VIIRS F1 Spatial Performance Characterization

NICSE (**N**PP SDS **I**nstrument **C**alibration **S**upport **E**lement)
Geometric Calibration Group

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NASA MODIS/VIIRS Calibration Workshop

January 25, 2010
Lanham, MD

Acknowledgements

- Thanks go to David Moyer of NICST(now the Aerospace Corporation) and Thomas Schwarting of NICST for an initial suite of BBR source code.
- Cooperation and assistance from Raytheon, NG, IPO, The Aerospace Corporation, MIT Lincoln Lab, NASA NICST and NASA NPP Project Science Office are very much appreciated.

Outline & Introduction

1. **FP6:** to test along-scan and along-track spatial response

   LSF = Line Spread Function & its derived optical properties:

   1) FOV = field of view (dynamic for scan (**DFOV**), instantaneous for track (**IFOV**)) → footprint size -> image resolution;
   2) MTF = modulation transfer function → image quality for M-bands;
   3) HSR = horizontal spatial resolution → image quality for I-bands.

2. **FP4:** to test scan and track spectral band registration (SBR) (separation of line of sight (LOS) from a reference) for band-to-band co-registration (BBR) performance characterization.

3. **FP5:** to measure/predict pointing stability

   1) Scan pointing variability relative to average scan speed and average scan start positions;
   2) Track pointing variability relative to rotation plane.

Note: 1. Day-night band (DNB) spatial performance (FOV/MTF/HSR) not assessed.
2. The results presented here are from Lab tests. On-orbit performance is expected to vary.

FP6 Line Spread Function Tests

Test configuration:

In scan direction, TMC SIS and BB source projected through phased reticle slits

1) Cold Performance Plateau (-21^{o}C AOA) through ZnSe and Quartz windows;
2) Nominal Performance Plateau (-11^{o}C AOA) through ZnSe and Quartz windows.

In track direction, TMC SIS and BB source projected through stepped reticle slits in ambient only (limited test in TVac gave similar IFOV, MTF and HSR results).

Image Resolution Specifications – FOVs

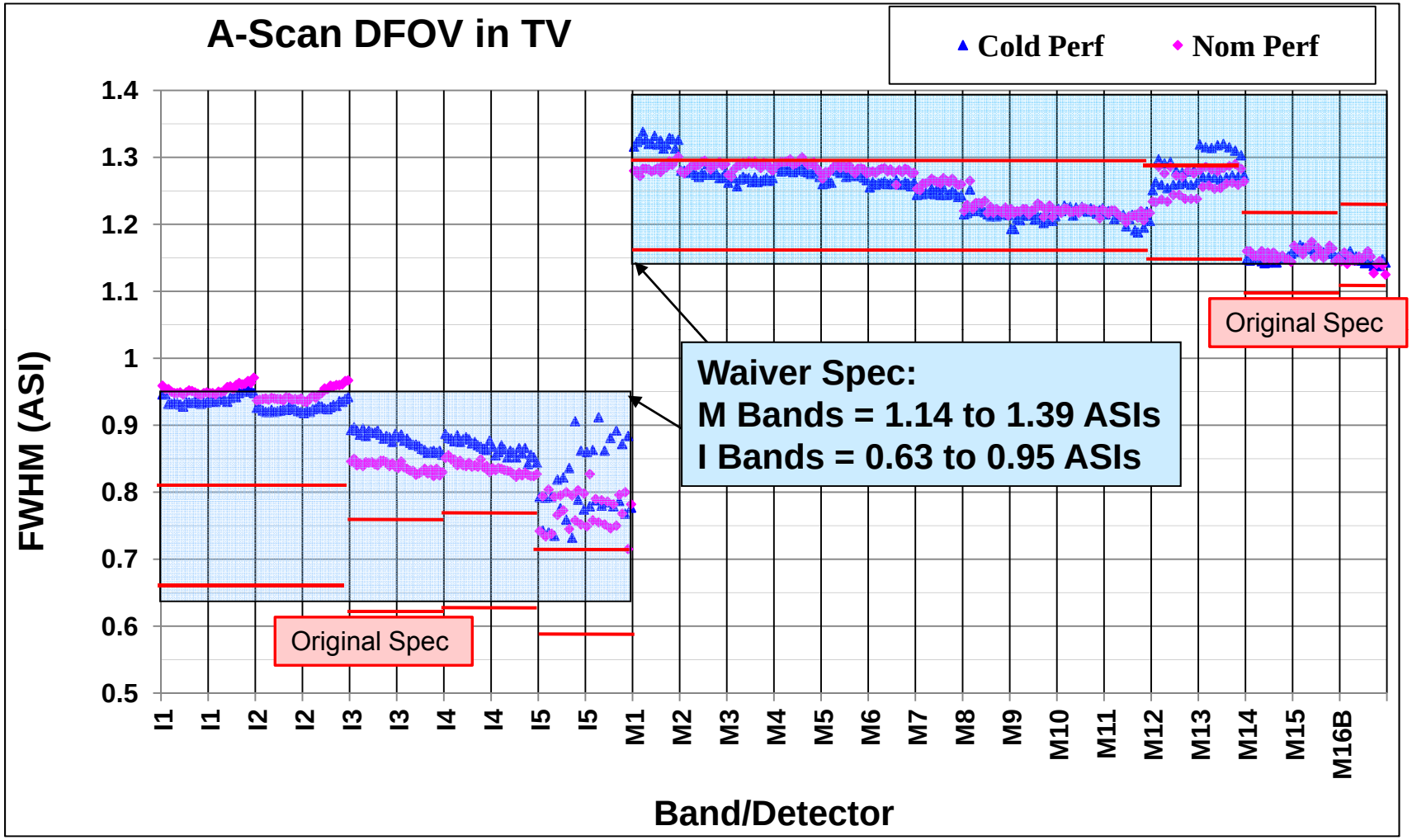
- Scan Dynamic Field of View (DFOV), including integration drag
  - Given by Full Width Half Maximum (FWHM) of Line Spread Function (LSF)
  - I-bands, original Spec
    - I1, I2: 114 μrad
    - I3: 108 μrad
    - I4: 109 μrad
    - I5: 102 μrad

    ±10% } Approved waiver Spec (RDW-047A)
    123 μrad (=0.79 ASIs), ±20%
  - M-bands: original Spec
    - M1 to M11: 382 μrad
    - M12, M13: 379 μrad
    - M14, M15: 362 μrad
    - M16: 364 μrad

    ±5% } Approved waiver Spec (RDW-047A)
    393 μrad (=1.25 ASIs) ±10%
- Track IFOV, without integration drag
  - Given by FWHM of LSF curve
  - I-bands: IFOV = 445.5 μrad ±5% } ±10% Approved waiver Spec (RDW-047A)
  - M-bands: IFOV = 891 μrad ±5%

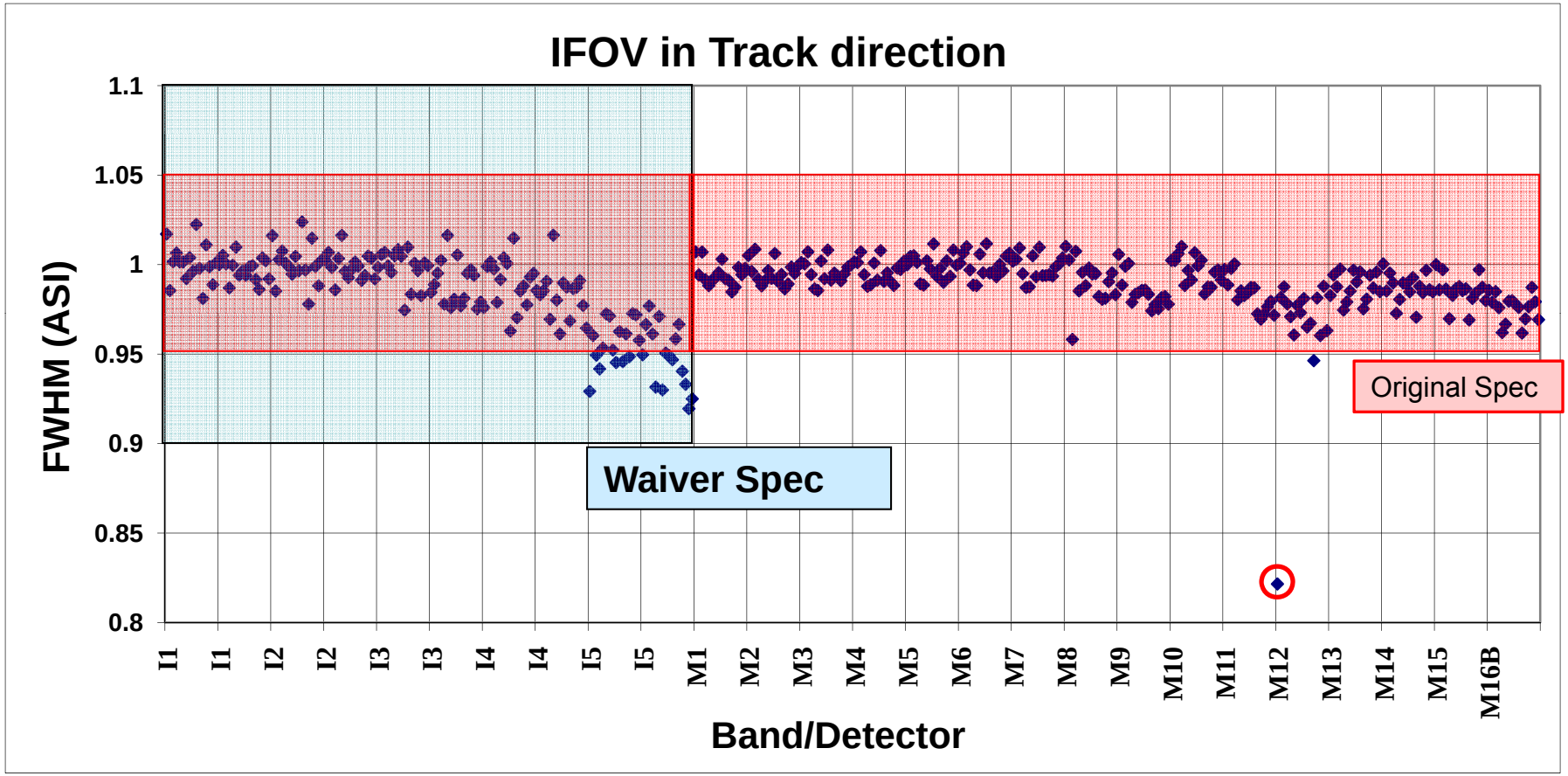
- Note: un-aggregated angular sampling interval (ASI)
  - I-bands scan ASI = 155.83 μrad (128 m @ nadir)
  - M-bands scan ASI = 311.66 μrad (256 m @ nadir)
  - I-bands track ASI = 445.5 μrad (367 m @ nadir)
  - M-bands track ASI = 891 μrad (734 m @ nadir

Scan DFOV Results in TV



1. Almost all 432 detectors meet DFOV waiver Spec. Most M-band detectors also meet original DFOV Spec.
2. Some detectors in bands I1, I2 are marginally out-of-Spec at Nominal Perf Plateau. Their DFOVs at Hot Perf Plateau are expected to be a little worse.

Track IFOV Results (Amb only)



All detectors meet track IFOV Spec, except:

Known underperforming M12 D1 has IFOV way below Spec (too small).

M-bands Image Quality Spec – MTF

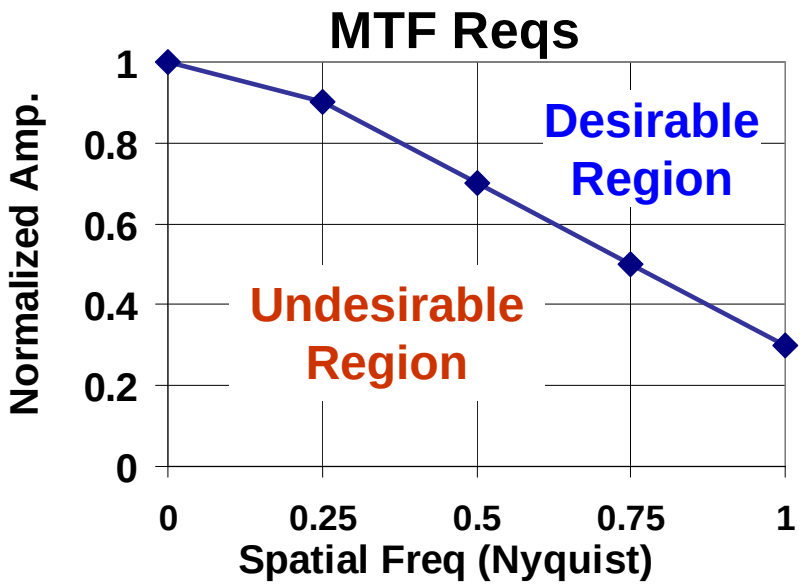
- M-band Modulation Transfer Function (MTF): the magnitude of the Fourier transform of the sensor LSF as a function of spatial frequency in the scan and track directions normalized to one at the origin.
- The MTF requirements are to exceed values specified at fractional Nyquist frequency, which is the spatial frequency two horizontal sampling intervals (HSI) apart:

