



KOMPSAT-3A Cal/Val



KOMPSAT-3A Cal/Val Summary

Nov. 19, 2015

**Korea Aerospace Research Institute, CVT
DooChun Seo, DongHan Lee**

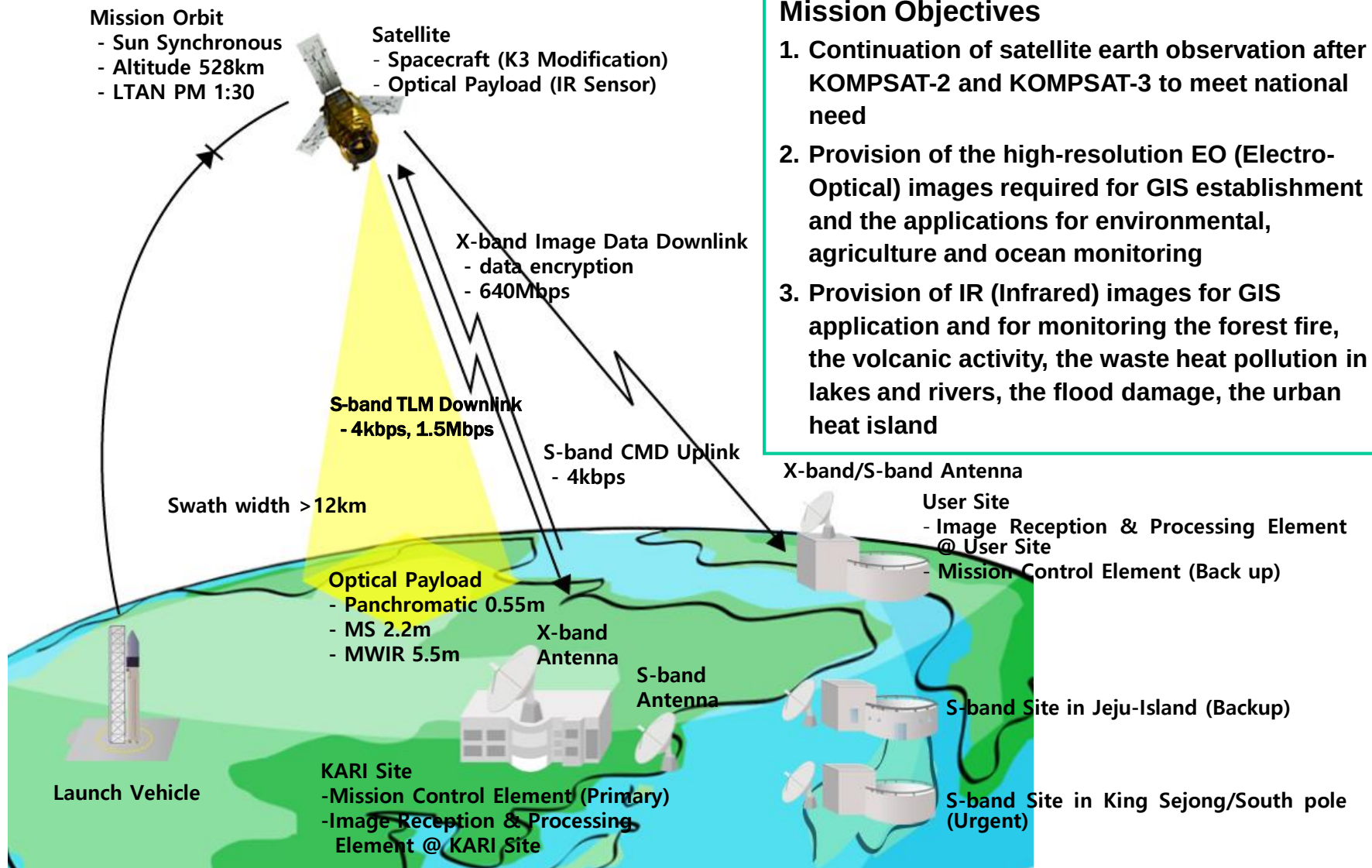


Contents



- KOMPSAT-3A & Cal/Val Overview for KOMPSAT-3A
- Radiometric Cal/Val
- Spatial Cal/Val
- Visible Absolute Radiometric Cal/Val
- Geometric Cal/Val
- Summary

System Architecture



Mission Objectives

1. Continuation of satellite earth observation after KOMPSAT-2 and KOMPSAT-3 to meet national need
2. Provision of the high-resolution EO (Electro-Optical) images required for GIS establishment and the applications for environmental, agriculture and ocean monitoring
3. Provision of IR (Infrared) images for GIS application and for monitoring the forest fire, the volcanic activity, the waste heat pollution in lakes and rivers, the flood damage, the urban heat island

