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<b>4. TITLE AND SUBTITLE</b>	<b>5a. CONTRACT NUMBER</b>
	<b>5b. GRANT NUMBER</b>
	<b>5c. PROGRAM ELEMENT NUMBER</b>

<b>6. AUTHOR(S)</b>	<b>5d. PROJECT NUMBER</b>
	<b>5e. TASK NUMBER</b>
	<b>5f. WORK UNIT NUMBER</b>

<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b>	<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>
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<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>	<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>
	<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>

**12. DISTRIBUTION/AVAILABILITY STATEMENT**

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**

**15. SUBJECT TERMS**

<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>
<b>a. REPORT</b>	<b>b. ABSTRACT</b>	<b>c. THIS PAGE</b>			<b>19b. TELEPHONE NUMBER (Include area code)</b>



## How Satisfied Are Soldiers with Their Ballistic Helmets? A Comparison of Soldiers' Opinions about the Advanced Combat Helmet and the Personal Armor System for Ground Troops Helmet

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Many factors are considered during ballistic helmet design, including comfort, weight, fit, and maintainability. These factors affect soldiers' decisions about helmet use; therefore, rigorous research about soldiers' real-life experiences with helmets is critical to assessing a helmet's overall protective efficacy. This study compared soldiers' satisfaction and problem experience with the advanced combat helmet (ACH) and the personal armor system for ground troops (PASGT) helmet. Data were obtained from surveys of soldiers at Fort Bragg, North Carolina. Ninety percent of ACH users were satisfied overall with their helmet, but only 9.5% of PASGT users were satisfied ( $p < 0.001$ ). The most frequently reported problems for the ACH involved malfunctioning helmet parts. The most frequently reported problems for the PASGT involved discomfort. This analysis indicated that there was a strong soldier preference for the ACH over the PASGT, which could enhance its already superior protective qualities. It also demonstrated the usefulness of soldiers' assessments of protective equipment.

### Introduction

Many factors are considered during ballistic helmet design.<sup>1</sup> One major factor is the ability to defeat missiles. Other important factors, known as human use factors, are related to the ways in which a helmet affects the wearer and influence the probability that a helmet will be worn.<sup>2</sup> These factors include comfort, fit, weight, and maintainability. When developing a helmet, designers must make tradeoffs between these factors. For example, one important tradeoff that designers must always make is between the amount of ballistic protection and weight. Increasing the amount of ballistic protection a helmet provides also increases its weight. As its weight increases, a helmet becomes more uncomfortable and burdensome to the wearer, which results in the helmet not being worn as often as it should be. When problematic human use factors reduce helmet use, military personnel increase their risk of sustaining brain injuries, because a helmet cannot protect against injury when it is not used.

According to Carey,<sup>1</sup> U.S. Army neurosurgeons who served in Vietnam were concerned about soldiers sustaining unnecessary

brain injuries from small fragments because they were not wearing their ballistic helmets. Lack of comfort and heat retention were cited as the reasons why soldiers were not wearing their helmets. Other research by Carey et al.<sup>3</sup> on a series of 20 fatal and 8 nonfatal, combat-related, head wound cases from Vietnam found that all of the fatal head wounds resulted from fragments striking unprotected areas of the head and not the helmets. Those authors also identified four cases in which helmets prevented brain injuries when fragments struck the victims' heads. Because of this link between helmet use and brain injury risk, it is important to identify any human use characteristics that could possibly reduce helmet use by soldiers.

The methods used to evaluate helmets play an important role in the quality and usefulness of the information that is produced. Helmets used by the U.S. Army undergo rigorous testing in laboratories during initial development and even after they have been fielded. However, in evaluations of human use characteristics, it is important to supplement laboratory findings with rigorous survey methods designed to obtain information directly from large numbers of soldiers who used their helmets in an operational setting, such as during an actual deployment or a combat training exercise. This ensures that the soldiers' assessments are based on realistic experiences. It is also important to use a carefully designed survey instrument that combines both open- and closed-ended questions. Open-ended questions allow soldiers to comment about their helmets in detail, whereas closed-ended questions provide standardized data that are conducive to quantitative analysis.

