Spatial Quality from Edge target imaged by KOMPSAT-3
(& KARI methodology of MTF Estimation, ver. 2019)
(Jan. 2014 ~ July 2019)

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(Sample) KARI’s MTF Estimation from Edge target

(MTF Code Ver. 2016.12.14)

• V(0.25) = MTF value at a Quarter frequency
• A(0~0.5) = Area from 0~0.5
• A(0~0.25) = Area from 0~0.25
• A(0.25~0.5) = Area from 0.25~0.5

Additional Estimators
<table>
<thead>
<tr>
<th>Agenda</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Status of Edge target in worldwide</td>
</tr>
<tr>
<td>2. Spatial Quality of KOMPSAT-3 by KARI methodology</td>
</tr>
</tbody>
</table>
## Comparison of Spatial quality Estimators (Draft)

- We need fill in this table continuously.

<table>
<thead>
<tr>
<th>Estimator</th>
<th>Good</th>
<th>Weak</th>
<th>Applicable Targets</th>
<th>Recommend</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>RER</td>
<td>High reliable</td>
<td></td>
<td>Edge</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>Edge slope</td>
<td>High reliable</td>
<td>Weak has: Need GSD each imaging</td>
<td>Edge</td>
<td></td>
<td>Difficulty in measuring Good for big GSD</td>
</tr>
<tr>
<td>FWHM</td>
<td>High reliable</td>
<td></td>
<td>Edge, Point</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>MTF @ Nyq.</td>
<td>Popular</td>
<td>Low reliable</td>
<td></td>
<td></td>
<td>Normal</td>
</tr>
<tr>
<td>MTF @ 0.25</td>
<td></td>
<td>Low reliable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTF Area 0~0.5</td>
<td>High reliable</td>
<td></td>
<td>Edge, Point, Periodic</td>
<td></td>
<td>OK</td>
</tr>
<tr>
<td>MTF Area 0~0.25</td>
<td>High reliable</td>
<td></td>
<td></td>
<td></td>
<td>OK</td>
</tr>
<tr>
<td>MTF Area 0.25~0.5</td>
<td>High reliable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTF Area 0.25~0.5</td>
<td>Low reliable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## List of Standard Edge targets

<table>
<thead>
<tr>
<th>Target</th>
<th>Description and Dimensions</th>
<th>Orientation (to true north)</th>
<th>Lat / Long</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salon de Provence, France</td>
<td>60m x 60m, 2x2 checkerboard, painted tar pad</td>
<td>~-3° / 87°</td>
<td>43.60583N 5.12028E</td>
<td>Good</td>
</tr>
<tr>
<td>Stennis Space Center, USA</td>
<td>45m x 45m (?), 2x2 checkerboard</td>
<td></td>
<td>23.51972N 119.58333W</td>
<td>Need Repainting</td>
</tr>
<tr>
<td>Penghu, Taiwan</td>
<td>60m x 60m, 2x2 checkerboard, painted surface</td>
<td>0° / 90°</td>
<td>30.38667N 89.62861E</td>
<td>Need Repainting</td>
</tr>
<tr>
<td>Big Spring, USA</td>
<td>40m x 40m, 2x2 checkerboard, painted concreted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baotou city, China</td>
<td>48m x 48m for a single panel, contrast (W/B) &gt; 5:1</td>
<td>5°</td>
<td>40.85167N 109.62889E</td>
<td>Good</td>
</tr>
<tr>
<td>Mongol with KARI</td>
<td>70m x 70m, 2x2 checkerboard, painted surface</td>
<td>-11.19°</td>
<td>47.71049N 106.98953E</td>
<td>Good</td>
</tr>
<tr>
<td>Shadnagar, India</td>
<td></td>
<td></td>
<td>16.902709N 78.195753E</td>
<td>Good</td>
</tr>
</tbody>
</table>

Salon, Stennis, Penghu, Baotou, Mongol, India imaged by KOMPSAT-3, GSD (0.7m) http://calval.cr.usgs.gov/rst-resources/sites_catalog/
Salon de Provence, France

- Imaging date: 2017.08.03
- Tilt angle: -7.42deg

Imaged by KOMPSAT-3
(GSD: 0.7m)

