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Image data Quality for KOMPSAT-3

June 6, 2014

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Agenda

- Calibration and Validation in KARI
  - ✓ Image data Quality for User in KARI
  - ✓ Performance of KOMPSAT-3 after Cal/Val
  - ✓ Additional Cal/Val items for normal period

- KOMPSAT-3 Image data Quality (IQ) for Normal operation
  - ✓ IQ Checking & Monitoring
  - ✓ Quality checking for KOMPSAT-3 image data (Draft)

- Issues and Discussion

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Satellite data Calibration and Validation team (SCV)

Mom~! & Dad~! of Artificial Remote Sensing Satellite
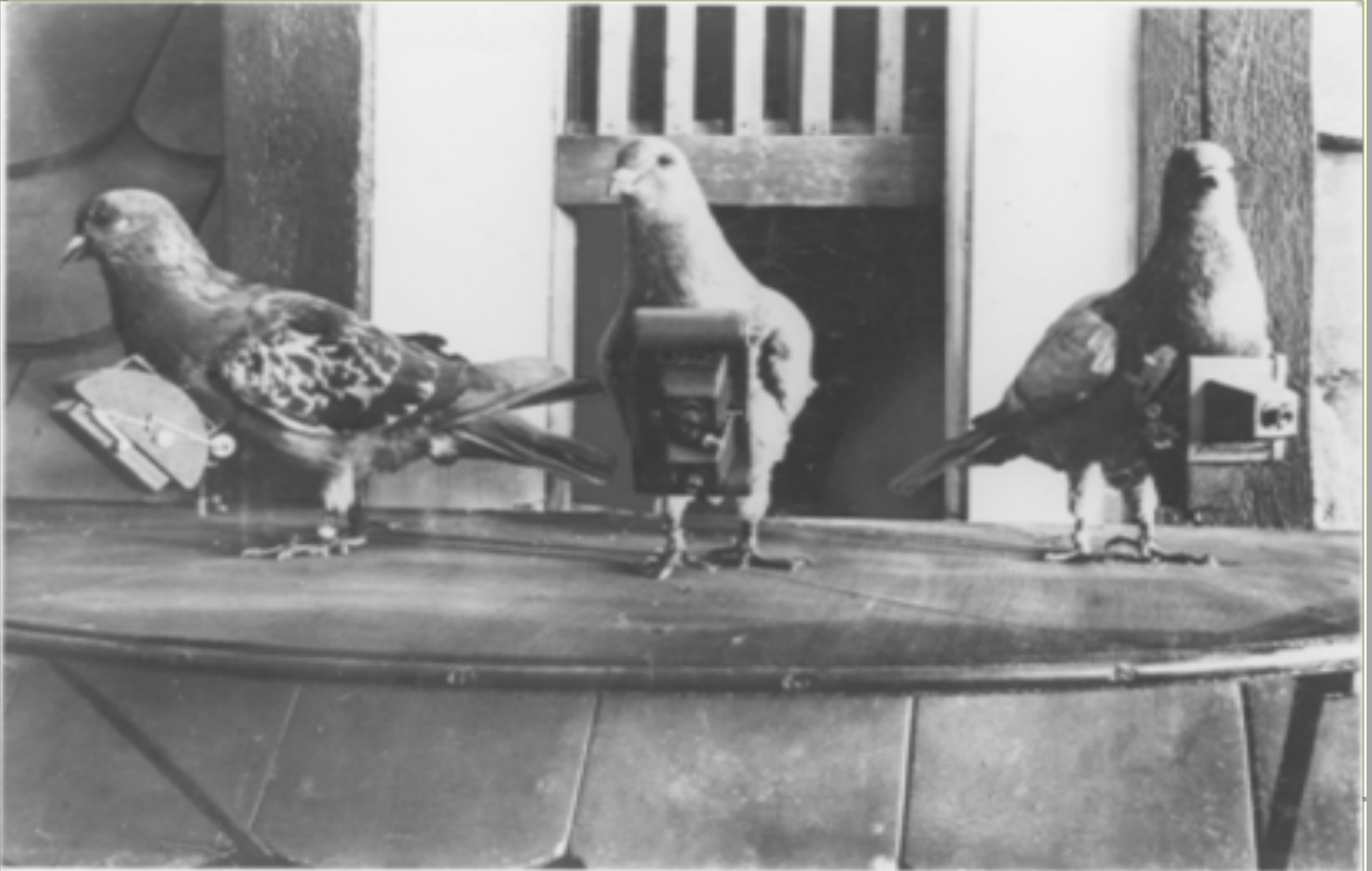
Calibration & Validation in KARI

Image data Quality for User in KARI

- **Image data Quality for Users**
  - There is a **technical gap** between the **requirement for manufacturing the satellite** and the **requirement for the image data quality for Users**.
  - Need & Define the **item** and the **quantitative value** for the image data quality for Users
    - Almost Users have eyes without the concept of the quantitative image data quality~!
  - There are Two kind of the Quality items for Users;
    - Representative items: MTF, SNR, GSD, Absolute radiometric Gain/Offset, Radiometric resolution, etc.
    - Different valued items per each image data: Noises, etc.

- **With only technology of manufacturing of Satellite and Sensor, the requirements of Users cannot be complied.**
  - Periodical monitoring of the image data Quality
  - Optimal ground processing for the Satellite and the Sensor
  - Continually talking and feed back with Users

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Satellite data Calibration and Validation team (SCV)
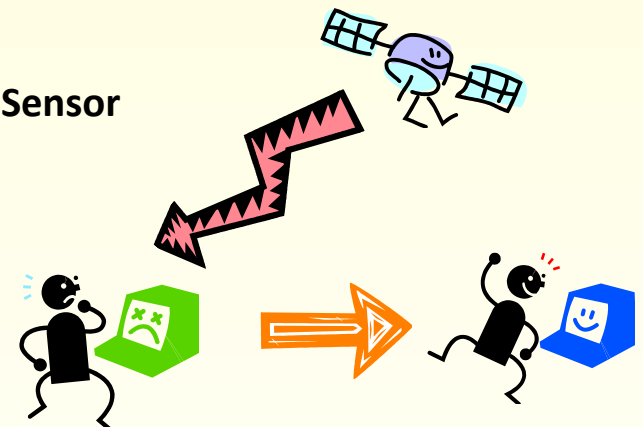
Performance of KOMPSAT-3 after Cal/Val

|	Key Item	Requirement Value	Validated Value	Constraint
CVP I	SNR	100	>> 100 (TDI 64)	
	MTF	8%(PAN) 12%(MS)	Across: 8~10% (TDI 64) Along: 6~8% (TDI 64) > 19% (MS)	Strip imaging Level 0
	GSD	0.7m(PAN) 2.8m(MS)	0.7m (PAN)	Strip & Nadir imaging
	Pointing accuracy	1.2km	Across: 90m Along: 1 sec	Strip imaging
	Location accuracy	70m CE90	< 70m CE90	With POD & PAD Strip imaging
CVP II	MTF after MTFC	13%(PAN) 19%(MS)	> 20% (PAN)	Level 0
	Registration	0.5pixel RMS (MS)	0.5pixel RMS (MS)	Strip imaging
	Ortho-image accuracy	3.5m CE90 (Horizontal)	3.5m CE90 (Horizontal)	Strip imaging

