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Joint Service General Purpose Mask (JSGPM) Human Systems Integration (HSI) Evaluation: Comfort and Vision Correction Insert Stability Evaluation

by Lamar Garrett, William H. Harper, Samson V. Ortega, and Timothy L. White

ARL-TR-3900 **September 2006**

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Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5425

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14. ABSTRACT

Soldiers, first responders, and search-and-rescue personnel are among those whose job requirements include exposure to hazardous and toxic elements. The Joint Service General Purpose Mask (JSGPM), XM50/XM51 is being developed as the next generation of respirators for all ground personnel of the U.S. Armed Forces. The JSGPM, together with personal protective equipment, allows the operators the flexibility to tailor their protection, based on mission threat, thereby minimizing weight, bulk, and heat stress. This study looked at JSGPM from a systems development perspective and evaluated comfort, stability, donning and doffing procedures in comparison to the M40 series mask. Four configurations (M40 series mask with Joint Service Lightweight Integrated Suit Technology [JSLIST, jacket only], XM50 with hood, XM50 with JSLIST [jacket only], and the XM50 with JSLIST [jacket only] and modified mask beard) were tested. The analysis showed that there were no significant differences among any of the characteristics rated for the responses to the comfort and vision correction inserts questionnaire. The results of the comparative questionnaires showed that 94% of the Soldiers rated the XM50 mask as better than the M40 series mask.

15. SUBJECT TERMS

configuration; equipment; human factors; JSGPM; mask; M40 series; NBC; XM50

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1. Background

The Joint Service General Purpose Mask (JSGPM), XM50/XM51, is being developed as the next-generation general purpose respirator for all ground personnel of the U.S. Armed Forces. The JSGPM is a lightweight, protective mask system, which may be fielded in two versions (consisting of XM50 mask, carrier, and accessories). One version is used for field and shipboard operations (XM50), and the other version is used by combat vehicle crews (XM51). The JSGPM incorporates state-of-the-art technology to protect U.S. forces from all known threats. The mask components are integrated to reduce the impact on the wearer's performance and to minimize equipment compatibility issues. The mask, combined with other nuclear, biological, and chemical (NBC) protective equipment, provides an integrated NBC protective system. The protective mask, together with other new and developmental personal protective equipment, allows the operators the flexibility to tailor their protection, based on mission threat, thereby minimizing weight, bulk, and heat stress. The final design of the JSGPM meets numerous performance specifications ranging from contaminant filtering capabilities to packaging size to user comfort. Unique features of the field (XM50) and combat vehicle (XM51) versions of the JSGPM concepts include a single, panoramic lens to minimize visual encumbrance, lower inspiratory (30 mm of H_2O at 85l/min) and expiratory (10 mm of H_2O at 85l/min) air flow resistances. This is a significant improvement when compared to predecessor mask systems such as the M40 and MCU-2/P higher inspiratory (50 mm of H_2O at 85l/min) and expiratory (24 mm of H_2O at 85l/min) air flow resistances. However, when one changes the M40/MCU2/P, C2A1 filter canister, differences between filter lots may result in a slight change in the breathing resistance by ±5 mm.

The Product Manager (PM), JSGPM, Edgewood Chemical and Biological Command, Maryland, requested the U.S. Army Research Laboratory's (ARL) Human Research and Engineering Directorate to conduct a comfort and vision correction insert stability study and to assess other human factors issues associated with the JSGPM.

1.1 Objectives

The objectives of this study were four-fold:

- Evaluate the comfort level with a JSGPM, with and without a modified mask beard,
- Evaluate the stability of the interface between the JSGPM protective mask and a vision correction insert during wear,
- Evaluate the war fighter's ability to don and doff the JSGPM effectively, and
- Compare the comfort, stability, and correct wearing of the JSGPM against the current NBC protective mask system, the M40 series mask.

1.2 Participants

The 34 male participants used during this study, which was conducted at Fort Drum, New York, held the following military occupational specialties (MOS): 11B, 13D, 19D, 21B, 25F, 63B, 63J, 74D, 88M, 91W, and 98C. The participants ranged in age from 19 to 38 years (mean = 24.8 years), with 7 months to 20 years of military service (mean = 3.4 years). Twelve Soldiers elected not to participate in the study. One Soldier elected not to participate after completing the first trial. Two Soldiers were unable to participate during the last three days of this study, partly because of their medical profiles, and five participants did not participate on the last day of the trials.

1.2.1 Pre-test Orientation and Volunteer Agreement

Investigators assembled the Soldiers and provided an orientation about the purpose of the study and their participation. The Soldiers were briefed about the objectives of the study and procedures for each experimental condition. The Soldiers were informed how the test results were to be used and the benefits the military expected from this study.

Following the pre-test orientation, the volunteer agreement affidavit (see appendix A) was explained and its contents verbally presented. Afterwards, time was taken to address questions from the Soldiers. The Soldiers were then given the volunteer agreement affidavits, which they read and signed if they decided to volunteer. If the Soldier chose not to participate, he was instructed to report back to his unit.

1.2.2 Health and Demographics

The volunteer Soldiers completed a health and demographics questionnaire (see appendix B) to document information related to their medical history and level of experience wearing respiratory protection equipment. The investigators asked the Soldiers if any of them had a medical profile or history that would jeopardize their safety if they participated in the study.

The investigators screened Soldiers for normal or corrected-to-normal visual acuity in both eyes with the use of a Titmus[1] 2a vision tester. A Titmus 2a vision tester (Model QV-7M) was used to measure acuity, stereo depth, and color vision. Correction inserts were issued to Soldiers when unaided visual acuity in each eye was less than 20/20 for military vehicle operators, flight personnel, and enlisted personnel with Profile I occupational requirements and unaided binocular visual acuity of less than 20/40 for all other personnel (additional information regarding vision correction inserts is presented in Army Regulation 40-63, 1986). Vision correction inserts were issued to all Soldiers who required them.

[1]Titmus is a registered trademark of Titmus Optical, Inc.

1.2.3 Anthropometrics

Anthropometric measurements (see appendix C) were taken for each Soldier (see figures 1 and 2). Thirteen anthropometric measurements (stature, weight, bitragion coronal arc, bitragion crinion arc, bitragion frontal arc, bitragion subnasale arc, bitragion chin arc, bitragion submandibular arc, head circumference, bizygomatic breadth, head breadth, head length, and interpupillary breadth) were taken for each Soldier. These data are presented in appendix C. All measurements were made in accordance with those described in the anthropometric measurement handbook (Gordon, Churchill, Clauser, Bradtmiller, McConville, Tebbetts, & Walker, 1989). The measurement data were converted to percentile values based on data from the 1988 Army Anthropometric Survey (Gordon et al., 1989) to determine if the sample of Soldiers used in this study was representative of the user population.

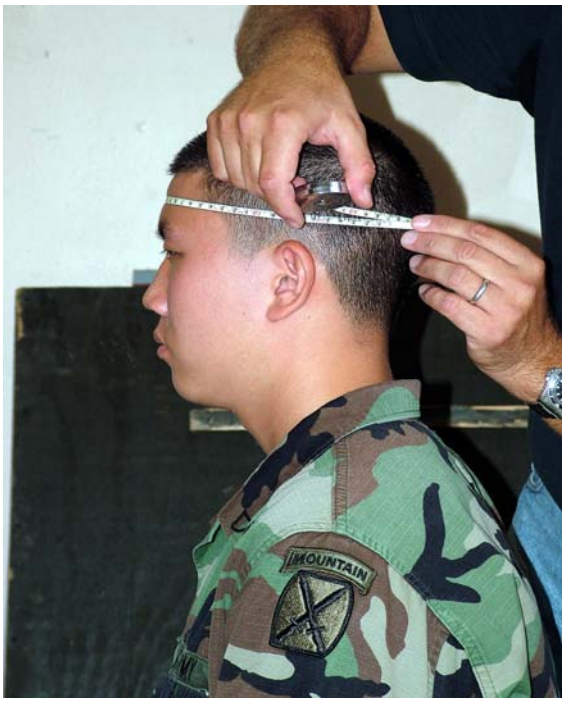

Figure 1. Anthropometry measurement of Soldier head circumference.

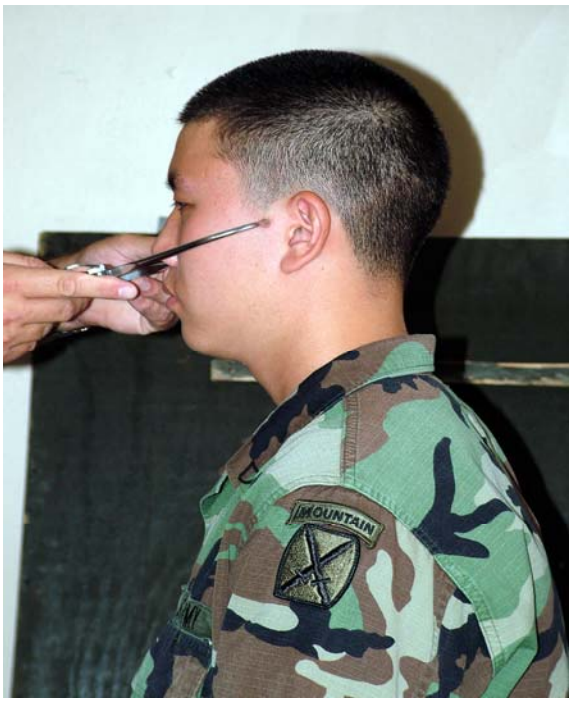

Figure 2. Anthropometry measurement of Soldier bizygomatic breadth.

1.3 Equipment Configurations

For ease of managing the four different configurations, a letter was designated for each configuration of the XM50. The M40 series mask with Joint Service Lightweight Integrated Suit Technology (JSLIST, jacket only) was designated as “configuration A”; the XM50 with hood was designated as “configuration B”; the XM50 with JSLIST (jacket only) was designated as “configuration C”; and the XM50 with JSLIST (jacket only) and modified mask beard was designated as “configuration D”.

The XM50 is a lightweight, protective mask system incorporating state-of-the-art technology to protect U.S. forces from all current and future threats. The mask components were designed to minimize impact on the wearer and maximize its ability to interface with current and future service equipment and protective clothing. The design consists of a butyl-silicone blend face piece with a skull cap suspension system, twin conformal filters, and a panoramic urethane lens. The M40 series provides respiratory, eye, and face protection against chemical and biological agents. The mask consists of a silicone rubber face piece with an "in-turned" peripheral face seal and binocular rigid lens system. A face-mounted canister (gas and aerosol filter) can be worn on either the left or the right cheek. Microphone, hose, and canister carrier are provided for combat vehicle applications.

The JSLIST overgarment is a universal, lightweight, two-piece, front-opening suit that can be worn as an overgarment or as a primary uniform over underwear. It has an integral hood, bellows-type sockets, high-waist trousers, adjustable suspenders, adjustable waistband and a waist-length jacket that enhances system comfort, improves system acceptance, and maximizes compatibility with the individual user equipment.

The four different configurations for this study are shown in figures 3 through 10.

Figure 3. Configuration A (front view).