This article presents the results from a study designed to elicit soldier feedback about their helmets by using the survey methods described above. It compares soldiers' opinions about the two main types of ballistic helmets currently in use by the U.S. Army, namely, the advanced combat helmet (ACH) (Fig. 1) and the personal armor system for ground troops (PASGT) helmet (Fig. 2). The PASGT has been widely used by the U.S. Army since the early 1980s and is still in widespread use. In 2003, however, the Army began replacing it with the ACH. The ACH is based on the Special Operations Forces' highly successful modular integrated communication helmet. The ACH, compared with the PASGT, features increased blunt-impact and ballistic protection, improved field of view, better three-dimensional sound localization, better compatibility with mission equipment, and a more comfortable fit and is ~0.5 pounds lighter.<sup>4</sup> These improvements should translate into improved soldier performance, reduced combat injuries, and a strong user preference for the ACH.

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The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

This manuscript was received for review in May 2006. The revised manuscript was accepted for publication in January 2007.



Fig. 1. The ACH (official U.S. Army photograph).



Fig. 2. The PASGT (official U.S. Army photograph).

### Methods

Data from a convenience sample of 1,123 soldiers stationed at Fort Bragg, North Carolina, were analyzed. These soldiers were participating in an institutional review board-approved observational study of the incidence and outcomes of traumatic brain injuries in U.S. Army paratroopers.<sup>5</sup> This included an evaluation of the efficacy of the ACH and PASGT in reducing the incidence and severity of traumatic brain injuries. The data used for this analysis were collected from July 2004 through January 2005.

The data for this analysis were obtained from a survey that asked the soldiers to identify the type of combat helmet they were using at the time the survey was administered (current helmet type) and whether they had used any other type of combat helmet in addition to their current helmet in the 24 months before completing the survey (Fig. 3). The soldiers were also asked to rate how much they "liked" or "disliked" their current helmet with respect to five characteristics, that is, comfort, fit, weight, maintainability, and overall impression. In addition, the soldiers were asked whether they had experienced any problems with their current helmet in the 24 months before completing the survey and whether they had been deployed outside the continental United States (CONUS) during those same 24 months.

The  $\chi^2$  test was used to determine whether there were differences in the percentages of ACH and PASGT users who were satisfied with their helmet with respect to each of the five characteristics listed in Figure 3. Soldiers who selected "like strongly" or "like somewhat" for a particular characteristic were considered to have been satisfied with that characteristic. Those who selected the "dislike somewhat" or "dislike strongly" responses were considered to have been dissatisfied with the particular characteristic. Soldiers who selected "neutral" were considered to be neither satisfied nor dissatisfied with the particular characteristic.

A  $\chi^2$  test was also performed to determine whether there was a difference in the percentages of ACH and PASGT users who experienced problems with their helmets. The specific helmet problems reported by these soldiers were grouped according to problem type, and the percentages of ACH and PASGT users reporting each type of problem were calculated. A tabular analysis was then used to determine which types of problems were the most prevalent for each helmet type.

A subset analysis was performed to determine whether soldiers' opinions about their current helmets were influenced by previous experience with a different helmet. These analyses used data from soldiers who had been in the Army 2 years or less, because we only had data about previous helmet use for the 24 months prior to completion of the survey. The  $\chi^2$  test was used to determine whether any differences were statistically significant.

Another subset analysis was performed to determine what impact, if any, being deployed might have had on soldiers' opinions of their helmets. These analyses used data from ACH and PASGT users who had been deployed outside the CONUS in the 24 months before completion of the survey and data from users who had not been deployed outside the CONUS. Soldiers who used both the ACH and PASGT during those 24 months were not included in the deployment-related analyses, because the helmet they used while deployed might have been different from the helmet they rated in the survey. The  $\chi^2$  test was used to determine whether any differences were statistically significant.

