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Document Title: Enhanced Ergonomic Model of Repeating RAP Launcher with Tech-Data Package

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Document No.: 236946

Date Received: December 2011

Award Number: 2004-IJ-CX-K054

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Final Report

ENHANCED ERGONOMIC MODEL OF REPEATING RAP LAUNCHER WITH TECH-DATA PACKAGE

**Performed Under
National Institute of Justice
Grant 2004-IJ-CX-K054**

This project was supported by Award No. 2004-IJ-CX-K054 awarded by the National Institute of Justice, Office of Justice Programs, US Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this publication/program/exhibition are those of the author(s) and do not necessarily reflect the views of the Department of Justice.

Summary

This report details the successful efforts of Vanek Prototype Co. (the Company) to redesign, as a more commercializable model, the ring airfoil projectile (RAP) launcher first fabricated under NIJ grant 2002-IJ-CX-K015. As part of this effort, the Company developed a computerized tech-data package for all the parts that comprise the new launcher, then constructed a working model based on that package, using CNC machinery to demonstrate the ability to mass manufacture the launcher. To fulfill the deliverable requirements of this grant, the Company also fabricated one hundred RAP projectiles, one hundred supporting sabots, and ten shell-cases with integrated reloadable hi/lo chambers and one hundred blank charges to power them.

The equipment was successfully demonstrated to the relevant Government authorities on February 28, 2006, after which the Government assumed control over the deliverables.

Background

The completion of NIJ grant 2002-IJ-CX-K015 yielded the successful demonstration of a ten-shot, repeating, hand-held launcher (Fig. 1) for the RAP (Fig. 2) as a less-than-lethal weapon for Police, Military, and Corrections. Criticisms of that launcher centered around its weight, size, and its lack of ergonomic dimensional relationships similar to existing two-hand weapons in general use. It was concluded that the potential of the RAP and the repeating launcher as a commercializable invention

could be demonstrated much more effectively by redesigning the launcher to be smaller, more ergonomic, and lighter, as suggested.

Certain other criticisms were also noted. The trigger of the first launcher was of the double-action, "safety" kind, which required the trigger to be drawn through about three quarters of an inch to compress the firing pin spring before firing. Although this provided added insurance against inadvertent firing, it was deemed to be too cumbersome in firing to be of value. The suggestion was made that the trigger be of the short-draw, light pull type, to better emulate the triggers on most standard semi-auto weapons in common use by law enforcement. The suggestion was also made that the launcher would benefit from the incorporation of a retractable butt-stock, to allow for convenient storage or to facilitate shooting in confined areas. A final suggestion was that the tubular magazine, used to hold the RAP cartridges, appeared to be too easily damageable.

With these and other suggestions in mind, and with general agreement from those observing that the demonstrated RAP and launcher system had potential, the Company applied for a additional grant from NIJ early in 2004. The thrust of the application was to propose an effort to reconstruct the launcher in a form closer to that which the market for LTL weapons wanted, and to add commercial potential to the result by creating a CAD tech/data package.

As the Company's application was being processed, negotiations were entered with Function Engineering, a Palo Alto, CA engineering firm to redesign the launcher and create a CAD package for this from a basic redesign protocol of the launcher that would be provided by Vanek. Function Engineering had performed well in the prosecution of the previous grant. At the direction of Abe Flatau, Vanek Prototype's aeroballistics consultant, this firm had made CAD design packages from Abe's drawings for his two-piece Advanced Segmented RAP (ASRAP) design. Function then made molds for this leading-edge design and produced test quantities of these projectiles. These performed as Mr. Flatau expected, much exceeding the range and accuracy of the M-742 RAG, the prior state-of-the-art LTL ring airfoil projectile (Fig. 3).

As the negotiations proceeded, it became apparent that the cost of creating a CAD package for the launcher was going to be much higher than originally anticipated. It appeared that expected funding from the anticipated grant would not be sufficient to cover the cost of this task. Throughout 2004 and into 2005, efforts were made to pare the project to fit available funding, while fulfilling the basic requirements of the grant.

On August 25, 2004, NIJ approved grant 2004-IJ-CX-K054 to build a redesigned launcher plus sufficient RAPs and support material for one hundred shots. These would be deliverables on Government request. Final paperwork completion yielded actual funding on January 11, 2005, the de-facto start date of the effort.

