RADARSAT-1 Image Quality - Update

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ABSTRACT

The Canadian earth observation satellite, RADARSAT-1 was launched on November 4, 1995 and put into routine operations on April 1, 1996. Since then almost four years of successful operation have been completed, utilizing data for their intended applications. In this paper, we are primarily concerned with image quality associated with the image products generated by the Canadian Data Processing Facility (CDPF) for different SAR operating beams and modes. A chronology is presented which reviews the image quality evolution of RADARSAT-1 since launch, complementing previously presented reviews on this subject. Data will be given on various image quality parameters related to impulse response, location error, antenna pattern, and radiometric stability.

INTRODUCTION

RADARSAT-1 was launched in November 1995, commissioned in March 1996, and put into routine operation on April 1, 1996. Since then almost four years of successful operation have been completed, utilizing data for their intended applications. The end-to-end image quality specifications and goals are set out in the RADARSAT System Specification document [1]. Previous publications on RADARSAT-1 performance may be consulted for further information describing image quality and calibration performance since launch [2],[3],[4]. This paper discusses radiometric and image quality performance since the start of the Maintenance Phase after the products were declared calibrated.

RADIOMETRIC CALIBRATION AND IMAGE QUALITY PERFORMANCE

RADARSAT-1 has been under the Maintenance Phase since the end of the Radiometric Calibration Phase. Maintenance Phase started in February 1997. Tracking of beam calibration and image quality parameters is performed on a routine basis. Measurement parameters include point target impulse response measures: range and azimuth impulse response widths (IRW), range and azimuth peak sidelobe ratios (PSLR), integrated sidelobe ratio (ISLR), and absolute location error (ALE), using images of RADARSAT Precision Transponders (RPT). Radiometric accuracy performance is tracked by measuring deviations in measured pattern when compared to the calibrated pattern for any given beam, using images of the Amazon Rainforest. Special purpose software tools have been developed to track performance of radiometric and image quality parameters, and to compare those values against RADARSAT System Specifications. Some of them are described in [5].

Fig. 1 shows typical results for relative radiometric accuracy as measured for Beam S3 since its calibration date of May 1997. It also shows the period when the beam shape changed which resulted in its re-calibration. The re-calibration task for the beam S3 was completed in April 1999, but the resultant payload file was made effective October 1998 when a degradation in radiometric accuracy was first noticed. Details of re-calibration process are presented in another paper in these proceedings [5]. Figs. 2, 3 and 4 show IRW results for all three chirps, for all single beams. PSLR, ISLR

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and ALE measured results, each combined for all three chirps, are shown in Figs. 5, 6 and 7, respectively.

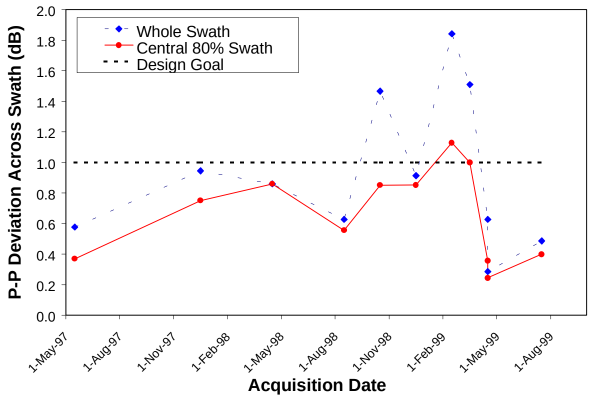

Fig. 1: Radiometric Accuracy Performance for Beam S3

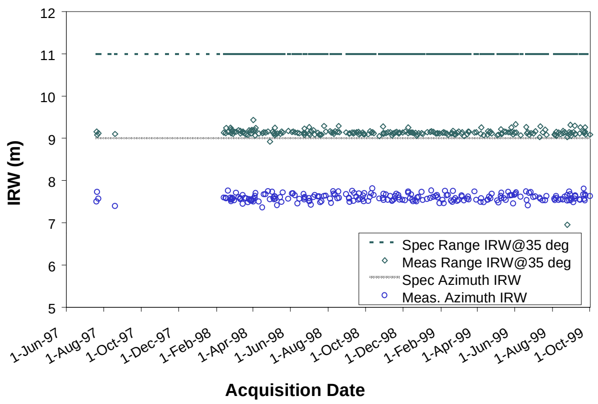

Fig 2: Range and Azimuth Impulse Response Width for Chirp 1 Beams (BW=30.00 MHz)