$$f_{nyquist} = \left(\frac{1}{2 * HSI} \right)$$

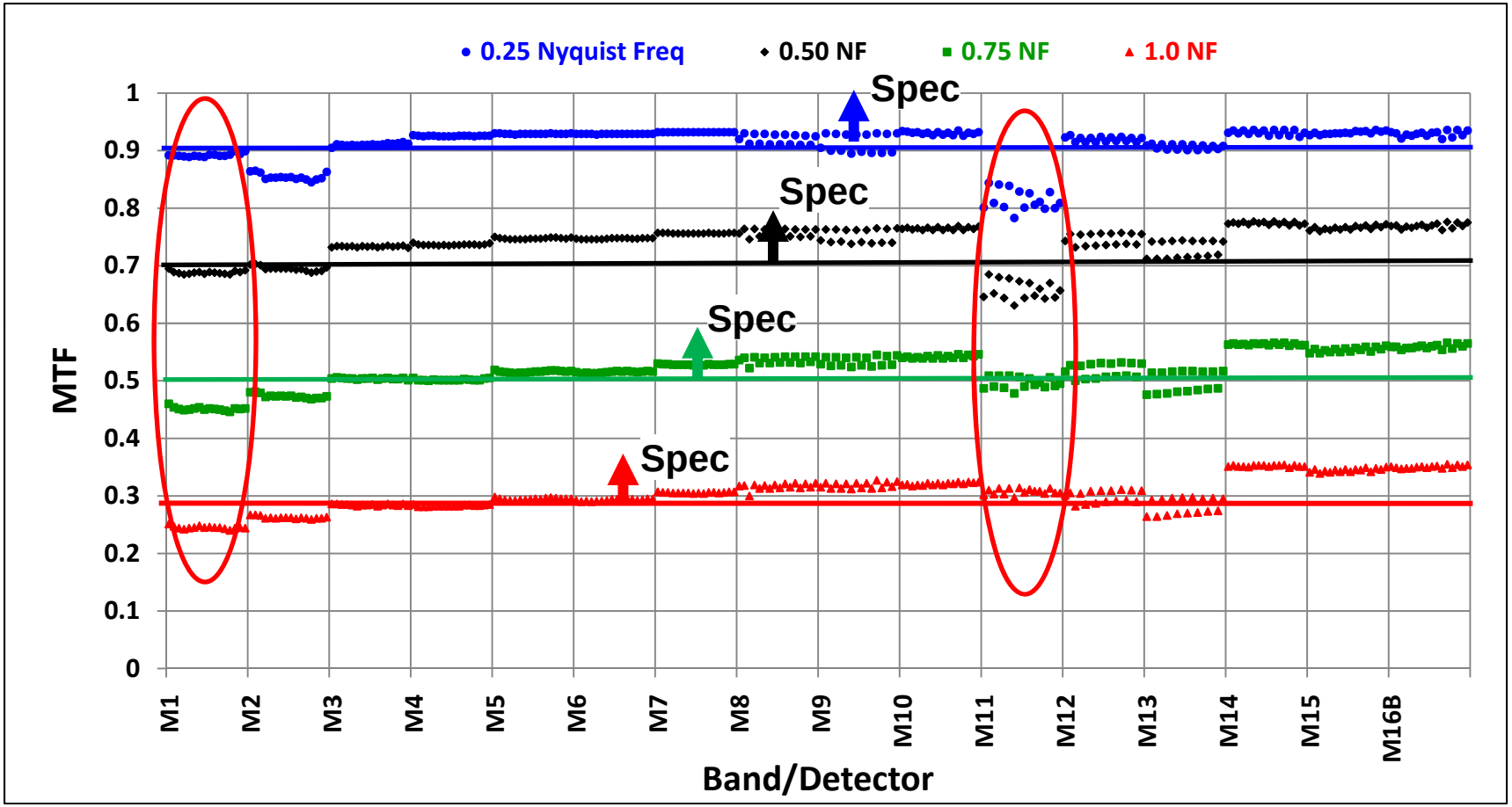
Nyquist Freq. Fraction	MTF
0.00	1.0
0.25	0.9
0.50	0.7
0.75	0.5
1.00	0.3

0.29

Approved waiver Spec (RDW-047A)

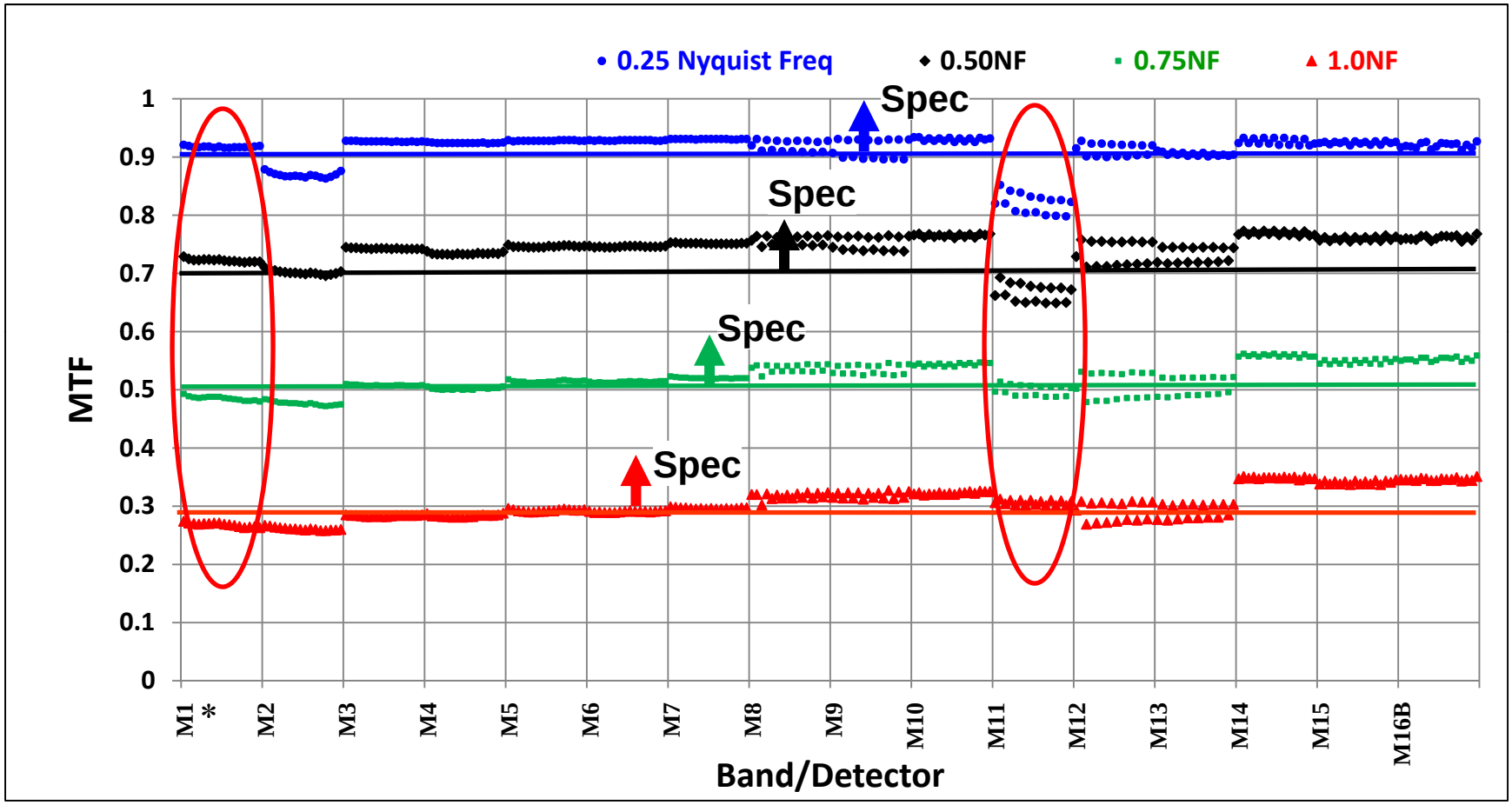


Scan MTF Results in TV (Cold Perf)



- Many M-band detectors, such as M1-4, M11, odd detectors in M12 and M13, are marginally out-of-Spec in MTF.
- M1, M11 is out-of-Spec due to LSF side lobe and/or “high heel”.

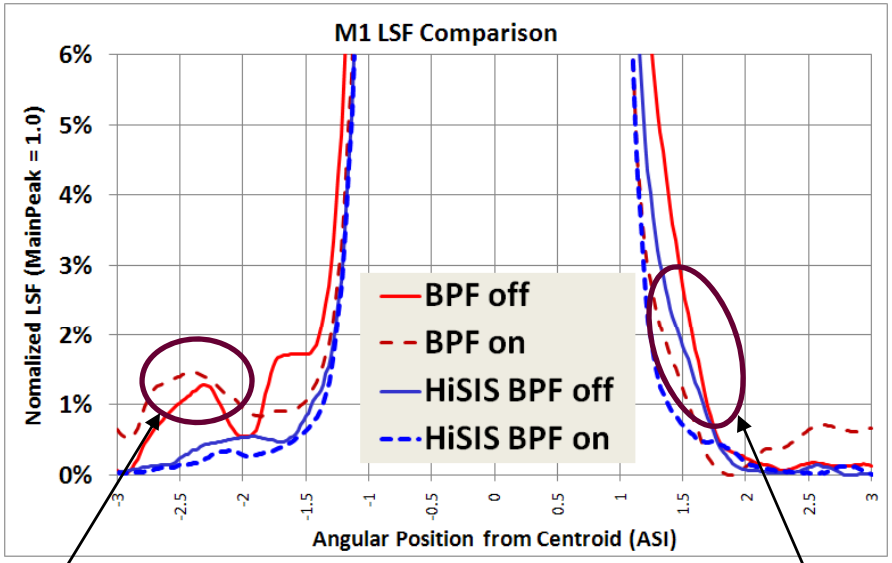
Scan MTF Results in TV (Nom Perf)



* M1 data from a special test at Hot Performance Plateau using bright SIS without band pass filter

- Many M-band detectors, such as M1-4, M11, odd detectors in M12 and M13, are marginally out-of-Spec in MTF.
- M1, M11 is out-of-Spec due to LSF side lobe and/or “high heel”.

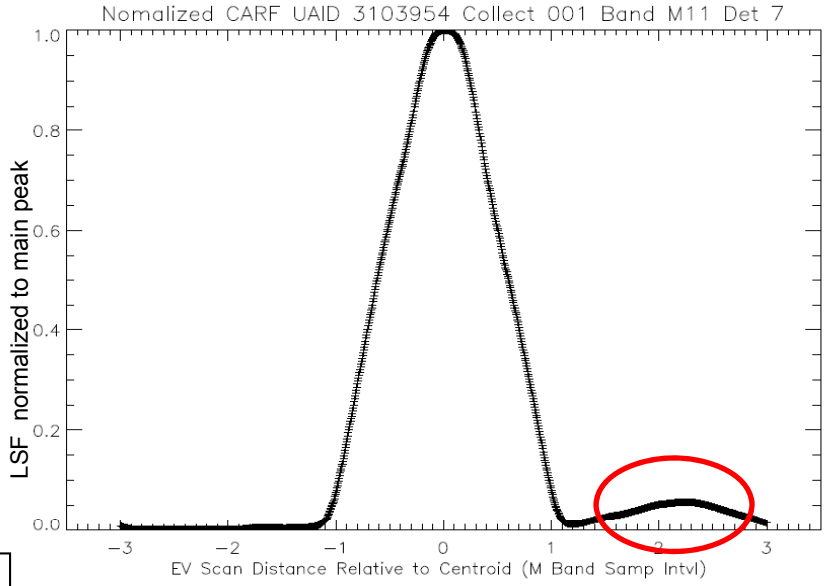
Anomalous LSFs



Leading sidelobe
Bright SIS suppresses it.

