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FINAL TECHNICAL REPORT

**NIJ Funding Opportunity 2006-NIJ-1193
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Officer Safety Equipment**

ERGONOMIC LOAD BEARING SYSTEMS

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1.0 Introduction and Project History

In 2006, the NIJ awarded a grant to Blackhawk Products Group (“BLACKHAWK!”) to develop and test ergonomic load bearing systems, with the goal of alleviating the discomfort, fatigue and chronic physical problems reportedly suffered by many police officers as the result of the weight of their equipment-laden duty belts pressing on their hips, nerves and lower backs over many years in uniform. As stated by the NIJ in its “Solicitation for Concept Papers - Officer Safety Equipment” (Oct. 2005, CFDA Number 16,560), “Law enforcement officers need more ergonomic load-bearing systems that better distribute equipment weight over their bodies. Present equipment setups tend to cause back injuries.” The NIJ did not request a scientific or medical study confirming the injuries reportedly caused by police duty belts, but rather sought practical alternatives to the conventional duty belt as the method of carrying the officer’s equipment. At BLACKHAWK!’s request, the deadline for completion of this project was extended by NIJ, ultimately to October 31, 2009. BLACKHAWK! has developed a concealable, under-the-shirt suspender system that transfers some of the duty belt’s weight to the officer’s shoulders, relieving weight and pressure on the officer’s lower back and hips. The prototype system has now been field tested with good results and positive feedback. This report provides the technical details of BLACKHAWK!’s work on this NIJ-funded project.

2.0 Executive Summary

Police duty belts, and the weight and shape of the equipment carried on them, not only cause discomfort and fatigue to the officers wearing them, but over the years of the officer’s career are believed to cause chronic physical problems for some officers, including, it is believed, serious back, leg, hip and nerve ailments. Due to the conservative nature of the U.S. police community, and the demand that officers present a traditional and sharp appearance in uniform, the solution to these problems most likely to be accepted by the greatest number of police agencies appears to be a concealable duty belt suspender system which is worn underneath the officer’s uniform shirt. The suspenders are attached with keepers to the duty belt through small openings sewn into the officer’s uniform shirt for this purpose. After considering different conceptual approaches to the load-bearing problem, and creating and analyzing prototypes of several of these concepts, BLACKHAWK! developed two versions of a “concealed” duty belt suspender system. Both versions were initially field tested by a small group of experienced officers (Round I), after which one of the two versions was selected for further testing. This selected prototype version was then field tested by a second group of officers (Round II). After minor refinements, the prototype was further field tested by a third group of officers (Round III). In total, the three groups of field testers represented a wide range of individual body types, sizes, ages, degrees of

experience, and physical condition. Data and comments were gathered from a total of 20 field testers, comprising 12 males and 8 females. The field testers, who were primarily patrol officers, used the suspenders on the job for lengths of time generally ranging from a few weeks to over eight months. With a few notable exceptions discussed below, the majority of the testers found that the suspenders provided significant improvement in the comfort of wearing their duty belts, and/or relieved the waist, hip and back pain they regularly experienced when wearing their duty belts. Accordingly, with minor refinements in design and materials as indicated by the field testing feedback, it thus appears that concealable duty belt suspenders of the type developed through this program may relieve the discomfort reportedly caused by police duty belts for many officers. The prototype suspender system may also prevent or alleviate the chronic physical problems reportedly caused by the long-term wearing of duty belts, although an appropriate medical study would likely be needed to definitively make this determination.

3.0

Outlining the Problem

3.1. A Brief History of Police Equipment. Police officers in the United States have, for roughly the past 150 years, carried most of the essential tools of their trade on their belts. In the mid-nineteenth century, the sole tool, at least for the officer policing in the big Eastern cities, was a nightstick. By the 1870's, a revolver was common, at least in the West, along with spare cartridges, often carried in leather loops on the belt. Soon, handcuffs were added. By the 1960's, many police began to carry portable radios on their belts. Today, the police officer's "duty belt," as it is called, often supports from 10 to as much as 20 pounds or more of equipment, typically including a semi-automatic pistol in a heavily-constructed, rigid duty holster, a magazine pouch with two spare pistol magazines containing 12-18 rounds of ammunition each, one or two pairs of handcuffs (one of the field testers reported carrying four pairs of handcuffs), a radio with batteries, a baton (solid or expandable), a flashlight, pepper spray, rubber gloves in a glove case, and possibly a Taser, spare Taser cartridges, a cell phone, a duty knife with glass breaker and seat-belt cutter, a citation book (at least for the foot patrol officer), keys, and other items.

3.2 Enter the Duty Belt. The duty belt that provides the foundation on which the officer's tools are supported has traditionally been a heavy, rigid, leather belt of so-called "Sam Browne" style, 2-1/4" wide, with a square or rectangular metal buckle. The better leather belts are made of two layers of leather, glued and stitched tightly together, to increase the belt's stiffness for the purpose of supporting the holstered handgun and other items it must carry. In order to provide some support for the weight of the equipment, as well as the solid foundation needed in order for the officer to draw his handgun effectively from many of the newer security holsters (which often require a forward or rearward rocking motion of the handgun to unlock it from the holster, thus requiring a holster which does not, itself, move on the belt during the draw), the duty belt is often attached to the trousers belt beneath it by several "keepers" spaced at intervals around the belt.

These keepers are leather or synthetic straps, typically ½” to ¾” wide, that are placed around both the duty belt and the trousers belt beneath it, after which the keeper is fastened into a closed loop either with two metal snaps or with Velcro to hold the two belts together and thus restrict the duty belt’s movement on the user’s waist. Alternatively, duty belts are sometimes made with hook-and-loop (“Velcro”) material on their underside, to attach them, without keepers, to a trousers belt faced with corresponding Velcro material.

The paramount purpose of the duty belt is, of course, to allow the officer to carry his most important items of equipment in a manner that will make them both secure, and readily accessible when needed. Especially critical items the officer must be able to draw quickly during a confrontation, such as the handgun or the baton, need to be positioned where they are easily reachable – ideally, in fact, reachable by either hand. Putting the holstered handgun, expandable baton, or similar objects too far back on the belt, however, can make them press uncomfortably into the back of the car seat when the officer is seated in a patrol car. Also conflicting with the need for equipment accessibility, any large object, such as a holstered handgun or a vertical magazine pouch, may press intolerably into the officer’s stomach or ribs at the belt’s top edge, and into the officer’s upper thighs at the bottom edge, when the officer is seated in a police car – a problem that gets worse if the officer puts on weight, as many do, after leaving the academy.

Ideally, the weight of equipment should be evenly distributed on the officer’s right and left sides, rather than having all of the heaviest objects on one side. Officers are cautioned to put no hard or rigid items of equipment very far rearward of their hips, where the item could cause kidney or spine injuries if the officer were to fall on his back, or even just by sitting in a car seat, grinding the object into his back for hours on every tour of duty.

The typical female officer, as well as more slender male officers, has an additional problem in not having as much “real estate” – that is, as much expanse of duty belt on which to position their equipment – as do officers with larger waistlines. Officers report that some departments are unsympathetic to their problems in this regard, expecting the officer with the 26-inch waist to carry the same items of equipment – and in the same relative locations on the belt, no less – as the officer with the 40-inch waist. Here, as in the selection of footwear, it is just not the case that “one size fits all.” Indeed, the slimmer officer, whether male or female, may simply not be able to carry every item of equipment that a larger officer carries – at least, not without wearing a backpack in addition to the duty belt. For such officers, even finding space for an additional belt keeper to stabilize the duty holster may present a challenge.

In the past, many agencies further supported their Sam Browne belts with a leather strap, diagonally crossing the officer’s chest and going over one shoulder, attached to the duty belt front and back. These chest straps were sometimes made

of breakaway design, in case an attacker sought to manhandle an officer by grabbing him by the strap during a fight. The single, diagonal shoulder strap did, at least, serve to transfer some of the weight carried on the duty belt from the officer's hips to one shoulder.

3.3 Physical Problems Caused by the Duty Belt. Today, however, few agencies still use the shoulder strap. The result is that all of the considerable weight of the duty belt presses downward on the officer's hips. Depending on the officer's physique, physical condition, the material and construction of the belt itself, the equipment carried on it, and the nature of the officer's duties (e.g., foot patrol, vehicle patrol, etc.), the heavy duty belt presses down hard on the officer's hips, and as it does so it constricts the officer's lower back and reportedly presses on sensitive nerves. Some officers find their belts constantly sliding downward over their hips, requiring them to tug the belt back up again and again throughout their tour of duty. Tightening the belt in an attempt to keep it from sliding down increases the discomfort to the officer's back, hips, and nerves. The tight belt sometimes causes the rigid shank and belt loop of the modern, high-security duty holster to bite into the officer's hip, resulting in pain or potential physical problems.

The hard bottom edge of the duty belt, usually not contoured for the curved shape of the human torso, often cuts into the officer's hips, causing discomfort and physical problems. Experience both of the project team and of law enforcement officers in general indicates that some of the modern synthetic belts with plastic stiffening inserts between their layers can be the worst offenders in this regard due to their unyielding construction, while traditional leather duty belts are in the middle range of comfort (or discomfort), and woven nylon belts can be the least offensive of the three, as they tend to flex more and conform better to the shape of the officer's waist and hips. Nylon belts offer the additional advantage that they are more easily sterilized after potential exposure to pathogens borne in blood or other bodily fluids to which the officer's equipment may be exposed. Widening (with sewn-on edge binding) and padding the bottom edge of the duty belt, as some manufacturers' models do, can further improve officer comfort and reduce physical problems. Sitting in a patrol car for extended periods of time, as many officers do, relieves some of the weight from the officer's hips, but reportedly can result in a different set of lower back and/or nerve problems in return.

Studies and collective law enforcement experience indicate that over the officer's ten, fifteen, twenty years or more wearing a duty belt, the belt's weight and pressure often cause not only daily discomfort and fatigue, but also cause or contribute to a wide variety of chronic physical ailments, including lower back pain, lower back problems, leg and hip problems, numbness and tingling of the fronts of the upper thighs, sciatica and other nerve ailments. **See, e.g., Janowitz, I., "Ergonomics Evaluation: Duty Belt/Holster Design" submitted to the California Highway Patrol, March 24, 1998; and Richard-Jacobi, K., "Duty Belts and Overuse Injuries," NLETA Online Magazine, December 2003.** In

addition to duty belts, the above-cited CHP study found that careful holster selection and use could have a significant effect on the officer's physical comfort and health, the critical aspects of the duty holster being its belt loop and shank design, the angle (cant) at which it positioned the handgun, and the placement of the holster in a location on the belt which is optimal for the given officer.

3.4 The Issue of Appearance. U.S. law enforcement is a field that, perhaps due to its conservative nature, places a high value on tradition. Radical changes are slow in coming. Borrowing heavily from the military, the sharp, neat appearance of uniformed officers is of great importance in most agencies, and even a minor deviation from the agency's dress code can subject the officer to reprimand or discipline. In the past, at least, some agencies were so insistent on the uniform appearance of their officers that they went so far as to require all officers to wear their holsters on the same side, regardless of whether the officer was right-handed or left-handed. While such an extreme demand for consistency may now, thankfully, be largely a thing of the past, it is clear to our project team that any major deviation from a traditional uniformed police appearance, such as wearing externally-visible suspenders, an equipment vest, or a uniform shirt with equipment pouches sewn into it, would at this time still be unacceptable to most U.S. police agencies, and thus would not offer a practical solution to the duty belt's physical problems for the majority of officers who suffer – or may sooner or later suffer – from such problems.

3.5 Holistic Approach. It should be recognized that the best approach to solving the physical problems caused by duty belts is not simply to adopt the under-the-shirt duty suspenders developed through this project. Instead, the duty suspenders should be viewed as one element (albeit an important one) of a total approach. As recommended by specialists in this field (**see articles cited in Section 3.3 above**) and also by several of our field testers, other elements of the total program should include: (1) the officer's physical conditioning through regular exercise, including core strengthening and stretching exercises, (2) the officer's maintenance of appropriate body weight, (3) selection of a good duty belt design, such as a 2" nylon belt with a padded lower edge, (4) careful consideration and selection of the equipment carried on the duty belt, so as to lighten the load to the greatest extent possible, consistent with officer safety and the job to be done, (5) careful positioning of the selected equipment on the duty belt, including even weight distribution on both sides of the body, and avoidance of items positioned where they could cause kidney or spine injuries, or are likely to cause other physical problems, (6) careful selection of the duty holster, including the design of the belt loop and shank, and the angle at which the handgun is canted, and (7) consideration of providing lumbar supports in police cars, as well as lumbar supports or ergonomically correct desk chairs for officers who spend many hours in the office at their desks or computers.

4.0 Initial Design Approaches and Concepts

BLACKHAWK!'s project team began by conducting various individual, small-group, and entire-team "brainstorming" sessions, after which three possible approaches to the police officer's load bearing problem initially emerged. These three approaches were: (1) an improved duty belt and some sort of suspension system to transfer as much of the belt's weight as possible off the officer's hips, (2) an improved type of uniform pants, with cargo pockets (similar to the familiar military BDU's) but also with fitted pouches to hold certain selected items of the officer's required equipment, and (3) a uniform "equipment shirt" with secure pockets and pouches for certain items of equipment, similar in concept to a tactical vest, but closer to a uniform shirt in its general appearance.

The suspension systems initially considered included fairly complex under-the-shirt harnesses, and also futuristic-looking systems that utilized the carrier for the officer's ballistic vest as the load-bearing element of the system, with various types of attachment mechanisms to connect the duty belt to the ballistic vest carrier. An outside consultant engaged by BLACKHAWK! helped to design some of these options, and prototypes were made of several of them, **see Appendix 10.3**. Initial attempts to modify uniform shirts so as to permit the straps of duty suspenders, concealed underneath the shirt, to pass through the shirt to attach to the duty belt, consisted of horizontal slots in the shirt, akin to giant buttonholes, with Velcro flap-style closures. **See Appendix 10.3 at page 46**

Ultimately, the team rejected these "futuristic" concepts and dropped them from further development at this time, for a number of reasons. It was felt that the equipment-carrying pants and shirt, if made to carry any significant pieces of the officer's equipment, would not present the conventional, tailored, traditional uniformed appearance that the majority of U.S. police agencies seemed to demand, at least at the present time. The resulting appearance of the officer wearing these uniform items would, it was felt, range from "sloppy" (with bulging equipment pockets in pants and shirt) to perhaps "militaristic," "SWAT-like," or "too aggressive" in appearance to the public, rather than the neatly-uniformed, traditional-appearing officer who "serves and protects."

In addition, the equipment pants and shirt concept, and the load bearing system using a specially-designed belt suspended from the officer's ballistic vest carrier, were all highly dependent on the size and shape of the individual officer, the specific uniform type(s) utilized by his or her agency, the type of body armor worn (or, in some cases, not worn at all, or worn on some assignments or days and not on others) by the particular officer, etc. Many agencies in the temperate climate zone have different winter vs. warmer weather uniforms, and many agencies have different uniforms for specialized units (patrol, bike patrol, motorcycle patrol, marine patrol, aviation unit, equestrian officers, etc.). The result would be the need to design, set up production systems for, manufacture and market a myriad of different models and model variations, in order to address the

many styles of uniforms, belts, vests, carriers, and officer body types that would need to be accommodated in order to allow widespread use of the load bearing system developed.

