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Overview

The Air Force Research Laboratory's (AFRL) Deputy Capability Lead for Space Superiority requested unclassified information regarding a historic research effort nicknamed "Rods from God." The customer further clarified the formal name of the project, "Project Thor."

Findings

HDIAC identified several reports related to Project Thor, but these reports do not indicate that Project Thor and the Rods from God program are the same. Instead, HDIAC surmises that data derived from Project Thor served as the foundation for subsequent developments related to the Rods from God concept.

Project Thor, established in 1947 and conducted at Aberdeen Proving Ground with involvement from Johns Hopkins University, aimed "to correlate the mass and velocity of shell fragments with the probability of damage to an aircraft component [1]." The project spawned a number of technical reports and led to the development of several equations, which were likely used in the 1980's to study penetration mechanics of much larger projectiles [2].

Because Rods from God likely involved the use of long rods dropped from space [3], research on long rod penetration mechanics was important to its development. One primary report in this focus area, produced by the U.S. Army Armament Research and Development Command's Ballistic Research Laboratory in 1983, studied the effect of long tungsten rods penetrating steel. It found that during penetration, the rod creates a cavity while simultaneously eroding away [4]. A key component of this process comes from the eroding rod model, which is summarized by a set of three equations:

Mass: $L = P - U$

Momentum: $\rho_p \, LU = \, -\Sigma_p$

Modified Bernoulli: $\Sigma_p + \frac{1}{2}\,\rho_p\,(U-P)^2 = \,\Sigma_t + \frac{1}{2}\,\rho_t\,p^2$

Where L is the instantaneous length of the penetrator, U is the speed, P is the depth of penetration, Σ is flow stress, and subscripts p and t denote penetrator and target. Figure 1 illustrates the complex mechanics of long rod penetration and its effects on a target.

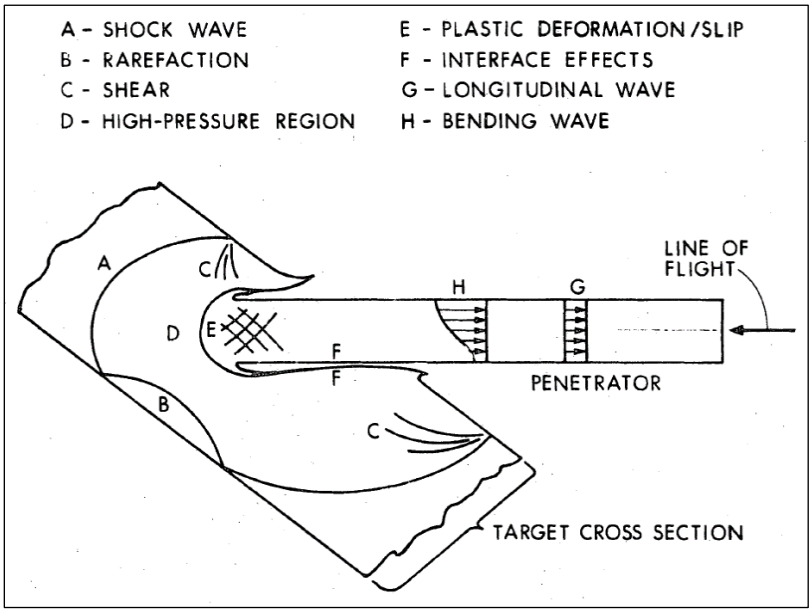

Figure 1: Principal features of long rod penetration [4].

The eroding rod model presents “a sound theory of penetration for long rods” as evidenced by its predictions [3]. Figure 2 demonstrates the qualitative features of the eroding rod model with nondimensional penetration plotted as a function of nondimensional striking velocity. As target strength increases, the curve moves to the right, and as penetrator strength increases, the curve moves left. The eroding rod model demonstrates that penetration is proportional to the length of the penetrator, all things being equal. This model also indicates that for fixed L_o/D and a fixed amount of kinetic energy, there is an optimum striking velocity for maximized penetration.

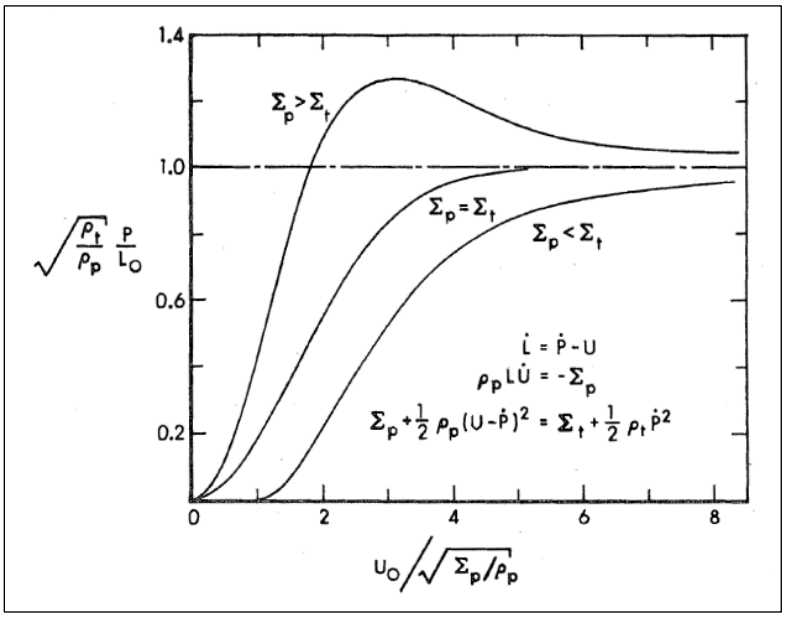

Figure 2: Typical predictions of the eroding rod model [4].

Conclusion

HDIAC identified several documents regarding Project Thor, as well as subsequent projects utilizing Project Thor equations for analyzing long rod penetration mechanics. However, none of these documents explicitly mention Rods from God. A broader evaluation of Rods from God is available through an HDIAC Core Analysis Task, which would investigate the Rods from God program in the classified space and include interviews with individuals familiar with/involved in the project.

We request your feedback on this Inquiry: https://www.hdiac.org/new-inquiry-assessment-form/

References

1. Project Thor: History and Current Activities (Rep.). (1954). Baltimore, MD: Johns Hopkins University.
2. Roach, L. K., Klopcic, J. T., & Quigley, E. F. (1984). Compilation of Mass, Velocity Region Graphs for Penetration of Metallic Barriers by Steel Fragments as Predicted by the Thor Equations (Rep. No. ARBRL-TR-02561). Aberdeen Proving Ground, MD: U.S. Army Armament Research and Development Center Ballistic Research Laboratory.
3. Williams, A. (January 11, 2019). Concerning the Rods from God program. [Email].
4. Wright, T. W. (1983). A Survey of Penetration Mechanics for Long Roads (Rep. No. ARBRL-TR-02496). Aberdeen Proving Ground, MD: U.S. Army Armament Research and Development Center Ballistic Research Laboratory.