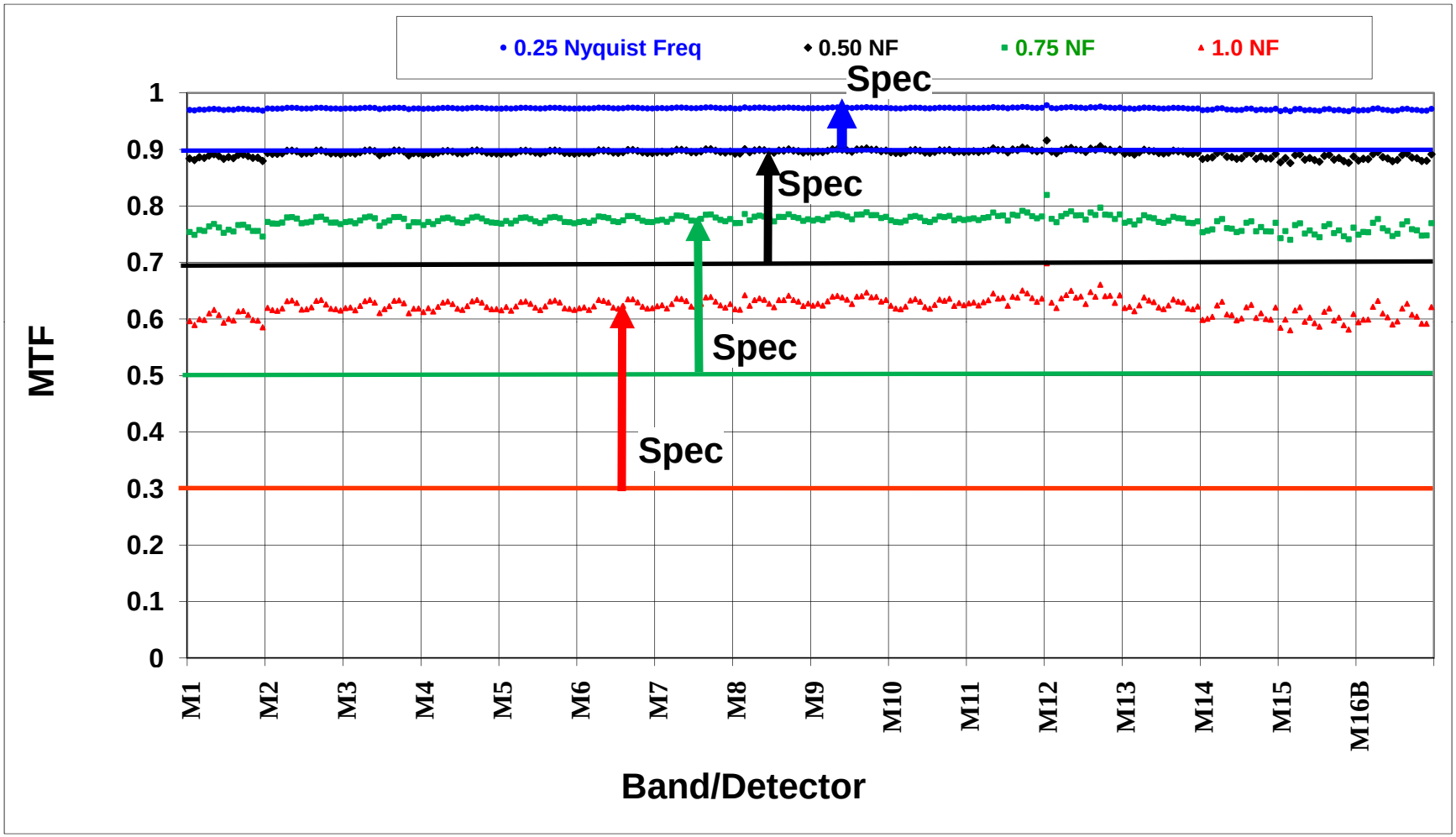
Trailing "high heel"
Band pass filter
(BPF) masks it.

M1 LSF
Trailing "high heel"
& leading sidelobe



M11 LSF, trailing sidelobe
4 – 6%, 2.2 ASIs away from the center of the main lobe

Track MTF Results (Amb only)



MTF for all M-bands meets Spec in ambient.

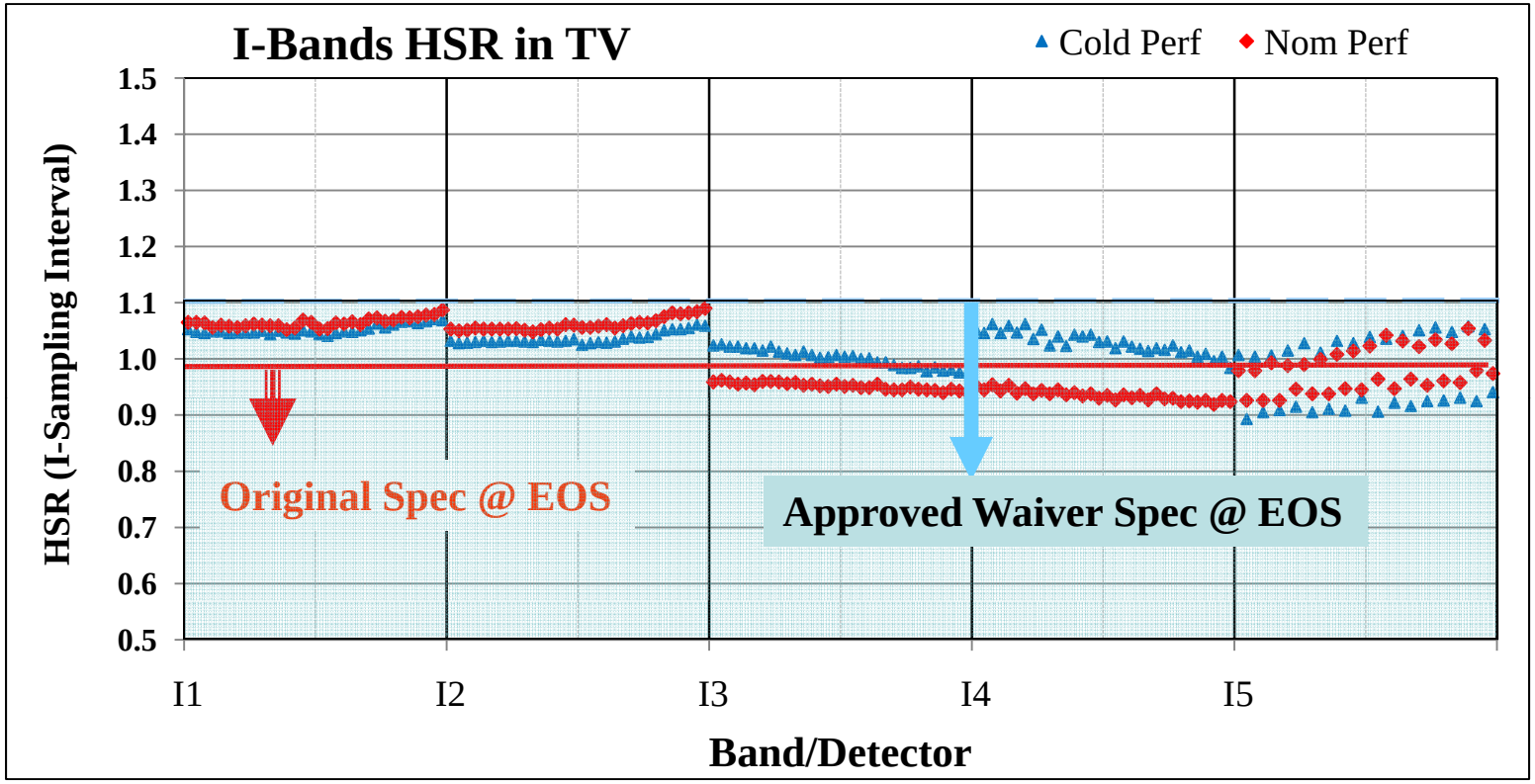
I-bands Image Quality Spec – HSR

I-band Horizontal Spatial Resolution (HSR): the distance on the earth's surface, both in-track and cross-track, corresponding to one-half the longest spatial wavelength at which the sensor MTF has dropped to 0.5

$$MTF\left(\frac{1}{2*HSR}\right)=0.5$$

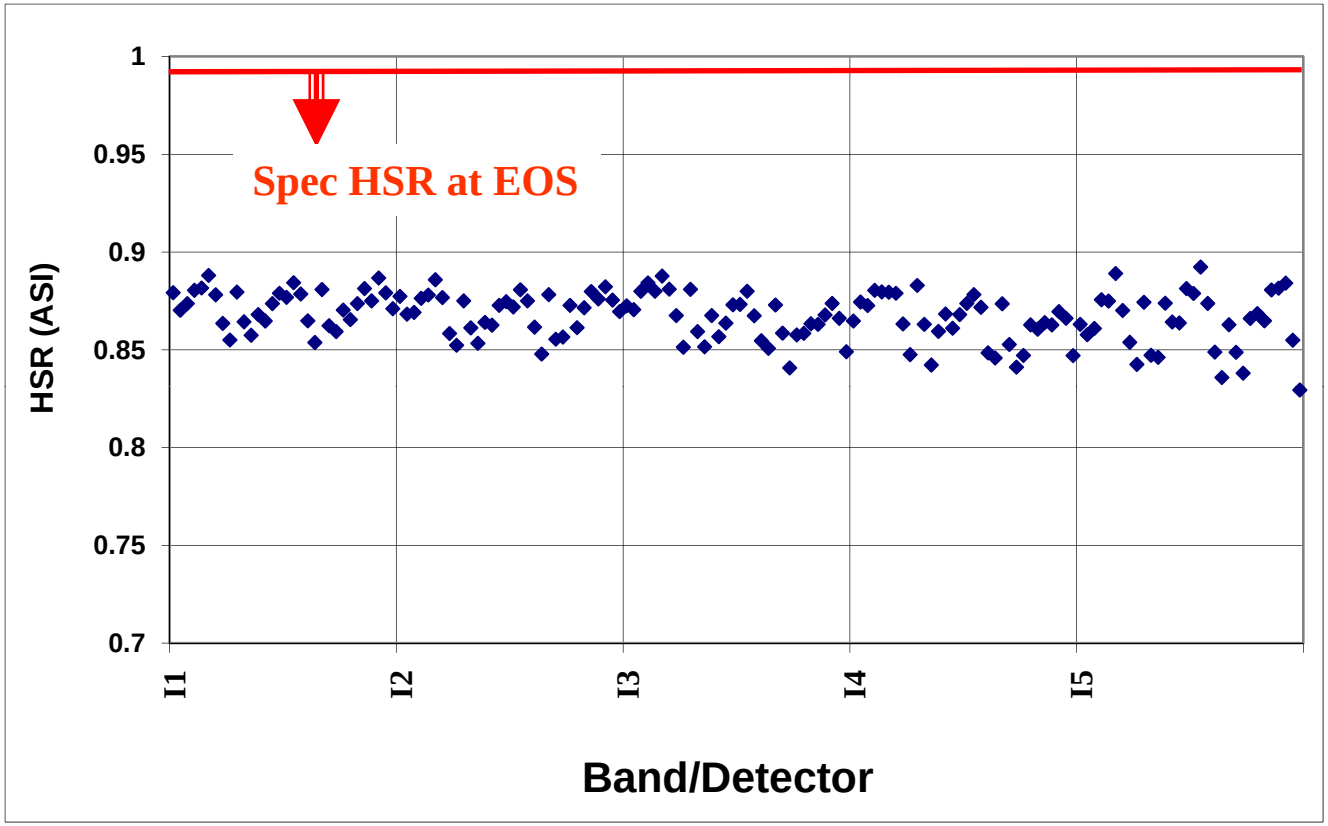
1) HSR ≤ 0.4 km @ nadir – ample margin in scan and track direction (results not shown here).
2) HSR ≤ 0.8 km @ end of scan (EOS)
   - Approved Waiver Spec to 0.9 km **(171 μRad = 1.096 ASIs)** in scan direction.

Scan HSR Results in TV



HSR for all I-bands meets waiver Spec.

Track HSR Results (Amb only)



HSR for all I-bands meets Spec in ambient.

Summary of Spatial Response Testing

1. Overall, the tested spatial response parameters meet Spec, with some detectors marginally out-of-Spec (In general, our results agree with RTN/NG and AERO results, but there are differences due to different approaches in constructing LSFs).
2. In scan direction
   1) Almost all 432 detectors meet DFOV waiver Spec. Most M-band detectors also meet original DFOV Spec;
   2) All I-band detectors meet HSR waiver Spec;
   3) Many M-band detectors, such as M1-4, M11, odd detectors in M12 and M13, are marginally out-of-waiver-Spec in MTF.
3. In track direction, all detectors meet IFOV, HSR and MTF Spec, except: M12 d1, a known underperforming detector, that fails IFOV Spec.
4. On-orbit FOV, HSR and MTF performance is expected to be better without ground test equipment effects such as TVac window & TMC optical blur.
5. NG is evaluating impacts on EDRs from band M11 LSF side lobe
6. Marginal non-compliances to Spec (original or waiver) in spatial responses (DFOV & MTF) do not significantly affect EDRs – further waver Spec (BER-W249) has been approved.

