3D Hydrocode Analysis of Novel Asymmetrical Warhead Designs

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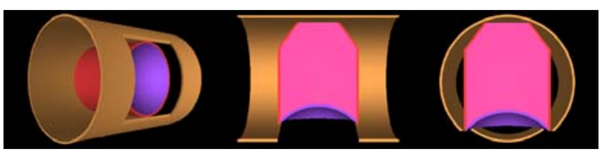
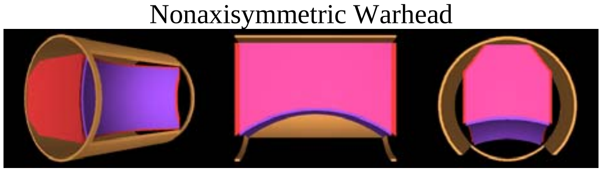
ABSTRACT

In fly over shoot-down munitions, the warhead is mounted perpendicular to the symmetry axis and flight path of the cylindrical carrier. The cylindrical carrier places a geometric constraint on conventional axisymmetric warheads. This constraint limits the warhead's diameter, weight, and consequently lethality. In most fly-over shoot down munitions, conventional axisymmetric warheads could not be used, since they would be too small to defeat the required target. The nonaxisymmetric (NAS) warhead concept over comes these constraints by utilizing the volume along the carrier's axis to put more explosive and liner mass into the warhead, and hence to put more kinetic energy on target. Figure 1 below shows the geometric constraints that a cylindrical carrier places on conventional axisymmetric warhead and also how a NAS warhead fully utilizes the volume available within the carrier are both shown.



Isometric view Section view End view

Nonaxisymmetric Warhead



Isometric view Section view End view

Figure 1: Comparison of conventional axisymmetric warhead with nonaxisymmetric warhead

INTRODUCTION

In the late 1970s, there was an interest in fly-over shoot down systems, which is when the US. Army Armament, Research, Development, and Engineering Center (ARDEC) began developing NAS warheads. This paper will briefly describe how NAS EFP warhead technology has evolved over the years. Some of the examples given will show how three dimensional (3D) hydrocodes became an essential design tool for NAS warheads.

The first NAS EFP warheads, tested in 1979, had a conventional (2D) axisymmetric liner design that was truncated or sliced to fit within a NAS configuration. A picture of the axisymmetric warhead, that was the basic test-bed for the first NAS warhead designs, is shown in figure 2. The axisymmetric warhead was simulated with both 2D and 3D hydrocodes and the results are show in figures 3 & 4. The 3D simulation indicated some buckling in the EFP. Only flash radiograph coverage was available during this test and it was not possible to verify the presence of buckling. Although the 3D simulations showed some buckling, the results of both 2D and 3D simulations matched the test data. As expected the 2D hydrocodes are adequate design tools for simulating axisymmetric warheads.

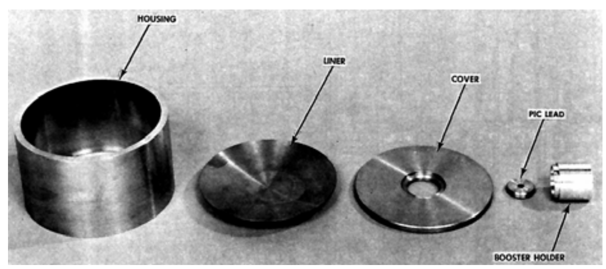


Figure 2: Axisymmetric EFP warhead hardware

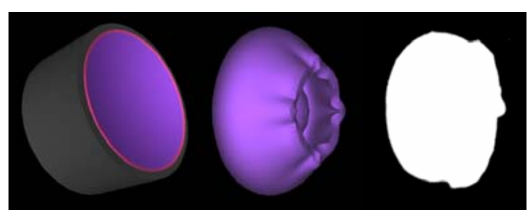


Figure 3: Comparison of 3D hydrocode simulation with flash X-rays from axisymmetric warhead test

PROTOTYPE WARHEAD

After this initial test, the axisymmetric liner and explosive billet had sections trimmed to a roughly ellipsoidal shape. Figure 5 shows how the first NAS warhead was made from modified axisymmetric warhead hardware. This first NAS warhead design was simulated with the 2D and 3D

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **00 DEC 2004**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **3D Hydrocode Analysis of Novel Asymmetrical Warhead Designs**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US.ARMY RDECOM-ARDEC AMSRD-AAR-AEE-W, Building 3022 Picatinny, NJ 07806-5000**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S)
		11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2005 in Orlando, Florida. , The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**3**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

hydrocodes (figures 6 & 7). The 2D simulations were completed in both axisymmetric and plane strain modes. Figure 8 demonstrates the limitations of using 2D hydrocodes in simulating a 3D warhead design.

