SOLDIER CAMOUFLAGE FOR OPERATION ENDURING FREEDOM (OEF): PATTERN-IN-PICTURE (PIP) TECHNIQUE FOR EXPEDIENT HUMAN-IN-THE –LOOP CAMOUFLAGE ASSESSMENT

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ABSTRACT

Historically, camouflage development has been reactive, with development occurring after deployment to a new theater in reaction to environmental/terrain differences in those theaters, and camouflage evaluation has generally relied on the subjective responses of a small number of human observers in the field. In response to direction from a May 2009 House Appropriations Committee Report for "a camouflage pattern that is suited to the environment of Afghanistan.", a camouflage integrated product team was quickly established to develop and execute a Secretary of the Army-approved, four-phase plan, which centered on building the science of camouflage pattern evaluation to enable informed Army Leadership decisionmaking. This effort involved extensive collaboration between the US Army Natick Soldier Research Development and Engineering Center and the US Army Aberdeen Test Center (ATC), with input from the Program Executive Office (PEO) Soldier (PEO-Soldier) and Fort Benning's Maneuver Center of Excellence (MCOE), Soldier Requirement Division (SRD). The key tasks for the portion of the effort reported here involved conducting a Soldier survey to quantify the extent of the issue, identifying the uniform/personal protective equipment (PPE) combinations for inclusion, obtaining relevant background images for the test, ensuring that the manner in which the combinations would be represented maintained all relevant color, spatial and scale information, determining the manner in which the responses of the Soldier observers would be measured and performing the data analysis. All of this was accomplished within 28 days. The methodology described is a paradigm shifting technique enabling the Army to advance camouflage development and assessment from reactive to proactive and to rapidly and objectively determine camouflage pattern performance for future areas of operation.

1. INTRODUCTION

Congressional language in the May 2009 House Appropriations Committee Report (US House of Representatives, 2009) directed the Army to "provide combat uniforms to personnel deployed to Afghanistan with a camouflage pattern that is suited to the environment of Afghanistan." The current Army Combat Uniform (ACU) in the 3-color Universal Camouflage Pattern (UCP) was fielded in 2004. Senior enlisted personnel deployed to Afghanistan expressed serious concerns to the Committee regarding UCP's camouflage effectiveness during combat operations in that environment. Previous testing on alternative patterns conducted by the US Army Natick Research, Development and Engineering Center (NSRDEC) (Dugas et al, 2005; Rock et al, 2009) had concentrated on pattern effectiveness testing using either blending or detection methodologies. Testing had not, with the exception of one test reported in Dugas et al, 2005, included the effect of body armor and other equipment usually worn over the uniform in combat situations, which can easily cover 30-40% of a Soldier's observable body surface. Beginning in July, 2009, NSRDEC, in cooperation with PEO-Soldier and the MCOE/SRD at Fort Benning, began discussions on alternate uniform and personal protective equipment (PPE) patterns and pattern combinations that could address the Congressional requirement. A 4-phase effort was approved by the Secretary of the Army in September, 2009 to address the immediate camouflage concern (Office of the Secretary of the Army, 2009):

- Phase I – Immediate Action,
- Phase II – Build the Science,
- Phase III – OEF-Specific Uniform, and
- Phase IV – Army Combat Uniform Decision.

Only Phase II, Build the Science, will be discussed here. Phase II, Part 1 involved obtaining feedback from