FP4 Spectral Band Registration Tests

Test configuration

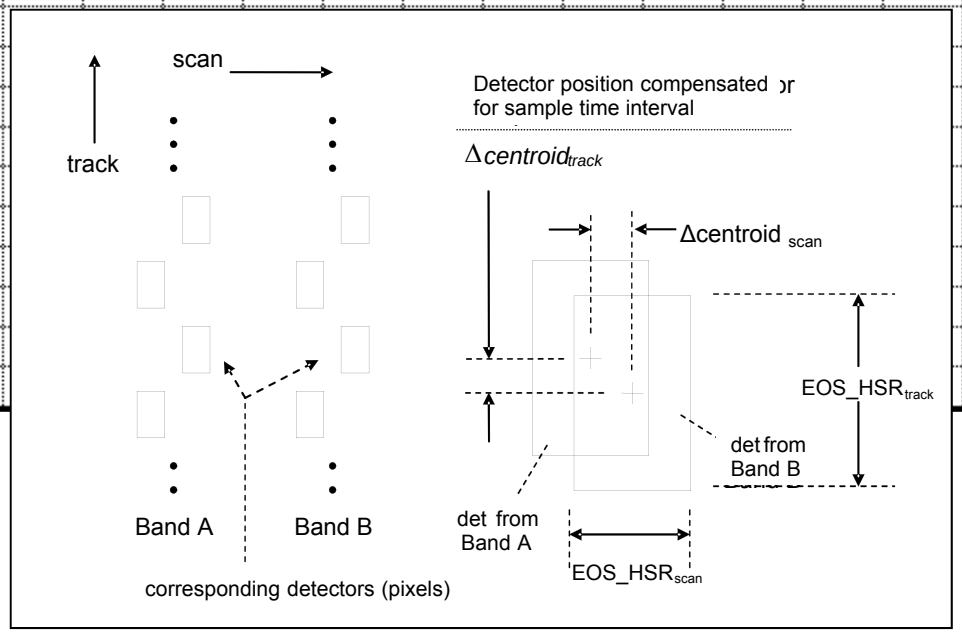
TMC SIS and BB source projected through phased reticle slits in both scan and track direction

1) Cold Performance Plateau (-21^{o}C AOA) through ZnSe and Quartz windows
2) Nominal Performance Plateau (-11^{o}C AOA) through ZnSe and Quartz windows
3) Thermal Cycle (+28^{o}C AOA) through ZnSe window (opportunistic proxy for Hot Performance Plateau (-1^{o}C AOA))

Band-to-Band Co-Registration (BBR) Specification

"At least 99.7% of corresponding pixel samples"

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	I1	I2	I3	I4	I5
M1		0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M2			0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M3				0.64	0.70	0.64	0.64	0.64	0.64	0.64	0.70	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M4					0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M5						0.64	0.80	0.64	0.64	0.64	0.70	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M6							0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M7								0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M8									0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M9										0.64	0.64	0.80	0.80	0.80	0.80	0.80	0.64	0.64	0.64	0.64	0.64
M10											0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M11												0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
M12													0.80	0.80	0.80	0.80	0.64	0.64	0.64	0.64	0.64
M13														0.80	0.80	0.80	0.64	0.64	0.64	0.64	0.64
M14															0.80	0.80	0.64	0.64	0.64	0.64	0.64
M15																0.80	0.64	0.64	0.64	0.64	0.64
M16																	0.64	0.64	0.64	0.64	0.64
I1																		0.80	0.80	0.80	0.80
I2																			0.80	0.80	0.80
I3																				0.80	0.80
I4																					0.80
I5																					

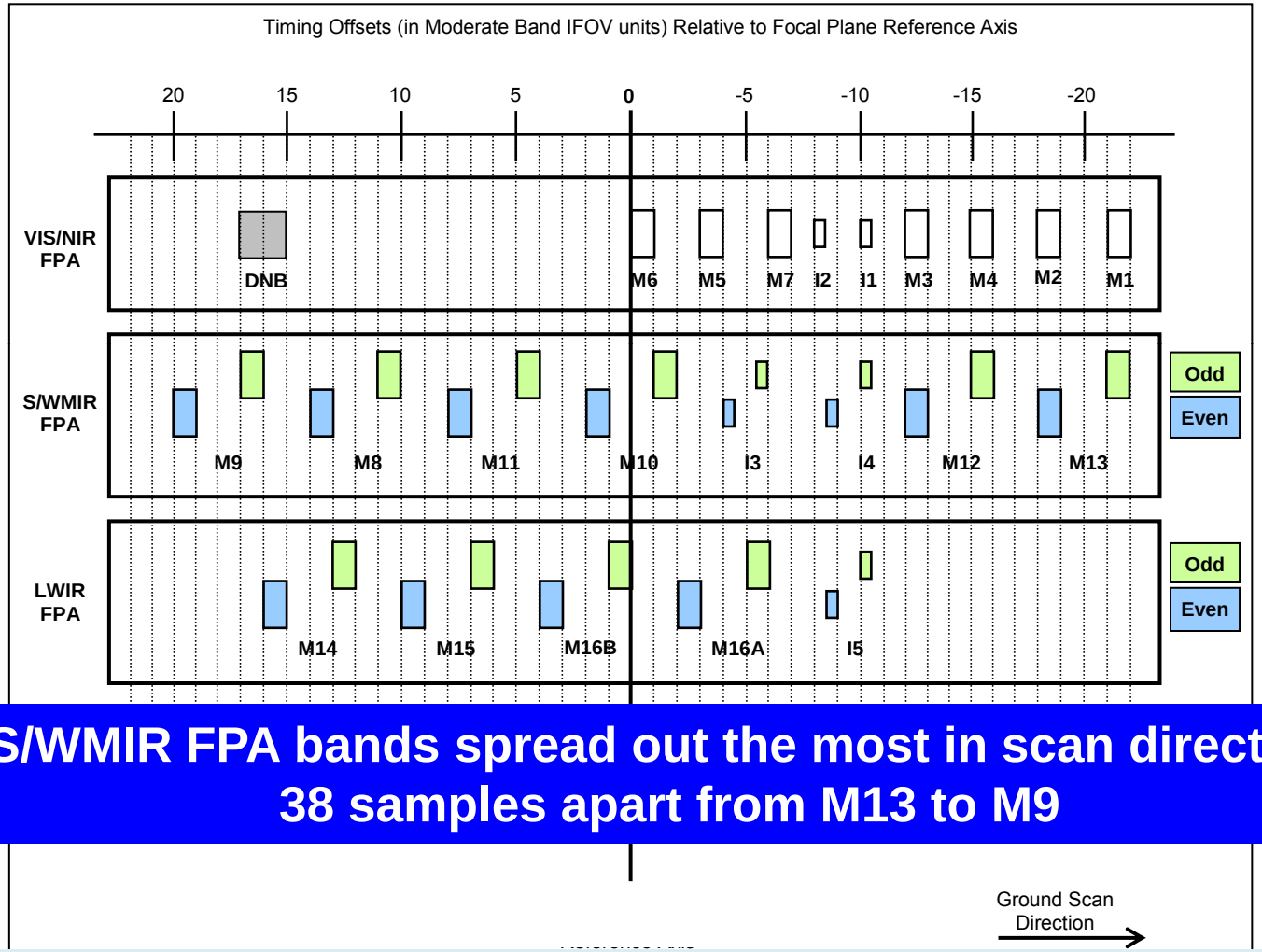


DDR = (1-ΔCentroid_track) * (1-ΔCentroid_scan) for un-aggregated pixels.

$BBR_{99.7\%}$ ~ min(DDRs) w/in band pair

Note: Specified HSR(or ASR)@EOS is almost exactly as HSI (or ASI)@EOS

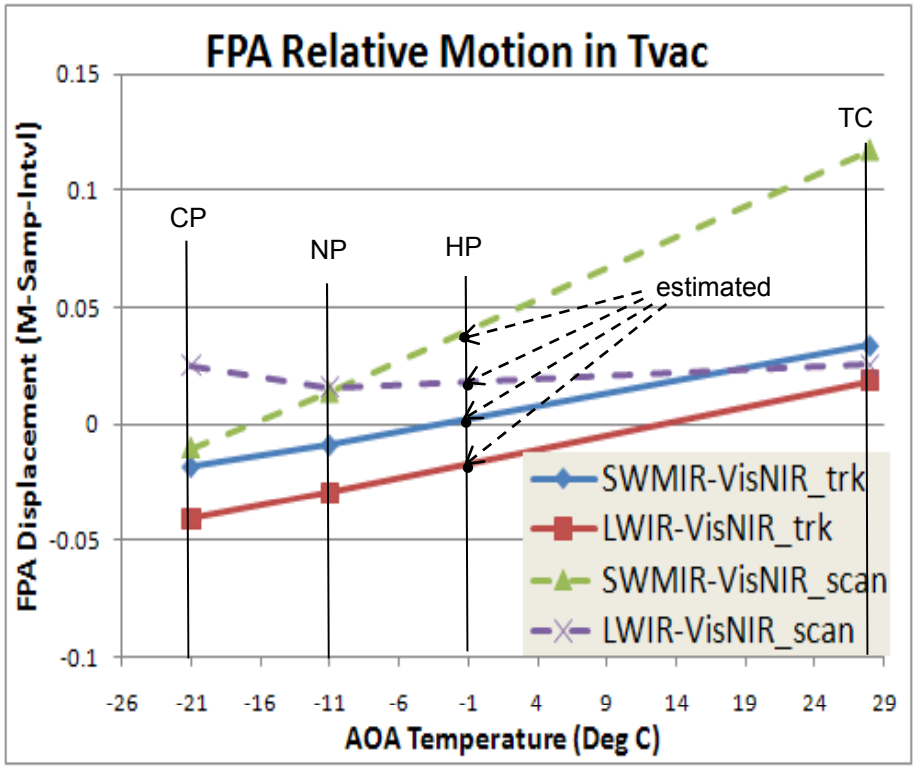
VIIRS Band/Detector Physical Layout

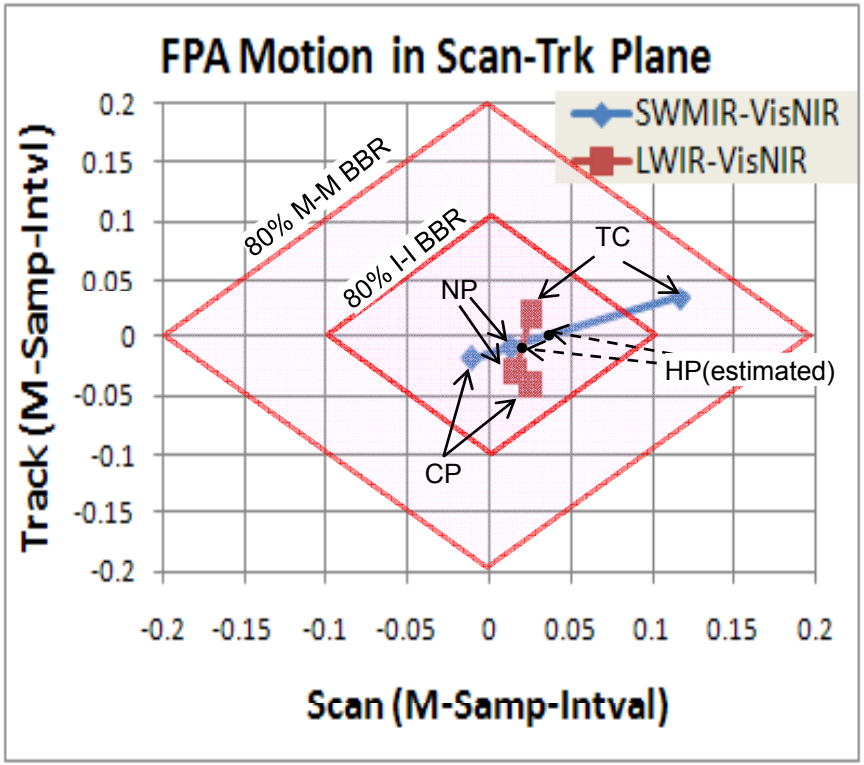


S/WMIR FPA bands spread out the most in scan direction, 38 samples apart from M13 to M9

3 focal planes: VisNIR, SWMIR, LWIR; + 1 DNB (no BBR Spec)
21 bands (16 M-bands (M16A, M16B merged in space or just sent down one), 5 I-bands)
16 detectors in each M-band; 32 detectors in each I-band