After careful consideration, and designing, building and analyzing several prototypes, the project team decided that neither the body armor carrier-based system nor the modified duty belt system would be a feasible approach, as either method would require police agencies, in many cases, to abandon their current body armor and/or duty belts, and purchase totally new equipment in order to employ these types of load bearing systems. The result, it was felt, would be that few agencies would try the new system, and any advantages the system might offer would thus be unavailable to the vast majority of police officers.

Accordingly, the project team's thinking evolved toward a simpler suspender system, that would attach with keepers to any officer's existing duty belt, but in which the suspenders themselves would be concealed underneath the officer's shirt, so as to permit the agency to use its existing uniform(s) – with minor shirt modifications for the suspender attachment straps – and not be dependent on the agency, or the individual officer, using any specific brand or model of body armor, or even using body armor altogether.

On a world-wide basis, military forces faced with load bearing needs even more severe than the police officer's have utilized external suspender systems from World War I through the present time. The U.S. military's "Y" and "H" pattern suspenders, attaching by metal hooks to metal grommets in the webbing pistol belt, are well known, and do an admirable job of permitting substantial weight to be carried on the soldier's belt by transferring a significant portion of that weight to the soldier's shoulders. Another similar solution is the carpenter's heavy-duty suspenders, used to support a tool belt that often carries a weight load similar to the police officer's.

Police duty suspenders designed to be worn outside the officer's shirt have been offered in the past by several manufacturers, and have been used by a number of agencies, where they have reportedly gotten positive results in transferring some of the weight of the duty belt equipment to the officer's shoulders. **See Appendix 10.1.** Problems with the exposed suspenders included: (1) their sloppy or non-conventional appearance, (2) the possibility of their catching on things and thereby entangling or entrapping the officer, and (3) the risk that an attacker could use the straps as an obvious means by which to grab and manhandle the officer during a fight. In response to concerns (2) and (3), some of these non-concealable duty suspenders were designed to attach to the duty belt with breakaway keepers that unsnapped when much force was applied to them. Some users reported frustration at having their keepers regularly unsnap in routine use; one officer (not a field tester) interviewed by a project team member demonstrated that he had sewn shut the breakaway keepers on his suspenders to keep them from unsnapping at inopportune moments. This officer reported a major improvement in his back

problems since beginning to wear the duty suspenders, an improvement he said was clearly the result of wearing the suspenders.

At an interim progress meeting with the NIJ, both the “futuristic” concepts and the simpler, more universally-usable concealed suspender system were demonstrated by a PowerPoint presentation and, in some cases, in prototype form, and the pros and cons of each approach were discussed. The project team communicated to NIJ its inclination not to pursue the various “futuristic” concepts, and instead to focus its energies on the simpler, more universally-usable, concealed suspenders. The NIJ representative in charge of monitoring this project agreed, and the project’s further work was accordingly directed along the concealed suspenders approach.

5.0 The Selected Suspender/Keeper System

5.1 Description of the Suspender/Keeper Systems Selected for Field Testing.

5.1.1 Boa Dial-Adjustable Version. The Boa version of the prototype suspenders consists of a padded harness passing over each of the user’s shoulders, similar in design to a handgun shoulder holster harness. A nylon strap with Velcro adjustment, or a circular plastic “X” juncture, connects the two shoulder sections behind the user’s neck, between the shoulder blades. Each shoulder harness passes over the front and rear of the shoulder, and joins below the user’s armpit, where the front and rear straps connect to a nylon pad. The nylon pad holds a knob-shaped Boa Technology dial-type adjustment dial, by means of which the user can lengthen or shorten a loop of vinyl-covered steel wire by turning the dial. Attached to the bottom end of the dial-adjustable loops of wire on the user’s right and left sides are nylon straps with metal clips that attach to nylon belt keepers. The nylon strap and metal clip on each side passes through the slot in the officer’s modified uniform shirt, to allow the belt keeper to attach and provide support to the officer’s duty belt at a point approximately even with the side-seam of his uniform trousers. **See photos, Appendix 10.4.**

5.1.2 Velcro Strap Adjustable Version. The Velcro adjustable version of the prototype duty suspenders is similar to the Boa version, except that instead of the Boa adjustment knobs, it utilizes Velcro-controlled gross adjustments in the nylon straps that pass down from the right and left shoulder harnesses, combined with plastic adjustment buckles that permit the straps to be shortened or lengthened several inches to allow fine adjustments to be made by accessing the strap ends through the slots in the modified uniform shirts. The plastic buckles are quick-detachable by the user, by means of a glove-compatible pinch-to-release design. **See photos, Appendix 10.5.** Although the Boa adjusters are believed to be of high quality, the project team nevertheless felt the simplicity and less mechanical nature of the Velcro strap adjustable system would tend to make it more reliable in extended field use and under adverse conditions.

Note that, with either the Boa or the Velcro adjustment system, the user has the option of determining how much of the duty belt's weight he or she transfers off the hips and waist, and onto the shoulders. Slack suspenders will leave all or almost all of the weight and pressure on the user's hips and waist, while tight suspenders can transfer virtually all of the duty belt's weight to the user's shoulders. Individual users may prefer to adjust the ratio based on their own comfort, physical condition, or the nature of activity in which they are engaged – for instance, foot patrol versus seated for long periods in a vehicle or behind a desk. Analogizing the duty suspenders to a backpack with shoulder straps and a hip belt, the user may also wish to tighten and loosen the suspenders from time to time during the day, to give either his shoulders or his hips a rest by temporarily transferring more of the weight to the other part of his body.

5.2 Modifications to Officer's Uniform Shirt. In order to allow the attachment of the concealed suspenders to the duty belt, the officer's uniform shirts must be modified to provide an opening through which to access the polymer pinch-clips on the nylon adjustment straps at the bottom ends of the suspenders in order to attach the suspenders to the duty belt keepers. The required opening is about 4" long, and is easily located and made by opening up a 4" section of the side seam on either side of a typical uniform shirt. **See close-up photo of modified shirt opening in Appendix 10.5 on page 61.** The extra material of the shirt's front and back panels at the seam is sewn into a narrow hemmed edge on either side of the opening, and the opening is bar-tacked at its top and bottom to prevent the seam from opening any further. The modification can be done easily and inexpensively in a few minutes by a uniform supplier, or by any professional or amateur tailor or seamstress with a sewing machine. The field testers in Rounds I and II were supplied by BLACKHAWK! with uniform shirts that had been modified by a uniform supplier. Field testers in Round III were not provided with modified shirts, but had their uniform shirts modified themselves locally (typically by their uniform suppliers or a tailor) using a sheet containing a diagram and easy-to-follow instructions provided by BLACKHAWK!. Comments from some field testers resulted in further refinement of the shirt modification instructions to their present form. **See Appendix 10.6.** In addition, consideration should be given to the best methods for modifying non-traditional uniform shirts, including bicycle patrol shirts and golf-type shirts (see **Section 7.5.7 below**).

6.0 Field Testing

6.1 Round I. In Round I of the field testing, prototype duty suspenders of both types (Velcro adjustable, and Boa adjustable) were provided to four testers who are all highly experienced police officers with many years of law enforcement service, and who are, in addition, nationally-recognized instructors of various law enforcement skills (firearms, defensive tactics, bicycle patrol tactics, etc.). These four officers were selected for the initial field testing because it was felt that their level of experience would make their comments and reactions most valuable in

refining the prototype suspenders for further field testing. After extensively testing the prototype suspenders themselves, two of these four testers then, in turn, each provided their prototypes to another officer in their agency to field test, making a total of six (6) field testers in Round I of the field tests. Four of these testers were male, and two female. They were of widely differing sizes, body types, and levels of physical conditioning, and some had physical ailments of the types reportedly caused by (or even, in some cases, medically diagnosed as being caused by) years of wearing police duty belts. Evaluation of the prototype suspenders by these testers took place from July through November, 2008. The testers used the prototype suspenders throughout a wide range of police duties, including routine patrol both on foot and in patrol cars, while seated in chairs, engaged in physical training activities, and on bicycle patrol. Some of the testers wore the prototype suspenders in their patrol activities every day for months. Several testers wore the prototype suspenders continuously for as long as twelve (12) hours at a time, and one wore the suspenders throughout a reported 50-60 working shifts. Some wore the suspenders while wearing their soft body armor, and others wore the suspenders, at least at times, without body armor. Preliminary feedback was gathered from the testers during and after their testing of the prototypes by telephone discussions, emails and letters, after which the prototypes they used were returned to BLACKHAWK! for inspection, evaluation and re-use. More detailed data and feedback were subsequently gathered from these six testers by means of a structured telephone interview, in which the interviewer solicited responses to questions on a printed survey form (see Section 7.0 and following, below). As a result of Round I, the prototype style using the Boa adjustment system was eliminated from further testing, in favor of the Velcro-adjustable system.

6.2 Round II. In Round II of the field testing, Velcro-adjustable prototype duty suspenders were provided to a second group of five (5) field testers. Four of the five, comprising two males and two females, were from the Norfolk (Virginia) Police Department, selected because its proximity to the BLACKHAWK! factory allowed BLACKHAWK! to conduct an initial briefing session for these field testers on the use of the suspenders before the testing began. These four individuals were selected for their varying sizes and body types, and one was selected, in part, because of his duty-related back problems. The remaining (male) field tester in Round II is a nationally-recognized police firearms instructor and use of force training consultant. This second round of field testing began in February 2009, and several of the testers are still using the suspenders as this report is being prepared in October 2009. After they used the prototype suspenders for about two weeks, preliminary data and feedback was gathered from these field testers by means of structured telephone interviews using a printed survey form, with further feedback gathered in October 2009.

6.3 Round III. In Round III of the field testing, the National Law Enforcement Training Center (“NLETC”) distributed Velcro-adjustable duty belt suspenders to nine (9) officers in five different law enforcement agencies from

whom data was gathered. (Duty belt suspenders were also distributed by NLETC to an additional four officers who either had not yet tried them, or who could not be reached to collect data, by the time of this report.) The field testers in this group included five males and four females. These field testers were selected by the NLETC, without any direct involvement by BLACKHAWK! Field testing by this group began in September 2009, with data and feedback gathered from the group by structured telephone interviews in the latter part of October 2009.

6.4 Field Testing Data and Feedback. Data and feedback from the three rounds of field tests is contained in Section 7.0 (“Results and Findings”) and in Appendices 10.09 and 10.10, below.

7.0 Results and Findings

7.1 Communicating with Field Testers; Gathering Data and Feedback. BLACKHAWK!’s initial communications with the field testers in Round I were primarily by telephone, after which the testers were sent prototype suspenders. Uniform shirts were provided to BLACKHAWK! by the testers, and were modified by BLACKHAWK! with side openings and returned to the testers for use in the evaluation. BLACKHAWK! communicated with the testers periodically over the following 2-4 months by telephone and email. Some of these testers provided written comments to BLACKHAWK! by email. At the end of each tester’s evaluation of the prototype suspenders, the prototypes were returned to BLACKHAWK! for inspection and re-issue to other testers. Testers were asked to sign a prototype evaluation agreement/non-disclosure agreement, and testers in Rounds I and II were given gift credits by BLACKHAWK!, redeemable for BLACKHAWK! products of the user’s choice. Unlike the field testers in the first two rounds, those in Round III did not receive BLACKHAWK! gift cards, their only incentive being the opportunity to participate in the evaluation of the load-bearing system. As mentioned above, four of the testers in Round II were from the Norfolk Police Department, which is located near the BLACKHAWK! facility in Norfolk, Virginia. This allowed these testers to be given a short briefing and demonstration of how to adjust and use the duty suspenders by a BLACKHAWK! employee at the start of the Round II field testing. Field testers from Rounds I, II and III all provided structured feedback by means of a telephone interview with a consultant engaged by BLACKHAWK! for the purpose. The field testers answered questions the consultant asked, using a printed telephone survey form, a copy of which is provided in Appendix 10.8. No attempt was made at any time to stifle negative comments or criticisms of the prototype suspenders; to the contrary, at all times BLACKHAWK! and its consultant made it clear that what was desired was the field tester’s honest opinions and reactions, including negative comments and criticisms where applicable.

7.2 Positive Findings.

7.2.1 Increased Comfort. Far and away, the field testers identified the major benefit of the prototype system as increased comfort in wearing their duty belt and/or the reduction of pain in the waist, hips and back, by better distributing the weight of the duty belt, shifting some of the weight off the officer's hips and waist, and transferring it to the officer's shoulders. Representative comments from the field testers on this feature included the following:

“The best feature was the transfer/distribution of weight and pressure from my hips, waist and lower back to my shoulders.” (Field Tester II-1)

“[The best feature was] the distribution of the duty belt weight over more of my body.” (Field Tester II-2)

“The best feature was taking the weight off my hip bones.” (Field Tester II-4 – female)

“[The best feature was] taking the load off my waist – distributing it to my shoulders – and it helped my posture, too!” (Field Tester I-6)

“The best [feature] was the weight distribution, instead of all of it on my hips.” (Field Tester I-3)

“The best thing was the reduction of stress on my hips and lower back.” (Field Tester I-2)

“ ... taking the weight off my lower back.” (Field Tester I-1)

7.2.2 No Need to Keep “Hitching Up” the Duty Belt. Several of the field testers commented that a major benefit was that the suspenders helped to keep their duty belt from slipping down in use. Representative comments are as follows:

“Also, it kept my duty belt from slipping down over my hips, which usually makes me have to keep tugging it back up throughout my shift. And by holding up the duty belt, I didn't have to over-tighten the belt to keep it in place, which usually puts a lot of strain on my lower back.” (Field Tester II-1)

“[The best feature was] holding my belt up.” (Field Tester I-5)

7.2.3 Other Comments. One tester apparently took for granted the benefit of the duty suspenders in distributing the duty belt's weight from his hips to his shoulders, commenting that “[The best feature is that] they're concealable – there's no safety risk from someone grabbing on to them.” (Field Tester II-3)

Asked for “any other comments,” one field tester said, “I wish I’d thought of it – it’s a very good design, well thought-out.” (Field Tester II-3)

One field tester, who wore the prototype suspenders an estimated 50-60 times (every patrol shift he worked for three months), simply asked, “When can I get a pair?” (Field Tester I-6)

Another field tester, who found the suspenders relieved the pain he regularly experienced in his waist and back, commented, “I love them. Can I keep them? I don’t want to give them back.” (Field Tester III-4)

One of the several female field testers (Field Tester I-4) who criticized the difficulty of detaching and reattaching the suspenders to use the toilet, commented that, although she knew this might not be the direction in which this research project was headed, or an alternative that would be acceptable to most police departments, the best solution for female officers might be a duty equipment vest, which they could simply slip off to use the toilet, and slip back on afterwards. See Sections 7.3 and 7.3.8 below for further discussion of this problem reported by several female officers.

Another field tester (Field Tester II-2) suggested trying to eliminate the shoulder harness altogether, replacing it with a “V” (or “chevron-shaped”) reinforcing strap sewn to the inside of the officer’s shirt on either side of his or her torso, with the downward point of the “V” being an attachment point for the belt keepers. The officer felt that, especially with tight-fitted, elastic shirts such as bike patrol shirts, this might offer enough support for the duty belt that the suspenders could be eliminated.