Figure 4. Configuration A (rear view).

Figure 5. Configuration B (front view).

Figure 6. Configuration B (rear view).

Figure 7. Configuration C (front view).

Figure 8. Configuration C (rear view).

Figure 9. Configuration D (front view).

Figure 10. Configuration D (rear view).

1.4 Instrumentation

1.4.1 Fort Drum Light Fighter School 1-Mile Course

The light fighter school course at Fort Drum, New York, consisted of a generally flat asphalt surface approximately 1 mile in length. The course consisted of a starting and stopping point and markings along various points of the circular route.

1.4.2 Questionnaires

Three questionnaires (see appendices D through F) were used during this study to collect human factors data related to the comfort and stability of the vision correction inserts: 3-hour wear trial survey, comparative questionnaires, and vision correction inserts survey.

1.4.3 M41 Protection Assessment Test System (PATS)

The M41 PATS was used to assess the adequacy of each participant's XM50 mask fit. The M41 PATS is a small portable instrument designed to provide the Soldier with a simple, rapid, and accurate means of validating the face piece fit of his protective mask. The M41 PATS instrument is 240 mm x 190 mm x 140 mm in size, weighs approximately 3 lb, and is based on a miniature condensation nucleus counter (CNC). The CNC operates by continuously sampling and counting microscopic particles that occur naturally in the surrounding air. The M41 PATS measures the

concentration of these particles inside and outside the mask and, from these values, calculates a fit factor. The fit factor is a measure of the quality of the face seal. The M41 PATS ensures that the Soldier's assigned protective mask is properly sized and fitted and has no leaks. The system aids in sizing and fitting of protective masks by quantitatively assessing the degree of protection provided by the mask once it has been donned. Investigators obtained fit factor measurements while volunteers completed a five-exercise routine consisting of normal breathing, deep breathing, side-to-side head movement, up and down head movement, and rotation of the jaw. Each of the fit factor exercises lasted 1 minute.

1.4.4 XM50 Mask Vision Correction Inserts

The present insert for XM50 mask is a single size, (see figures 11 and 12). It has a 44-mm eye with a 30-mm bridge and is secured by means of integral split mounting half rings with slide insert fasteners (see figures 13 and 14).

Figure 11. Vision correction inserts (front view).

Figure 12. Vision correction inserts (rear view).

Figure 13. JSGPM (XM50 mask) with correction inserts (front view).

Figure 14. JSGPM (XM50 mask) with correction inserts (rear view).

2. Experimental Design

2.1 Independent Variables

The independent variables for the 3–hour wear trials were the equipment configurations (conditions A, B, C, and D) shown in table 1.

Table 1. Individual equipment configurations matrix.

Configurations	Equipment
A	M40 mask, with JSLIST jacket only, BDUs, combat boots, load-bearing vest (LBV), personal armor system for ground troops (PASGT) or modular integrated communications helmet (MICH)
B	JSGPM with hood, BDUs, combat boots, LBV, PASGT or MICH
C	JSGPM with JSLIST jacket only, BDUs, combat boots, LBV, PASGT or MICH
D	JSGPM with JSLIST jacket only and modified mask beard, BDUs, combat boots, LBV, PASGT or MICH

Note: All configurations consist of the same equipment except for the following items:

1. Configuration A. M40 mask with JSLIST (jacket only)
2. Configuration B. JSGPM with hood
3. Configuration C. JSGPM with JSLIST (jacket only)
4. Configuration D. JSGPM with JSLIST (jacket only) and modified mask beard

2.2 Dependent Variables

The dependent variables were

a. Comfort and compatibility observations.

b. Responses to comfort and compatibility questionnaires were completed during post-action interview.

c. The number of equipment failures and shortcomings for the XM50 mask.

d. Donning and doffing times.

2.3 Matrix

The Soldiers wore four equipment configurations over 4 days. The presentation order was counterbalanced as shown in table 2.

Table 2. Order of presentation matrix.

Test Participant (TP) Number	Trial 1	Trial 2	Trial 3	Trial 4
3	B	A	C	D
4	B	A	D	C
7	A	C	B	D
8	A	C	D	B
9	B	C	D	A
12	B	D	A	C
13	A	B	C	D
14	A	B	D	C
15	B	C	A	D
16	A	D	B	C
18	A	D	B	C
20	B	D	C	A
21	C	A	B	D
22	C	A	D	B
23	C	B	A	D
24	C	B	D	A
25	C	D	A	B
26	C	D	B	A
27	D	A	B	C
28	D	A	C	B
30	D	B	A	C
34	D	B	C	A
35	D	C	A	B
36	D	C	B	A

3. Procedure and Methodology

The Soldiers were given a briefing about data collection procedures to be followed throughout the study. All participants were trained how to use and maintain the XM50, using the methods provided during instructor and key personnel training (IKPT). Before each evaluation trial, a visual inspection of the Soldiers' equipment was performed, and each Soldier was fitted with the mask to ensure that all war-fighter equipment was properly donned.

After each comfort trial, ARL experimenters and contractors from AVON Corporation[2] examined the XM50 mask for any visible damage that may have occurred during the comfort trials. Any questions concerning the evaluation trial were addressed at that time.

[2]Avon is widely regarded as a market leader in the design and manufacturer of high performance NBC protection respirators for the military, Special Forces, police, and civil defense.

4. Comfort and Vision Correction Inserts Stability Evaluation

The comfort trial consisted of a 3-hour mask wear trial. During the 3 hours of the wear trial, participants were divided into three groups and performed their normal military duties (e.g., conducted vehicle maintenance in the motor pool and 10-km road marches). A 5-minute water break was given every 30 minutes. After the 3-hour wear trial, participants removed and stowed their masks, participated in timed donning trials, and completed the applicable questionnaires (see appendix D). After completion of the questionnaire, an interview was conducted with all participants to ensure adequate understanding of all questionnaire responses and comments. All Soldiers completed a total of four comfort trials, one trial per equipment configuration over the course of 4 days. Participant comments, questionnaire responses, and investigator observations regarding comfort were documented throughout all evaluations.

4.1 Clothing and Equipment and Load Configurations

The clothing and equipment items that each Soldier wore or carried during this evaluation are shown in table 3.

Table 3. Comfort and vision correction inserts stability trial equipment load configuration.

Item Description	Weight (lb)	Weight (kg)
Underclothing and socks	0.48	0.22
Battle dress uniform	3.80	1.73
Belt with buckle	0.44	0.20
Boots (direct molded sole)	4.10	1.86
PASGT helmet (medium)	3.30	1.50
Modular lightweight load-carrying equipment (MOLLE) tactical LBV	1.56	0.71
JSLIST (jacket only)	2.99	1.36
M40 series mask with carrier	4.16	1.89
JSGPM (XM50 mask) with carrier	2.96	1.34
JSGPM hood	0.41	0.19
Accessory pack	2.11	0.96
Canteen with cover, and 1 quart of water (two each)	6.60	3.00
Individual first aid kit	0.17	0.08
Total M40 Series Mask load Configuration A	**27.60**	**12.55**
Total JSGPM with hood load Configuration B	**26.81**	**12.19**
Total JSGPM with JSLIST load Configuration C	**28.51**	**12.96**
Total JSGPM with JSLIST and modified beard load Configuration D	**28.51**	**12.96**

4.2 Questionnaires

Questionnaires were designed to elicit Soldiers' opinions about their experiences in wearing the M40 series and JSGPM mask systems. The questionnaires were designed to enable Soldiers to

rate the system on a 6-point scale ranging from “much better” to “much worse” (in which much better = 6, better = 5, slightly better = 4, slightly worse = 3, worse = 2, and much worse = 1). Questionnaires were given to each Soldier to complete after each daily trial. Soldiers rated features about each mask system pertaining to comfort, compatibility, and durability. A comparative questionnaire was administered at the completion of the study to rate the M40 against the XM50. Sample questionnaires are shown in appendices D through F.

4.3 Familiarization and Training

During the first day, the Soldiers were screened for visual acuity, were issued and properly fitted with an XM50 and an M40 series mask, and had anthropometric measurements taken. The Soldiers were given a demonstration how to don and doff both masks properly and safely and were taught how to maintain both masks during IKPT. In addition, the Soldiers practiced the donning and doffing procedures until they were comfortable with them. They were then trained how to complete all the evaluation questionnaires. The training and familiarization took 2 days.

5. Participant Scenario

Four configurations were examined during this study. Each system was worn by the Soldiers on the light fighter school course during this study. The daily scenario that was used to conduct the comfort and vision correction inserts stability study is shown in table 4. This scenario was repeated daily for 4 days. The comfort wear trial times for each Soldier and any human factors and compatibility issues observed were recorded.

Table 4. Research participant scenario.

a. Soldiers arrived at test site in the morning.
b. Soldiers were briefed about the day’s events, received equipment training, and were issued equipment.
c. Soldiers conducted a series of donning trials and donned individual equipment (i.e., XM50 mask, vision correction, etc.) and prepared to conduct the equipment configuration trial.
d. Soldiers performed a 3-hour wear trial, conducted timed donning trials, sanitized mask after use, and completed questionnaires. Experimenter(s) inspected all equipment. Shortcomings or failures observed by Soldiers or experimenter(s) were documented.
e. Soldiers took a 5-minute water break every 30 minutes during the 3-hour wear trial.
f. Soldiers completed comparative questionnaires after post action interview.

5.1 Three-Hour Wear and Vision Correction Inserts Stability Trial Evaluation

The M40 series mask, XM50 mask, and vision correction inserts were evaluated during the 3-hour wear trials. Separate training and research trials were conducted for each mask configuration.

5.2 Training

A New Equipment Training Team (NETT) from Sobran Incorporated trained the Soldiers in the procedures, proper use, and maintenance of the XM50 mask system and various components. Training took about approximately 4 hours.

The Soldiers were fitted with a JSLIST overgarment jacket and donned the XM50 mask carrier, placing it in its predetermined operational location. The carrier contained the mask and all other items specified in the operator's card. The Soldiers practiced the donning procedures, including removal of the mask from the mask carrier, until they were comfortable with the operating procedures. The procedures required for donning and doffing the XM51 NBC protective hood and the JSLIST overgarment with hood were explained in detail, were demonstrated, and were practiced.

Once the Soldiers were comfortable with donning and doffing the XM50 mask, they performed a timed donning trial at the command of "gas". The standard for donning a protective mask is 9 seconds or less. This includes clearing and ensuring that the mask was properly sealed. Once the mask had been donned, Soldiers continued to don the appropriate NBC protective hood. Comfort trials were conducted in all test configurations. Experimenters observed the donning procedures and recorded donning trial times. Following the trials, the M41 PATS was used to determine the fit factor of randomly selected masks. After each trial, Soldiers removed and cleaned their individual masks before the next use.

