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RTO AGARDograph **AG-SCI-095**

Guidelines for Camouflage Assessment Using Observers

(Instructions pour les évaluations de camouflage faisant appel à des observateurs)

This AGARDograph has been sponsored by the Systems Concepts and Integration Panel.

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The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Guidelines for Camouflage Assessment Using Observers

(RTO-AG-SCI-095)

Executive Summary

Using military observers in the field is the preferred method to evaluate the effectiveness of camouflaged targets. However, it is also a time consuming, labor intensive, logistically difficult and expensive procedure to use. In order to provide a reasonable alternative, the procedures outlined in these guidelines describe an approach to improve the reliability and repeatability of visual trials.

The content of these guidelines contains the collective knowledge of SCI-095 gathered over the span of the four years of the task group and provide a framework for the user to conduct an assessment. These guidelines address a typical situation where comparison between different camouflage treatments is desired, as opposed to determination of an absolute range. The statistical analysis procedures presented are a minimal set of descriptive statistics that produce acceptable results. More exhaustive analytical techniques exist and are left to the user to investigate.

Based on a comparative digital photosimulation trial conducted by SCI-095 in 2004 and similar trials carried out previously, it can be stated conclusively that following these recommended procedures and paying careful attention to the experimental set-up will produce consistent, reproducible target detection results that can be compared across different observer trials.

Instructions pour les évaluations de camouflage faisant appel à des observateurs

(RTO-AG-SCI-095)

Synthèse

L'utilisation d'observateurs militaires sur le terrain est la meilleure méthode pour évaluer l'efficacité du camouflage des cibles. Toutefois, c'est également une procédure réclamant beaucoup de temps et de main d'œuvre, problématique sur le plan logistique, et coûteuse. Afin de proposer une alternative correcte, les procédures indiquées dans ces instructions décrivent une approche visant à améliorer la fiabilité et la répétabilité des essais visuels.

Le contenu de ces instructions réunit les connaissances collectives du SCI-095, rassemblées tout au long des quatre années de travail du groupe, et fournit un cadre à l'utilisateur pour mener une évaluation. Ces instructions traitent de la situation typique où l'on souhaite faire la comparaison entre différents traitements de camouflage, plutôt que de déterminer une distance absolue. Les procédures d'analyses statistiques proposées représentent une série minimale de statistiques descriptives qui génèrent des résultats acceptables. Il existe d'autres techniques analytiques plus exhaustives, que l'utilisateur peut étudier.

En se fondant sur un essai de simulation photo numérique comparatif mené par le SCI-095 en 2004, et sur des essais similaires effectués précédemment, il peut être conclu qu'en se conformant à ces procédures recommandées, et en prêtant une grande attention au dispositif d'expérimentation, on obtiendra des résultats de détection de cible cohérents, reproductibles, qui pourront être comparés au cours de différents essais faisant appel à des observateurs.

Chapter 1 – INTRODUCTION

The purpose of this document is to provide guidelines for the collection and analysis of data to assess camouflage effectiveness in the visible spectrum. The following guidelines are based on the experience of NATO RTO Task Group SCI-095 on "Enhancement of Camouflage Assessment Techniques" (SCI-095) and have provided useful results. These guidelines can be adapted to meet the circumstances of a specific assessment.

The typical measure of effectiveness for a camouflage system is target detectability in a tactical situation. There are a number of technical parameters describing the physical characteristics of a camouflage material, such as color values, transmission, radar absorption, etc. These parameters can be measured in a laboratory using standardized procedures and apparatus and can provide some indication of field performance. However, there is no laboratory or other readily available measurements for detectability. In fact, the finding of NATO Workshop SCI-012 was that "At the present time, man-in-the-loop assessment is the only robust and effective method to evaluate [camouflage detectability]" [1]. Any such evaluation is complicated by the fact that many factors such as illumination, location, and seemingly random occurrences affect camouflage detection. To reduce the influence of these factors, the camouflage assessments are preferably done in a relative way (one or several camouflaged targets versus an uncamouflaged reference target) rather than in an absolute way (detection distance for this kind of target under these conditions).

Thus, in practice, the measure of effectiveness for camouflage, namely its detectability, is almost always evaluated by a number of observers, either in the field or in so-called photosimulations. The first part of a photosimulation records the field trial situation in imagery. These images are shown in a second step to observers in a laboratory setup.

A complete assessment involves the following steps, which are illustrated in Figure 1:

- Aim of the assessment (Which questions need to be answered?) (Chapter 2);
- Planning and implementing the field trial (Chapter 3);
- Use of field observers and/or collection of imagery (Chapters 4 and 5);
- Photosimulation Experiments (Chapters 5 and 6); and
- Statistical analysis of data (Chapter 7).

The advantages of photosimulation as opposed to a live observer trial are as follows:

- Ability to create a larger statistical data base;
- Field imagery sequence collected under one set of environmental conditions;
- The same imagery is viewed by all observers;
- Decreased cost compared to observer field trials;
- Less time spent in the field collecting data; and
- Experiment can be conducted at multiple locations, using different observer pools, with the same input imagery under controlled laboratory conditions.

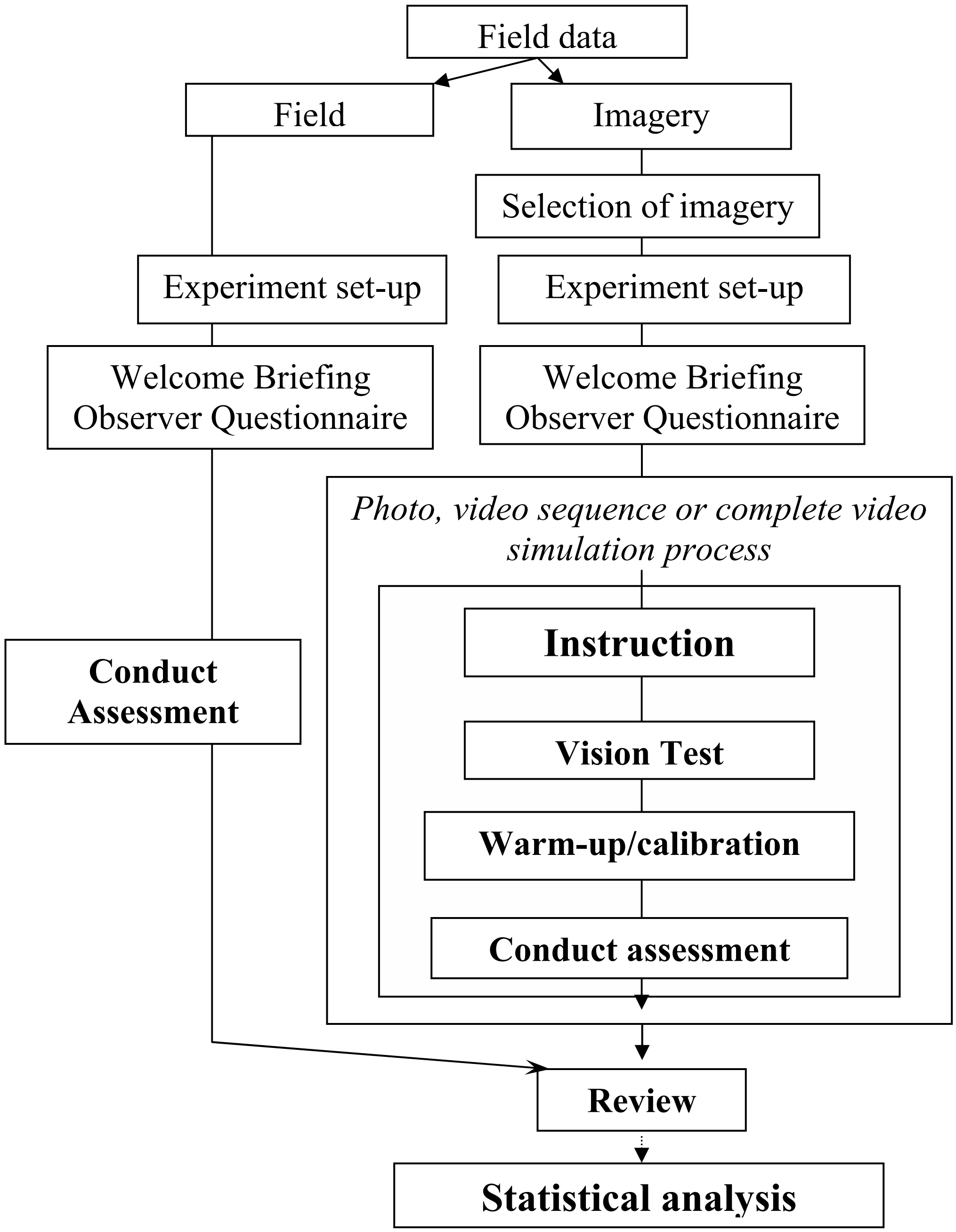

Figure 1: Flow Chart for Assessment.

