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Comparing EM Models to RCS Measurements for Building-Penetration Radar

B. Fasenfest, R. Ueberschaer

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Disclaimer

Comparing EM models to RCS measurements for building-penetration radar

Ben Fasenfest, LLNL
Ron Ueberschaer, SRI

For the DARPA VisiBuilding program, SRI International and Lawrence Livermore National Laboratory are using a variety of electromagnetic (EM) simulation codes and measurement techniques to analyze how radar pulses interact with building structures and materials. Of primary interest is how interior wall and corner reflections are delayed, attenuated, and dispersed by the exterior wall materials. In this paper, we compare microwave frequency-domain radar cross section (RCS) chamber measurements of scale models of simple buildings to finite-element and finite-difference full-wave time-domain and ray-tracing models. The ability to accurately reconstruct the building from these models is compared with the reconstruction from chamber measurements. We observe that careful attention to the spatial sampling in the EM models is essential to achieving good reconstruction at the higher frequencies.

Comparing EM Models to RCS Measurements for Building-Penetration Radar

Prepared by

Benjamin Fasenfest, LLNL

Ron Ueberschaer, SRI

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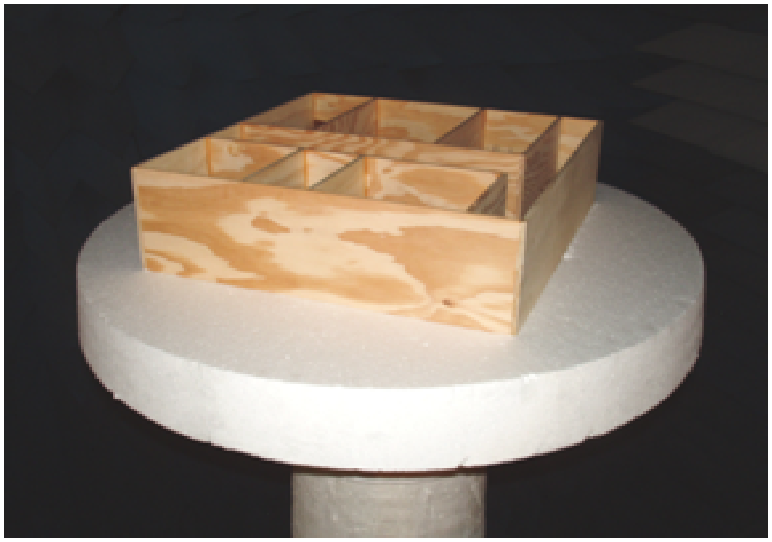
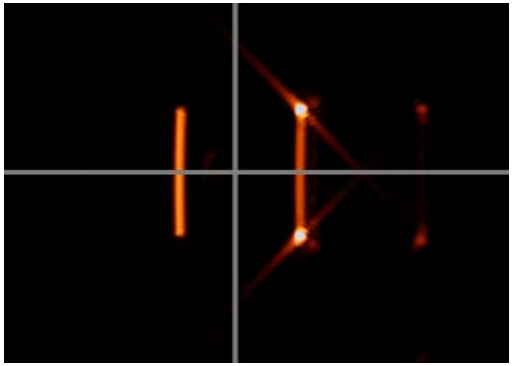
Chamber Models

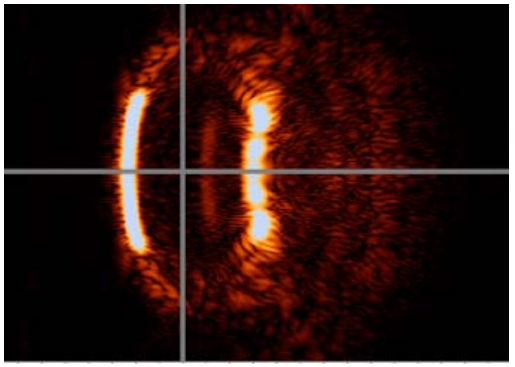


Several 20:1 plywood “buildings” were built and tested at an indoor range. These buildings were also simulated in 2-D, using EMSolve, a FEM-TD code. An ISAR imaging algorithm was applied to the results; the algorithm provided a much crisper image for the measured data.