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14. ABSTRACT
Historically, camouflage development has been reactive, with development occurring after deployment to a new theater in reaction to environmental/terrain differences in those theaters, and camouflage evaluation has generally relied on the subjective responses of a small number of human observers in the field. In response to direction from a May 2009 House Appropriations Committee Report for ?a camouflage pattern that is suited to the environment of Afghanistan.?, a camouflage integrated product team was quickly established to develop and execute a Secretary of the Army-approved, four-phase plan, which centered on building the science of camouflage pattern evaluation to enable informed Army Leadership decisionmaking. This effort involved extensive collaboration between the US Army Natick Soldier Research Development and Engineering Center and the US Army Aberdeen Test Center (ATC), with input from the Program Executive Office (PEO) Soldier (PEO-Soldier) and Fort Benning‟s Maneuver Center of Excellence (MCOE), Soldier Requirement Division (SRD). The key tasks for the portion of the effort reported here involved conducting a Soldier survey to quantify the extent of the issue, identifying the uniform/personal protective equipment (PPE) combinations for inclusion, obtaining relevant background images for the test, ensuring that the manner in which the combinations would be represented maintained all relevant color, spatial and scale information, determining the manner in which the responses of the Soldier observers would be measured and performing the data analysis. All of this was accomplished within 28 days. The methodology described is a paradigm shifting technique enabling the Army to advance camouflage development and assessment from reactive to proactive and to rapidly and objectively determine camouflage pattern performance for future areas of operation.

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Soldiers previously deployed to Operation Enduring Freedom (OEF). The purpose of this feedback was to identify the Soldier's perceptions of the OEF camouflage challenge. Phase II, Part 2 involved evaluating alternate uniform and PPE pattern combinations via a computerized Pattern-in-Picture (PIP) evaluation to inform a down-selection process (Hepfinger et al, 2010). Phase II, Part 3 consisted of capturing images of the final uniform/PPE combinations in relevant Afghanistan environments and will be reported elsewhere (personal communication, Kathryn Rock, 2010). Details of parts 1 and 2 follow.

2. PHASE II, PART 1: PROBLEM DEFINITION SURVEY

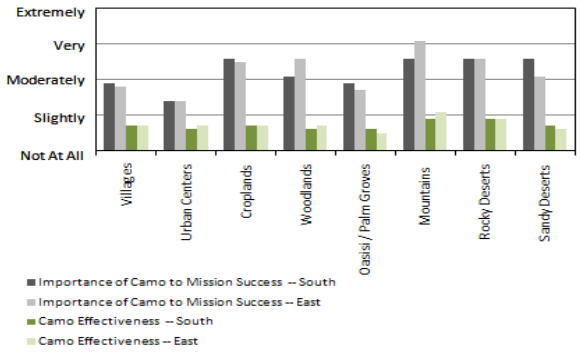
A survey was developed to validate that there was a problem, as perceived by the user community, with camouflage in Afghanistan. Therefore, Soldiers recently returned from OEF completed a survey related to the region of their OEF deployment, the type of missions they performed and the effectiveness of the UCP camouflage. Surveys were collected at Ft McCoy (n=191), Ft Bragg (219), Ft Campbell (385), Ft Lewis (98) and Ft Hood (1120) over the late August-early September 2009 timeframe. A total of 2,320 surveys were collected. Seventy-four surveys were dropped because they contained very little data for site by region, and an additional 203 were dropped because they did not wear the UCP uniform. Therefore, the following data is reported on 2,043 surveys.

Soldiers had been deployed to the eastern (1598) or southern region (445) of Afghanistan with deployments occurring during all four seasons. The most common mission sets in the east included one or more of the following: mountains (62%), villages (42%), rocky deserts (17%) and croplands (14%). The most common mission sets in the south included one or more of the following: villages (60%), sandy deserts (36%), rocky deserts (29%) and croplands (28%).

Overall, the importance of camouflage was rated lowest in villages, urban centers and oasis / palm groves and above 'Moderately Important' in croplands, woodlands, mountains, rocky deserts and sandy deserts. The effectiveness of the UCP in different environments was rated between 'Not at All' and 'Slightly Effective' in all regions except mountains in the east, where it was rated 'Slightly Effective' (Figure 1).

The Soldiers rated the importance of camouflage to the success of the mission type using a scale 'Not At All Important' (0) to 'Extremely Important' (4) for the following mission types: Sniper Position, Dismounted Patrol For A High Value Target, Establish/Maintain An Observation Post, Area Recon, Search & Destroy Mission, Route Recon, Dismounted Patrol (Humanitarian), Re-Supply and FOB/COP Security. Most respondents felt that camouflage was at least 'Moderately Important' for most mission types, with perimeter security and re-supply rating the lowest.

