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14. ABSTRACT
This TOP describes several procedures for using human observers to test camouflage performance. Detection data can be collected live in the field using one observer approaching the test article at a time, but these tests are time consuming and expensive to execute for collection of statistically significant data. This TOP presents alternate approaches that are more expedient and can be selected when balancing data requirements, time, and cost.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 01-1-025 5 May 2016
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CAMOUFLAGE PERFORMANCE TESTING USING OBSERVERS

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1. SCOPE.

This Test Operations Procedure (TOP) describes procedures for using human observers to test camouflage performance in the visible spectrum however, many of the techniques can be adapted to other spectral bands. The best data collection approach is live in the field using only one observer for each trial run but these tests are extremely time consuming and expensive to execute when gathering statistically significant data. This TOP presents alternative approaches that are more expedient that can be selected when balancing data requirements and cost.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Item	Requirement
Appropriate terrain	Appropriate terrain (woodland, desert, snow covered with and without vegetation, tropical, etc.) must be identified with unobstructed views out to distances of interest.

2.2 Instrumentation.

a. General.

Devices for Measuring	Permissible Measurement Uncertainty
Visual acuity test chart	Not applicable.
Color vision test chart	Not applicable.

b. Field Measurements.

Devices for Measuring	Permissible Measurement Uncertainty
Passive scoring system	± 0.05 degree
Range finder	± 0.1 meter (m)

c. Photo Simulation.

Devices for Measuring	Permissible Measurement Uncertainty
Digital photographic camera	Not applicable.
Camera lens	When attempting to approach the resolution of the human eye, lens focal length should be set to achieve on the order of 120 pixels per degree. However, carrying this resolution through the entire image processing chain is difficult and is not required for comparative testing.

Devices for Measuring	Permissible Measurement Uncertainty
Photometer	± 5 percent of reading
MacBeth Colorchecker Chart**	Not applicable.
Photographic gray card	Not applicable.
Spectralons (5 – 99 percent)	± 1 percent
Computer	Not applicable.
Computer monitor	Recommended minimum specifications: Diagonal viewable size: 24 inches Resolution: 1920 x 1200 pixels Contrast ratio: 1000 to 1 Color support: 16.78 million Pixel pitch: 0.27 mm
Image processing software	Not applicable.

3. REQUIRED TEST CONDITIONS.

Many factors must be considered when planning a camouflage performance test. Some of the most critical factors include terrain, lighting, environmental conditions, aspect angle, viewing angle, and configuration of test article. Observer experience and training are important factors to consider for any camouflage performance test.

a. Terrain can be classified in many ways such as woodland, desert, transitional, snow covered, tropical, etc. A series of comprehensive reports on this topic are available from the United States (U.S.) Army Corps of Engineers[1,2,3,4,5,6,7***]. The critical factors to consider are the distance between the test article and the observer, the width of the field of regard to be searched, and the time of year. The time of year impacts the vegetation state which includes verdant or dormant, vegetation density, and vegetation variety.

b. Illumination conditions such as front lit, backlit, top lit, clear, cloudy skies, etc. should be considered and documented. It may be cost prohibitive to sample all desired conditions so priorities may need to be established in the test design.

** The use of brand names does not constitute endorsement by the U.S. Army or any other agency of the Federal Government, nor does it imply that it is best suited for its intended application.

*** Superscript numbers correspond to Appendix B, References.

c. The aspect angle of the test article, in combination with viewing angle, relative to the ground plane of the observation should be considered in the test design. The impact of aspect angle, such as, front, front-quarter, side, etc. may be significantly different between Soldier systems and vehicles. The expanding proliferation of low-cost multi-spectral drones makes viewing angle relative to the ground plan an important consideration in test design. Further, off-the-shelf technology is no longer limited to the visible band. Thermal sensors are also now available on low-cost commercial drones. Collecting data from elevated positions is outside the scope of this TOP. However, manned and unmanned aerial platforms could be used for elevated image collection.

d. One of the most difficult factors to incorporate may be military relevance since camouflage must be seen to be tested. When good tactics, techniques, and procedures (TTPs) are used in militarily relevant scenarios there may be little to no opportunity to observe the test article. Further, when incorporating TTPs, great care must be taken to distinguish camouflage performance from the skill of the individual executing the scenarios.

e. According to the North Atlantic Treaty Organization (NATO) Guidelines for Camouflage Assessment Using Observers[8], military experience has not been shown to be a consistent major factor in determining detection range. But, the use of a practice series of images has been shown to be very important to overcome the learning effect on observers. If military personnel are required for testing, determine if Military Occupational Specialty (MOS) qualified Soldier-Operator/-Maintainer Test and Evaluation (SOMTE) personnel assigned to the U.S. Army Test and Evaluation Command (ATEC) are available to support the testing. If SOMTE are not available, ensure a Test Schedule and Review Committee (TSARC) request is submitted one year prior to the start of testing, or as early as possible. A Safety Release (SR) and Human Research Protection Plan (HRPP) must be obtained from ATEC prior to using military personnel as test participants.