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Satellite data Calibration and Validation team (SCV)

Additional Cal/Val items during Normal period

Item	Title	Content	Status
Monitoring FMC Temp	Monitoring the Stability of the FMC (Focus Mechanism Controller) Temperature	Star imaging per 2~3 month RER, FWHM, MTF	on going
Resampling method	Resampling method for KOMPSAT-3	Optimal Resampling method for KOMPSAT-3 to keep the Spatial Quality	on going
Pixel burst	On Only MS	Develop, Test and Apply the de-noising algorithm of it	Done
Port Difference	On Only MS	Develop, Test and Apply the de-noising algorithm of it	Done
Center Pattern Difference	Different noise between each CCD Detector	After reducing Compression noise, and updating RNUC and De-noising, the Center difference has been reduced.	Done
RNUC (Residual NUC)	Non-linearity behind DN 1500	New RNUC table has been updated in the Processing system.	Done
Compression noise	Many Compression noise in MS with Compression ratio '5.5'	Updated by PAN '5.5' and MS '3'	Done

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Satellite data Calibration and Validation team (SCV)

KOMPSAT-3 Product (Image data) Quality (IQ)
for Normal operation

Korea Aerospace Research Institute (KARI)
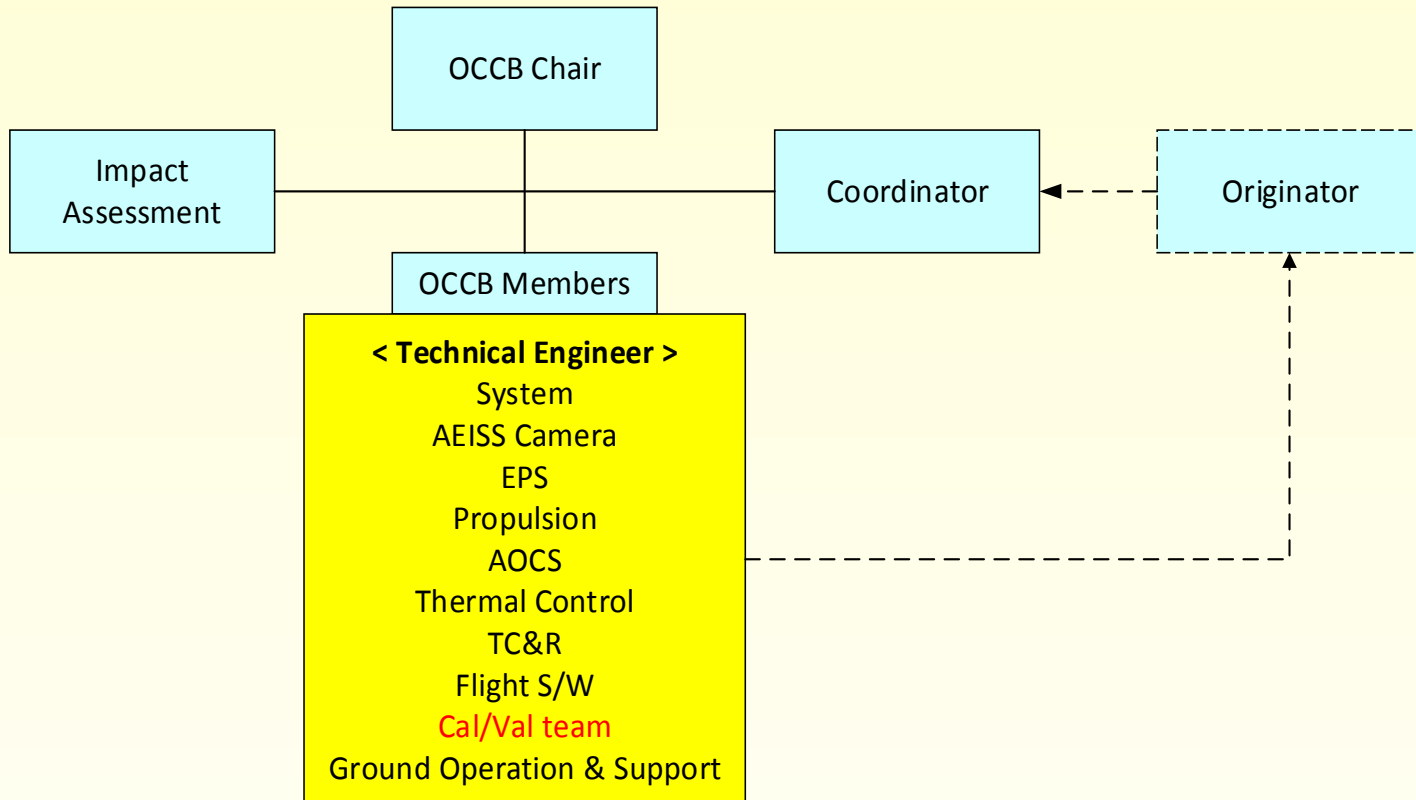Satellite data Calibration and Validation team (SCV)

