An Implementation of SAR Testbed and the Flight Test Results

HYUN-IK SHIN, KYUNG-IL KWON, SANG-HO YOON, HYUNG-SUK KIM, JEONGHUN HWANG, YOUNG-CHANG KO, SO-YEON KIM and KI-WAN KIM
Agency for Defense Development, Yuseong P.O. Box 35, Daejeon, KOREA
shi1124@add.re.kr kikwon@add.re.kr yoonsh@add.re.kr hskim@add.re.kr jhhwang@add.re.kr
ycko@add.re.kr soyeonkim@add.re.kr kiwankim@add.re.kr

Abstract: - SAR (Synthetic Aperture Radar) has been widely used for reconnaissance. Because of the advantage of getting high resolution images regardless of day and night, its demand is increasing for the military field. Because the SAR coherently combines many viewing angles to create a large synthetic aperture(narrow beam) radar, a testbed which is capable of moving straightly the SAR during the integration angle, is required. This paper describes the testbed developed to test and evaluate the SAR performance. It forms high-quality images in real time and archives the raw data for the purpose of post processing on the ground.

Key-Words: - SAR, Testbed, EGI, Electronic and Processing Set, Antenna and Gimbal Set

1. Introduction

The role of SAR is increasing for the military field because of the advantage of getting high resolution images regardless of day and night [1]. The main difference between SAR and detection radar is azimuth resolution. The azimuth resolution of a detection radar increases in proportion of the range to target, but the azimuth resolution of a SAR remains the same regardless of the range.

To obtain the same azimuth resolution regardless of the range, a SAR must receive the returned radar signal for the azimuth angle to earn the required resolution [2]. As the range is increased, a straight flight of several kilometers is required to acquire the signal. Therefore, the development of SAR and testbed must be carried out concurrently.

The purpose of the testbed is to allow the development of image formation algorithm, motion compensation techniques and autofocus algorithms in a controlled and repeatable environment [3-5]. It is implemented using car, rail or aircraft.

This paper describes the SAR testbed configuration using PA31-350 aircraft and the results of flight test to verify its functionality.

2. Configuration and Function

Fig. 1 shows the configuration of equipment mounted on the PA31-350 aircraft to implement the SAR testbed. It consists of SAR, GPS(Global Positioning System) receiver, EGI(Embedded GPS Inertial navigation sysyem), checking equipment, controller, power equipment and notebook PCs.

The SAR is divided by two items, electronic and processing set (EPS) and antenna and gimbal set (AGS). The EPS includes 1) transiver, 2) signal processor, 3) image former and 4) controller. The AGS consists of antenna and 2-axis gimbal.

The aircraft position data acquired using GPS receiver are stored in the notebook PC through RS232 port. That data is combined with another GPS data, received at the fixed ground, to perform the CDGPS(Carrier Phase Differential GPS) function. The calculated position from CDGPS is assumed actual flight path and used to analyze motion compensation performance.

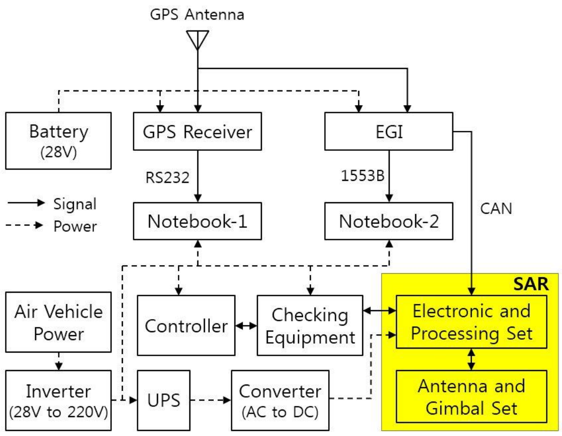


Fig. 1. Block diagram of the SAR testbed.

The EGI provides the EPS with the position, velocity and attitude data of aircraft through CAN(Controlled Area Network) communication. The EPS uses the data to form image in real time and also stores all of data required to form image after landing on the ground. This fuction is very effective to debug system problems and to improve the algorithm.

The checking equipment confirms the normal operation of the SAR on the ground before take-off, and loads the MDF(Mission Definition File) to be used for missions.

