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Technical Observation of the Rapid Prototype Development of the Rapid Airfoil Projectile

Grant Number 2004-IJ-CXK052



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**TECHNICAL OBSERVATION OF THE RAPID PROTOTYPE
DEVELOPMENT OF THE RAPID AIRFOIL PROJECTILE**

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Grant Number 2004-IJ-CXK052

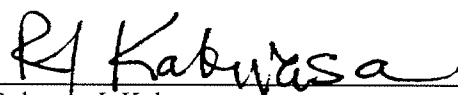
18 June 2006

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ABSTRACT/SUMMARY

The National Institute of Justice (NIJ) engaged the assistance of The Aerospace Corporation for certain limited tasks involving the production of a prototype less lethal launcher system under a coordinated Cooperative Research and Development Agreement (CREDA) with the Department of Homeland Security's Advanced Research Project Agency (DHSARPA). This project was specifically designed to produce a rapid prototype. Funding was sourced from the DHSARPA and administered through the Grant Management System (GMS) of the National Institute of Justice (NIJ). The purpose of the project was both to produce the prototype, and to create the capability to demonstrate the system characteristics to public protection and law enforcement agencies, including the US Border Patrol, the Federal Protective Services Agency, the US Marshall Service and interested local, state, and regional law enforcement agencies. DHSARPA solicited the assistance of The Aerospace Corporation to observe prototype development and testing, and to document and summarize this rapid prototyping process.

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Introduction

This is a report of activity in accordance with the NIJ grant #2004-IJ-CXK052, awarded to The Aerospace Corporation for the purpose of observation, liaison, and limited assistance in support of grant # 2004-IJ-CXK054, awarded to the Vanek Prototype Company of Sunnyvale, California. The purpose of the grant was to build and deliver a prototype launcher and a quantity of projectiles to the DHSARPA, within a specified grant period. The Department of Homeland Security (DHS) has designated this activity as a rapid prototyping, which is a part of their overall research and development effort.

There were several related goals encompassed in this project. In addition to testing the idea of rapid prototyping, this project was an effort to produce products based on operational requirements, and to take the research and development effort far enough to encourage interested manufacturers to commercially produce a less lethal launcher for the public safety and homeland security industries.

This project also exercised the capability of technology transfer among federal and the ability federal bureaucratic systems to coordinate and cooperate. In the case of the former, the Ring Airfoil Projectile (RAP) system originated in the Department of Defense (DOD), it was then selected and adapted to different operational requirements for the Department of Justice, and was finally advanced through a rapid prototyping process in the DHS. In the case of the latter, the DHS leveraged the funding mechanism of the DOJ's NIJ, as well as examining and analyzing field operational requirements collected by the NIJ, through its system of distributed operational support activities, known as National Law Enforcement and Corrections Technology Centers (NLECTC).

The period of performance for both grants was designated as 31 March 2004 through 30 April 2005. Federal administrative processing delayed the delivery of funding until 13 January 2006. As a result, the period of performance was adjusted to begin on 13 January 2005 and conclude on 31 January 2006. Subsequently, the end date was adjusted from 31 January 2006 to 28 February 2006.

The statement of work for The Aerospace Corporation did not include the responsibility of program management. Activity was limited to observation, monitoring, communication, and notation for quality process improvement.

The purpose of the Vanek technical effort was to produce a working prototype launcher and a quantity of projectiles. The goals of the Vanek Prototype Company were to fabricate the prototype advanced enough to encourage commercialization and to have a system that was useful for demonstrations to federal, state, regional, and local law enforcement, and public safety agencies for operational evaluation. This rapid prototype was to be derived from the Vanek Pre-Prototype Launcher System developed under a previous National Institute of Justice grant as a proof-of-concept device.

The DHSARPA emphasized the importance of rapid prototyping. The ability to respond to calls for operationally useful technology in a reasonable operational timeframe was considered an important focus of this project.

Background

System Description

The RAP prototype launcher system is a shoulder-fired, gas-operated, magazine-fed, pump-action, multishot less lethal weapon. It fires a 34-ounce ring-shaped airfoil projectile that is capable of carrying a liquid or solid payload. The system components consist of a launcher, a full-up round, and a magazine. The launcher consists of a barrel, a chambering mechanism, a firing pin, and a trigger mechanism. The full-up round consists of a primer and charge, a cartridge case, a combustion chamber, an expansion chamber, a sabot, and a projectile. The magazine is composed of a housing, a locking mechanism, and a spring mechanism.