Table 1 shows the Soldiers' camouflage effectiveness ratings of both the UCP that they wore and how they felt other camouflage patterns might have performed in theater. This was rated using the scale 'Not At All Effective' (0) to 'Extremely Effective' (4). A below 'Slightly Effective' rating was given to the UCP in the south and east and the Battle Dress Uniform (BDU) in the East. MultiCam® and Desert MARPAT were rated the highest in both regions.



Importance Scale: Not At All Important to Extremely Important

Effective Scale: Not At All Effective to Extremely Effective

Figure 1. Soldier-rated importance and effectivness of UCP camouflage

Table 1. Perceived Camouflage Pattern Effectiveness Ratings and Number of Responses

Pattern	South	East
UCP	0.8 (439)	0.9 (1577)
BDU	0.6 (391)	1.3 (1357)
Desert Combat Uniform (DCU)	2.2 (392)	1.4 (1335)
Desert MARPAT	2.8 (378)	2.2 (1297)
Woodland MARPAT	1.1 (368)	1.8 (1289)
MultiCam®	2.6 (370)	2.8 (1282)

When the Soldiers were asked to choose a single uniform to wear during their region-specific mission in Afghanistan, MultiCam® (south 43%, east 47%) and Desert MARPAT (south 39%, east 26%) were selected most frequently. Figure 2 is a graphic representation of Soldiers responses for all uniforms available in this question. The reasons they cited for pattern preferences

are listed below in Table 2. Reasons are ranked by percent chosen.

Over 80% of the Soldiers indicated there are critical pieces of equipment that should have the same pattern as the new combat uniform. Table 3 shows responses and the percentage of Soldiers who picked the item. The top five pieces of equipment selected are very similar for the southern and eastern region except for the ECWCS III system. The top 5 for each region are highlighted in yellow.

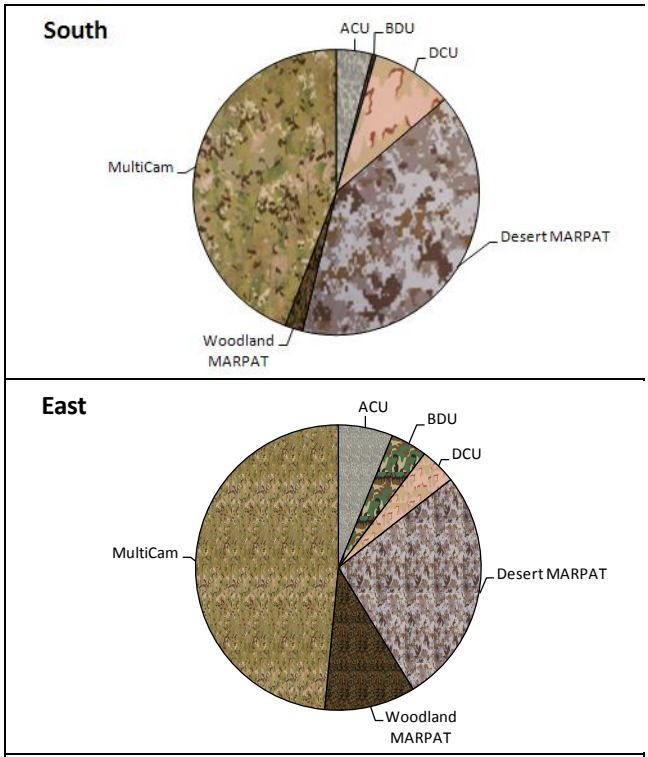


Figure 2. Soldier responses, percentage by region, of preferred uniform to wear, if possible, during their region-specific mission.

In summary, the survey data clearly indicated that the importance of camouflage varied depending on terrain and mission. Soldiers perceived camouflage to be relatively important for certain missions and the current Army camouflage was perceived to be not as effective as desired. Using these survey responses, the terrain types perceived as having the highest importance of camouflage to mission success were selected for use in the PIP evaluation (Phase II, Part 2). These terrain types were mountainous, cropland/woodland, rocky desert, and sandy desert.