(MTF Code Ver. 2016.12.14)
Stennis Space Center, USA

- Imaging date: 2014.04.30
- Tilt angle: 2.11deg

Edge Detection (Across, 20.56 deg)

Edge Spread Function (csaps= 0.98)

- RER = 0.4321
- SNR = 129.86

Line Spread Function (Resolution x 0.05)

- 80% = 0.883
- FWHM = 1.591
- 25% = 2.978

MTF

- MTF at Ny. = 12.32%

Imaged by KOMPSAT-3 (GSD: 0.7m)
Penghu, Taiwan

- Imaging date: 2014.04.29
- Tilt angle: 7.29deg

**Edge Detection (Across, 11.89 deg)**

**Edge Spread Function (csaps= 0.98)**

- RER = 0.4261
- SNR = 123.09

**Line Spread Function (Resolution x 0.05)**

- 80% = 0.853
- FWHM = 1.612
- 25% = 3.164

**MTF**

- MTF at Ny. = 11.99%

Imaged by KOMPSAT-3
(GSD: 0.7m)
Baotou, China

- Imaging date: 2017.08.03
- Tilt angle: 24.22deg

Imaged by KOMPSAT-3 (GSD: 0.7m)
Mongolia

- Imaging date: 2017.07.21
- Tilt angle: 5.42deg

Imaged by KOMPSAT-3 (GSD: 0.7m)
Agenda

1. Status of Edge target in worldwide

2. Spatial Quality of KOMPSAT-3 by KARI methodology
### Results from Edge targets with KOMPSAT-3

<table>
<thead>
<tr>
<th>Across</th>
<th>No.</th>
<th>RER</th>
<th>FWHM</th>
<th>MTF</th>
<th>MTF Area</th>
<th>SD/Ave</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nyq.</td>
<td>0.25</td>
<td>0~0.5</td>
</tr>
<tr>
<td>Baotou</td>
<td>185</td>
<td>0.394</td>
<td>1.727</td>
<td>9.23</td>
<td>26.59</td>
<td>39.68</td>
</tr>
<tr>
<td>Taiwan</td>
<td>21</td>
<td>0.408</td>
<td>1.749</td>
<td>8.94</td>
<td>29.06</td>
<td>40.65</td>
</tr>
<tr>
<td>Salon</td>
<td>272</td>
<td>0.393</td>
<td>1.773</td>
<td>8.86</td>
<td>26.77</td>
<td>39.08</td>
</tr>
<tr>
<td>India</td>
<td>19</td>
<td>0.396</td>
<td>1.757</td>
<td>9.55</td>
<td>25.10</td>
<td>40.00</td>
</tr>
<tr>
<td>Mongol</td>
<td>268</td>
<td>0.377</td>
<td>1.803</td>
<td>8.40</td>
<td>23.89</td>
<td>37.89</td>
</tr>
<tr>
<td>Ave</td>
<td>765</td>
<td>0.388</td>
<td>1.771</td>
<td>8.81</td>
<td>25.74</td>
<td>38.87</td>
</tr>
<tr>
<td>Max</td>
<td></td>
<td>0.441</td>
<td>1.558</td>
<td>12.31</td>
<td>35.33</td>
<td>44.34</td>
</tr>
<tr>
<td>Min</td>
<td></td>
<td>0.338</td>
<td>2.056</td>
<td>5.23</td>
<td>17.34</td>
<td>33.66</td>
</tr>
<tr>
<td>StdDev</td>
<td></td>
<td>0.020</td>
<td>0.087</td>
<td>1.19</td>
<td>3.24</td>
<td>1.99</td>
</tr>
<tr>
<td>SD/Ave</td>
<td></td>
<td>0.052</td>
<td>0.049</td>
<td>0.135</td>
<td>0.126</td>
<td>0.051</td>
</tr>
</tbody>
</table>

(Imaging period) Jan. 2014 ~ July 2019
1. RER & FWHM are stable.
2. MTF @ Nyq as estimator is not good.
3. Each of them shows a little different result.
   a. Status of them may be a little different.
      ✓ Cleaning, Some condition
(K3) RER, FWHM, MTF (Day)