5.3 Three-Hour Wear Trials and Vision Correction Inserts Research Scenario

The day after completing the training scenario, each Soldier was provided a respiratory protective mask (i.e., XM50 or M40 series) and protective equipment (i.e., JSLIST or XM51 hood) in accordance with the equipment configuration matrix. The Soldiers completed one trial per condition over the course of four days, as listed in table 3 of the individual equipment configuration matrix. The Soldiers performed their normal military duty activities throughout the duration of the trials. After each trial was completed, the research participant was asked to complete the 3-hour wear trial questionnaire, 3-hour comparative questionnaire, and if applicable, the vision correction inserts questionnaires shown in appendices D through F. Participants had at least a 5-minute water break every 30 minutes during the trials. Research participants completed no more than one trial per equipment configuration each day during the evaluation. Wet bulb globe temperature (WBGT), as well as other applicable weather data, were recorded before each trial.

The Soldiers received a briefing about the comfort trials and vision correction inserts scenario. This scenario was repeated over the course of 4 days. Investigators recorded the order in which Soldiers completed the trials and any human factors and compatibility issues they observed.

5.4 Questionnaires

Questionnaires were designed to elicit Soldiers' opinions about their experiences using the XM50 mask, compared to their current mask system (M40). The questionnaires were designed to enable Soldiers to rate the system on a 6-point rating scale. Questionnaires were given to each Soldier to complete after each daily trial. Additionally, a comparative questionnaire was given to each Soldier at the completion of the study. Features about each system pertaining to comfort, vision correction inserts stability, and equipment compatibility were rated. Sample questionnaires are shown in appendices D through F.

6. Data Analysis

6.1 Objective Measures

A chronology of the failures and shortcomings observed during the 3-hour comfort wear trial, vision correction inserts stability, mask donning times exercises, and summarized lists for any other compatibility and human factors problems observed is reported. Photographs and video footage of equipment damage and human factors issues were taken as necessary.

An analysis of variance (ANOVA) was conducted on the mask donning trial completion times, as a function of configuration. Means and standard deviations for the all the conditions are provided.

6.2 Subjective Measures

Questionnaire data were collated and used to compute descriptive statistics (means and standard deviations) for each of the configurations, except for the comparative questionnaire.

7. Results

7.1 Comfort and Vision Correction Inserts Stability Evaluation

The linear mixed model analyses showed that there were no significant differences between any of the characteristics rated for the responses to the comfort and vision correction inserts questions. The mean responses for the comfort trials (3-hour wear time) with each of the configurations are shown in table 5 and a comparative questionnaire with mean responses is shown in table 6.

Table 5. Summary of results of comfort trials (3 hour wear times) questionnaire.

	Mean (Standard Error)			
Characteristics rated	**Conf. A**	**Conf. B**	**Conf. C**	**Conf. D**
Q1 The mask around the eyes was	4.56 (0.22)	5.09 (0.21)	5.26 (0.21)	5.26 (0.21)
Q2 The mask periphery (around the combined contact points of the head, temples cheek and chin) was	3.33 (0.31)	4.47 (0.30)	4.65 (0.30)	5.05 (0.30)
Q3 The mask's nosecup was	3.72 (0.29)	4.82 (0.28)	5.01 (0.27)	4.74 (0.28)
Q4 The mask's head harness was	4.12 (0.27)	4.99 (0.27)	4.52 (0.26)	5.20 (0.27)
Q5 The mask around the throat was	3.80 (0.30)	4.89 (0.29)	4.45 (0.29)	4.21 (0.29)
Q6 The mask around the neck area was	3.93 (0.25)	5.14 (0.24)	4.75 (0.24)	4.47 (0.24)
Q7 The mask at your chin was	3.50 (0.22)	5.09 (0.21)	4.78 (0.21)	5.32 (0.21)
Q8 The mask at your forehead was	4.33 (0.29)	4.42 (0.28)	4.50 (0.28)	4.94 (0.28)
Q9 The mask overall was	3.54 (0.25)	4.93 (0.25)	4.86 (0.24)	5.03 (0.25)
Q10 The weight of the mask was	3.79 (0.22)	4.97 (0.21)	5.39 (0.21)	5.43 (0.21)
Q11 The thermal conditions of your face inside the mask were	3.53 (0.30)	4.36 (0.29)	4.56 (0.28)	4.84 (0.29)
Q12 The weight of the mask and helmet combined was	4.70 (0.31)	4.59 (0.30)	5.11 (0.30)	4.42 (0.30)
Q13 Wearing the mask carrier was	3.95 (0.28)	4.82 (0.28)	4.55 (0.27)	5.10 (0.28)

Legend: 6 = very comfortable, 5 = comfortable, 4 = slightly comfortable, 3 = slightly uncomfortable, 2 = uncomfortable, 1 = very uncomfortable

Q14 Inhaling through the mask while performing this trial was	3.70 (0.19)	5.30 (0.19)	5.24 (0.18)	5.67 (0.19)
Q15 Exhaling through the mask while performing this trial was	4.05 (0.16)	5.52 (0.16)	5.59 (0.15)	5.62 (0.16)

6 = very easy, 5 = easy, 4 = slightly easier, 3 = slightly difficult, 2 = difficult, 1 = very difficult

Q16 The fit of the mask was	4.48 (0.18)	5.11 (0.17)	5.43 (0.17)	5.43 (0.17)

Each equipment configuration was worn during the 3-hour wear comfort trial evaluation a total of 4 times by the 21 Soldiers. After each comfort trial, ARL experimenters and contractors from AVON Corporation inspected the XM50 mask for any visible damage that may have occurred during the comfort trials. There was some visible damage (module cover communication device flex) that occurred on the XM50 mask configurations.

The comparative questionnaire administered at the completion of the study solicited subjective opinions about the M40 versus the XM50 mask conditions from the 16 Soldiers, on a rating scale ranging from 6 to 1 (i.e., 6 = much better, 5 = better, 4 = slightly better, 3 = slightly worse, 2 = worse, 1 = much worse). In terms of the results, 15 of 16 questions asked of Soldiers were answered in favor of XM50 versus M40, with rating between 5 and 6. However, it was noted

that a number of Soldiers rated the XM50 slightly worse than the M40 when asked to compare "accidentally detaching the XM50/51 filter during filter change-out". A summary of the results of the comparative questionnaire by research participants is shown in table 6. Because this survey was administered to Soldiers only once at the end of the study, after they had worn all configurations, no comparisons could be made across the four conditions.

Table 6. Summary of results of comparative questionnaire.

Characteristics rated	**Mean**	**Std Error**
Q1 Compared to your current mask system, the comfort of the XM50/51 after 3 hours of wear was	5.94	0.06
Q2 Compared to your current mask system, the comfort of the XM50/51 when worn with mission-oriented protective posture (MOPP) gear and helmet was	5.25	0.27
Q3 Compared to your current mask system, XM50/51 breathing resistance during inhalation was	5.94	0.06
Q4 Compared to your current mask system, XM50/51 breathing resistance during exhalation was	5.81	0.10
Q5 Compared to your current mask system, the fit of the XM50/51 was	5.56	0.18
Q6 Compared to your current mask system, XM50/51 your field of view was	5.94	0.06
Q7 Compared to your current mask carrier, the XM50/51 modular two bag carrier system was	5.19	0.26

Std Error = Standard Error
Legend: 6 = much better, 5 = better, 4 = slightly better, 3 = slightly worse, 2 = worse, 1 = much worse

Q8 Compared to your current mask system, removing the XM50/51 air deflectors from the mask was	5.81	0.10
Q9 Compared to your current mask system, installing the XM50/51 air deflectors from the mask was	5.69	0.25
Q10 Compared to your current mask system, removing the XM50/51 inhalation valve from the filter mount was	5.44	0.20
Q11 Compared to your current mask system, installing the XM50/51 inhalation valve from the filter mount was	5.44	0.18
Q12 Compared to your current mask system, removing the XM50/51 self sealing valve from the filter mount was	5.75	0.11
Q13 Installing the XM 50/51 self sealing valve from the filter mount was	5.56	0.26

6 = very easy, 5 = easy, 4 = slightly easier, 3 = slightly difficult, 2 = difficult, 1 = very difficult

Q14 Having filter alignment marks on the XM50/51 during filter change-out was	5.06	0.34

6 = very useful, 5 = useful, 4 = slightly useful, 3 = slightly useless, 2 = useless, 1 = very useless

Q15 Accidentally detaching the XM50/51 filter during filter change-out was	**2.94**	0.38
Q16 Accidentally detaching the XM50/51 self sealing valve from the filter mount during filter change-out was	5.31	0.27

6 = very common, 5 = common, 4 = slightly common, 3 = slightly uncommon, 2 = uncommon, 1 = very uncommon

A summary of the Soldiers' comments (verbatim) regarding their experience with the XM50 mask during the comfort and vision correction inserts stability trials is shown in table 7.

Table 7. Summary of Soldiers' comments.

Research Participant Number	Comments
Configuration A (M40 mask with JSLIST)	
3	I experienced more breathing resistance while wearing the M40 series mask and some fogging did occur during the trial. I was experiencing a pressure on the outer portion of my head that was really uncomfortable.
4	No comments.
7	The M40 mask was very uncomfortable. It was difficult to breathe in.
9	No comments.
12	Complained of hot spot on the forehead and tightness across the forehead.
13	While wearing the PASGT helmet, it pushed down on the front of the mask and made the helmet unstable. Need to find a way to stabilize helmet when I'm wearing the mask. JSLIST was bunching up around the neck area, causing discomfort.
14	No comments.
15	No comments.
16	No comments.
18	No comments.
20	After wearing the XM50 mask during the previous three trials, I no longer like the M40 series mask. The nosecup is hard and uncomfortable in the M40 series mask and the drink tube is irritable because it either pushes against my lip or must be kept in my mouth. The XM50 drink system is easier to use and is more maneuverable and the breathing resistance is much better in the XM50 mask than the M40 series mask.
21	The M40 mask is not good. I can hear myself breathing through the mask filter and my breathing does not feel natural and the mask was causing a headache around the top edge of the mask. While pulling the drink tube out of the drink tube housing, it caused me to break the mask seal.
22	No comments.
24	No comments.
25	Experiencing hot spot on the top of his head and the temple straps were pressing against the side of his head.
26	No comments.
27	Complained of a headache near the top of the head.
28	No comments.
30	No comments.
34	Mask began to fog up after 30 minutes of wear time.
35	No comments.
36	No comments.
Configuration B (XM50 mask with hood)	
3	No comments.
4	No comments.
7	No comments.
9	Stated that the nose cup was pushing down on his nostrils.
12	No comments.
13	No comments.
14	The XM50 mask seals well.
15	No comments.
16	I experienced hot spots as a result of the mask buckles, around the cheek bones and on top of my head. The sunglass outserts clip did not seat properly in the slot on the left side of my mask. Felt pressure near the temple area and a hot spot near the brow strap area.
18	No comments.
20	The canteen top unsnapped too easily; however, the drinking system was generally better than the previous systems. The system allows me to drink more water in a shorter duration of time. The hood material was slippery and more difficult to grasp during the donning trials and this was affecting my donning trial time. Finally, the Soldier acknowledged that the breathing

