Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center

Equivalent Radar Cross Section:
What Is It and Why Is It Important?

Björn J. Döring, and Marco Schwerdt

DLR (German Aerospace Center), Microwaves and Radar Institute,
Oberpfaffenhofen, 82234 Weßling, Germany

The goal of radiometric calibration in synthetic aperture radar (SAR) is to achieve comparability between measurement results acquired with different systems (e.g. RADARSAT-2 and Sentinel-1), at different times (e.g. image stacks over many years), or with different system settings (e.g. center frequency or polarization). At the beginning of the calibration process stands the definition of the measurement quantity. We argue that the currently accepted measurement quantity for point targets, *radar cross section (RCS)*, is not actually the quantity that a SAR system measures, and propose to replace the quantity with *equivalent radar cross section (ERCS):*

> The **equivalent radar cross section (ERCS)** shall be equal to the radar cross section of a perfectly conducting sphere which would result in an equivalent pixel intensity if the sphere were to replace the measured target.

The concept "ERCS" has been introduced before [1]. In this presentation, we attempt to communicate the problem from different angles to make it more easily comprehensible and to contribute to a discussion in the CEOS community on a new definition of the radiometric measurement quantity in SAR. These topics are:

- Mathematical view: By reviewing the basic SAR convolution integral and the definition of RCS it becomes obvious why RCS cannot be the radiometric measurement quantity in SAR.
- Historical view: Considering early, comparably low resolution SAR systems with narrow bandwidths and small angular ranges, it is apparent why RCS has been an acceptable quantity in the past. The advancement towards higher accuracy and higher resolution systems makes a distinction between RCS and ERCS paramount though for today's and tomorrow's systems.
- Comparison with black bodies: The radiation characteristics of certain surfaces are completely specified if their temperature is known. These black bodies do not exist in nature; they are an idealization. The blackbody radiation at a given wavelength depends only on the temperature. A single number (the brightness temperature) is therefore sufficient to summarize the complex Planck spectrum of a blackbody.
  This is similar to a large, perfectly conducting sphere in SAR which is used as an idealized object in the ERCS definition. A single number (the sphere's cross sectional area) summarizes its properties.
- Comparison with stellar photometry: In the 18th century, different astronomers used different optical equipment to measure and compare the brightness of stars. Due to varying passbands (transfer functions) of lenses and photographic film, the results were not comparable. The problem was later solved by introducing standard photometric systems, where the passbands of the used equipment is standardized and calibrated.
  A comparable interaction exists between a SAR instrument and the measured terrain reflectivity due to the convolution operation in the processor. This we call the *SAR passband problem [2]*. We propose a similar approach to resolve the SAR passband problem by introducing standardized passbands (weighting/apodization functions at defined bandwidths).

By adopting ERCS as the measurement quantity in the future, calibration and measurement results become truly compatible across current and future narrow and particularly wideband, high-resolution, and high-accuracy SAR systems.

References

[1] Döring, B. J., & Schwerdt, M. (2013). The Radiometric Measurement Quantity for SAR Images. IEEE Transactions on Geoscience and Remote Sensing, 51(12), 5307–5314.

[2] Döring, B. J., & Schwerdt, M. (2015). The SAR Passband Problem: Analytical Model and Possible Practical Solutions. IEEE Transactions on Geoscience and Remote Sensing, in review.