Alternative Designs Report
Traumatic Brain Injury Reducing Army Combat Helmet

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Introduction

The proposed traumatic brain injury reducing army combat helmet has several key design features such as a custom made Kevlar shell, a layer of expanded polystyrene foam, and a lockable positionable chin guard. These features will be integrated into the design to provide ballistic, impact, and facial protection, respectively. While protection is of high importance when designing a combat helmet for military use, the comfort of the user must also be considered throughout the design process. The cooling ability, shape, and weight of the combat helmet all affect how comfortable the user will be while wearing it. The three following alternative designs aim to incorporate each aspect of comfort into the design of the traumatic brain injury reducing army combat helmet.

Alternative Design One: Cooling Design

The creation of a cooling mechanism to help relieve the accumulation of heat in a worn helmet is a task that is seemingly left alone in modern military helmets. Upon inspection of any of the helmets, there seems to be no true cooling property, although it could be argued that the newer lightweight helmets trade off protection for less mass and subsequently less heat generated around the head. The most likely reason why cooling has not been pursued is that it often trades protection away. For example, cooling in any type of non-combat helmet is generally accomplished by cutting holes in the helmet itself to allow the heat to rise upwards continually. This is not possible in a combat helmet because one a hole has been added to the material, the area around that hole now becomes the weakest structurally, thereby adding a potential risk of mechanical failure if a force is directed near this area. Also, the confidence of a soldier with holes in his/her helmet would most likely be undermined due to the creeping thoughts of shrapnel or a bullet going through the opening.

Thus, a material must be added that does the cooling. In commercial use an item commonly referred to an ice pack may help in this situation. Ice packs are simple containers with either purified water or gel refrigerant than can be frozen and then added to an area that will be cooled. They are also used therapeutically to help ease soreness in the body. Adding a sheet of these after the layers of expanded polystyrene can have the benefit of a cooling device without trading any protection. Although refrigerant contains better cooling properties, its potential
toxicity in the case of a spill makes it a poor choice. Therefore, purified water is a much better choice for this design.

The ice packs are in a reinforced bag and these small bags will be joined together to form a sheet of these ice packs. Because this sheet is made up of individual bags, it can be flexed to fit to the contours of the helmet. This sheet must be put in a place where it can be easily taken off and refrozen when necessary. Therefore, the layer right before the padding touching the head would be an optimal area to add this. The head padding would have to be removed, but since they already can be taken off in the currently used helmet design this should not be a problem. Also, the ice pack layer should not touch the head of the user because not only will the user’s head become too cold when in direct contact, the ice will melt rather quickly compared to when it is not in direct contact. Depending on the size of the sheet and the thickness of the ice, the amount of cooling this mechanism may provide varies from an hour to several hours. However, even when the ice is melted, the water will still remain cool for a long time due to water’s specific heat capacity and latent heat properties. Although this may not provide full cooling for an entire day, it is still much better than any cooling provided by any other combat helmet on the market. In addition, it may be viable for the user to have two sheets of ice packs so that the initial sheet can be replaced after about half a day’s work. Of course, this would mean that a soldier must have access to a freezer when off duty in order to refreeze his/her sheets of ice, but this should not be a large problem since they may be initially stored in a freezer that contains meat or other frozen foods if no other refrigeration facilities are in the area.

**Alternative Design Two: Neck Protection**

The client expressed a concern over the shape of the current Advanced Combat Helmet and how it occasionally caused soldiers to wear the helmet improperly, thus reducing the effectiveness of its protection. The client explained that under certain combat situations that called for lying on one’s stomach on the ground, many soldiers complained about helmet comfort. Since the back of the ACH is low, the rim and neck strap tend to dig into the soldiers’ necks, causing discomfort. To adjust this, many soldiers simply wear their helmets backwards, as the rim on the front of the helmet is higher and thus more comfortable. While it might improve comfort, this practice significantly reduces the protection provided by the ACH.
Since the neck needs to be protected, it is not reasonable to simply design the shell of the helmet to have a higher back rim. Instead, raising the back rim in addition to adding a neck guard would provide neck protection as well as comfort. To ensure ballistic protection, the neck guard will be made out of the same Kevlar material that the shell is made out of. Padding will also be placed on the inside for comfort. To accommodate to the various body positions a soldier may be in, the neck guard will be attached to the back of the helmet with a pin or a hinge. This will allow the neck guard to move along with the movements of the user. If the user is lying down, the neck guard will move up into the inner part of the helmet, placing minimal force on the neck. When the user stands up, the neck guard will move back down to its original position. These movements and the corresponding neck guard positions are shown in Figure 1.

Since the Advanced Combat Helmet is currently worn by all combat soldiers, this neck guard design will be accommodating to the variety of situations that a soldier may find themselves in. If they are required to lie on the ground, they will retain full head protection because the helmet will be worn properly, instead of backwards. If the soldier needs to jump up and stand quickly, the neck guard will simply fall back into its protective position. The neck guard is ideal in many situations due to the fact that it will move along with the user’s movements.

This design is not perfect however, as there are several negative aspects of this design. One problem is the removal of the neck strap that is currently part of the retention system. The

![Figure 1. Neck guard position while user is standing upright (left) and lying on their stomach (right).](image)
strap design will have to be altered to securely affix the helmet to the user’s head. An issue that could possibly occur while the user is lying on their stomach is if the neck guard moves up far enough to dig into the user’s head on the inside of the helmet. The occurrence of this situation would depend on the exact position the user is lying in, including the angle of extension of the head, but would cause discomfort to the user.

**Alternative Design Three: Lightweight Design**

The third design is a lightweight helmet, thinner helmet. The helmet will maintain similar shape to the others described, but be made on a slightly smaller scale with thickness and some padding sacrificed to lessen its heaviness. Previous military helmets made have received bad reviews from soldiers due to their heaviness and bulkiness. In addition, if the helmet is too large, it may reduce range of view and put the soldier at risk.

Various aspects of the helmet can be revised to make it lighter, less bulky, and provide a better range of view for the soldier. The current Advanced Combat Helmet (ACH) has a 0.400 inch thick shell. With a slight reduction of thickness, the heaviest component of the helmet can be greatly reduced. The new helmet would have a 25% reduction in thickness, resulting in a 0.300 inch thick shell. The shell is composed of a Kevlar matrix which is solid and dense, but provides very good protection against ballistics. With a reduction of thickness, some performance and protection would be lost in the case of ballistic impact, but there needs to be a balance between comfort and performance. In addition, the shaping and sizing of the helmet will be revised. The helmet will have a slightly smaller radius to allow for less padding in the system. The same thickness of polystyrene will be used in the helmet than in the previous designs. The polystyrene will aid against traumatic brain injury causing impacts. However, the comfort padding thickness will be lessened to additionally lighten the weight of the helmet and reduce bulkiness. The brim and side panels of the helmet will be moved upwards by about an inch to provide for a better field of view and a decrease in Kevlar material use.

The various modifications discussed will provide the soldier with a lighter and easier to carry helmet. Since the helmet will be slightly smaller, it will be less bulky and easy to store and carry by hand. The thinner helmet, with less padding around the soldier’s head, may also be cooler in the desert sun compared to the bulkier helmet. The helmet will provide the soldier with
an enhanced field of view due to the cut back design of the helmet. Negative aspects of these modifications include the lessened protectiveness of the helmet. A thinner Kevlar shell will not provide as much ballistic protection as the previous thicker one. In addition, less padding may provide less support for the soldiers head and be less comfortable.