The power required for the SAR and the testbed equipment is based on batteries and the aircraft DC 28V power supplier. The EGI and the GPS receiver consuming low power use the battery power, and the AC220V power required for the checking equipment and its controller is made from the DC28V of the aircraft. The DC28V power, which is required to operate the SAR equipment, is configured to be supplied through the UPS(Uninterruptible Power Supply) and AC/DC converter so that satble power can be supplied even during high power transmission.

3. Testbed Realization

Fig. 2 shows the fixtures required to mount the AGS in the central hole of the aircraft. As shown in the fig. 2, the mounting plate for the AGS is located inside the aircraft, the mounting plate for the radome and buffering rubber ring are located outside the aircraft. The plate support jig tightly connects the AGS mounting plate and the radome mounting plate.

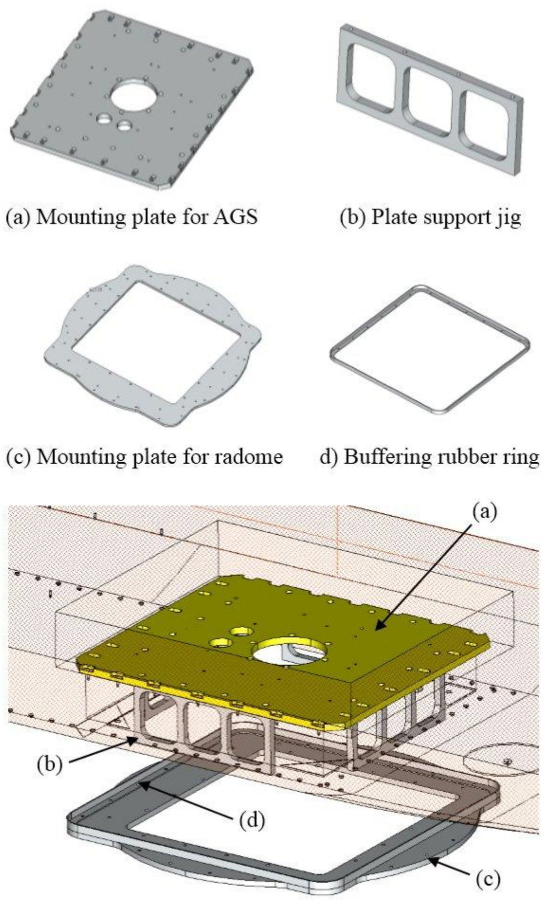


Fig. 2. Jig to install the antenna and gimbal set.

Fig. 3 shows the AGS installed to PA31-350 aircraft using the mounting fixtures shown in fig. 2. Fig. 4 is the SAR testbed, showing that the AGS and radome are located outside the center of the fuselage.

Fig. 3. The AGS installed to PA31-350 aircraft.

Fig. 4. The SAR testbed.

Fig. 5 shows the equipment installed inside the aircraft. In order to minimize the beam directional error of antenna, EGI is installed on the mounting plate for the AGS. The GPS antenna is installed at the top of the fuselage to maximize the receiving characteristic.

Fig. 5. Equipment installed inside the cabin.

4. Test Results

The flight test to verify the performance of the SAR equipment was carried out by repeating the same mission while flying in the form of race track as shown in fig. 6.