Chapter 2 – DESIGN OF ASSESSMENT

In military operations, the conditions present when an observation (detection) opportunity occurs are highly variable and generally unpredictable. As such, to obtain a true appreciation of the relative detectability of different camouflage treatments, one should deliberately vary conditions (backgrounds, observers, time of day, visibility, etc.) between detection trials and merge results to obtain an overall appreciation of average detectability. Irrespective of the number of different conditions selected to be used in the trials, the same set of conditions should be used with each camouflage treatment being evaluated. The variables relevant to the aim of the assessment are listed in accordance with their roles.

Dependent variables:

- Detection range;
- Recognition range; and
- Identification range.

Independent variables (controlled systematically on more than one level):

- Camouflage measure. Deterministic, several levels (e.g. three types of camouflage nets and no camouflage measure at all);
- Background. Deterministic, e.g. two levels (coniferous and deciduous);
- Time of the day. Deterministic, e.g. two levels (morning and afternoon); and
- Background section. Stochastic, one level for each target (the background section is nested within the background).

Fixed variables (kept constant on one level):

- Time of the year;
- Target vehicle. One specific type of vehicle;
- Direction of observation;
- Instruction of observers;
- Detection means. Eye observation only (sensor);
- Placing of targets within background section;
- Geographical area; and
- Weather (visibility greater than 4 km).

Randomized variables:

- Other weather conditions, especially illumination;
- Observers;
- Observation technique;
- Observation time; and
- Error of measurement.

The objective of such an assessment is to provide information for the evaluation and comparison of several camouflage measures against specific backgrounds. Typically, one or more camouflaged targets and one uncamouflaged target are compared. Due to the fact that the different parts of even apparently homogeneous backgrounds may influence the detectability of the targets differently, each of the targets must be displayed against each of the background sections within a given background. The observations against one combination of the targets and background sections within a given background are called a sub trial.

For each subtrial, we will have a sequence of imagery collections or a number of field observations. The observations will be performed by observers walking, being driven/flown down an observation path perpendicular to the background, approximately South to North. Imagery collection will follow the same path. The weather should be stable and preferably dry and clear, which is considered under most circumstances to represent a worst-case situation for camouflaged targets.

A minimum of 15 – 20 observers is recommended for good statistical sensitivity for a detection experiment, which is of primary interest in camouflage assessment. If the purpose of the test is recognition or identification, a larger number of observers is recommended, dependent on the difficulty of the task. The military target detection training/experience level of the observers may have little effect on detection, but may have a significant impact on the results of a recognition/identification test.

Chapter 3 – FIELD TRIAL PLANNING

The trial set-up is the same for each background type. Backgrounds should be selected with care and provide more than one likely location for target placement. Backgrounds should be subdivided into sections. The number of sections should be one greater than the number of targets to be tested to allow for an indication of guessing. For example, in Figure 2 three sections are indicated within the background region of interest. This will allow for the placement of two targets. The positions in which the targets are placed within the background sections are fixed during the whole trial. These should be marked with stakes if the targets cannot be kept stationary in their positions during the whole trial period to provide consistent target placement. Background sections should be relatively homogeneous and avoid obvious cues that could cause false alarms or draw attention to the target. In order to eliminate searching by observers, it is recommended that both the background region and the sections within the background should be clearly indicated with markers visible from the extreme range of the observation path and explained to the observers during the briefing. An alternative method is to use a photograph of the test area to indicate the boundaries of the test area (background region) to the observers.

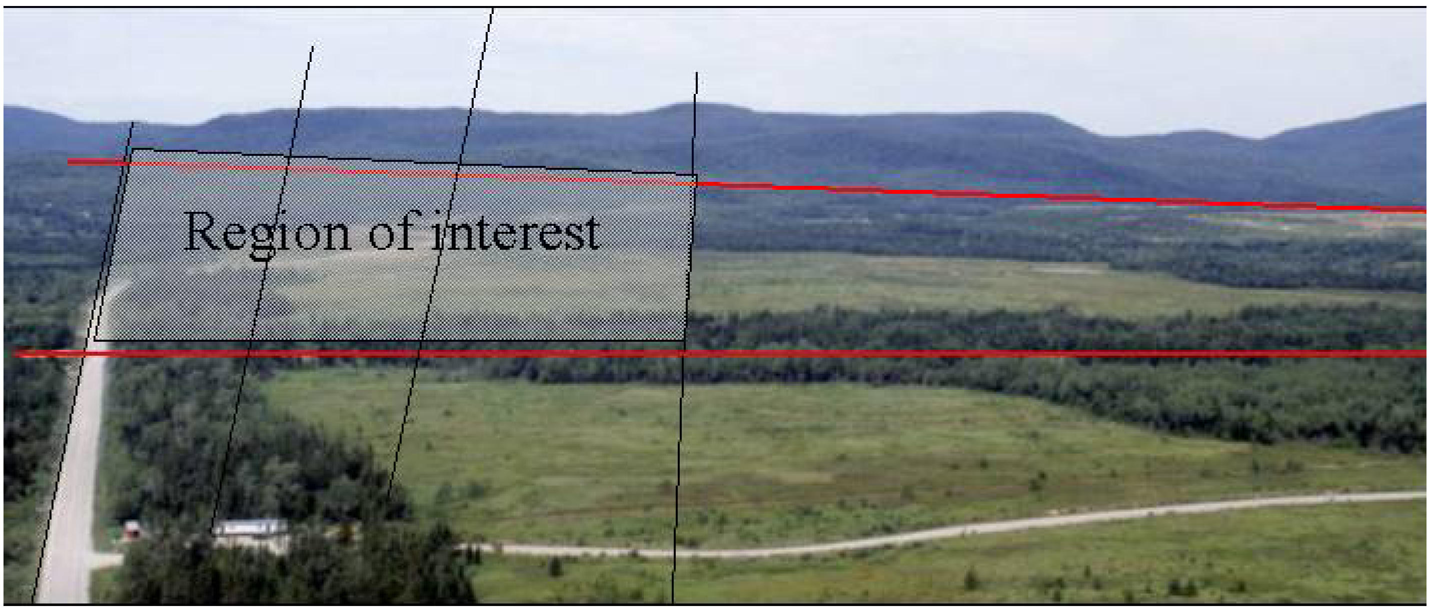

Figure 2: Example of a Trial Set-up.

Each sub trial should be carried out against one background during one day to minimize environmental changes (e.g. at peak illumination conditions). In each sub trial the targets are placed in a new combination relative to the background sections. This is done by means of a randomization plan. All targets will be displayed against all possible background sections in the trial. All the targets that are used in the trial should be of the same type. For example, if camouflage nets are used, they should be deployed in the same way at all times. To avoid possible gloss interaction, the windows and other reflective surfaces of the targets should be covered with a dull and dark material, e.g. Hessian.

The length and orientation of the observation path must be determined on site. If field observers are used, they should move along a specified path during the observations and this path should be marked in convenient intervals, e.g. 100 m. In this way the observation posts are defined. GPS could be used during an aerial trial. It must be possible to observe without hindrance the whole background used for the sub trial from each observation post. The criterion for a suitable start of the observation path is that no targets are detectable from the most distant observation post.