One field tester commented that, when he raised both arms at the same time to fire his weapon on the shooting range, the suspenders tended to exert downward force on his shoulders. Clearly, officers should practice firing while wearing their duty gear, including duty belt suspenders if used.

7.3 Negative Comments. Negative comments were received primarily from female field testers, several of whom found the “one size fits all” suspenders they were given to evaluate uncomfortable, ill-fitting, or unduly restrictive of their freedom of movement. Categories of negative comment were as follows:

7.3.1 Discomfort in Wearing the Duty Belt Suspenders. Three of the female field testers (Field Testers III-1, III-3, and III-9) gave the suspenders only one (1) point out of a possible 10 points for “comfort.” Significantly, however, the other five female testers gave the suspenders an average of 8.1 points out of 10 for comfort, with individual ratings ranging from 6 points to 10 points, and one of these testers commented that she “didn’t even know she had them on.” (Field Tester III- The field testers who found the suspenders very uncomfortable were all wearing the “one size fits all” (now designated “Large/XL/XXL” size) prototype

suspenders, before the Small/Medium size suspenders were developed. In addition, all three of these testers were from Round III, which, it was later determined, had received neither any written instructions nor any briefing or explanation of the proper way to adjust or wear the suspenders when the suspenders were distributed by NLETC. Two of these female testers complained that, when adjusted to take the weight of the duty belt off their hips, the adjustment straps “cut” (pressed) up under their armpits. The other tester simply described the discomfort as being caused by the suspenders being too restrictive of her ability to move, and also that the Velcro adjustments rubbed and annoyed her back just below her neck. One of these two individuals described herself as being “petite” and “short-waisted.” Significantly, the discomfort problem reported by these three (3) females was not experienced by the five (5) other female testers who used the suspender system. BLACKHAWK! believes the reported discomfort problem may result from the suspenders not being properly sized or adjusted for these users. More analysis and field testing will be needed to determine whether this is the case.

7.3.2 Difficulty in Attaching the Suspenders to the Duty Belt. Five (5) of the eight (8) female field testers gave the suspender system low marks (1 to 3 points out of a possible 10) for ease of putting them on and taking them off. They uniformly commented on the difficulty of reattaching the suspenders to their duty belts after lowering their uniform trousers and duty belts to use the toilet. They commented that when they detached the suspenders from their duty belts, the suspender attachment straps were then hard to access again through the slots in their uniform shirts. The other three female field testers gave the suspender system 5, 6 and 7 points out of 10, respectively, and one commented that putting the suspenders back on after using the restroom was “not so hard once you get used to it.”

7.3.3 Feeling that the Suspenders Restricted Freedom of Movement. One male and two female field testers (all from the same agency) criticized the suspenders for restricting their freedom of movement. The male field tester (Field Tester III-8) commented that he normally wears conventional, non-concealable suspenders with his duty belt, and finds them less restrictive. **Also see section 7.3.4**

7.3.4 “Rocking” of the Duty Belt. Field Tester III-8, who regularly wears conventional suspenders that attach front-and-rear to his duty belt, commented that he felt the single side attachment points of the BLACKHAWK! system caused his duty belt to “rock” back and forth. No other testers reported this problem.

7.3.5 No Room on Duty Belt to Attach Suspender Keepers. One female field tester (Field Tester III-7) reported that due to her small waist and the other equipment she had to carry on her duty belt, she could only find room to attach the duty belt suspenders on one side (her gun side), but could find absolutely no space on the opposite side of her duty belt to place the keeper to attach the other

suspender. Even so, she wore the suspender system for two weeks (10 shifts), and reported that it eased the weight of the duty belt, and the pain it caused her daily. She stated that if she could only find room to attach both sides of the suspenders, she would wear them on a regular basis.

7.4 Summary of Feedback from Field Testers. Personal characteristics of the field testers and feedback from the field testing is provided in **Appendices 10.09 and 10.10 below**. In summary:

- 12 out of 20 field testers said **they themselves would use the prototype duty suspenders on a regular basis**. Significantly, **11 out of 12 male field testers said they would use the prototype suspenders on a regular basis, while only one of the eight female field testers said she would do so**. Another female field tester (Tester III-7) said she would do so if she could find room on her duty belt to attach both suspenders (see Section 7.3.5 above).
- 18 out of 20 said **they would recommend the duty suspenders to other officers**.

On a scale of 1 to 10 (1 being the worst, 10 being the best), the field testers gave the prototype suspenders scores which averaged:

- **6.43 for comfort** (with individual tester's responses ranging from 1 to 10). Significantly, male field testers gave the suspenders an average comfort score of 7.23, while female field testers gave them an average score of 5.44.
- **6.70 for improving the comfort or ease of wearing their duty belt** (individual scores ranging from 1 to 10). Male field testers gave the suspenders an average score of 8.0 in this category, while female testers gave them only 4.63.
- **8.8 for allowing them to present a neat, professional appearance in uniform** (with scores ranging from 4 to 10); and
- **6.2 for ease or difficulty of putting the suspenders and duty shirt on, adjusting the suspenders as necessary, and removing the suspenders at the end of the shift** (with scores ranging from 1 to 10). Significantly, male field testers gave the suspenders an average score of 7.54 points in this category, while female testers gave them an average of only 3.50 points.
- The lowest average score was **5.10 in response to a question asking whether using the suspenders made the officer feel less tired/fatigued at the end of the day**, with individual scores ranging from 1 to 10. Again there was a significant difference in scoring between the male and the female field testers, with males rating the suspenders an average of 6.42 points in this category, and females an average of 3.13 points.

Overall, these results indicate that, for many male and some female officers, concealable duty suspenders can be one viable solution to the problem of better distributing the weight of equipment the officer must carry, thus improving officer comfort levels and possibly reducing the reported duty belt related injuries. The results also indicate that further efforts should be made to analyze and, if possible, correct the problems noted by several of the female field testers.

7.5 Areas for Prototype Improvement, Further Development or Research.

Based on feedback from the field testing, the following areas were identified for further exploration, analysis and consideration:

7.5.1 Comfort of Harness Straps on Neck and Shoulders. Several field testers commented that, while they appreciated the transfer of weight off their hips and waist, the transfer produced a corresponding, if less significant, increase in discomfort where the harness straps crossed their shoulders and neck. Some testers reported this caused some soreness in their shoulders by the end of the shift. In part the degree of sensitivity of the user's neck and shoulders may depend on whether or not body armor was worn under the suspenders, as body armor tends to distribute the transferred weight and soften the effect of the harness on the user's upper body. Also, note that BLACKHAWK! produced two types of prototype harnesses, one using a wide, soft, suede-like material (called "lammy suede") over the neck and shoulders, while the other used nylon webbing straps, which are narrower and not as soft. BLACKHAWK! has now refined the shoulder harness design to use the "lammy suede" material exclusively, in order to make the shoulder harness as comfortable as possible, even for users who, unlike most officers, will not be wearing the suspenders over body armor. In addition, the circular plastic "X" juncture behind the user's neck used on some of the earlier prototypes has been replaced by a nylon strap-type connection, with care taken to avoid any exposed hook-and-loop material that could annoy the user's skin if worn without intervening body armor.

7.5.2 Chest Strap. Three field testers commented that they thought a chest strap, connecting the right front and left front shoulder straps, might help keep the shoulder harness halves from slipping off their shoulders in use, or to prevent the sensation that the harness could slip off their shoulders.

7.5.3 Method of Attachment to Duty Belt. One field tester criticized the shiny nickel-finished snaps that connected to the belt keepers in the early Boa adjustable version of the suspenders he field tested. The shiny metal snaps have subsequently been replaced by black plastic "glove-compatible" pinch-fasteners that require less fine motor coordination to manipulate. Several field testers commented that the suspenders' belt keepers should be made as narrow and thin as possible, both to take up minimal space on an already-crowded duty belt, and because the thickness of the belt keepers can be annoying to the user when the duty belt presses the keepers into the user's hips or waist. In response, BLACKHAWK!

changed the keeper material, and the keepers used in the latest prototype suspenders are thinner than commonly available duty belt keepers. One field tester suggested a design that would allow the suspenders to attach to an officer's existing belt keepers, rather than requiring additional keepers that are just for the suspenders.

7.5.4 Instructions for Uniform Shirt Modification. BLACKHAWK! initially developed a diagram and instruction sheet for modifying a traditional uniform shirt to accommodate use of the duty suspenders. Two testers commented that the shirt modification instructions should be based on the actual location of the individual user's duty belt, as worn, relative to his uniform shirt, rather than locating the suspender opening by measuring up a fixed distance from the bottom edge of the uniform shirt, as the initial draft of the instructions said to do. According to the two testers who recommended it, such a belt-location-based system would better allow for differences in officers' physiques (short-waisted vs. long-waisted, etc.). In response, Blackhawk modified the shirt modification instructions to make them more "user friendly." See Appendix 10.6.

7.5.5 Instructions for Use of the Suspenders. While several field testers described the initial set-up and use of the duty suspenders as "self explanatory," if these duty suspenders are sold commercially, they should be accompanied by appropriate instructions for use, possibly containing line drawings or photographs to show how the suspenders are to be worn and adjusted. Consideration could be given to producing a DVD which could be shown to groups of officers by agencies issuing these duty suspenders, or to making a video clip available to individual users on line, showing the proper use and adjustment of the product. As mentioned by several field testers, a warning should probably be included in the materials, cautioning the user to be sure the positioning of the suspender keepers and straps does not interfere with the officer's ability to draw or safely carry his or her service pistol or other critical equipment on the duty belt. Two field testers mentioned the possibility of the suspender strap interfering with the grip of their handguns; another field tester made a similar comment concerning interference between the suspender strap and the grip of his Taser. Instructions now prepared by BLACKHAWK! (see Appendix 10.6) have taken the above comments into consideration. Consideration should be given to the recommendation of one field tester, a physical fitness and defensive tactics instructor, that the instructions might also emphasize that an officer's overall comfort, and possibly the potential to avoid or reduce duty-belt related ailments, depends not only on the use of duty belt suspenders, but also on other factors, including: (1) a program of regular exercise to maintain flexibility and core strength; (2) a proper balance of diet and exercise to avoid putting on excessive weight; (3) proper equipment selection, including a comfortable duty belt and holster, and the avoidance of an excessively heavy equipment load on the duty belt; (4) optimal positioning of the items of equipment on the duty belt; and (5) consideration of lumbar supports in patrol cars, and back-healthy desk chairs in the police station.

7.5.6 Suspender and Modified Uniform Shirt Appearance. Overall, the field testers rated the prototype system, including the modified uniform shirt, very high in allowing them to present a neat, professional appearance in uniform, and all but one tester felt their agencies would have no objection to the appearance of the modified shirt and suspender system. Several field testers commented that no one even noticed they were wearing the suspenders. Several other field testers, however, commented that a white undershirt or white body armor carrier could sometimes be seen through the suspender opening in the modified duty shirt. This was not a problem for officers whose uniform includes a dark-colored undershirt or body armor carrier (e.g., dark blue with a blue uniform, or dark brown with a brown uniform). In order to accommodate differences in posture and physical activities throughout the day, and variations in the exact positioning of the duty belt on the officer's body, a slightly longer suspender opening is preferable to a more tightly-fitted one. For this reason, and for greater simplicity in measuring and modifying traditional uniform shirts, simply wearing a dark undershirt (provided the officer's agency does not prohibit this) seems to be a simpler solution to the "undershirt visibility" problem than trying to create a suspender opening that fits tightly around the suspender straps.

7.5.7 Adaptation to Unconventional Duty Shirt Designs. As discussed above, traditional uniform shirts can easily and inexpensively be modified to permit the use of the prototype duty suspenders, and such shirts, in either long-sleeve or short-sleeve configuration, undoubtedly represent the uniform shirts worn by most American police officers. Nevertheless, consideration should also be given to ways in which unconventional uniform shirts, such as bike patrol shirts and golf-type shirts, can be modified to permit the use of duty suspenders of this design as well.

7.5.8 Ease of Detaching and Re-Attaching. Several female testers commented that, due to the female officer's need to undo the duty belt to lower their uniform trousers when using the toilet, it is important that the design permit easy detaching of the suspenders from the duty belt, and re-attaching when the officer is through using the toilet. One of these female testers was sufficiently bothered by the difficulty of detaching and re-attaching the suspenders that she said she would choose not to wear the prototype suspender system for that reason alone, due to the inconvenience factor and because she already "had so much other stuff to hook up each time" she put on her uniform. Several things are of note in this regard: (1) this particular tester did not currently have any of the physical ailments commonly associated with wearing heavy duty belts, and thus said she felt she had less to gain from using duty belt suspenders than officers who had problems wearing duty belts; and (2) despite the fact that she would not choose to wear the suspenders herself, she did not hesitate to say she would recommend them to others, who might benefit from them more than she would. This tester gave the suspenders only 3 points out of a possible 10 for ease of detaching and reattaching to the duty belt. Two other female testers gave the suspenders only one

point (out of a possible 10) in this category, while two other females gave it only 2 points out of 10. BLACKHAWK! has subsequently changed the prototype design to use glove-compatible, easily detachable and re-attachable pinch-fasteners to connect the suspender straps to the duty belt keepers, which should reduce the difficulty of detaching and re-attaching the suspenders when an officer dresses or undresses.

7.5.9 Sizing to Fit Smaller or Shorter-Waisted Officers. See Section 7.3.1 above. BLACKHAWK!'s subsequent development of a smaller size prototype, designated "Small-Medium," will hopefully solve the discomfort problem experienced by three (3) of the eight (8) female field testers. Further field testing will be needed to determine whether this is the case.

7.5.10 Problems With Abrasion and Fraying. One field tester (Field Tester I-2) reported that when he used the Boa system, the vinyl-covered steel adjustment wire eventually frayed, after which it would annoy his arm where it rubbed through his shirt. Another field tester (Field Tester II-2) reported that the Velcro-adjustable prototype caused some fraying of his UnderArmor undershirt. He felt it would not cause fraying of a conventional cotton undershirt, and in fact none of the other field testers reported such problems.

7.5.11 Back-Up Handgun Holster or Knife Pouch. Two of the field testers suggested that a holster could be provided that would attach to the suspenders, to keep a small back-up handgun concealed under the officer's shirt, and/or that a pouch could be provided for a concealed tactical knife. Holsters are available from several manufacturers that hold back-up handguns on the side straps of the officer's body armor, and some officers carry small handguns or knives in the trauma plate pockets of their ballistic vests. If desired, such a holster or knife pouch could easily be made for use in conjunction with the concealed duty suspenders.

7.5.12 Slipping Adjustment Straps. Two of the field testers commented that, during the course of their shift, the adjustment straps tended to slip (i.e., lengthen) somewhat in use, requiring that they readjust them periodically to maintain the degree of tension they wanted. Although these testers commented that the readjustment was easy to do, BLACKHAWK! is considering a modification in the design to eliminate this inconvenience.