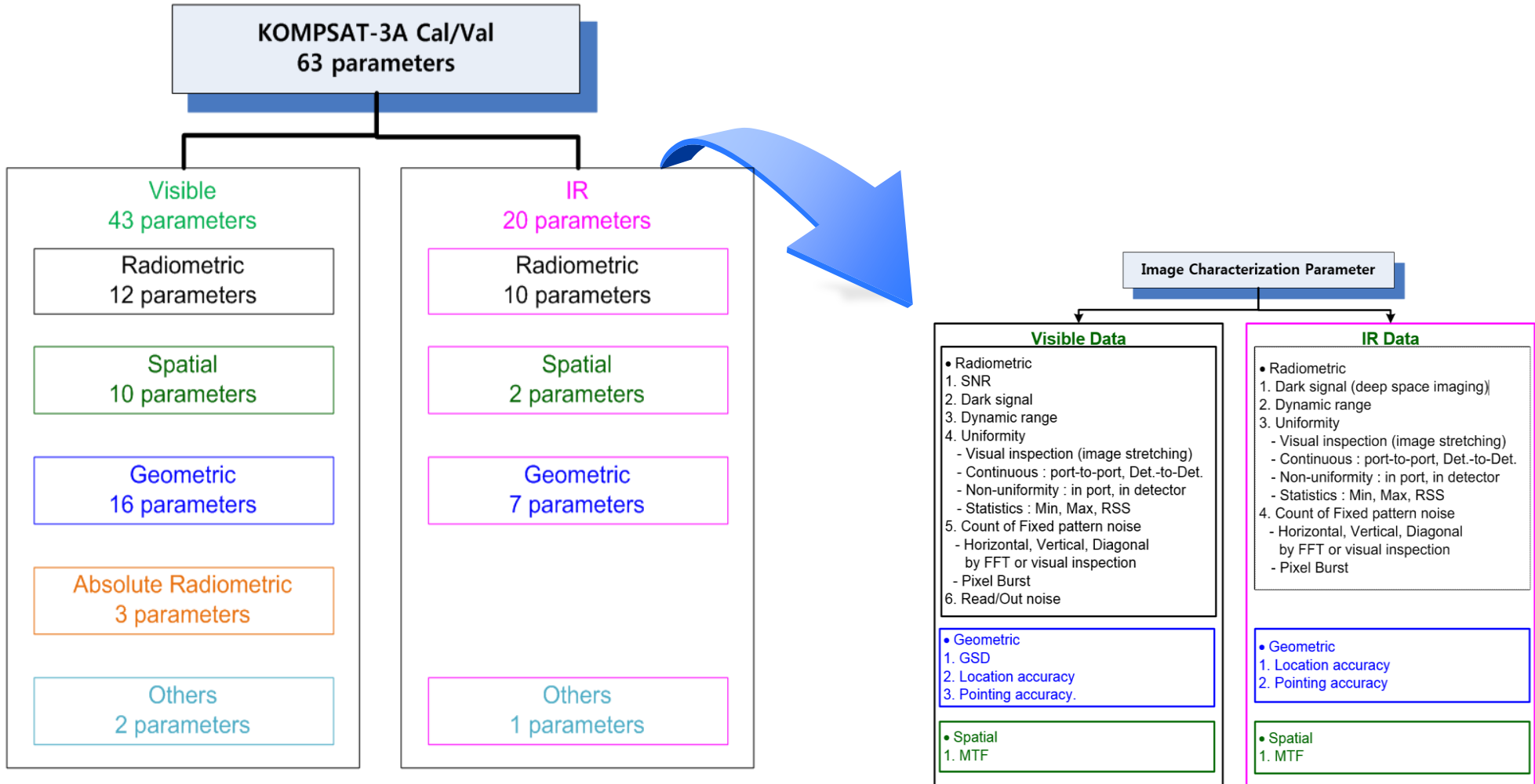


Major changes vs. K3



Satellite Contents	KOMPSAT-3	KOMPSAT-3A
Payload	PAN/MS	PAN/MS + IR
Spectral band	PAN & MS 450~900 nm	PAN & MS 450~900 nm / IR 3.3~5.2 um (NETD: 0.05K @ 300K)
GSD	PAN 0.7m / MS 2.4m	Pan 0.55m / MS 2.2m / IR 5.5m
Swath width	> 15km @nadir	> 12km @nadir
Imaging Time	10 min/orbit, Max. 50 min/day	10 min/orbit, Max. 50 min/day (IR)
Mission Orbit	685 km altitude	528 km altitude
Lifetime	4 years	4 years
Stowed Dimension	Ø 2.04 x 3.58 m	Ø 2.04 x 3.78 m
Satellite Mass	970 (MAX) kg	1,100 kg, max
Solar Panel Size	2.04 x 1.0 m	2.29 x 1.0 m
Power	1,300 Watt	1,400 Watt

Cal/Val Parameters





Cal/Val Phase I & II



	Cal/Val Phase I (System)	Cal/Val Phase II (Product)
Step	After System IOT	After Cal/Val Phase I
Document	Cal/Val Plan, Document, Procedure, Report	
Target	Satellite, AEISS-A	Satellite Data (Product)
Activity	Characterization Calibration Validation	Image data Restoration Calibration Validation
Data Level	Level 0, Ancillary	Level 1R , Level 1G
Requirement	System Specification	System Specification System Performance
Period	2015.03.26 Launched 2015.04.14~2015.06.12	2015.6.15~2015.09.04
Leader	MST + CVT	CVT

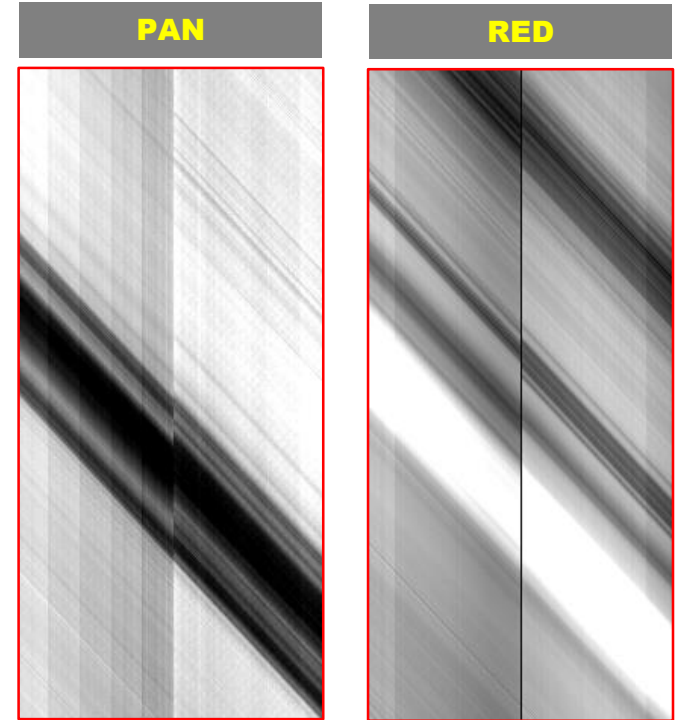
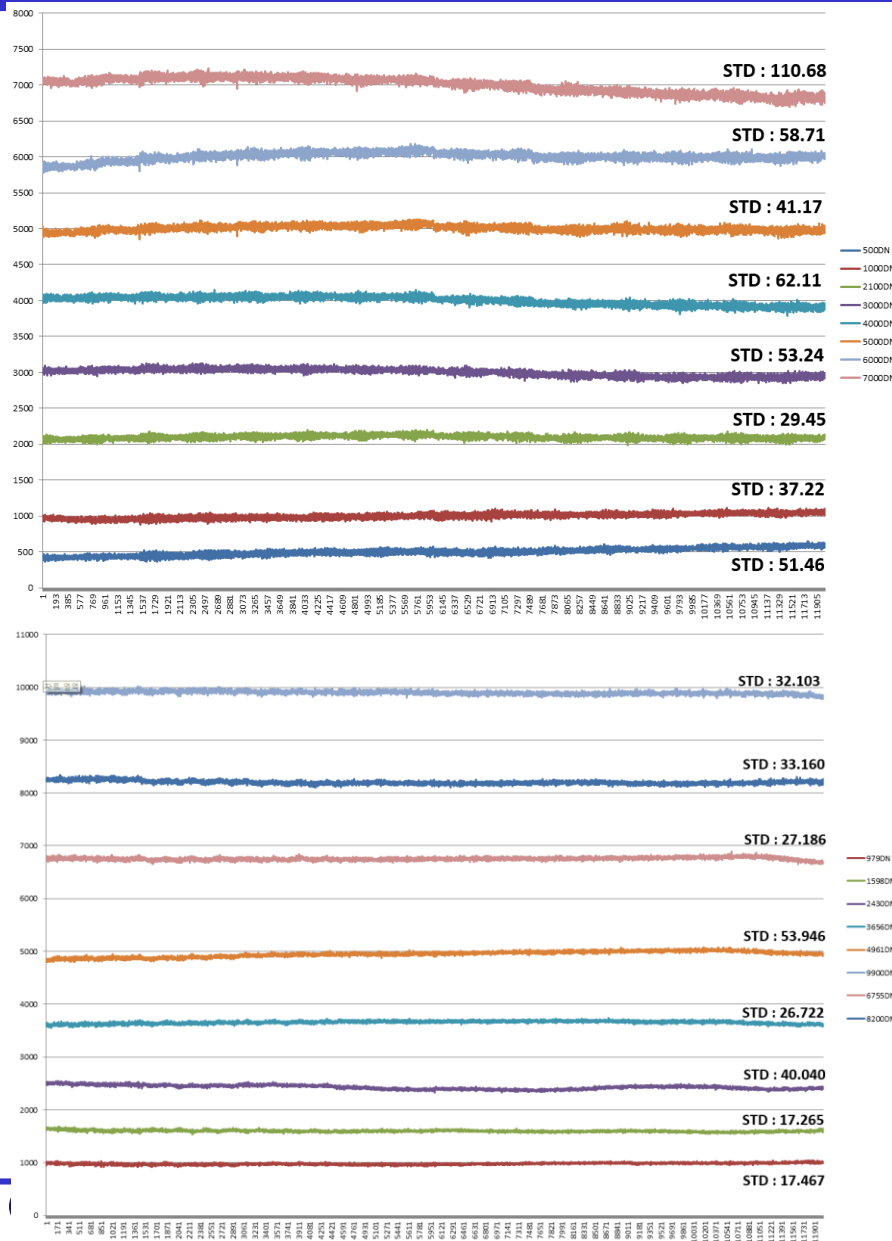