### Results

Table I indicates that 98% of the 1,123 respondents identified their current helmet as either the ACH ( $n = 535$ ) or PASGT ( $n = 570$ ). Seven respondents (0.6%) identified their current helmet as "other" and 11 respondents (1%) did not identify their current helmet. Only data from ACH and PASGT users were analyzed. Table I also indicates that 343 ACH users (64%) had not used another helmet type in the 24 months before completing the survey, whereas 185 (35%) had used another helmet type. Ninety-five percent of the ACH users who had used another helmet type reported using the PASGT. Among PASGT users, 415 (73%) had not used another helmet type, whereas 138 (24%) had used another helmet type. Eighty-five percent of the PASGT users who had used another helmet type reported using the ACH.

### Helmet Satisfaction

Figure 4 shows that more ACH users than PASGT users were satisfied with their helmet for all five of the characteristics eval-

A. What type of combat helmet are you currently using?  
 ACH     Kevlar (PASGT)     Other

B. Please tell us how you feel about your current combat helmet for each of the characteristics listed below.

	Like Strongly	Like Somewhat	Neutral	Dislike Somewhat	Dislike Strongly
Comfort	<input type="checkbox"/>				
Fit	<input type="checkbox"/>				
Weight	<input type="checkbox"/>				
Maintainability	<input type="checkbox"/>				
Overall Impression	<input type="checkbox"/>				

C. Have you experienced any problems with your current combat helmet in the last 24 months?  
 Yes     No     Don't Know

D. If you experienced problems, please describe them here. \_\_\_\_\_

E. Did you use any other type of combat helmet in the last 24 months?  
 Yes     No     Don't Know

F. What other type of combat helmet did you use in the last 24 months?  
 ACH     Kevlar (PASGT)     Other

G. Were you deployed outside the CONUS in the last 24 months?  
 Yes     No     Don't Know

Fig. 3. Survey questions used to evaluate helmets.

uated ( $p < 0.001$  for each of the five characteristics). More than 90% of ACH users were satisfied with their helmet's comfort, and >80% were satisfied with its fit, weight, and overall impression. Sixty-eight percent of ACH users were satisfied with their helmet's maintainability. Figure 4 also indicates that very few PASGT users were satisfied with their helmet. Only 30% of PASGT users were satisfied with their helmet's maintainabil-

ity, and 15% were satisfied with its fit. Less than 10% of PASGT users were satisfied with their helmet's comfort, weight, and overall impression.

**Helmet Problems**

Figure 4 shows that 25% ( $n = 132$ ) of all ACH users experienced problems with their helmet, whereas 30% ( $n = 169$ ) of all PASGT users experienced problems with their helmet. Although the difference between these proportions was not large, it was statistically significant ( $p < 0.001$ ). The types of problems most frequently reported for each helmet were distinctly different. The most frequently reported problems with the ACH were related largely to malfunctioning parts, whereas the most frequently reported problems with the PASGT were related largely to discomfort.

Table II lists the types of problems identified by ACH users. For each problem type, it shows the percentage of ACH users with helmet problems ( $n = 132$ ) who reported the problem and the percentage of all ACH users ( $n = 535$ ) who reported the problem. Forty-five percent of the soldiers who reported problems with the ACH (11% of all ACH users) identified problems with screws. Most of those comments were about screws either falling out of the helmet or becoming loose. Twenty-four percent of the soldiers with ACH problems reported problems with

TABLE I

DISTRIBUTION OF CURRENT HELMET TYPES ACCORDING TO USE OF ADDITIONAL HELMET TYPES IN THE 24 MONTHS BEFORE COMPLETING THE SURVEY

Current Helmet Type	No.			Total
	Used One Helmet Type	Used More than One Helmet Type	Did Not Indicate Whether Another Helmet Type Was Used	
ACH	343	185	7	535
PASGT	415	138	17	570
Other	6	1	0	7
Missing	5	4	2	11
Total	769	328	26	1,123