8.0 Plans for Continued Development of the Concealable Duty Belt Suspender System. At this point, it appears that the prototype concealable duty belt suspender system, with minimal further refinement in some of the areas indicated by the field testing, can offer significant benefits to many male and some female officers by reducing their discomfort in wearing heavy duty belts throughout long working shifts. It seems logical that use of the suspenders may also reduce the incidence or severity of back, nerve, leg and hip ailments commonly believed to be associated with the long-term use of duty belts. Ultimately, however, these physical benefits would

need to be proven and documented by controlled medical studies of large numbers of police users over considerable periods of time. In the meantime, individual field testers and others report that duty belt suspenders provide relief from their back, hip, nerve or leg ailments, and the majority of field testers report that an improvement in comfort and/or reduction in fatigue is provided by the suspenders' function in transferring a portion of the duty belt's considerable weight off their hips and waist, and onto their shoulders. Further design work appears necessary in order to make the suspender system comfortable for more female users, as well as to make the suspenders easier to reattach to the duty belt after unsnapping them to use the restroom. BLACKHAWK! intends to continue working on refinement of the prototype design, testing any further modifications to ensure their efficacy and suitability for the widest range of potential users.

9.0 Conclusion. Further work needs to be done to make the prototype suspender system acceptable to a larger number of female officers. Nevertheless, concealable duty belt suspenders of the prototype design appear at this point to be a viable concept that can offer a considerable improvement in comfort to hundreds of thousands of U.S. police officers who wear equipment-laden duty belts daily throughout their careers. In addition, such suspenders may possibly reduce the incidence and/or severity of physical ailments reportedly associated with the wearing of duty belts. While a long-term, scientific study would likely be needed in order to reach a definitive medical conclusion in this regard, feedback from the limited field testing conducted thus far indicates that concealable duty belt suspenders can, at a minimum, provide many officers who suffer from such ailments a means of reducing their pain, discomfort, or other symptoms, by taking a significant portion of the duty belt's weight and pressure off their hips and waist.

10.0 Appendices

10.1 Photo of non-concealable (traditional) duty suspenders



10.2 Photos of equipment shirts, duty overshirts and tactical vests



10.3 Photos and Diagrams of Early Stages

Original Concept #1

- The purpose was to story board a couple of different styles/ designs to refine down toward the final concept for prototyping.

project briefing
 Traditionalism at core in this sector of Law Enforcement; Conventional appearance is required.
 Room for modern materials & construction, as well as examining equipment placement.

equipment placement
 Conventional belt-oriented placement (traditional will be accepted quicker)
 Shirt/Carrier & Duty Trousers placements may be considered

load bearing system
 Over-the-Shirt versus less visible options
 Suspension System (Suspender-like or different)
 Address Conventional & Concealed Soft Armor
 Apply the Suspension/Load Bearing to Externally Worn Soft Armor/Tactical Vests

criteria
 Examining existing methods/products in the field as basis for acceptance.
 Attachment methods & belt loops
 Supports equipment
 Where & how to carry

attachment consideration
 Physical Considerations
 Men & Women
 Body Types
 Physical Condition
 Disabilities
 Skill Levels

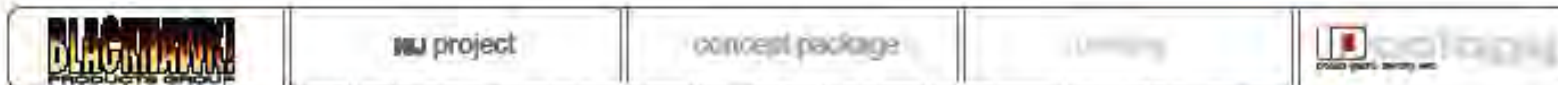
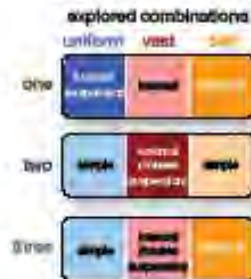
duty trousers (not addressed in three views)
 Traditional appearance - will (not) be considered
 Non-quality of construction
 Duty trousers
 Pulling
 Carry weight
 Carry method



usership understanding
 this system is taken on/off rarely throughout a work shift.
 there is no need to have a quick on/off function (escapable).
 users need to be able to run with the system, but not often.

design language
 stay conservative, traditional look.
 technical constructions need to be somewhat hidden

ideation approaches
 all concepts are in male proportion (specific female & unisex sizing/positioning will be examined in future packages)
 each ideation attempts to give different levels of usership, performance, and construction complexity
 three combinations examined of how elements interact
 each ideation takes a different combination of elements to support the suspension system (chart of right)





ideaion one

Uniform has built in suspension which interfaces with shoulder surface of the ballistic vest. Small holes allows buttons to exit outside of the uniform & support the belt.



ideaion two

Suspension integrated into a ventilated external ballistic vest. Loops on the vest allow for belt to load on vest structure. uniform is beneath system & color tonal.



ideaion three

Side location on uniform enable suspension to connect with belt. Adjustments for suspension are accessed on lateral sides of the uniforms front pockets.

consideration	ideaion one	ideaion two	ideaion three
uniform shirt	+++++ heavy	[+++++] minimal	+++++ moderate
ballistics vest	++++ moderate (internal)	[++++] moderate (external)	++++ heavy (internal)
cost	++++ moderate	[++++] minimal	++++ heavy
ease of use	++++ moderate	[+++++] easiest	+++++ most complex
performance	++++ moderate	[+++++] least	++++ highest
complexity	++++ moderate	[+++++] least	++++ highest

Ideation One



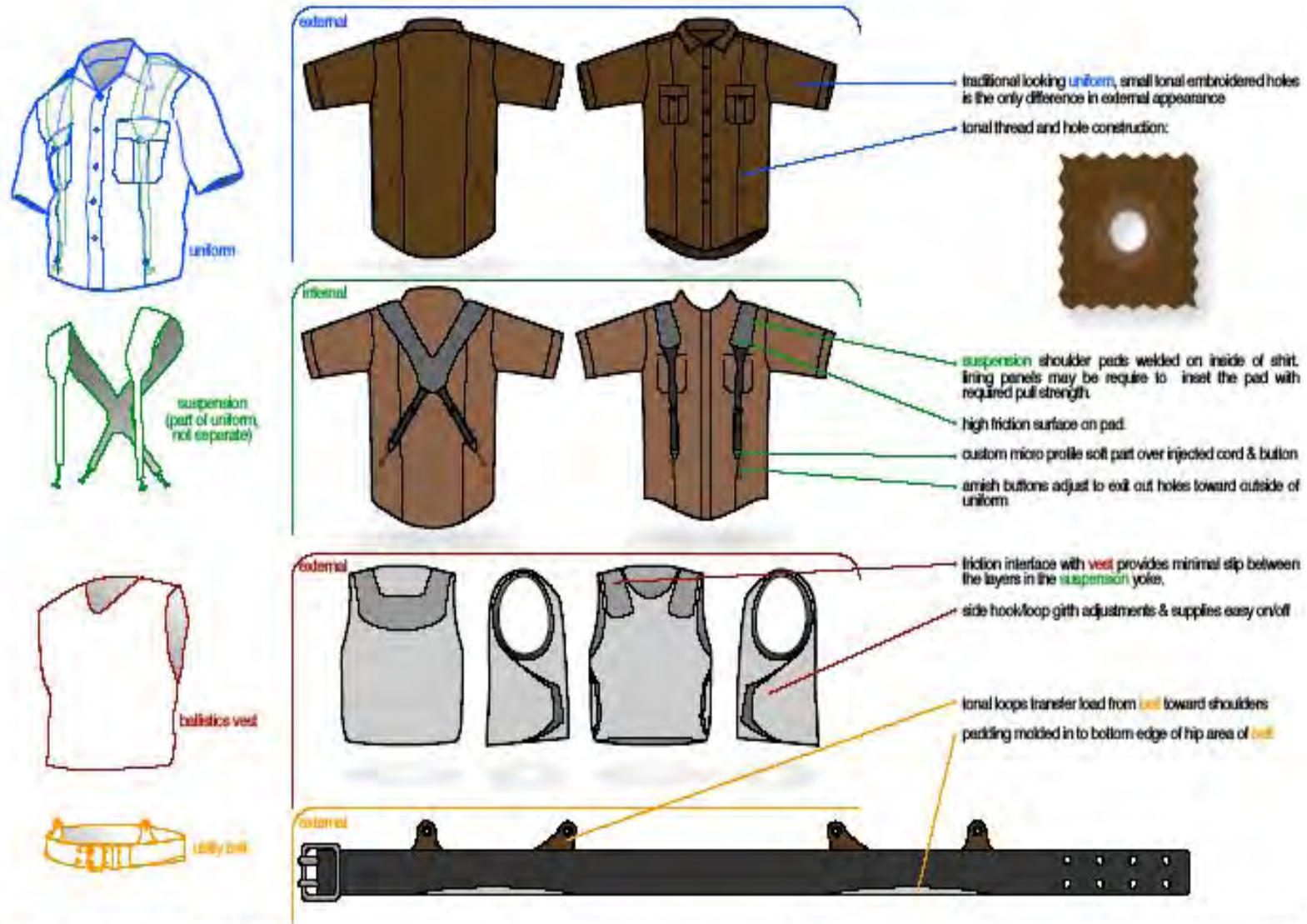
NIJ project

concept package

ideation one



Ideation One



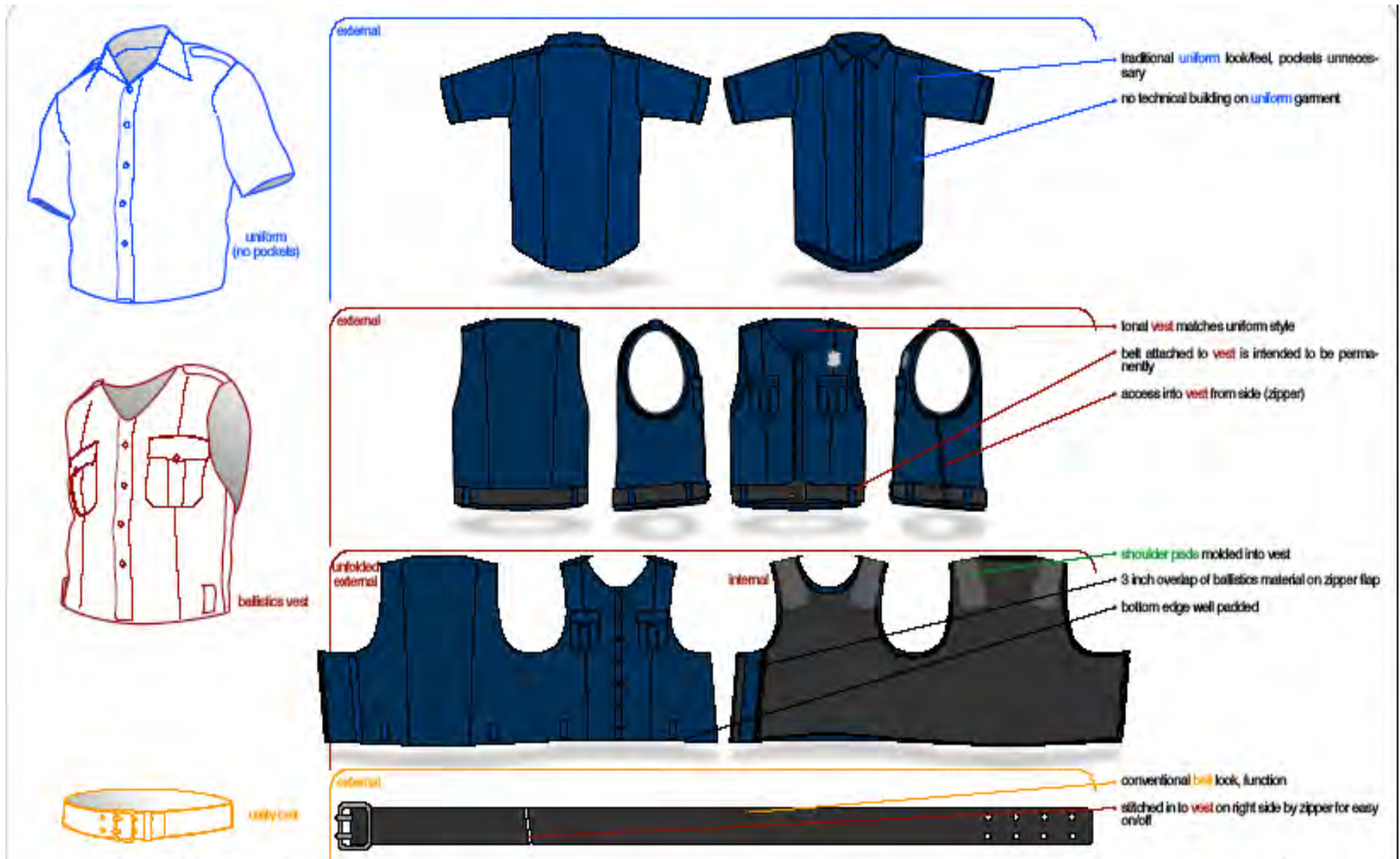
Ideation Two



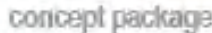




- suspension integrates into a ventilated ballistic vest. loops on the vest allow for belt to load on vest structure. uniform is below and tonal.
- suspension utilizes shoulder width of vest
- ballistic vest
- traditional uniform below has traditional look/feel
- ventilation materials on inside of vest
- side zipper for easy on/off of vest/look unit
- loops support look
- traditional look look/feel and function
- bottom look edge does not hit pant level, lower vest edge protects hips.
- vest is proportionally longer to go over the pants belt line (i.e. only one belt is seen externally)

