FIELD TEST OF KOMPSAT-5 CALIBRATION EQUIPMENT

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1. INTRODUCTION

In the republic of KOREA, the KOMPSAT-5 (K-5, the fifth of KOrea MultiPurpose SATellite) is the first trail as a satellite with SAR (Synthetic Aperture Radar) payload. It has been funded by its government and realized by KARI. K-5 has GOLDEN mission including five (5) categories, which are GIS (Geographic Information System), Ocean & Land management, and Disaster & ENvironment monitoring. In order to support GOLDEN mission, K-5 with SAR payload has three (3) operational modes and also uses X-band frequency (9.66GHz). Three (3) operational modes are Standard (ST-mode), High-resolution (HR-mode), and Wide-swath mode (WS-mode), which has 3m in 30km, 1m in 5km, and 20m in 100km.

K-5 CALVAL (Calibration&Validation) activities are categorized as relative & absolute radiometric calibration and pointing calibration. The design of distributed targets (DT), point targets (PT), and calibration site can allow K-5 CALVAL activities to be successfully executed. K-5 has fifty (50) beams, which are total number of 19 beams for HR-mode, 31 beams for ST-mode. For WS-mode will use a combination using 19 beams of ST-mode. On the basis of Antenna Model covered all many beams, the antenna model shall be validated through acquired real-data during in-orbit test (IOT) phase. Therefore, DT and PT images in calibration sites will be key-conditions to perform K-5 CALVAL.

2. CALIBRATION SITE FOR POINT TARGETS

The radiometric calibration asks for proper definition of calibration sites in terms of RCS, number, placement and orientation of manmade PT, and in terms of characteristics of locations. Major points are to consider PT detectability and DT homogeneity with understanding how K-5 is operated in its orbit. In case of DT, well verified area through other studies is the Amazon forest. Additionally according to resolution of SAR and/or K-5 accessibility, homogenous DT including features less than Amazon's will be utilized.

The area of calibration site for PT shall be flat or with gentle slope, far from hills or mountains which cause layover, ambiguities and other disturbing effects (e.g. multipath). Therefore, Areas covered by forests shall be avoided, whilst preference is for meadows and bare soil. In addition, flat agricultural regions, sowed with crops of wheat, barley, and alfalfa may be of interest for that. The site where corner-reflectors as PTs will be placed shall be stable, in order to ensure a precise location and orientation of each calibrator. Manmade structures as below must be avoided around the calibrators.

- fences, banks, and other artifacts
- electrical pylons, buildings and antenna

[Fig. 1. Mongolia CAL Site]

The above condition can allow the visibility of corner-reflectors in SAR images to be improved fundamentally. The PT site area shall be a homogeneous low-backscattering background. If NRCS (Normalized Radar Cross Section) lower than 0 dBm^2/m^2 can be assumed as reference value, the backscattering value of the site area shall be such to guarantee a signal to clutter ratio (SCR) greater than 30dB.

Mean σ^0 of Mongolia shows around -20 dB in Global map of a yearly mean σ^0 ERS at C-band [2]. It was found the trend of backscattering coefficient σ^0 is increasing monotonically as frequency increases [5]. CAL site with mean σ^0 around from -10 dB to 0 dB at X-band can be chosen when K-5 noise floor is reflected. Mongolia, which has several large-areas with meadow and bare soil over the world, is suitable for the site. Its large area can also support wish points for PT deployment related to K-5 accessibility.

3. PASSIVE POINT TARGETS

K-5 CALVAL will use two (2) kinds of corner-reflector for high resolution and others. Their configuration has been designed as trihedral type in Fig. 2. In order to find calibration constant (K) suitable for SAR Products, RCS of corner-reflector shall be measured and analyzed with absolute accuracy level. The main factor controlling RCS is its size related to reflected power of CR under nominal condition.

$$a = \sqrt[4]{0.239 \cdot SCR \cdot \sigma^0 \cdot \lambda^2 \cdot A_{gr}} \qquad \text{(Eq.1)}$$

Where a is the inner edge length of CR, σ^0 is NRCS of the considered background clutter, λ is the wave-length of X-band (9.66GHz), and A_{gr} is the area as ground azimuth and range resolution of the radar.

The considerable CR size in Eq. 1 can be expressed as the below with relationship among SCR, σ^0, wave-length and ground resolution [1, 3]. In this case, it has been considered the SCR is sufficiently large because the site may be not homogenous due to temporary variation of σ^0 [4].

a) HR-mode CR **b) ST-mode CR**

Fig. 2 the CR configuration of K-5

Relatively the trihedral CR as passive point targets can give benefits to build high absolute radiometric accuracy because of robustness, simple physical-operation, no time-delay of reflection, and several CR usability with low cost. Too big or small PT image in comparison with its ground resolution will affect PT energy calculation at its point. The optimal CR size can give good condition to analyze absolute radiometric accuracy. In spite of above points, the incorrect or unstable deployment of CR definitely will induce error or wrong value.

