A Method for Characterizing Three-Dimensional Spatial Channels for High Speed Railroad Scenarios

Linli Cui[(1)], Jayson Eppler[(2)] and David G. Michelson[(3)]
[(1)] University of Electronic Science and Technology of China, Chengdu, China
[(2)] MDA Corporation, Richmond, BC V6V2J3
[(3)] University of British Columbia, Vancouver, BC, V6T1Z4, http://rsl.ece.ubc.ca

When the receiving platform moves in a straight line at constant velocity, as in the case of high-speed rail, the scenario begins to resemble that of a bistatic synthetic aperture radar (BiSAR). Because we can predict the range-Doppler history of the returns from each scatterer observed over time, we can extract the family of returns from a given scatterer over time and focus them into a single point. In this manner, we can vastly improve both the amplitude and angular resolution of the system. In synthetic aperture radar, the technique is often referred to as Doppler focusing.

Exploitation of the range-Doppler history of a given scatterer to resolve its amplitude and location allows us to dramatically reduce the complexity of the measurement system required to collect spatial channel data. The system of antennas and receivers usually associated with MIMO channel sounders can be reduced to a single receiver equipped with a broad beam antenna. In the case of wireless channel sounding from a trackside base station to a high-speed train, however, the combination of the close proximity of the scatterers and the wide separation between the transmitter and receiver make Fourier domain scene reconstruction techniques untenable. Instead, a time domain technique called back projection is much more appropriate.

At first glance, the BiSAR approach to wireless channel measurement seems somewhat limited because it will only return two-dimensional spatial channel information. However, the close proximity of the scatterers and the wide separation between the transmitter and receiver causes the Doppler focusing spread to increase with target height in a predictable way. This secondary effect is too small to be exploited in SAR imaging of the earth's surface from air or space but can be successfully exploited when using BiSAR techniques to characterize three-dimensional spatial channels for high-speed rail scenarios.