IQ Checking and Flow

- Regularly Processing & IQ Checking by Operator
- Regularly Monitoring by Cal/Val team
- If any IQ issues, report to OCCB by Cal/Val team
- According to the OCCB procedure, carrying out it
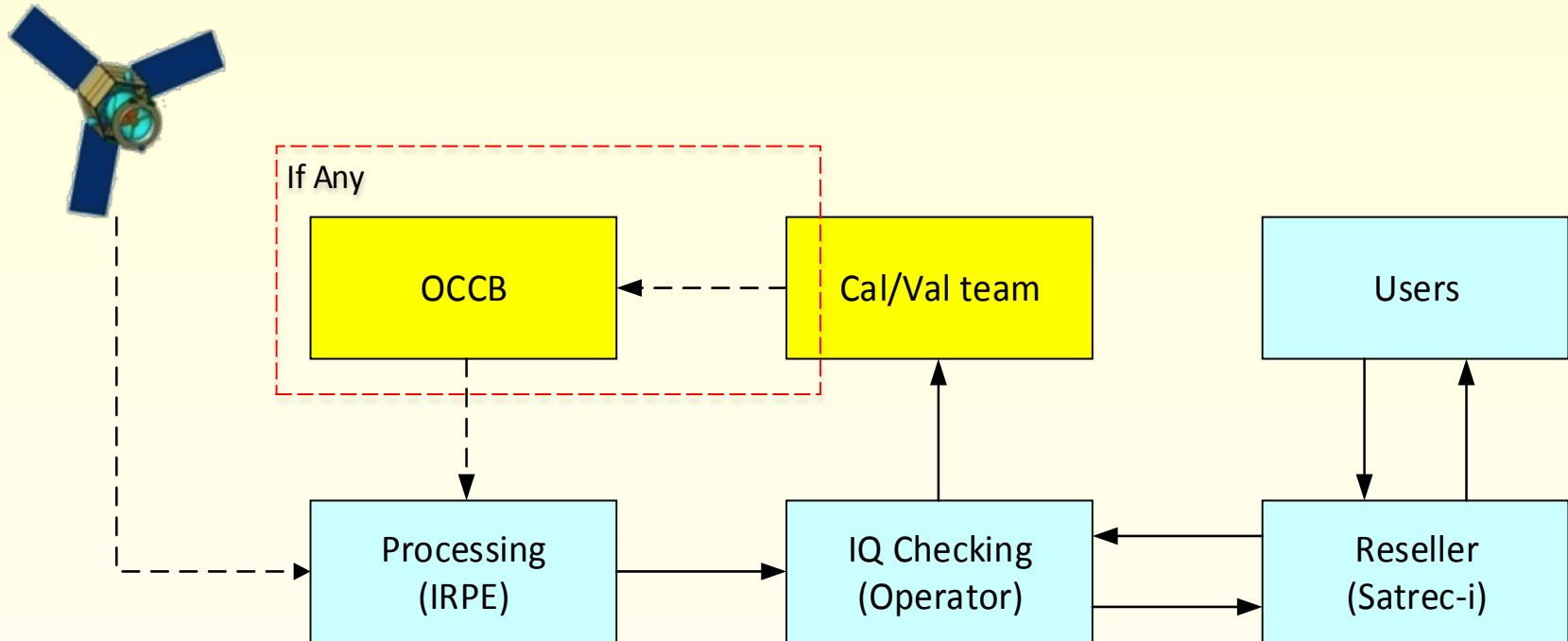
Monitoring and Additional Cal/Val

- Monthly meeting for KOMPSAT-3 Operation and Status
  - ✓ Also checking and talking the Product (Image data) Quality.

- Operational Configuration Control Board (OCCB)

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                    ┌──────────────┐
                    │  OCCB Chair  │
                    └──────┬───────┘
                           │
┌─────────────┐            │            ┌─────────────┐      ┌─────────────┐
│   Impact    │────────────┼────────────│ Coordinator │◄─ ─ ─│  Originator │
│ Assessment  │            │            └─────────────┘      └─────────────┘
└─────────────┘     ┌──────┴───────┐                                 ▲
                    │ OCCB Members │                                 │
                    └──────────────┘                                 │
         ┌────────────────────────────────┐                         │
         │     < Technical Engineer >     │                         │
         │            System              │                         │
         │         AEISS Camera           │                         │
         │             EPS                │                         │
         │          Propulsion            │                         │
         │             AOCS               │─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─┘
         │        Thermal Control         │
         │             TC&R               │
         │          Flight S/W            │
         │          Cal/Val team          │
         │    Ground Operation & Support  │
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Quality Checking for K3 Product (Draft)

QR (Quality Report) for KOMPSAT-3 Image Data

QR No.	QR-K3-20130314-0001		
User No.	SI		
Product ID	K3_20130310175432_04341_19891327_L1R		
S/W Version	PMS. V1.0.130306.001		
Processing Date	2013-03-06	Processed By	KARI, Gil-Dong Hong

Anomalies Image		Band (◎- Level 2, ●- Level 3)					Constraint (TBR)			Check	Comments
		MS				PAN	Level 1	Level 2	Level 3		
		B	G	R	N						
Dynamic range							> 1000	500-1000	< 500		
Saturation							< 1%	1-2%	> 2%		
Abnormal Pixel (except Blooming)							~2	3~10	> 10		
Equalization: inter-Detector (NUC)							20DN	20~50DN	> 50DN		
Pattern noise	diagonal, horizontal, vertical, First pixel						none	isolated noise	recurrent noise		
	Center Pattern						none	isolated noise	recurrent noise		
	Pixel burst (Port difference)						20DN	20~50DN	> 50DN		
Compression noise							none	isolated blocks	recurrent blocks		
Registration (MS-MS)							< 0.5	0.5-0.75	> 0.75		
Registration (MS-PAN)							< 0.5	0.5-0.75	> 0.75		
Location accuracy							< 70m	70-150m	> 150m		
Comments / Image chip											
Review Date						Reviewed By					
Review Comments											

❖ QR (Quality Report) is the Internal report in KARI to monitor the KOMPSAT-3 Product (Image data) Quality.

Quality Checking for K3 Product (Draft)

Anomalies Image		Constraint (TBR)		
		Level 1	Level 2	Level 3
Dynamic range		> 1000	500~1000	< 500
Saturation		< 1%	1~2%	> 2%
Abnormal Pixel (except Blooming)		~2	3~10	> 10
Equalization: inter-Detector (NUC)		20 DN	20~50 DN	> 50 DN
Pattern noise	diagonal, horizontal, vertical, First pixel	none	isolated noise	recurrent noise
	Center Pattern	none	isolated noise	recurrent noise
	Pixel burst (Port difference)	20 DN	20~50 DN	> 50 DN
Compression noise		none	isolated noise	recurrent noise

※ Constraint - Level 1: Accepted, Level 2: To be Proposed, Level 3: Rejected
※ Cloud, Water, Snow area: to be take off for constraints: saturation, compression, NUC and pattern noise

Isolated & Recurrent (TBR)

	Isolated	Recurrent
Number	2~4	>= 5
Area of 1 part	100x100	100x100
DN difference	20~50 DN	> 50 DN

Level 1: Accepted
Level 2: To be Proposed
Level 3: Rejected

※ In case of Compression noise, there is no limitation of the number of the compressed region for the Level 2.