The purpose of the launcher is to propel the RAP projectile downrange at a muzzle velocity of 210 feet per second and at a rotation of 5000 revolutions per minute. The pump-action cycling operation ejects a spent round from the breach (if present), extracts a new round from the six-shot magazine, and places it in the breech for firing.

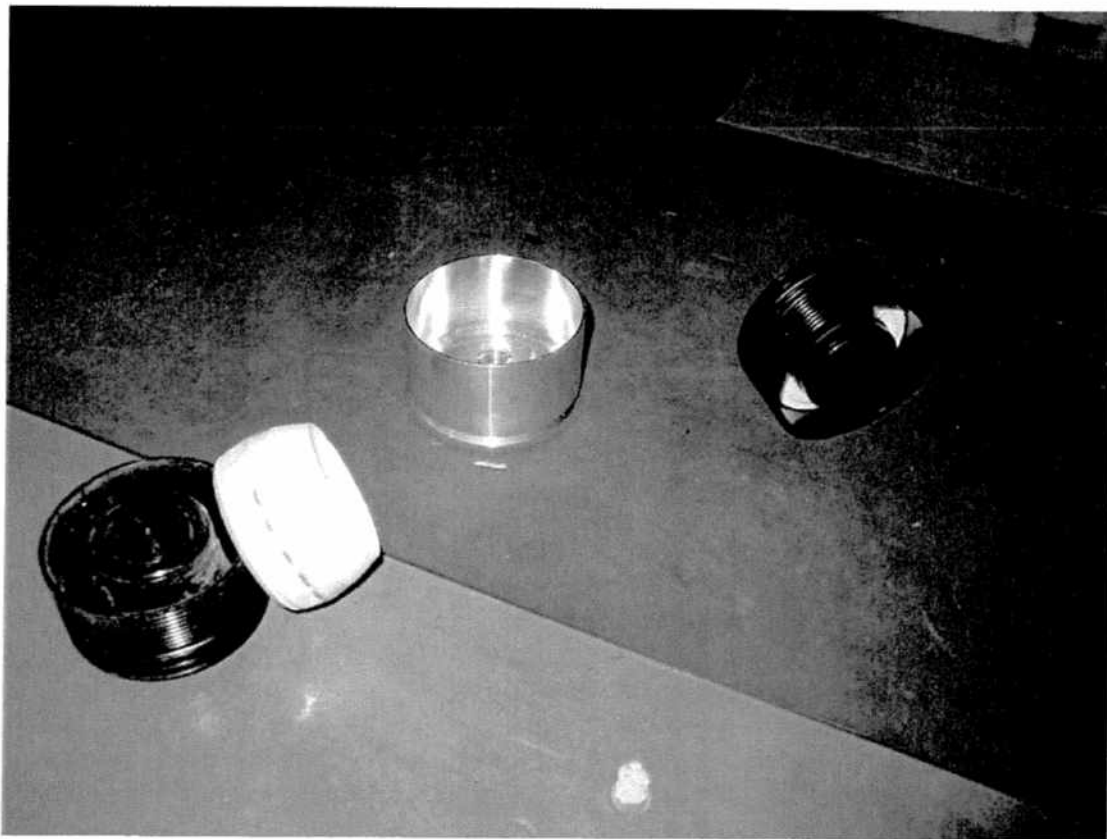


Figure 1. Components of the complete, self-contained round. From left to right, the sabot, the RAP projectile with payload, the cartridge, and sabot.