Radiometric Cal/Val: NUC



Lab NUC table	
DN	Std.Dev
500	51.46
1000	37.22
2000	29.45
3000	53.24
4000	62.11
5000	41.17
6000	58.71
7000	110.68

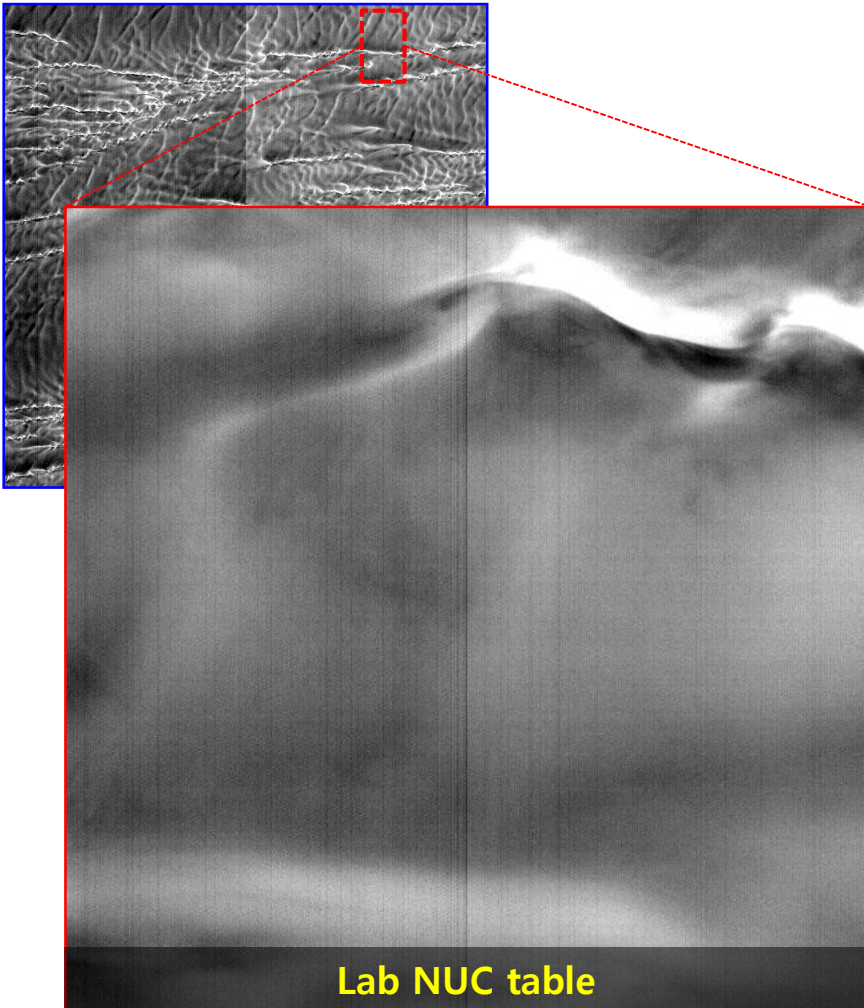
Cal NUC table	
DN	Std.Dev
979	17.467
1598	17.265
2430	40.040
3656	26.722
4961	53.946
6755	27.186
8200	33.160
9900	32.103