Table 2. Soldier Responses Indicating Reason for Preferred Camouflage Pattern, Ranked High to Low Frequency

MultiCam® Rank (n = 90)	**Desert MARPAT Rank (n = 65)**
Effective in multiple environments within the region	Has preferred colors for the region
Offers good blending	Offers good blending
Has preferred colors for the region	Offers good concealment at long range
Offers good concealment at long range	Effective in multiple environments within the region
Has right number of colors for region	Has right number of colors for region
Effective over many seasons within the region	Effective over many seasons within the region
Has preferred pattern for the region	Has preferred pattern for the region
Offers good concealment at close range	Offers good concealment at close range
Have seen its effectiveness in theatre (in this region)	Have seen its effectiveness in theatre (in this region)
Have seen its effectiveness in theatre (outside this region)	Have seen its effectiveness in theatre (outside this region)

Table 4. Critical Equipment Pieces Identified by Soldiers that Should be in the Same Pattern as the Uniform by Region

	South	East
Body armor (IOTV)	86	76
Plate carrier	33	34
Magazine pouches	37	41
Grenade pouches	17	16
Improved first aid kit	21	21
Helmet cover	82	78
Knee and elbow pads	9	8
ECWCS III	86	7
Modular sleep system	5	6
MOLLE hydration bladder kit	16	11
MOLLE rifleman set	18	15
MOLLE field pack	16	12
Drop leg panel	< 1	7
Magazine drop bag	0	< 1
Assault pack	47	45
Rucksack	30	24
Name tapes	8	14
Patrol or boonie cap	28	24

3. PHASE II, PART 2: PATTERN-IN-PICTURE (PIP) EVALUATION

During Phase II, Part 2, the PIP computerized evaluation was developed and executed in collaboration with PEO-Soldier, MCOE/SRD, and ATC. Given the

expense and time required to field test multiple camouflage alternatives and the extremely short time available, a digital rendering methodology was developed to assist with the downselection process. This evaluation technique allowed 57 uniform and PPE pattern combinations to be evaluated in Afghanistan terrains. Digital representations of current military, former military, commercial and experimental Soldier camouflage patterns in Afghanistan imagery were presented to observers using forced choice methodology.

3.1 Background terrain images

Background terrain images with a Macbeth color reference chart in the scene, taken in Afghanistan using a good quality digital camera of known characteristics, were desired for the experiment. Background terrain images collected in Asadabad and Jalalabad, Afghanistan were available from a data collection conducted in August 2008 by NRL. Background images representing the mountainous, cropland/woodland and high desert terrains were selected for the PIP evaluation based on survey results. Halfway through the two week observer test, a sandy desert image was added to the evaluation for completeness. A calibrated image obtained from U.S. Army Night Vision and Electronic Sensors Directorate, taken at 29 Palms, CA, was identified by previously deployed service members as being representative of terrain in southern Afghanistan.

3.2 Identification of camouflage patterns

A total of 17 camouflage pattern candidates were selected for inclusion in the PIP evaluation. The mix included 7 current/former military (i.e. Army, Marine Corps, Special Forces), 1 commercial and 9 experimental patterns, which were color modifications to existing patterns. The candidate patterns were categorized as a 'universal', 'woodland,', or 'desert' variant. The criteria used when selecting these patterns included, but were not limited to, previous evaluation results, availability in existing inventory and ease of production for near-term fielding. Each uniform pattern was paired with either a matching solid or pattern PPE currently in the Department of Defense (DOD) inventory. Not all uniform candidates were matched with every PPE candidate, but every uniform candidate was matched with itself. In some instances, certain combinations were not considered to be a logical or effective combination for near-term fielding and, therefore, were not included in the evaluation. Table 4 shows the candidate uniform and PPE options investigated.