ISAR using a 90 degree aperture



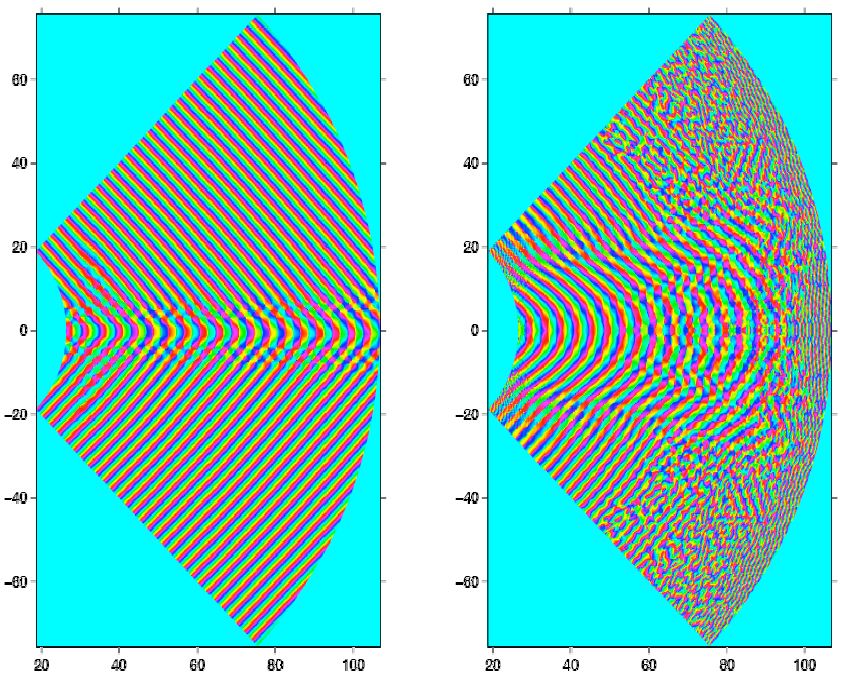
Measured



Simulated

High-Frequency Errors

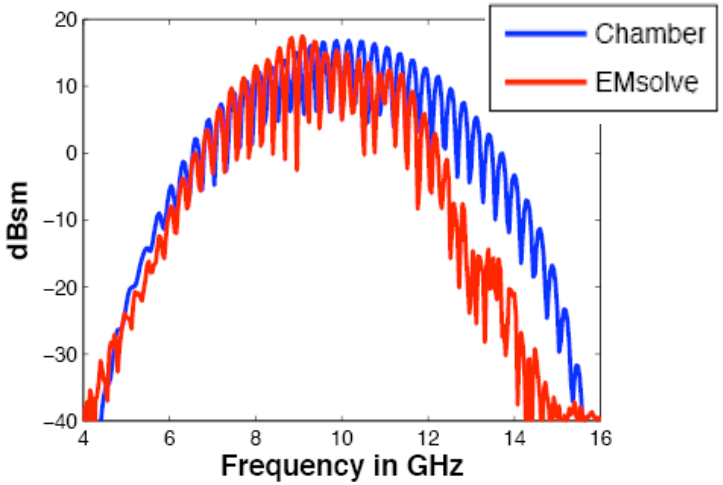
Phase vs. Spatial Frequency



Measured

Simulated

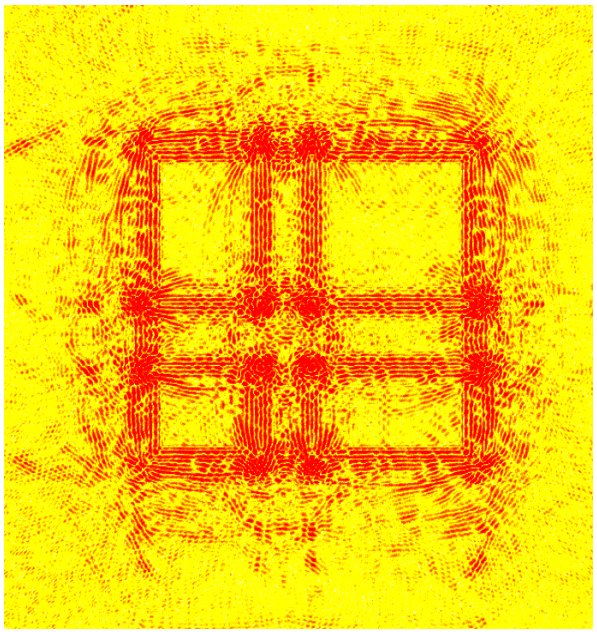
Radar Cross-section at Broadside



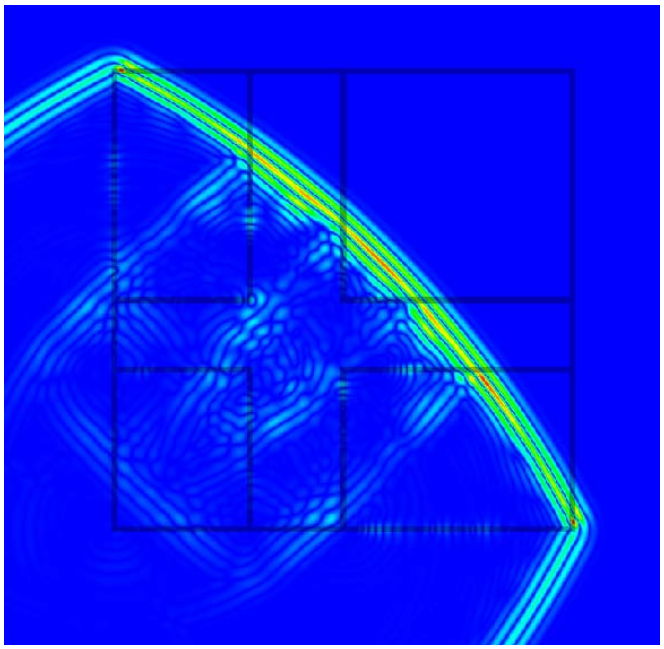
Both the radar cross-section and the spatial phase used in ISAR show high frequency errors for the simulated data. The FEM mesh was judged to be to coarse at the highest frequencies, consisting of only 5 cells/wavelength in the wood at 16 GHz.