1. ‘Day’ from KOMPSAT-3 launch
2. RER & FWHM are Fluctuating & Decreasing.
   a. (Decreasing) Overall
   b. (Fluctuating) Oct~Feb in 2015, 2017, 2018, 2019
3. Two possible reasons
   a. Seasonal variation
   b. KOMPSAT-3: Reliability down
1. RER, FWHM & MTF don’t depend on Edge angle.
2. A little Slope by Edge target (????)
(K3) RER, FWHM, MTF (Roll tilt angle)

1. RER, FWHM & MTF don’t depend on Roll tilt angle.
(K3) RER, FWHM, MTF ($\Delta$DN)

1. (K3) 14bit (0~16383 DN)
2. RER, FWHM & MTF don’t depend on $\Delta$DN.
(K3) RER, FWHM, MTF (SNR)

1. RER, FWHM & MTF don’t depend on SNR.

- Method for measuring SNR has to be Updated~!
  
  a. Edge target is not Uniform. (Need Cleaning, Sweeping & Re-painting)
  
  b. SNR of K3 > 100
1. Weak relation between RER and FWHM
2. There is a relation between SNR and ΔDN.
   • Plan to change the Reasonable SNR calculation method
(K3) MTF area on MTF curve plot

1. MTF area is stable.
2. MTF area don’t depend on Roll tilt angle & Edge angle.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SD/Ave</th>
<th>Parameter</th>
<th>SD/Ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>RER</td>
<td>0.051</td>
<td>MTF area 0~0.5</td>
<td>0.051</td>
</tr>
<tr>
<td>FWHM</td>
<td>0.049</td>
<td>MTF area 0~0.25</td>
<td>0.040</td>
</tr>
<tr>
<td>MTF</td>
<td>0.135</td>
<td>MTF area 0.25~0.5</td>
<td>0.108</td>
</tr>
<tr>
<td>MTF 0.25</td>
<td>0.126</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. MTF area don’t depend on ΔDN (????)
2. MTF area don’t depend on SNR.
3. (Day) MTF area may be Fluctuating & Decreasing.
4. Two possible reasons
   a. Seasonal variation
   b. KOMPSAT-3: Reliability down (????)
(K3) MTF area on MTF curve plot

1. Good relation between MTF area and RER & FWHM.
Summary and Future works (1/2)

1. Each of Edge target shows a little different result of RER, FWHM & MTF
   a. Status of them may be a little different. (Cleaning, Some condition, etc.)

2. RER, FWHM may be Fluctuating and Decreasing by two possible reasons (Oct~Feb 2015, 2017, 2018, 2019)
   a. (Fluctuating) Seasonal variation
   b. (Decreasing) KOMPSAT-3: Reliability down

3. (Edge angle) RER, FWHM & MTF don’t depend on Edge angle.

4. (Roll tilt angle) RER, FWHM & MTF don’t depend on Roll tilt angle.

5. (ΔDN) RER, FWHM & MTF may or not depend on ΔDN

6. (SNR) RER, FWHM & MTF don’t depend on SNR.

7. As Spatial quality estimator
   a. MTF @ Nyq. is not good.
   b. RER & FWHM are Stable.
   c. MTF Area 0.5 & 0.25 are Stable

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SD/Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>RER</td>
<td>0.051</td>
</tr>
<tr>
<td>FWHM</td>
<td>0.049</td>
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<td>MTF</td>
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<td>MTF area 0~0.25</td>
<td>0.040</td>
</tr>
<tr>
<td>MTF area 0.25~0.5</td>
<td>0.108</td>
</tr>
</tbody>
</table>
Summary and Future works (2/2)

8. There is a relation between SNR and ΔDN.
   a. Edge target is not Uniform. (Need Cleaning, Sweeping & Re-painting)
   b. SNR of KOMPSAT-3 > 100

9. Maintenance and Monitoring be Needed to;
   a. Keep and Share the status of the Edge targets (CCTV?)
   b. Imaging by the several satellites

10. MTF area is stable
    a. MTF area don’t depend on Roll tilt angle, Edge angle, SNR & ΔDN.
    b. (Day) MTF area also be Fluctuating. (Oct~ Feb in 2017, 2018, 2019)

11. Good relation between MTF area and RER & FWHM.
    a. Weak relation between RER and FWHM

< Future work >

① KOMPSAT-3A will be added, and Along direction too

② CEOS WGCV IVOS, GeoSpatial W/G