

Demining Final Report

Problem

Personal Protective Equipment (PPE) is a deminer's last defense against landmine and unexploded ordnance (UXO) detonation. Specifically, PPE is effective against blast mine explosions, which are by far the most common in occurrence, and "secondary" (rock, sand, etc.) fragmentation. Fragmentation landmines are much more difficult to protect against, requiring more expensive, expansive, and heavy solutions. These however are also easier to detect, having extensive amounts of metal, and are utilized less often due to cost.

Currently there is a great need for more comfortable and useable personal protective equipment. The main problem is not that the equipment is ineffective, but rather that the equipment does not promote proper use. For face protection, there is one main option in the form of the visor. This consists of a molded polycarbonate sheet supported by a head strap or helmet. The current design is heavy causing substantial neck strain and promoting removal. Further, the visor suffers from fogging due to environmental humidity and more commonly the user's breath, promoting lifting the visor for unimpeded viewing. The visor also suffers from excessive scratching due to improper care, which again leads to lifting the visor for clear vision. Finally, the design puts a large barrier in front of one's mouth, impeding proper communication and once again encouraging raising the visor. All this visor lifting and removal makes for a cumbersome user experience and more importantly negates the purpose of the visor.

Deminer body armor is slightly better at accomplishing its purpose, coming in the form of an apron that protects from the lower neck down to the knees. This part of the PPE currently suffers from overheating problems, limited shoulder protection, no arm protection, and cumbersome rear straps, but is overall acceptable.

The current combination of individual visor protection and upper body protection does create one egregious problem, the disconnect that occurs in the neck region of the user. This occasionally fatal gap has been acknowledged as being a significant problem area, and is currently addressed by the addition of a "blast collar", the effectiveness of which is questionable.

Cost within such operations is a large issue, with tight budgets third world implementation requiring inexpensive and low maintenance equipment. Current visors are priced in the low-\$100s, with aprons in the mid-\$100s, and any replacement solutions would have to be no more expensive.

Finally, we acknowledge that there are similar projects being tested by Rofi at this time, namely an "all-in-one" design and an "ice hockey styled" mask, however, our group feels these designs still have outstanding issues and that therefore the project is still worth pursuing. (Appendix I)

Process

The current problems found in the personal protective equipment used for humanitarian demining, have lead this group to propose a new protection option through the integration of the visor and upper body protection. Having identified the problems we wish to address and having conducted research on general humanitarian demining, PPE, and to a limited extent on the needs and wants of the deminer, we followed by investigating various conceptual solutions with open minds, considering both the sophisticated and simplistic. (Appendix A)

Though the main emphasis of this project was generating a new design, in doing so there were various possible changes considered including: interchanging polycarbonate for Kevlar to reduce cost, adding padding to the inside of a visor to serve as an impact dampener during an explosion, leaving a side opening for communication, adding an internal attachment to eliminate fogging around the visually essential areas, adding reflective material to increase the visibility of deminers to others, attaching stacking “feet” to prevent visor scratching during storage, and adding interchangeable front face plates for less expensive scratch maintenance.

The next step in our product development was to use a set of criteria to narrow our concepts to the three most viable solutions. The criteria evaluated the design with respect to the issues outlined above, with each criterion evaluated on a scale of ± 2 , and the concepts with the highest total score were chosen for further development. (Appendix C) The chosen concepts are shown below:



Figure 1: Basic-T

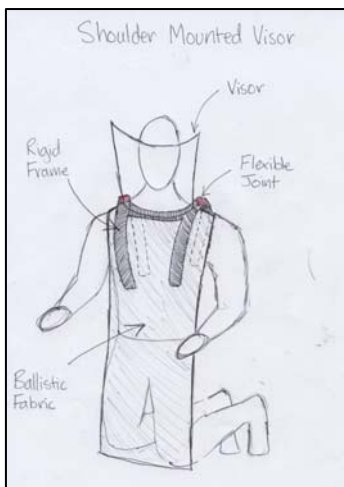


Figure 2: Shoulder-Mounted

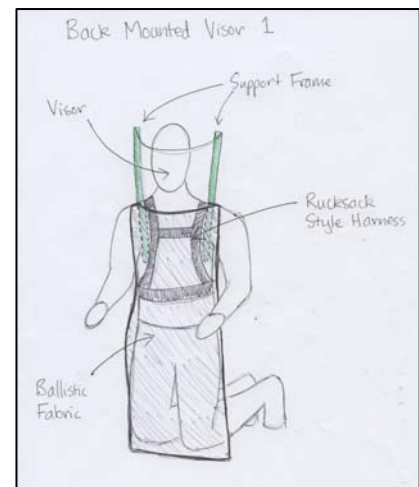


Figure 3: Back-Mounted

The back-mounted design scored lowest of the three chosen designs and an initial cardboard mockup verified this, showing the design to be cumbersome and impractical. The decision was taken at this point to discontinue this design.

The basic-T design scored well on the criteria in part due to its simple and straightforward design. Unfortunately during the design process it proved extremely difficult to implement the concept without removing this simplicity and so the concept

was not developed further. The group feels that the basic-T design still has good potential if the implementation issue can be overcome.

The initial cardboard mockup of the shoulder-mounted design showed that the design certainly had potential. The next stage of the design process was to produce an acrylic prototype. Acrylic was chosen as it is easy to work with.

Design

First Iteration

The first iteration of the shoulder-mounted prototype was manufactured from a single sheet of acrylic. The design was promising but had a number of lesser problems such as: shoulder and chest adjustability, sufficiency of side protection, visual impairment (due to a bend in the line of sight), comfort, weight, ventilation, snagging, and over-engineering (Lexan “straps” are unnecessary).

Lessons Learnt

The major lesson learned from the first iteration were that the shoulder-mounted design is viable, but not as a one-piece design. While this would be elegant from a manufacturing viewpoint, the compromise results in an issue of loose shoulder “straps”, which would not hold the visor during a blast and a susceptibility to cold bending on the flat surfaces.

Second Iteration

The second iteration aimed to address three major issues: looseness, cold bending, and vision impairment. To achieve these goals it was decided to move to a three piece design with the pieces joined using bolts. To address the problem of looseness the shoulder straps were moved closer together and depth adjustability was added. The geometry of the design was also altered so that the various components would reinforce each other and the dimensions and angles of the design were altered to improve visibility.

Lessons Learnt 2

The second iteration successfully addressed several of the issues from the first iteration. In particular the design substantially improved on fit and visibility. The issue of cold bending was partially addressed but concerns with regard to the over-engineering of the “straps” remain. The iteration also increased in weight and still lacked proper side protection particularly during rotational movements that occur when feeling for prongs. (Appendix H)

Further Work

The next stage in the project would be to address the persisting issues from the second iteration, mainly side protection. Once all the existing issues have been addressed, a Lexan prototype should follow. This must be blast tested to ensure effectiveness and then it must be determined exactly how the product would be produced given available manufacturing resources.

One possibility that was not pursued further is the addition of removable faceplates. This would reduce the impact of scratching as the faceplate could be replaced if it became scratched. Additionally if the faceplate can be easily raised it might help to readily address communication and ventilation problems.

The group developed a couple new rough concepts after the second iteration for considering in future iterations. (Appendix G)

As mentioned previously the group believes the basic-T design still has great potential and that any future groups should also consider this concept.

Furthermore it may be worth considering some of the other initial concepts, in particular the “diving helmet”, as some of the features in these concepts might be useful in future designs and iterations.

Lessons

A number of lessons were learned over the course of the semester. First, acrylic displays no visible signs of change upon heating and is bendable after approximately 30 seconds of heating per inch of bend length at a standard quarter inch material thickness when using a 1100W heat gun. Lexan, on the other hand, bubbles when heated and initial tests suggest it requires longer heating times than acrylic. Finally, as a cautionary note acrylic is extremely brittle and great care should be taken when handling it. The group managed to inadvertently shear several acrylic parts over the course of the semester.

Appendices

Appendices have been removed due to proprietary and copyrighted content.

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