3.3 Color Correlation of Patterns

The colors in the patterns were extracted from digital images of physical samples of camouflage material in front-lit conditions taken under clear skies using a Canon EOS D30 digital color camera at ATC. The patterns were either inkjet or production printed, with the exception of Universal AOR, which was only produced digitally. These images were correlated with the background images described in the next section. Correlation is defined in this instance as color balancing the images to account for color temperature of the illuminant and adjusting the exposure of the images to account for the differences in light level, exposure, f-stop and gain of the digital camera. This process was facilitated by placing a Macbeth Color Checker™ in each image and taking the images with the camera set to RAW image collection mode. The images were then imported into Adobe® Photoshop® CS3 Extended image processing software. The color balance was set with the "White Balance Tool" in Photoshop® by clicking on the gray chip on the Macbeth chart, bottom row third column from the right (see Figure 3). The reflectivity of this chip is considered "middle gray" and is approximately 18% reflective making it a good reference for color balance and exposure adjustments. The intensity was set to approximately 160 on the same gray chip using the exposure slider bar in Photoshop®.

Table 4. Candidate Uniform and PPE Patterns and Colors Included in Study

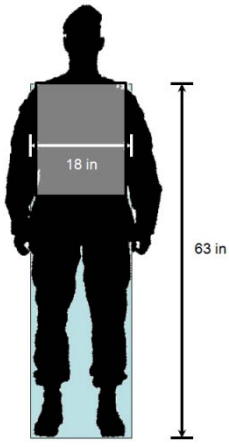
Uniform Pattern				PPE Color / Pattern
Universal	Woodland	Desert		
UCP Mod C	Woodland MARPAT	Desert MARPAT		UCP
UCP Mod D	Woodland Scorpion	Desert Brush		Coyote
MultiCam	Battle Dress Uniform (BDU)	Desert Scorpion		Ranger Green
MultiBrush	Woodland Digital	Desert Combat Uniform (DCU)		BDU
UCP	AOR-2	DCU Digital		Khaki
Universal AOR		AOR-1		MultiCam
				Matching

Figure 3. Digital image of camouflage sample with Macbeth chart

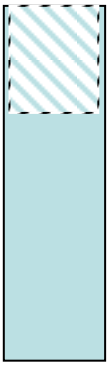
Once the images were color balanced and the exposure was set to a common level, the images were imported into Photoshop®. Contiguous areas of individual colors were outlined and a histogram was generated to extract the mean red, green and blue values of the individual color channels. These values, referred to in this paper as correlated RGB triplets, were then sent electronically to NSRDEC to enter into full-scale multi-channel digital camouflage patterns. These full-scale digital patterns were then sent back to ATC where they were digitally cut to size as described in section 3.4.

3.4 Rendering of Uniform/PPE Combinations into Background Images

Once the uniform and PPE candidates to be evaluated were identified, it was necessary to combine them prior to insertion into the background images. Due to the compressed timeline driven by the deadline to Congress, it was decided to use a rectangle to represent a Soldier wearing the candidate patterns. In order to get the relative height and width dimensions correct, a volunteer was outfitted with an appropriately-sized Improved Outer Tactical Vest (IOTV) and measured from ground-to-shoulder for the height of the rectangle and from armpit-to-armpit for the width of the rectangle. This individual measured 63" from ground to shoulder and 18" wide at the armpits. The size large IOTV was 20" long and 16.5" wide, representing approximately 30% of the rectangular surrogate Soldier.



Surrogate Soldier measurements



Template showing relative sizes of uniform (solid) and PPE (lines)

Example pairing used in observer test (i.e., Ranger Green PPE on an AOR-2 uniform)

Figure 4. Sample of uniform/PPE combination used for PIP evaluation

Having established the dimensions for the surrogate Soldier and PPE, the digital files of the candidate camouflage patterns were then scaled to correspond with what their appearance would look like once printed. Because each digital camouflage pattern file generally represented a single repeat, multiple scaled files needed to be "stitched" together in order to cover the required area. That is, each pattern file could not simply be "stretched" to fit the 18" x 63" rectangle but needed to be combined in the correct number of repeats and orientation to fill the rectangle. Figure 4 illustrates the rectangular template and a sample of one of the actual combinations used in the observer test.

After the uniform and PPE were combined, they had to be resized to represent the actual area covered by a Soldier standing at the same distance in the image. A six foot tall person at 46 yards in one of the Canon D30 images (see Figure 5), was used as a reference to calculate the height and width in pixels that the patterns would cover in these images at 45 yards.