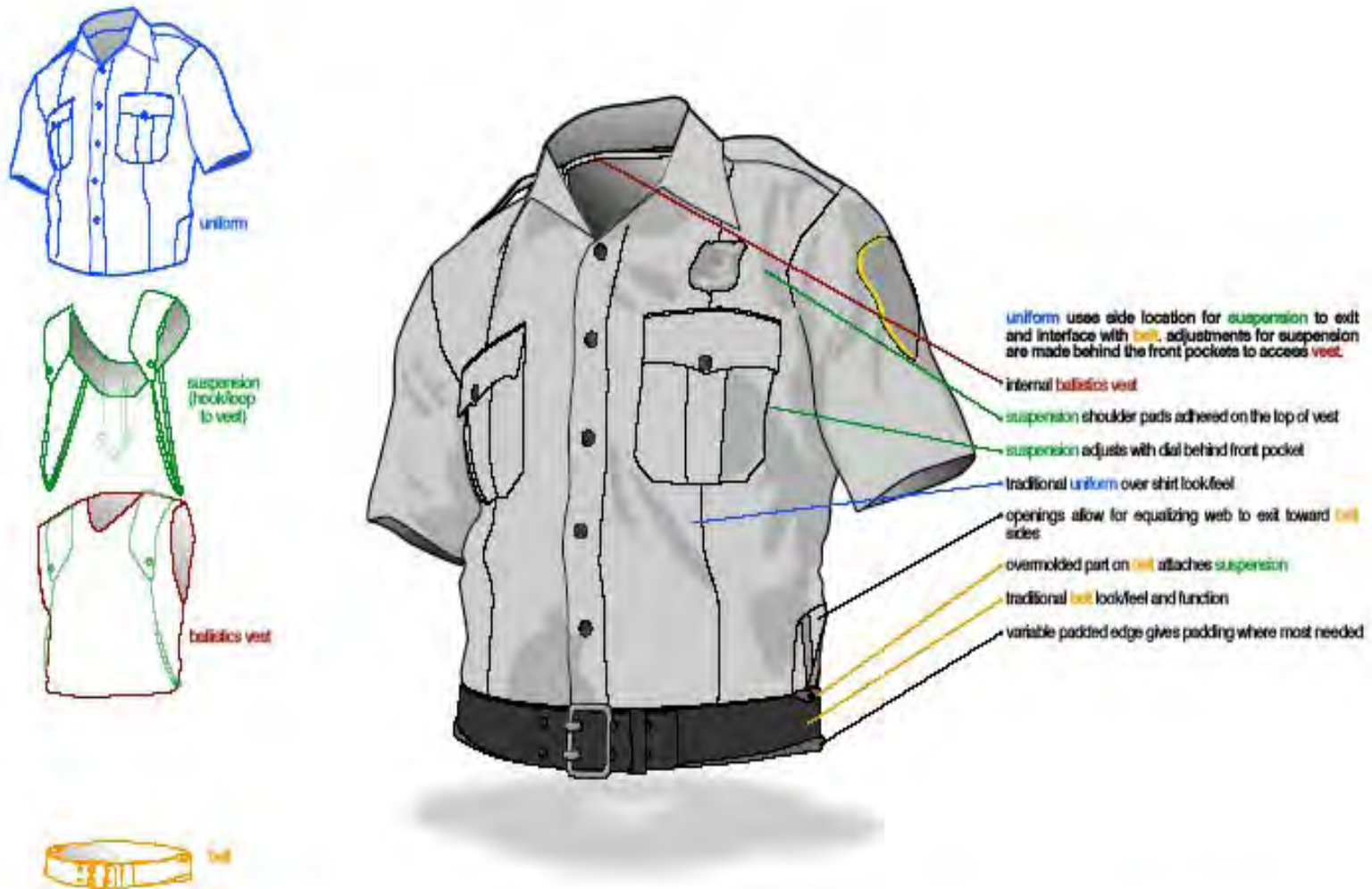
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Ideation Two



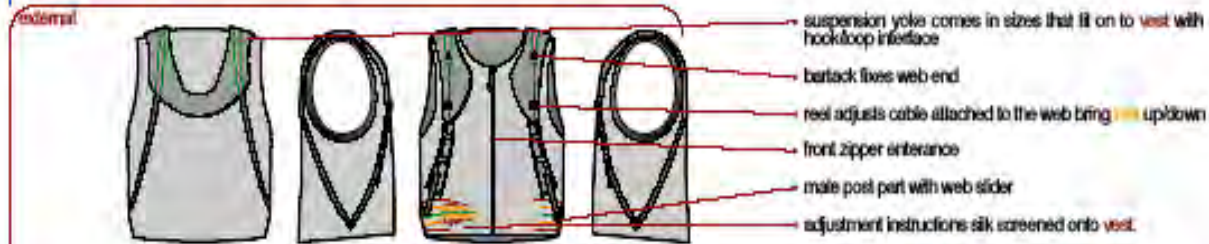
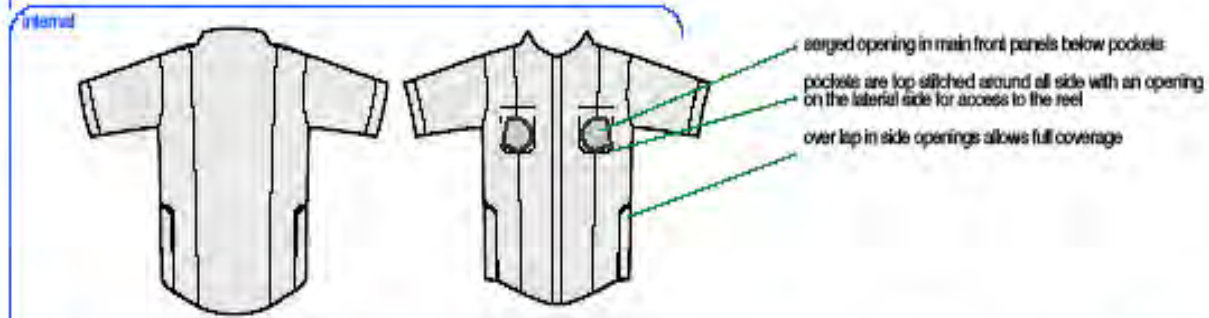






Ideation Three



	<p>HW project</p>	<p>concept package</p>	<p>ideation three</p>	
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Ideation Three



	<p>NW project</p>	<p>concept package</p>	<p>© 2003 DLA</p>	
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Refined Concept #2

- This concept was the refinement to one style from concept #2 and as a result a completed prototype for proof of concept .
- Accompanying pages show this concept prototype and list the drawbacks to this approach.



project briefing
Tactical uniform is due in the second half of 2010. Current uniform is a mix of tactical and traditional. Need for modern materials & construction, as well as existing equipment placement.

equipment placement
Conventional belt-oriented placement (traditional) will be accepted quickly. Belt, Canine & Duty Trousers placement (new) to be considered.

load bearing system
Over-the-shoulder vests less visible options.
Suspension system (suspenders or different).
Adjustable carry frame & Concealed Soft Armor.
Apply the suspension load bearing to extremely worn soft armor/tactical vest.

criteria
Examining existing methods/products in the field to look for inspiration.
Attachment methods & belt loops.
Support equipment.
Where & how to carry.

attachment consideration
Physical Considerations.
Male & Female.
Body Types.
Physical Condition.
Capabilities.
Skill Levels.

duty trouser (not addressed in phase one)

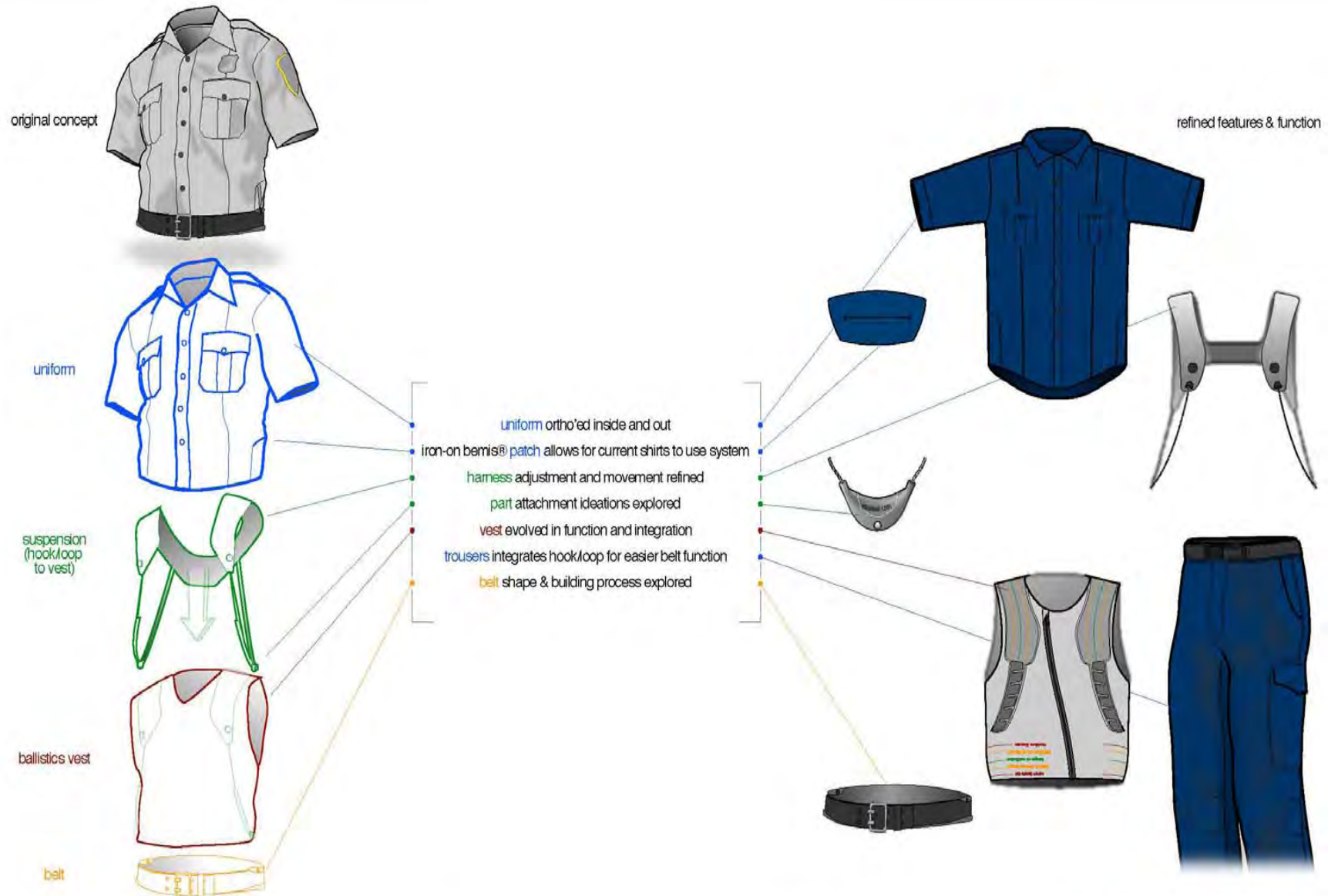
phase two briefing
work with ideation three from phase one
improve function & features with supplied feedback (emails & phone calls in late July)

conversion
address conversion of in-use gear with implementation of system components
both duty shirt & trousers need to be focused on this application

suspension ergonomics
women's issues need addressing (pending receipt of gear request to further this research)
on/off access examination necessary (bathroom, water escape, etc)

sizing consideration
sku sizing chart generated

duty trouser
initial integration exploration necessary (more details to be explored in the next phase)



NIJ project

refined concept

key package concepts



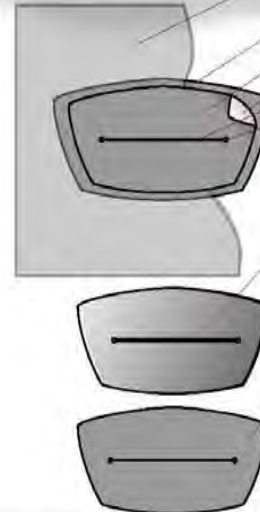
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	extra large	large	medium	small	extra small	comments/options
uniform	 <p>men's fit block</p>			 <p>women's fit block</p>		women's specific sizing through out?
harness	←		 <p>can be used on all three sizes of vest</p>		→	women's specific harness further addressing breast patterning?
vest	←				→	conventional sizing for vests as currently offered in the market potential to offer more one color?
belt	 <p>40 - 46</p>	 <p>36 - 42</p>	 <p>32 - 38</p>	 <p>28 - 34</p>	 <p>24 - 30</p>	six inch adjustment on all sizes capturing 24 - 46 inch waists need wider sizing?
 <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>NIJ project</p> </div> <div style="text-align: center;"> <p>refined concept</p> </div> <div style="text-align: center;"> <p>sizing offering matrix</p> </div> <div style="text-align: center;">  </div> </div> <p style="font-size: small; text-align: center;">© Copyright 04 Sept 07 All Rights Reserved. This document contains proprietary information of Ecology LLC. It is not to be used or reproduced without the written consent of Ecology LLC.</p>						

conceived duty shirt



patch option to existing shirts



- laser cut bemis® patch glues to size of in use shirt to allow clean exit of systems cable or web
- shirt material
- backing patch
- front patch
- bemis® material (corner shown folded back)
- line marked for cutting
- die cut holes
- injection molded straight guide matches front patch
- front patch

kit is sold with clear and simple instructions:
 1. make two measurements
 2. iron the patches on to the shirt for 1 minute
 3. stick shirt in the freezer for 5 minutes
 4. cut shirt with straight guide provided

