 3-pixel and 2-pixel aggregation regions**

Paragraph	Subject	Specified Value	NPP Exclusion
40.7.6-3	b. Horizontal Reporting Interval [VIIRS Guarantee]	HCS	
40.7.6-29	c. Horizontal Coverage [VIIRS Guarantee]	Oceans	
	d. Measurement Range		
40.7.6-13	1. Ocean Color	1.0 - 40 W m^ -2 micrometer^ -1 sr^ -1	
40.7.6-14	2. Optical Properties, A bsorption	0.01 - 10 m^ -1	
40.7.6-15	3. Optical Properties, Scattering	0.01 - 50 m^ -1	
40.7.6-6	4. Optical Properties, Chlorophyll [VIIRS Guarantee]	0.05 - 50 mg/m^3	
	e. Measurement Accuracy		
40.7.6-17	1. Ocean Color, Operational	10%	
40.7.6-19	2. Optical Properties, Operational	40%	
40.7.6-7a	3. Chlorophyll, Operational, Chl < 1.0 mg/m3 [VIIRS Guarantee]	15%	
40.7.6-7b	4. Chlorophyll, Operational, 1.0 Chl < 10 mg/m3 [VIIRS Guarantee]	30%	
40.7.6-7c	5. Chlorophyll, Operational , Chl > 10 mg/m3 [VIIRS Guarantee]	50%	
	f. Measurement Precision		
40.7.6-22	1. Ocean Color, Operational	5%	
40.7.6-24	2. Optical Properties, Operational	20%	
40.7.6-8a	3. Chlorophyll, Operational, Chl < 1.0 mg/m3 [VIIRS Guarantee]	20%	
40.7.6-8b	4. Chlorophyll, Operational, 1.0 < Chl < 10 mg/m3 [VIIRS Guarantee]	30%	
40.7.6-8c	5. Chlorophyll, Operational, Chl > 10 mg/m3 [VIIRS Guarantee]	50%	
	k. Excluded Measurement Conditions [VIIRS Exclusions]		
40.7.6-30a	1. Strongly Absorbing Aerosols With Single Scattering Albedo ω0(555) < 0.7		
40.7.6-30b	2. Dissolved Organic Matter Absorp tion Dominant Waters, DOM Absorption a(410) > 2m^ -1		
40.7.6-30c	3. Very Turbid Coastal Waters, Mass Loading > 60 mg/l		
40.7.6-30d	4. Sun Glint < 36 deg		
40.7.6-30e	5. Orbit Other Than Nominal 1330 or 2130 Orbit		
40.7.6-30f	6. Within 12 mill iradian of an Area 12 mrad x 12 mrad or Greater that is At Least the Bright VIIRS Radiance		
40.7.6-30g	7. Beyond a Swath Width of 1700 km		
40.7.6-30h	8. Aerosol Optical Thickness > 1.0		

Ocean color is defined as the spectrum of water-leaving radiances (L_w), i.e. the portion of the visible-near infrared light that is reflected at the surface. All geophysical quantities of interest, e.g., the concentration of phytoplankton pigment chlorophyll α (chlorophyll-α) and the inherent optical properties of absorption and scattering of surface waters (ocean optical properties), are derived from these L_w values. Normalized water-leaving radiances are measured in mW cm^{-2} μm^{-1} sr^{-1}. Ocean optical properties, absorption, and scattering are estimated at each measured visible wavelength, and have units of m^{-1} while chlorophyll-α is measured in mg m^{-3}. This EDR is required under clear, daytime conditions only. "Clear" for this EDR is a cloud mask indicator of "confidently clear" for the horizontal cell of interest. Day condition for this EDR is when the solar zenith angle is less than 70 deg and when the cloud mask does not indicate that the cell of interest is in shadow.