The resolution of the digital pattern images was reduced to the appropriate size using bi-cubic interpolation in Photoshop® and these images were then digitally placed in the background images. This step adjusted the size of the pattern to match the scale of the background images and also decreased the resolution of the pattern in a fashion that would approximate what would have been captured with the digital color camera at 45 yards in the field. Figure 6 shows each of the four backgrounds and the target position within the image. Note that the terrain descriptors for the terrain backgrounds do not exactly match the descriptors in the terrain survey. To date there has not been any standardization of terminology for terrain features with regard to camouflage. This should be considered in future work.

Figure 5. Six foot tall human at 46 yards in Background 1.

3.5 Observer Evaluation

The uniform/PPE/background terrain combinations were used to create a forced choice observer test using custom software developed by ATC. Observer data collection was conducted at Fort Hood and Fort Campbell using four individual stations. Each station consisted of a laptop, mouse and monitor. The observer evaluation ran from a Dell laptop that was not accessible to the observer; observers used only the mouse and monitor. The monitor was a 21.3-inch Samsung SyncMaster 214T color monitor with a maximum resolution of 1600 x 1200 pixels and the viewing distance was set to 22". Each observer was supervised by a test controller (i.e., one test controller for two observers) to ensure proper procedures were followed. Test controllers were situated behind the observer to prevent interference during the evaluation.

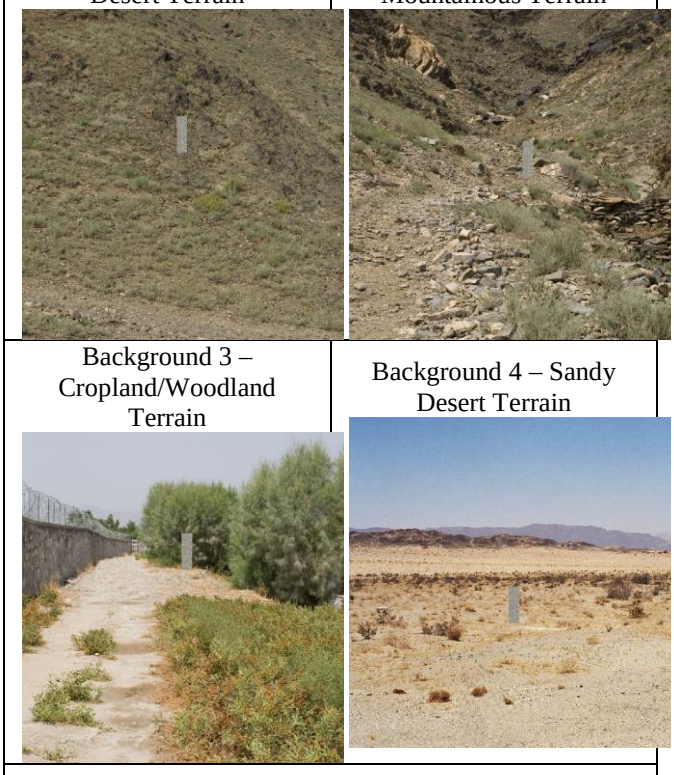


Figure 6. Terrain images used for PIP evaluation.

Observers were provided with instruction on the purpose and procedures for the test and shown sample images as training. After completion of the training sequence, observers were shown the first pair of images and asked to click on the grey box underneath the uniform/PPE combination that blended better with its immediate background. A sample screenshot from the test is shown in Figure 7. Each of the 57 combinations was shown paired with every other combination for a given background so that observers were comparing the blending in the same background for each given presentation. Presentation order to the observers was randomized. Furthermore, each combination was presented randomly on either the left or right hand side of the monitor. These layers of randomization resulted in a matrix with 19,152 combinations using three backgrounds and 25,536 combinations when the fourth background was added. Each observer was shown two 120 combination sequences for a total of 240 combinations.