4. TEST PROCEDURES.

4.1 Summary of Test Procedures.

a. Several alternatives for camouflage performance testing are presented in this TOP to provide options when designing a test. The procedures include a method for collecting detection data live in the field with multiple observers simultaneously; a photo simulation process for collecting images in the field to present in a laboratory environment to gather detection data; and an even more expedient method to collect images in the field and test how well camouflage matches the background (also known as blending) in the laboratory. Brief descriptions of each process are presented below and the detailed procedures are presented in Sections 4.2 and 4.3.

b. A straightforward and fundamental process for analyzing camouflage performance in the field is documented in TOP 02-2-615A, Security from Detection (Vehicles)[9]. The procedure utilizes observers walking towards vehicles, one at a time, across terrain until the vehicles are detected. While the results may well represent real-world performance, the amount of time required to collect statistically significant data across a variety of camouflage options, terrains, lighting conditions, etc., is extreme and conditions can change dramatically from one trial run to the next such as clear to cloudy

c. Analyzing camouflage in the field with one observer at a time yields results that may be most representative of detection range that would be experienced in real world operations, but it is generally impractical from a time perspective. Another option for field trials is presented in Section 4.2. The process utilizes multiple observers simultaneously searching for camouflage placed at random locations throughout a field of regard. Data are collected from observers with a passive scoring system that allows the observers to indicate the location of the target within a fraction of a degree. The disadvantage of this method is that observers can become familiar with the terrain and the locations used to place test articles which can increase their ability to locate test articles as the test progresses. This makes it critical to randomize the order in which test articles are presented along with the locations in which they are placed. Familiarity with the terrain can result in longer detection ranges than would be achieved from data collected with observers only seeing the terrain once. However, these data are still valid for camouflage performance comparison.

d. Another approach to further expedite data collection is through photo simulation as described in a Guidelines for Camouflage Assessment Using Observers (reference 8). The camouflage assessment guide describes a procedure for image collection and presentation of 35 mm slides on a projection screen. Moving to photo simulation dramatically speeds up presentation of scenes and allows the test to be taken to the observers. Technology has changed quickly in the last decade and continues to evolve rapidly. This TOP presents a photo simulation process in Section 4.3 that utilizes laptop computers to present images on high quality monitors while simultaneously collecting data on the location the observer believes test articles are located in the scene. This enables data to be collected from multiple observers simultaneously and has been utilized on numerous test efforts collecting data from eight observers simultaneously. While the detection ranges may not be absolute (the same as what would be obtained in the real world) they do allow for efficient comparison of camouflage performance. Photo simulation also makes it possible to efficiently collect data from observers by presenting images first at long range and then zooming in so observers cannot memorize the terrain as they can with randomly placed items in a single field of regard. It is important to note that there will almost certainly be differences in detection range between photo simulation and field trials but photo simulation can still be a cost effective way to study relative differences in camouflage performance.

e. An even more expedient camouflage performance test technique presented in this TOP is blending, which is based on Magnitude Estimation. Magnitude Estimation is described in Human Experimental Psychology[10]. With this process, the observer is asked to rate how well the camouflage blends with the surrounding terrain on a sliding scale. The advantage to this process is speed, but the drawback is the results may be considered more subjective than detection. With this methodology, the location of the camouflage must be known and at close range. If it is recognized, observer bias may impact the data if there is a reason to favor or dislike a particular camouflage treatment. Further, it is difficult to explain the military relevance of blending results. Still, this technique may be the only option when very large data sets need to be analyzed or time is very limited. It may be best suited to a rapid down-select from many options to a few for follow on detection studies. This procedure is presented in the photo simulation portion of this TOP but it can also be applied in the field.

4.2 Field Trials.

4.2.1 Facility.

a. Test Site. The test site should be representative of the operational terrain of interest such as woodland, desert, snow covered, tropical, etc. The test site should take into account the test methodology to accommodate the required ranges. Locations that test articles are placed should include the range at which 50 percent (%) of the observers detect the test article and ideally include ranges at which all observers detect and no observers detect it to allow generation of a full probability of detection curve. The color and density of vegetation and color of exposed soil, along with illumination (direct, diffuse, day/night), should be considered and documented when choosing the location for the test for analysis in the visible spectrum.

NOTE: Classifying terrain can be very difficult. For example, the open areas between woodland and desert, sometimes referred to as transitional, might also be classified as woodland or desert depending on the density of the vegetation.

b. Observer Booths. Observer trailers, such as those shown in Figure 1, can be utilized to accommodate up to 24 observers simultaneously when performing a Probability of Detection (Pd) test. The large trailer holds up to twelve observers and the two small trailers hold six observers each. All are collocated facing the Field of Regard (FOR) to minimize parallax differences between observer viewing positions. The individual booths are separated so observers cannot see what direction others are looking to locate test articles. The large trailer has an extra booth in the center to allow observation of the field and coordination of data collection among the three trailers which includes raising and lowering of blinds to obscure the view of the field between runs.

Figure 1. Observer trailers.

4.2.2 <u>Instrumentation</u>.

a. Determining whether an observer actually detected a test article in the field can be challenging and time consuming. Methods, such as using range cards to segregate the field into sectors, can be coarse and cumbersome. A Passive Scoring System (PSS) can be used to automate the process and provide far greater accuracy and speed in data collection. An example of a Passive Scoring System, based on manual pan and tilt heads, can be seen in Figure 2. The heavy-duty tripod heads provide a stable surface for the sights. The azimuth and elevation of the sensor can be adjusted using the cranks which operate smoothly and remain in position when released. Digital data are gathered from the system using optical shaft encoders attached to the azimuth and elevation pivot shafts and can be collected during the entire run. The encoders are highly accurate at 8000 pulses per revolution, yielding an angular accuracy of 0.045 degrees.

Figure 2. Passive Scoring System.

b. The space between the two lower trailers, shown in Figure 1, can be used to locate cameras on stable ground to document what the observers see. During a test using unaided eyes, two high quality color cameras would typically be used to collect imagery. One with a wide field of view to document the scene and one with a narrow field of view to document test article configuration. When the cameras are implemented, a canopy or other devices must be used to obscure the cameras from the observers to prevent them from seeing where the imagers are pointed. If collected appropriately, images could later be run through a photo simulation to collect detection data in the lab for comparison to results collected live in the field. Images can be collected in other spectral bands for follow-on analysis. Additionally, sensors can be collocated in the space between the trailers to monitor illumination levels or other relevant environmental conditions.

