Verification of the CADRCS RCS tool for NCTR work

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Abstract: This paper looks at the suitability of using the CADRCS RCS prediction tool for research into a class of NCTR work where the radar will give a high resolution output of the target, either a High Range Resolution (HRR) plot or Inverse Synthetic Aperture radar (ISAR) image. Calculated results from CADRCS are compared with measured results of a test target. The comparison is done for both the RCS and ISAR images.

Keywords: RCS, ISAR, NCTR, modelling, verification

1. Background

Modern radar systems are used increasingly not only for the detection of targets, but also for guiding the weapons to the target and increasingly also to help in classifying targets as friendly or hostile using non-cooperative target recognition (NCTR) techniques.

Some of the NCTR techniques use wide bandwidths so as to resolve more of the target. Whereas most traditional radars use a maximum bandwidth of approximately 10 MHz, these radars can use bandwidths of up to 1 GHz and beyond.

The development and use of these NCTR algorithms is still in the experimental phase. It is very useful to be able to generate high fidelity radar data of known and varied platforms. As such, it is very important that data be generated with electromagnetic simulations.

One commercial RCS tool is CADRCS [1], a windows based program from CSS that provides high resolution RCS simulation using CAD models of the target of interest. CADRCS uses ray tracing combined with physical optics to calculate the RCS of the target.

To verify the usefulness of the data obtained, a comparison with measured data was done using ISAR processing. The specific ISAR tool used was developed by the University of Pretoria for near field and far field RCS measurements [2] and is used extensively for creating ISAR images of measured data.

2. Test target

A test target to be used for the validation was designed. A major restriction was that the target was to be measured in the compact range of the University of Pretoria, and for high fidelity RCS measurements the maximum target size is 1.0 m. To partly compensate for the small target, a large bandwidth of 2 GHz was used so that a decent image resolution of better than 10 cm could be found. The target consists of a corner reflector, a square open box (called the inlet) and a sphere and a CAD drawing is shown in Figure 1.

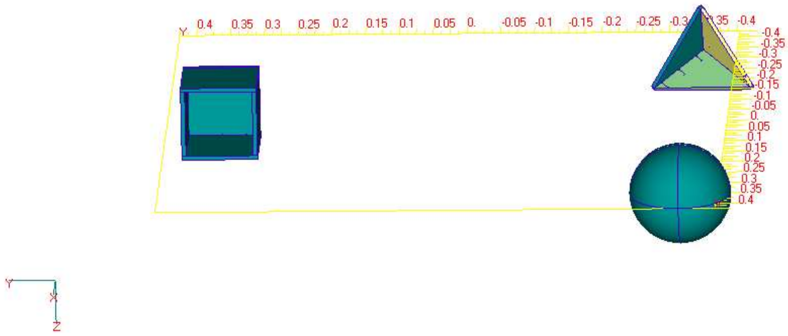

Figure 1. Designed Test target.

3. Results on test target

The first results (Figure 2 and Figure 3) show the RCS at 9.5 GHz in the main area of interest where both the corner reflector and inlet show the traditional RCS pattern. Figure 4 and Figure 5 show the RCS over the complete planar angular range. Figure 6 shows the reflection points as output by CADRCS for 9.5 GHz and an angular angle of -12°.

To test the data validity for NCTR applicability, ISAR images was created from the data. Please note that the plane wave is coming from the top for the measured results and from the bottom for the calculated results (this is because of different phase interpretation conventions in the measured and calculated data). Figure 7 shows the ISAR image from measured data using a frequency span of 8.5 to 10.5 GHz and angular data from -10° to 10. As can be seen the individual targets with size of about 100 mm is starting to be resolved. Figure 8 shows the CADRCS calculated ISAR image from the same data as shown in Figure 7. Figure 9 shows the measured data image and Figure 10 shows the CADRCS calculated data image using the same parameters except for angles of 0° to 20°. This clearly shows the effect of the test target turning.

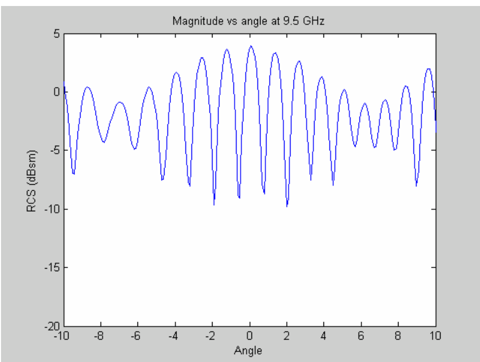

Figure 2. Measured RCS of the test target at 9.5 GHz, angles from -10° to 10°.

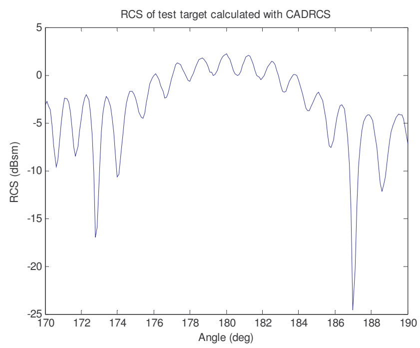

Figure 3. CADRCS calculated RCS of the test target at 9.5 GHz, angles from -10° to 10° (180° shift in angles between measured and computed).