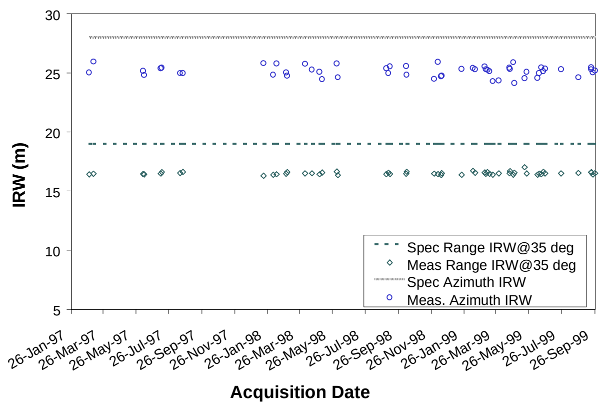

Fig. 3: Range and Azimuth Impulse Response Width for Chirp 2 Beams (BW=17.28 MHz)

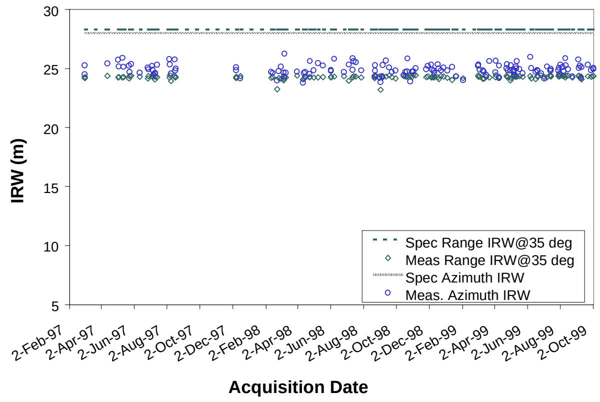

Fig. 4: Range and Azimuth Impulse Response Width for Chirp 3 Beams (BW=11.58 MHz)