It is important that the field trial be implemented without any delays or confusion. To ensure this, it is highly recommended that a pre-trial be conducted prior to the actual trial. All relevant activities of the field trial should be tested during the pre-trial. One sub trial set-up is selected for the pre-trial and a few observers, who do not participate in the trial itself, perform the observations.

Chapter 4 – FIELD OBSERVATIONS

4.1 OBSERVATION PROCEDURES

For each sub trial a group of 15 to 20 observers should be available to provide adequate statistical sensitivity. An observer should, due to the learning effect, participate in only one sub trial against each background. The observers are not allowed to see the trial set-up before their participation. Before starting their observations the observers are briefed on their task. The briefing should take place at a point from which the targets cannot be seen. The briefing should be verbal but based on a written briefing to ensure that all groups of observers are briefed in the same way. A briefing example is shown in Annex A.1. The observers should be allowed to ask questions to ensure that they have understood their task correctly. After the briefing the observers are supplied with the necessary equipment to record their observations. One example is a paper observation form (e.g. Annex A.2), however, there may be other recording methods. It is important that no misunderstandings occur as to the performance of the observations, including the filling in of the observation forms. Those who are charged with giving the briefings should be carefully instructed to ensure that each briefing is identical.

The observers move along the observation path and perform their observations at each observation post independently of each other. Here they observe the marked background used for the sub trial and record their detections on the form, indicating in which section of the background (as identified during the instructions) a target has been observed, if any. Ideally, there should be no restrictions as far as observation time is concerned, but the experiment should be conducted as quickly as possible to minimize the amount of change in the illumination conditions. A knowledgeable supervisor should collect the observation forms at the end of the observation and make an initial check of the entries made by the observers and record any abnormalities that may influence the data analysis. Observers should not be allowed to communicate with each other during the sub trial or with observers from other groups before completion of the entire trial.

4.2 EXAMPLE FIELD OBSERVER EXPERIMENT

An example of the kind of adaptation and flexibility that can be achieved through the use of these guidelines is the Camouflage Assessment Trial conducted by NATO SCI-095 on 15-17 October 2002, in Germany [2]. A cable car carried the observers from the top of a mountain towards a military vehicle located along a wood line in the valley below. The cable car system provided a means to do repeated and controlled trials in which observers traveled at constant speed towards the wooded area containing the target vehicle. Observer runs were conducted over three consecutive days. As observers in the cable car moved down the mountainside, they scanned an area in the field of regard. The observer indicated on a photograph of the trial area the location of any potential military targets. This allowed the supervisors to confirm when the observer located the target. The time at which the observer first correctly pointed to the location of the target (Initial Detection) was recorded. Upon detection of a vehicle, observers were asked to describe the class of vehicle (Recognition/Classification) and identify the vehicle (Identification), if possible. The times at which Recognition and Identification took place were also recorded. The recorded times were later converted to range from the target for analysis. Complete details on the conduct of the live observer trial and the analysis of the results are provided in Reference 2.

Care was taken to ensure that the observers did not view the observation area on the ride up in the cable car. On arrival at the starting point, the observers were given a briefing explaining the purpose of the trial, and any questions were answered. One observer was used at a time. Trial procedures were again briefed in detail and any questions were answered prior to beginning the descent in the cable car. The observer was given a pen to point out on the picture the location of any potential military targets. This made it possible for the supervisors to verify that the observer located the target of interest. The time at which the observer first correctly pointed to the location of the target of interest was recorded as the initial detection. Recognition was defined as the time at which the observer first stated that the target was a small wheeled military vehicle.

Chapter 5 – PLAN FOR COLLECTION OF IMAGERY

The following methods for collecting imagery of targets have proven to be successful in past experiments. The test designer should use the method that makes the most sense for the particular target and location that is being evaluated.

Spacing of the images should be such that the target cannot be detected at the longest range but can be detected/recognized/identified at the closest range, depending on the purpose of the experiment. The spacing between the images does not need to be constant but should result in a reasonable number of images for the observer test. There should be a larger number of images collected around the anticipated detection range. For vehicle-sized targets, good results in detection experiments have been obtained with 16 to 20 images in the data set and with typical spacing of 200 – 250 meters at the longer ranges and 100 meters at the closer ranges. Depending on the intent of the experiment, imagery may be taken from the ground or from an aerial platform.

In each sub trial photographs are taken of the targets and their backgrounds. There should be sufficient atmospheric visibility and cloud cover height during the photographing to allow for good quality images. It is important to remember that the field of regard should be centered in the image, however, the target should not be consistently centered in the full image. Also, care should be taken to limit the amount of sky in the image because of the sky's effect on exposure. The photographing typically takes approximately 30 minutes and should be done during the corresponding sub trial period utilizing the best-suited weather. For example, during a Coyote practice trial [3], images were collected at the ranges shown in Table 1 below.

Table 1: Example of Imagery Collection Ranges (m) from the Coyote Trial

Image #	Range
1	2500
2	2250
3	2000
4	1800
5	1600
6	1400
7	1200
8	1100
9	1000
10	900
11	800
12	700
13	600
14	500
15	400
16	300

5.1 PHOTOGRAPHIC SLIDES

Traditional 35 mm slides should be obtained using a good quality camera (e.g. Minolta Dynax 600 SI) and high quality, ISO 400, 35 mm color slide exposure film (e.g. Kodak ISO 400 Elite Chrome Select, Daylight, 35 mm) and processed using standard commercial slide processing.

5.2 DIGITAL IMAGES

At the time these guidelines were written, successful results were obtained using a Sony TVR-950 digital camera using the automatic exposure setting on the camera. Images were 1156 x 840 pixels and were saved as JPG files. In addition, 35 mm slides can be scanned to provide digital imagery. Good results have been obtained by scanning with a flatbed, Nikon Coolscan, Model 4EED scanner using Photoshop 7. They were saved as TIFF images, 24 bit true color, no compression, 2900 x 2900 pixels, with a file size of approximately 28.7 MB. Scanning, however, is not recommended, and if digital images are to be used, they should be taken directly with a good quality digital camera.

In one instance photographs and images were gathered at the same time from a helicopter using two cameras to photograph targets deployed along the edge of a wood line. One was a high quality commercial digital camera equipped with a normal 50 mm lens. The second was an equally high quality commercial 35 mm auto focus film camera equipped with an identical 50 mm lens. It was determined prior to the trial that an equivalent of ISO 400 setting would be used. A high ISO would allow the photographer to select a high shutter speed to counteract the effects of vibration encountered during flight and to maintain the lens' aperture in the range of f4 – f8, best for a fast normal lens. A highly experienced and professional armed forces combat photographer performed the task.

Chapter 6 – PHOTOSIMULATION EXPERIMENTS

The evaluation of photographs by observers in a laboratory setting is called photosimulation. Slides (analog images) of the target and its surroundings are shown to groups of observers and their observations form the basis for the evaluation. The method repeats to some extent, indoors, what takes place in the field during a field trial. One can claim that instead of taking the observers to the field, one records an image of the scene to be evaluated and takes it to the observers for display on a screen. Compared with field observations, photosimulation adds extra media, namely the optics of camera, projector and film. This contributes to the fact that so far it has not been possible to reproduce the detection range of a field trial from a corresponding photosimulation experiment. However, photosimulation is still a good method for *ranking* the camouflage measures, not *determining absolute detection ranges*. The photosimulation experiment includes exactly the same independent variables as the field trial since the photographer will collect the imagery during the field trial. Observer evaluation of the imagery can be accomplished by a variety of techniques. The most well known technique is analog photosimulation using 35 mm slides [4, 5]. Advances in image collection technology now offer digital alternatives. Following are two procedures, analog and digital, that have been successful in prior experiments. Tools with additional features are available, such as POSE and SAFARI [6, 7, 8], that provide for automatic recording of observer responses, as well as other features, that are further described in the SCI-095 final report [9].