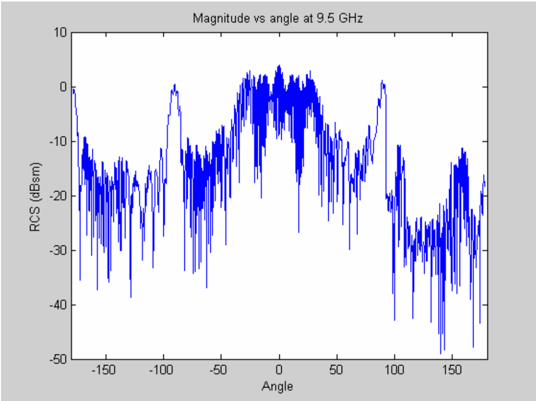

Figure 4. Measured RCS of the test target at 9.5 GHz, angles from -178° to 178°.

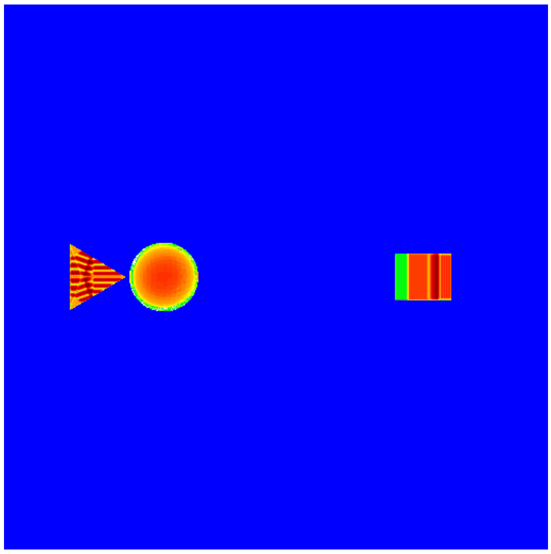

Figure 6. CADRCS Reflection points of the test target at 9.5 GHz and angle of -12°.

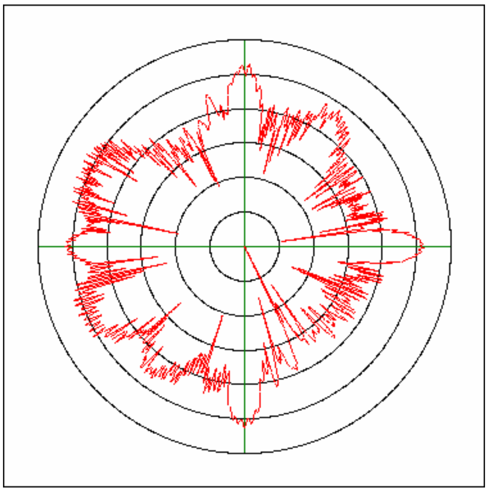

Figure 5. CADRCS calculated RCS of the test target at 9.5 GHz, angles from -180° to 180°.

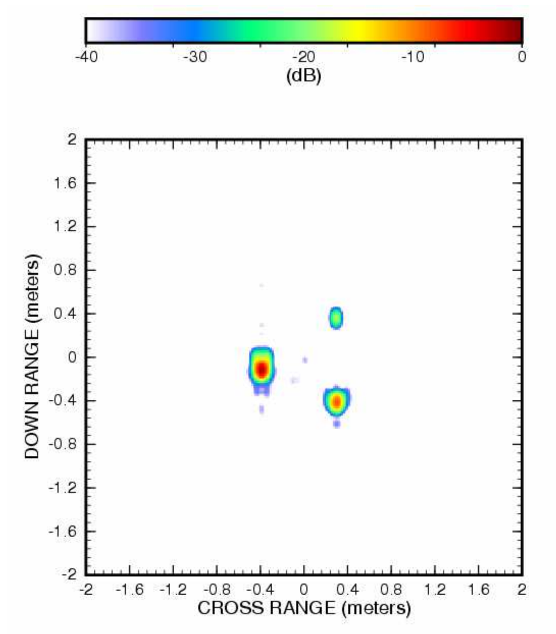

Figure 7. ISAR image of measured test target using frequencies 8.5 to 10.5 GHz and angles -10° to 10°. Calculated and displayed 4 m square.