Description of Effort Under NIJ Grant 2004-IJ-CX-K054

By the time funds were received, The Company had concluded that it would not be possible to create a CAD design package and have a launcher fabricated from it with available funding. It was decided that a successful delivery of promised hardware would require a plan similar to that pursued under grant 2002-IJ-CX-K015. This model distributed the entire duty to build the redesigned launcher directly to Vanek Prototype itself, while giving to Function Engineering the task of designing, testing, and providing a package for the payload/dissemination system of the RAP, and to make the required number of RAPs.

This plan would allow Vanek to repeat the successful program of construction of a demonstration launcher that was done under the previous grant. It would also free up some funds to allow Function money to begin work on the as yet unfulfilled task of developing an industrial protocol for filling the cavities of the RAP with a payload (a talc simulant for CS or capsicum). The desire to have a CAD package developed for the launcher had to be dropped, though. This was unfortunate, given the value such a package would have toward selling the invention to industry.

Throughout the first quarter of 2005, the Company labored to complete its redesign of the launcher, begun on Sept. 26, 2004, the day following the award of the grant. Negotiations with Function Engineering turned toward the model that would restrict their efforts and costs to those involved with RAP development only (plus the cost of procuring sabots and cartridges). The Company began to purchase the tools and materials needed to construct a model of the launcher. A request was made to NIJ to adjust the completion date of the grant to February 28, 2006, since the date of actual funding had been delayed. The new completion date was approved.

Enter Aegis Industries—Plans Changed to Use the Kansas City Plant

In late March, 2006, Vanek Prototype was introduced to Aegis Industries, a start-up company engaged in the development of innovative police equipment. Aegis Industries immediately showed a strong desire to acquire an interest in the RAP and Multishot launcher that Abe Flatau and Chet Vanek invented and held patents on. Aegis became proactive in helping the Company to find a way of procuring a tech/data package and industrial fabrication of the launcher, as originally hoped for. Nevertheless, at the time the Company deemed it prudent to continue moving in the direction it had concluded would insure successful on-time delivery of expected hardware, until convinced that a different plan would prove superior.

Aegis Industries discovered that the Federal facility, the Kansas City Plant (KCP) had a program to make its engineering assets available for contract with qualified firms. The qualifications required that the task to be undertaken, be of direct benefit to the taxpayer by demonstrably aiding or advantaging Federal, state, or local government agencies in the pursuit of their duties. The RAP project easily qualified. The Company entered into negotiations for the services of the Kansas City Plant, because of the prospect of obtaining first-class engineering support for the redesigned launcher at a price that could never be obtained in the commercial market. Negotiations with Function

Engineering were suspended.

A visit was made to KCP on May 3-5, 2005. Drawings and a list of tasks were brought to discuss the prospective project. Mr. Abraham Flatau attended as consultant to the Company, with Chet Vanek, the Proprietor. The meeting with KCP business/engineering personnel concluded on the positive note that the available funds would likely be sufficient to mount an effort to create a CAD tech/data package for the launcher, produce at least one launcher, and produce sufficient RAPs, sabots, and shell-cases to satisfy the requirements of the grant.

One large action would be required of the Company. That would be to create detailed engineering drawings, showing all dimensions, of all of the parts to the launcher. In effect, this meant that much of the time the Company would have used to build an actual launcher would instead be used to make these drawings. (In practice, the one who has invented something does not need detailed drawings to build it—but then the invention, though functioning as its inventor intended, does not have an engineering drawing as needed to replicate it—hence, the desire to obtain an engineering package with the redesign of the launcher under this grant.) A factor in doing it this way was the strong urging of Aegis Industries. This company was showing increasing interest in acquiring rights to the RAP and launcher. They needed a CAD data package to facilitate rapid engineering prototype construction to begin the commercialization process.

Negotiations with KCP led to the signing of a contract between KCP and the Company (June 7, 2005 for Vanek, and June 22, for KCP). KCP agreed to create a CAD package from paper drawings supplied by Vanek and fabricate at least one launcher using this package. KCP also agreed to fabricate cartridges, sabots, and RAPs from drawings supplied by the Company. Certain other engineering tests were agreed to by KCP.

For its part, the Company would be required to fabricate the barrel and sabot-stripper assembly (Fig. 4). This was because the rifling of the barrel was deemed too highly specialized a task to be done by other than the Company, given the limitations in funding. The Company agreed to this arrangement since it had just upgraded (April, 2005) its in-house rifling facility to fabricate the unique rifling, deemed from experience, most applicable to RAP launch in a soft plastic sabot.

Throughout the summer of 2005, the Company, in the form of Mr. Vanek at a small plastic drawing board, derived exact, dimensioned, piece-part drawings plus a detailed parts list for all of the launcher parts (example, Fig 5). Twenty separate drawings were prepared, some containing dimensioned sketches of several parts. The drawings were digitally photographed and sent via the Internet to KCP.