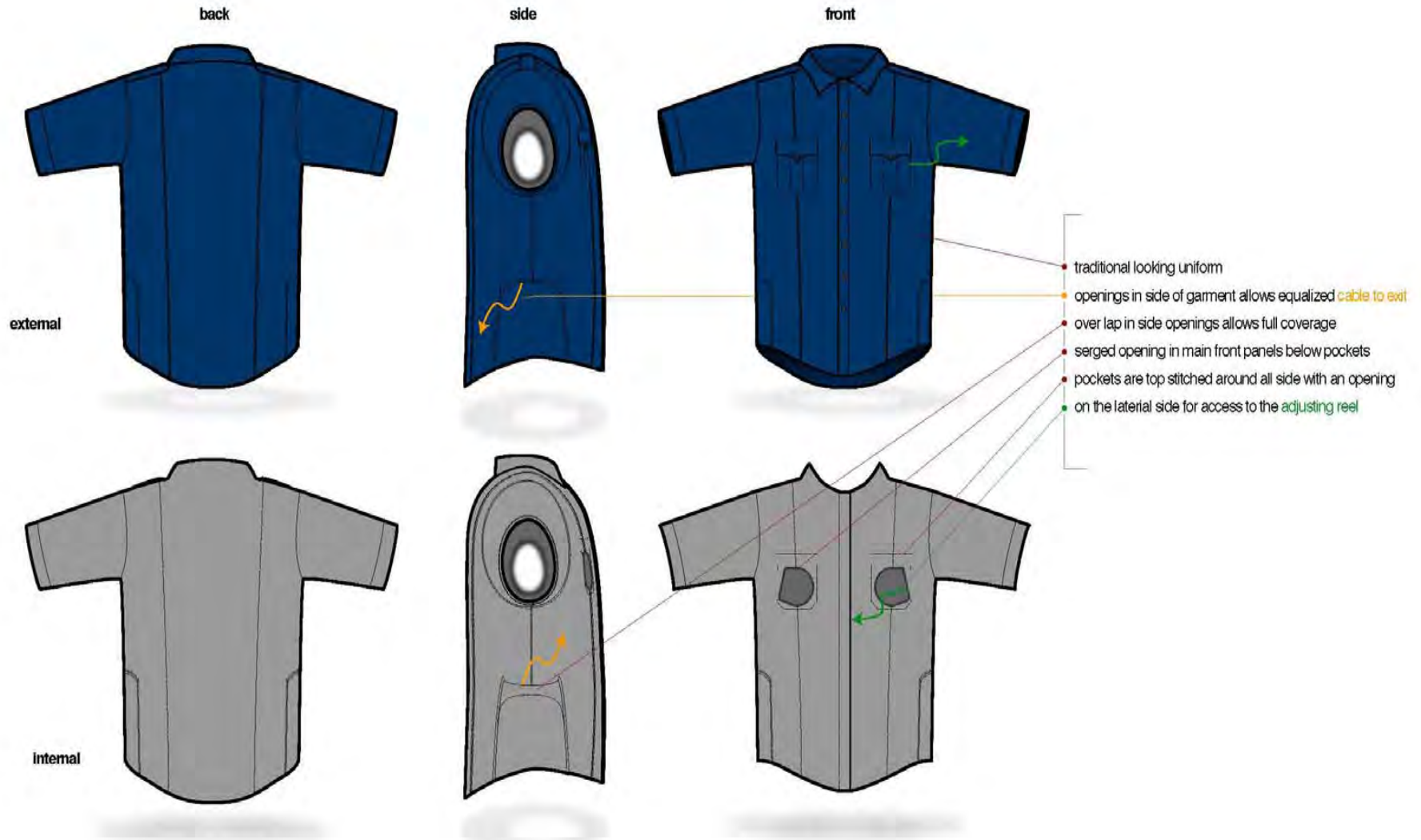


nij project

refined concept

application





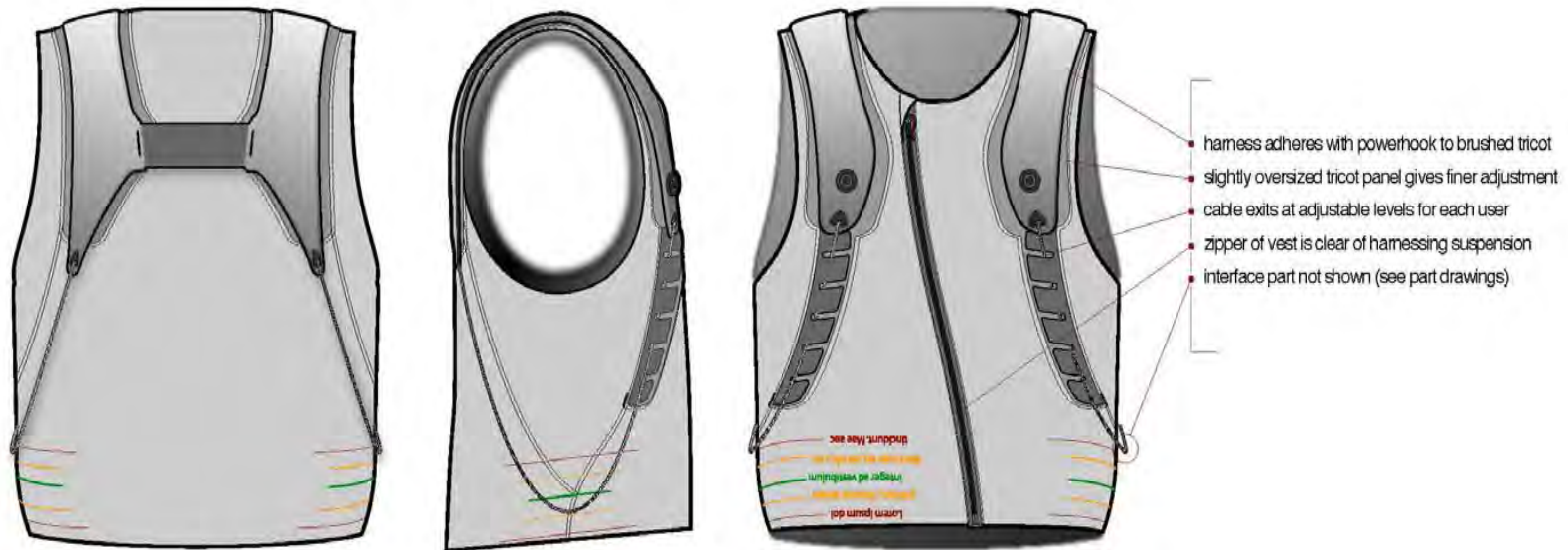
NIJ project

refined concept

uniform



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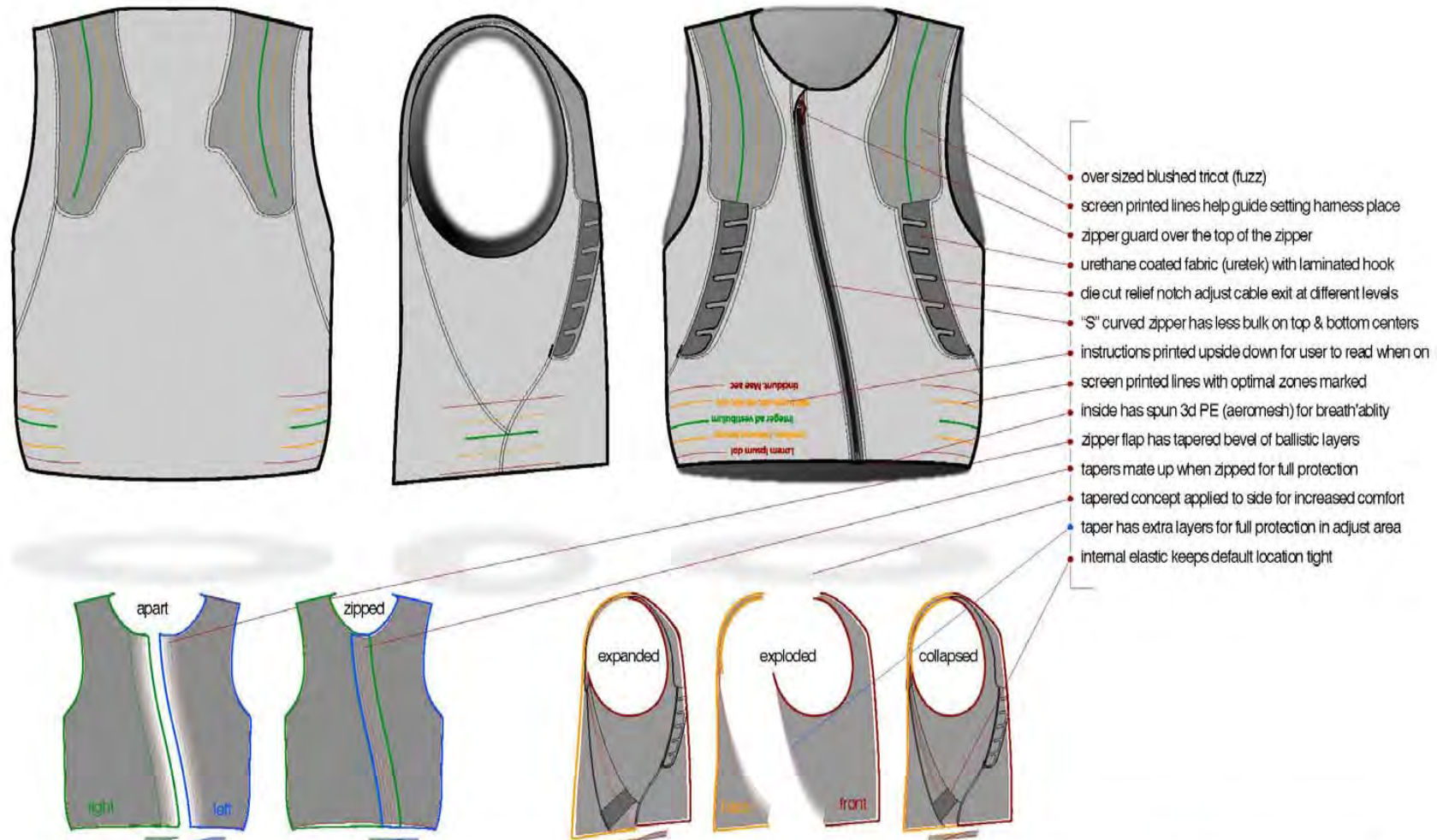
NIJ project

refined concept

vest & harness interface



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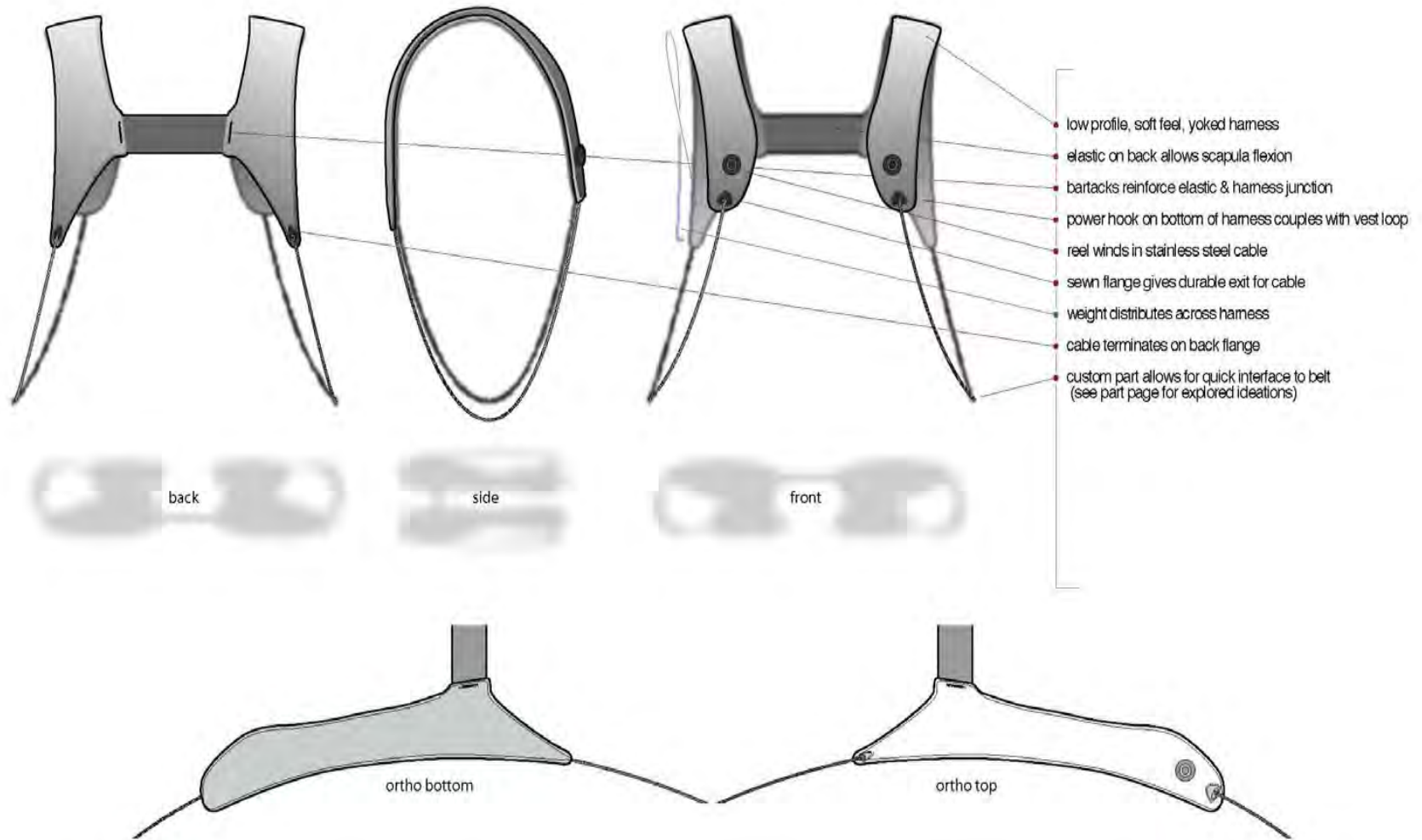
NIJ project