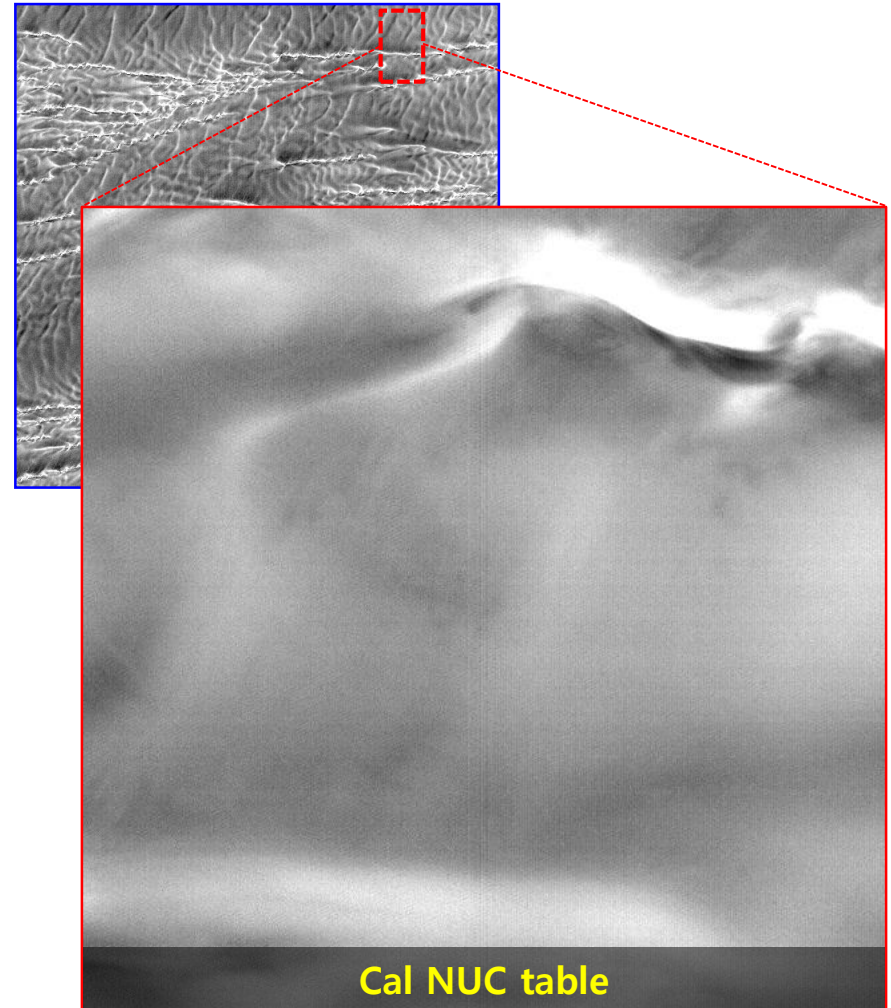
Side Slither

- **PAN Comparison**

- LAB & Cal PAN Comparison



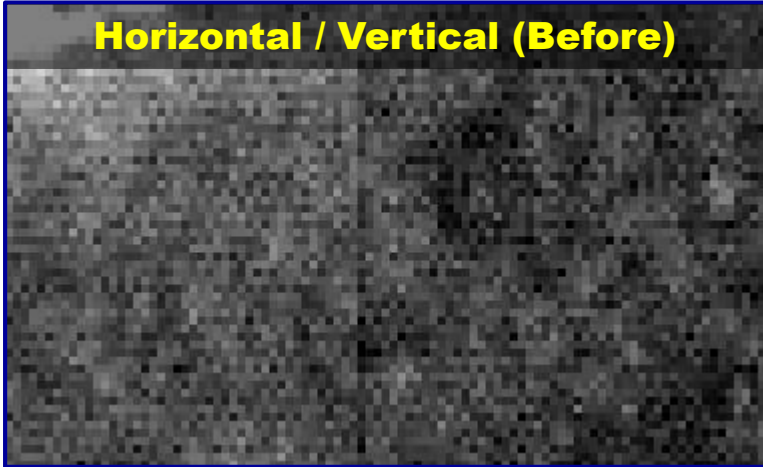
Lab NUC table



Cal NUC table

- Restoration of Fixed Pattern Noise

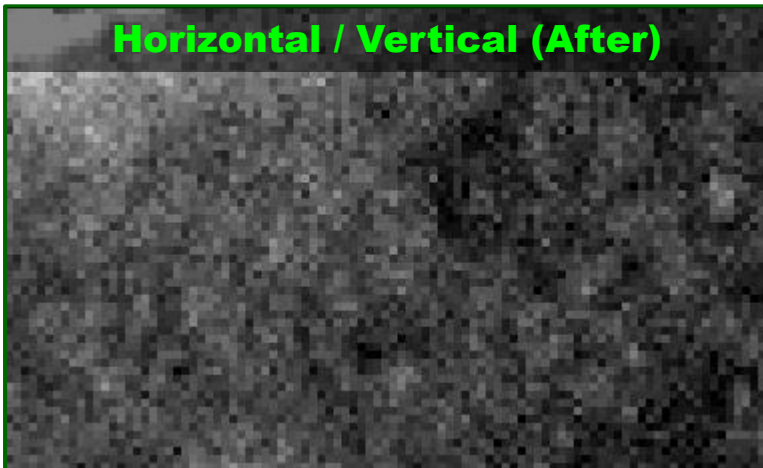
Horizontal / Vertical (Before)



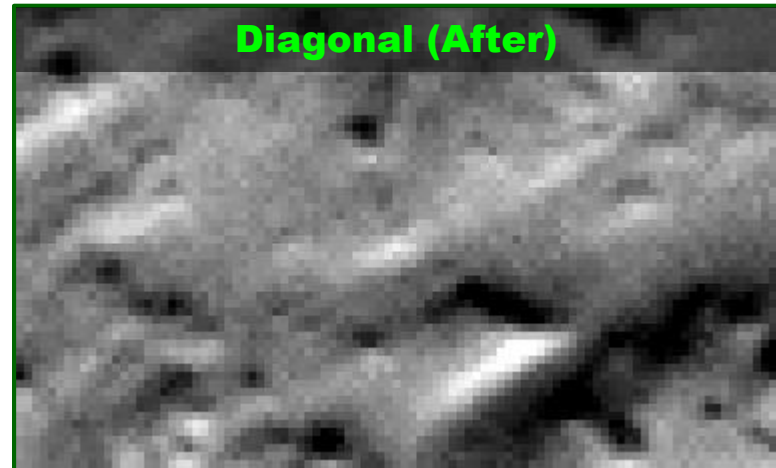
Diagonal (Before)



Horizontal / Vertical (After)



Diagonal (After)

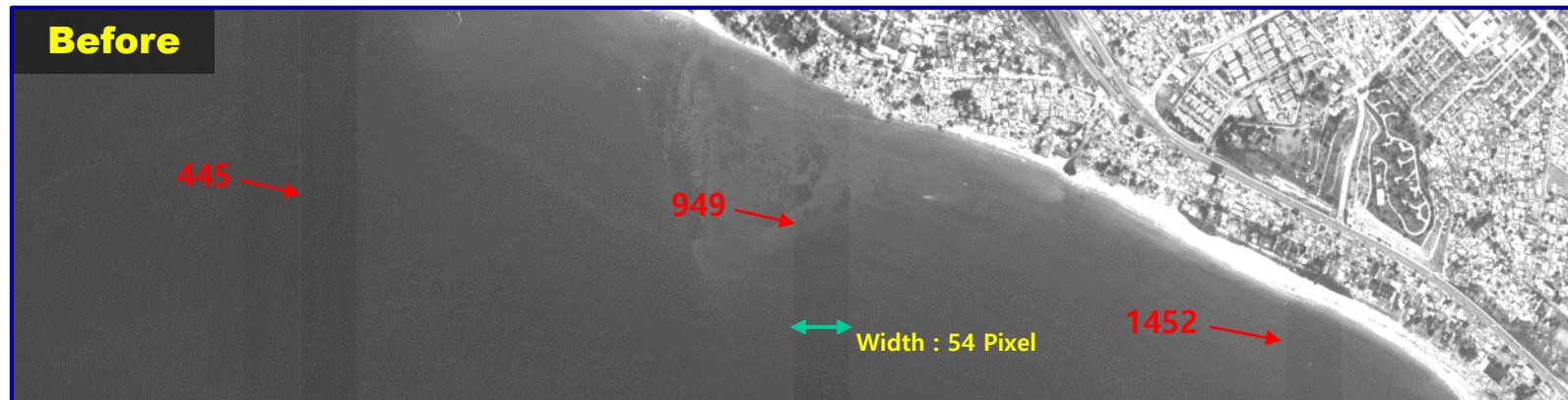


Radiometric Cal/Val: Noise

- Pixel Burst

- Validation test set : 2015/06/14 12:34:31

- Line Rate : 12410
 - Line Time : $(1.0/12410) \times 10^9 = 80580$
 - Burst Position: 445 / 949 / 1452 Column



