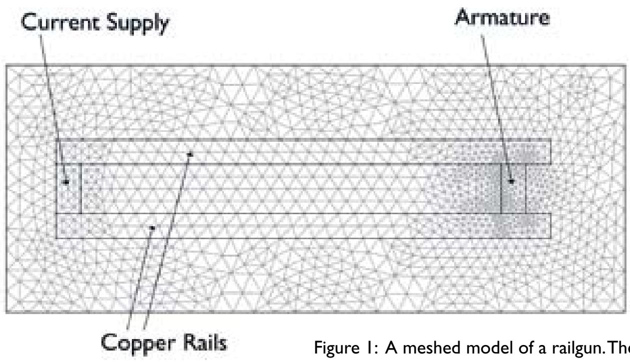

Figure 1: A meshed model of a railgun. The power supply on the left provides a current pulse to the parallel rails, and the armature (projectile) completes the circuit.

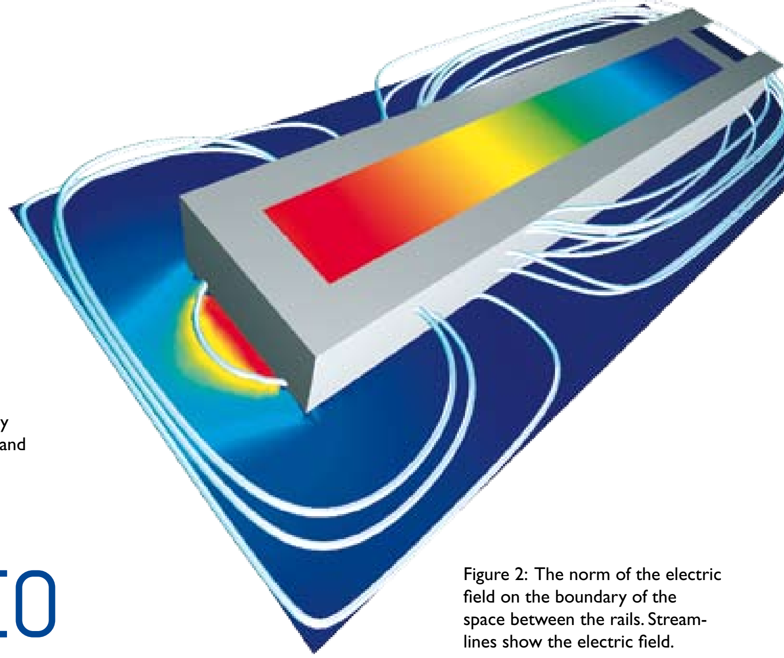

Figure 2: The norm of the electric field on the boundary of the space between the rails. Streamlines show the electric field.

A new approach to railgun operation

A DISCUSSION WITH DR. PAUL J. COTE, BENET LABORATORIES, US ARMY RESEARCH

Railguns—which propel a projectile using electromagnetic forces instead of chemical explosions—promise to revolutionize projectile launchers. Compared to conventional guns, they can double muzzle velocities and thus increase firing ranges with less drift. Such guns have been built and operated successfully on a test basis, but several problems are holding them back from usage in the field. To solve these problems, researchers must understand the inner workings of these weapons, and a group at the US Army Research Engineering and Development Command, Watervliet, NY, is using COMSOL Multiphysics to do so.

In a railgun, a power supply creates a voltage across two parallel conductive rails, and a conductive projectile, called the armature, touches each rail to complete the circuit path (Figure 1). A voltage pulse creates a very high current, and the resulting magnetic field accelerates the projectile along the rails and then out the muzzle. Typical peak currents in large systems can exceed 1000 kA.

This current, however, creates problems, especially along the rails, which are prone to considerable erosion due to the high heat generated by the current and also the propulsion of the armature. Another source of rail damage is the transition of the armature conductive interface from a molten layer to a high temperature plasma-brush interface. Railguns today require that the rails be replaced frequently, which limits their effective use as standard weapons.

How are the EM fields generated?

Considerable research is required to find the best materials and design for effective railguns. But how, exactly, are the electromagnetic fields generated, and what is their distribution? A new approach to railgun analysis proposes local flux creation as the source of the EMF associated with armature motion. As the armature moves, the space behind it is continually filled with new flux, so the induced EMF exists in the immediate vicinity of the armature so that potentially damaging high fields exist along most of the length of the railgun. The design team turned to COMSOL Multiphysics to get some insight into the problem, and they found that the modeling results offer an understanding of previously unexplained phenomena (Figure 2).

With these multiphysics models the research team made two discoveries. First, they demonstrated that the transmission-line equation applies to railguns. Second, with the model they also showed that local flux creation can have a profound effect on current distribution in and around the armature. ■

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From left to right, Drs. Krystyna Truszkowska, Paul Cote, and Mark Johnson inspect the damage on the armature after a test firing of the subscale launcher.