4.2.3 Preparation.

a. The test site should be selected to provide multiple locations for random test article placement so observers cannot anticipate the next location from one run to the next. If several types of backgrounds exist within the FOR, the FOR can be divided into sectors or lanes.

b. The minimum number of observers should be based on the requirement to establish a statistical-reliable data base of results. However, choices can be made between increasing the number of repetitions with fewer observers and fewer repetitions with a large number of observers.

c. Ideally, observers would be Soldiers with the desired MOS. If military personnel with applicable MOS are not available, then alternate observers can be chosen having age and vision characteristics compatible with the MOS Soldiers they are representing.

d. A test matrix should be developed that includes test articles, illumination conditions (such as front lit, backlit, side lit, diffuse, etc.), test article orientation, test article location (azimuth and distance), terrain/local background (such as open terrain or tree line). Null scenarios should be included with no test article in the scene so observers know there may be cases when no test article is present. The test matrix should be designed for equal exposure of each type of each test article for all variables such as range, lighting, etc. Plan to repeat all scenarios in the test matrix if time permits.

e. Range bins are typically established through the FOR to provide multiple locations to collect data at similar ranges. For example, during day time testing for Soldier systems, range bins might be from 100 to 600 meters in 100 meter increments.

f. Locations where test articles will be placed should be surveyed and marked with stakes and a “truth table” should be established for accurate scoring of azimuth and elevation of each location. Positions should avoid obstruction to the field of view from any observer position and avoid obvious cues that may draw attention to the target.

g. The FOR boundaries should be clearly marked so observers understand the limits of the search, prior to the start of testing.

h. Documentary color photographs should be taken of the test set-up including the FOR. Typically, only one test article is in the FOR for each run, and occasionally no test articles will be placed in the FOR. The Pd field test presentations should be randomized so the observers cannot anticipate the next location or test article type.

4.2.4 Observer Training.

Before starting, observers should be briefed on their task and allowed to run through several practice trials so that they are comfortable with the task, procedures, and equipment used to record the data. Test articles or surrogates should be used in practice trails to be sure the observers know what they are searching for/rating but, practice trials should not be used in the analysis. The observers should be encouraged to ask questions regarding the procedures and instructions to ensure that the task is well understood.

4.2.5 Observer Data Collection.

a. During each of the test trial runs, control of observer communication between each other and with observer controllers must be maintained at all times.

b. Where all observers are presented with a given run configuration, no communications are to be allowed at all beyond that specified for the conduct of the run. Observers shall keep all comments regarding their observations to themselves.

c. The observers should be allowed sufficient time to scan the FOR. One to two minutes may be appropriate when searching a large FOR (e.g., 120° horizontally). If a test article is detected, the observer may be asked to describe the test article in detail for recognition and identification.

d. Observers should be seated prior to the start of a trial to prevent them from seeing test articles being placed into position. The test coordinator should receive a signal from the down range coordinator that the test article is at respective range, posture, position, or azimuth, as well as all down range support personnel are in the appropriate hide position before initiating the start of trial.

e. The test coordinator should give the observers a countdown that will initiate the start of the trial and tell the observers to “stand up and observe”. The observers are given a limited time to find the test article(s) based on the size of the FOR.

f. When a target is found, the observers will use the tracking device (shown in Figure 2) to indicate the position of the test article. The scoring system will record azimuth and elevation, and the time that the button is pressed.

g. After the target has been located, or if no test article is found when time has elapsed, the observers should return to the seated position to await instructions for the next run or event.

h. This sequence will continue until all of the test matrix trials are complete.

4.2.6 Documentation Images.

Color digital images should be collected during each trial run to verify test article configuration, position, orientation, etc. for documentation and to answer any questions that may arise in post-test analysis.

4.3 Photo Simulation.

Photo simulation consists of image acquisition, image processing, photo simulation development and photo simulation presentation. It is further broken into two techniques, detection and blending. Descriptions are as follows.

4.3.1 Preparation.

A test matrix should be developed that includes test articles, illumination conditions (such as front lit, backlit, side lit, diffuse, etc.), test article orientation, imaging sensor and test article location (GPS coordinates) to calculate azimuth and distance, terrain, and local background (such as open terrain or tree line). The test matrix should be designed for equal exposure of each type of test article for all variables such as range, lighting, etc.

4.3.2 Image Acquisition.

a. Image acquisition for Pd.

(1) Select methodology. Test article remains at one location and camera is moved to achieve change in range or camera is held at one location and test article is moved in incrementally to achieve a change in range. Keeping the test article at one location has the advantage of a consistent background eliminating one confounding variable.

(a) Target stationary - camera moving. This methodology follows the NATO RTO-AG-SCI-095 Guidelines (reference 8), where the test article is static at one location and the camera acquires data from various ranges. A typical scenario consists of image acquisition from the furthest range bin to the nearest range bin location. This procedure minimizes trials and ground disturbances that could cue the observers of the test article location in the photo simulation testing.

(b) Camera stationary - target moving. In this methodology, the camera(s) stays in one location. The test article(s) will be located at various defined range bins. This scenario is similar to procedures described in Section 4.2, Field Trials.

(2) Select test article(s) location(s), for all range bins, following the test matrix.

(3) Select camera location(s).

(4) Choose location for calibration standards.

(5) Illumination. Typically, images are collected during daytime, under clear sky condition, with the test article oriented for front lit illumination.

(6) Camera settings. Typical camera settings for daytime image collection are presented in Table 2, along with rationale.

TABLE 2. TYPICAL CAMERA SETTINGS.