	resistance was much better with JSGPM and stated that he did not sweat as much in this system, compared with the current mask system.
21	No comments.
22	Experienced a hot spot as a result of the head harness.
24	No comments.
25	No comments.
26	No comments.
27	His canteen assembly coupler interior sleeve assembly was dislodged while attempting to drink water from the canteen.
28	No comments.
30	The PASGT helmet was pushing down on the front of the mask and causing pressure on the forehead.
34	The XM50 mask felt like it was pushing into his jaw and the back of his jaw was becoming sore as a result. He did not notice this when he wore the modified version of the XM50 mask.
35	No comments.
36	No comments.
Configuration C (XM50 mask with JSLIST)	
3	The JSLIST was pushing the mask beard down into his neck (Adam's apple). His buddy repositioned the JSLIST and the problem was resolved
4	No comments.
7	The M40 mask was very uncomfortable. It was difficult to breathe in.
9	He had a strange feeling around his neck and Adam's apple while wearing the JSLIST.
12	No comments.
13	While he wore the PASGT helmet, it pushed down on the front of the mask and made the helmet unstable. Need to find a way to stabilize helmet when he wears mask.
14	No comments.
15	No comments.
16	I experienced hot spots as a result of the mask buckles, around the cheek bones and on top of my head. The sunglass outserts clip did not seat properly in the slot on the left side of my mask. The participant stated that he was not issued a PASGT or MICH and that one was not available for this trial.
18	The participant also stated that the thigh strap on the mask carrier was much better than the thigh strap on the M40 series mask carrier. This carrier is more comfortable, more stable, and the strap was hardly noticeable during the wear trial.
20	No comments.
21	He was experiencing a hot spot near the brow strap area.
22	No comments.
24	The JSLIST felt like it was bunching up around the throat and he was experiencing pressure at the very top of the forehead as a result of front portion of the mask. He thinks the problem resulted from a combination of the PASGT helmet and the XM50 mask.
25	No comments.
26	No comments.
27	No comments.
28	No comments.
30	No comments.
34	The mask was hurting his jaw.
35	No comments.
36	No comments.
Configuration D (XM50 mask with JSLIST and modified mask beard)	
3	No comments.
4	No comments.
7	No comments.
9	My canteen assembly coupler interior sleeve assembly was dislodged while attempting to drink water from the canteen and I experienced hot spots in the front and back of head.
12	No comments.
13	No comments.

14	No comments.
15	No comments.
16	A puddle of water was forming in the chin cup pocket and he tried leaning forward and blowing the water out, but the water began to build up in the bottom lip of the mask chin cup pocket.
18	No comments.
20	The push tab, located on the bottom of the voice amplifier, made it difficult to remove the drink tube from the drink tube housing assembly. The voice projection unit (VPU) makes it difficult to fully uncoil the drink tube from the drink tube housing assembly without removing the VPU.
21	No comments.
22	No comments.
24	No comments.
25	Was experiencing a mild headache near the brow strap area.
26	No comments.
27	No comments.
28	The interior nosecup did not feel like it was properly sealed around the interior filter housing unit after being emplaced following mask reassembly. The attachment feels flimsy and not real sturdy and the ring portion of the nosecup does not seem to fit the filter housing well because it seemed to be stretched.
30	The PASGT helmet tends to press down on the XM50 mask, causing discomfort.
34	His breathing was restricted because the nose cup was tight, pinching his nostrils partially shut, and pushing down on his nostrils. Additionally, the Soldier stated, "If the nose cup sat higher in the mask, my breathing would not be restricted. It was easier to breathe when the nose cup is lifted slightly and sun lens outserts were great."
35	Complained of a headache after 20 minutes from the start of the donning trial.
36	Stated that his drinking tube disconnected from exterior mask face piece housing assembly.

7.2 Mask Donning Trial Times

Each day following the comfort trial (3-hour wear time) Soldiers completed three practice trials before conducting the actual mask donning trial. The results of the mask donning trial times by research participant, each trial, and configuration are shown in table 8. A linear mixed model analysis was conducted on the mask donning trial completion times. The linear mixed model analyses showed that there were no significant differences ($F = 51.432$, $p = 0.345$) between the XM50 or M40 series mask configurations. The vision correction inserts questionnaire sample size was too small to conduct statistical analyses ($N = 6$).

Table 8. Record of mask donning trial times (seconds).

Research Participant	Conf. A	Conf. B	Conf. C	Conf. D
3	9.94	7.9	7.41	11.81
4	6.51	7		
7	5.03	7.22	6.65	6.97
9	10.04	12	8.35	9.78
12	5.5	7.02	7.28	6.6
13				
14	7.44	6.5	7.25	6.1
15	7.9	10.5	6.59	5.57
16	7.64	7.19	8.95	7.03
18	8.5	7.34	7.87	7.78
20	10.2	6.59	7.07	7.79
21	11.43	7.25	8.09	7.85
22	5.06	6.53	7.25	
24	4.85	7.37	7.14	6.28
25	10.79		16.82	4.75
26	6.32	7.12	6	6.13
27	7.17	7.34	7.16	7
28	7.87	5.75	4.84	6.54
30	7.97	6.28	4.81	7.06
34	7.79	11.15	8.22	8.17
35	12.65	13.53	11.85	8.47
36	8.81		6.28	8.31
Means	**8.07**	**7.86**	**7.73**	**7.26**
Std. Dev.	**2.12**	**2.15**	**2.55**	**1.62**

A = M40 mask with JSLIST (jacket only)
B = JSGPM with hood
C = JSGPM with JSLIST (jacket only)
D = JSGPM with JSLIST (jacket only) and modified mask beard

8. Investigator Observations

Since there were not enough individual protective masks to issue to each Soldier, investigators decided to distribute the masks based on the configuration matrix throughout the duration of the trial. This was done on the first day of the trials.

Several problems were noted regarding the PASGT helmet. During disassembly of the XM50 after the 3-hour wear trials, investigators noticed that the temple strap mask harness clip buckle (left size) broke before mask fitting (see figure 15). It was also noted that a relatively small number of Soldiers were unable to localize sound when they wore the PASGT helmet. However, after switching to a MICH, the Soldiers were able to successfully localize sound. Because of the shortness of the brow straps, the mask was adjusted beyond the recommended factory setting to accommodate participant 9 in Configuration B during the initial mask fitting exercise (see figures 16 through 18).

Figure 15. Broken XM50 mask temple strap clip buckle fastener.

Figure 16. Brow straps adjusted beyond recommended setting.

Figure 17. Brow straps adjusted beyond recommended setting (overhead view).

Figure 18. Brow straps adjusted beyond recommended setting (left side view).

When the Soldier attempted to loop the brow strap through the XM51 hood, an unnatural pull was created and the material bunched up (see figure 19). To correct the problem, the brow straps were removed from the XM51 hood loops and readjusted to correct the comfort issue. This adjustment appeared to have corrected the problem. After anthropometry measurements for participant 9 (Configuration B) were checked, it was noted that the Soldier was beyond the 98th percentile anthropometry measure for several head (i.e., head circumference, head length, etc.) and facial (i.e., bitragion chin arc) measurements.

Figure 19. XM51 hood material bunching up after being fitted.

During the comfort trials, it was obvious that several of the participants experienced problems. For participant 16 (Configuration B), the sunglass outserts clip was not seated properly in the slot on the left side of the mask. The Soldier was initially fitted with a large XM50 mask using the M41 PATS; however, the location of the eyes and the nose cup indicated that the mask was too large. It was determined that the Soldier required a medium mask. Participant 9 was identified as "hard to fit" after informing the researchers that a medium size mask beard felt very uncomfortable and the nose cup interfered with his field of view. The Soldier was resized and reissued a large XM50 mask before the start of the first trial. Within 10 minutes after the first trial began and 30 minutes after the initial observation, it was clearly visible that the Soldier had an issue with fogging. The probable causes of this issue were (a) the Soldier was hard to fit with a mask and (b) the proximity of the relief distance between the mask lens and the forehead, which restricted the amount of turbulence (air flow) within the interior of the mask. In addition

to the fogging issue, the Soldier stated that he was experiencing a headache. The Soldier's mask (Configuration C) was removed after 1 hour and 30 minutes of participation as a safety precaution (see figures 20 and 21).

Figure 20. Hard to fit Soldier after 1 hour 30 minutes of wear time in Conf. C (front view).

Figure 21. Hard to fit Soldier after 1 hour 30 minutes of wear time in Conf. C (side view).

Participant 13's (Configuration C) vision correction inserts were fogging while he breathed through the nose. However, while he breathed through his mouth, the vision correction inserts did not fog up as much (see figures 22 though 23). The experimenters removed the participant's mask to troubleshoot the problem. It was observed that the left side pop valve was missing. The valve was replaced and the Soldier's mask still fogged up. The Soldier was instructed to remove the mask again.

The experimenters observed that the right side of the mask air flow management system of the non-modified mask was not properly seated onto the interior filter housing (see figure 24). After 2 hours 30 minutes of wear time, the Soldier still experienced fogging inside the XM50 mask. Therefore, the corrections made earlier did not resolve the fogging issue. It was noted that the fogging issue was now on the opposite side (right side lens). The Soldier was instructed to remove the mask and the vision correction inserts. The participant donned the mask and walked around the test area to determine if fogging would still occur. The Soldier informed the experimenter that the fogging problem was no longer occurring once the vision correction inserts were removed.

Figure 22. Soldier's XM50 mask fogging while he wore vision correction inserts.

Figure 23. Soldier's XM50 mask fogging while he wore vision correction inserts (side view).

Figure 24. XM50 mask air flow management system not properly seated into the filter housing.

Participant 13's (Configuration C) XM50 mask began to fog up (see figure 25) almost immediately after he donned the mask. After the Soldier was instructed to clear and reseal the mask, he was instructed to remove the mask. After a closer observation by the researchers, it became obvious that the interior valve disks were missing. After the valve disks were installed, the Soldier donned the mask onto his face and experienced no further problems with fogging.

Participant 20's (Configuration C) XM50 mask was making a whistling sound. This was because of an incorrectly emplaced pop valve in the outlet valve housing assembly. The valve was replaced and the Soldier experienced no further problems.

Participant 21 (Configuration C) experienced a hot spot near the brow strap area. The Soldier was refitted with the mask because the reflex seal on the inside of the mask was bent as a result of the positioning of the brow strap. The brow straps were removed from the hood to prevent the reflex seal from pinching or bending the XM50, causing the Soldier discomfort. The mask was refitted and no further problems occurred.

Figure 25. Soldier's XM50 mask fogging because of missing interior valve disk.

Participant 22's (Configuration C) XM50 mask began to fog up approximately 15 minutes after he donned it. Additionally, the Soldier wore vision correction inserts, but it is unclear if this contributed to the fogging problem. The fogging issue was corrected after the Soldier removed and re-donned the mask.

Participant 25's (Configuration B) XM50 mask began to fog up 2 hours into the comfort trial. The Soldier informed the experimenters that he was breathing through his nose when the fogging began. After closer observation by the researchers, it became obvious that the interior mask nosecup was not properly sealing against the bridge of the nose. This allowed air turbulence to flow up and across the lens, causing the lens to fog up. The experimenters instructed the Soldier to remove his mask. The Soldier was refitted, cleared, and sealed the XM50 mask. The Soldier experienced no further problems.