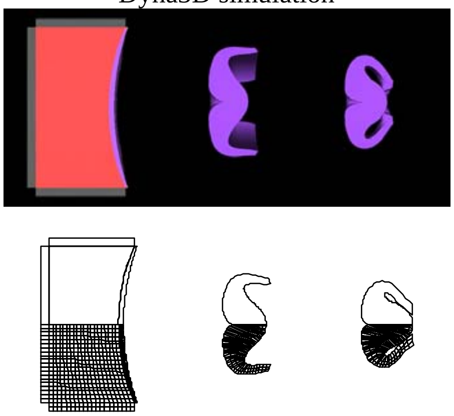


Figure 4: 2D and 3D hydrocode simulation of axisymmetric warhead

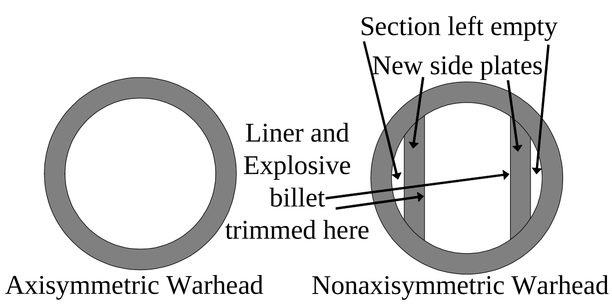


Figure 5. Nonaxisymmetric warhead made from modified axisymmetric case

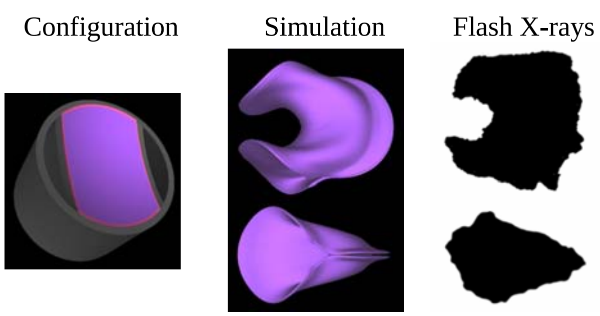


Figure 6: Early nonaxisymmetric warhead test and 3D hydrocode simulation

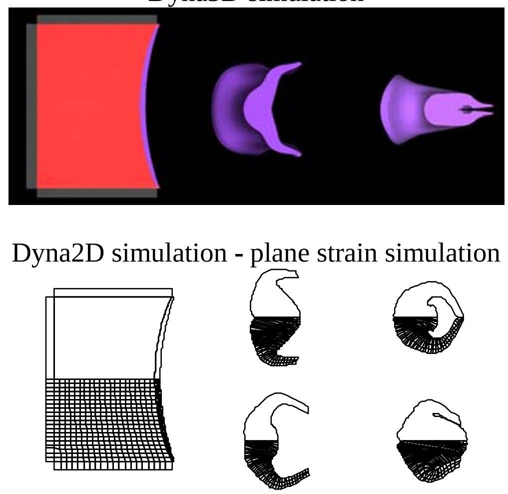


Figure 7: 2D and 3D simulation of non-axisymmetric warhead

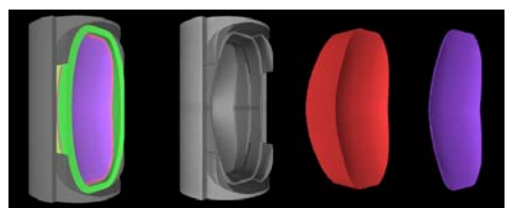


Figure 8: Dyna3D model of updated NAS EFP warhead

3D DESIGNS ANALYSIS AND DATA

As target requirements for Fly-over shoot down munitions became defined, it was clear that there was a need to design EFPs that would have reasonable length and compactness. Thus, the 2D design methodology used in early NAS warhead designs were inadequate and 3D design methodologies were developed (figure 9). Also, with the 3D computer hydrocode, the warhead designer had an accurate tool that enabled him to design Liners with complex 3D surface profiles. NAS Warhead technology has progressed into the formation of more compact and longer EFPs (figure 10). This even includes the formation of EFPs with stabilizing tail features as shown in figure 11.

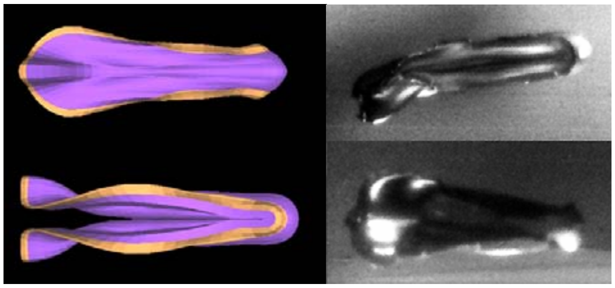


Figure 9: Current NAS EFP designs

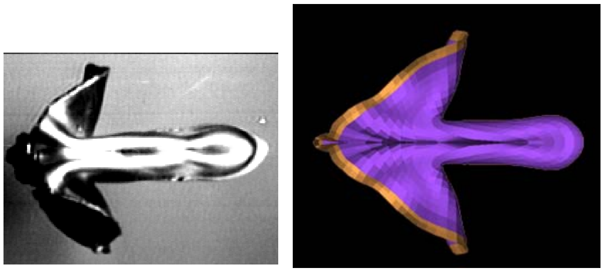


Figure 10: Aerostable NAS EFP

CONCLUSIONS

In summary, NAS warhead technology has evolved from simple truncated 2D liner designs to liners with more complex 3D profiles. As show above in order to form EFP shapes with good length to diameter (L/D) ratios and stabilization features, Liners with 3D profiles are required. It's also clear that 3D hvdrcode tools are needed for the design process.