6.1 TRADITIONAL ANALOG PHOTOSIMULATION

In a traditional photosimulation trial, analog images recorded in the field are projected as color slides to observers under controlled (laboratory) conditions. The field trial should be set-up to accommodate the intended photosimulation evaluation and to allow extraction of the desired information. Additional information can be found in Reference 10.

6.1.1 Design of the Experiment

The photosimulation is performed in a darkened room ensuring enough space for the appropriate installation of the projector, projection screen and observers, and that is free from distractions. The light in the room should be such that it does not influence viewing of the screen. Slides are viewed by an observer from a fixed, predetermined distance, a2, calculated by:

$$a2 = (a1 \times f1) / f2$$

where

where	al	=	distance projector – screen
	a2	=	distance observer – screen
	f1	=	focal length of camera
	f2	=	focal length of projector

An observation chair is positioned in the calculated spot and is attached to the floor to keep its position fixed throughout the photosimulation.

A standard commercial 35 mm slide projector can be used to project the slides. The projector should be positioned directly behind and above the observer to present a centered unobstructed image. The distance of the projector from the screen should be adjusted to project an image on the screen that is 2.0 m wide. The slide projector should be set to automatic, changing slides at a preset time interval, which is determined from a test run. Typically this would be 15 seconds.

Two data recorders sit behind and to the side of the observer's chair. The data recorders should be positioned so that they can easily hear any comments from the observer and see the target locations identified by the observer. The use of two data recorders allow results to be confirmed/validated and ensure a more complete and accurate experiment. It is best if at least one of the data recorders conducts the data analysis.

After the room has been set-up, the photosimulation supervisor organizes one or more test runs in order to check the procedure and to ensure optimal conditions. A typical viewing room set-up is shown in Figure 3.

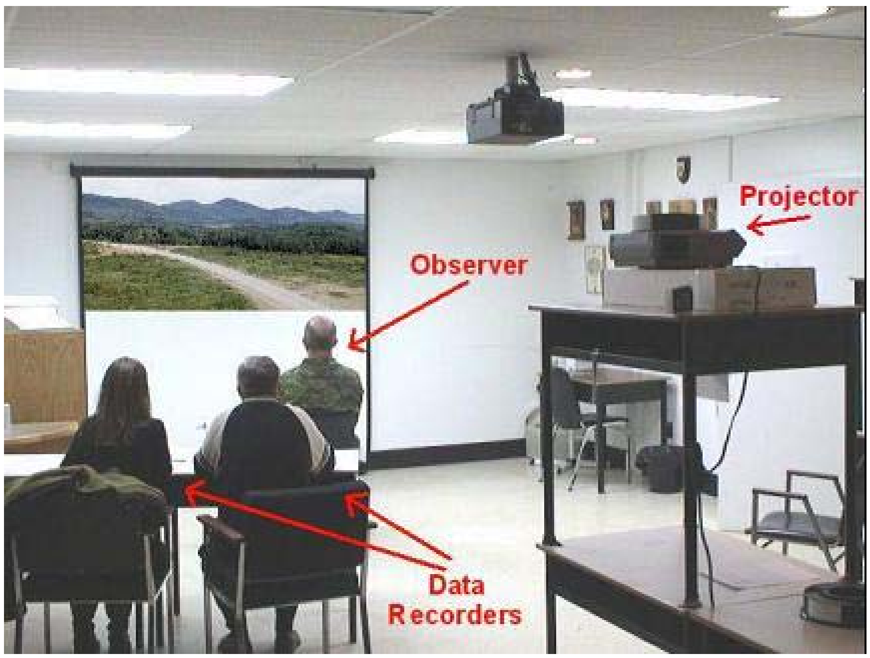

Figure 3: Typical Viewing Room Set-up.

Prior to initiation of the photosimulation test, the observers are given an introductory briefing in a separate room describing the goals of the photosimulation and what each observer is required to do. For best results, the briefing should be conducted from a printed script so that each observer group is given exactly the same background information. A typical briefing is at Annex A.3. Ideally the observers should be soldiers and be trained for the specific observation task used in the photosimulation. Following the briefing, each observer should be given a questionnaire to complete. This questionnaire collects background information on the individual: military occupation, age, gender, visual acuity and previous training in vehicle detection or photosimulation trials. A copy of a sample questionnaire is contained in Annex A.4.

Observers should enter the viewing room one at a time and sit in the designated chair in front of the projection screen. The observer is again briefly instructed on how the trial will be conducted and what actions are required. The observer is provided with a laser pointer (or similar device) and instructed to use the pointer to indicate the location of any targets he/she detects in the projected slide. The observer is asked to familiarize himself/herself with the operation of the laser pointer. While this activity is taking place, the completed questionnaire for the observer is reviewed by the data recorder and any ambiguous information clarified. If the observer indicated on the questionnaire that he required corrective lenses, the test supervisor should confirm that they are being worn. The observer is then shown two series of slides presented in the same manner, one as practice and one the test series.

Directly thereafter the photosimulation with the test series can begin, starting with the slide at the longest associated range to the target. As each slide is shown to the observer, the data recorders capture the observer's comments and record the slide number at which the target was detected, recognized or identified. Corresponding ranges are derived from the associated slide numbers. The supervisor controls the experiment including briefing and handling of the slide projector. After finishing the run, the observer leaves the room and is reminded not to discuss the trial with anyone until the end of the trial. The next observer enters the room and the procedure is repeated.

Typically, 15 to 20 observers are required to obtain a statistically relevant result. However, in order to avoid learning effects the observer should not view more than two series of slides, each of a different background. The use of a practice imagery series is very important in a photosimulation trial. It overcomes any potential learning effect on observers, allowing unbiased results to be obtained for the imagery of interest. Consistent use of the same warm-up imagery provides a mechanism to confirm that different trials have been conducted in the same consistent manner and that it is valid to compare detection results between these trials that may have been conducted at different times and/or in different geographic regions. Use of the Coyote imagery series, described here, has yielded a median detection range of 950 meters with a 95 percent confidence interval of 850 – 1067 meters for fifteen observers. Future photosimulation trials employing this imagery series should expect to obtain similar results.

6.1.2 Example Photosimulation Experiment

At CFB Valcartier (Quebec, Canada) training area, imagery of an uncamouflaged and camouflaged Coyote, LAV-III, was collected from a helicopter platform. Views of the terrain area and the target vehicle are shown in Figures 4 and 5, respectively. The observer was shown two series of projected 35 mm slides. The first series of slides was a practice set. It was explained that the imagery (terrain) in the second set would be very different from the first set of slides viewed, but the observer's task remained the same: to detect military targets, point out where they were located and describe the class of vehicle detected. Each series of imagery consisted of 16 slides and was shown to the observer in succession beginning with the slide with the longest associated range to the target. Each successive slide decreased in range and was presented to the observer for 14 seconds before the next one was displayed.