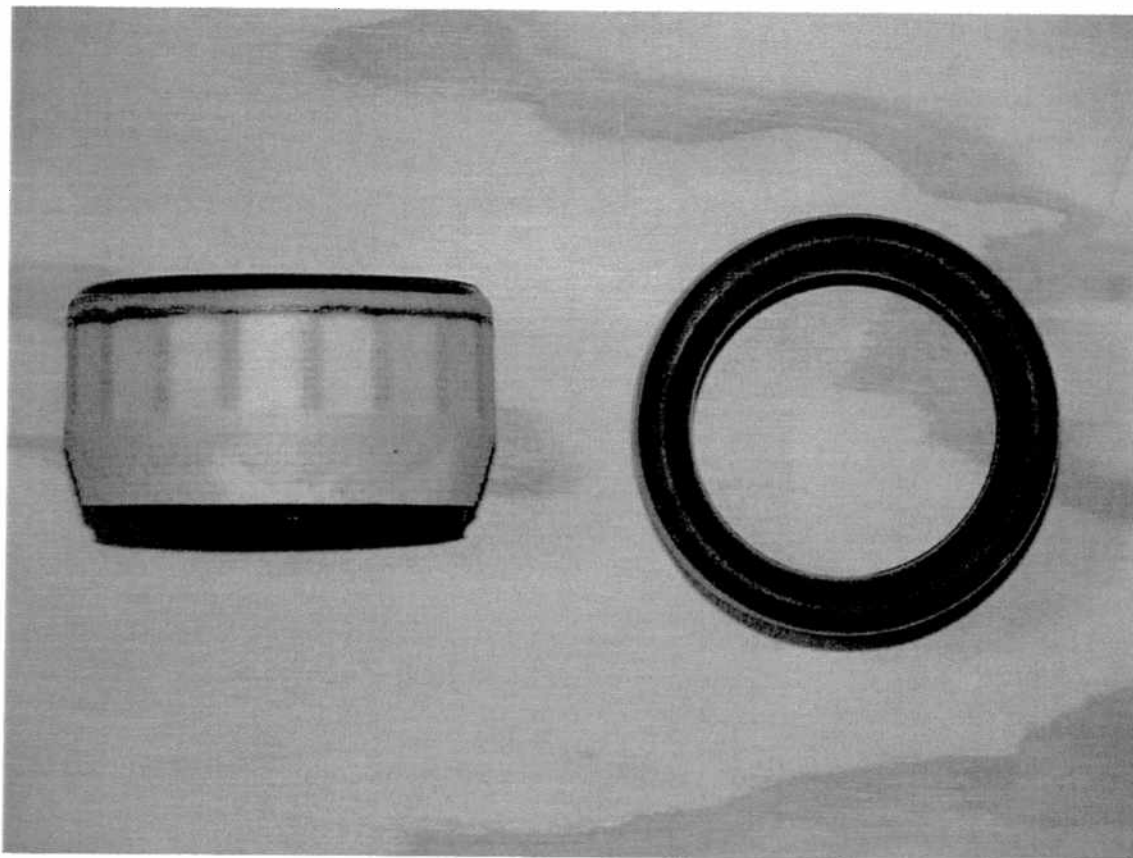


Figure 3. The original ring airfoil grenade, the explosive grenade in the shape of a ring airfoil.

The DOD initiated research into non-lethal weapons in the mid-1990s. During this time it rediscovered and rejected the RAP riot control system as a possible solution. The NIJ initiated a technology program to update and improve the system for public safety use as a less lethal weapon, modifying the system based on field requirements from law enforcement and corrections agencies.

The NIJ awarded two grants to modify the basic technology and adapt the RAP to public-safety requirements. The second grant produced a basic pre-prototype multi-shot launcher and an advanced projectile.

In 2004, the DHS initiated a Cooperative Research and Development Agreement (CREDA), managed through the NIJ grant-management system, to produce a rapid prototype launcher and a quantity of full-up rounds. The DHS also provided funding to The Aerospace Corporation to observe the rapid prototype program and provide limited testing and liaison assistance to the effort. The Aerospace Corporation was not given program management status or authority. This report documents and describes the activity of The Aerospace Corporation.

Analysis and Discussion

DHSARPA Rapid Prototype Development

The intent of the DHSARPA's Rapid Prototype Development Program is to speed the development of promising technology. It follows, to some degree, the DOD model of an advanced technology demonstration (ATD). Unlike the DOD, which contracts for exclusive purchase with funding guarantees, the DHSARPA technology effort must be developed enough, or useful enough, to be commercialized and sold in the public-safety and protective-services industry. Commercialization in the case of DHSARPA involves a higher degree of business risk for the potential manufacturer and distributor. The DHSARPA program is, therefore, both an effort to develop products that meet very specific industry requirements, and an activity that takes the technology to a point that lessens risk enough that a manufacturer would seriously consider product commercialization.

The RAP system addresses several specific field requirements that have not been yet met by current operationally deployed systems. These requirements include, but are not limited to, the following characteristics.