FEATURE	SETTING	RATIONALE
Optic	35mm, F/1.4	A 35 mm lens on modern professional grade cameras typically provides adequate resolution. The low F number is a “fast” lens that allows a large amount of light to reach the detector.
International Organization for Standards (ISO) (A rating system of the image sensor sensitivity, developed by the International Organization for Standards)	100 (Max400)	A low ISO reduces gain and minimizes noise in the image for high quality images.
F-STOP	F/8	The F/8 setting is a compromise that provides some depth of field (focus across multiple distances but still allows a great deal of light to get to the detector for high quality images.
Camera Mode	Aperture priority or aperture value (AV)	Allows camera to select optimal exposure for aperture setting by varying shutter speed.
Camera Setting	Manual Focus (optic and camera body)	Assures camera is focused on test article.
Exposure Bracket	Auto (-1, 0, +1)	Exposure at three levels increases probability of having an optimally exposed image available for post processing
Flash Control	Flash Firing Disabled	Should use natural light only
Aspect Ratio	3:2	
Color Temp	5200K	No impact on unprocessed data (RAW) images which will be color balanced in post processing based on gray card in scene. Only impacts documentary Joint Photographic Experts Group (JPEG) that is stored with RAW image.
Color Space	Adobe 1980	Only impacts JPEG during image capture. Adobe 1980 is typically selected for RAW images as well in post processing.
File Setting	RAW and JPEG (L)	Stores RAW image that can be adjusted and optimized along with a representative JPEG of much lower resolution that can be used to organize and screen images.
Trigger	Single	Typically only one image is needed at each exposure level. Professional cameras typically have the option to collect sequences as well to capture quickly changing events.
Set Date/Time	User preference.	Local time is typically the easiest to use.

(7) A typical image acquisition sequence starts with the test articles one at a time until all are acquired. Figure 3 shows an example of a Pd photo simulation image sequence from furthest to closet ranges.

Figure 3. Example image series (far to close) for Pd photo simulation.

(8) Log all pertinent information on test site and test article conditions. See list in Section 5.2.

b. Image acquisition for blending.

(1) Develop an image collection test matrix to include test article(s), various lighting conditions (front lit, backlit and side lit), test article orientation, range, and positions in accordance to the test requirements documentation.

(2) Select test article locations according to the test matrix.

(3) Camera location. For Soldier systems a range of 50 m is typical for image collection. Beyond 50 m patterns may not have much impact on the blending.

(4) Camera settings. See Table 2.

(5) Calibration standards placement in the image scene. Calibration standards are typically co-located in the scene approximately 5 m from the cameras in the center bottom of the camera's field of view, as shown in Figure 4.

Figure 4. Calibration standards setup for visible acquisition.

(6) Configure test article at desired location in desired configuration in accordance with the test matrix.

(7) Illumination. Follow test requirements documentation.

(8) Acquire imagery for each test article(s), and background(s) combination as defined per test requirements.

(9) Log all pertinent information on test site and test article conditions as described in Section 5.2.

4.3.3 Image Processing.

a. Facilities. An office environment is typically used to process images.

b. Instrumentation for blending is presented in Section 2.2.

c. This procedure is applicable to both Pd and Blending Image Processing.

(1) Color balance image and set the exposure level on the green channel, sampling on chip 22 (Neutral 5) of the MacBeth ColorChecker® Chart (Figure 5), to a digital count of 164 for consistency. Care must be taken to ensure that the test article and background areas are not overexposed. If one or both are overexposed, continue reducing exposure level until the images are properly exposed.

Figure 5. MacBeth ColorChecker® Chart with assigned chip number.

(2) Resize the images to the correct size for the monitor and viewing distance to achieve unity (1X) magnification using the formula in Equation 1. Figure 6 shows an example of the calculation of the image height on monitor for a 36-inch (in.) viewing distance.

$$Image\ Height\ on\ Monitor = \frac{Actual\ Height\ in\ the\ field\ x\ Eye\ Distance\ to\ monitor}{Distance\ from\ Sensor\ to\ SUT} \qquad \text{Equation 1}$$

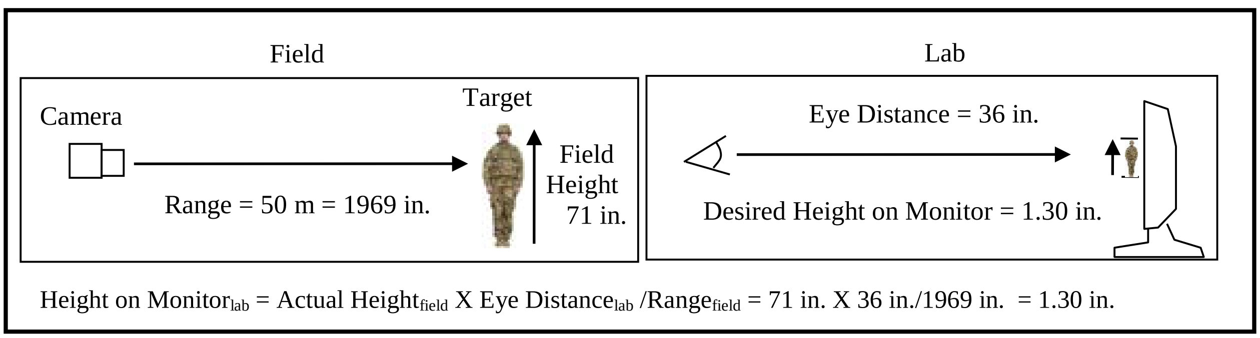

Figure 6. Calculation of a human size target height on monitor for 36-in. viewing distance setup.

(3) Crop the resized image to properly fit the computer monitor display. If, after cropping the image, the MacBeth ColorChecker® can still be seen in the image, it is typically "cloned" out to avoid distracting the observer.

(4) Save images to bmp or other lossless file format such as tiff. Figure 7 shows an example of the final composite image to be used in photo simulation.

Figure 7. Composite image of test article in the scene to be used in photo simulation.

4.3.4 Photo Simulation Software Development.

a. Create photo simulation matrices. Matrices should be created to present the images in a randomized sequence. Consideration must be given to the number of times a background is presented to an observer to prevent the observer from learning the location(s) where test articles are placed. This is not a concern for blending since test article location is known however, it can be a concern for detection tests. If backgrounds are repeated to test multiple candidates, the ability of observers to memorize locations may be reduced by changing the location in the scene that the test articles appear (by shifting the sensors view of the scene) and/or by presenting many alternate backgrounds before a background is repeated.

b. For Pd photo simulation, create a scoring database containing the specific coordinates of all test article's location in all presented images. This database is used for scoring of the observer detection response.

c. Implementation of photo simulation software should include the following features:

(1) Ability to perform setup configuration. Configuration setting should include observers' number, test type (Blending or Pd), Pd time duration between images, and session.