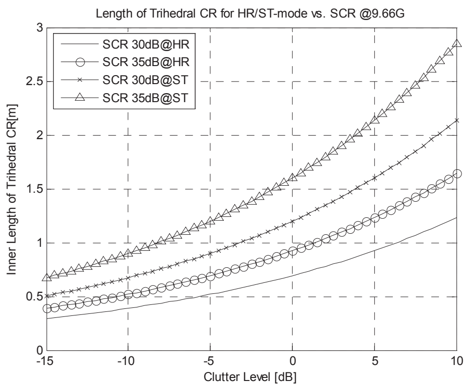
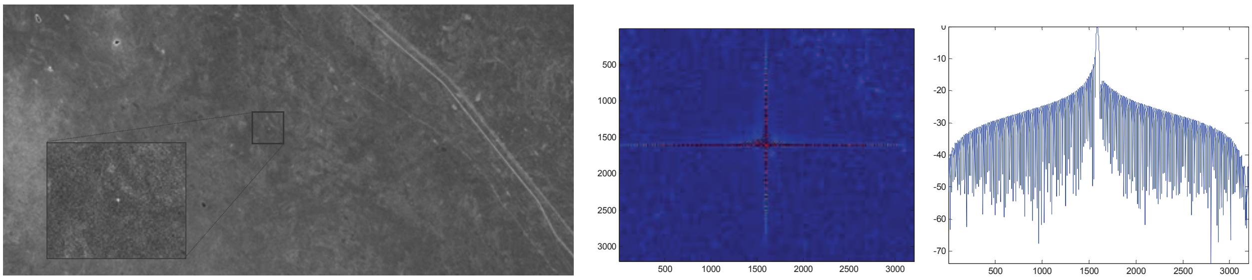


Fig. 3 Inner Length of Trihedral CR

The detectability of CR beyond its visibility can be achieved through trade-off of CR size decision. Typically more than 30 dB of SCR can be applied to detect a point of CR in the image. The clutter level of Mongolia site in Fig. 4 can be considered as around -10 dB. Considering the worst case of Mongolia environment including assumed seasonal variation, the value of 0 dB can be suitable for design clutter level.

For the HR-mode case with 1m ground resolution at 45 of incidence angle, CR size can be designed as about 1m at 35 dB SCR in Fig. 3 and as about more than 1.5m at 35 dB SCR for the ST-mode case. In order to endure certain gust in Mongolia and reduce its weight, CR for ST-mode has been designed to use honey-comb aluminum panel for trihedral plate. During CAL site construction in Mongolia, several CRs for HR/ST-mode installed on two types of concrete basements. Accurate GPS measurement of each CR has been performed.



a) HR-mode CR in X-band SAR Image **b) Oversampled CR Data** **c) Range Profile**

Fig. 4 Corner-reflector of Mongolia CAL Site acquired by TerraSAR-X

Using CR measurement and positioning, the CR for HR-mode based on its measurement was pointed to predicted pass of TerraSAR-X pass. The analysis of HR-mode using X-band real SAR image was being done. The designed RCS of HR-mode CR was analyzed and its maximum value at symmetric boresight axis is 35.76 dBm^2. In the comparison of 34.69 dBm^2 calculated with real SAR image, can be a meaningful value as first analysis.

4. CONCLUSION

To analyze radiometric accuracy at CALVAL position shall need to use reliable reference targets and homogeneous site. Trihedral CRs as passive point targets can allow K-5 CALVAL to build absolute radiometric accuracy under relative one using distributed targets. On the basis of CR's performance firstly analyzed with X-band real SAR images, designed and developed CRs can be used for K-5 reference targets. In real scenario, it can be also sufficient equipment for K-5 CALVAL.

5. REFERENCES

[1] Anthony Freeman, "SAR Calibration: An Overview," *Transactions on Geoscience and Remote Sensing*, IEEE, Vol. 33, No. 6, pp. 1107-1121, Nov. 1992.

[2] Catherine p., Ina T., Filipe A., Beatrice M., and Merhez Z., "Estimation of the aerodynamic roughness length in arid and semi-arid regions over the globe with the ERS scatterometer," *Journal of Geophysical Research*, American Geophysical Union, Vol. 110, D09205, 2005.

[3] Jason N., Paris W. V., David S., Ryan E., and Lloyd G., *Expendable Trihedral Corner Reflectors for Target Enhancement and Position Control in RADARSAT-1 Fine Beam Mode SAR Imagery: Results from an Exercise Narwhal Pre-Trial Deployment*, Defence R&D Canada, Ottawa, Sep. 2004.

[4] L. M. H. Ulander, "Accuracy of using Point Targets for SAR Calibration," *Transactions on Aerospace and Electronic Systems*, IEEE, Vol. 27, No. 1, Jan. 1991.

[5] Skolnik M., *Radar Handbook*, McGraw-Hill, Newyork, 2008.