(IQ) Dynamic Range

Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Dynamic range (0 ~ 16363)	> 1000	500~1000	< 500
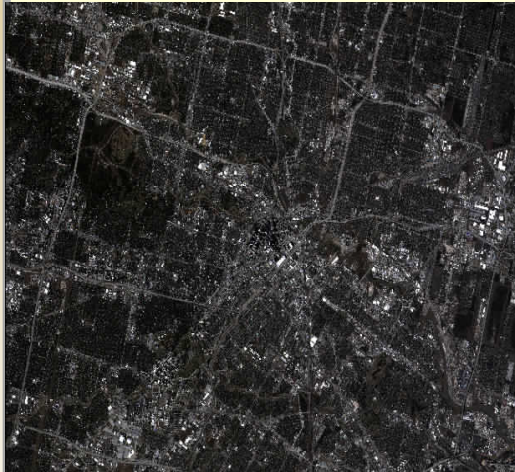
K3_20130110191806_03480_18511222_L1R♪

K3_20130310175432_04341_19881329_L1R♪
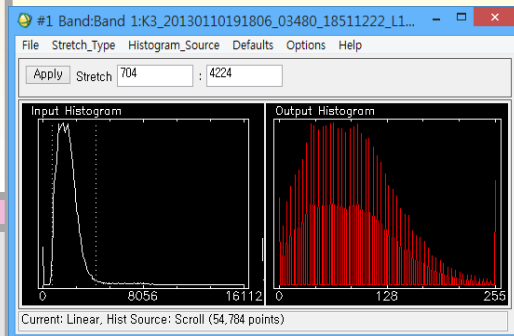
Histogram of Linear 2% in Scroll window in ENVI♪
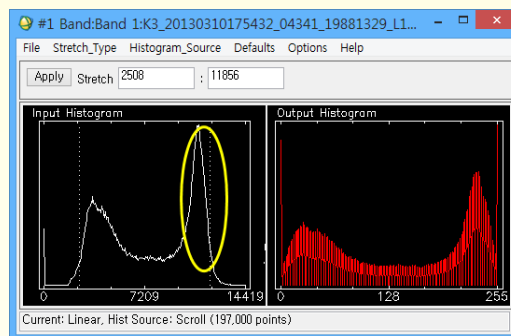
- Linear 2% in Scroll window in ENVI (TBR)
  - ✓ DN(Max – Min)
  - ✓ "3500" = 4224 - 704

- Except the next area
  - ✓ Uniform bright area
  - ✓ Forest, Farm, Desert, Ice, Mountain, Big river, Big lake, etc.
  - ✓ Snow, Cloud, Ocean, etc.

- Only ROI requested by User

- ❖ User want a sufficient dynamic range in the satellite radiometric resolution.
  - ✓ KOMPSAT-3: 14bit
  - ✓ 0 ~ 16383
  - ✓ Not stretching in the Processing system

(IQ) Saturation

Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Saturation	< 1%	1~2%	> 2%
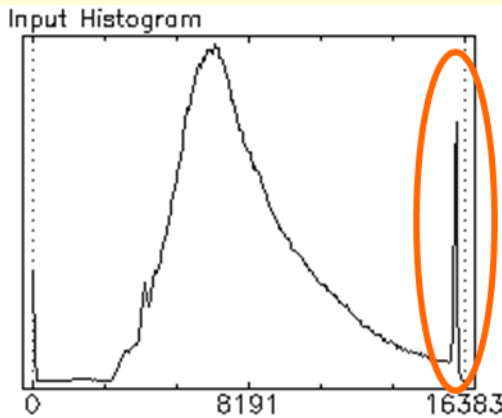
MS Green band: Saturation in SF (2012.06.05)♪
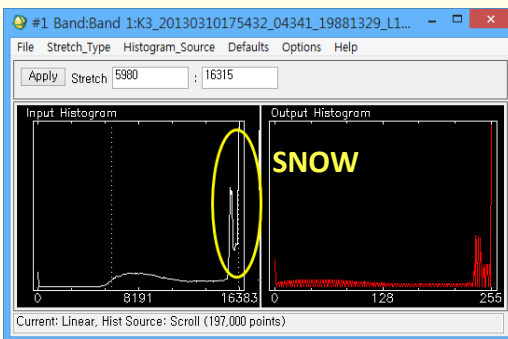
K3_20130310175432_04341_19881329_L1R_B♪

- Basically, >16383 DN, but
  - ✓ The Saturated area has a width of DN after the Processing system

- Except the next area
  - ✓ Snow, Ice, Cloud, Salt desert, etc.

- Only ROI requested by User

- ❖ User never want a saturated image data product.
  - ✓ Several exposures of Satellite be needed according to the imaging area.
  - ✓ KOMPSAT-3 has Two TDI stages.
  - ✓ KOMPSAT-3 data collection planning system has a Radiance (Reflectance) calculating module in Worldwide.

(IQ) Abnormal pixel (except Blooming)

Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Abnormal pixel (No. of Part)	~2	3 ~ 10	> 10
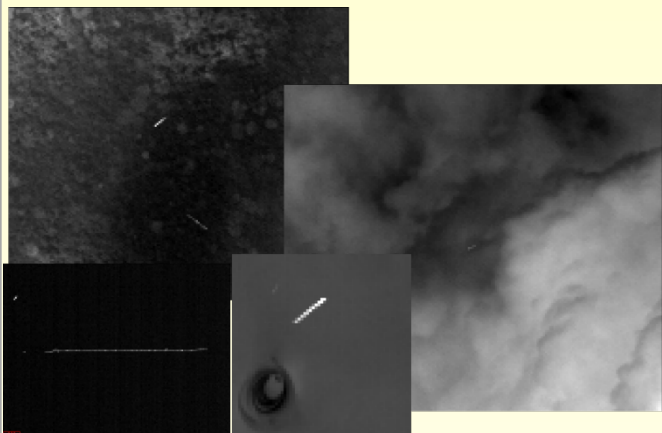
Speckle noise in MS♪
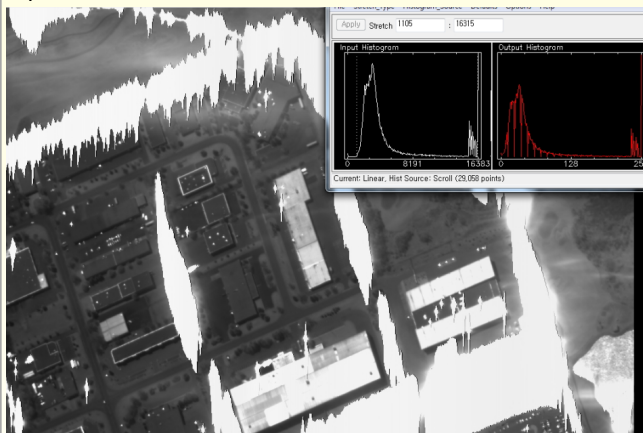
- Abnormal DN of any Pixel
  - ✓ (ex.) Speckle noise
  - ✓ Number of Abnormal parts in a image data product
  - ✓ Not number of abnormal pixels

- Except Blooming
  - ✓ But, in case of Big and Large blooming, KARI Cal/Val team will inspect it.
  - ✓ (ex) Left bottom figure.
  - ✓ (TDI CCD)

- ❖ User don't want the Abnormal pixel
  - ✓ User needs the location of the Abnormal pixel.