Apparent FPA Centroid Motion in TVac

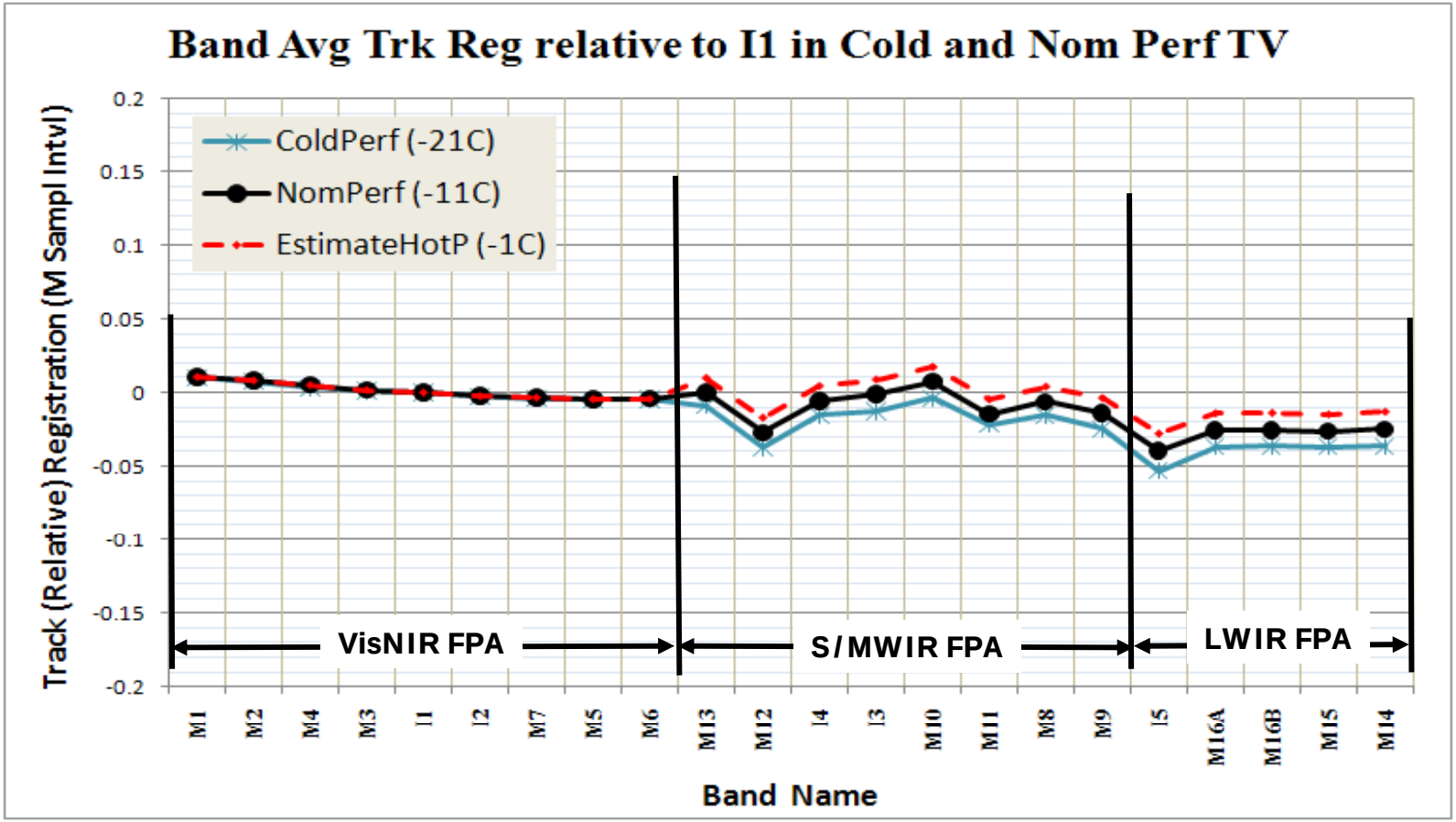




CP = Cold Perf, NP = Nominal Perf, HP = Hot Perf, TC = Thermal Cycle

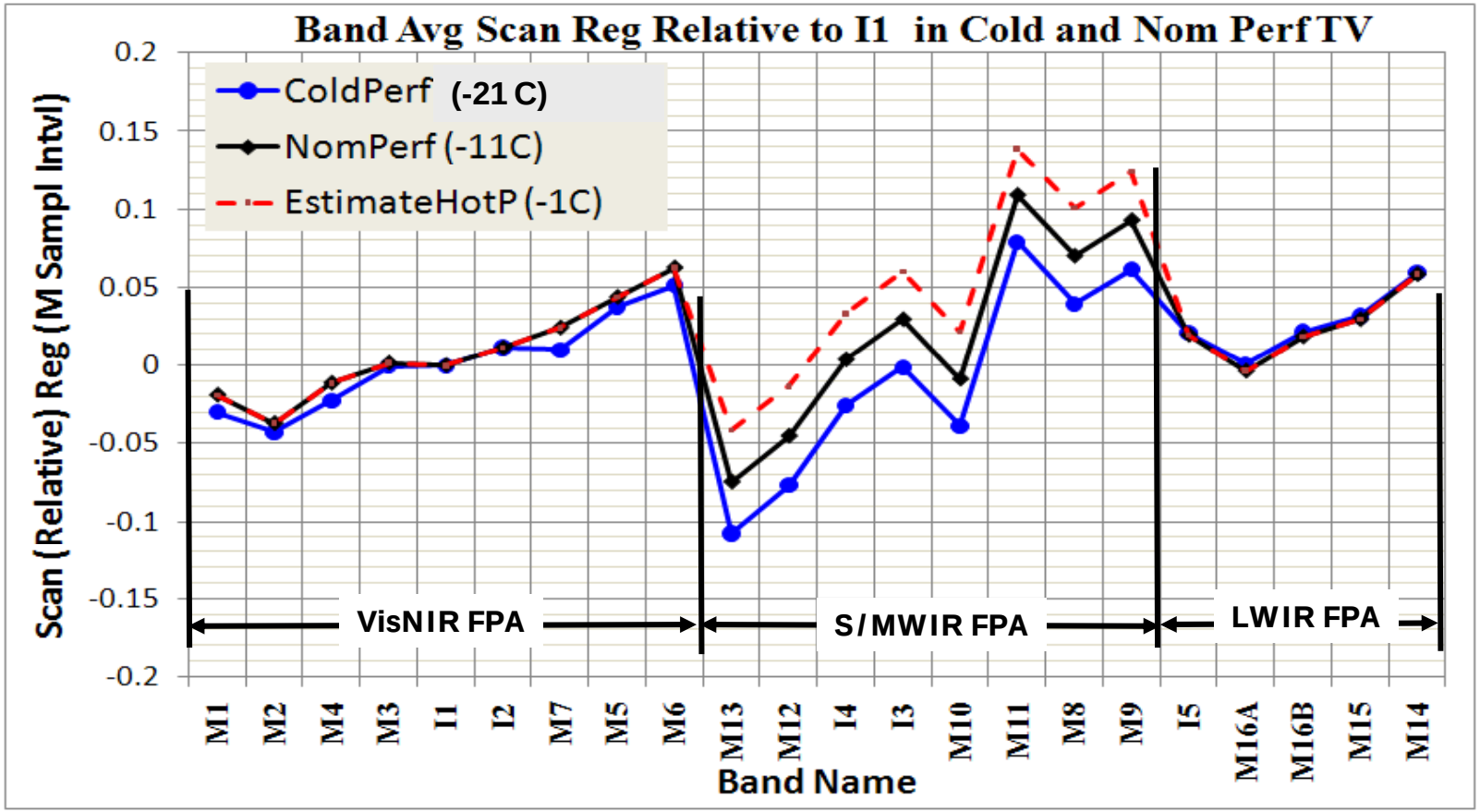
- FPA centroids do move as temperature changes
- We can estimate SBRs at Hot Performance Plateau
- FPA centroids are close to each other

Track Relative Registration



- SWMIR and LWIR FPAs move closer to VisNIR FPA as temperature goes up
- Track SBR is not adjustable, but it is pretty good as is

Scan Relative Registration



- The upward slopes within FPAs indicate mismatch between effective focal length (EFL) and scan speed (already maxed out), which causes mis-registration between edge band pairs (e.g. M9 vs M13)
- M12, M13 are the farthest away from the LWIR bands
- Scan SBR is adjustable through uploadable tables

Worst BBR @ Cold Perf Plateau

|<----Worst BBR = Minimum(12 or 24 DDR (detector-to-detector co-registration) pairs for HAM A and B sides) ---->|

|<---------- # of detector pairs having BBR out-of-Spec ----------->|

|<----Worst BBR = Minimum(DDR pairs for HAM A and B sides) ---->|

Band	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16A	M16B	I1	I2	I3	I4	I5
M1		0.97	0.94	0.97	0.89	0.87	0.91	0.86	0.84	0.94	0.82	0.86	0.87	0.85	0.88	0.90	0.88	0.93	0.92	0.91	0.94	0.87
M2	0		0.94	0.97	0.89	0.88	0.92	0.86	0.84	0.96	0.82	0.88	0.89	0.85	0.88	0.90	0.88	0.94	0.92	0.92	0.94	0.87
M3	0	0		0.96	0.94	0.92	0.97	0.91	0.89	0.93	0.88	0.85	0.86	0.90	0.92	0.94	0.93	0.99	0.97	0.97	0.95	0.92
M4	0	0	0		0.92	0.90	0.95	0.89	0.87	0.94	0.85	0.86	0.87	0.88	0.90	0.93	0.91	0.96	0.95	0.95	0.96	0.90
M5	0	0	0	0		0.98	0.96	0.97	0.95	0.90	0.92	0.82	0.83	0.94	0.95	0.91	0.94	0.95	0.96	0.94	0.92	0.93
M6	0	0	0	0	0		0.95	0.96	0.96	0.89	0.93	0.81	0.81	0.95	0.94	0.90	0.93	0.93	0.95	0.93	0.91	0.91
M7	0	0	0	0	0	0		0.94	0.92	0.93	0.90	0.85	0.85	0.91	0.93	0.94	0.94	0.98	0.99	0.97	0.94	0.92
M8	0	0	0	0	0	0	0		0.96	0.89	0.92	0.83	0.82	0.94	0.95	0.92	0.94	0.92	0.94	0.94	0.92	0.93
M9	0	0	0	0	0	0	0	0		0.87	0.95	0.83	0.79	0.96	0.94	0.89	0.92	0.90	0.92	0.92	0.90	0.91
M10	0	0	0	0	0	0	0	0	0		0.84	0.89	0.89	0.85	0.88	0.91	0.89	0.93	0.93	0.95	0.97	0.87
M11	0	0	0	0	0	0	0	0	0	0		0.81	0.78	0.93	0.90	0.86	0.89	0.88	0.90	0.89	0.86	0.88
M12	0	0	0	0	0	0	0	0	0	0	0		0.92	0.83	0.86	0.87	0.86	0.85	0.84	0.87	0.90	0.87
M13	0	0	0	0	0	0	0	0	1	0	0	0		0.79	0.82	0.84	0.82	0.86	0.85	0.86	0.89	0.81
M14	0	0	0	0	0	0	0	0	0	0	0	0	6		0.96	0.92	0.95	0.90	0.91	0.90	0.88	0.94
M15	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.98	0.92	0.94	0.93	0.91	0.97
M16A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.97	0.95	0.94	0.96	0.94	0.96
M16B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.94	0.94	0.92	0.97
I1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.94	0.89	0.81
I2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.88	0.82
I3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.81
I4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.77
I5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	

|<---------- # of detector pairs having BBR out-of-Spec ----------->|

0.79 Red = out-of-Spec BBR

0.84 Yellow = BBR with low margin (< 5%)

0.86 White = Compliant BBR

6 Brown = # of detector pairs out of Spec

Worst BBR @ Nominal Perf Plateau

|<----Worst BBR = Minimum(12 or 24 DDR (detector-to-detector co-registration) pairs for HAM A and B sides) ---->|

Band	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16A	M16B	I1	I2	I3	I4	I5
M1		0.96	0.95	0.97	0.89	0.87	0.91	0.84	0.83	0.95	0.81	0.89	0.90	0.86	0.90	0.92	0.90	0.94	0.93	0.91	0.93	0.89
M2	0		0.95	0.97	0.89	0.87	0.91	0.84	0.83	0.95	0.81	0.92	0.92	0.86	0.89	0.92	0.90	0.94	0.93	0.91	0.93	0.89
M3	0	0		0.98	0.94	0.91	0.96	0.89	0.87	0.96	0.85	0.89	0.90	0.91	0.94	0.95	0.94	0.99	0.97	0.95	0.97	0.94
M4	0	0	0		0.92	0.9	0.94	0.87	0.86	0.97	0.84	0.89	0.90	0.89	0.92	0.95	0.93	0.98	0.96	0.94	0.96	0.92
M5	0	0	0	0		0.97	0.97	0.95	0.93	0.93	0.90	0.86	0.85	0.96	0.96	0.92	0.94	0.94	0.96	0.98	0.95	0.93
M6	0	0	0	0	0		0.95	0.97	0.95	0.91	0.92	0.84	0.83	0.97	0.94	0.89	0.92	0.92	0.94	0.96	0.93	0.91
M7	0	0	0	0	0	0		0.92	0.91	0.95	0.88	0.87	0.88	0.94	0.96	0.93	0.96	0.97	0.98	0.98	0.97	0.95
M8	0	0	0	0	0	0	0		0.96	0.89	0.93	0.84	0.82	0.95	0.91	0.88	0.91	0.89	0.91	0.93	0.91	0.89
M9	0	0	0	0	0	0	0	0		0.87	0.96	0.82	0.79	0.93	0.90	0.85	0.88	0.88	0.89	0.92	0.89	0.88
M10	0	0	0	0	0	0	0	0	0		0.84	0.90	0.89	0.89	0.92	0.95	0.93	0.97	0.96	0.95	0.97	0.91
M11	0	0	0	0	0	0	0	0	0	0		0.82	0.78	0.90	0.87	0.83	0.86	0.86	0.87	0.89	0.87	0.85
M12	0	0	0	0	0	0	0	0	0	0	0		0.92	0.87	0.90	0.91	0.90	0.89	0.88	0.87	0.90	0.90
M13	0	0	0	0	0	0	0	0	1	0	0	0		0.83	0.86	0.88	0.86	0.90	0.89	0.87	0.89	0.85
M14	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.92	0.95	0.91	0.92	0.94	0.92	0.94
M15	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.97	0.94	0.95	0.96	0.94	0.97
M16A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.97	0.95	0.94	0.92	0.96	0.95
M16B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.96	0.95	0.95	0.97
I1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.91	0.96	0.83
I2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.94	0.96	0.85
I3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.84
I4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.82
I5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

|<---------- # of detector pairs having BBR out-of-Spec ---------->|

|<---Worst BBR = Minimum(DDR pairs for HAM A and B sides) --->|

|<---------- # of detector pairs having BBR out-of-Spec ---------->|

0.79 Red = out-of-Spec BBR

0.82 Yellow = BBR with low margin (< 5%)

0.86 White = Compliant BBR

1 Brown = # of detector pairs out of Spec

Estimated Worst BBR @ Hot Perf Plateau

|<----Worst BBR = Minimum(12 or 24 DDR (detector-to-detector co-registration) pairs for HAM A and B sides) ---->|