Participant 28 (Configuration D) informed the experimenters that the interior nosecup did not feel like it was properly sealed around the interior filter housing unit during reassembly of the XM50 mask. He reported that the attachment felt flimsy and not sturdy. The ring portion of the nosecup did not seem to fit around the filter housing well, possibly because of stretching. The vision correction insert frame pressed on his forehead. The experimenters observed that the vision correction inserts were not connected to the holding pin, located on the interior of the XM50 mask (see figure 26). The vision correction inserts were adjusted (lowered two notches) to correct the problem.

Figure 26. XM50 mask vision correction inserts were not connected to the holding pin.

Participant 35 (Configuration D) informed the experimenters that a puddle of water was forming in the XM50 mask chin cup pocket. The Soldier tried leaning forward and blowing out, but the water had puddled at the bottom lip of the mask chin cup pocket. The water was spattering up into his face when he breathed hard. The Soldier was instructed to remove the mask to diagnose the issue. When the experimenters and contractors examined the mask, they noticed there was very little water in the chin cup pocket. The water had not been draining from the hole in the chin cup pocket (see figures 27 and 28).

The front module cover communication device flexed when the participant attempted to remove his drinking tube from the drinking tube housing (see figure 29). The push tab on the bottom of the voice amplifier made it difficult to remove the drink tube from the drink tube housing assembly (see figure 30). The Soldier (Configuration D) demonstrated that the location of the bottom push tab on the VPU made it difficult to fully uncoil the drink tube from the drink tube housing assembly without removing the VPU. The sound of the VPU was heard from a distance not exceeding 5 meters; however, the sound quality was clear and understandable.

Figure 27. Inside view of XM50 nose-cup after fluid build-up.

Figure 28. Inside view of XM50 mask chin cup pocket after fluid build-up.

Figure 29. XM50 mask front module cover communication device flexed while the Soldier was attempting to remove the drink tube from the drink tube housing assembly.

Figure 30. XM50 mask with modified mask beard voice amplifier push tab (bottom).

After mask sanitation, one of the XM50 mask drink tube hose assemblies detached from the drink tube housing assembly (see figure 31).

Mask serial number KO50513 (Configuration D) had two marks on the outer eye lens. We were not certain what had caused this (see figure 32).

Figure 31. XM50 mask drink tube hose assembly detached from the drink tube housing assembly.

Figure 32. XM50 mask with two marks on the outer eye lens.

9. Discussion

As indicated by the responses to the comparative questionnaires, table 6 showed (in general) that Soldiers rated the XM50 mask as better than the M40 series mask in 15 of the 16 questions. A review of the comfort (3-hour wear time) and comparative questionnaires comments indicates that all the Soldiers had a much higher perception of the XM50 mask, when compared to the M40 series mask. Most Soldiers liked the comfort and durability of the XM50 mask. They also liked the drinking system and accessory pack of configurations C and D and stated that this mask is a vast improvement over the M40 mask series mask system. The Soldiers said they believe that the XM50 mask improvements will greatly enhance survivability.

Comfort (3-hour wear time) and vision correction inserts stability was investigated through questionnaires, the Soldiers' comments, and experimenters' observation. At the completion of the study, a comparative questionnaire was administered to the Soldiers to provide their opinions of the M40 series and XM50 mask systems. There are no criteria for the comfort trial (3-hour wear time) other than existing published reports (Caretti & Barker, 2002). The requirement for mask donning is 9 seconds or less to clear and seal the protective mask, and this requirement was met by a majority of Soldiers. The vision correction inserts questionnaire did not have enough participants to determine trends; therefore, the analyses could not be addressed since the sample size was too small. Note that a number of Soldiers chose not to participate in this study.

There were a small number of fogging issues related to the XM50 non-modified and modified masks. One possible cause of these issues was attributable to the proximity of the relief distance between the mask lens and the forehead, which restricted the amount of turbulence (air flow) within the interior of the mask. One common issue that continued to surface was the number of complaints of "hot spots," which in most cases, was also associated with headaches or discomfort. Finally, there were times during the trial when the equipment was damaged or it malfunctioned (see figures 15 and 29). This often occurred during mask fitting or reassembly of the XM50 mask. However, since the XM50 was a prototype mask, equipment malfunction and damage was quite common and generally surfaced during field testing.

Overall, Soldiers rated all the mask characteristics to be significantly better for the XM50 configurations than for the baseline M40 series mask system, except for the fogging issues during the comfort trials (figures 22 and 23). This shows that the Soldiers, in general, favored the XM50 configurations since most of the ratings were slightly higher than the M40 series mask. A similar trend can be seen for the comparative questionnaire, where Soldiers' ratings of the XM50 configurations were also in the higher categories (table 9).

As shown in tables C-1 and C-2, there is a wide range of values and percentiles for each of the anthropometric measures obtained from the Soldiers. This shows large anthropometric variability in the Soldiers who participated in this study and the facial and head measurement generally included Soldiers below the 5th percentile male values to above the 95th percentile male values.

The fact that there were no female participants in this group of Soldiers is a shortcoming of this study, and it forces the designer to make modifications based solely on the opinion and performance of male Soldiers. Therefore, the authors strongly encourage additional tests to gather unbiased opinions of the XM50 mask from female participants.

With respect to the comfort trials of the XM50 configurations, the results indicated positive ratings of 5.52, 5.59, and 5.67 for the B, C, and D configurations, respectively. This indicates that Soldiers, in general, highly rated the comfort of the XM50 masks, based on their experience in this test.

10. Conclusions

1. The 10-km road march did not affect the integrity of XM50 mask configurations.

2. The integration between the JSLIST and PASGT helmet with the XM50 mask slightly affected the integrity of XM50 mask configurations. This was evidenced by the number of comments made about the XM50 mask configurations by Soldiers after the 3-hour wear trial over the course of 4 days.

3. There were no significant differences for the donning trial completion times between any of the configurations.

4. Most of the Soldiers positively rated the comfort and durability of the XM50 mask while they acknowledged that the breathing resistance was much better with the XM50 mask configurations than the M40 series mask.

5. The XM50 mask configurations' drinking system was positively rated by the majority of Soldiers.

6. There were a number of comfort issues as a result of hot spots; most were related to the brow and temple straps (head and forehead) with the XM50 mask configurations.

7. A small number of fogging issues were observed that were a direct or indirect result of restricted air flow with the modified XM50 mask configuration.

8. The vision correction inserts' stability was positively rated by the majority of users; however, a number of fogging issues occurred when the vision correction inserts were worn with the XM50 modified mask.

9. The location and length of the thigh strap on the XM50 mask carrier were an improvement over the M40 series mask carrier. Overall, the accessory pack and XM50 mask carrier received positive ratings.

10. There were a number of comfort and compatibility issues with M40 series mask configuration.

11. Overall, user acceptance of the XM50 mask configurations was excellent for both comfort and durability performance.

11. Recommendations

1. Move or reposition the VPU push tab (located on the bottom) off to the side of the VPU device to prevent interference with the drink tube system

2. Shorten the XM51 hood straps by approximately 2 inches (5.08 cm).

3. Add an alignment indicator to ensure proper emplacement of filters during filter change-out or routine maintenance.

4. Make the brow strap approximately 0.25 inch (0.64 cm) longer to accommodate Soldiers with a longer head length.

5. Incorporate the air flow deflector of the current XM50 mask into the final design.

6. Ensure that all warning and cautions in the operator card address the importance of proper emplacement of all disks and valves.

7. Ensure that the mask is compatible with the current combat helmet systems.

8. Conduct a future study that includes female participants to determine any wear issues and user acceptance of XM50 mask system.

9. For future studies, the authors strongly encourage that a comparison questionnaire for each condition be administered after the completion of each trial. This is to compare perception of masks as the Soldier experiences each (Configuration A to B, A to C, etc.).

12. References

Caretti, D. M.; Barker, D. J. *Joint Service General Purpose Mask (JSGPM) Engineering Design Test (EDT) – Wearer Trials*; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, 2002.

Department of the Army. *Ophthalmic Services*, Army Regulation 40-63. Washington, DC, 1986.

Gordon, C. C.; Churchill, T.; Clauser, C. E.; Bradtmiller, B.; McConville, J. T.; Tebbetts, I.; Walker, R. A. *1988 Anthropometric Survey of U.S. Army Personnel: Summary Statistics Report 1989*; Technical Report Natick/TR-89-027; U.S. Army Natick Research, Development, and Engineering Center: Natick, MA, 1989.

13. Bibliography

Cohen, K. S. *Protocol: ERDEC Field Element Protocol for Respiratory Protective System 21 Demonstration*; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, 1994.

Departments of the Army and Air Force. Heat Stress Control and Heat Casualty Management; Technical Bulletin 507/Air Force Pamphlet 48-152 (I). Washington, DC, 2003.

Joint Service Integration Group. Joint Service General Purpose Mask (JSGPM) Operational Requirements Document (ORD). Fort McClellan, AL, 30 September 1998.

Science Applications International Corporation. Initial Safety Assessment Report for the Joint Service General Purpose Mask. Abington, MD, June 2001.

U.S. Army Center for Health Promotion and Preventive Medicine. Health Hazard Assessment for the Joint Service General Purpose Mask. Aberdeen Proving Ground, MD, February 1999.

U.S. Army Soldier Biological and Chemical Command. Performance Specification, Joint Service General Purpose Mask. Aberdeen Proving Ground, MD, 1999.

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Appendix A. Volunteer Agreement Affidavit

VOLUNTEER AGREEMENT AFFIDAVIT:
ARL-HRED Local Adaptation of DA Form 5303-R. For use of this form, see AR 70-25 or AR 40-38

The proponent for this research is:	**U.S. Army Research Laboratory Human Research and Engineering Directorate Aberdeen Proving Ground, MD 21005**

Authority:	Privacy Act of 1974, 10 U.S.C. 3013, [Subject to the authority, direction, and control of the Secretary of Defense and subject to the provisions of chapter 6 of this title, the Secretary of the Army is responsible for, and has the authority necessary to conduct, all affairs of the Department of the Army, including the following functions: (4) Equipping (including research and development), 44 USC 3101 [The head of each Federal agency shall make and preserve records containing adequate and proper documentation of the organization, functions, policies, decisions, procedures, and essential transactions of the agency and designed to furnish the information necessary to protect the legal and financial rights of the Government and of persons directly affected by the agency's activities]
Principal purpose:	To document voluntary participation in the Research program.
Routine Uses:	The SSN and home address will be used for identification and locating purposes. Information derived from the project will be used for documentation, adjudication of claims, and mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State, and local agencies.
Disclosure:	The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this data collection.

Part A • Volunteer agreement affidavit for subjects in approved Department of Army research projects.
Note: Volunteers are authorized medical care for any injury or disease that is the direct result of participating in this project (under the provisions of AR 40-38 and AR 70-25).