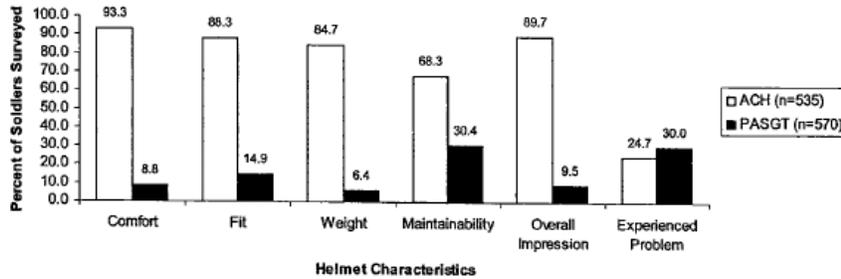


Fig. 4. Percentages of ACH and PASGT users who were satisfied with their helmets, according to helmet characteristic. All differences between the ACH and PASGT were statistically significant ( $p < 0.001$ ).

straps. Those problems usually involved straps becoming loose, but some soldiers reported that strap components, such as buckles and brackets, broke.

Seventeen percent of the soldiers who had problems with the ACH reported problems with pads (Table II). There were two main types of problems associated with the pads, that is, pads becoming hard in cold weather and pads becoming loose or falling out. Another of the more frequently reported problems with the ACH was difficulty obtaining spare parts. Fourteen percent of the soldiers who reported problems with the ACH identified this as a problem. Since this survey was administered, however, the Army has taken steps to remedy the spare parts availability problem, and it is likely that soldiers' perceptions have changed.

Table III lists the types of problems identified by PASGT users. For each problem type, it shows the percentage of PASGT users with helmet problems ( $n = 169$ ) who reported the problem and the percentage of all PASGT users ( $n = 570$ ) who reported the problem. Four of the six most frequently identified problem categories for the PASGT involved discomfort. Twenty-one percent of the soldiers who reported problems with the PASGT (6% of all PASGT users) stated that it caused headaches, especially after being worn for extended periods of time. Nineteen percent of the soldiers with PASGT problems indicated that the helmet was too heavy. Eleven percent of the soldiers reported that the helmet caused skin irritation or cuts on their heads, including scratches, indentations in the skin, bald spots, hot spots, and reduced circulation. Sixteen percent of the soldiers simply stated that the PASGT was uncomfortable, without indicating any specific type of discomfort.

Another type of problem that was frequently reported for the

PASGT involved fit (Table III). Many of the soldiers reported that the PASGT fit them poorly. Examples of poor fit were that the helmet was unstable, it was issued without being properly fitted, and it was loose-fitting. Strap problems were also among the more frequently reported problems. Many soldiers who reported problems with straps indicated that the chinstraps were uncomfortable. Others indicated that the chinstraps broke or that components of the chinstrap, such as fasteners, did not work properly.

**Effects of Previous Helmet Experience on Satisfaction and Problem Experience**

Satisfaction levels and problem experience among soldiers who had used only the ACH were similar to those of ACH users who had also used the PASGT in the 24 months before completing the survey (Table IV). None of the differences among ACH users was statistically significant. Similarly, satisfaction levels and problem experience among soldiers who had used only the PASGT were similar to those of PASGT users who had also used the ACH (Table IV).

TABLE II  
TYPES OF PROBLEMS IDENTIFIED FOR THE ACH

Problem Types	Percentage of ACH Users with Helmet Problems (n = 132)	Percentage of All ACH Users (n = 535)
Loose screws	44.7	11.0
Loose/broken straps	23.5	5.8
Hard/loose pads	16.7	4.1
Spare parts unavailable	14.4	3.6
Heat retention	6.1	1.5
Poor fit	2.3	0.6
Falls off head	2.3	0.6
Other	4.5	1.1

TABLE III  
TYPES OF PROBLEMS IDENTIFIED FOR THE PASGT

Problem Types	Percentage of PASGT Users with Helmet Problems (n = 169)	Percentage of All PASGT Users (n = 570)
Causes headaches	20.7	6.1
Too heavy	18.9	5.6
Uncomfortable	16.0	4.7
Poor fit	13.6	4.0
Uncomfortable straps	12.4	3.7
Causes cuts and skin irritation on the head	11.2	3.3
Loose screws	5.9	1.8
Causes neck/back problems	5.9	1.8
Difficulty shooting from prone position	5.3	1.6
Problems with webbing	4.7	1.4
Problems with night vision equipment	3.0	0.9
Heat retention	3.0	0.9
Interferes with body armor	2.4	0.7
No padding	2.4	0.7
Restricts hearing	2.4	0.7
Falls off head	2.4	0.7
Other	6.0	1.8