1. The system was originally developed and tested for use as a minimally injurious riot control system. It was built with the intent of not killing its victim.
2. The travel of the projectile is based on a flight trajectory rather than a ballistic trajectory. The accepted difference between the two is that the former can achieve three times the distance at one-third the elevation, and is considerably more efficient in energy conservation over range. The term "aeroballistic" is used to define this characteristic of RAP.
3. The projectile is considered safe at muzzle velocity outward. "Safe" is defined as not capable of breaking human bones or of causing serious eye damage.
4. The system is designed to carry a payload. The general standard for operational kinetic energy less lethal weapons used in American law enforcement and public safety is a projectile shot from either a 12-gauge shotgun, or a 40-mm launcher. Other launchers in operational use that carry a payload include the pepperball gun, produced by Jaycor, Incorporated, and the FN 303 produced by FN Herstal, Incorporated. of the aforementioned rounds have the payload capacity of the RAP.
5. The system was originally designed to use both kinetic energy and payload delivery. The purpose of the fusion of this technology was to make the system more robust and effective.
6. RAP is operational from point blank to a distance of 60 meters, or beyond. At present, here is no commercially available, operationally implemented launcher, device, or projectile that has this capability.

Several issues of operational implementation are encountered when using RAP. These issues include, but may not be limited to, the list below.

Technology Development

The project did not involve excessive technology risk. The preprototype, produced by basic machining methods under one of the two previous NIJ grants, had developed most of the experimental parts of the technology. The main focus of effort for the production of the launcher was to reduce weight, include ergonomics as part of the design criteria, and improve durability and reliability. The preprototype launcher weighed approximately 14 pounds. The goal for the rapid prototype was six to seven pounds.

Improvements to the full-up round were considered, but set aside due to underfunding and available time. Certain improvements to address weight and cost were considered, but not pursued. The construction of the cartridges was intended to be changed from aluminum to plastic; however baseline pressure measurements, required for that decision, were not programmed. An automated method for the filling and sealing of the projectile's payload was considered, but later eliminated because of budget constraints and higher priorities. Efforts to consider cost savings with the use of commercial off-the-shelf components were also considered, and discussed, but were not implemented.

Analysis: As with all developmental projects, ideas and modifications surfac as work progresses. The focus of the effort remained on prototype production. Noting useful concepts and ideas for future implementation was the most valuable product of the development process. The method of incremental improvement on the prototype was decided upon as the appropriate course of cation.

Final Products and Outcomes

The rapid prototype was demonstrated for representatives of the DHS and the NIJ on 28 February 2006 at the KCP. The demonstration was conducted at the facility's indoor firing range and consisted of nine launches. Each firing was individually executed and examined.

The prototype system, consisting of the launcher, the six round magazine, 10 cartridge cases with associated parts, 100 sabots, and 100 payload-filled RAPs were delivered, as specified, to the federal representatives. Federal representatives arranged for the system to be delivered and tested by the Applied Research Laboratory at Pennsylvania State University, as part of the DHSARPA follow-on activity to the rapid prototyping program.

Analysis: The project activity accomplished all of the specified activity and some of the implied activity.

Summary/Conclusions

The development and research activity of this rapid prototyping project produced a launcher and associated system parts, demonstrated the system, and delivered the product and associated research to appropriate federal officials. The technology risk of this effort was relatively low. Of the total time involved, 60 percent was available for development, research, and production, and 40 percent involved a time delay. The stakeholders involved included representatives from the operational community and the federal research community. The complete history of the projects includes technology transfer among three federal agencies. The final result met the basic requirements of the project.

