# Optimal Ultrasonic Surface Displacement and Velocity Estimation in the Presence of Surface Roughness

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An analytic model is developed for the ultrasound field reflected off a moving surface in the presence of random surface roughness for an ultrasonic displacement sensing system in bistatic configuration. The model incorporates the beampattern of both the source and receiver ultrasound transducers as well as spectrum of the rough surface. Conventional approaches for estimating surface displacement and velocity amplitudes based on the laser vibrometer, such as coherent interferometry and incoherent doppler shift spectra, are applied to the ultrasound system. Simulation with the model indicates that surface displacement and velocity estimation is highly dependent upon measurement geometry such as the area of surface insonified and angle of incidence of the system, height and correlation length scales of the rough surface, and frequency and duration of the ultrasound pulse. The model is then applied to determine an optimal measurement scheme for the ultrasound displacement sensor in land-mine confirmation.