(2) Ability to start the program implementation through a dropdown menu or start button.

(3) Ability to move to the next image.

(4) Ability to pause the program.

(5) Ability to interpret the observer response. For example, in Blending Photo - Simulation, implementation of a slider bar along a scale of 1 “stands out” to 100 “perfect match”. This allows the observer to grade the blending performance of the test article in background.

(6) Ability to log the observer responses.

4.3.5 Photo Simulation Presentation.

a. Facilities.

(1) Configure the observer stations layout such as shown in Figure 8.

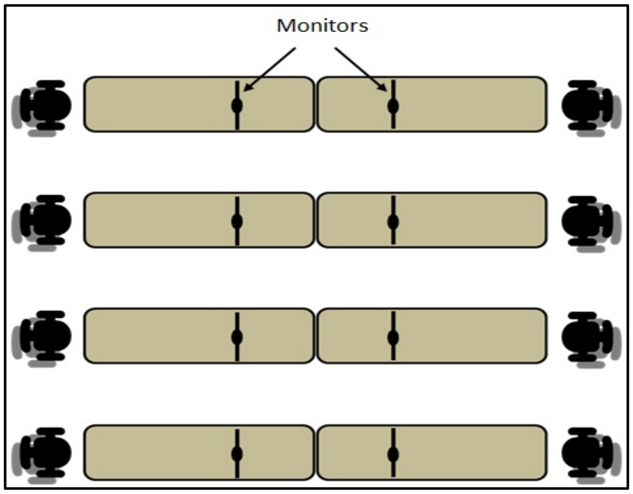

Figure 8. An example of observer station layout for photo simulation.

(a) The distance between the observer and monitor is calculated using Equation 1.

(b) The observer stations must be spaced to prevent distraction between observers during the photo simulation testing.

(2) Room lighting must be controlled to provide uniform illumination.

(3) The front surface of the monitors must be adjusted to minimize glare from overhead light and/or windows. The impact of the surrounding illumination can be documented with a photometer by measuring luminance (cd/m2) of the monitor with pixels first set to black and then set to white to calculate contrast ratio (white-black)/black. This can be done on several areas of the monitor to check for uniformity and to identify areas subject to glare from light sources in the room.

b. Instrumentation. See Section 2.2.

c. Observers. Collect demographics and eye test data on observers as described in Section 5.

d. Probability of Detection Photo Simulation.

(1) Observers are given a limited amount of time to detect test articles in an image. Times may vary based on requirements, size of image being searched, or even range to target. For example, the photo simulation could be structured to follow Field Manual (FM) 3-22 Rifle Marksmanship[11] that allows 3 seconds to hit target at 50 meters and adds one additional second for every 50-m increment beyond that. In a photo simulation it may be advisable to allow a few extra seconds for movement of the cursor.

(2) Observers indicate the test article location in the scene using the mouse cursor to click on the spot where he/she thinks the test article is located.

(3) The software determines a "hit" or "miss" by comparing the observer clicked coordinates to the corresponding one in the scoring database. A one indicates a correct detection and a zero indicates a miss.

(4) The software should record data to include:

(a) Date.

(b) Time.

(c) Session.

(d) Test article identity, model number, serial number, and configuration.

(e) Distance from camera(s) to test article(s).

(f) Background type.

(g) Observer response.

(h) Detection time.

(i) Detection result.

e. Blending Photo Simulation.

(1) Observers are asked to rate the effectiveness of the test article(s) to blends into the immediate background using a scale between 1 and 100. A response of 1 is "stands out" and 100

is a “perfect match” to the background. An example of the blending photo simulation graphical user interface is shown in Figure 9.

Figure 9. Example of Blending Photo simulation graphic user interface.

(2) The software should record the following data.

(a) Date.

(b) Time.

(c) Session.

(d) Test article identity.

(e) Background type.

(f) Observer number.

(g) Observer response.

5. <u>DATA REQUIRED</u>.

5.1 <u>Observer Results</u>.

a. Detection. Hit, miss or no detect for each image.

b. Blending. Rating from 1 to 100.

5.2 Test Conditions.

a. Date.

b. Time.

c. Test site location.

d. Background classification/description.

e. Test article description (including model and serial number when applicable).

f. Test article configuration, azimuth, range, etc.

g. Illuminant azimuth and elevation.

h. Sky condition (clear, partly cloudy, overcast, etc).

i. Visibility and meteorological data (may be needed for comparison to data collected at a different time).

5.3 Observer Demographics and Vision.

a. Data will be collected on observers after they are assigned a unique identification number for anonymity in reporting. Demographic information will be collected and should include age; years in service; MOS; years in MOS; and years of experience searching for targets. Visual acuity and color vision are not measured to screen out observers but rather, to document observer performance for the record since it is difficult to anticipate all questions that will be asked after a test has been completed.

b. Visual Acuity. Binocular (both eyes open) Distance Visual acuity data will be collected. It can be determined through the use of a standardized vision screener such as the Titmus vision screener. Testing should be administered and scored as described in the instruction manual for the device. An expedient method in the field may use a Snellen, Landolt "C", or Sloan chart. Testing should be administered and scored as described in the instructions for the chart. In both cases it should be noted whether the visual acuity was achieved with or without correction (i.e., spectacles or contact lenses). An example of a Snellen chart is presented in Figure 10.