Units: Ocean Color: W m^{-2} μm^{-1} sr^{-1} Ocean Optical Properties: m^{-1} Chlorophyll: mg m^{-3}

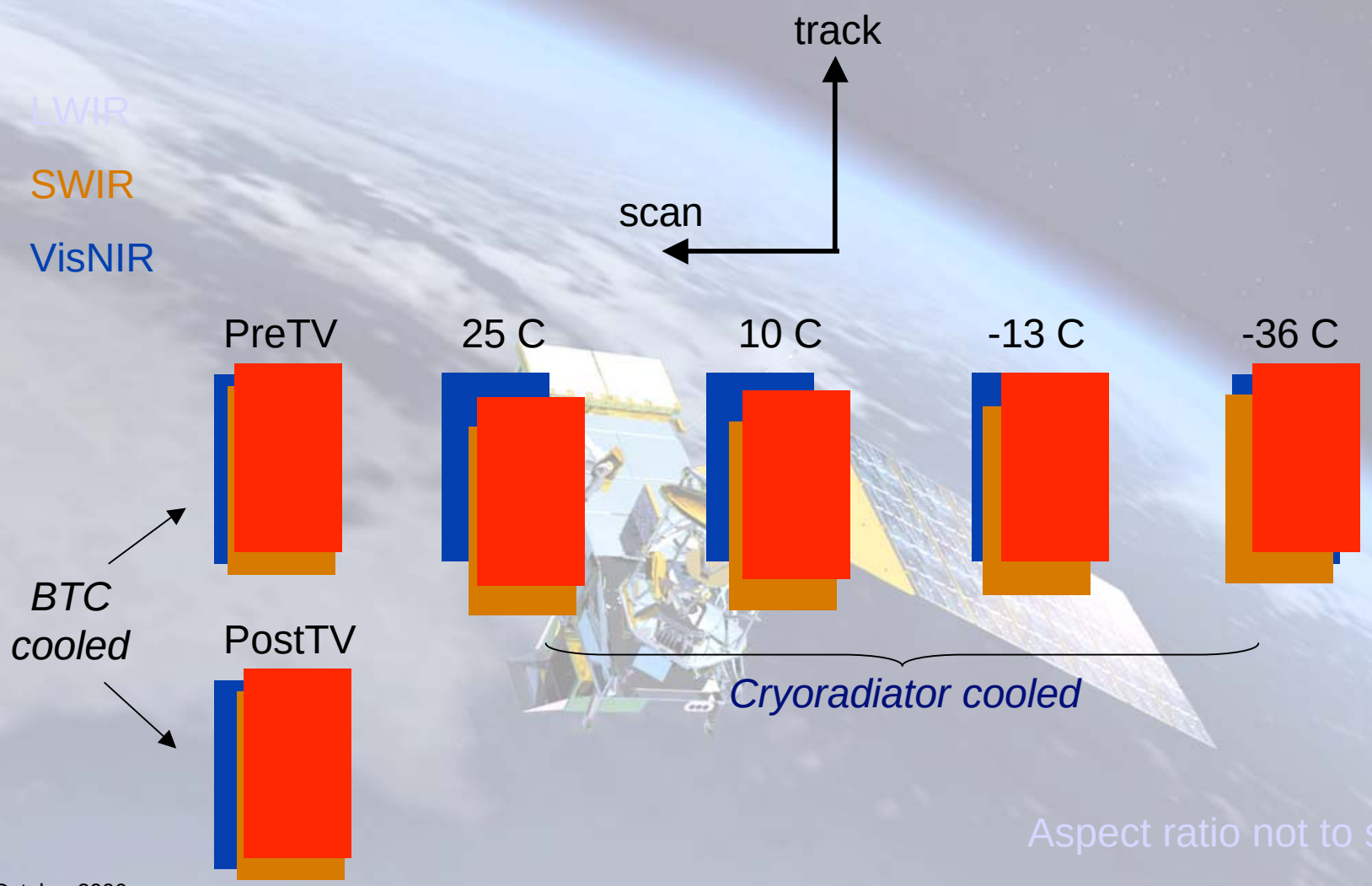
Predicted Temperature Environments



VIIRS Development Effort – Teammates Staffing

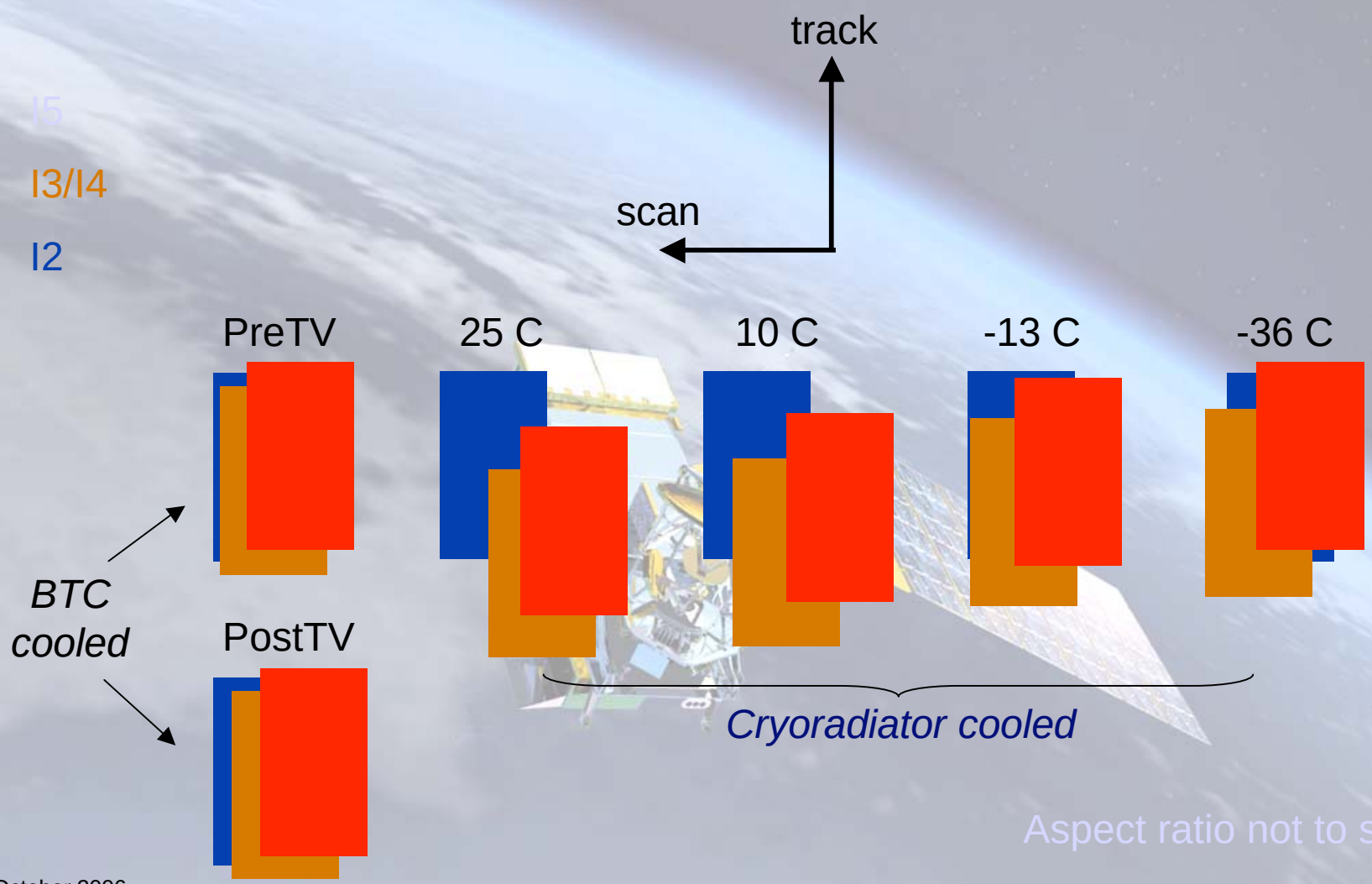
- Engineering Efforts supported by several organizations
- Raytheon-SBRS effort [Ed Clement, Eric Johnson and colleagues]
- NGST [Eric Kinder, Jim McCarthy and colleagues]
- IPO [Gary Ross, Bob Murphy and colleagues]
- NASA-GSFC [Tim Trenkle, GSFC engineering]
- Aerospace [Frank DeLuccia, JR Swenson and colleagues]
- MIT-Lincoln Labs, Navy Research Laboratory and Raytheon – El Segundo

Moderate HSR: observed FP avg. registration shifts in TV for the VIIRS EDU, Mod. HSR units



Aspect ratio not to scale

Imaging registration shifts in TV for the VIIRS EDU, Imaging HSR units



Aspect ratio not to scale