Title of Research Project:	Joint Service General Purpose Mask (JSGPM) Human Systems Integration (HSI) Evaluation: Comfort and Vision Correction Insert Stability Evaluation	
Human Use Protocol Log # Number:	**ARL-20098-05044**	
Principal Investigator:	Lamar Garrett	Phone: (410) 278-3413 E-Mail: lgarrett@arl.army.mil
Associate Investigator(s)	Sam Ortega Bill Harper Timothy White	Phone: (410) 278-5990 E-Mail: sortega@arl.army.mil Phone: (410) 278-5955 E-Mail: bharper@arl.army.mil Phone: (410) 278-5884 E-Mail: twhite@arl.army.mil
Location of Research:	Fort Drum, New York	
Dates of Participation:	26 September 2005 – 3 October 2005	

Part B • To be completed by the Principal Investigator
Note: Instruction for elements of the informed consent provided as detailed explanation in accordance with
Appendix C, AR 40-38 or AR 70-25.

Purpose of the Research

You are invited to participate in a study designed to evaluate the next generation Department of Defense (DoD) Nuclear, Biological and Chemical (NBC) protective mask, the Joint Service General Purpose Mask (JSGPM). The primary purpose of this evaluation is to: 1) assess the Soldier ability to don and doff the JSGPM, 2) assess the comfort level of the JSGPM with and without a modified mask beard in comparison to the M40 series mask, and 3) evaluate the vision correction insert and assess the spectacle insert stability and compatibility with the JSPGM prototype. The results will be used to create assessments and recommendations in support of the JSGPM, program. This evaluation is being conducted by the Army Research Laboratory (ARL), Human Research Engineering Directorate (HRED) at the request of the Product Manager for NBC Defense Systems from the Edgewood Chemical and Biological Command.

Procedures

After you have read and signed this Volunteer Agreement Affidavit, you will then be assigned a research participant number. Photographs and videotape may be used at any time during this study to adequately document evaluation conduct, problem areas or observations. You can refuse to have your picture taken if you wish. You will be given an opportunity to communicate any concerns to the investigators "off the record" and will be provided several options for refusing or withdrawing in a private manner. Your personal information and data recorded from experimental participants will be kept in a secured location in the offices of the Army Research Laboratory, Aberdeen Proving Ground, Maryland, building 459.

Next, you will be asked to complete a health and demographics questionnaire. If you answer "yes" to any of the options given in question 1, 2, or 3 regarding ailments in the past 15 days, you will be evaluated by a Physician Assistant prior to being permitted to participate in the evaluation.

You will be screened for normal or corrected-to-normal visual acuity via examination with a Snellen eye chart and Titmus Vision Tester. Next, you will be fitted with a JSGPM w/hood and JSLIST (jacket only) and vision correction inserts, as required.

Once you are issued and fitted with a JSGPM and individual protective equipment attached to your clothing, you will be trained how to use and maintain the XM50 using the methods provided during Instructor and Key Personnel Training (IKPT). Also, you will be trained how to complete all evaluation questionnaires. Prior to each evaluation trial, a visual inspection will be performed to ensure that all experimental and warfighter equipment are donned properly.

You will complete a total of six trials, one trial per equipment configuration over the

course of 6 days. Each trial will require you to wear the JSGPM for a period of 3 hours. You will be given a 5-minute water break every 30 minutes during the trial. At the end of each trial you will remove your equipment and complete a 3 hour Wear Trial Questionnaire and a 3 hour Wear Comparative Questionnaire. Additionally, you will complete a Vision Correction Inserts Questionnaire if you wore vision correction inserts. You will be issued and fitted with a JSGPM w/hood, JSLIST (jacket only), and PASGT helmet. You will receive training on how to properly use, store and maintain the XM50. Following the training, you will be provided with a copy of the equipment configuration matrix. Total participation time will be 4 hours per day covering a period of 6 days, to include Saturday and Sunday.

Benefits

You will receive no direct benefits from participating in this study. However, the data you provide from this research will be the used to create performance assessments and design recommendations in support of the JSGPM.

Participant's Rights: Any published data will not reveal your identity. Your participation in this evaluation is voluntary. If you choose not to participate in this evaluation, or if later you wish to withdraw from any portion of it, you may do so without penalty. Military personnel are not subject to punishment under the Uniform Code of Military Justice for choosing not to take part as human subjects. No administrative sanctions can be taken against military or civilian personnel for choosing not to participate as human subjects. The furnishing of your social security number and home address is mandatory and necessary for identification and locating purposes to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this study. Information derived from this study will be used to document the evaluation, to implement medical programs, to adjudicate claims, and for the mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State, and local agencies. Collection of this information is authorized by 10 USC 3013, 44 USC 3101, and 10 USC 1071-1087.

Under the provisions of AR 40-38 and AR 70-25, volunteers are authorized all necessary medical care for injury or disease which is the proximate result of their participation in this study.

Risks

Risks associated with this evaluation are minimal and are less than those encountered by war fighters during their normal operational field assignments. Heat stress and dehydration are considered the leading risks. You are advised that there are wild animals, snakes, and poisonous insects in the vicinity of some of the test sites and to take the appropriate precautions. All other risks anticipated in this evaluation are typical of the every day risks encountered by personnel working out of doors in this area. Flying insects at the test site are a concern. You will be encouraged to use insect repellent, which will be available on site. You will notify the principal investigator if you are bitten, and investigators will closely monitor you. You will be encouraged to use insect repellent, which will be available at the test site, and we ask that you inspect yourself frequently for insects.

The JSGPM design does not have any identified uncontrolled risks. The precautions pertinent to this evaluation apply to wear of all masks: There is the potential for skin rash or ammonia off-gassing. The former problem occurs rarely. If it does occur, you simply stop participating and the rash goes away. For the latter problem, if you encounter a filter that has an ammonia off-gassing problem, inform one of the experimenters and the experimenters will replace the filter. There are no long-term medical hazards from the smell. Off-gassing filters will be labeled to record the problem. All masks will be cleaned with sanitary respirator wipes before use. Also, mask drinking system components will be sanitized before and after use.

Members of the test administration staff will be close to you throughout all evaluation trials to assist you should a problem arise. If you ask to terminate the test, begin to have problems with your mask or if a mask becomes damaged, your participation in the evaluation will be stopped and your mask will be removed. Care will be taken to minimize risks. A copy of TB Med 507 will be kept available at all times. If the WBGT equals or exceeds 75°F testing will be halted. Water will be available to you at all times. You will have a 5-minute water break every 30 minutes during the trials. In addition, outdoor activities will be suspended during any weather conditions that are inherently dangerous or will cause evaluation trials to be dangerous. If it is raining or if there is an accumulation of water on the ground, outdoor test activities will be moved indoors, if conditions are believed to be unsafe.

Confidentiality

All data and information obtained about you will be considered privileged and held in confidence. Photographic or video images of you taken during this data collection will not be identified with any of your personal information (name, rank, or status). Complete confidentiality cannot be promised, particularly if you are a military service member, because information bearing on your health may be required to be reported to appropriate medical or command authorities. In addition, applicable regulations note the possibility that the U.S. Army Medical Research and Materiel Command (MRMC-RCQ) officials may inspect the records.

Disposition of Volunteer Agreement Affidavit

The Principal Investigator will retain the original signed Volunteer Agreement Affidavit and forward a photocopy of it to the Chair of the Human Use Committee after the data collection. The Principal Investigator will provide a copy of the signed and initialed Affidavit to you.

Contacts for Additional Assistance

If you have questions concerning your rights on research-related injury, or if you have any complaints about your treatment while participating in this research, you can contact:

Chair, Human Use Committee	OR	**Office of the Chief Counsel**
U.S. Army Research Laboratory		**U.S. Army Research Laboratory**
Human Research and Engineering Directorate		**2800 Powder Mill Road**
Aberdeen Proving Ground, MD 21005		**Adelphi, MD 20783-1197**
(520) 538-4705 or (DSN) 875-4705		**(301) 394-1070 or (DSN) 290-1070**

I do hereby volunteer to participate in the research project described in this document. I have full capacity to consent and have attained my 18th birthday. The implications of my voluntary participation, duration, and purpose of the research project, the methods and means by which it is to be conducted, and the inconveniences and hazards that may reasonably be expected have been explained to me. I have been given an opportunity to ask questions concerning this research project. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights or project related injury, I may contact the **ARL-HRED Human Use Committee Chairperson at Aberdeen Proving Ground, Maryland, USA by telephone at 410-278-4152 or DSN 298-4152.** I understand that any published data will not reveal my identity. If I choose not to participate, or later wish to withdraw from any portion of it, I may do so without penalty. I understand that military personnel are not subject to punishment under the Uniform Code of Military Justice for choosing not to take part as human volunteers and that no administrative sanctions can be given me for choosing not to participate. I may at any time during the course of the project revoke my consent and withdraw without penalty or loss of benefits. However, I may be required (military volunteer) or requested (civilian volunteer) to undergo certain examinations if, in the opinion of an attending physician, such examinations are necessary for my health and well being.

Printed Name of Volunteer (First, MI., Last)	
Social Security Number (SSN)	***Permanent Address of Volunteer***
Date of Birth ***(Month, Day, Year)***	
Today's Date ***(Month, Day, Year)***	***Signature of Volunteer***
Signature of Administrator	

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Appendix B. Health and Demographics Questionnaire

Health and Demographics Questionnaire

Participant Number: _____ Date: _____

1. Have you ever taken medication or been treated by a physician for any of the following ailments? (Please circle your response)

Dizziness or fainting spells	Yes	No
Chronic respiratory illness	Yes	No
Asthma	Yes	No
Shortness of breath	Yes	No
Heart trouble	Yes	No
High or low blood pressure	Yes	No
Chest pain with exercise	Yes	No
Diseases of the arteries	Yes	No
Diabetes	Yes	No

2. Have you, in the past 15 days, taken medication or been treated by a physician for any of the following ailments? (Please circle you response)

Dizziness or fainting spells	Yes	No
Chronic respiratory illness	Yes	No
Asthma	Yes	No
Shortness of breath	Yes	No
Heart trouble	Yes	No
High or low blood pressure	Yes	No
Chest pain with exercise	Yes	No
Diseases of the arteries	Yes	No
Diabetes	Yes	No

3. Do you have any other current or past ailments, which may prevent you from participating in the evaluation tasks described to you in the volunteer consent form? (Circle One): Yes No

3a. If yes, please describe the ailment(s) below:

_____
_____
_____
_____
_____
_____

4. Please circle the phrase that you feel best describes your history of tobacco use?

(Circle One): Never Used Tobacco
Stopped more than 10 years ago
Stopped less than 10 years ago
Light User (less than one pack a per week)
Average User (more than one pack a per week)
Heavy User (more than one carton a week)

4a. If you do use tobacco what type of tobacco do you use? (Circle all that apply):

Smoke Cigarettes
Smoke Cigars
Smoke a Pipe
Chew Tobacco
Use Snuff
Other: _____

5. Please characterize your current regular aerobic exercise habits (e.g. jogging, cycling).

(Circle One): Do not participate in regular aerobic exercise
Do aerobic exercise 1 to 3 times a week
Do aerobic exercise 4 to 5 times a week
Do aerobic exercise 6 to 7 times a week

6. What is your branch of service? (Circle One):
Air Force Army Marine Corps Navy Coast Guard

7. What is your age? _____

8. How long have you been in the service? _____ years _____ months

9. Please list below your primary MOS, ASI, NEC or AFS and briefly describe your job:
_____
_____
_____
_____

9a. How long have you been performing this MOS, ASI, NEC or AFS? _____ years _____ months

10. What is your gender? (Circle One): Male Female

11. Do you wear vision correction devices (glasses, contact lenses)? (Circle One):
Yes No

11a. If yes, what type of vision correction device do you wear most often?