With the drawings finally complete, the Company visited KCP on August 22-25, to assess progress and give assistance where needed to correct the KCP generated CAD drawings, and to explain the functionality of the parts. The visit was very productive and gave confidence that the KCP CAD package could be used to generate a physical

launcher that would work as intended. The CAD drawings (example, Fig. 6) were signed-off by the Company so KCP could commence fabrication.

Beginning in September 2005, the Company began work on the barrel (Fig.7). This was finished in three weeks, and shipped to KCP to assist in their fitting together of the launcher parts they were now having made. The Company was now free to spend time on the fabrication of its already existing alternative sabot stripper concepts.

Contract Signed with Aegis Industries—Primary Grant Goal Achieved

On Sept.15, 2005, Messrs. Flatau and Vanek came to a meeting-of-the-minds with Aegis Industries. Flatau and Vanek signed a contract with Aegis Industries, giving it an exclusive license to the RAP related intellectual property (I.P.) in the LTL field that Flatau and Vanek had generated prior to seeking Government aid in building physical models. (This I.P. was used as the basis of their solicitation of the first grant from NIJ to construct the working models of RAP and launcher.) Aegis would be obligated by the contract to initiate a commercialization of the RAP and launcher—a major goal of the NIJ Grant program.

In October of 2005, the Company suggested to KCP that fabricated parts to the launcher be sent to Vanek for final fitting, or “gunsmithing,” since experience had shown this to be a time consuming task that required skill. There was agreement at KCP because they had expended more funds than they expected on the CAD task and were worried about pulling up short toward the end of the project. This idea was not received well by Aegis Industries because of the fear that any changes in the parts the Company might make, in the process of fitting, might not be properly reflected in the CAD tech/data package at KCP. The Company agreed and instructed KCP to fit the parts to functional status, and annotate the CAD design with any changes made in the process.

Final Phase of the Project—Attempts to Construct an Alternative Design Sabot-Stripper

From late September of 2005 until the completion-date of the grant, the Company worked on alternative forms of the sabot-stripper shown in the patent drawings of Flatau and Vanek. The existing sabot-stripper (Fig. 8) fabricated under the previous grant (2002-IJ-CX-K015) successfully performed its task in the final demonstration of that grant. This sabot-stripper could easily be attached to the barrel of the redesigned launcher, now being fabricated at KCP under the present grant. Nevertheless, the Company deemed it a good use of the remaining time to the completion date (Feb. 28, 2006) to attempt fabrication of alternative forms that were lighter and less bulky, and to test these for functionality.

First Alternative Sabot-Stripper

The first alternative used a number of flat rings made of resilient plastic or rubber (Fig. 9) ensconced in a housing that screwed on to the muzzle of the barrel (Fig. 10). The

mode of functionality by which this alternative would work, was that the sabot was to strike the inner rim of a given number of these “stop-rings” and be immediately slowed (Fig. 11) releasing the RAP abruptly and accurately, as the original sabot-stripper did. But unlike the original sabot-stripper, which halts the sabot, then kicks it forward and out the muzzle, using a special “finger” device, the alternative design was to allow the sabot to retain a small amount of its original momentum, allowing it to clear itself from the muzzle. In hi-speed video tests done at Aerospace Corp., this arrangement proved incapable of sufficiently slowing the sabot. The problem was that each added plastic stop-ring would increase the total restoration force, as well as increasing the mass needed for impacting and slowing the sabot to the desired residual velocity. This meant that the exiting sabot was subjected to an increasing radial squeezing force as more rings were added to increase the impacting mass. It was discovered that one could not add enough stop-rings to acquire the needed impact-mass before the increased restoration force squeezed the exiting sabot inward too much and disturbed the RAP, as it simultaneously separated from the sabot.

An attempt was made to use super-elastic Nitinol alloy as the material of the stop-rings (Fig. 9, the metal ring). The intent was to make use of the greater density of this metal over plastic to add more impact mass. Nitinol was chosen because of its anomalously low Young’s modulus for a metal. But this too, appeared not to work as desired because the modulus was yet too high and the restoration force too great. It should also be noted that Nitinol is very expensive and also is murder on cutting tools. The task of cutting a petalled stop-ring (inward-facing petals were cut in the Nitinol ring to allow them to bend outward when struck by the sabot) was very difficult and consumed too much time.

