Insight into the Single Scatter Subtraction (S^3) Technique for Rough Surface Scattering

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The Single Scatter Subtraction (S^3) technique is an attempt to obtain a modification of the Magnetic Field Integral Equation which leads to an equation that is more amenable to an iterative solution. It has been previously been shown that extracting the single scatter part of the current from the integral term leads to an algebraic result for the complete single scatter part of the current and an integral equation for the multiple scatter part. Single scatter is defined as the part of the current that is a local solution and therefore depends only on the behavior of the surface and incident field at the point in question. Until very recently, attention has been devoted to obtaining results and understanding the single scatter part of the current. For a single sinusoid surface, it was found that total single scatter current differs from the Kirchhoff current by the inclusion of a term that is proportional to the surface curvature. Given that this result was obtained by numerical means, the limits of its validity were well established. Extensive testing with multiple sinusoidal surface height components showed that the curvature result retained its validity. While there are only a few unanswered questions about the behavior of this single scatter part of the current, it is now time to investigate the multiple scatter part.

The unknown current in the multiple scatter integral is equal to $J_{ms}(x') - J_{ms}(x)$ where x' is the integration variable and x is the observation variable. Initial attempts to solve the multiple scatter part of the current by iteration indicated very poor to nonexistent convergence. In an attempt to understand the reason for the failure of an iterative solution, $J_{ms}(x')$ was expanded in a Taylor series about x' = x. This leads to a series of successively higher order derivatives of the current evaluated at x' = x and no explicit dependence upon the current. This appearance of only the derivatives of the current clearly shows why the iterative approach will most likely fail, i.e., it is the derivatives of the multiple scatter current that are important and they cannot be "fed" by an approximate multiple scatter current as done in an iterative solution.

However, it will be shown that one can use the integral equation for the multiple scatter current along with the series expansion to develop a recurrence relationship between the derivatives of the current. This enables the elimination of, say, the first two orders of derivatives in terms of a series comprising the third order and higher. Hopefully, elimination of these first two orders will yield sufficient accuracy and it will not be necessary to include higher order current derivatives in the calculation of the multiple scatter current. These points will be discussed and numerical results will be presented to explain the approach.