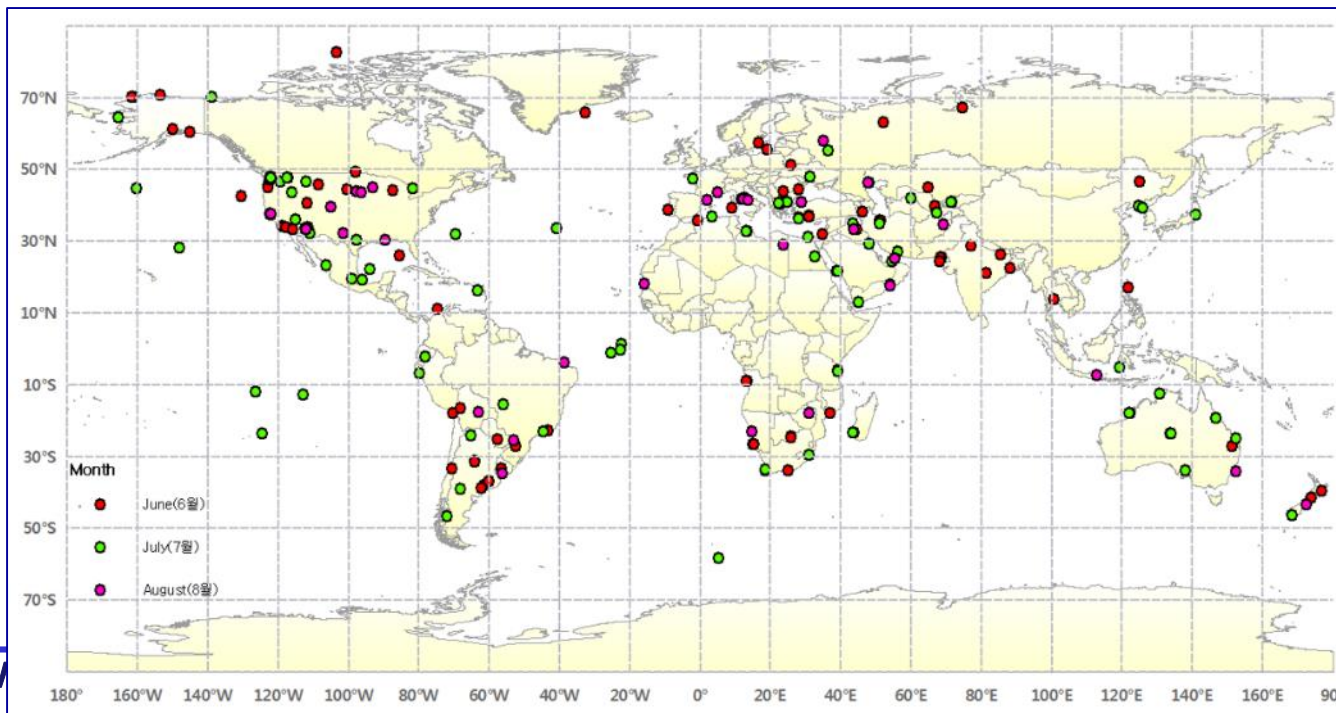
• Image Characterization

– Validation test set : 2015.04.01 ~ 2015.08.27

- 576 set : April(121), May(71), June(193), July(138), August(53)
- KOMPSAT-3A Normal TDI / Binning Setting

Normal	PAN	MS1 (Blue)	MS2 (Green)	MS3 (Red)	MS4 (NIR)
Compression	5.5:1	5.5:1	5.5:1	5.5:1	5.5:1
TDI level	3	3	2	2	1
TDI Line	64	64	32	32	8
MS Binning		Ave	Ave	Ave	Sum

Bright	PAN	MS1 (Blue)	MS2 (Green)	MS3 (Red)	MS4 (NIR)
Compression	5.5:1	5.5:1	5.5:1	5.5:1	5.5:1
TDI level	3	3	1	1	1
TDI Line	64	64	8	8	8
MS Binning		Ave	Sum	Sum	Ave





Radiometric Cal/Val



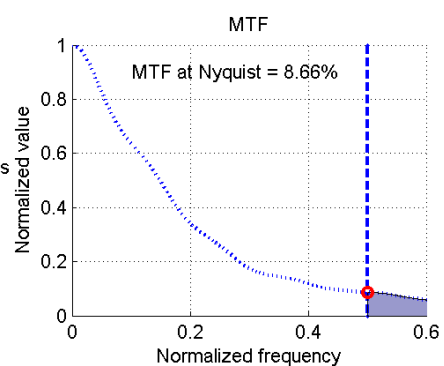
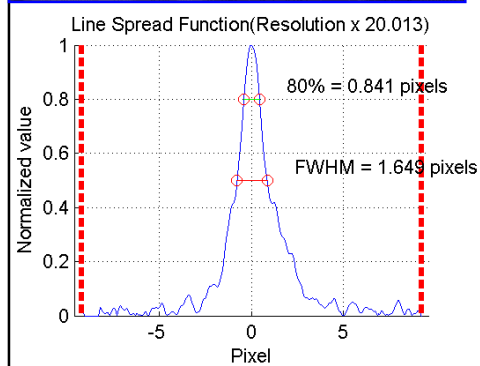
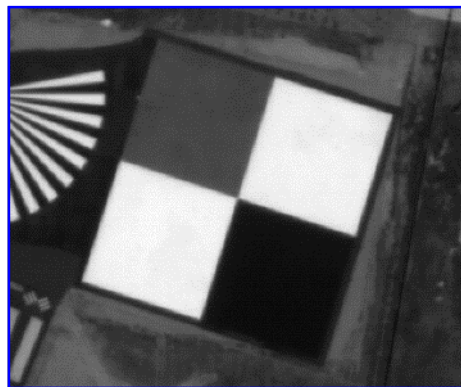
- Image data Characterization

	Req.	Initial Value	Quality after Cal/Val
SNR	> 100	> 100	> 100 (Jun~Aug, Ave : 121)
Dark Signal	< 25 DN (≒ 0.15%)	PAN < 8.3 DN (MS, Ave. 5.4)	PAN < 8.3 DN (MS, Ave. 5.4)
Dynamic Range	N/A	PAN(>2800), BLUE(>2900), GREEN(>5300), RED(>4000), NIR(>3000)	PAN(>2620), BLUE(>2909), GREEN(>4381), RED(>4924), NIR(>7514)
Fixed Pattern Noise	N/A	Horizontal, Vertical, Diagonal	Horizontal, Vertical, Diagonal
Systematic Noise	N/A	Pixel Burst, MS Green band noise, Port difference, First pixel noise	Pixel Burst , MS Green band noise, Port difference, First pixel noise
Random Noise	N/A	Compression noise, Blooming	Compression noise, Blooming
Uniformity	N/A	Uniformity Std.Dev. < 56 (DN : 500 ~ 8000)	Uniformity Std.Dev. < 34 (DN : 500 ~ 9000)

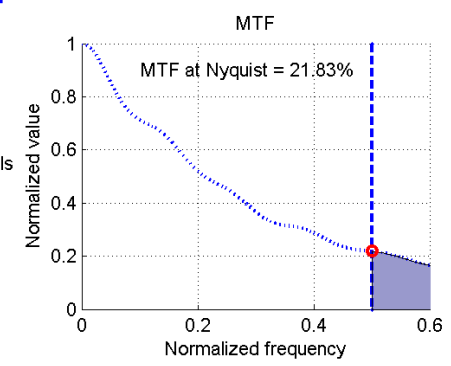
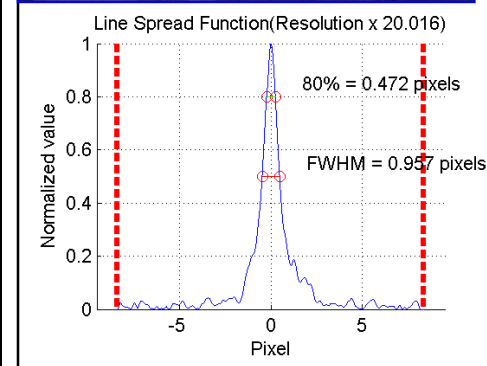
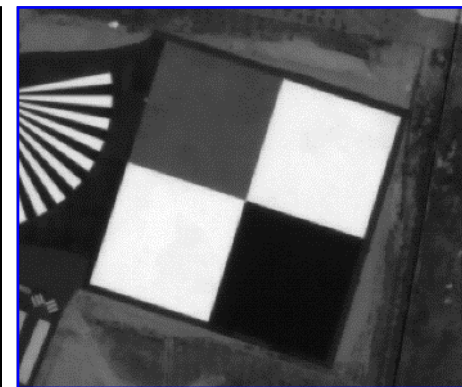
Spatial Cal/Val: MTFC

- MTF Compensation (Wiener filter with PSF matrix from Star imaging)
 - Validation test site : Bautou Edge Target
 - Date: 2015-07-07 05:38:14 Roll/Pitch/Yaw: -14.0 / -0.5 / 2.7

Before MTFC							
Across				Along			
SNR	RER	FWHM	MTF	SNR	RER	FWHM	MTF
61.78	0.373	1.649	8.66	113.5	0.377	1.841	7.75



After MTFC							
Across				Along			
SNR	RER	FWHM	MTF	SNR	RER	FWHM	MTF
60.43	0.548	0.957	21.83	88.11	0.556	1.036	21.62