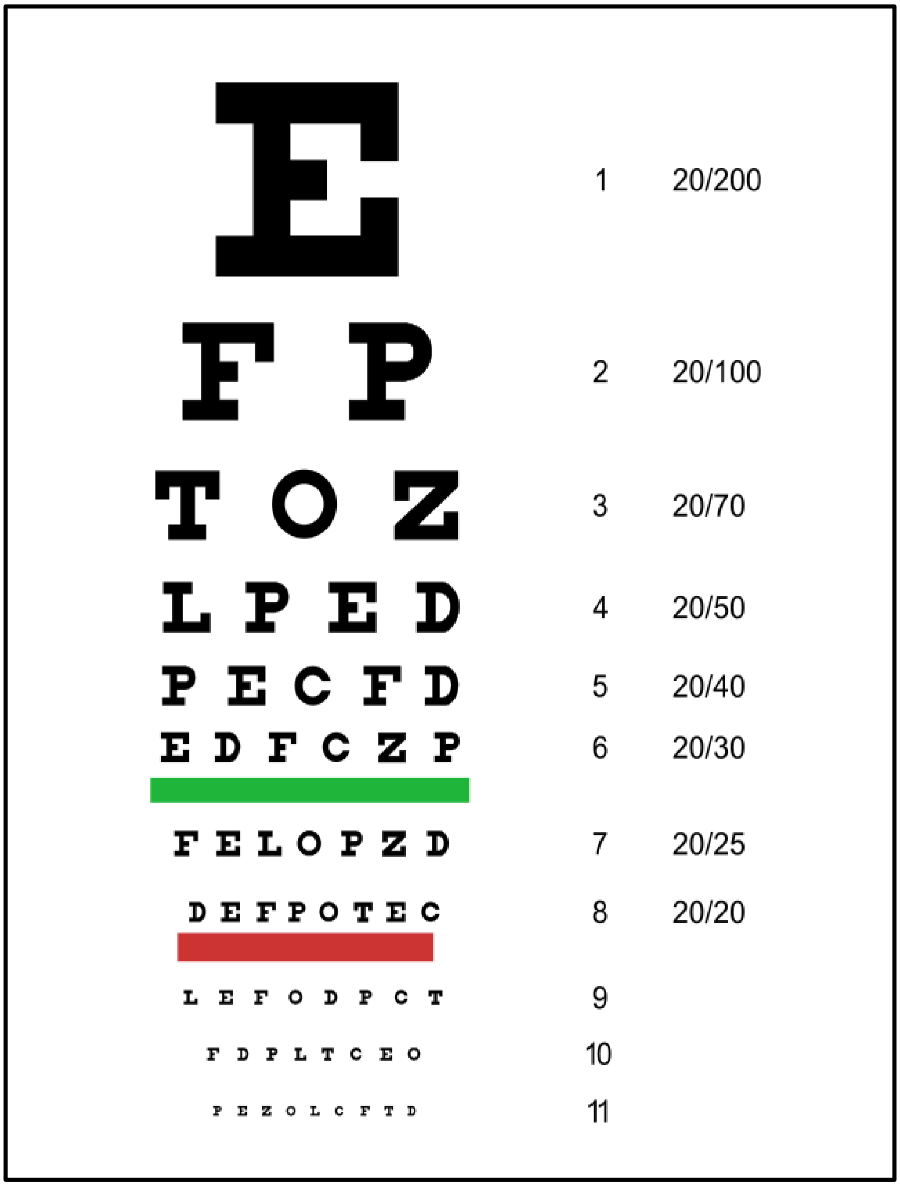

Figure 10. Snellen visual acuity chart.

c. Color Vision. Color vision will be assessed binocularly (both eyes open). It can be determined through the use of a standardized vision screener such as a Titmus vision tester. Testing should be administered and scored as described in the instructional manual for the device. An expedient method for assessment of color vision can be accomplished using the Ishihara Pseudo-Isochromatic Test book which uses plates such as the one shown in Figure 11. Testing should be administered and scored as described in the instructions for the test.

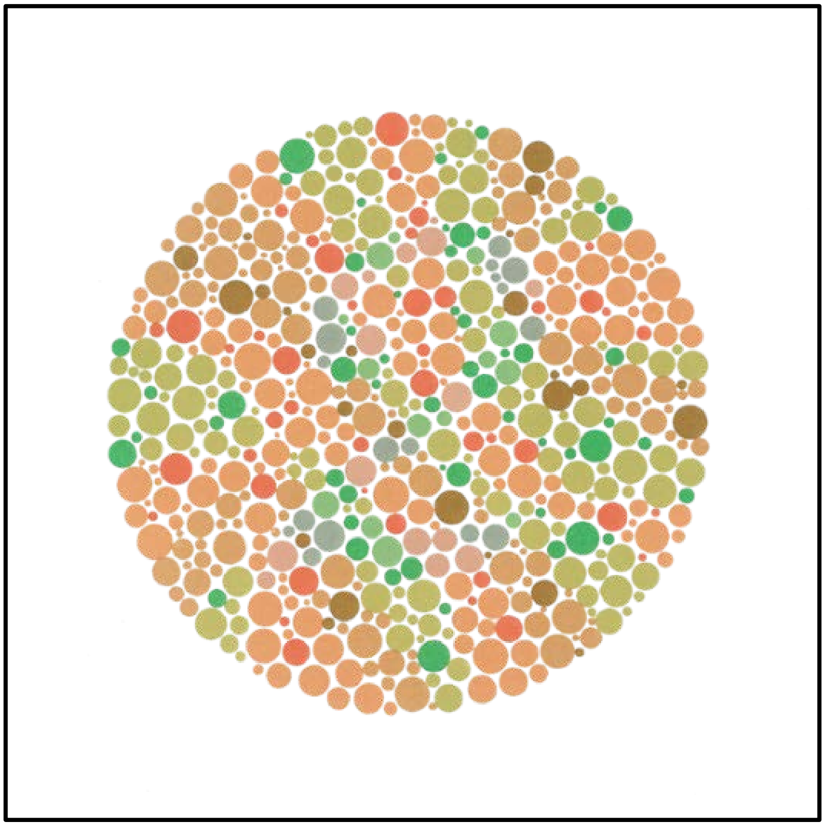

Figure 11. Sample Ishihara plate. Normal subjects can hardly read it, but most of those with red-green deficiencies see the figure "2" in it.

d. A form typically used to collect demographic and eye test data is presented in Figure 12.