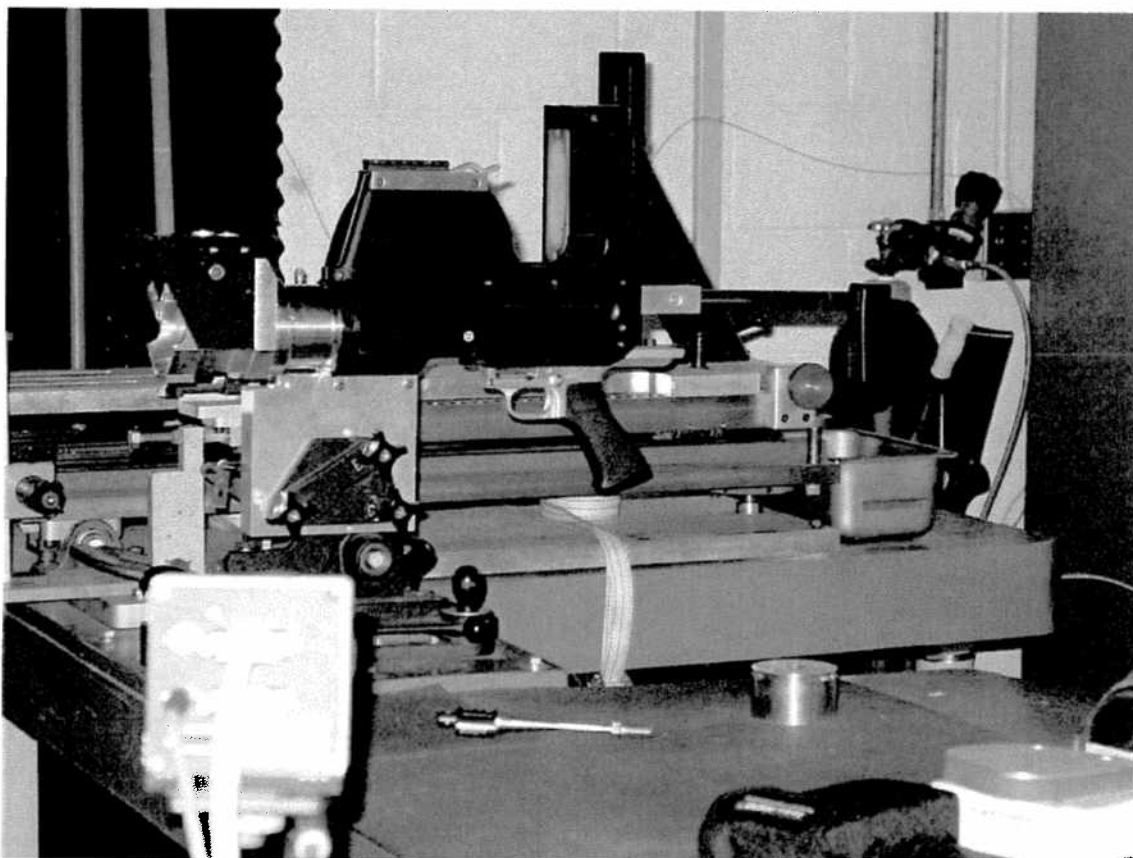


Figure 5. Vanek prototype launcher on test stand (A). The launcher is mounted on a test stand for operational testing and evaluation. The sabot-projectile separator and the barrel are essentially the same as the pre-prototype launcher, but the housing of the chambering and ejecting system has been reduced in size and weight, and the shoulder stock has been replaced by an adjustable and retractable stock. The changes have created a significant difference in size, weight, and balance.

References

1. Kansas City Plant Project Management Plan
2. Kansas City Plant Work for Others Program Policy
3. Department of Homeland Security Rapid Prototype Program Plan
4. The Vanek Prototype Company RAP Launcher Program Plan
5. National Institute of Justice Grant # 2004-IJ-CXK052
6. National Institute of Justice Grant # 2004-IJ-CXK054
7. National Institute of Justice Strategic Challenges Document

Terms

Aeroballistic: Used in reference to the ring airfoil, this refers to a projectile launched ballistically but, because of shape, it has certain characteristics of flight, most notably, the conservation of energy over distance. In the specific case of the RAP, the heuristic rule is that for the same launch energy the RAP will go three times the distance at one-third the elevation of a ballistic projectile.

Airfoil: An aerodynamic shape such as an airplane wing that produces lift because of its aerodynamic shape. The design includes a leading edge, a trailing edge, a chord, a center of pressure, and a center of gravity.

Ring airfoil grenade: The original conceptual design of the US Army Research Laboratory, from which the Ring Airfoil Projectile was derived. This original design was initially intended to become an explosive grenade launched from a grenade launcher. This also includes the derivative less lethal projectile, produced circa 1975, and intended for use as the projectile for a riot control system issued to the National Guard. The grenade is in the shape of a ring, and the ring has the same characteristics as a wing or airfoil, with a leading edge, a trailing edge, and a chord.

Ring Airfoil Projectile: The projectile used in the system, renamed, and redesigned from the original concept of the Ring Airfoil Grenade. See figure 2.

Sabot: The part of a round of ammunition used to transfer spin, propulsion, or both, to a launched projectile. It encases, or cradles, the round of ammunition, and transfers the energy of the launch to the projectile.

Type Classified: In the vernacular of the Department of Defense Acquisition Management system, the designation of equipment after testing, approval, and production. Generally, it implies that certain military specifications have been required and met.

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