FDTD Kirchhoff Migration

Kirchhoff Migration Image

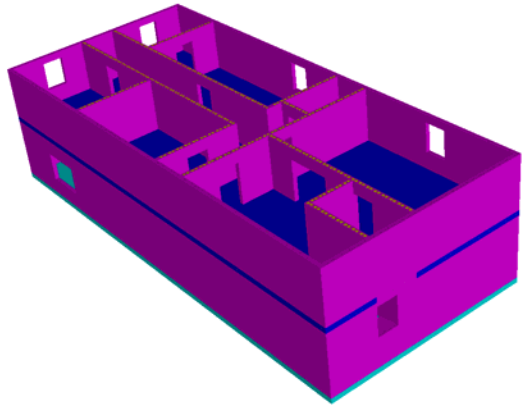


Scattered Electric Field



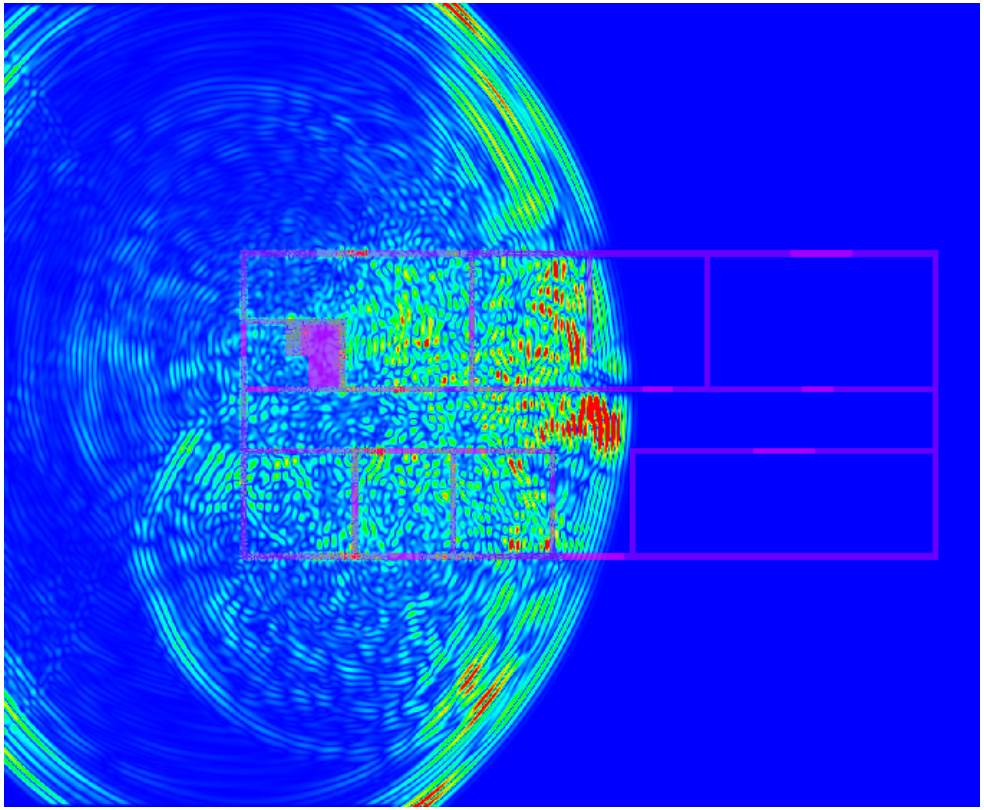
The models were refined to 10 cells/wavelength at the highest frequency, and rerun using EMSolve FDTD. These simulated results were more accurate than the FEM results, producing better images. The results of 600 monostatic returns were used with Kirchhoff Migration to image the building, producing a clear image of the building and its interior walls.