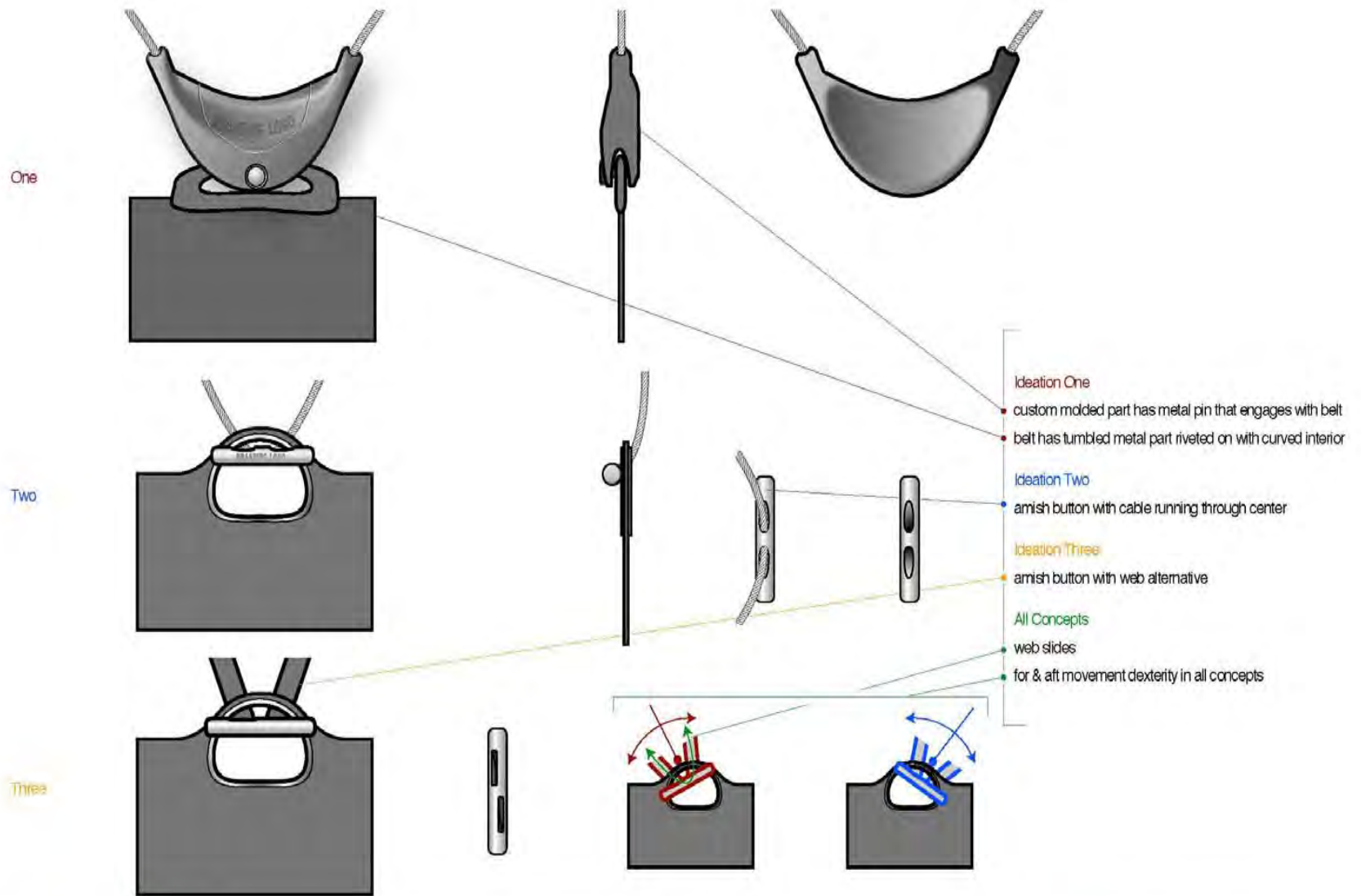
refined concept

vest

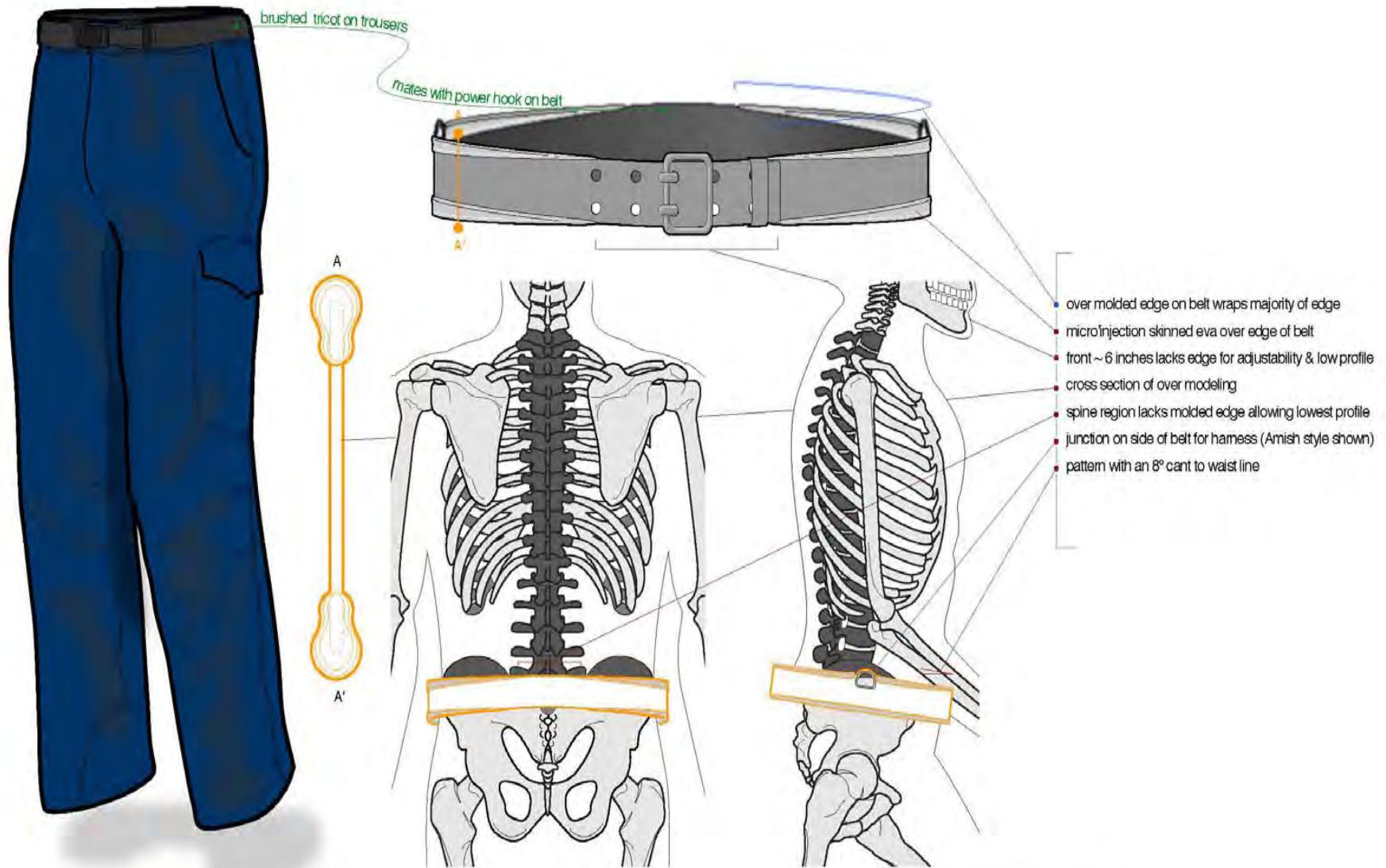


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	<p>NIJ project</p>	<p>refined concept</p>	<p>junction part</p>	
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NIJ project

refined concept

belt



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BOA Concealment Armor Carrier

- Originally considered as best solution, however, there were drawbacks.
 1. Had to be used with a very specific armor package or purchase of new armor from BPG
 2. Would have to be "fitted" to each individual along with body armor to maintain correct body armor coverage
 3. Location of BOA reels on front of carrier were easy to access, but made the system feel "bulky". This would have been accentuated by use with female officers as well as causing fit issues.
 4. BOA reels also have moving parts/cables-potential fail points and replacement part issues.



BOA Concealment Armor Carrier



A. Prototype of Modified Duty Shirt



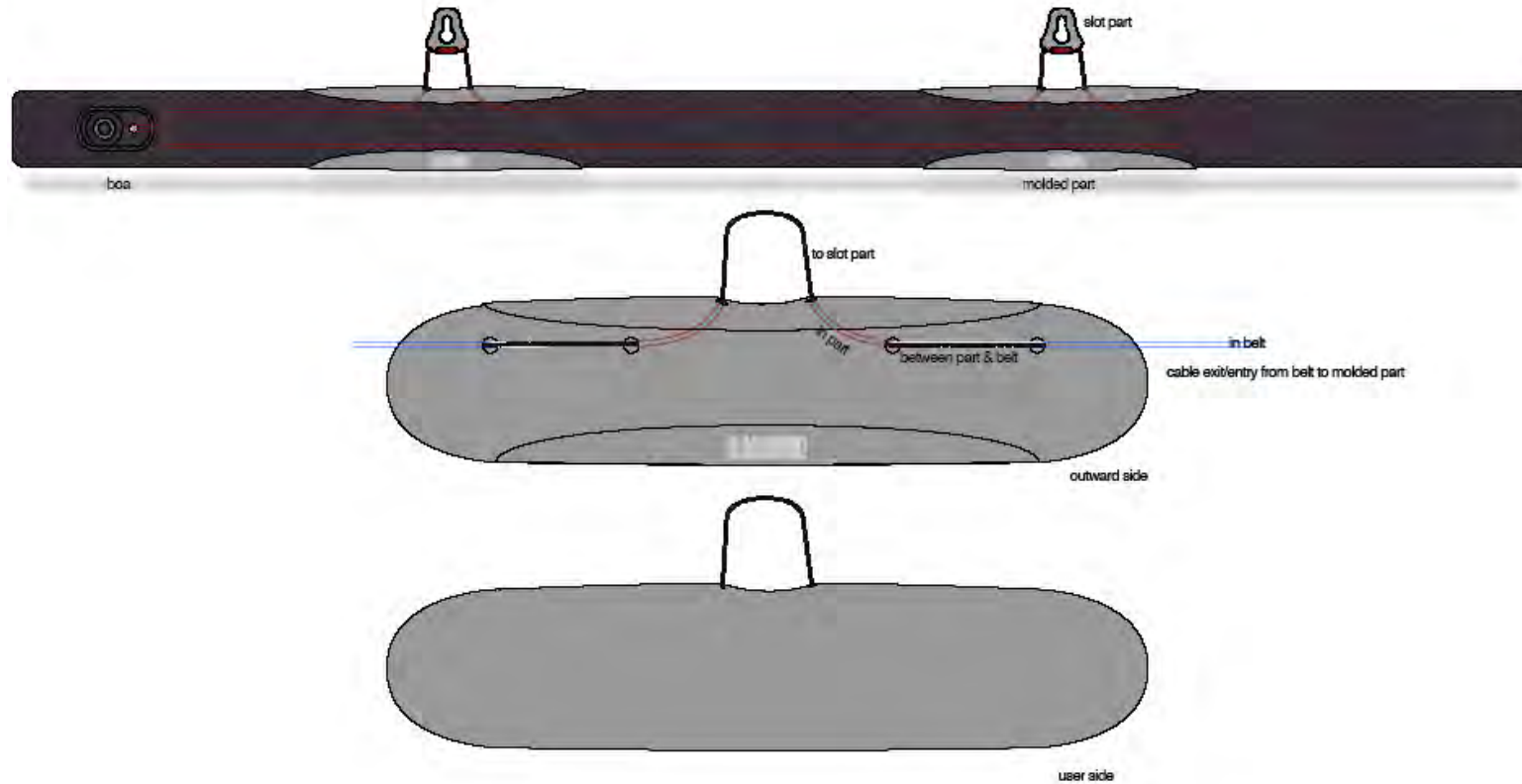
B. Horizontal Suspenders Slot in Prototype Duty Shirt

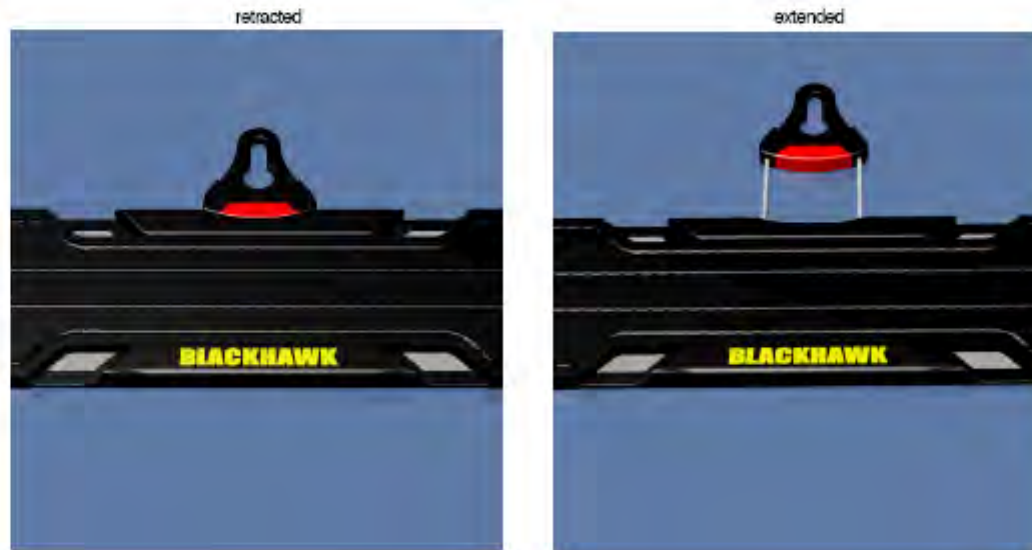


Belt with BOA Enclosed System

Concept #3

- This was an attempt to build the BOA system and adjustment thereof into the Duty Belt. While good in theory, daily usage as well as manufacturing proved to be problematic.





NW project

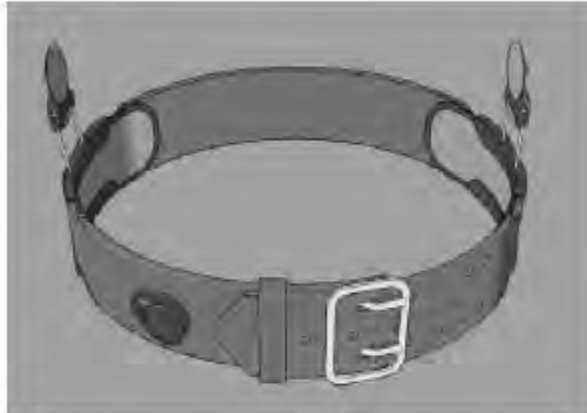
system refinements

initial molded parts







side



front



on user

	NJ project	system refinements	evolved overview	
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belt with adjustable hip pads



parts exploded

boa

nylon with TPU over-molding

slot-&-post part



NIJ project

system refinements

evolved concept

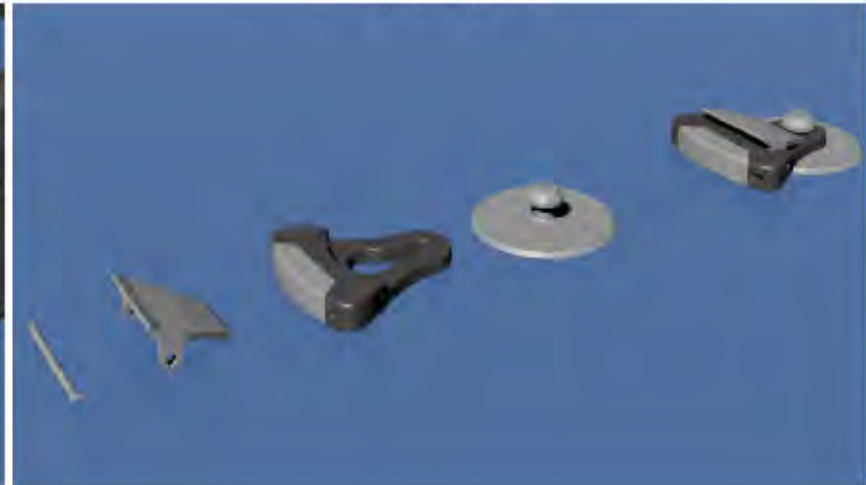


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2 inches **adjustability** forward & backward



slot & post parts exploded



custom parts



overmolded pad parts exploded



This was a concept that would route the BOA through the Duty Belt and attach to the Ballistic carrier.

The drawbacks to this system were very high

- Extremely complicated to manufacture and very specific parts
- BOA reel on the duty belt interfered with duty gear and lacing of duty belt accessories
- Very difficult to take on and off – restroom issues.

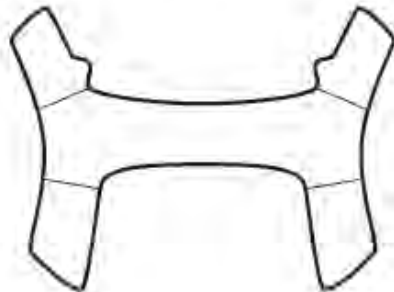


Simplified BOA Attachment System

Concept #4

•While this part and approach simplified manufacturing and did not use a specific carrier it had a high liability issue due to wrapping around the body armor panels and pulling the body armor coverage down away from the arm pit, we chose to move away from this approach back to a shoulder carried adjustment.

na project



testing feedback



prototype round three



date _____

name _____

prototype style: Single Boa Double Boa Triglide Web Hook Adjust Web

size & pattern comments _____

functionality comments _____

adjustment comments _____

buckle comments _____

belt interface _____

ease of use _____

simplified more? _____

additional comments _____







Straps mounted to side portions pulled down body armor sides rendering this design non-effective.



10.4 Photo of BOA Adjustable System

BOA Adjustable System

BOA Harness – Adjustable

- Moves the BOA to the sides of the body
- Universal Fit and can be used with any type of body armor
- Still had mechanical moving parts which could potentially fail in the field.



10.5 Photo of Velcro Strap Adjustable System

Velcro Strap Adjustable System

Velcro Harness- Adjustable

- Mechanical Version - least complicated
- Broad range fit for any type of body armor or body type
- No need to buy specific armor packages
- No moving parts to fail



Velcro Harness – Adjustable



Velcro Harness Adjustable



- The horizontal slit in the uniform shirt worked much better
- Longer slit worked for longer and shorter torso officers
- Required no additional pieces to modify

BLACKHAWK!

INSTRUCTIONS FOR ERGONOMIC DUTY BELT HARNESS

Part #44H001BK & 44H002BK



**Top Shoulder
Harness Adjustment**

1. Put on harness over body armor and adjust for comfort
2. There is extra webbing on top and sides of shoulder harness, so once adjusted you can trim/cut by stitch mark and burn edge
3. Attach belt keepers to duty belt – belt keepers are removable (side release buckle)
4. Pull up on ladderlock to release tension
5. Pull webbing down to shorten length, adjust to a comfortable position

Ladderlock

Webbing

Side Release Buckle for Quick Release

Belt Keepers



6. Put Duty Shirt on over top harness once it is adjusted to a comfortable position

Duty Shirt Modification Instructions:

As a guide for altering your duty shirt, please see below chart for measurements.