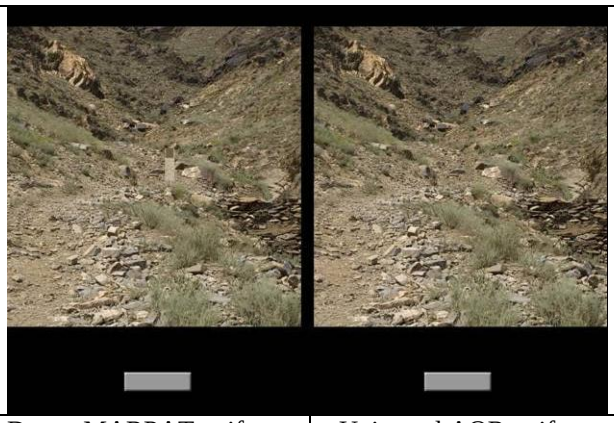


Figure 7. Screenshot from PIP observer evaluation

3.6 PIP Results

The observer PIP evaluation was completed by 231 participants during the period of 1-11 Sep 2009. Table 5 provides summary demographics for the participants. A total of 191 participants had spent 12-18 months deployed to OEF, 34 had less than 12 months and 6 had more than 18 months deployment experience in OEF. Approximately half (115) of the participants indicated that their Military Occupational Specialty (MOS) was 11B/11C Infantryman. This was the most common MOS in the study.

Table 5. Summary Observer Demographics

Location	Number (N)	Male	Female	Mean Age (years)
Fort Campbell	119	105	14	27
Fort Hood	112	111	1	24
Total	231	216	15	26

A total of 47,084 pairs were presented and evaluated by the observers. Each uniform/PPE combination

appeared in approximately 473 pairings per background, although there were only 232 pairings for background 4, which was added during the second week of observer testing. Table 6 summarizes the results from the observer testing. Due to space limitations, only the top10 and bottom 10 overall performers are shown. The values indicate the percentage of pairings where the uniform/PPE combination was rated as blending better than the combination it was paired with. The BG1 through BG4 columns list the percentages for that specific background, while the "Overall" column is the average of the scores for the four backgrounds. The combinations listed in Table 7 have been sorted from high to low according to their overall ratings. The top 10 performers for a given background are highlighted in light green and the bottom 10 performers for a given background are highlighted with tan.

Top performers by Background were:

In Background 1, the rocky desert terrain, the top 10 performers were as follows:

- MultiCam® uniform with matching PPE, Coyote PPE and Ranger Green PPE;
- Woodland MARPAT uniform with matching PPE, Ranger Green PPE and Coyote PPE and
- Woodland Digital uniform with matching PPE, BDU PPE, Ranger Green PPE, and Coyote PPE.

In Background 2, the mountainous terrain, the top 10 performers were as follows:

- MultiCam® uniform with matching PPE, Ranger Green PPE, Coyote PPE, and Khaki PPE;
- Universal AOR uniform with matching PPE and Coyote PPE;
- Woodland Scorpion uniform with MultiCam® PPE and Ranger Green PPE;
- AOR-2 uniform with matching PPE; and

MultiBrush uniform with matching PPE.

In Background 3, the cropland/woodland terrain, the top 10 performers were as follows:

- Woodland Digital uniform with matching PPE, BDU PPE, Ranger Green PPE and Coyote PPE;
- AOR-2 uniform with matching PPE, Ranger Green PPE, and Coyote PPE;
- Woodland MARPAT uniform with matching PPE and Ranger Green PPE; and
- UCP-C uniform with matching PPE.

In Background 4, the sandy desert terrain, the top 10 performers were as follows:

- DCU Digital uniform with matching PPE, Khaki PPE, and Coyote PPE;
- AOR-1 uniform with matching PPE and Khaki PPE;
- Desert Brush uniform with matching PPE;
- Desert MARPAT uniform with matching PPE and Khaki PPE; and
- DCU uniform with matching PPE and Khaki PPE.