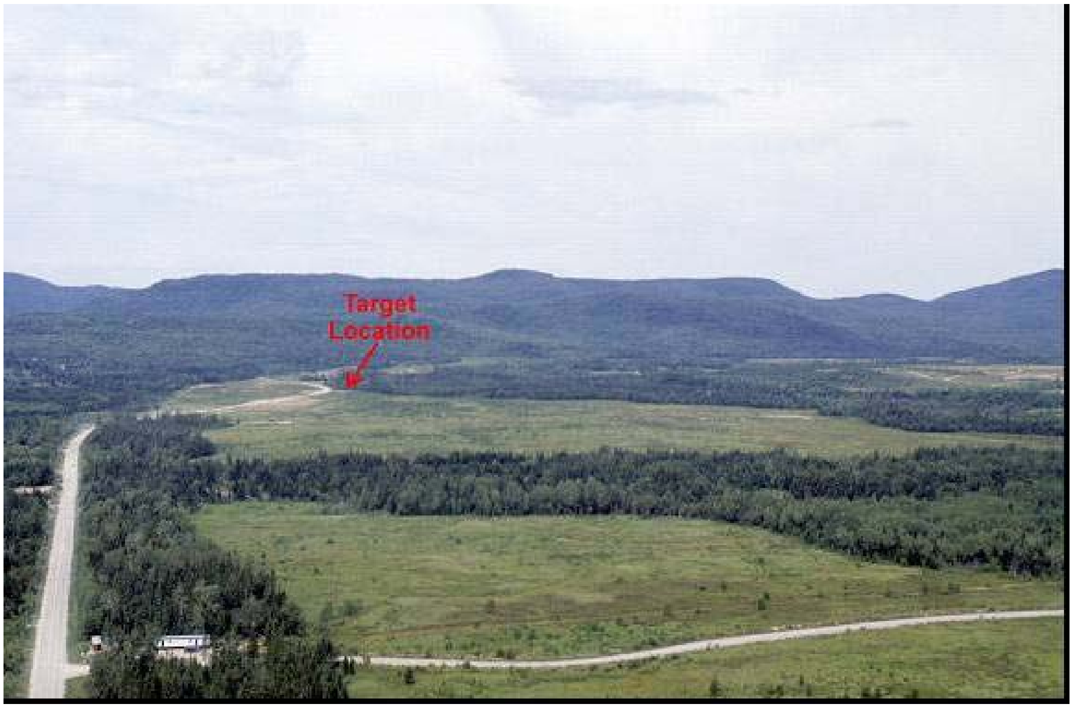

Figure 4: Coyote Target Area.

Figure 5: Close-up of Coyote Target Vehicle.

As each slide was shown to the observer, two data recorders captured the observer's target Initial Detection, Recognition and Identification results. The range associated with the slide when the observer first pointed to the target location was recorded as the initial detection range. The range associated with the displayed slide when the observer was able to describe the general characteristics of the target vehicle was recorded as the recognition range. The observer was deemed to have recognized the target in the practice set when he/she stated that it was a light armored vehicle or wheeled armored vehicle or wheeled personnel carrier. The observer identified the vehicle by declaring that the target was a LAV or Coyote vehicle. Again, the range associated with the slide shown when the observer first identified the vehicle was recorded. During the photosimulation trial two data recorders completed separate data sheets to record the results for each observer and slide set. An example of a data sheet used for the Coyote series of slides is shown in Annex A.5.

False targets were also recorded. A false target was taken to be any object/area pointed to on the slide that was not the target vehicle. When this occurred, the range associated with the slide was recorded along with any comments made by the observer. This information was recorded for possible future analysis. (Note: No analysis of the false target information is planned or performed in this guidebook.)

After having viewed the practice series and one of the experimental slide series, the observer was informed that their participation in the trial was complete. The observer was thanked and reminded not to discuss the trial.

6.2 DIGITAL PHOTOSIMULATION

Recognizing that current digital technology is fast approaching the quality of photographic slides, SCI-095 used digital imagery in a classical photosimulation. An initial approach was to digitize the slides available and use a computer and monitor instead of a projector and screen. However, the group does not recommend digitizing slides. If a digital photosimulation is planned, image collection in the field should be done with a good quality digital camera.

Presenting the images on a computer monitor offers possibilities for simplifying data collection. Image presentation can be partly or fully automatic; observer response can be recorded by the computer. Good results have been obtained by using laptop computers and commercial software. Alternative, more sophisticated and costly methods are also available but are not addressed in these guidelines (see Reference 9).

6.2.1 Design of the Experiment

Imagery can be presented to the subjects using a computer in the same manner as in the classical photosimulation experiment. Because of the lower resolution of the computer monitor compared to slide projections, observer distance to the image does not need to be controlled as in the classical experiment. As a result, each observer can determine an individual viewing distance from the monitor. An introductory briefing should be provided to the observers describing the task and what is required of them and demographic information should be obtained. A sample briefing is shown at Annex A.6. Imagery should be presented in a manner that automatically advances the image after 14 seconds. The test coordinator collects the observer's responses as before and a sample data collection sheet is shown at Annex A.7.

Using the off-the-shelf equipment described below, reasonable agreement with analog photosimulation results has been achieved. Use of other types of hardware and software may have unknown influence on the results.

6.2.2 Example Laptop Photosimulation

The laptop photosimulation is a variation on the basic photosimulation technique. The procedure used during an Italian photosimulation trial conducted in June 2003 is described here.

Observers viewed each image for a fixed time while sitting in a chair placed in front of the laptop used for the trial. The laptop screen was 15” in size, with a width of 29.5 cm and a resolution of 1024 x 768 pixels. The chair was positioned in a way that the distance from observer’s eyes and the screen was approximately 30 cm. The observers were free to slightly adjust their distance from the screen and its inclination in the way they felt most comfortable. The images were shown through a commercial presentation software package for convenience (PowerPoint), in which the first image was viewed for an indefinite time, while the remaining images had a fixed viewing time and advanced automatically. The viewing time for each image was fixed to 14 seconds, see [10] for considerations about this choice. The images were imported into the presentation so that the image filled the entire screen.

The observers came into the viewing room one at a time and sat in front of the laptop. Trial procedures were briefed in detail, and the observer was given a pointer (a pencil) for use during the trial. An alternative method is to include the observer briefing as the first slide in the presentation. Two or three sets of digitized slides were shown. The first set was always the practice series as used in the traditional photosimulation described earlier in this chapter.

The observers were instructed to point out any potential military target they saw in the images with the pointer and, whenever possible, identify the target. The range associated with the image on which the observer first correctly pointed at the target was recorded as initial detection range. Recognition range was defined as the range associated with the image on which the observer first correctly recognized the type of military vehicle.

Chapter 7 – DATA ANALYSIS

An important principle in the analysis of camouflage data is that the type of analysis to be carried out determines the way the data must be handled [11]. This principle will be explained and illustrated with practical examples. There are two different types of analysis that will be discussed in this report. In the first type of analysis, the data values are treated as sample points from a distribution and the analysis is concerned with statistical estimates of distribution parameters (Sections 7.2 and 7.3). In this case the order of the data values is not important and there is no other information associated with any given data point. In the second type of analysis, the distinguishing feature is that each data point has one or more covariates (factors) associated with it (Section 7.5). For example, if the analysis is concerned with the possible effect of observer age on detection, then age is a covariate and each detection range datum has an observer age associated with it. The time of each observation and even the order of observations are examples of possible covariates of interest.

Although detection, recognition and identification ranges are always reported as positive values, it is mathematically convenient in the analysis to treat ranges as negative values. In the subsequent discussion and examples of trial results, all ranges will be listed as negative values. Also, the subsequent discussion and examples will focus on detection results only, for brevity, but the procedures discussed apply equally to recognition and identification data.

7.1 DATA ADJUSTMENT

The recommended trial procedures described previously yield observer detection data that are interval-censored. In the experiments observers have the opportunity to make detections at pre-defined intervals, dictated by the associated ranges of the slides, digital images or viewing posts. In this circumstance, observers do not have an opportunity to make detections between the interval ranges. Thus when an observer detects a target, the detection range is biased towards a lower value. Given that the observer did not detect the target at the previous longer range, one would expect that detection would have taken place somewhere in the interval between the preceding detection opportunity and the one where detection occurred.

Similarly, if the observer did not detect the target after viewing all the images or observing from all the observing posts, one can speculate that detection would have taken place somewhere between the range of the last image/observing post and the target location (range = 0 m). Using a detection range value of zero in this circumstance biases the datum towards a lower value.

The bias associated with the raw detection results can be minimized by adjusting the detection range values. Two procedures are recommended:

- The uniform-spacing method, when there is no covariate information associated with the detection range data.
- The single-value spacing method when covariate data will be used in the analysis.

These data adjustments are particularly important when comparing detection data that has been collected using different range intervals. Adjusting the raw detection data reduces the potential for biased statistical analysis results due to imagery range-selection effects.

Table 2 presents hypothetical raw detection results for two camouflage treatments, which will be used to demonstrate the application of these two data-adjustment techniques. For demonstration purposes, the detection results are deemed to be based on detection opportunities at the ranges listed in Table 1.