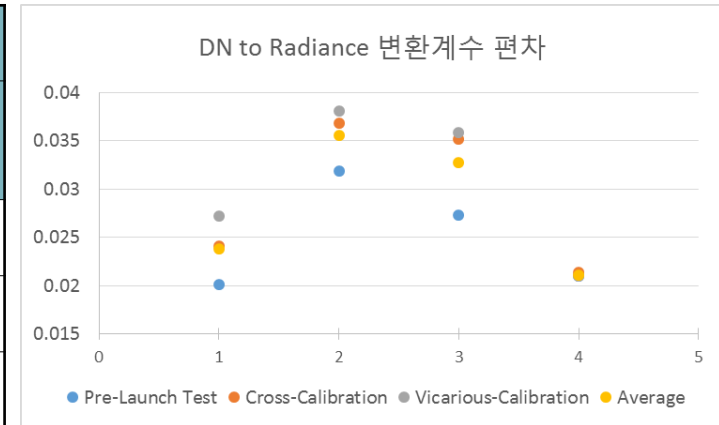
- MTFC

– 2015.06.26 13:53:18 Roll 24.8



• Pre-launch, Cross, Vicarious Cal/Val Results

Type	Converting coefficient of KOMPSAT-3A (Avg)			
	Blue (64/Avg.)	Green (8/Sum)	Red (8/Sum)	NIR (8/Avg.)
(A) Pre-Launch Test	0.0201193	0.0318322	0.0272958	0.0209972
(B) Cross-Calibration	0.0241647	0.0370177	0.0348327	0.0212927
(C) Vicarious-Calibration	0.0272564	0.0380902	0.0358089	0.0210058



• DN-to-Radiance coefficients

$$- L_{\lambda} = Gain \times DN$$

- Blue: 0.0257106 - Green : 0.0375540

- Red: 0.0353208 - NIR : 0.0211493

Unit : [W/m²/sr/μm]



• GSD (Ground Sample Distance)

– Calibration Activity : PAN, MS, IR CCD Alignment, Focal length

– PAN

- Baseline PAN Detector Size = 8.75 μm
- Estimated PAN Focal Length = 8.56181021142 m
- Baseline Height = 528 km
- **GSD @528km = 0.540 m**
- System requirement: Nadir GSD@528km < 0.55 m

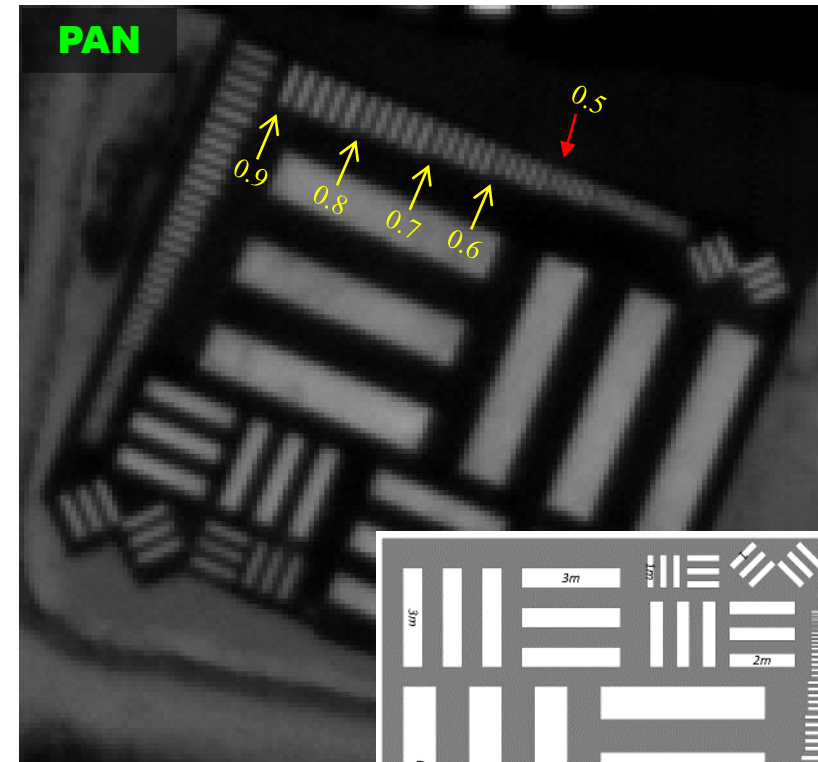
– MS

- **GSD @528km = 2.158 m**
- System requirement: Nadir GSD@528km < 2.2 m

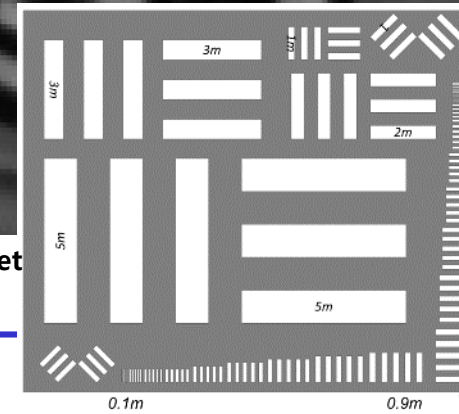
• K3A Test imaging

• GSD :0.545m/0.543m(Across/Along)