20130513031053_05267_024_P7
Large Blooming by the direct solar incidence reflection

(IQ) Equalization: inter-Detector (NUC)

Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Equalization (NUC)	20 DN	20~50 DN	> 50 DN

K3_20130103212714_03379_17041356_L1R_P♪
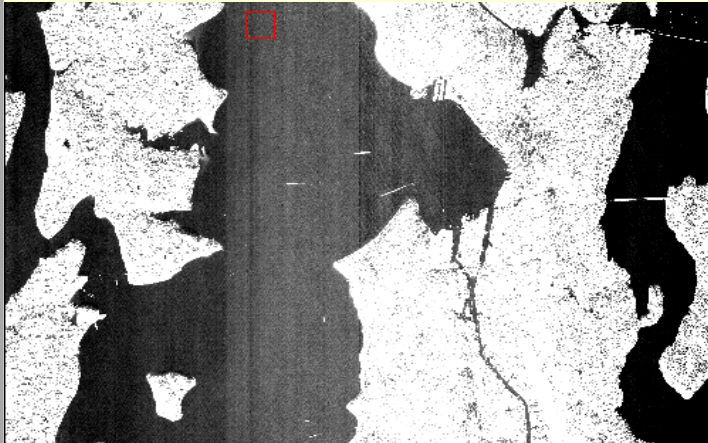
- At less than around 1500DN, NUC is NOK.
  - ✓ Different DN range per each Band
  - ✓ Lake, Ocean, River, Dark Shadow, etc.

- RNUC module in IRPE PMS has been Ready
  - ✓ Updated RNUC table

- ❖ One of the main purpose of the High resolution image data product is 'detecting and recognizing' on a Land area.
  - ✓ but, User also want clear image in the coast and lake area.

K3_20130103212714_03379_17041356_L1R_P

Spatial Profile
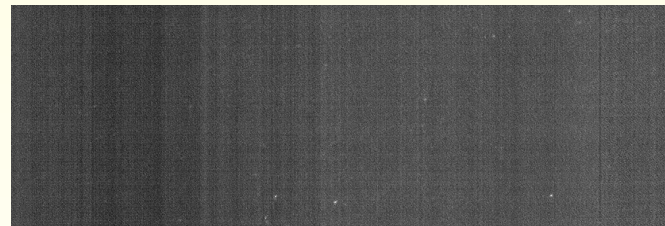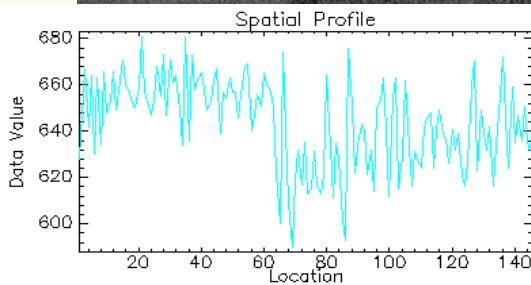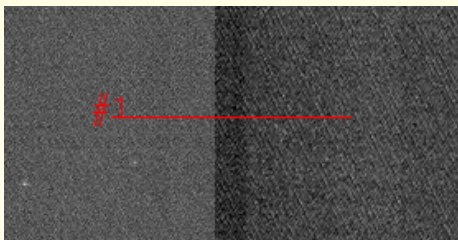
Updated RNUC table (Additional Cal/Val item)

CALL0F_121115181118_02661 (PAN)
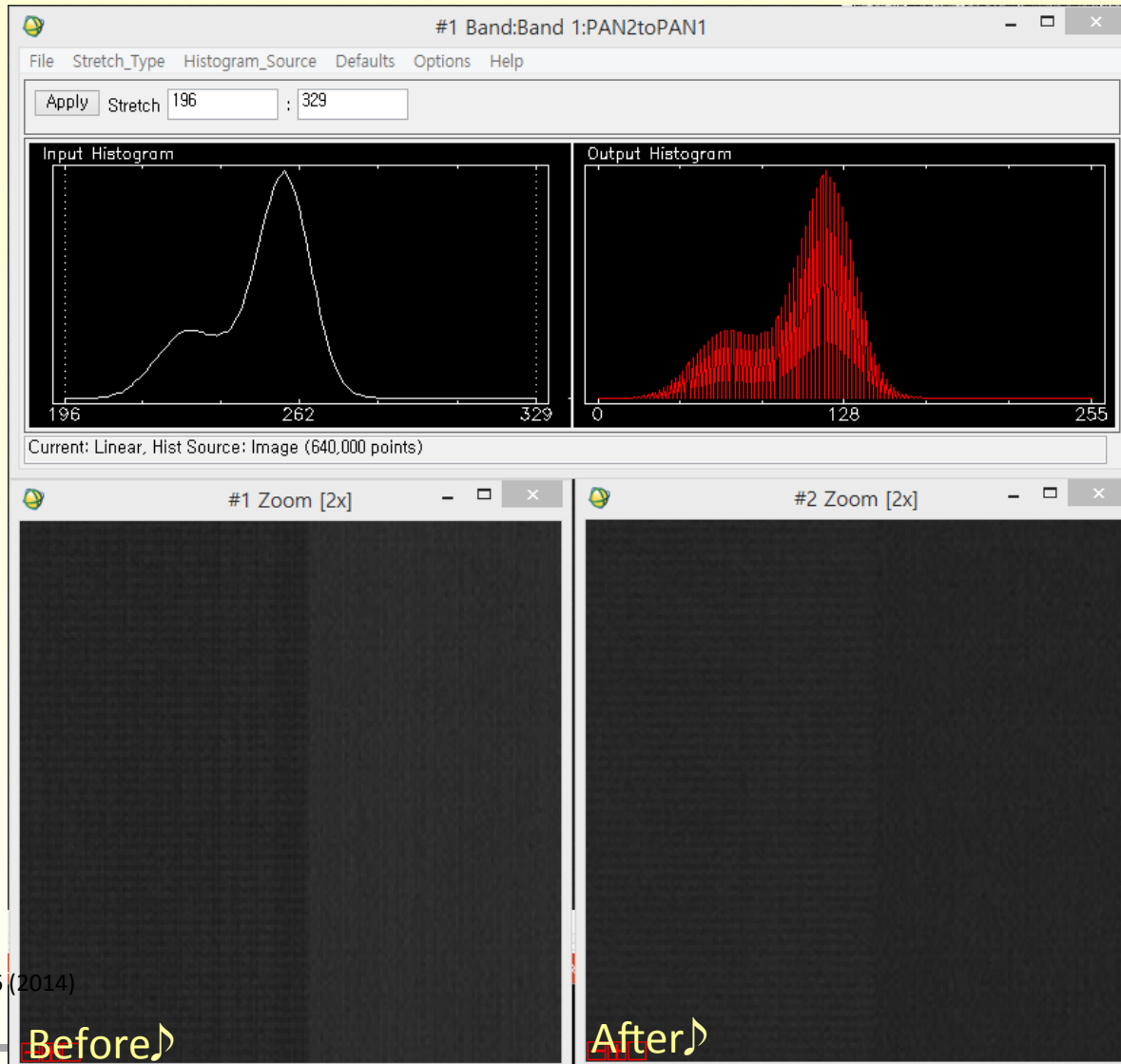
Pattern noise
(Diagonal, Horizontal, Vertical, First pixel)

Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Pattern noise (Diagonal, etc.)	none	isolated	recurrent

	Isolated	Recurrent
Number	2~4	>= 5
Area of 1 part	100x100	100x100
DN difference	20~50 DN	> 50 DN
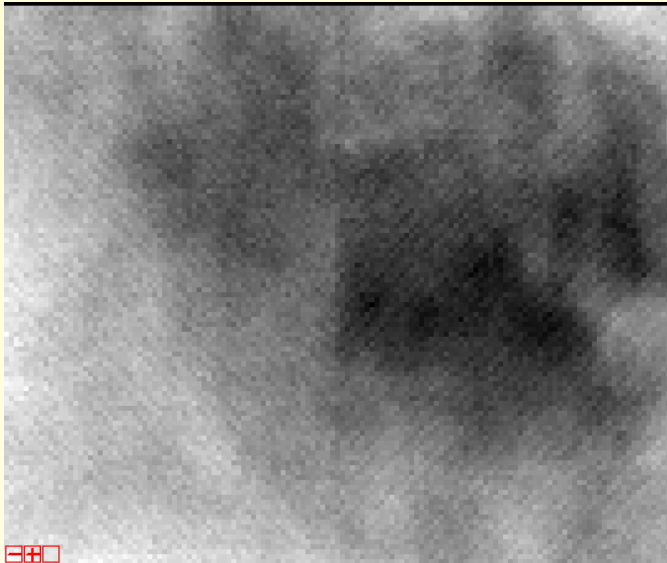
Diagonal noise in MS Green♪
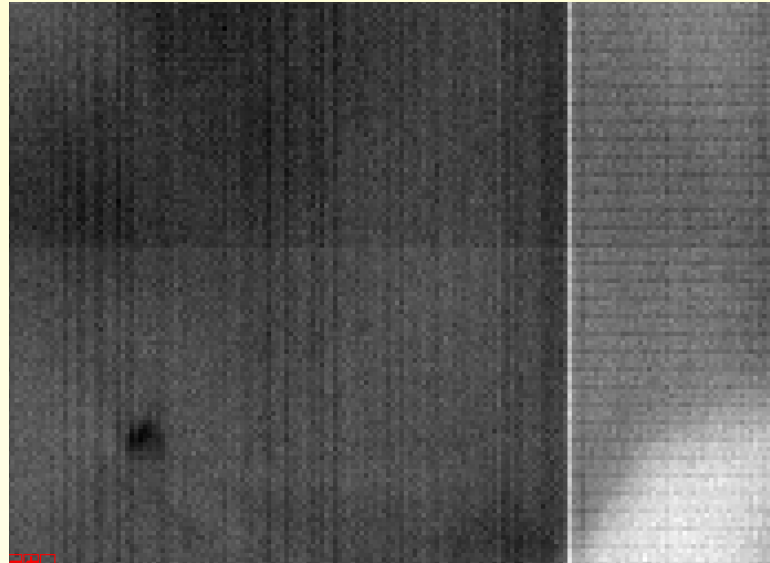
Vertical, Horizontal, First pixel noise in PAN

- KOMPSAT-3 Radiometric resolution is '14 bit'
- The background noise level is '15 DN'
- ❖ User may be difficult to determine any information by the pattern noise.
    - ✓ A rough de-noising may reduce and remove any information.
    - ✓ So, the optimized de-noising for KOMPSAT-3 has been applied.

Pattern noise (Center pattern difference)

| Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Pattern noise (Center pattern)	none	isolated	recurrent

	Isolated	Recurrent
Number	2~4	>= 5
Area of 1 part	100x100	100x100
DN difference	20~50 DN	> 50 DN
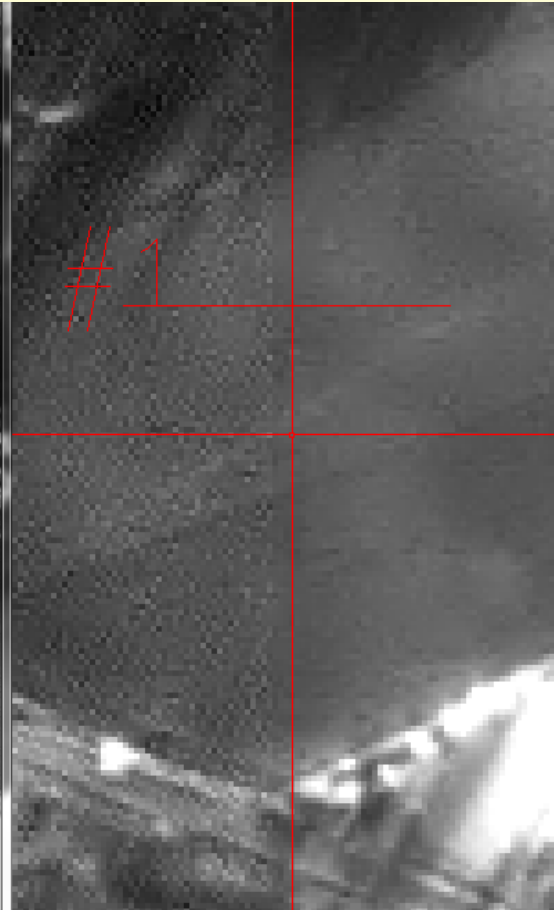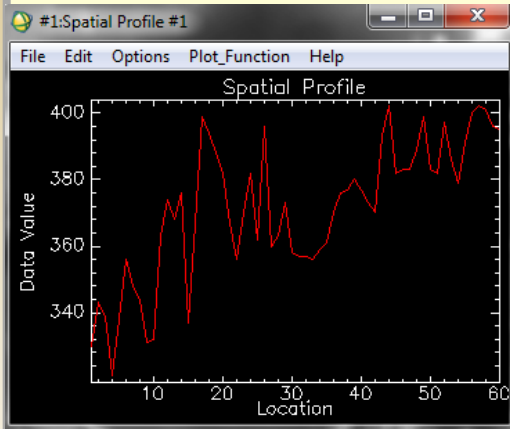
- The noise on Each detector is different
  - ✓ Pattern noise
  - ✓ Compression noise
  - ✓ RNUC

- ❖ User don't want any noise
 - ✓ The optimized de-noising for KOMPSAT-3 has been applied.