Table 2: Hypothetical Raw Detection Results

Camouflage Net A			Camouflage Net B		
Observer Session	Age	Detection Range (m)	Observer Session	Age	Detection Range (m)
1	38	-1000	16	38	-900
2	40	-1100	17	40	-900
3	32	-1600	18	32	-1100
4	36	-900	19	36	-800
5	28	-900	20	28	-900
6	36	-900	21	36	-1000
7	37	-800	22	37	-1600
8	38	-1000	23	38	-700
9	38	-1000	24	38	-600
10	38	-1600	25	38	-500
11	33	-1100	26	33	-1000
12	37	-700	27	37	-900
13	25	-800	28	25	-900
14	32	-900	29	32	-500
15	37	-800	30	37	-1000

If one was solely interested in comparing the general detectability of the two camouflage nets, the detection data should be adjusted by the uniform-spacing method. To apply this method, one identifies the number of data samples applicable to each range value. Then these detections are equally spaced between the range where detection took place and the next longer range value. Consider the following example. Let R_a be the range where n detections took place and R_b is the range related to the next longer-range image. With the uniform spacing, the n observations are given range values that are equally distributed between R_a and R_b, with $(R_a – R_b) / (n + 1)$ as the spacing. In Table 2, there are three detections of camouflage net A with a range value of -1000 m. From Table 1, the next longer-range image has an associated range of -1100 m. The uniform spacing procedure would convert the three ranges to -1025, -1050 and -1075 m. These adjusted ranges cannot be associated with any particular observer. Applying the uniform-spacing procedure to the range data of Table 2 yields the results shown in Table 3. As the adjusted detection data using the uniform-spacing method is no longer associated with observers, it can be ordered as shown in Table 3, which facilitates subsequent analysis.

Table 3: Detection Ranges Adjusted for Uniform Spacing

	Camouflage Net A	Camouflage Net B
Data Value	Detection Ranges (m)	Detection Ranges (m)
1	-1733	-1700
2	-1667	-1150
3	-1167	-1075
4	-1133	-1050
5	-1075	-1025
6	-1050	-983
7	-1025	-967
8	-980	-950
9	-960	-933
10	-940	-917
11	-920	-850
12	-875	-750
13	-850	-650
14	-825	-567
15	-750	-533

The single-value-spacing adjustment is appropriate when one wishes to relate some information to the detection ranges. For example, one may be interested in investigating if there is a relationship between detection range and observer age. In this case, each detection range must be associated with an observer age. Here, the only valid adjustment method to minimize bias is to replace each detection range with the mid-point value between the raw detection range and the next longer range, i.e. $(R_a + R_b)/2$. Applying this procedure to the range data in Table 2, produces the results shown in Table 4.

Table 4: Detection Results Adjusted for Single-Value Spacing

Camouflage Net A			Camouflage Net B		
Observer Session	Age	Adjusted Detection Range (m)	Observer Session	Age	Adjusted Detection Range (m)
1	38	-1050	16	38	-950
2	40	-1150	17	40	-950
3	32	-1700	18	32	-1150
4	36	-950	19	36	-850
5	28	-950	20	28	-950
6	36	-950	21	36	-1050
7	37	-850	22	37	-1700
8	38	-1050	23	38	-750
9	38	-1050	24	38	-650
10	38	-1700	25	38	-550
11	33	-1150	26	33	-1050
12	37	-750	27	37	-950
13	25	-850	28	25	-950
14	32	-950	29	32	-550
15	37	-850	30	37	-1050

7.2 CUMULATIVE FREQUENCY DISTRIBUTION

It is often useful and informative to create a cumulative frequency distribution curve for camouflage data. This curve shows the percentage of observations that occurred at or before each range. To create a cumulative frequency distribution curve, it is appropriate to use the uniform-spacing method to adjust the raw observations as no additional (covariate) information is desired. The data from Table 3 were used to create the curves shown in Figure 6.

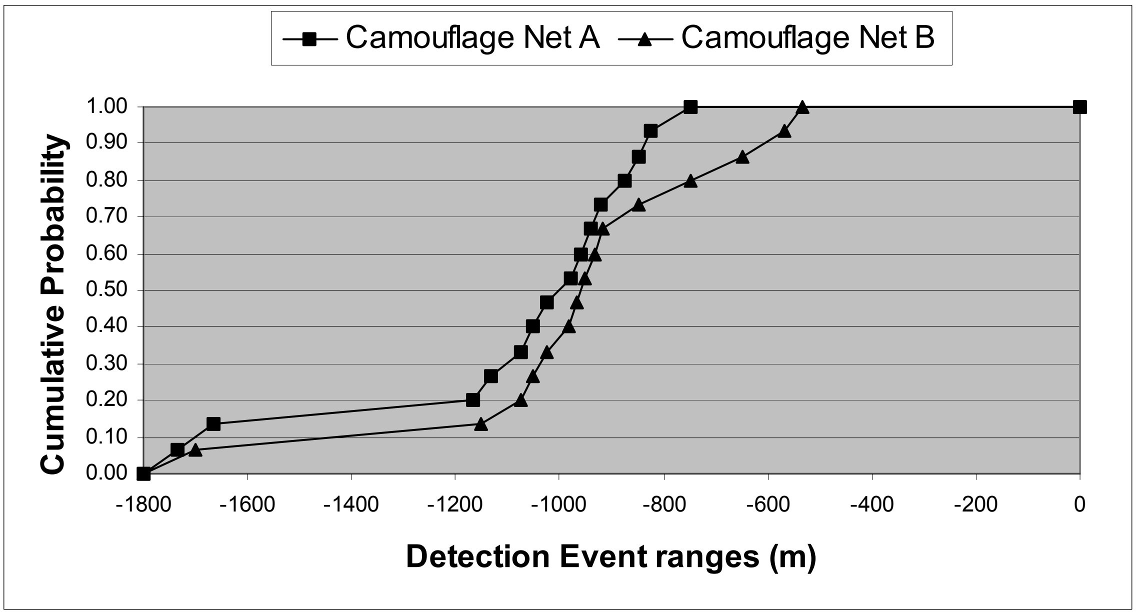

Figure 6: Cumulative Initial Detection Probability Curves.

7.3 DESCRIPTIVE STATISTICS

7.3.1 Median

A standard way to summarize a set of data using numerical methods is to calculate a central value for the data such as the mean or median. The median is preferred over the mean for camouflage data because extreme data points, such as unusually high or low initial detection ranges, could skew the mean and make the central value appear higher or lower. The median is unaffected by such outliers.

To calculate the median, first adjust the raw data observations, if necessary, using the uniform-spacing method. The median is the middle value of an ordered set of observations (i.e., the ordered set of the adjusted values). When the number of observations is odd, the median is the middle value. When the number of observations is even, the median is the average of the two middle values.

For example, the median of the 15 ordered data values in Table 3 is the eighth value, -980 m for camouflage net A and -950 m for camouflage net B.

7.3.2 Confidence Interval

The calculated median for the data sample is an estimate of the true value for the total population, which is unknown. It is understood that the true population median will likely be a value somewhat higher or lower than the estimate. The range of values about the estimated median, within which the true median is expected to lie, can be determined. This is the uncertainty or **confidence interval** associated with the estimate of the median. The confidence interval is an estimate of upper and lower limits, with an associated confidence level, within which the true statistic is likely to lie. The confidence level (a percentage, usually 95%) indicates how certain the analyst wants to be that the interval includes the true median. Higher confidence levels increase the likelihood that the true median will be in the interval, but widen the range of the interval. Smaller sample sizes also tend to increase the width of the confidence interval.

Methods to calculate the confidence interval associated with an estimate of the median can be found in standard statistical textbooks, such as References 12 and 13. Also, standard statistical analysis software, such as Analyse-it® for Microsoft Excel® can compute confidence intervals with the estimate for the median. For example, for the data in Table III, the 95% confidence interval for the median for camouflage net A is -1133 to -873 m while for camouflage net B the 95% confidence interval is -1050 to -750 m.

7.3.3 First Percentile

In some cases one may be less interested in understanding average performance and more concerned about exceptional performance. There are several possible statistics that can be used to describe the longest range at which initial detection might take place.