DEMOGRAPHIC QUESTIONNAIRE

Test Location: ________________________________

Observer No: ______ Age: ______ Gender: F / M

Rank: ______________ MOS: ___________________________

Time in MOS: (yr/mo) _______________________

Time in Service: (yr/mo) __________________

Combat Experience: (yr/mo) ______________________

Combat experience related to analyzing camouflage performance. Such as reconnaissance, stalking, target detection etc.

____

____

____

____

EYE TEST DATA
(Filled out by staff)

Color Test

Plate No.	1	2	3	4	5	6	7	8	9	10
Number										

Acuity Test

Line No. completed correctly: ___________________________________

Magnitude Estimation Test Station No. _______

Tally	Set

Figure 12. Typical form used to collect demographic and eye test data.

5.4 Observer Results.

a. Detection data. Result for each run indicating whether observer correctly detected the test article, detected something that was not the test article (incorrect response), or no response for each run in a field trial or scene presented in a photo simulation.

b. Blending Data. Individual scores for each scenario rated by observers.

6. PRESENTATION OF DATA.

The primary focus of this TOP is to present several techniques for collecting data from observers, and to provide alternatives that can be adapted to the time and resources available for testing. Statistical analysis is not a primary focus but brief examples of detection and blending data presentation are provided for consistency. A comprehensive discussion of analytical techniques, along with sample data, can be found in NATO Guidelines for Camouflage Assessment Using Observers (reference 8).

6.1 Detection Data.

Detection data are plotted for a notional camouflage system in Figure 13 to show the change in probability of detection with respect to range. Typically, the goal is to find R_{50} which is the range at which 50% of the observers detected the test article. Data used to create the plot are presented in Table 3. Confidence intervals (CIs) can also be placed on the data points as shown in Tables 4 and 5.

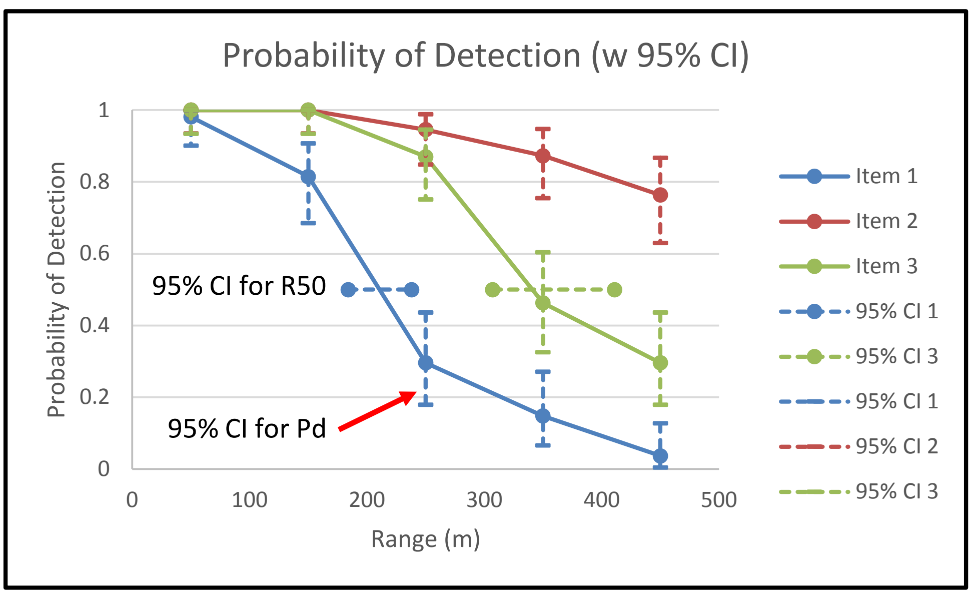

Figure 13. Detection data.

TABLE 3. PROBABILITY OF DETECTION DATA

RANGE (m)	PROBABILITY OF DETECTION (% correct detections)		
	Item 1	Item 2	Item 3
50	0.98	1.00	1.00
150	0.81	1.00	1.00
250	0.30	0.95	0.87
350	0.15	0.87	0.46
450	0.04	0.76	0.30

TABLE 4. DETECTION UPPER AND LOWER BOUNDS FOR 95% CONFIDENCE INTERVALS

RANGE	95% CONFIDENCE BOUNDS FOR Pd		
	Item 1	Item 2	Item 3
50 Upper	1.00	1.00	1.00
50 Lower	0.90	0.94	0.93
150 Upper	0.91	1.00	1.00
150 Lower	0.69	0.94	0.93
250 Upper	0.44	0.99	0.95
250 Lower	0.18	0.85	0.75
350 Upper	0.27	0.95	0.60
350 Lower	0.07	0.76	0.33
450 Upper	0.13	0.87	0.44
450 Lower	0.00	0.63	0.18

TABLE 5. R_{50} RANGE 95% CONFIDENCE INTERVALS

RANGE	95% CI FOR R50	
	Item 1	Item 3
184	0.5	
238	0.5	
307		0.5
411		0.5

6.2 Blending Data.

a. Blending data are presented as individual data points with confidence intervals. An example of such data are plotted in Figure 14 with 95% confidence intervals, and the values are presented in Table 6. The data in this example were collected on a scale of 1 to 100 with 1 being a "stands out" and 100 being a perfect match to the background.