Pattern noise (Pixel burst, Port difference)

Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Pattern noise (Pixel burst)	none	isolated	recurrent

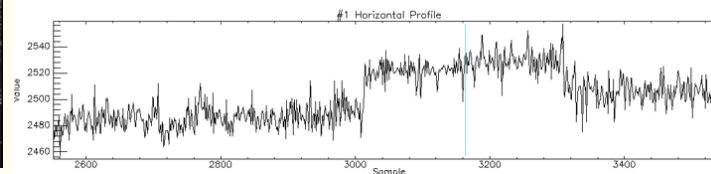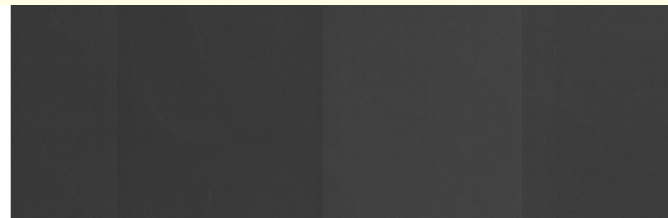|	Isolated	Recurrent
Number	2~4	>= 5
Area of 1 part	100x100	100x100
DN difference	20~50 DN	> 50 DN
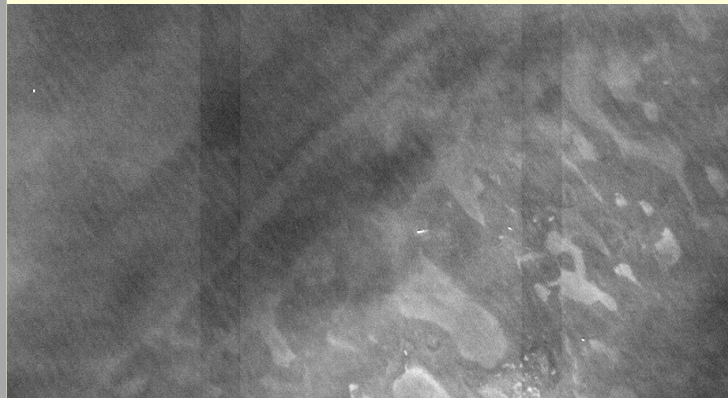
Pixel burst in K3_20130205112349_03855_02531233_L1R_B

- Only MS band
  - ✓ Width of Pixel burst is '50 pixel'
  - ✓ Width of Port Diff is '300~1500'
  - ✓ DN difference is '20~50 DN'

- ❖ User don't want any noise
  - ✓ The optimized de-noising for KOMPSAT-3 has been applied.
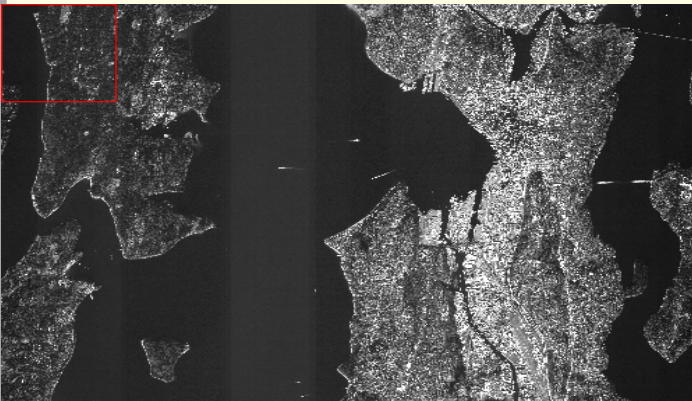
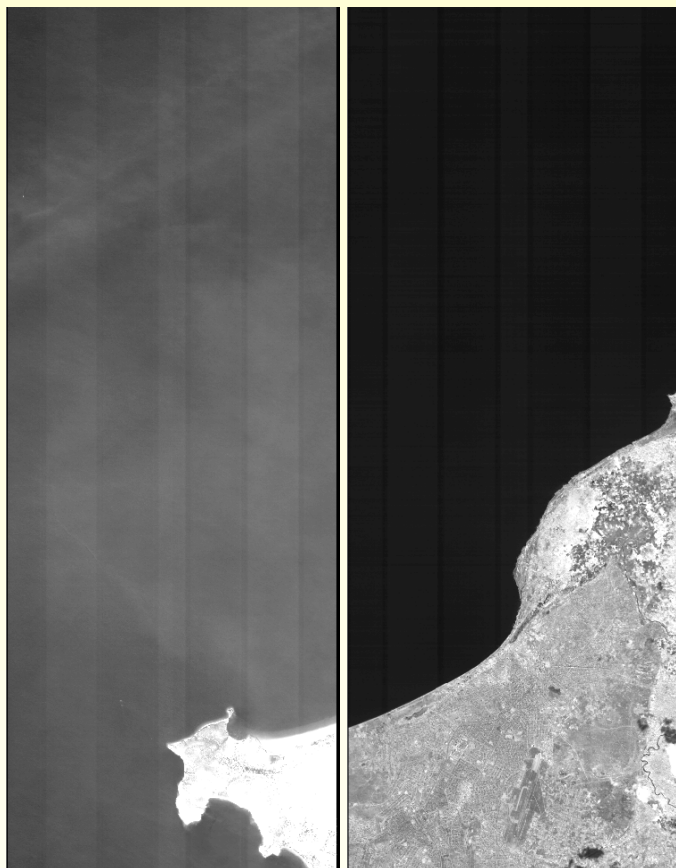Port difference in K3_20130103212714_03379_17041356_L1R_B

Profile of Port difference

Reducing Pixel burst (Additional Cal/Val item)
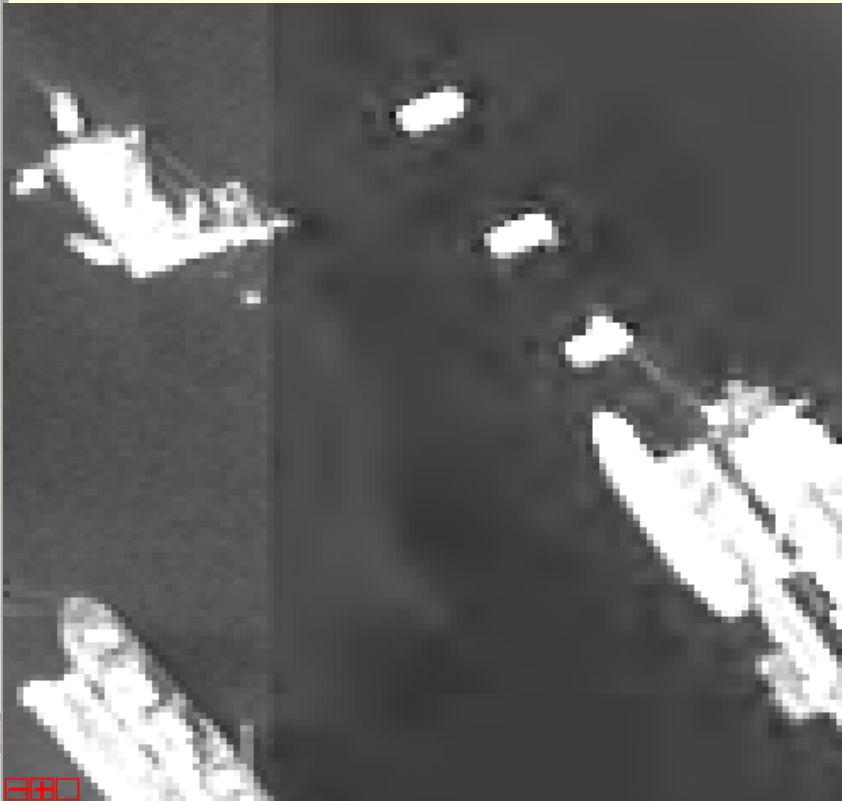
CALL0F_20120616032915_00432_024 (MS Green)