It is recommended that the estimated first percentile of the distribution of observations be used as a standard descriptive statistic. The first percentile is the distance at which an observer has a one percent probability of initially detecting the target. The number of observers used in typical tests is not large enough to actually encounter this threshold, but it can be derived from the test distribution.

In order to calculate the first percentile, first adjust the N raw data observations, if necessary, using the uniform spacing method. Then sort the data in decreasing order of magnitude and denote the data value with the largest magnitude as $X_{(1)}$. Next calculate the median as explained above and denote it by $X_{.50}$. The estimated first percentile, denoted by $X_{.01}$ is given by the following formula:

$$X_{.01} \quad = \quad X_{.50} - 2.326\left(\frac{X_{(1)} - X_{.50}}{\alpha(N)}\right)$$

The value $\alpha(N)$ may be obtained from Annex A.8. A detailed derivation of the first percentile formula is given in [11]. To illustrate the calculation of the first percentile, consider the data in Table 3. In this case of camouflage net A, $N = 15$, $X_{.50} = -980$, $X_{(1)} = -1733$ and $\alpha(15) = -1.736$. Therefore the estimated range of the first percentile for camouflage net A is -1989 m.

$$X_{.01} \quad = \quad -980 - 2.326\left(\frac{-1733 - (-980)}{-1.736}\right) \quad = \quad -1989$$

Applying the same formula to the data for camouflage net B yields a first-percentile range of -1955 m.

This formula assumes that the probability density function of the distribution of detection ranges has a peak near the median and decreases steadily towards longer ranges. This is to say that the greatest number of detections occurs near the median and the numbers of detections decrease as the magnitude of the range value get larger and larger. Practical experience with photosimulation and field observation trials has demonstrated this assumption to be reasonable and valid.

While, in general, it is recommended that assumptions about the nature of the distribution of detection ranges be avoided in the analysis of results, such an assumption is unavoidable in creating a simple, practical formula for the calculation of the first-percentile descriptive statistic.

7.4 TESTING FOR SIGNIFICANT DIFFERENCES

The analysis of camouflage effectiveness is often concerned with the evaluation of observer performance for differing camouflage treatments. Several statistical tests are used depending on the experimental design of the camouflage trial. The two main characteristics that determine which statistical test is appropriate are the number of camouflage treatments being evaluated and whether the observations are paired or independent. If each observer views more than one of the camouflage treatments being evaluated, then the data are paired. Conversely, if a different group of observers views each camouflage treatment, then the data are independent. Table 5 lists the recommended statistical procedure for the four situations that commonly occur. The mathematical derivation of these tests is explained in most statistical handbooks, such as References 12 and 13. The practical application of these tests will be discussed below.

Table 5: Statistical Tests for Different Experimental Designs

	Independent Observations	Paired Observations
2 Camouflage Treatments	Wilcoxon Two-Sample Test (Mann-Whitney Test)	Wilcoxon Two-Sample Paired Test
3 or more Treatments	Kruskal-Wallis Test	Friedman Test

Note that each of the recommended statistical tests is a non-parametric test. Nonparametric tests make no assumptions about the nature of the distribution of observations. As such, the statistical tests are robust. However, the tests may be less sensitive to small differences between medians of different data sets than statistical tests that make assumptions about the nature of the data distributions. As it is felt that camouflage assessment trials are conducted to identify significant differences between camouflage treatments, the non-parametric statistical tests achieve this goal. Parametric tests require the user to confirm that the nature of the distribution of observations fits the assumptions of the test. This requires additional tests on the data. For simplicity and robustness, non-parametric statistical test are recommended for camouflage analysis.

7.4.1 Wilcoxon Two-Sample Test

The Wilcoxon two-sample test, also referred to as the Mann-Whitney test, provides a methodology to determine if there is a statistically significant difference between the medians of two sets of independent data. The Wilcoxon test is most often used to assess differences between detection performance against two differently camouflaged targets for two groups of observers.[1] Note that the Wilcoxon two-sample test requires that the two samples of observers be independent. This means that each observer views only one of the targets under investigation. If the same observer views both targets, the observations are said to be paired and this Wilcoxon test is not appropriate. The analysis of paired observations will be discussed below.

The output from a Wilcoxon test is a "p-value" indicating the strength of evidence that the difference between the median detection ranges for the two camouflage treatments is a random effect and the detectability of the targets is the same. For camouflage effectiveness analysis, a p-value less than or equal to 0.05 indicates a statistically significant difference. A p-value between 0.05 and 0.10 indicates some evidence of a difference.

In order to apply the Wilcoxon two-sample test, first adjust the values of the raw observations, if necessary, using the uniform spacing method. Then, a statistical software package such as the Statistical Analysis System (SAS) or Analyse-it® for Microsoft Excel® can be used to apply the test on the adjusted data values.

7.4.1.1 Example of the Application of the Wilcoxon Two-Sample Test

An example of the use of the Wilcoxon two-sample test is the comparison of observer detection performance for the two camouflage treatments shown in Table 2. To test simply for a difference in detection performance between the camouflage types, the data are first adjusted using the uniform spacing method with results shown in Table 3. Recall that the median detection range for camouflage A is -980 m, while the median detection range for camouflage B is -950 m. The Wilcoxon two-sample test is then applied to the data of Table 3. The results of this Wilcoxon test using the Analyse-it software are contained in file 'Wilcoxon _Example.xls' on this CD-Rom, on the RTO Website and in Annex A.9. The results of the Wilcoxon test produce a p-value of 0.3245, indicating that there is no statistically significant difference in the median detection ranges for camouflage types A and B. In other words, there is no evidence to suggest that the detectability of the two camouflage types is different.

7.4.2 Wilcoxon Two-Sample Paired Test

The Wilcoxon two-sample paired test is used to assess differences between detection performance against two differently camouflaged targets when the observations are paired.[2] Paired observations occur when each observer views both of the targets under investigation. As each observer views both targets, the observations are not independent and the earlier Wilcoxon two-sample test is not applicable or appropriate.

In order to apply the Wilcoxon two-sample paired test, first adjust the values of the raw observations, if necessary, using the single-value spacing method. The single-value spacing method is applied because the link between the detection ranges for each camouflage treatment and the observer the data relate to must be retained. Once the data are adjusted, a statistical software package can be used to apply the test.

7.4.2.1 Example of the Wilcoxon Two-Sample Paired Test

The data in Table 2 will be used in this example. For the purposes of this demonstration, it will be assumed that observers in Observing Sessions 1 and 16 are the same person, as is the observer in Observing Sessions 2

[1] This test can also be used to evaluate the detection performance of two independent groups of observers for the same target on two different occasions.

[2] This test can also be used to evaluate the detection performance of paired observations for the same target on two different occasions.

and 17, similarly for Observing Sessions 3 and 18, etc. In this case, the detection data for the two camouflage treatments are not independent, so the Wilcoxon two-sample paired test is the appropriate test to apply. The single-value-spacing-adjusted data of Table 4 is used in the test. The input data and results are contained in the file named 'Wilcoxon_Paired_Example.xls' on this CD-Rom, on the RTO Website and in Annex A.9.

The results using the Analyse-it software show that the p-value is 0.2412, indicating that there is no statistically significant detection difference between camouflage treatment A and B. When an experiment uses the same observers to obtain detection data for different targets, one expects to see less variability in the results than for different observers. So, any variability observed in data obtained in these circumstances is a strong indicator of differences. This is why the p-value is much lower using this paired test compared to the standard two-sample test, even though the same input data was used in both tests. This indicates the importance of understanding the nature of the data and applying the appropriate statistical test.

7.4.3 Kruskal-Wallis Test

The Kruskal-Wallis test is a non-parametric test that is used to determine if there is a statistically significant difference between three or more **independent** groups of sampled data, regardless of their distribution. When there are only two groups in the comparison, the test becomes a Wilcoxon two-sample test. To apply the Kruskal-Wallis test, first adjust the values of the raw observations, if necessary, using the uniform-spacing method. Then, a statistical package such as Analyse-it can be used. If the test returns a p-value that is less than or equal to 0.05, then two or more groups of the sampled data have medians that are significantly different. In this case, further analysis is required in order to determine how to partition the datasets into groups with equal medians. A "maximum likelihood" method, which will be described subsequently, is recommended to accomplish this further analysis.