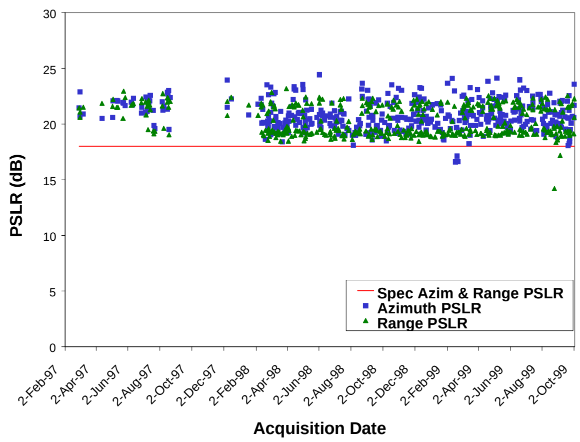

Fig. 5: Peak Sidelobe Ratio for all Beams

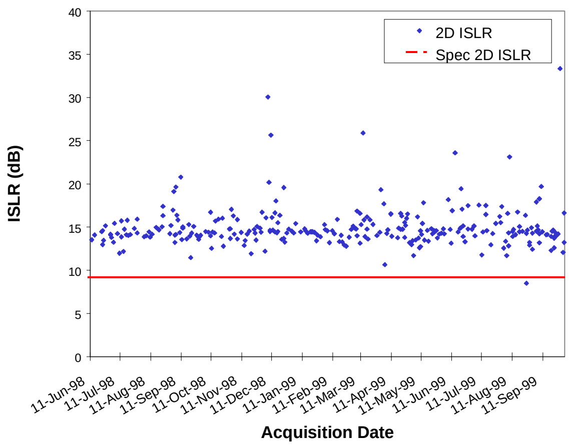

Fig. 6: Integrated Sidelobe Ratio for all Beams

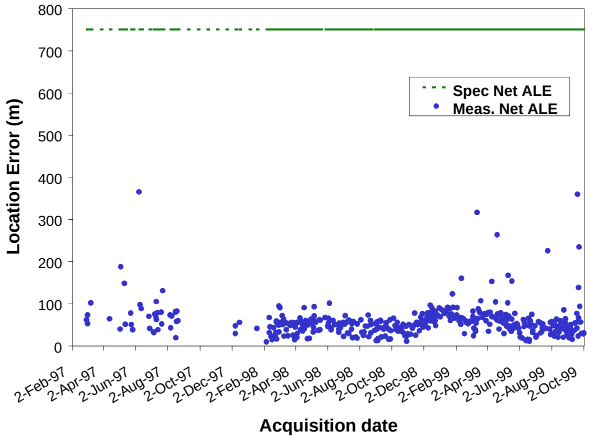

Fig. 7. Absolute Location Error for all Beams

All measured results for radiometry and point target indicate that both radiometric and image quality performance of RADARSAT-1 SAR are within the system specification, except when beams are being re-calibrated.

SCANSAR CALIBRATION

The CDPF ScanSAR processor has some problems in estimating the Doppler centroid and elevation beam pointing. As a result, scalloping effects and beam boundaries are observed in a number of ScanSAR images. Some improvements have already been made and work is continuing to upgrade the processing software, minimizing these problems. However, effective February 1, 1999, all ScanSAR images generated by the CDPF are radiometrically calibrated. As an illustration, a gamma-nought measurement for the Amazon Rainforest from a recent Narrow ScanSAR product is shown in Fig. 8. Based on a limited set of Amazon Rainforest data it is found that the worst case absolute accuracy is +/- 1.35 dB, and relative accuracy is 2.7 dB within any image or between any two images. Users will most typically have imagery with radiometric accuracy of +/- 1 dB, or better in absolute level (2 dB or better in relative level).

In addition to radiometric errors, some parts of some ScanSAR imagery may suffer from scalloping errors. Typical scalloping error when present is about 1.5 dB peak to peak, but in some cases it could be worse depending upon the terrain features. The scalloping errors are expected to be reduced when planned upgrades to the CDPF are completed. It should be noted that a constant Gamma-Nought of –6.5 dB was used for the Amazon Rainforest for all ScanSAR incidence angles as a reference in calibrating ScanSAR.

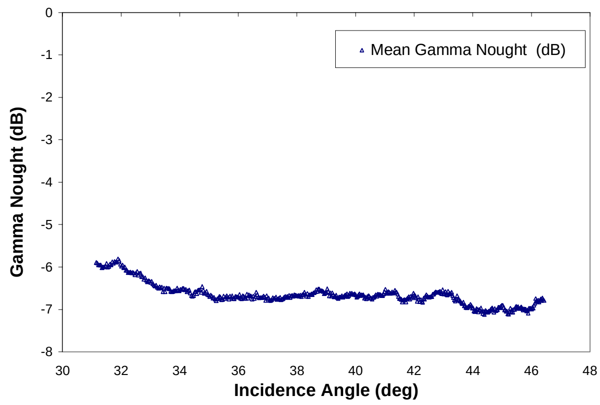

Fig. 8. Gamma-Nought for a ScanSAR Narrow Image of the Amazon Rainforest

RE-CALIBRATION OF SINGLE BEAMS

By the process of tracking the beam radiometric accuracy performance on a routine basis as part of the Maintenance Phase, a few beams were recently observed to have relative radiometric accuracy within a scene more than the design goal of 1 dB. The affected beams were W1 and F4. When investigated in detail it was found that the radiometric degradation was caused by changes in elevation beam pattern for these two beams. The beams were then re-calibrated in December 1998. Subsequently, additional measurements made on these beams indicate improved radiometric accuracy, which is well within the design goal. Similar behaviour was later noticed on beams S3 and S6. These beams were re-calibrated in April 1999. More recently beam S1 was re-calibrated in June 1999.

CONCLUSIONS

The measured relative radiometric accuracy in calibrated single beams is within the design goal. Beams W1, F4, S3, S6 and S1 have been re-calibrated due to changes in their elevation beam patterns. All other Image Quality parameters are performing better than the system specification. ScanSAR calibration has been completed and further improvements to the CDPF ScanSAR processor are forthcoming to improve radiometry and scalloping effects.

REFERENCES

[1] “RADARSAT System Specification”, *Canadian Space Agency Document RSCSA-SP0002, Rev. C, 1996.*

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