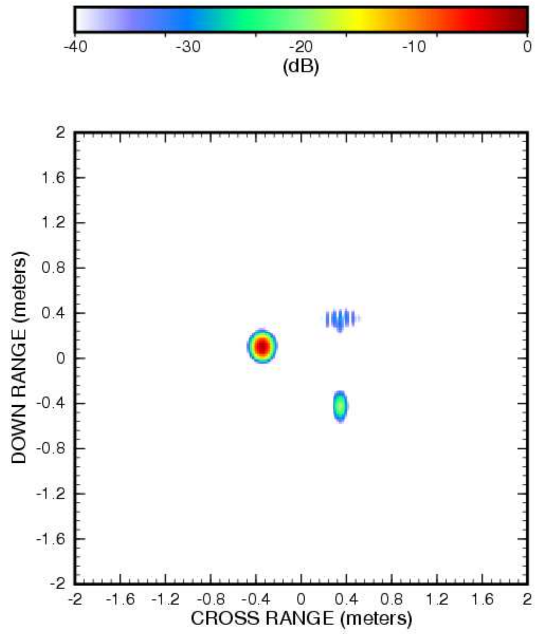

Figure 8. ISAR image of CADRCS calculated test target using frequencies 8.5 to 10.5 GHz and angles -10° to 10°. Calculated and displayed 4 m square.

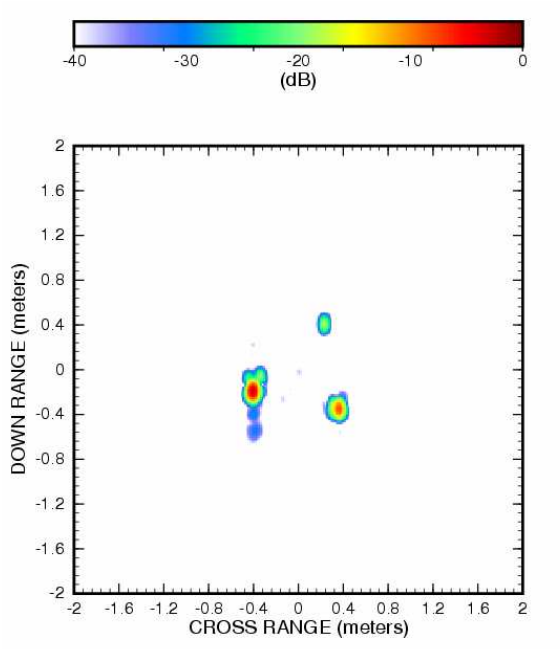

Figure 9. ISAR image of measured test target using frequencies 8.5 to 10.5 GHz and angles 0° to 20°. Calculated and displayed 4 m square.

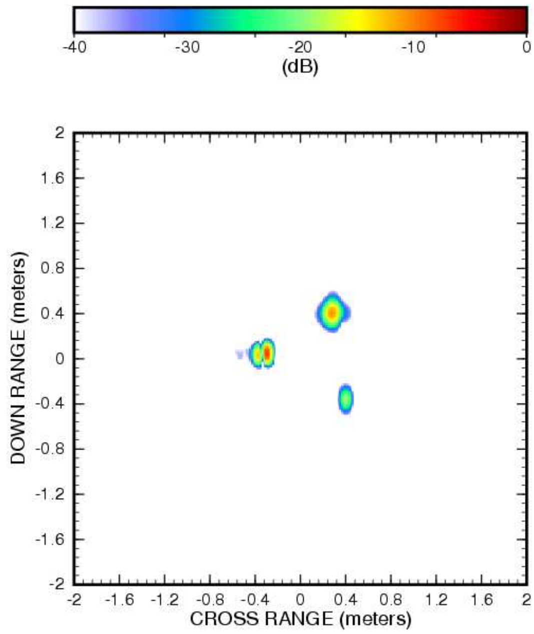

Figure 10. ISAR image of CADRCS calculated test target using frequencies 8.5 to 10.5 GHz and angles 0° to 20°. Calculated and displayed 4 m square.

4. Discussion

The raw RCS results compares reasonably well with a discrepancy in the level of the ripple. The measured results show a much larger ripple than the calculated results. This is probably due to a slight misalignment in the elevation plane between the three targets for the measurements.

The ISAR images obtained show that it is possible to obtain high fidelity ISAR images from CADRCS computational data that compares in general with the measured data. From the images of Figure 7 and Figure 8 one can see that the corner reflector was not completely shielded in the measurements. The measured image shows the inlet to have a continuous low level return until the specular return at the back, while the computed image shows a single return. Figure 9 and Figure 10 also show slightly different detail plots for the measured and calculated images of the inlet and the corner reflector. Although the calculated inlet image does not show a single return, the return is shown to be orthogonal to the propagation direction. This means that there are some phase errors in the calculated data from that contributor. This is worth some more investigation.

The results obtained show that there is potential to using CADRCS for generating realistic data to be used in NCTR research. An ISAR image (and probably also HRR plots) with the correct number of scatterers of the correct size was created. The fine details of the individual scatters were however not always correct. This may lead to inaccuracies in classification if these details are used in NCTR algorithms.

5. References

[1] CADRCS web page: http://www.cadrcs.com/.

[2] J.W. Odendaal and J. Joubert, (1996). “Radar cross section measurements using near-field radar imaging”, *IEEE Trans. Instrumentation and measurement.* **45**, 948-954.