- Roll/Pitch/Yaw: -1.39/0.1/2.82

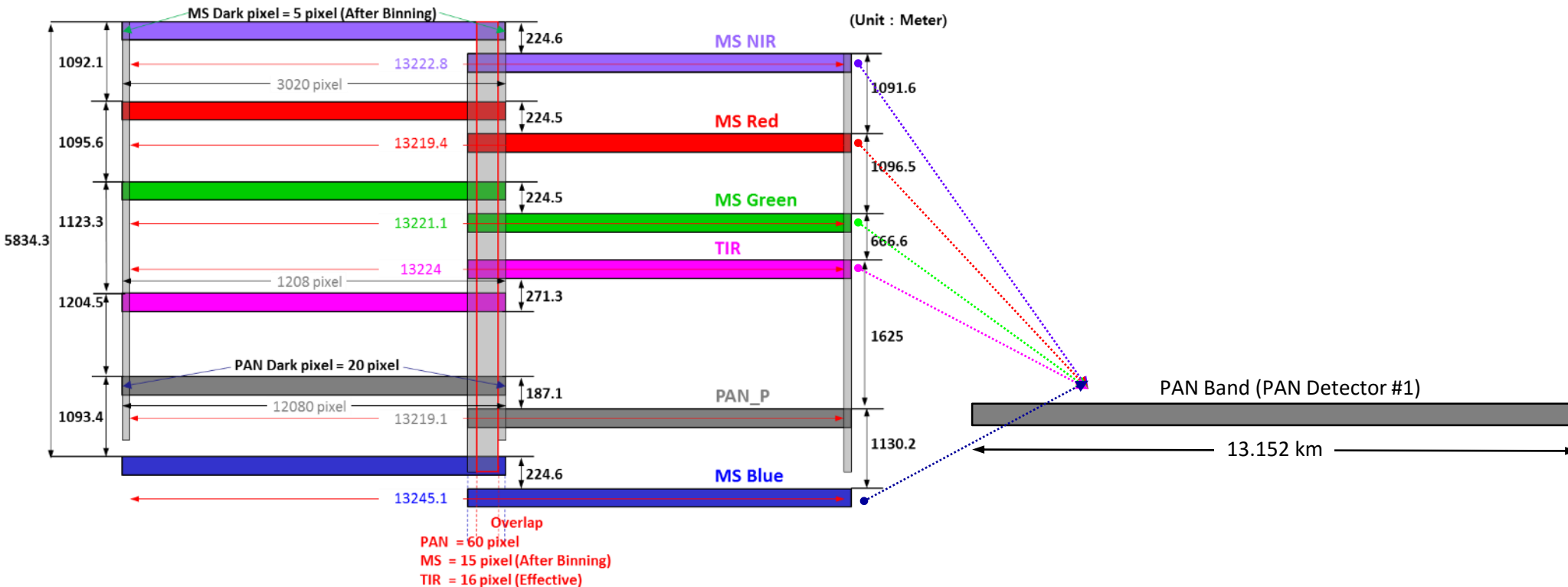


➤ China(Baotou), Bar target



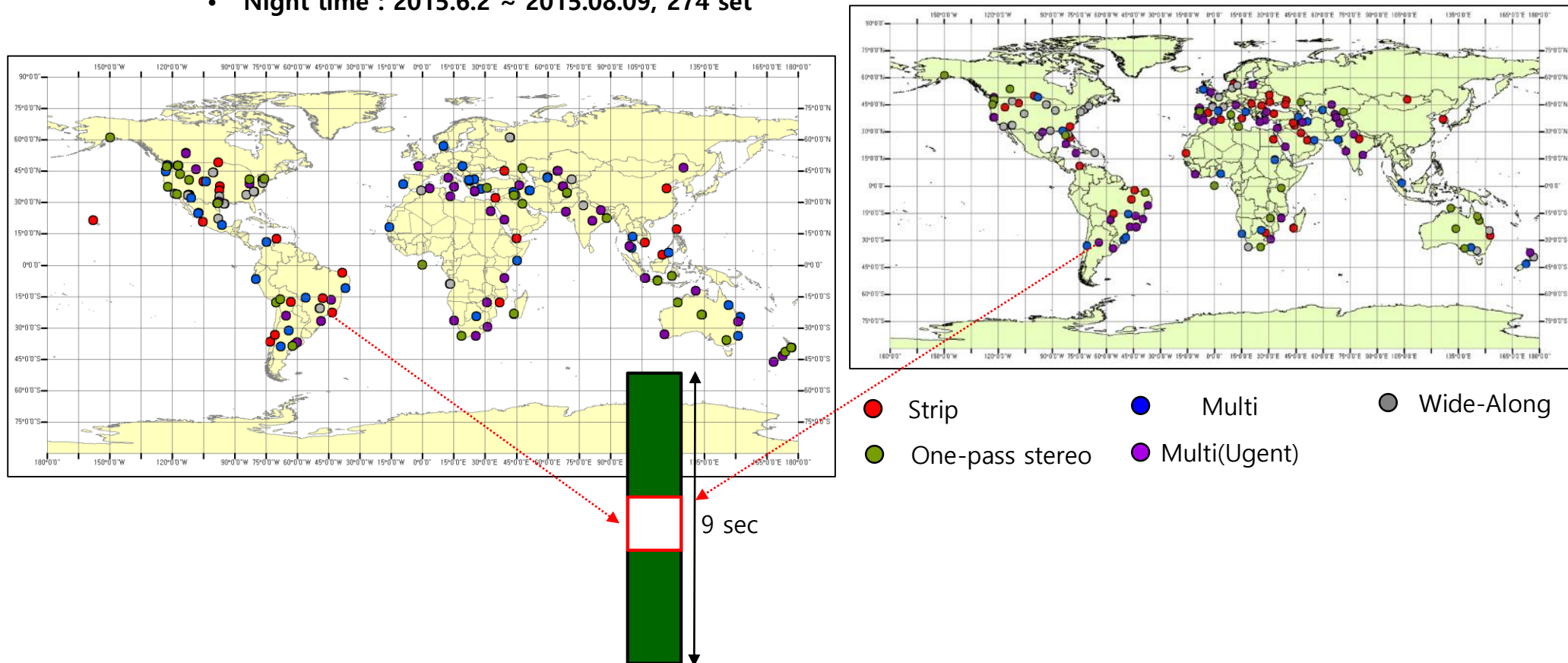
• Swath width & CCD Alignment

- Calibration Activity : PAN, MS, IR CCD Alignment, Focal length, Overlap area correction, Band-to-Band Registration
- Swath width : 13.152km, Nadir, 528km



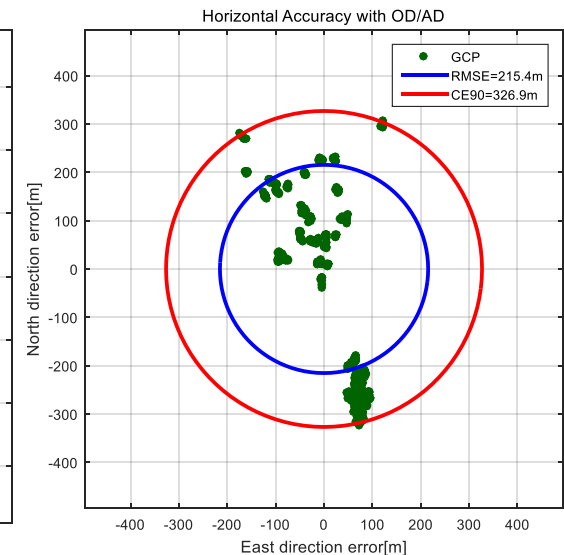
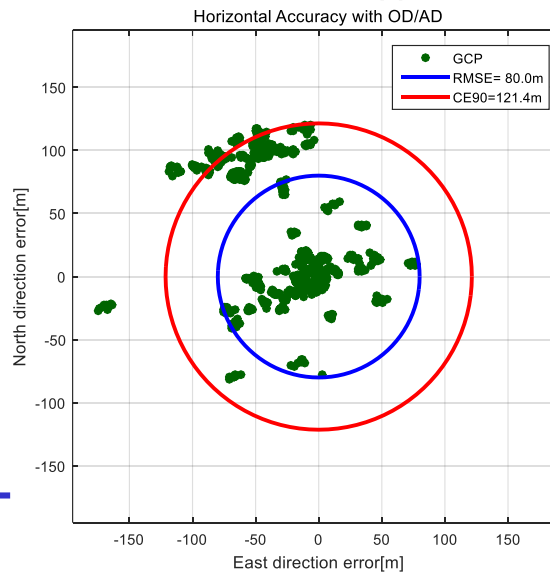
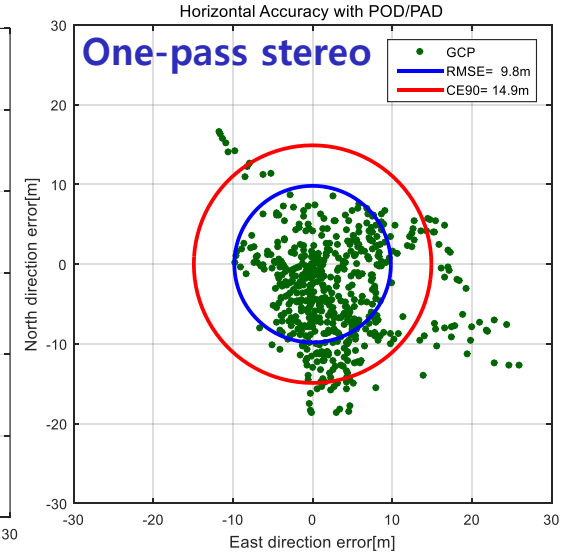
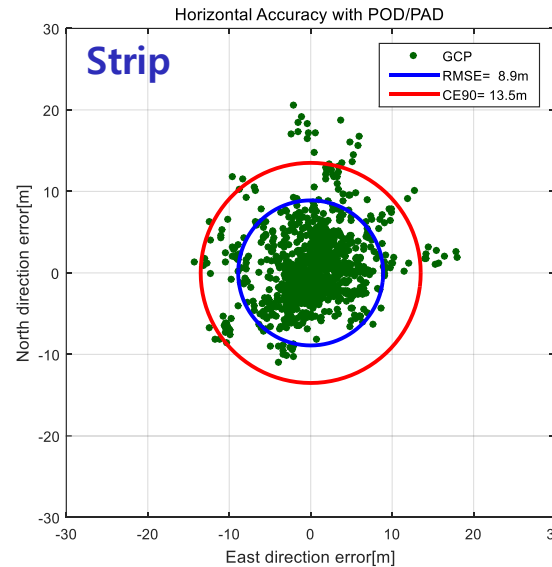
• Location Accuracy