Before♪

After♪

Korea Aerospace Research Institute (KARI)
Satellite data Calibration and Validation team (SCV)

Compression noise (Additional Cal/Val item)

Anomalies Image	Constraint (TBR)		
	Level 1	Level 2	Level 3
Compression noise	none	isolated	recurrent

	Isolated	Recurrent
Number	2~4	>= 5
Area of 1 part	100x100	100x100
DN difference	20~50 DN	> 50 DN

K3_20130210093832_03927_04161188_L1R_B

- Compression ratio is '5.5' by CCSDS 122.0-B-1 (Wavelet)
  - ✓ PAN has a little
  - ✓ MS has many
  - ✓ Uniform area nearby high frequency are a in city

- ❖ User don't want the compression noise
  - ✓ KOMPSAT-3 has been changed
    - • PAN: '5.5'
    - • MS: '3'
  - ✓ KOMPSAT-3 has little compression noise with the Compression ratio '3'.

Monitoring of KOMPSAT-3 Product Quality
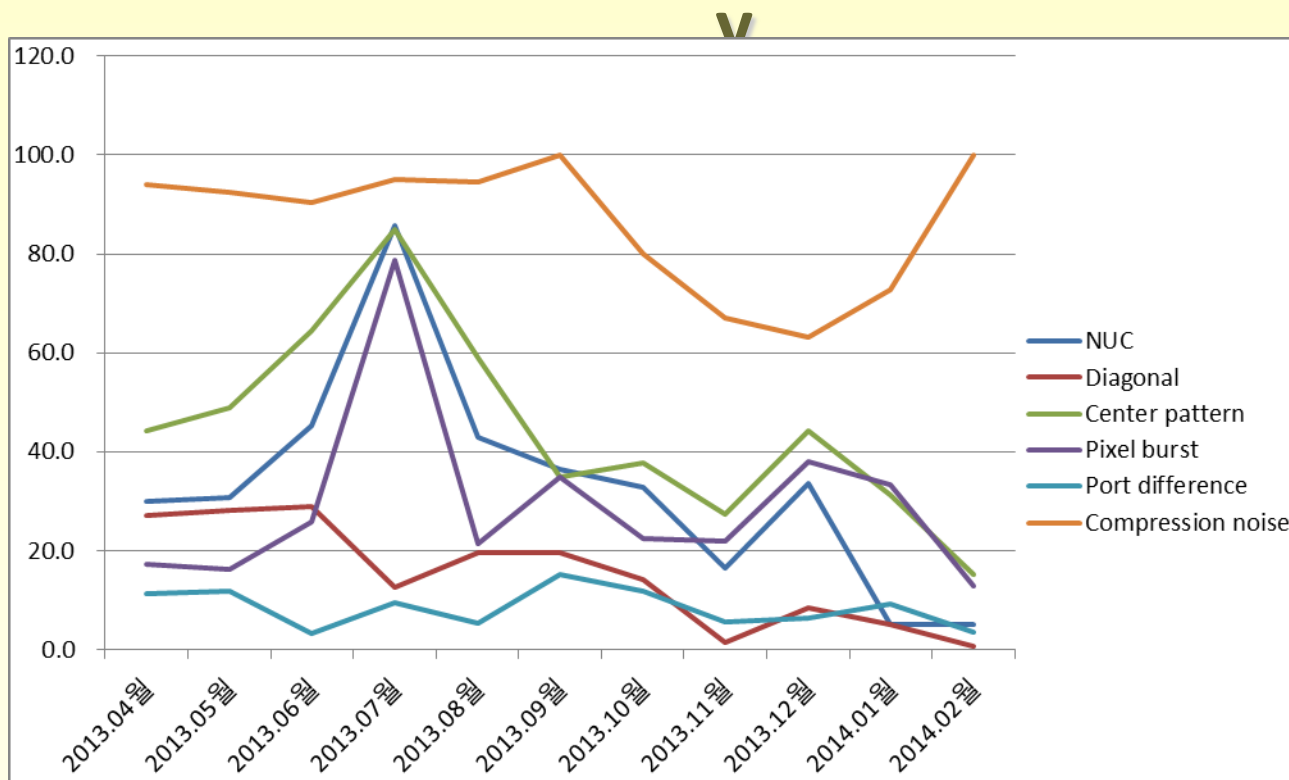
- Reducing the Noise from Jan. 2014 after applying the additional Cal/Val
- But, Compression noise is still high.
    - ✓ Because User(reseller) can choose the Compression ratio and still use '5.5' for MS image data.

Issues and Discussion

Issues and Discussion

- QR (Quality Report), that is the Internal report in KARI to monitor the KOMPSAT-3 Product (Image data) Quality, is Draft just now.

- Definite quantitative value for the image data Quality has to be determined.
  - ✓ For, and From User
  - ✓ Items, and Value of them

- The main purpose of KOMPSAT-3 is just 'Detecting and Recognizing'.
  - ✓ High resolution remote sensing satellite (GSD @ nadir = 0.7m)
  - ✓ Any difference of the image data Quality according to Resolution?
  - ✓ If no, what is the representative item of the image data Quality for them?

- In case of KOMPSAT-3 & KOMPSAT-2,
  - ✓ After Cal/Val, all Requirements of the image data Quality were Complied.
  - ✓ But User didn't comply the Quality of K3 & K2 Product,
  - ✓ and then, Additional Cal/Val works for User have been done and doing~!

- We need more works for it~!

Representative & Product Quality (?)

- These are my Questions and Concerns.
- Is there standard and general Representative and Product Quality for Users?

	Car	Computer	Imagery	Remark
by Purpose	Bus, Sedan, SUV, Truck, etc.	Server, Desktop, Laptop, Tablet, etc.	SAR, IR, Visual, Resolution, etc.	
by Budget	Bentz, BMW, Lexus Toyota, Honda, Kia	?	WV, GeoEye Pleiades, KOMPSAT SPOT, Landsat	
Representative	Engine size, etc.	CPU, Memory, HDD (SSD), Weight, OS, etc.	GSD, MTF, SNR, etc.	Performance (Specification)
Product Quality (IQ)	Scratch, Driving, etc.	Dead pixel, OS, S/W, KB, Mouse, etc.	Noise, etc.	Users can look at & recognize

Thank you for KOMPSAT~!

Korea Aerospace Research Institute (KARI)
Satellite data Calibration and Validation team (SCV)