TABLE IV  
PERCENTAGES OF CURRENT ACH AND PASGT USERS WHO WERE SATISFIED WITH THEIR HELMETS ACCORDING TO PREVIOUS HELMET EXPERIENCE IN THE 24 MONTHS BEFORE COMPLETING THE SURVEY

Previous Helmet Experience	Percentage Satisfied With Helmet Characteristic					
	Comfort	Fit	Weight	Maintainability	Overall Impression	Experienced Problems
Current ACH users						
Used ACH only (n = 149)	94.0	88.6	87.8	63.0	89.9	27.5
Used ACH and PASGT (n = 99)	93.9	84.5	84.0	69.9	88.7	22.2
Current PASGT users						
Used PASGT only (n = 247)	9.0	15.9	7.8	33.6	8.5	27.3
Used PASGT and ACH (n = 62)	4.8	6.5	3.3	23.0	6.5	35.5

No differences were statistically significant. Only those who had been in the Army  $\leq 2$  years were included.

### Effects of Deployment on Satisfaction and Problem Experience

Deployment history affected soldiers' perceptions about some aspects of the ACH. Eighty-one percent of ACH users who had not been deployed were satisfied with the comfort of their helmet, but 95% of those who had been deployed were satisfied with that characteristic (Fig. 5). Being deployed had the opposite effect on views about the maintainability of the ACH. Eighty-nine percent of ACH users who had not been deployed outside the CONUS were satisfied with the maintainability of their helmet, but only 65% of those who had been deployed were satisfied with that characteristic (Fig. 5). Both of these differences were statistically significant ( $p = 0.004$  for comfort;  $p = 0.036$  for maintainability). Deployment did not affect satisfaction levels regarding the fit and weight of the ACH. It also did not affect soldiers' overall impression of the ACH. However, these results should be read cautiously, because of the small number of nondeployed ACH users who completed the survey.

Deployment history had little effect on soldiers' perceptions about the PASGT (Fig. 6). Fewer deployed soldiers (11.1%) than nondeployed soldiers (18.7%) were satisfied with the fit of the PASGT ( $p = 0.033$ ). Also, fewer deployed soldiers (28.5%) than nondeployed soldiers (36.1%) were satisfied with the maintainability of the PASGT ( $p = 0.021$ ). However, despite being statistically significant, these differences were small. Deployment history did not result in any statistically significant differences in satisfaction with the comfort and weight of the PASGT. It also did not result in a difference in the soldiers' overall impression of the PASGT.

### Discussion

This analysis indicated that more ACH users than PASGT users were satisfied with the comfort, fit, weight, and maintainability of their helmet (Fig. 4). It also indicated that the percentage of ACH users who experienced problems with their helmets was slightly lower than the percentage of PASGT users who experienced problems (Fig. 4), but the specific types of problems reported by ACH and PASGT users were different (Tables II and III). The most commonly reported problems among ACH users involved malfunctioning parts, and several soldiers reported difficulties obtaining replacement parts. The most commonly reported problems among PASGT users were related to that helmet's weight and lack of comfort. Satisfaction levels and problem reports were similar regardless of whether soldiers used both the ACH and PASGT or just one of the two (Table IV).