Band	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16A	M16B	I1	I2	I3	I4	I5
M1		0.96	0.95	0.97	0.89	0.87	0.91	0.82	0.81	0.92	0.78	0.93	0.93	0.87	0.91	0.93	0.91	0.94	0.93	0.88	0.91	0.90
M2	0		0.95	0.97	0.89	0.87	0.91	0.82	0.80	0.91	0.78	0.94	0.96	0.87	0.90	0.93	0.91	0.94	0.93	0.88	0.91	0.90
M3	0	0		0.98	0.94	0.91	0.96	0.86	0.84	0.94	0.82	0.92	0.92	0.92	0.95	0.96	0.95	0.99	0.97	0.92	0.95	0.95
M4	0	0	0		0.92	0.90	0.94	0.85	0.83	0.93	0.80	0.93	0.94	0.91	0.94	0.96	0.94	0.98	0.96	0.90	0.93	0.93
M5	0	0	0	0		0.97	0.97	0.91	0.89	0.95	0.87	0.90	0.88	0.97	0.97	0.93	0.95	0.94	0.96	0.96	0.97	0.95
M6	0	0	0	0	0		0.95	0.93	0.91	0.93	0.89	0.88	0.85	0.98	0.95	0.90	0.93	0.92	0.94	0.98	0.96	0.92
M7	0	0	0	0	0	0		0.89	0.87	0.96	0.85	0.91	0.90	0.95	0.97	0.94	0.97	0.97	0.98	0.94	0.98	0.96
M8	0	0	0	0	0	0	0		0.96	0.89	0.93	0.84	0.82	0.92	0.89	0.85	0.88	0.87	0.88	0.93	0.91	0.86
M9	0	0	0	0	0	0	0	0		0.87	0.96	0.82	0.79	0.90	0.87	0.83	0.85	0.85	0.86	0.92	0.89	0.85
M10	0	0	0	0	0	0	0	0	0		0.84	0.90	0.89	0.92	0.95	0.93	0.95	0.94	0.95	0.95	0.97	0.93
M11	0	0	0	0	0	0	0	0	0	0		0.82	0.78	0.88	0.85	0.80	0.83	0.82	0.83	0.89	0.87	0.82
M12	0	0	0	0	0	0	0	0	0	0	0		0.92	0.89	0.93	0.94	0.92	0.93	0.92	0.87	0.90	0.93
M13	0	0	0	0	0	0	0	0	1	0	0	0		0.86	0.89	0.91	0.89	0.93	0.91	0.87	0.89	0.88
M14	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.92	0.95	0.92	0.93	0.97	0.95	0.94
M15	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.97	0.95	0.96	0.94	0.97	0.97
M16A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.97	0.96	0.95	0.90	0.93	0.95
M16B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.97	0.92	0.96	0.97
I1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.83	0.90	0.85
I2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.86	0.93	0.87
I3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.79
I4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.85
I5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	

|<---------- # of detector pairs having BBR out-of-Spec ---------->|

|<----Worst BBR = Minimum(DDR pairs for HAM A and B sides) ---->|

0.79 Red = out-of-Spec BBR

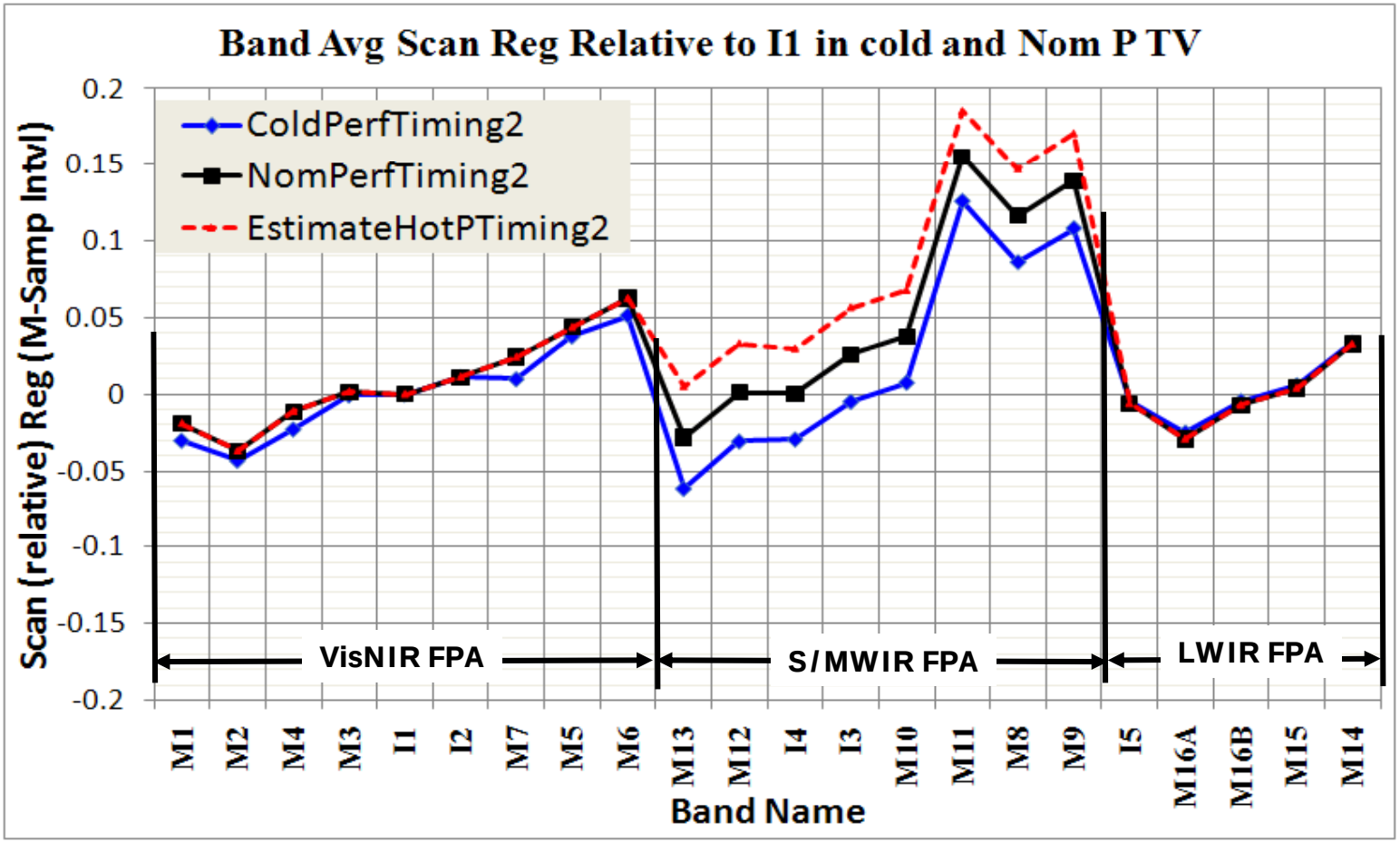
0.82 Yellow = BBR with low margin (< 5%)

0.86 White = Compliant BBR

3 Brown = # of detector pairs out of Spec

Scan Relative Registration

can be adjusted for better BBR between M12/M13 and LWIR bands



- Recommend further scan timing adjustments in exchange of BBR between M9 and LWIR bands (Spec'd BBR between M11/M8 and all other bands is less stringent)

Update uploadable tables to FSW to accomplish the following:
W/MWIR FPA up 4.62% relative to VIsNIR, while I3,I4 down 5% relative to M-bands
LWIR FPA down 2.55% relative to VIsNIR FPA

BBR Improvements

Nom Perf

Band	M9	M12	M13	M14	M15	M16A	M16B	I4	I5
M9		0.82	0.79	0.93	0.90	0.85	0.88	0.89	0.88
M12	0		0.92	0.87	0.90	0.91	0.90	0.90	0.90
M13	1	0		0.83	0.86	0.88	0.86	0.89	0.85
M14	0	0	0		0.96	0.92	0.95	0.92	0.94
M15	0	0	0	0		0.95	0.97	0.94	0.97
M16A	0	0	0	0	0		0.97	0.96	0.95
M16B	0	0	0	0	0	0		0.95	0.97
I1	0	0	0	0	0	0	0	0.96	0.83
I2	0	0	0	0	0	0	0	0.96	0.85
I3	0	0	0	0	0	0	0	0.93	0.84
I4	0	0	0	0	0	0	0		0.82
I5	0	0	0	0	0	0	0	0	

Band	M9	M12	M13	M14	M15	M16A	M16B	I4	I5
M9		0.82	0.79	0.86	0.83	0.78	0.81	0.84	0.81
M12	0		0.92	0.94	0.96	0.92	0.95	0.95	0.94
M13	1	0		0.90	0.93	0.94	0.93	0.94	0.92
M14	0	0	0		0.96	0.92	0.95	0.94	0.94
M15	0	0	0	0		0.95	0.97	0.96	0.97
M16A	1	0	0	0	0		0.97	0.94	0.95
M16B	0	0	0	0	0	0		0.97	0.97
I1	0	0	0	0	0	0	0	0.96	0.86
I2	0	0	0	0	0	0	0	0.95	0.85
I3	0	0	0	0	0	0	0	0.93	0.80
I4	0	0	0	0	0	0	0		0.86
I5	0	0	0	0	0	0	0	0	

Cold Perf

Band	M9	M12	M13	M14	M15	M16A	M16B	I4	I5
M9		0.83	0.79	0.96	0.94	0.89	0.92	0.90	0.91
M12	0		0.92	0.83	0.86	0.87	0.86	0.90	0.87
M13	1	0		0.79	0.82	0.84	0.82	0.89	0.81
M14	0	0	6		0.96	0.92	0.95	0.88	0.94
M15	0	0	0	0		0.95	0.98	0.91	0.97
M16A	0	0	0	0	0		0.97	0.94	0.96
M16B	0	0	0	0	0	0		0.92	0.97
I1	0	0	0	0	0	0	0	0.89	0.81
I2	0	0	0	0	0	0	0	0.88	0.82
I3	0	0	0	0	0	0	0	0.93	0.81
I4	0	0	0	0	0	0	0		0.77
I5	0	0	0	0	0	0	0	5	

Band	M9	M12	M13	M14	M15	M16A	M16B	I4	I5
M9		0.83	0.79	0.89	0.87	0.82	0.85	0.85	0.84
M12	0		0.92	0.90	0.93	0.94	0.93	0.94	0.94
M13	1	0		0.86	0.89	0.91	0.89	0.93	0.88
M14	0	0	0		0.96	0.92	0.95	0.90	0.94
M15	0	0	0	0		0.95	0.98	0.93	0.97
M16A	0	0	0	0	0		0.97	0.96	0.96
M16B	0	0	0	0	0	0		0.94	0.97
I1	0	0	0	0	0	0	0	0.89	0.84
I2	0	0	0	0	0	0	0	0.87	0.82
I3	0	0	0	0	0	0	0	0.93	0.84
I4	0	0	0	0	0	0	0		0.81
I5	0	0	0	0	0	0	0	0	

Before

7% trade, up for M12/M13 , down for M9

After

Rationale for Further Scan Timing Adjustments

EDR ID#	Band Wavelength (um)	M9 1.378	M12 3.7	M13 4.05	M14 8.55	M15 10.76	M16 12.01
1	Imagery	x	x	x	x	x	x
2	Sea Surface Temp		x			x	x
4	Cloud Base Height		x	x	x	x	x
5	Cloud cover/Layers		x	x	x	x	x
6	Cloud Optical Part Size		x		x	x	x
7	Cloud Thickness		x		x	x	x
8	Cloud Top Height		x	x	x	x	x
9	Cloud Top Pressure		x	x	x	x	x
10	Cloud Top Temp		x	x	x	x	x
11	Land Surface Temp.		x	x		x	x
12	Active Fires			x		x	x
16	Surface Type		x	x	x	x	x
28	Total Prec Water		x	x	x	x	x
29	Cloud Mask (IP)	x	x	x	x	x	x

		VIS	NIR	SWIR	MWIR	LWIR
Ocean						
Land	x	Denotes bands that are **Not** primary inputs into algorithm. Used as internal check for algorithm.				
Aerosol						
Clouds						
Ice and Snow						

Courtesy of Hassan Oudrari

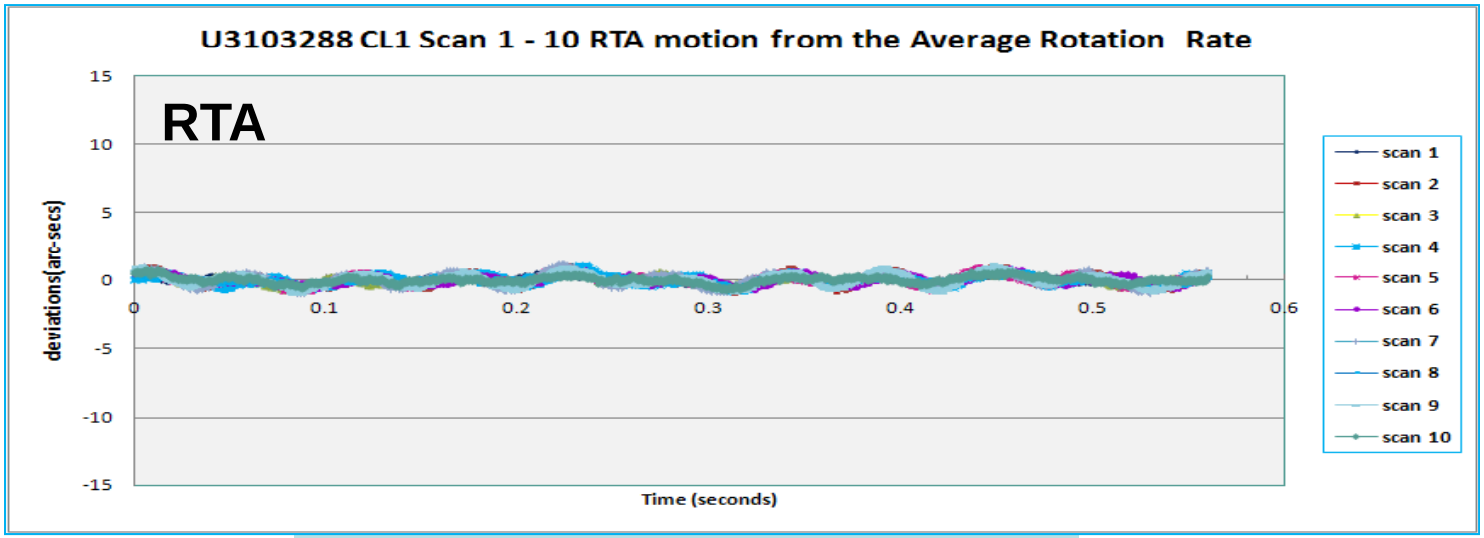
- Band M9 is used once for VCM and 0 EDR with other bands
- Bands M12/M13 are used in VCM and 12 EDRs with other bands
- M12/M13 vs LWIR band co-registration is more important than M9 vs LWIR band co-registration