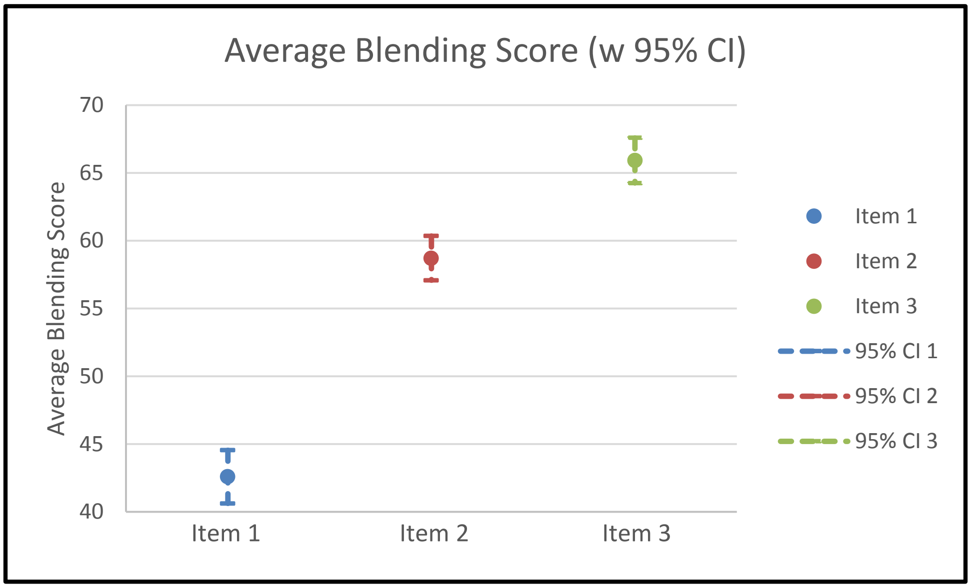

Figure 14. Blending data.

b. In Table 6, UB is the upper bound, LB is the lower bound, and the mean is found in the last row.

TABLE 6. AVERAGE BLENDING SCORE WITH UPPER AND LOWER 95% BOUNDS

LIMIT	ITEM 1	ITEM 2	ITEM 3
UB	45.2	60.9	68.1
LB	40.0	56.6	63.7
Mean	42.6	58.7	65.9

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APPENDIX A. ABBREVIATIONS.

AFRICOM	U.S. Africa Command
ATEC	U.S. Army Test and Evaluation Command
AV	aperture value
cd	Candela
CENTCOM	U.S. Central Command
CI	confidence interval
CRREL	Cold Regions Research and Engineering Laboratory
ERDC	Engineer Research and Development Center
EUCOM	U.S. European Command
FM	Field Manual
FOR	field of regard
HRPP	Human Research Protection Plan
in.	inch
ISO	International Organization for Standards
JPEG	Joint Photographic Experts Group
LB	lower bound
m	meter
mm	millimeter
MOS	military occupational specialty
NATO	North Atlantic Treaty Organization
NORTHCOM	U.S. Northern Command
PACOM	U.S. Pacific Command
Pd	probability of detection
PSS	passive scoring system
SOMTE	Soldier-Operator/-Maintainer Test and Evaluation
SOUTHCOM	U.S. Southern Command
SR	Safety Release
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee
TTPs	tactics, techniques, and procedures
UB	upper bound

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APPENDIX B. REFERENCES.

1. Ryerson, Charles C., et al., U.S. European Command (EUCOM) Natural Backgrounds and U.S. Analogs, Engineer Research and Development Center (ERDC) / Cold Regions Research and Engineering Laboratory (CRREL) M-12-1, September 2012.

2. Ryerson, Charles C., et al., U.S. Pacific Command (PACOM) Natural Backgrounds and U.S. Analogs, ERDC/CRREL M-13-1, August 2013.

3. Ryerson, Charles C., et al., U.S. Northern Command (NORTHCOM) Natural Backgrounds and U.S. Analogs, ERDC/CRREL M-13-2, September 2013.

4. Ryerson, Charles C., et al., U.S. Central Command (CENTCOM) Natural Backgrounds and U.S. Analogs, ERDC/CRREL M-13-3, September 2013.

5. Ryerson, Charles C., et al., U.S. Africa Command (AFRICOM) Natural Backgrounds and U.S. Analogs, ERDC/CRREL M-13-4, September 2013.

6. Ryerson, Charles C., et al., U.S. Southern Command (SOUTHCOM) Natural Backgrounds and U.S. Analogs, ERDC/CRREL M-13-5, October 2013.

7. Coplin, Alexis L. and Ryerson, Charles C., Estimating Natural Background Dormancy, ERDC/CRREL TR-15-7, April 2015.

8. NATO Guidelines for Camouflage Assessment Using Observers, RTO-AG-SCI-095, February 2005.

9. TOP 02-2-615A, Security from Detection (Vehicles), 24 February 2010.

10. Snodgrass, J.G.,Levy-Berger, G. and Haydon, M. Human Experimental Psychology. Oxford University Press, New York, 1985.

11. FM 3-22, Rifle Marksmanship M16A1, M16A2/3, M16A4, and Carbine, 13 September 2006.

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APPENDIX C. APPROVAL AUTHORITY.

CSTE-TM 5 May 2016

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 01-1-025 Camouflage Performance Testing Using Observers, Approved for Publication

1. TOP 01-1-025 Camouflage Performance Testing Using Observers, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

This TOP describes procedures for using human observers to test camouflage performance in the visible spectrum. Many of the techniques can be adapted to other spectral bands. The best data collection approach is live in the field using only one observer for each trial run, but these tests are extremely time consuming and expensive to execute when gathering statistically significant data. This TOP presents alternative approaches that are more expedient and can be selected when balancing data requirements and cost.

2. This document is approved for publication and will be posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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JENNIFER P. CHEW
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FOR

RAYMOND G. FONTAINE
Director, Test Management Directorate (G9)

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Signatures and Soldier Performance Division (TEDT-AT-WFT), U.S. Army Aberdeen Test Center, 400 Colleran Road, Aberdeen Proving Ground, Maryland 21005-5001. Additional copies can be requested through the following website: http://www.atec.army.mil/publications/topsindex.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.