Standard distance from bottom of shirt up to bottom of opening:

Small	6 1/2"
Medium	7 1/4"
Large	8"
X-Large	8 3/4"
XXL	9 1/2"



- Instead of using the standard measurements provided in the above chart, you may prefer to put on your uniform shirt and duty belt as you normally wear them. Mark your shirt on both sides at the top of your belt (top edge of your pants), and start the slot opening at the marks.
- The slot opening should measure approximately 4" on the side seam.
- The edges of the slot opening should be reinforced with bar tack stitching to prevent shirt from tearing at the seam.

WARNINGS:

1. Be sure your placement of the duty belt harness does not interfere with drawing your handgun or other critical equipment.
2. At the shooting range, practice firing while wearing the duty belt harness to be sure it doesn't interfere with use of your handgun or shoulder weapons.
3. Practice unsnapping the duty belt harness using the quick release side release buckles, to be sure you can remove your duty belt quickly in an emergency.

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PGIM003BA

10.7 Professional Biographies of Key Project Team Members

Fred Storms came to BLACKHAWK! after a 23-year career in the U.S. Air Force. His duties for the Air Force included responsibility for the construction and refinement of air crew life support equipment. This included advancing both safety and comfort in the areas of survival gear, vests, flight suits and harnesses. Mr. Storms is in charge of breadboarding and prototyping all of the sewn gear at BLACKHAWK!, including the prototype duty suspenders involved in this project.

Clif Cook owned an outdoor products manufacturing company that did contract work for Michaels of Oregon. When his company was purchased by Michaels, he became that company's Vice-President of Manufacturing. Mr. Cook's patent for making holsters from a synthetic, tri-layer laminate allowed Michaels to successfully enter the law enforcement market with a then-unique product line. He eventually left Michaels to start Delta Design Goup with Eric Yeates (see below), advancing the development in the use of superior, non-traditional synthetics for law enforcement duty gear. He is now Vice President of Manufacturing at BLACKHAWK!, where in addition to his administrative duties he continues to take an active role in the research and design of new products, including load-bearing equipment and these prototype duty suspenders.

Eric Yeates began his formal design career at Michaels of Oregon, where he was assigned to the R&D shop, helping to develop that company's complete line of tri-layer laminate duty gear, as well as a number of duty and tactical holsters. He left Michaels to do contract design and consulting work, eventually joining Clif Cook to form Delta Design Group. When that firm was acquired by BLACKHAWK!, Mr. Yeates became Executive Director of BLACKHAWK!'s R&D operation in Norfolk, Virginia. He is responsible for the technical side of all product development within BLACKHAWK!'s ten divisions, including holsters, duty gear, military gear and clothing. His work at BLACKHAWK! has included design of holsters and molded duty gear, and extensive work with outside contractors in the areas of duty clothing, gloves and footwear.

Scott Ferros is BLACKHAWK!'s CFO. Mr. Ferros is a CPA licensed in several states. He holds a BBA from Western Michigan University and an MBA from the University of Portland. Prior to coming to BLACKHAWK! as its CFO, Mr. Ferros held a similar position at Michaels of Oregon.

Chuck Buis was a police officer with Dekalb County, Georgia. In addition to his primary duties as a detective, he was a certified defensive tactics instructor and officer survival instructor, leading to his now lifelong study of holsters, duty gear and related police equipment. He left police work to become a District Sales Manager for Smith & Wesson's Law Enforcement Division, then progressed from there to become involved in the design and sale of police duty gear for Michaels of

Oregon, eventually becoming Director of the Law Enforcement Division for that company. He is currently Category Manager of the Holster, Belt and Duty Gear lines of products for BLACKHAWK!, where he is instrumental in the design and selection of the products that make up these revolutionary lines of duty gear.

Tom Marx was a Chicago police officer, field training officer and competitive shooter. He left the Chicago Police Department to take a full-time job as an instructor at the Smith & Wesson International Training Academy, which provided him with further experience in evaluating the workings and shortcomings of police duty equipment. Due to his degree in mechanical engineering, S&W promoted Tom to a position in the marketing department, where he worked with the engineering department to develop new products for law enforcement. Tom formed S&W's Law Enforcement Support Team as a liaison with the engineering department, and was promoted to Director of Domestic Law Enforcement. He eventually left S&W to organize the Law Enforcement Division at Michaels of Oregon, where he worked in the overall development of that company's law enforcement product line, designing and/or patenting a number of new products himself. His work included coordinating a group that developed a synthetic duty belt of the California Highway Patrol, meeting the sophisticated ergonomic/physiological requirements of that agency. His involvement in this duty belt suspender project included product conceptualization through the advanced prototype development and design selection stage.

Zach West began his career in 1994, when he founded a small sewing company focused on custom climbing, biking and kayaking gear. In 1999 he joined Dana Design, where he did research for load-bearing systems, and worked with prototype construction and new product development. He has subsequently worked in R&D and new product development for K2 Sports, and done freelance design work through his design firm, IDEology. BLACKHAWK! has availed itself of Mr. West's extensive knowledge of fabrics, materials and manufacturing methods, load-bearing issues and human factors, in the conceptualization and design of the early prototypes in this project.

Emanuel Kapelsohn has been a nationally-recognized law enforcement firearms trainer and use of force consultant for some 30 years, training over 15,000 people since 1979. During that time, his trainees have ranged from police academy recruits to senior instructors, tactical teams and countersnipers. A graduate of Yale University (with honors) and Harvard Law School, he has been a practicing trial lawyer, has written and reviewed use of force policies for law enforcement agencies, has chaired shooting review boards, has developed training curricula for agencies, states and manufacturers of police weaponry, has written over 100 published articles in the field of weapons and police training, has authored, co-authored or edited training standards and reference works used on a national basis, and has represented officers involved in shootings. He was Technical Editor of The Police Marksman magazine, and an editor of The Firearms Instructor magazine. He has also worked as an expert witness in civil and criminal

cases, in state and federal courts throughout the United States, in matters involving police training and tactics, weapons, use of force, and shooting scene reconstruction. As an expert witness, his clients have included the US Department of Justice, several federal agencies, major cities and police departments, and the Attorney Generals' Offices of several states. He is an adjunct instructor in the Criminal Justice Department at Indiana University, where he teaches a course entitled "Police Use of Force." He has served on the board of directors of the International Association of Law Enforcement Firearms Instructors ("IALEFI") for 24 years and as vice president of that organization for some 18 years; was a charter member of the American Society of Law Enforcement Trainers ("ASLET"), and has been a member of the National Tactical Officers Association ("NTOA"), the International Law Enforcement Educators' and Trainers' Association ("ILEETA"), and the American Society for Industrial Security ("ASIS"). He has been an active reserve deputy sheriff for some 14 years, with experience including training, warrant service and patrol. Mr. Kapelsohn performs his consulting work and conducts law enforcement training programs through his own company, The Peregrine Corporation, which has been in continuous operation since 1985. Both in his work as a police trainer, and in his work as a reserve police officer, Mr. Kapelsohn has worn, used and tested a variety of duty belts, holsters and related police equipment over the past 30 years. He has worked as a consultant to manufacturers of holsters and other police equipment, and as an expert witness in cases involving weapon retention and holster design. His participation in this project is as a consultant, field tester, gatherer of data and feedback (by telephone interviews with the other field testers, and to assist in preparing the final technical report.

10.8 Telephone Survey Form (blank)

Questions for telephone survey of duty suspender testers:

2/4/09 rev.

1. Name
2. Sex
3. Age
4. Height
5. Weight
6. Law enforcement agency
7. Nature of duty (patrol, plainclothes, investigative, training, bike patrol, motorcycle, etc.) - If duty is divided among several functions, please list and provide approximate percentage of your time spent in each function.
8. How long have you been a law enforcement officer?
9. How long have you worn a duty belt on a regular basis?
10. Fitness level:
 - a. Do you consider yourself to be in good physical condition?
 - b. Do you consider yourself to be athletic?
 - c. Do you exercise regularly? (Describe)
 - d. Do you have any physical problems/illnesses/disabilities? (Describe)
 - e. Do you have/have you had back problems? (Describe)
 - f. Have you experienced numbness on the fronts of your upper legs/thighs?
 - g. Have you experienced strained/pulled muscles in your mid-back, possibly with pain radiating toward your upper back or shoulders?
 - h. Have you had sciatica?
 - i. Have you had hip problems/hip pain?

11. Have any of the above physical problems pre-dated your wearing of a police duty belt?
12. With regard to the above physical problems (note: specify which problem, if several are listed above):
 - a. How long has the problem persisted?
 - b. How frequently have you experienced the problem?
 - c. When you are not working, or are working in a non-uniform assignment where you are not wearing a duty belt, has the problem:
 1. gone away
 2. become less severe
 3. stayed the same
 4. gotten worse
13. List the items you carry on your duty belt:
14. Approximate weight of your duty belt with all equipment carried on it:
15. Type of duty belt you use: a. nylon b. leather c. laminate (synthetic with polymer stiffening insert)
16. Has wearing your duty belt ever caused you physical problems, pain, discomfort? (Describe)
17. Which model of Blackhawk duty suspenders did you test? a. Boa b. velcro adjustments
18. How many times did you wear the Blackhawk duty suspenders? _____ times
19. Between what dates did you wear them? From _____ to _____, 2008.
20. Length of time worn on each occasion: Average _____ hours per day
Shortest duration of wear on one occasion _____ hours.
Longest duration of wear on one occasion _____ hours.

21. Did you use uniform shirts modified to accommodate the suspender system? ____
22. Did you wear a ballistic vest while wearing the suspender system? ____
23. Did you use the suspender system while:
 - a. standing
 - b. walking
 - c. sitting in a car
 - d. sitting in a chair
 - e. other (bicycle patrol, motorcycle patrol, etc.)
24. Did you find the suspenders themselves comfortable to wear? (Rate from 1 to 10, 1 being the least comfortable, 10 being the most comfortable.)
25. Did using the suspenders make it more comfortable/easier to wear your duty belt? (Rate from 1 to 10, 1 being the least improvement, 10 being the most improvement.)
26. Did using the suspenders make you feel less tired/fatigued at the end of the day? (Rate from 1 to 10, 1 being the least improvement, 10 being the most improvement.)
27. Did using the suspenders (and modified duty shirt, if applicable) allow you to present a neat, professional appearance in uniform? (Rate from 1 to 10, 1 being the least neat/professional, 10 being the most neat/professional.)
28. How easy or difficult was it for you to put on the suspenders and modified uniform shirt, adjust the suspenders as needed, and remove the suspenders and shirt? (Rate from 1 to 10, 1 being the most difficult to put on/adjust/remove, and 10 being the easiest to put on/adjust/remove.)
29. Would you wear these suspenders on a regular basis?
30. Would you recommend these suspenders to other officers?
31. What do you feel is the best feature or benefit of these duty suspenders?
32. What do you feel is the worst feature or aspect of these duty suspenders?

Please give your suggestions for improving this feature or aspect:

10.9 Characteristics of Field Testers

Sex: Male: 60%
Female: 40%

Age: 25-29: 1
30-34: 3
35-39: 5
40-44: 4
45-49: 2
50-54: 2
55-59: 3

Age, mean: 41.95

Height Range, Male: 5'7" to 6'3"
Mean Height, Male: 5'10.8"
Weight Range, Male: 175 to 238 lbs.
Mean Weight, Male: 209.5 lbs.
Height Range, Female: 5'2" to 5'9"
Mean Height, Female: 5'5.25"
Weight Range, Female: 119 to 160 lbs.
Mean Weight, Female: 135.88 lbs.

Number of years in law enforcement, least: 2
Number of years in law enforcement, most: 36
Number of years in law enforcement, mean: 16.3

Number of years wearing duty belt, least: 2
Number of years wearing duty belt, most: 27
Number of years wearing duty belt, mean: 15.8

Law enforcement duties: patrol 80%
other* 5%
mixed patrol/other* 15%

(* "other" includes training, command, investigative, etc.)

Officers who consider self to be in good physical condition: 90%
Officers who consider self to be "athletic": 70%
Officers who exercise regularly (at least 3 times per week): 90%
Officers with back problems, post wearing duty belt: 55%
Officers with hip problems, post wearing duty belt: 35%
Officers with leg problems, post wearing duty belt: 30%
Has duty belt caused physical problems, pain, discomfort? yes 90%
no 10%

Items carried on duty belt:

- handgun & holster: 100%
- spare magazines & pouch: 100%
- handcuffs: one pair: 75%
- two pairs: 20%
- four pairs: 5%
- baton: 50%
- baton holder (only): 35%
- pepper spray: 65%
- flashlight: 55%
- flashlight holder (only): 5%
- radio: 100%
- cell phone: 10%
- pager: 5%
- Taser: 55%
- rubber gloves: 25%
- keys/key case: 30%
- knife/multi-tool: 10%
- weapon light: 10%

Approximate weight of duty belt with equipment:

- least: 9 lbs.
- most: 28 lbs.
- don't know: 35%
- average: 16.42 lbs.

Type of duty belt used:

- leather 75%
- nylon 10%
- synthetic/laminate 15%

10.10 Tabulation of Field Testing Results

Number of times prototype suspenders worn:	Round I: Least: 4x Most: 55x Mean: 24x
	Round II: Least: 8x Most: 30x Mean: 14.2x
	Round III: Least: 1x Most: 30x Mean: 9.72x
Length of time worn in hours, per occasion worn:	Shortest: 0.5 hour Longest: 18 hours Mean: 8.48 hours
Was body armor worn while wearing suspenders?	Yes: 90% No: 10%
Was modified uniform shirt worn while wearing suspenders?	Yes: 100% No: 0%
Were suspenders comfortable? (1-10 scale, 1=least, 10=most):	Range: 1 to 10 Mean: 6.43 Mean, male testers: 7.23 Mean, female testers: 5.44
Did suspenders make wearing duty belt more comfortable, easier? (1-10 scale, 1=least improvement, 10= most improvement)	Range: 1 to 10 Mean: 6.70 Mean, male testers: 8.0 Mean, female testers: 4.63
Did using suspenders make you less tired at end of day? (1-10 scale, 1=least improvement, 10=most improvement)	Range: 1 to 10 Mean: 5.10 Mean, male testers: 6.42 Mean, female testers: 3.13

Did wearing the suspenders and modified uniform shirt allow you to present a neat, professional appearance in uniform?
(1 – 10 scale, 1=least neat, professional, 10=most neat, professional) Range: 4 to 10
Mean 8.8

How difficult was it to put on the suspenders and modified uniform Shirt, adjust the suspenders as needed, remove suspenders and shirt at end of shift? (1 -10 scale, 1=most difficult, 10=easiest) Range: 1 to 10
Mean: 6.2
Mean, Male testers: 7.54
Mean, Female testers: 3.50

Would you wear these suspenders on a regular basis? Yes: 60%
No: 40%
Mean, Male testers: 92%
Mean, Female testers: 13%

Would you recommend these suspenders to other officers? Yes: 90%
No: 10%

Considering only the appearance of these suspenders and modified uniform shirt, do you believe your agency would allow officers to wear them? Yes: 95%
No: 5%

Considering the benefits, if any, you believe these suspenders provide, do you believe your agency would consider issuing them to its officers: No: 40%
Yes: 55%
Yes, to officers with physical problems or medical needs: 5%