Summary of Relative Registration Testing

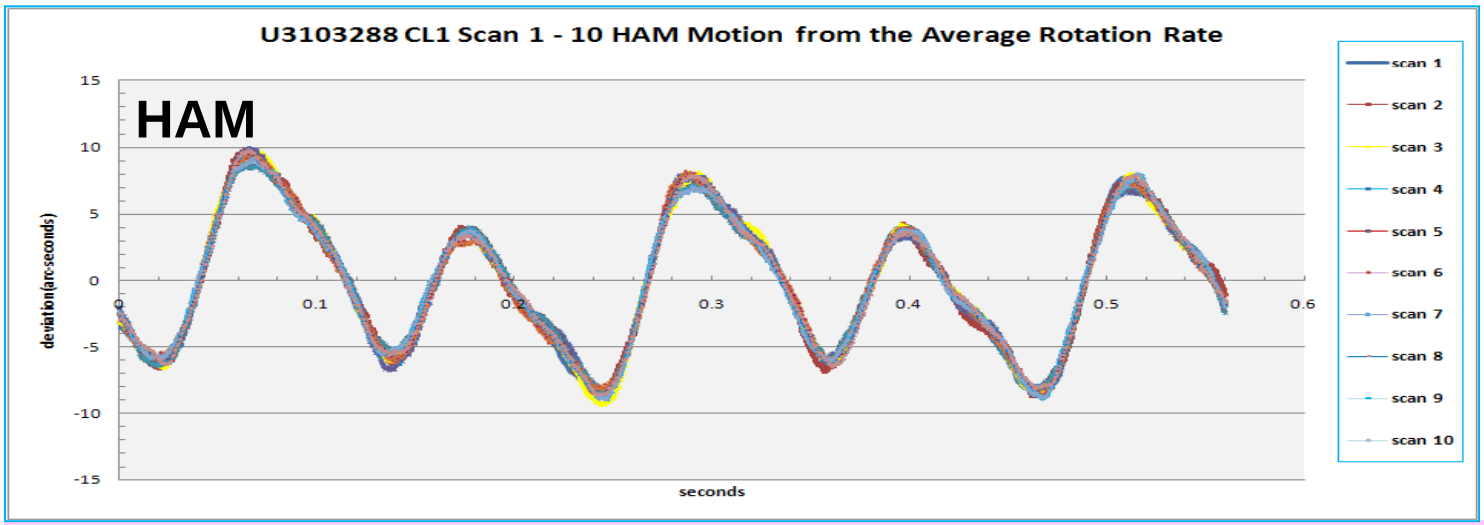
1. BBR from ground tests meets Spec except for a few detector pairs (Our results are comparable with RTN & AERO results < 2%)
2. The main scan error source is the mismatch between scan rate and EFL, which causes mis-registration between band pairs on edges of FPAs
3. On-orbit effects, e.g., spacecraft jitter, FPA-FPA thermal displacements, are expected to make BBR for some band pairs worse
4. Recommend further scan timing adjustments to improve more important BBR between M12/M13 and LWIR bands (~ 7%) in exchange for less important BBR between M9 and LWIR bands

FP5 Pointing Stability

Offsets of RTA/HAM from linear motion

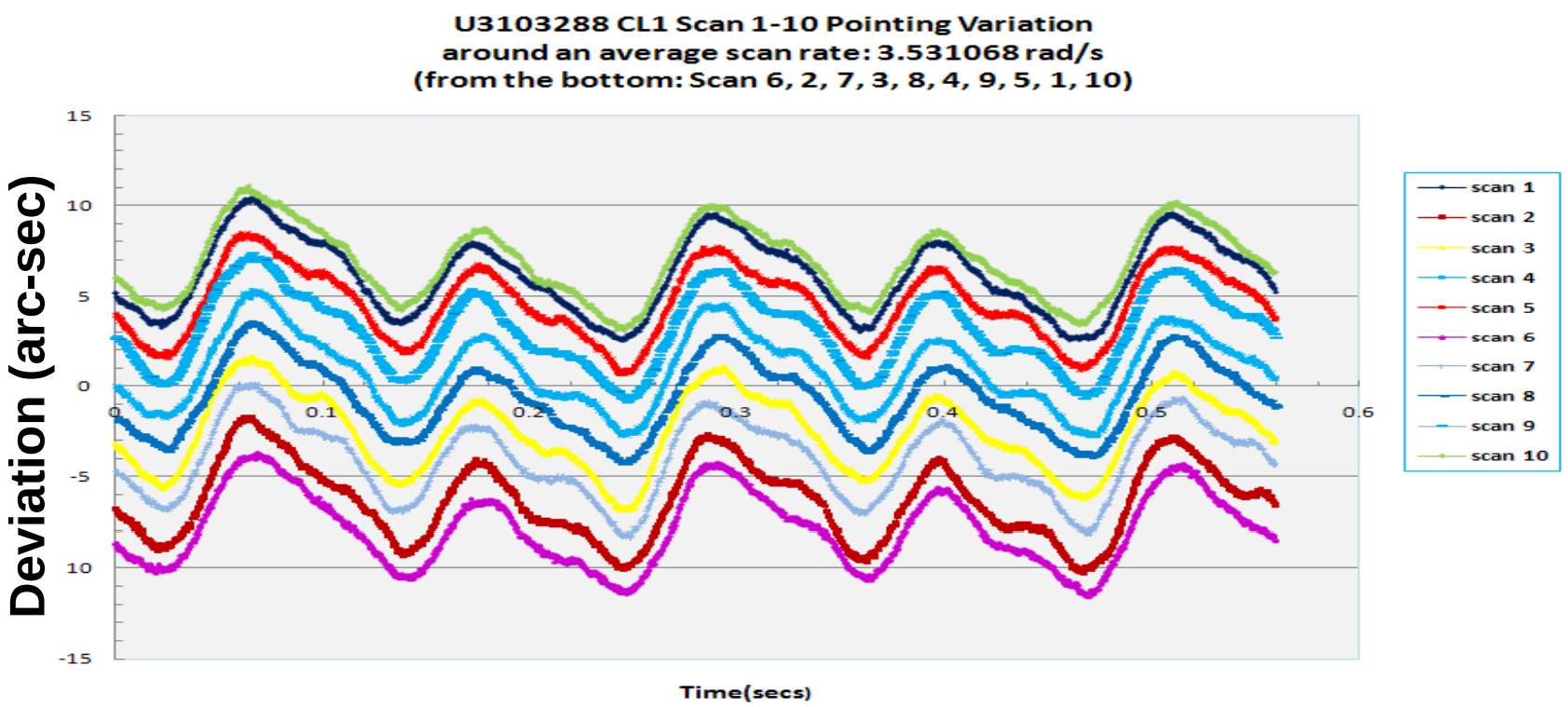


RTA offsets are pretty small



HAM offsets dominate the pointing variability in scan direction

Pointing Variation due to Variable Scan Start & Non-Linear Scan Rate

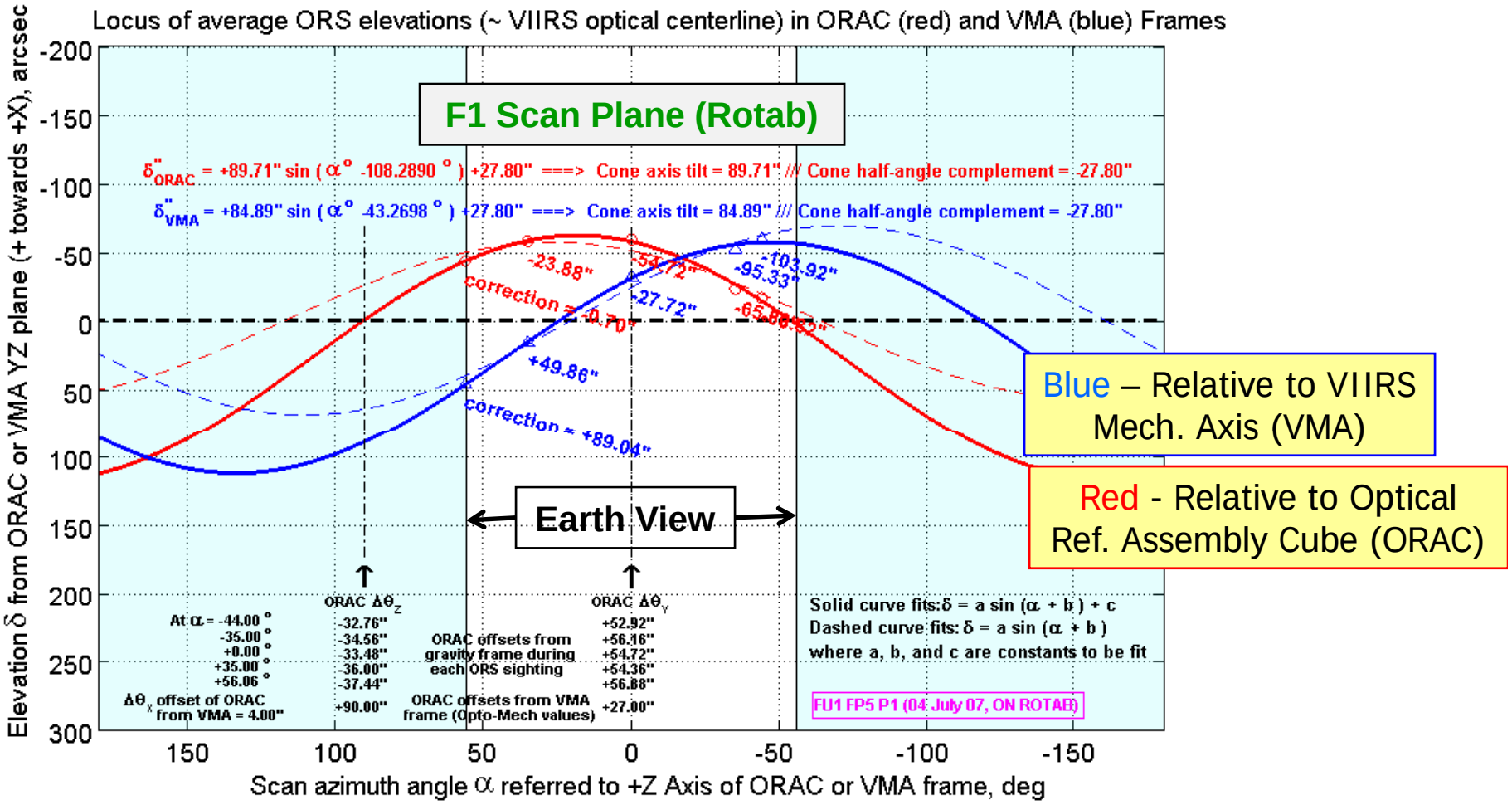


Example pointing deviation from average scan rate and average scan start bias

Scan pointing follows the curves with full complement of RTA/HAM encoder/timestamps information.

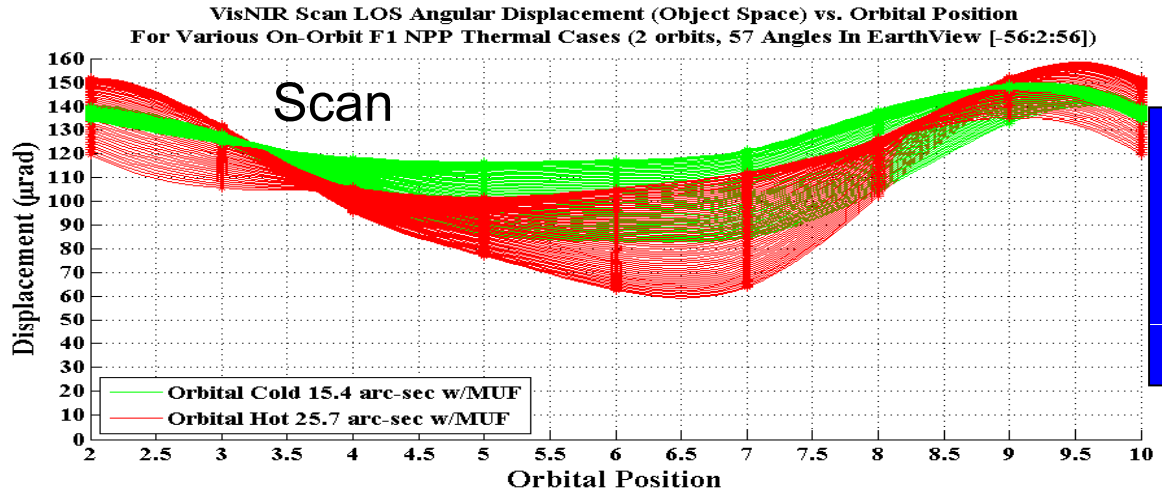
This would be the pointing error in scan direction if the sample spike events cause the loss of timestamps.