Further tests, using high-speed videography at Aerospace Corp. in December of 2005, were used to confirm the insufficient performance of the flexible stop-ring alternative. The allowable plastic stop-ring stacks were seen to be unable to slow the sabot sufficiently. The Nitinol stop ring was also seen to be insufficient in its slowing of the sabot. In the second performance test it disintegrated, breaking off two of its petals and spitting them out after the sabot. In all of the tests, the RAP appeared to exit the sabot poorly and accuracy appeared to be affected. Because time was growing short before the completion date, it was decided to cease experimentation on this sabot stripper. It was decided to attempt a different form of this concept.

Second Alternative Sabot-Stripper

This alternative sabot-stripper used swinging steel-teeth (Fig. 12). The fabrication of this was not attempted in the first grant because it was a meticulous thing to make, compared to the swinging stop-ring device, and because there was little time left before the old launcher had to be demonstrated. This concept required a radial arrangement of six or eight inwardly pointing teeth (like the petals of the flexible stop-rings tried before). The teeth were to pivot on axis pins anchored at properly indexed circumferential locations around the lip of the stripper-housing. The teeth would be kept pressed against the muzzle of the stripper-housing by magnetic extension springs. These were used because they offered enough closing force to keep the teeth firmly fixed to the muzzle

and properly positioned for impact of the sabot rim, as the sabot with RAP exited the muzzle. Such springs would also give a diminishing restoration force as the teeth opened, following impact. This would insure that the soft polyethylene (PE) sabot would not suffer the squeezing action that caused the flexible stop-ring concept to fail, yet the steel teeth could be made to the proper mass for the desired impact velocity-attenuation of the sabot. As the teeth swung open, following impact, the suddenly slowed sabot was to release the full velocity RAP. The slowed sabot would exit the muzzle at a low velocity, insuring that it would not be the cause of injury to a close target. Meanwhile, the teeth of the stripper would have arrived at the full open position, where they would impact a polyurethane bumper. There, they would feel the pull of the magnetic springs and gently snap back into the closed position, ready for the next shot.

Work on this alternative sabot-stripper began in early January, 2006 and was substantially complete by mid-month. Much time was spent fitting the eight teeth to their mounts and making sure they did not bind or get stuck as they swung through their prescribed arc. The stripper was sent to Aerospace Corp. for hi-speed video tests, using the same single-shot test-bed launcher on which was previously mounted the flexible stop-ring sabot stripper.

The first hi-speed video test, taken at Aerospace Corp., showed a shocking failure of this device to allow release of the RAP accurately. The sabot was seen to exit the muzzle highly canted to the barrel axis, its rim severely disrupting the flight path of the RAP as it separated from the sabot. But the second test showed nearly the expected behavior for this device. In this test, the RAP was seen to exit the muzzle undisturbed and fly forward properly. The sabot was seen to exit the muzzle well after the RAP. It too, exited with near proper orientation (a slight cant was observable). The third test showed results as bad as the first. This created a mystery. Why was result, of one of the tests, nearly what was expected (hoped for) but the others so bad?

The sabot stripper was shipped back to the Company. It was given a more rounded rear edge—the interface between the muzzle of the barrel and the rear of the device's stop-chamber. The stop-chamber itself was given a minor taper, narrowing toward the stripper's muzzle. It was inferred from viewing the videos that the sabot was tripping on the interface between the barrel and the stop-chamber, since it was known that the stop-chamber was tight and the rear edge was sharp. The assembly was refitted to relieve some sticking of the teeth, that had appeared after these tests, and the refurbished device was returned to Aerospace Corp. The completion date was now only one month away.

The results of hi-speed video tests with the relieved device were just as bad as the first test. The same canting of the exiting sabot was observed, the same disruption of the RAP. Later, the single-shot test-bed was taken to KCP to give a demonstration of the RAP. The test-bed was hand held in the demo. All five shots showed the same problem of RAP flight disruption and inaccuracy as was observed in the high-speed video tests, before. Fortunately, the demo was saved because the old launcher, with its tried and true swinging stop-ring sabot stripper was available (the Company had sent it earlier to KCP

to provide background on multi-shot launcher functionality). Shots taken from the old launcher were accurate.

The single-shot test-bed and the swinging-tooth sabot stripper were returned to the Company. Consideration of the mode of use, during the failed demo, suggested that the cause of the problem was recoil. The magnetic springs were possibly not holding the teeth in place as the test-bed recoiled when hand-held. The possibility that recoil was the problem was not considered in the prior hi-speed tests because the test-bed was securely clamped in a vise when fired. Later it was disclosed that the vise was not clamping the test-bed so strongly. In fact, for the second test one of the changes made was to tighten the vise strongly, after it was noticed that the test-bed had moved a bit on firing. The tighter hold on the test-bed could have been the reason that the second test gave much better results.