Satisfaction levels remained high among ACH users and low among PASGT users regardless of whether the respondents had been deployed outside the CONUS. However, some variation in satisfaction among ACH users occurred when deployment history was taken into account. More deployed ACH users than nondeployed ACH users were satisfied with the comfort of their helmet. However, fewer deployed ACH users were satisfied with their helmet's maintainability, compared with those who were not deployed. These results are not surprising, considering that large numbers of soldiers were recently deployed to active war zones where they needed to wear their ballistic helmet more often than did those who were not deployed outside the CONUS. It is possible that the need to wear ballistic helmets more fre-

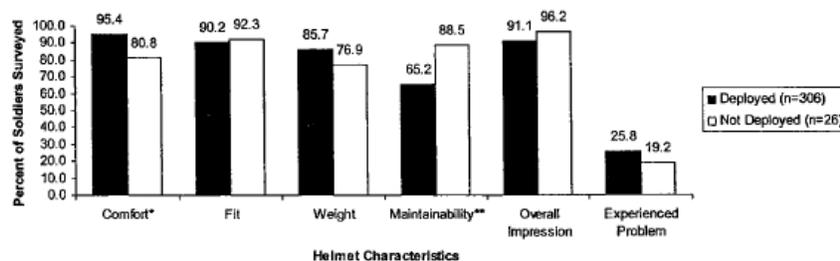


Fig. 5. Percentages of deployed and nondeployed ACH users who were satisfied with their helmets according to helmet characteristic. Only those who used a single helmet were included. \*, Difference between deployed and nondeployed users was statistically significant ( $p = 0.003$ ). \*\*, Difference between deployed and nondeployed users was statistically significant ( $p = 0.036$ ).

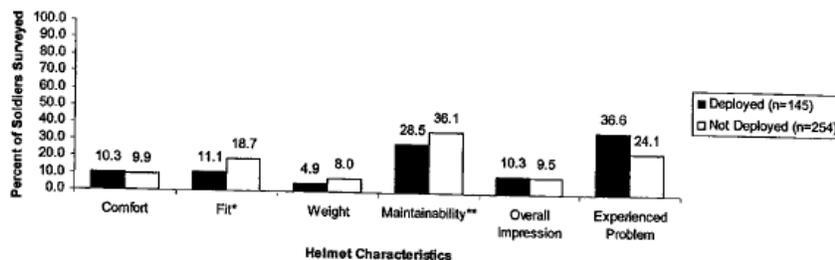


Fig. 6. Percentages of deployed and nondeployed PASGT users who were satisfied with their helmets, according to helmet characteristic. Only those who used a single helmet were included. \*, Difference between deployed and nondeployed users was statistically significant ( $p = 0.033$ ). \*\*, Difference between deployed and nondeployed users was statistically significant ( $p = 0.021$ ).

quently while deployed might have resulted in greater appreciation of the improved comfort of the ACH. The need to wear helmets more frequently might also account for the lower level of satisfaction with the maintainability of the ACH among deployed soldiers, because it is possible that increased use of the helmet resulted in more "wear and tear" on the ACH's components. The ACH's advantage over the PASGT in terms of human use characteristics suggests that soldiers might be willing to wear it more frequently than the PASGT, which could decrease their risk of sustaining a brain injury. Unlike the PASGT, which had many problematic human use characteristics, the only problematic characteristic of the ACH was maintainability. However, the ACH's maintainability problems may be short-lived, because the Army has taken steps to increase the availability of spare parts for the ACH; as more spare parts become available, the frequency of complaints about the ACH's maintenance problems should decrease. The Army is also retrofitting chin straps on the ACH, which should decrease complaints about the helmet.

A major strength of this analysis is that it relied on data from a large sample of soldiers (ACH,  $n = 535$ ; PASGT,  $n = 570$ ). Another strength is that the soldiers surveyed used their helmets in an operational environment, rather than in an experimental setting. A weakness is the small number of ACH users ( $n = 26$ ) who had not been deployed outside the CONUS. However, as more surveys are collected at Fort Bragg, the amount of data available for nondeployed ACH users may increase.

## Conclusions

This analysis has shown that soldiers are more satisfied with the ACH than with the PASGT. The high level of satisfaction with the ACH might motivate soldiers to wear it more often than the PASGT, thereby reducing the risk of sustaining a brain injury. The analysis has also demonstrated the usefulness of systematically surveying large numbers of soldiers to acquire information about helmets. It is important for the Army to continue assessing soldiers' levels of satisfaction with their ballistic helmets, especially when existing helmets are modified or new helmets are being considered. This can provide additional data that can augment the laboratory studies that are routinely used to evaluate helmets.

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