Large-Scale FDTD Simulation

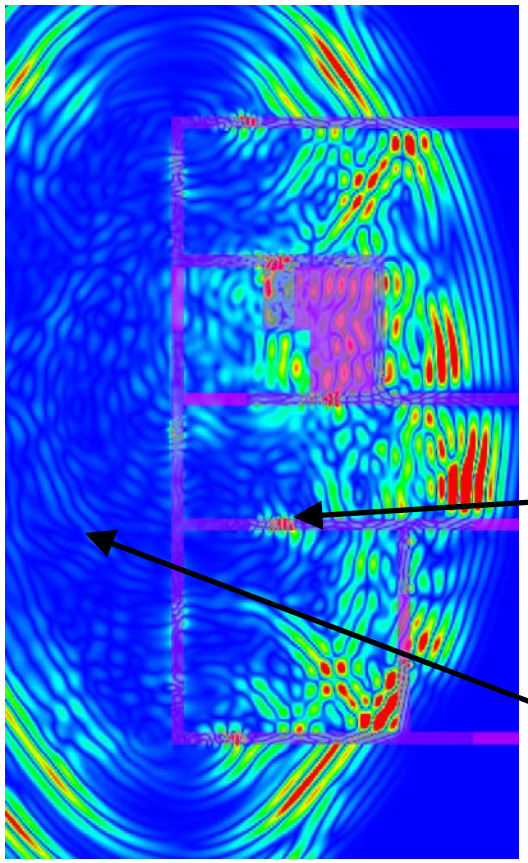


EMSolve FDTD was used to model a 5000 sq. ft. two story building using LLNL's Zeus supercomputer. The simulation required 12 hours on 384 processors to model one transmit propagating through the 1.6 billion cell mesh.

Electric field magnitude of the pulse in the lower story. The waveguiding effect of the long hallway can clearly be seen.



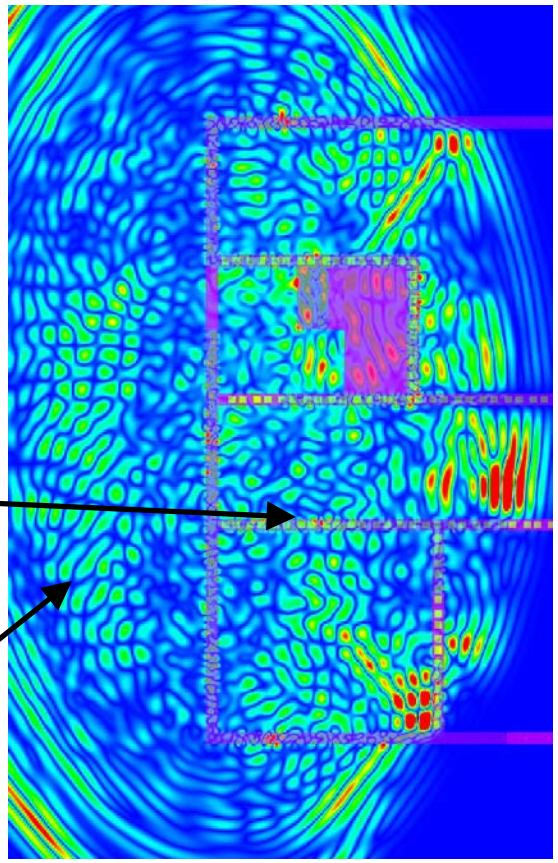
Realistic Wall Materials



The large building was simulated both with solid concrete walls and with rebar in exterior walls and cinderblock interior walls. Several differences between the two cases are easily seen.

•Inner-wall waveguiding effect suppressed by cinderblock

•Broadened Reflection from rebar



Homogeneous Walls

Rebar and Cinderblock Walls