It was resolved to perform a test in which recoil force was not placed on the swinging-tooth sabot stripper during firing. The breech of the test-bed was de-coupled from the barrel. This is exactly the same circumstance that exists in the multi-shot launcher, so such a test would actually be more relevant. The breech-pin was removed and weight was added to the breech to limit recoil energy. The barrel and its attached sabot-stripper were mounted in a vise, and the device loaded. The test showed what appeared to be perfect results. Another test showed the same. It was concluded that recoil was indeed the culprit, spoiling the hi-speed video tests and the hand-held demo.

The sabot stripper was dis-assembled to relieve the sticking-tooth problem that again had cropped up. It was noticed that some of the eight magnets forming the spring were shattered. This type of powerful permanent magnet (type NIB) is brittle. It is probable that the shock of firing caused the magnets in their assemblies to vibrate hard enough to strike their housings and cause some of them to crack apart.

This discovery, combined with understanding of the recoil-induced opening of the teeth, caused the Company to abandon the magnetic spring as a means of holding the teeth in the closed position. The design was changed to use torsion springs on extended pivot pins. The springs chosen were the strongest that could be used in the limited space inside the sabot-stripper housing. The date of this change was close to the Feb. 28 completion date of the grant, so this would be the last effort to build a successful alternative sabot-stripper. The performance of this redesigned device would determine if the final demonstration would be held using the existing successful sabot stripper, a model of which was demonstrated in the previous grant, or if a new alternative might be introduced.

After one week of work to make the redesigned pivot-pins and fit the torsion springs to each of the teeth (the sabot-stripper housing had to be relieved to allow the teeth to fully recoil with this new assembly) the redesigned device was tested using the test-bed in recoil mode. Results were better than those using the weaker magnetic springs, but still there was inaccuracy seen in the flight-path of the launched RAP. (Here,

a standard video-cam was used in high shutter-speed mode. This allowed playback of still frames of the RAP travelling about 35 feet to the point of aim.)

After the test, it was discovered that the sticking-tooth problem had returned. Some of the teeth would not fully close under their own spring torsion. This was relieved again by disassembly and loosening of the pivot-pin-holes in both the stripper housing and in the teeth, followed by lubrication with graphite. The refurbished stripper was tested again, this time using the test-bed in recoilless mode, as described above. This test was successful. Results were the same as the first such test, using the stripper with magnetic springs. The RAP was seen in the hi-shutter speed standard video to travel accurately to the point of aim. However the stripper's teeth again showed the problem of sticking, or lack of closure under their own power, on inspection after the test.

Unfortunately, there was no more time to resolve this problem before the final demonstration. The successful sabot stripper, from the previous grant, would have to be used in the demo. An adapter was made to mate the existing sabot-stripper to the barrel of the multi-shot launcher being constructed at KCP, and shipped. While the Company believes there is merit in these concepts, they have yet to be proven.

Final Demonstration of the RAP and Launcher at KCP

The Company arrived at KCP to inspect the launcher and RAPs three days before the final demonstration. The launcher was complete, except for the magazine and its fit and function with the launcher. Here, it must be admitted that the task was a bit too large for the time and money available. The launcher was fire-able, though, and could be demonstrated for this most important function. The Company pointed out a few small problems with the operation of the launcher, which KCP was able to fix before the demonstration. KCP had successfully fabricated one hundred RAPs, and ten reloadable shellcases with hi/lo chambers. The Company provided one hundred PE sabots, and had fabricated one hundred blank charges for reloading, because KCP was unable to make these due to facility regulations. All deliverables were now complete and available at KCP, except for the charges, which would have to be shipped under proper label as ammunition to the requesting agency.

The launcher was fired in demonstration twelve times. The point-of-aim, indicated by a red-dot sight mounted on the launcher, was high, but there was no time or ammunition to adjust this. As the relative point of impact was perceived, shots could be sent fifty yards to accurately impact a man-target. There was a problem with the clearing of the sabot from the sabot-stripper because of improper sabot lubrication—this was deemed not to be significant. In certain shots the RAP appeared to be disrupted. This may indicate a problem with the softness of the sabot. On impact with the stop-ring of the sabot-stripper, the PE sabot may be crumpling and damaging the RAP—a problem easily fixed by returning to sabots made of harder plastic—but more tests need to be done to understand what actually caused the few disrupted shots.

The demonstration of the firing functionality of the launcher and the RAP was deemed a success by those attending. The grant program complete, the Company looks forward to the commercialization process made possible by this grant.