F1 scan plane tilts
in Ambient test w/ VIIRS on Rotab

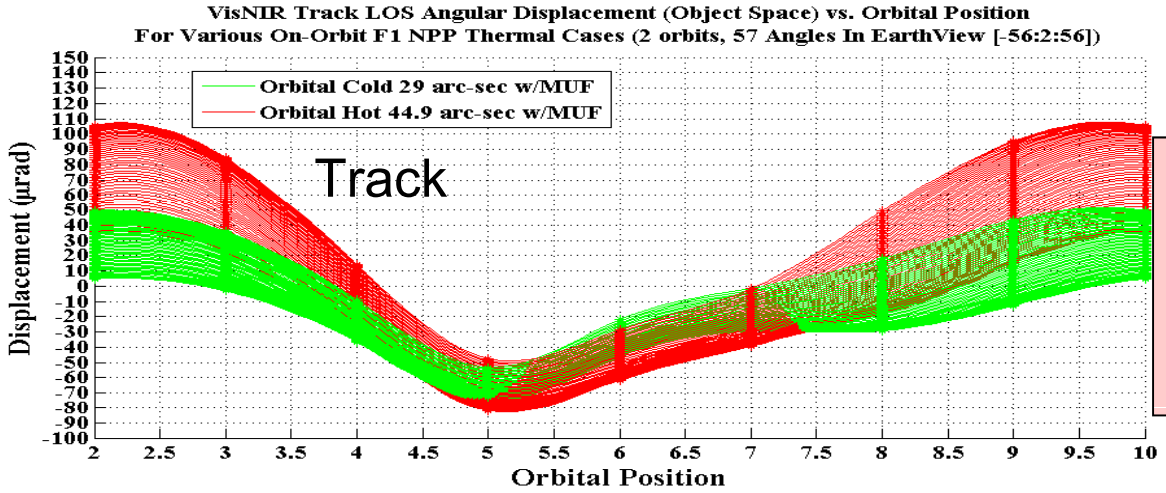


Possible along track pointing variations

VisNIR FPA LOS Variations Predicted by STOP (Structure, Temperature and Optical Performance) Model



Daily scan 25.7 arcsec meets
Spec = 30 arcsec



Daily track 44.9 arcsec
Spec = 30 arcsec
Waiver to 45 arcsec

Courtesy of RTN Pointing PVR

Summary of Pointing Stability

1. Overall, Pointing meets Spec.
2. Models show that dynamic thermal pointing variation is expected to be large and must be compensated for in IDPS S/W.
3. Sample spike events (only occurring in redundant electronic side A) may result in potential loss of RTA/HAM encoder information. A contingency plan for geolocation should be developed.

Backup Slides

1. BBR with on-orbit effects
2. BBR results with proposed new scan timing adjustments

On-orbit BBR with other effects

including jitter

Units:	ASR	CF																					
		M1	M2	M3	M4	I1	M5	M6	I2	M7	M8	M9	I3	M10	M11	I4	M12	M13	M14	M15	I5	M16A	M16B
Requirement	M1	0.000	0.958	0.926	0.949	0.925	0.828	0.807	0.905	0.856	0.650	0.628	0.761	0.761	0.671	0.771	0.735	0.749	0.689	0.718	0.768	0.775	0.731
	M2	0.640	0.000	0.934	0.961	0.934	0.836	0.815	0.917	0.866	0.655	0.633	0.770	0.775	0.677	0.779	0.772	0.784	0.697	0.725	0.774	0.783	0.739
	M3	0.640	0.640	0.000	0.955	0.980	0.899	0.877	0.973	0.928	0.713	0.690	0.824	0.789	0.739	0.833	0.765	0.752	0.754	0.783	0.822	0.803	0.796
	M4	0.640	0.640	0.640	0.000	0.948	0.873	0.846	0.939	0.897	0.686	0.661	0.795	0.794	0.705	0.814	0.765	0.775	0.727	0.756	0.797	0.811	0.770
	I1	0.640	0.640	0.640	0.640	0.000	0.916	0.894	0.958	0.938	0.732	0.711	0.669	0.796	0.748	0.692	0.763	0.761	0.777	0.798	0.676	0.809	0.816
	M5	0.640	0.640	0.700	0.640	0.640	0.000	0.967	0.932	0.958	0.784	0.756	0.814	0.765	0.800	0.812	0.719	0.704	0.811	0.826	0.811	0.803	0.827
	M6	0.640	0.640	0.640	0.640	0.640	0.640	0.000	0.912	0.945	0.803	0.777	0.793	0.761	0.818	0.800	0.706	0.674	0.835	0.828	0.800	0.791	0.828
	I2	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.000	0.958	0.746	0.730	0.699	0.805	0.762	0.686	0.765	0.754	0.782	0.806	0.673	0.816	0.801
	M7	0.640	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.000	0.753	0.728	0.833	0.780	0.767	0.841	0.749	0.723	0.789	0.818	0.836	0.817	0.834
	M8	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.000	0.946	0.894	0.865	0.957	0.880	0.789	0.764	0.823	0.783	0.702	0.702	0.755
	M9	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.000	0.868	0.834	0.932	0.855	0.766	0.725	0.802	0.753	0.676	0.663	0.719
	I3	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.800	0.640	0.640	0.640	0.000	0.939	0.894	0.930	0.885	0.874	0.743	0.770	0.604	0.786	0.794
	M10	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.000	0.873	0.932	0.870	0.860	0.716	0.750	0.736	0.798	0.770
	M11	0.640	0.640	0.700	0.640	0.640	0.700	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.000	0.890	0.826	0.771	0.802	0.793	0.723	0.711	0.768
	I4	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.800	0.640	0.640	0.640	0.800	0.640	0.640	0.000	0.905	0.890	0.724	0.749	0.608	0.787	0.775
	M12	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.640	0.640	0.000	0.910	0.657	0.706	0.772	0.777	0.730
	M13	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.640	0.640	0.800	0.000	0.608	0.645	0.711	0.710	0.662
	M14	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.640	0.640	0.800	0.800	0.000	0.947	0.874	0.867	0.922
	M15	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.640	0.640	0.800	0.800	0.800	0.000	0.914	0.911	0.965
	I5	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.800	0.640	0.640	0.640	0.800	0.640	0.640	0.800	0.640	0.640	0.640	0.640	0.000	0.932	0.939
	M16A	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.640	0.640	0.800	0.800	0.800	0.800	0.640	0.000	0.942
	M16B	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.800	0.640	0.640	0.640	0.640	0.800	0.800	0.800	0.800	0.640	0.800	0.000

M9 vs other bands

M12 / M13 vs LWIR

Source: NG BER-W230R2 (RTN RDW-W024B)

Worst BBR @ Cold Perf Plateau

(Potential BBR improvement for bands M12/M13 with LWIR bands)

(Scan timing adjustments from Nominal Perf Test (+proposed) have been applied to the measurements in Cold Perf Test)

|<-------Worst BBR = Minimum(12 or 24 DDR (detector-to-detector co-registration) pairs for HAM A and B sides) ------->|

Band	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16A	M16B	I1	I2	I3	I4	I5
M1		0.97	0.94	0.97	0.89	0.87	0.91	0.82	0.79	0.91	0.78	0.90	0.91	0.87	0.90	0.92	0.90	0.93	0.92	0.92	0.94	0.89
M2	0		0.94	0.97	0.89	0.88	0.92	0.82	0.79	0.92	0.78	0.92	0.93	0.87	0.90	0.92	0.90	0.94	0.92	0.92	0.94	0.90
M3	0	0		0.96	0.94	0.92	0.97	0.86	0.85	0.97	0.83	0.89	0.90	0.92	0.95	0.91	0.94	0.99	0.97	0.97	0.94	0.93
M4	0	0	0		0.92	0.90	0.95	0.85	0.82	0.95	0.80	0.91	0.92	0.90	0.93	0.93	0.93	0.96	0.95	0.95	0.96	0.92
M5	0	0	0	0		0.98	0.96	0.92	0.90	0.95	0.87	0.86	0.87	0.96	0.93	0.89	0.92	0.95	0.96	0.94	0.91	0.90
M6	0	0	0	0	0		0.95	0.94	0.92	0.94	0.89	0.85	0.86	0.95	0.91	0.87	0.90	0.93	0.95	0.93	0.90	0.89
M7	0	0	0	0	0	0		0.89	0.87	0.98	0.85	0.89	0.90	0.93	0.95	0.91	0.94	0.98	0.99	0.97	0.94	0.93
M8	0	0	0	0	0	0	0		0.96	0.89	0.92	0.83	0.82	0.91	0.88	0.85	0.87	0.87	0.89	0.89	0.87	0.86
M9	0	0	0	0	0	0	0	0		0.87	0.95	0.83	0.79	0.89	0.87	0.82	0.85	0.86	0.87	0.87	0.85	0.84
M10	0	0	0	0	0	0	0	0	0		0.84	0.89	0.89	0.92	0.95	0.92	0.94	0.97	0.98	0.96	0.94	0.92
M11	0	0	0	0	0	0	0	0	0	0		0.81	0.78	0.86	0.83	0.79	0.82	0.83	0.85	0.84	0.82	0.81
M12	0	0	0	0	0	0	0	0	0	0	0		0.92	0.90	0.93	0.94	0.93	0.89	0.89	0.92	0.94	0.94
M13	0	0	0	0	0	0	0	0	1	0	0	0		0.86	0.89	0.91	0.89	0.90	0.90	0.91	0.93	0.88
M14	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.92	0.95	0.92	0.93	0.93	0.90	0.94
M15	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.98	0.95	0.95	0.95	0.93	0.97
M16A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.97	0.92	0.91	0.94	0.96	0.96
M16B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.94	0.96	0.94	0.97
I1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.93	0.89	0.84
I2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.92	0.87	0.82
I3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.84
I4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.81
I5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

|<---------- # of detector pairs having BBR out-of-Spec ---------->|

|<----Worst BBR = Minimum(DDR pairs for HAM A and B sides) ---->|

|<---------- # of detector pairs having BBR out-of-Spec ---------->|

Worst BBR @ Nominal Perf Plateau

(Potential BBR improvement for bands M12/M13 with LWIR bands)

(Proposed scan timing adjustments have been applied to the measurements in Nominal Perf Test)

|<----Worst BBR = Minimum(12 or 24 DDR (detector-to-detector co-registration) pairs for HAM A and B sides) ---->|

Band	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16A	M16B	I1	I2	I3	I4	I5
M1		0.96	0.95	0.97	0.89	0.87	0.91	0.80	0.79	0.91	0.77	0.92	0.94	0.89	0.92	0.92	0.92	0.94	0.93	0.91	0.93	0.92
M2	0		0.95	0.97	0.89	0.87	0.91	0.80	0.78	0.90	0.76	0.92	0.96	0.89	0.92	0.94	0.92	0.94	0.93	0.91	0.93	0.91
M3	0	0		0.98	0.94	0.91	0.96	0.84	0.83	0.93	0.81	0.93	0.94	0.93	0.96	0.92	0.95	0.99	0.97	0.96	0.97	0.94
M4	0	0	0		0.92	0.90	0.94	0.83	0.81	0.92	0.79	0.93	0.95	0.92	0.95	0.93	0.95	0.98	0.96	0.94	0.96	0.94
M5	0	0	0	0		0.97	0.97	0.90	0.89	0.97	0.86	0.90	0.90	0.96	0.93	0.89	0.92	0.94	0.96	0.97	0.95	0.91
M6	0	0	0	0	0		0.95	0.92	0.90	0.96	0.88	0.88	0.88	0.95	0.91	0.87	0.90	0.92	0.94	0.95	0.93	0.89
M7	0	0	0	0	0	0		0.88	0.87	0.95	0.84	0.92	0.92	0.96	0.95	0.91	0.94	0.97	0.98	0.99	0.97	0.93
M8	0	0	0	0	0	0	0		0.96	0.89	0.93	0.84	0.82	0.88	0.85	0.81	0.84	0.85	0.86	0.88	0.86	0.82
M9	0	0	0	0	0	0	0	0		0.87	0.96	0.82	0.79	0.86	0.83	0.78	0.81	0.83	0.85	0.87	0.84	0.81
M10	0	0	0	0	0	0	0	0	0		0.84	0.90	0.89	0.95	0.92	0.89	0.91	0.93	0.94	0.96	0.93	0.89
M11	0	0	0	0	0	0	0	0	0	0		0.82	0.78	0.83	0.80	0.76	0.79	0.81	0.82	0.84	0.82	0.78
M12	0	0	0	0	0	0	0	0	0	0	0		0.92	0.94	0.96	0.92	0.95	0.94	0.93	0.92	0.95	0.94
M13	0	0	0	0	0	0	0	0	1	0	0	0		0.90	0.93	0.94	0.93	0.95	0.94	0.92	0.94	0.92
M14	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.92	0.95	0.94	0.95	0.96	0.94	0.94
M15	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.97	0.96	0.96	0.95	0.96	0.97
M16A	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		0.97	0.93	0.92	0.90	0.94	0.95
M16B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.95	0.93	0.97	0.97
I1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.92	0.96	0.86
I2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.95	0.85
I3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.80
I4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.86
I5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

|<---------- # of detector pairs having BBR out-of-Spec ---------->|

|<---------- # of detector pairs having BBR out-of-Spec ---------->|

|<----Worst BBR = Minimum(DDR pairs for HAM A and B sides) ---->|