- Calibration Activity : Absolute AOCS Cal, KPADS, Band Alignment, Focal length, Overlap area correction
- Validation test site
 - Day time : 2015.6.2 ~ 2015.08.09, 325 set
 - Night time : 2015.6.2 ~ 2015.08.09, 274 set



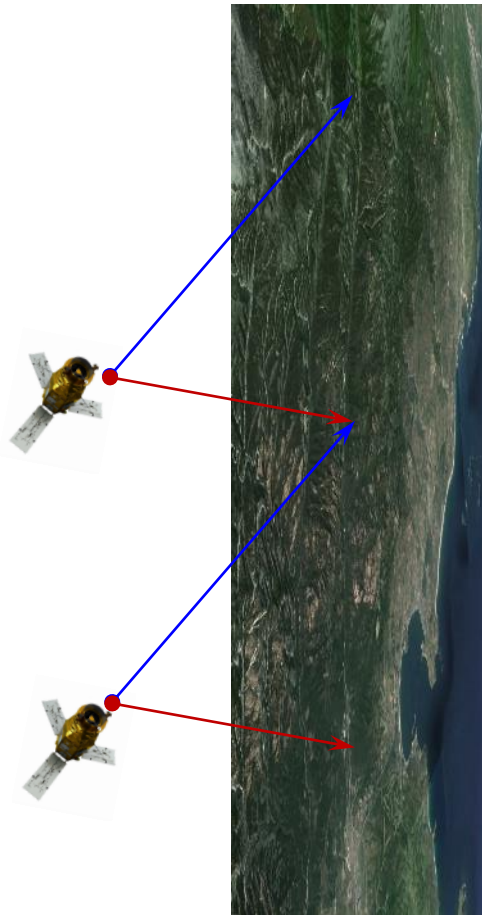
• Location Accuracy : Day-time, Strip, One-Pass Stereo

- K3A Accuracy(Strip)
 - POD/PAD : 13.5m CE90
 - OD/AD : 121.4m CE90
- K3A Accuracy(Stereo)
 - POD/PAD : 14.9m CE90
 - **OD/AD : 326.9m CE90**
 - Pitch $\approx \pm 30$



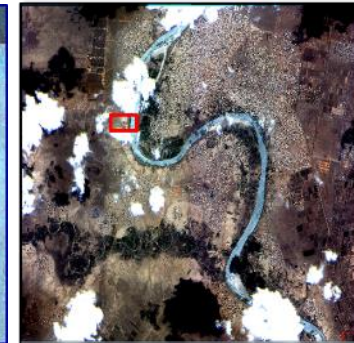
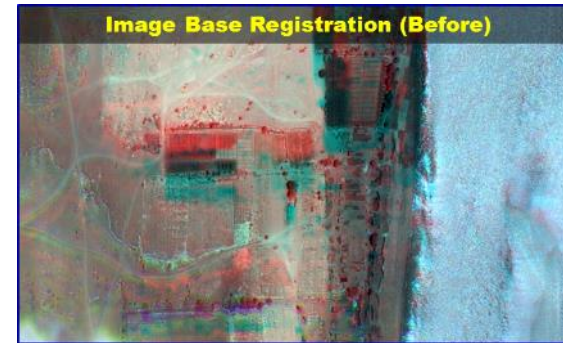
• Band-to-Band Registration

- Calibration Activity : KPADS, Detector & Band Alignment, Focal length, Overlap area correction, Sensor Model base Inter-Band Registration



$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{MS} = k' M_{Body}^{Sensor} M_{Orbit}^{Body} M_{ECEF}^{Orbit} \begin{bmatrix} X - X'_L \\ Y - Y'_L \\ Z - Z'_L \end{bmatrix}$$

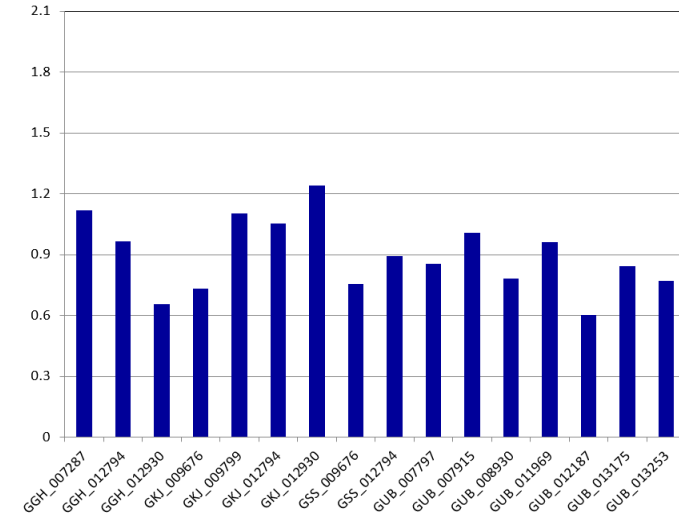
$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} X_L \\ Y_L \\ Z_L \end{bmatrix} + \frac{1}{k} \left(M_{Body}^{Sensor} M_{Orbit}^{Body} M_{ECEF}^{Orbit} \right)^T \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{PAN}$$



Geometric Cal/Val Results

• Mapping Accuracy : Planimetric accuracy

- Calibration Activity : KPADS, Band Alignment, Focal length, Overlap area correction
- Control point : GCP No. < 9 points
 - **RMSE : 0.99 pixel (0.5m)**
 - **CE90 : 1.50 pixel (0.8m)**
- Check point
 - **RMSE : 0.91 pixel (0.5m)**
 - **CE90 : 1.39 pixel (0.8m)**



• System requirement & Compliance

Category	System Attributes	Visible	Cal/Val Results
Spatial	MTF	PAN : 8% MS : 12%	PAN : 10~11% MS : 23%
	MTFC	PAN : 13% MS : 19%	PAN : 20%
Radiometric	SNR	>100	>100
	NETD	N/A	N/A
Geometric	GSD	0.55m, 2.2m	0.540m/2.158m (Nadir, 528km)
	Swath width	>12km	13.152km (Nadir, 528km, MS-IR-PAN)
	Location (Strip, One-pass stereo)	70m(POD/PAD)	13.5m(Strip image) 14.9m(One-pass stereo)
		285m(OD/AD)	121.4m(Strip image) 326.9m(One-pass stereo)
	Registration	0.5 pixel	0.3 pixel (Strip, One-pass stereo, Multi)
	Ortho-image	3.5m	0.8m (Strip image)