(Circle One):
Glasses
Contact Lenses
Other: _____

12. Do you typically wear vision corrective inserts with your current protective mask?

(Circle One):
Yes No

13. Please rate your perceived level of experience with protective mask systems.

(Circle One):
Very Experienced Experienced Slightly Experienced Not Experienced

14. If applicable, please circle all masks with which you have experience.

(Circle all that apply):
M40 series M42 M17 M45 Other:_____

15. If applicable, please circle the mask you currently use.

(Circle One):
M40 series M42 M17 M45 Other:_____

16. Have you ever had an adverse reaction, before, during or after wearing a mask?

(Circle One):
Yes No

16a. If yes, please describe this reaction in detail:
_____
_____
_____

17. What is your education level?

(Circle One):
GED
12 years (High School Graduate)
13-15 years (Some College)
16 years (College Graduate)
Greater than 16 years (Post Graduate Education)

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Appendix C. Anthropometrics Measurement Summary

Table C-1. Summary of range, minimum, maximum, mean, standard error, and standard deviation for anthropometric measures and percentiles.

	N	Range	Min	Max	Mean	Std. Error	Std. Dev.
STATURE	21	20.1	166.8	186.9	176.26	1.06	4.87
STATURE %	21	85	10	95	53.10	5.02	22.99
WEIGHT	21	38.2	58.5	96.7	81.68	2.57	11.76
WEIGHT %	21	92	2	94	58.52	6.89	31.59
BITRAGION CORONAL ARC	21	4.0	32.6	36.60	34.98	0.24	1.09
BITRAGION CORONAL ARC %	21	82	2	84	43.10	5.70	26.12
BITRAGION CRINION ARC	21	7.5	28.6	36.10	32.42	0.37	1.67
BITRAGION CRINION ARC %	21	98	1	99	46.14	6.76	30.98
BITRAGION FRONTAL ARC	21	7.2	27.2	34.40	30.45	0.32	1.45
BITRAGION FRONTAL ARC %	21	98	1	99	50.48	6.32	28.98
BITRAGION SUBNASALE ARC	21	6.4	25.5	31.90	29.15	0.32	1.43
BITRAGION SUBNASALE ARC %	21	98	1	99	48.52	7.17	32.87
BITRAGION CHIN ARC	21	7.2	28.0	35.20	32.16	0.39	1.77
BITRAGION CHIN ARC %	21	96	1	97	41.38	7.19	32.97
BITRAGION SUBMANDIBULAR ARC	21	5.9	27.2	33.10	30.27	0.33	1.52
BITRAGION SUBMANDIBULAR ARC %	21	95	1	96	44.33	6.90	31.60
HEAD CIRCUMFERENCE	21	9.8	52.8	62.60	56.80	0.42	1.94
HEAD CIRCUMFERENCE %	21	98	1	99	50.19	6.09	27.90
BIZYGOMATIC BREADTH	21	2.5	12.7	15.20	14.10	0.13	.618
BIZYGOMATIC BREADTH %	21	96	1	97	54.95	6.93	31.76
HEAD BREADTH	21	2.6	13.80	16.40	15.33	0.15	.67
HEAD BREADTH %	21	97	1	98	60.52	6.88	31.52
HEAD LENGTH	21	4.1	18.4	22.5	19.78	0.18	.87
HEAD LENGTH %	21	96	3	99	49.96	6.31	30.90
INTERPUPILLARY BREADTH	21	1.7	5.7	7.4	6.40	0.09	.43
INTERPUPILLARY BREADTH %	21	98	1	99	45.88	6.47	31.70

Table C-2. Summary of anthropometric data

TP No.	Stature (cm)	Stature %	Weight (kg)	Weight %	Bitragion Coronal Arc (cm)	Bitragion Coronal Arc %
3	170.8	24	75.4	42	34.80	34
7	177.1	59	80.3	59	34.90	37
9	177.6	62	94.6	91	36.60	84
12	176.4	55	68.4	18	35.30	49
13	176.3	55	95.8	93	36.10	73
14	185.6	93	66.9	14	33.90	13
15	186.9	95	83.8	70	32.60	2
16	169.4	18	58.5	2	33.30	6
18	178.6	68	79.8	58	34.50	26
20	166.8	10	96.7	94	35.80	65
21	175.2	48	70.6	25	35.70	62
22	175.8	52	91.2	87	36.10	73
24	175.5	50	72.8	32	34.60	28
25	181.0	79	95.8	93	35.70	62
26	174.0	41	85.7	76	34.10	17
27	172.8	34	66.2	13	33.20	5
28	180.6	77	78.3	52	35.90	67
30	176.6	56	96.3	93	34.90	37
34	171.3	27	76.0	44	35.70	62
35	179.2	71	93.2	90	36.20	75
36	174.0	41	89.0	83	34.60	28

TP No.	Bitragion Crinion Arc (cm)	Bitragion Crinion Arc %	Bitragion Frontal Arc (cm)	Bitragion Frontal Arc %	Bitragion Subnasale Arc (cm)	Bitragion Subnasale Arc %
3	31.50	17	30.00	35	30.40	86
7	32.60	50	30.20	42	28.80	36
9	36.10	99	34.40	99	31.90	99
12	32.50	46	29.70	25	28.50	27
13	32.80	57	31.50	84	30.50	88
14	32.40	43	31.10	74	29.80	71
15	28.60	1	28.10	1	28.00	14
16	29.30	1	27.20	1	25.50	1
18	31.70	21	30.00	35	28.60	30
20	33.60	80	31.90	91	30.90	93
21	32.50	46	30.20	42	27.90	12
22	33.80	84	31.80	90	30.70	91
24	32.20	36	30.60	57	28.50	27
25	35.10	98	30.60	57	28.30	21
26	31.20	11	29.90	32	28.70	33
27	31.60	19	30.40	50	28.30	21
28	32.10	33	30.50	53	29.20	50
30	33.70	82	31.30	79	30.90	93
34	31.30	13	28.90	7	28.10	16
35	33.20	69	30.20	42	29.90	74
36	33.00	63	30.80	64	28.80	36

TP No.	Bitragion Chin Arc (cm)	Bitragion Chin Arc %	Bitragion Submandibular Arc (cm)	Bitragion Submandibular Arc %
3	32.70	54	31.50	77
7	32.40	45	30.80	62
9	35.10	97	31.20	71
12	30.70	8	28.80	13
13	35.20	97	33.10	96
14	32.50	48	29.50	27
15	31.20	15	29.20	20
16	28.00	1	27.20	1
18	31.20	15	30.50	53
20	34.20	88	31.00	66
21	30.20	4	28.30	7
22	34.80	95	32.00	86
24	32.30	42	29.00	16
25	31.10	13	30.90	10
26	31.90	31	29.80	34
27	31.90	31	29.00	16
28	32.10	36	30.30	48
30	33.70	80	32.80	94
34	30.50	6	29.70	32
35	32.60	51	31.90	84
36	31.00	12	29.10	18

TP No.	Head Circum-ference (cm)	Head Circum-ference %	Bizygomatic Breadth (cm)	Bizygomatic Breadth %	Head Breadth (cm)	Head Breadth %
3	55.80	27	14.80	90	16.10	95
7	57.00	57	13.90	41	15.20	54
9	62.60	99	14.60	84	15.60	80
12	57.10	59	14.10	56	15.20	54
13	58.20	83	14.70	87	15.40	68
14	58.30	84	14.00	49	15.50	74
15	53.80	2	13.20	6	14.30	5
16	52.80	1	12.70	1	13.80	1
18	56.80	51	13.30	8	14.30	5
20	57.10	59	14.50	80	15.20	54
21	55.60	23	14.20	62	15.40	68
22	56.60	46	15.20	97	15.70	84
24	57.10	59	13.70	27	15.20	54
25	55.90	29	14.30	69	16.30	98
26	57.00	57	13.50	16	15.40	68
27	56.10	33	13.40	12	14.50	10
28	57.20	62	14.50	80	16.40	98
30	58.50	87	14.50	80	15.90	91
34	54.70	9	14.00	49	15.30	61
35	57.80	76	14.50	80	16.10	95
36	56.80	51	14.50	80	15.20	54

TP No.	Head Length (cm)	Head Length %	Interpupillary Breadth (cm)	Interpupillary Breadth %
3	18.90	12	6.40	44
7	20.00	66	6.10	16
9	22.50	99	7.40	99
12	20.20	76	6.40	44
13	20.30	80	6.75	78
14	20.30	80	6.70	74
15	18.40	3	6.30	34
16	18.60	6	5.70	1
18	20.00	66	6.25	29
20	19.60	43	7.05	93
21	19.00	15	6.05	13
22	19.70	49	6.40	44
24	20.70	92	6.45	50
25	19.00	15	6.25	29
26	20.00	66	6.60	65
27	19.60	43	6.70	74
28	19.20	23	6.70	74
30	20.70	92	6.60	65
34	19.20	23	5.70	1
35	20.00	66	5.85	4
36	19.60	43	6.70	74

Appendix D. Vision Correction Inserts Questionnaire

Vision Correction Inserts Questionnaire

Participant Number: _____ Configuration: A B C D Date: _____

For the following questions place a check in the box next to the response that best describes your opinion of the equipment you wore during this trial.