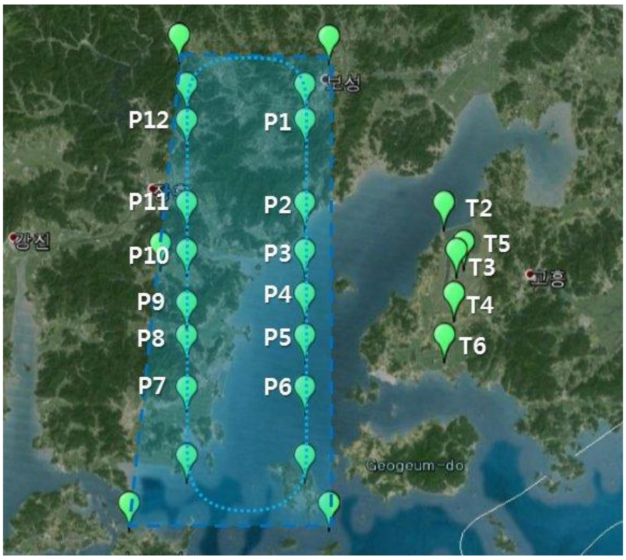


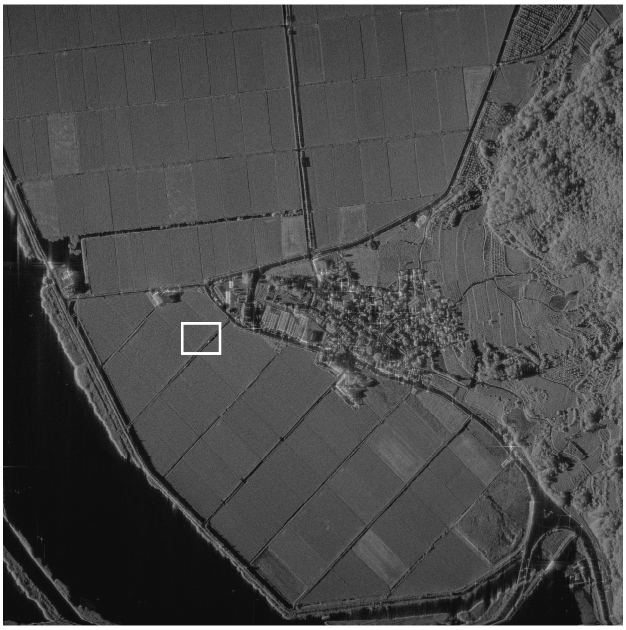
Fig. 6. Flight scenario.

The coordinate accuracy of the SAR image was verified by comparing the center coordinate of MDF with the center coordinate of the SAR image. Instead of IRF(Impulse Response Fuunction), the SAR resolution was confirmed by whether two point targets(corner reflectors) spaced 2.5 times of the resolution are distinguished in the image. This method is used by ELTA Systems Ltd of Israel. Fig. 7 shows the corner reflectors installed in the image area to verify the SAR resolution.

Fig. 7. Corner reflectors.

Fig. 8 shows the high resolution(spot) SAR image formed in real time and optical image for the same area. In fig. 8, the corner reflectors are located in the rectangular area.

(a) EO image



(b) SAR image (Spot)

Fig. 8. Optical image and SAR image.

Fig. 9 is the image enlarging the area, which corner reflectors are located for the purpose of checking the resolution, and shows that 3 CRs are distinguished.

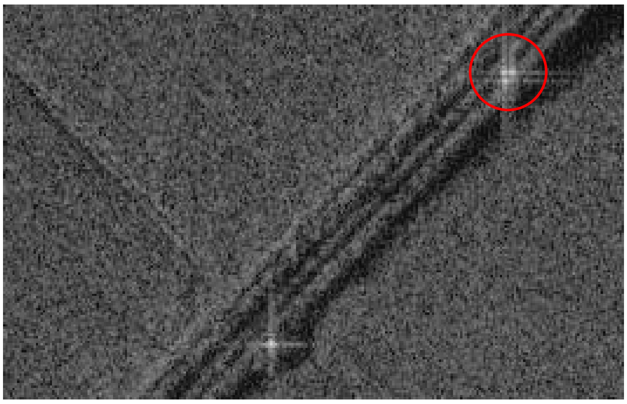


Fig. 9. The image for 3 corner reflectors.

5. Conclusions

The SAR testbed was implemented, and the flight test was carried out to verify its effectiveness. The resolution performance of the SAR was verified through the obtained images.

Because the EPS acquires not only real time image but also raw data at the same time, this testbed is very useful for data acquisition as well as development of SAR algorithms.

References:

[1] A. Moreira et al., "A Tutorial on Synthetic Aperture Radar," IEEE Geoscience and Remote Sensing Magazine, March 2013, pp. 6-42.

[2] J. C. Curlander and R. N. McDonough, Synthetic Aperture Radar Systems and Signal Processing, John Wiley and Sons, Inc., New York, 1991.

[3] Peter Hoogeboom, et al., "The PHHRUS Project, Results of the Definition Study Including the SAR Testbed PHARS," IEEE Transactions on Geoscience and Remote Sensing, Vol. 30, No. 4, July 1992, pp. 723-735.

[4] Bruce Walker, et al., "A High-Resolution, Four-Band SAR Testbed with Real-Time Image Formation," International Geoscience and Remote Sensing Symposium, 1996, pp. 1881-1885.

[5] B. J. Smith, W. Gamer and R. Cannon, "Precision Dynamic SAR Testbed for Tactical Missile," 2004 IEEE Aerospace Conference Proceedings, 2004, pp. 2220-2224.