Table 6. Selected PIP Observer Results; Each Uniform Appeared in Approximately 473 Pairings for Backgrounds (BG) 1 through 3 and 232 Pairings for Background 4

Uniform / PPE Combination	Blended Better %				
	BG 1	BG 2	BG 3	BG 4	Overall*
MultiCam® / Match	93.1	96.0	72.5	58.3	80.0
MultiCam® / Coyote	85.1	88.2	64.3	54.8	73.1
MultiCam® / Ranger Green	83.3	90.7	70.6	46.7	72.8
Woodland Scorpion / MultiCam®	67.7	88.8	69.2	58.7	71.1
Universal AOR / Match	71.3	96.0	41.5	67.2	69.0
MultiCam® / Khaki	70.9	87.8	57.8	55.5	68.0
AOR-2 / Match	77.4	80.0	85.1	29.3	67.9
Universal AOR / Coyote	71.5	84.5	42.2	62.6	65.2
Woodland Scorpion / Match	52.9	72.1	66.7	51.5	60.8
DCU digital / Coyote	13.6	31.2	19.4	86.3	37.6
Desert Scorpion / Khaki	19.9	32.8	28.8	68.0	37.4
BDU / Match	60.8	14.7	59.8	1.3	34.1
DCU digital / Khaki	7.2	21.6	17.2	89.7	33.9
BDU / Ranger Green	51.2	13.0	51.9	4.3	30.1
UCP/ UCP	20.6	23.7	34.6	32.3	27.8
BDU / Coyote	53.6	11.7	38.3	3.8	26.9
DCU / Match	5.3	10.3	8.1	80.4	26.0
DCU / Coyote	7.3	12.6	9.8	71.0	25.2
DCU / Khaki	3.8	10.0	7.7	76.9	24.6
** Sorted On Overall*	Top 10		Bottom 10		

The results for Background 4 demonstrate the difficulty in obtaining a pattern that performs well over a wide range of background types: none of the top 10 performers in Background 4 were within the top 10 for Backgrounds 1-3. In fact, many of them were in the

bottom 10 in those three backgrounds. The results for the UCP uniform with matching PPE, which is the currently fielded combination, are consistent with the anecdotal feedback that lead to the Congressional interest in an improved camouflage pattern for OEF: UCP is in the bottom 10 overall across all four backgrounds and did not perform well in any of them. These UCP results are consistent with the survey results discussed in Section 2. Based on the overall scores, all four of the MultiCam® variants were in the top 10, as was the Woodland Scorpion with MultiCam® and matching PPE. Also in the top 10 were the Universal AOR uniform with matching and Coyote PPE and the AOR-2 uniform with matching and Coyote PPE. The bottom 10 performers based on overall scores included all of the PPE variants paired with BDU and DCU, as well as DCU Digital with Khaki and Coyote PPE, Desert Scorpion with Khaki PPE and UCP with UCP PPE.

The observer results also demonstrate the improved blending that is achieved when using PPE that matches the uniform. In the 16 cases where a pattern was evaluated with both matching PPE and an alternative, the matching PPE combination was rated as blending better than the alternatives in 14 out of 16 cases based on overall scores. The two instances where the matching PPE combination came in second were the Woodland and Desert Scorpion variants. Here, the uniform paired with MultiCam® PPE outperformed the matching combinations.

CONCLUSIONS

A survey conducted of 2,250 Soldiers recently returned from at least one tour in Afghanistan clearly indicated that the importance of camouflage varies depending on terrain and mission. Soldiers perceive camouflage to be relatively important for certain missions and the current Army camouflage is perceived to not be as effective as desired. Using survey responses to select the terrain types perceived to be the most important for effective camouflage, the PIP methodology was developed on an accelerated timeline for the rapid prototyping and evaluation of a number of camouflage color/pattern uniform/PPE combinations for possible use in OEF. Color consistency between images collected from a variety of operators and equipment, at disparate times and locations, was carefully maintained through the use of a Macbeth color standard. An observer experiment was constructed from the combination of digital pattern images with digital background images, incorporating the psychophysics of human perception into an experiment that was easy to use from the Soldier perspective. As demonstrated in previous testing, the digital format utilized here enables a large number of Soldiers to evaluate systems under the same conditions by bringing the test to the observer instead of bringing the observer to the field, resulting in incredible amounts of feedback on many combinations in a short period of time and at a reasonable cost.

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