1. The vision corrective inserts inside of the mask were:

- □ Very Stationary
- □ Stationary
- □ Slightly Stationary
- □ Slightly Unstationary
- □ Unstationary
- □ Very Unstationary

2. Vision through the JSGPM vision corrective inserts was:

- □ Very Clear
- □ Clear
- □ Slightly Clear
- □ Slightly Hazy
- □ Hazy
- □ Very Hazy

3. When moving your head up and down the vision corrective inserts were:

- □ Very Stable
- □ Stable
- □ Slightly Stable
- □ Slightly Unstable
- □ Unstable
- □ Very Unstable

4. When moving your head left and right the vision corrective inserts were:

- □ Very Stable
- □ Stable
- □ Slightly Stable
- □ Slightly Unstable
- □ Unstable
- □ Very Unstable

5. Depth Perception while wearing the mask with vision corrective inserts was:

- □ Very Good
- □ Good
- □ Slightly Good
- □ Slightly Poor
- □ Poor
- □ Very Poor

6. Glare created by the mask lenses while wearing vision corrective inserts was:

- □ Very Common
- □ Common
- □ Slightly Common
- □ Slightly Uncommon
- □ Uncommon
- □ Very Uncommon

7. Left and Right field of view while wearing vision corrective inserts was:

- □ Very Good
- □ Good
- □ Slightly Good
- □ Slightly Poor
- □ Poor
- □ Very Poor

8. Up and Down field of view while wearing vision corrective inserts was:

- □ Very Good
- □ Good
- □ Slightly Good
- □ Slightly Poor
- □ Poor
- □ Very Poor

9. Overall, the vision corrective inserts were:

- □ Very Comfortable
- □ Comfortable
- □ Slightly Comfortable
- □ Slightly Uncomfortable
- □ Uncomfortable
- □ Very Uncomfortable

10. The impact of the mask while wearing vision corrective inserts while performing your duties was:

- □ Extreme Impact
- □ Moderate Impact
- □ Slight Impact
- □ No Impact (as if you were not wearing a mask)

11. Was your vision obstructed while wearing vision corrective inserts? □ Yes □ No

12. If yes, please describe the obstruction in detail:

_____

_____

_____

13. Did the mask fog up or accumulate any sweat while wearing vision corrective inserts during this trial? □ Yes □ No

14. If yes, did fog up or accumulate sweat, which eye?

□ Left □ Right □ Both

15. How much did the fogging or sweat accumulation affect your performance? □ Extremely □ Moderately □ Slightly □ Not at all

16. Did the vision correction inserts pinch or cut your skin? □ Yes □ No

17. If the vision correction inserts did pinch or cut your skin, please describe in detail:

_____

_____

_____

18. Did movement, did the world seem to jump or move while wearing the vision correction inserts. □ Yes □ No

19. If the world seems to jump or move, please describe in detail:
_____
_____
_____

20. Did you experience any pressure points while wearing vision corrective inserts during this trial? □ Yes □ No

21. If you did experience pressure points, please describe feeling and the location in detail:
_____
_____
_____

22. Did the vision correction inserts dislodge from the mask at any time during this trial? □ Yes □ No

23. If the vision correction inserts did dislodged, please describe how in detail:
_____
_____
_____

24. Please list any additional comments you may have concerning the vision corrective inserts:
_____
_____
_____

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Appendix E. Comfort (3 hour Wear Time) Trial Questionnaire

3 hour Wear Trial Questionnaire

Participant Number: _____ Configuration: A B C D Date: _____

Helmet (Circle One): No Helmet PASGT MICH

For the following questions put a check in the box next to the response that best describes your opinion.

1. The mask around the eyes was:

- □ Very Comfortable
- □ Comfortable
- □ Slightly Comfortable
- □ Slightly Uncomfortable
- □ Uncomfortable
- □ Very Uncomfortable

2. The mask periphery (around the combined contact points of the head, temples cheek and chin) was:

- □ Very Comfortable
- □ Comfortable
- □ Slightly Comfortable
- □ Slightly Uncomfortable
- □ Uncomfortable
- □ Very Uncomfortable

3. The mask's nosecup was:

- □ Very Comfortable
- □ Comfortable
- □ Slightly Comfortable
- □ Slightly Uncomfortable
- □ Uncomfortable
- □ Very Uncomfortable

4. The mask's head harness was:

- □ Very Comfortable
- □ Comfortable
- □ Slightly Comfortable
- □ Slightly Uncomfortable
- □ Uncomfortable
- □ Very Uncomfortable

5. The mask around the throat was:

- □ Very Comfortable
- □ Comfortable
- □ Slightly Comfortable
- □ Slightly Uncomfortable
- □ Uncomfortable
- □ Very Uncomfortable

6. The mask around the neck area was:

- □ Very Comfortable
- □ Comfortable
- □ Slightly Comfortable
- □ Slightly Uncomfortable
- □ Uncomfortable
- □ Very Uncomfortable

7. The mask at your chin was:

- Very Comfortable
- Comfortable
- Slightly Comfortable
- Slightly Uncomfortable
- Uncomfortable
- Very Uncomfortable

8. The mask at your forehead was:

- Very Comfortable
- Comfortable
- Slightly Comfortable
- Slightly Uncomfortable
- Uncomfortable
- Very Uncomfortable

9. The mask overall was:

- Very Comfortable
- Comfortable
- Slightly Comfortable
- Slightly Uncomfortable
- Uncomfortable
- Very Uncomfortable

10. The weight of the mask was:

- Very Comfortable
- Comfortable
- Slightly Comfortable
- Slightly Uncomfortable
- Uncomfortable
- Very Uncomfortable

11. The thermal conditions of your face inside of the mask were:

- Very Comfortable
- Comfortable
- Slightly Comfortable
- Slightly Uncomfortable
- Uncomfortable
- Very Uncomfortable

12. The weight of the mask and helmet combined was:

- Very Comfortable
- Comfortable
- Slightly Comfortable
- Slightly Uncomfortable
- Uncomfortable
- Very Uncomfortable

13. Wearing the mask carrier was:

- Very Comfortable
- Comfortable
- Slightly Comfortable
- Slightly Uncomfortable
- Uncomfortable
- Very Uncomfortable

14. Inhaling through the mask while performing this trial was:

- Very Easy
- Easy
- Slightly Easy
- Slightly Difficult
- Difficult
- Very Difficult

15. Exhaling through the mask while performing this trial was:

- □ Very Easy
- □ Easy
- □ Slightly Easy
- □ Slightly Difficult
- □ Difficult
- □ Very Difficult

16. The fit of the mask was:

- □ Very Good
- □ Good
- □ Slightly Good
- □ Slightly Poor
- □ Poor
- □ Very Poor

17. Please discuss in detail any compatibility problems you may have experienced between the mask and the individual equipment you wore during this trial:

_____
_____
_____

18. Please discuss in detail any comfort related comments or issues you may have experienced during this trial:

_____
_____
_____

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Appendix F. 3 hour Wear Trial Comparative Questionnaire

3 hour Wear Trial Comparative Questionnaire

Participant Number: ___ Configuration (Circle One): A B C D Date: _____

Helmet (Circle One): No Helmet PASGT MICH

For the following questions put a check in the box next to the response that best describes your opinion.

1. Compared to your current mask system, the comfort of the XM50/51 after three hours of wear, was:

- ☐ Much Better
- ☐ Better
- ☐ Slightly Better
- ☐ Slightly Worse
- ☐ Worse
- ☐ Much Worse

2. Compared to your current mask system, the comfort of the XM50/51 when worn with MOPP Gear and helmet was:

- ☐ Much Better
- ☐ Better
- ☐ Slightly Better
- ☐ Slightly Worse
- ☐ Worse
- ☐ Much Worse

3. Compared to your current mask system, XM50/51 breathing resistance during inhalation was:

- ☐ Much Better
- ☐ Better
- ☐ Slightly Better
- ☐ Slightly Worse
- ☐ Worse
- ☐ Much Worse

4. Compared to your current mask system, XM50/51 breathing resistance during exhalation was:

- ☐ Much Better
- ☐ Better
- ☐ Slightly Better
- ☐ Slightly Worse
- ☐ Worse
- ☐ Much Worse

5. Compared to your current mask system, the fit of the XM50/51 was:

- ☐ Much Better
- ☐ Better
- ☐ Slightly Better
- ☐ Slightly Worse
- ☐ Worse
- ☐ Much Worse

6. Compared to your current mask system, XM50/51 your field of view was:

- ☐ Much Better
- ☐ Better
- ☐ Slightly Better
- ☐ Slightly Worse
- ☐ Worse
- ☐ Much Worse

7. Compared to your current mask carrier, the XM50/51 modular two bag carrier system was:

- Much Better
- Better
- Slightly Better
- Slightly Worse
- Worse
- Much Worse

8. Compared to your current mask system, removing the XM50/51 air deflectors from the mask was:

- Very Easy
- Easy
- Slightly Easier
- Slightly Difficult
- Difficult
- Very Difficult

9. Compared to your current mask system, installing the XM50/51 air deflectors from the mask was:

- Very Easy
- Easy
- Slightly Easier
- Slightly Difficult
- Difficult
- Very Difficult

10. Compared to your current mask system, removing the XM50/51 inhalation valve from the filter mount was:

- Very Easy
- Easy
- Slightly Easier
- Slightly Difficult
- Difficult
- Very Difficult

11. Compared to your current mask system, installing the XM50/51 inhalation valve from the filter mount was:

- Very Easy
- Easy
- Slightly Easier
- Slightly Difficult
- Difficult
- Very Difficult

12. Compared to your current mask system, removing the XM50/51 self sealing valve from the filter mount was:

- Very Easy
- Easy
- Slightly Easier
- Slightly Difficult
- Difficult
- Very Difficult
- Not Applicable

13. Installing the XM 50/51 self sealing valve from the filter mount was:

- Very Easy
- Easy
- Slightly Easier
- Slightly Difficult
- Difficult
- Very Difficult
- Not Applicable

14. Having filter alignment marks on the XM50/51 during filter change-out was:

- Very Useful
- Useful
- Slightly Useful
- Slightly Useless
- Useless
- Very Useless

15. Accidentally detaching the XM50/51 filter during filter change-out was:

- Very Common
- Common
- Slightly Common
- Slightly Uncommon
- Uncommon
- Very Uncommon

16. Accidentally detaching the XM50/51 self sealing valve from the filter mount during filter change-out was:

- Very Common
- Common
- Slightly Common
- Slightly Uncommon
- Uncommon
- Very Uncommon

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Appendix G. Demographics and Vision Summary

Table G-1. Demographic data summary

Soldier ID No.	Age (years)	Time in Service (months)	Grade	MOS
3	23	37	E-4	11B
4	25	19	E-3	13D
7	23	33	E-4	25F
8	22	50	E-3	11B
9	20	12	E-3	91W
12	19	18	E-3	11B
13	22	17	E-3	74D
14	21	33	E-4	74D
15	21	36	E-4	74D
16	32	108	E-5	11B
18	20	27	E-4	98C
20	30	119	E-5	74D
21	23	17	E-3	63J
22	38	241	E-6	74D
23	28	48	E-4	88M
24	20	13	E-1	88M
25	34	60	E-4	21B
26	22	51	E-4	11B
27	20	21	E-3	19D
28	22	22	E-4	74D
30	35	108	E-5	74D
34	20	7	E-2	19D
35	28	58	E-4	21B
36	26	30	E-4	74D

Table G-2. Vision screening summary

Soldier ID No.	Corrective Eye Wear	Dominant Eye	Far Visual Acuity Both Eyes	Color Vision
3	Yes	R	20/50	Normal
4	No	R	20/30	Normal
7	No	R	20/20	Normal
8	Yes	R	20/40	Normal
9	Yes	R	20/13	Normal
12	No	R	20/18	Normal
13	No	R	20/30	Normal
14	No	R	20/20	Normal
15	No	R	20/25	Normal
16	No	R	20/25	Normal
18	No	R	20/13	Normal
20	No	R	20/17	Normal
21	Yes	R	20/22	Normal
22	No	R	20/17	Abnormal
23	No	L	20/13	Normal
24	No	R	20/18	Normal
25	Yes	L	20/20	Normal
26	Yes	R	20/18	Normal
27	No	R	20/13	Normal
28	Yes	R	20/13	Normal
30	No	R	20/13	Normal
34	Yes	L	20/22	Normal
35	No	R	20/17	Normal
36	Yes	R	20/15	Normal

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