7.4.3.1 Example of the Kruskal-Wallis Test

For this example we will assume that another observer trial with a third camouflage treatment (Camouflage Net C) was conducted. The observer data and detection results are shown in Table 6. Table 6 also contains adjusted detection results according to the single-value-spacing method, to preserve the association with the observer and the observer age. The detection results for camouflage treatment C were also adjusted using the uniform-spacing method to allow a comparison of these results with those for camouflage treatments A and B to be made. The detection results adjusted by the uniform-spacing method are shown in Table 7, sorted by detection range.

Table 6: Detection Results for Camouflage Treatment C

Camouflage Net C			
Observer Session	Age	Raw Detection Range (m)	Adjusted Single-Spacing Detection Range (m)
31	38	-1000	-1050
32	40	-700	-750
33	32	-900	-950
34	36	-1000	-1050
35	28	-1200	-1300
36	36	-900	-950
37	37	-900	-950
38	38	-800	-850
39	38	-1200	-1300
40	38	-1800	-1900
41	33	-800	-850
42	37	-800	-850
43	25	-900	-950
44	32	-700	-750
45	37	-800	-850

Table 7: Detection Results Adjusted by Uniform Spacing

Camouflage Net C	
Data Value	Uniform-Spacing Detection Range (m)
1	-1900
2	-1267
3	-1233
4	-1067
5	-1033
6	-980
7	-960
8	-940
9	-920
10	-880
11	-860
12	-840
13	-820
14	-767
15	-733

From Table 7, it can be seen that the median detection range is -940 m. Applying the procedure to calculate the first-percentile range returns a value of -2226 m for camouflage C.

If one wished to test for differences in detectability between the three camouflage treatments (A, B, and C), the Kruskal-Wallis test should be used as these are independent sets of data and involve more than two cases. Again, a statistical software package can be used to conduct the test. The file named 'Kruskal-Wallis_

Example.xls' on this CD-Rom, on the RTO Website and in Annex A.9 contains the results of applying this test to the detection data (adjusted by the uniform-spacing method) for camouflage treatments A, B, and C. The Kruskal-Wallis test returns a p-value of 0.5588, indicating that there is no statistically significant difference between the median detection ranges of the three camouflage treatments.

7.4.4 Friedman Test

The Friedman Test is a non-parametric test that is used to determine if there is a statistically significant difference between three or more groups of paired data, regardless of their distribution. When there are only two groups in the comparison, the Wilcoxon two-sample paired test should be used. To apply the Friedman Test, first adjust the values of the raw observations, if necessary, using the single-value spacing method. Then, the test can be applied using a statistical package such as SAS or Analyse-it. If the test returns a p-value that is less than or equal to 0.05, then two or more groups of the sampled data have medians that are significantly different. In this case, further analysis is required in order to determine how to partition the datasets into groups with equal medians. If there had been a difference, the different dataset groupings could have been identified by using the maximum likelihood method.

7.4.4.1 Example of the Friedman Test

This example will use the data presented in Tables 4 and 6. It is assumed that the same observers viewed each of the three camouflage treatments (A, B and C). It is assumed that Observer 1 participated in Observing Sessions 1, 16 and 31; Observer 2 took part in Observing Sessions 2, 17 and 32, and so on. Then, the detection data generated from the 45 observing sessions are related to only 15 observers. As the detection range data are not independent, it is important to retain the linkage between the data and the observer that generated it. Hence, the data adjusted by the single-value spacing method will be used for the statistical analysis.

Applying the Friedman test on the adjusted data of Tables 4 and 6 produces a p-value of 0.8040, indicating that there is no statistically significant difference between the detection results of the three camouflage treatments. The input data and results of the Friedman test using the Analyse-it software are contained in the file 'Friedman_Example.xls', on this CD-Rom, on the RTO Website and in Annex A.9. If there had been a difference, the different groups could have been identified by doing pair-wise comparisons using the Wilcoxon two-sample paired test.

7.4.5 Maximum Likelihood Method

The maximum likelihood method is applied when the Kruskal-Wallis or Friedman tests identify that there is a difference among the median values associated with three or more datasets. In such a circumstance, further analysis is required to determine which datasets have statistically similar medians and which are different. The maximum likelihood method utilizes the previously described statistical tests to determine the "best" way to combine the datasets into groups of statistically similar median detection ranges. The maximum likelihood method has the desirable attribute that it will always separate the datasets into at least two groups, consistent with the results of the Kruskal-Wallis or Friedman tests.

To apply the method, one begins by ordering the datasets according to the median detection range values. Potential separation points are identified between adjacent data sets, as shown in Figure 7. Each separation point divides the datasets into two data groups formed by combining all the detection range data from all the datasets on the same side of the separation point. Note that the original detection range results must be used to produce the combined dataset and the detection ranges must then be re-adjusted using the uniform spacing method. The two data groups are compared using the Wilcoxon two-sample test for differences in their median detection ranges. The p-value from the Wilcoxon test indicates the strength of evidence that the datasets should be divided at the separation point being examined. The p-value for each potential separation point is calculated and compared. The lowest p-value indicates the strongest evidence that the associated separation point should be chosen to split the datasets. After splitting the datasets into two groups based on the most likely separation point, there may be more than one dataset in either group. When this occurs the datasets in the group(s) are tested for differences using the appropriate statistical test. If the test indicates that a difference exists, then the datasets within the group must be separated using either the Wilcoxon two-sample test when there are two datasets in the group or the maximum likelihood method if there are more than two datasets in the group. This process is repeated until there are no differences indicated within any of the defined data groups. It is possible that the process could separate every dataset into a different group, in which case every dataset is different from every other dataset.

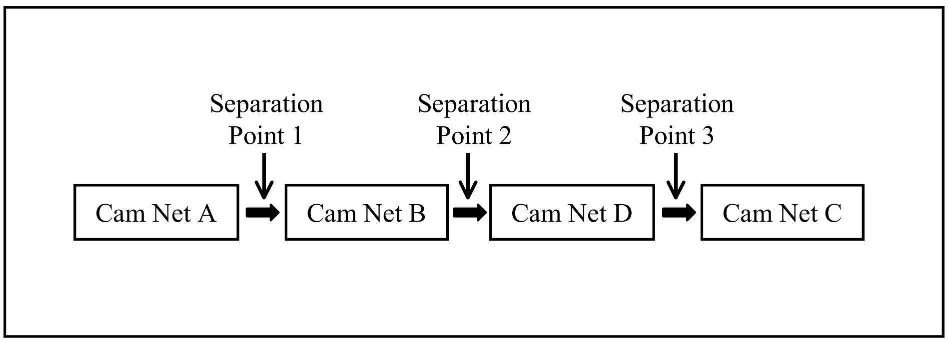

Figure 7: Possible Separation Points.

7.4.5.1 Example of the Maximum Likelihood Method

The maximum likelihood method will be demonstrated using the detection range data shown in Table 8. The detection ranges in Table 8 are fictitious and associated with four hypothetical camouflage nets for vehicles. The ranges are raw detection ranges derived from imagery with the associated detection ranges shown in Table 1. It is also assumed that different observers were used to collect the data for each net, so the data are independent. Results of the applied statistical tests will be reported, but the calculations will be left to the reader to perform.

Table 8: Detection Range Datasets

Detection Range (m)	Cam Net A	Cam Net B	Cam Net C	Cam Net D
Observer 1	-1400	-1400	-800	-1200
Observer 2	-1200	-1400	-800	-1200
Observer 3	-1100	-1200	-800	-900
Observer 4	-1100	-1000	-800	-800
Observer 5	-1100	-1000	-700	-800
Observer 6	-1000	-1000	-600	-800
Observer 7	-1000	-1000	-500	-700
Observer 8	-1000	-1000	-400	-700
Observer 9	-1000	-900	-400	-700
Observer 10	-1000	-900	-400	-700
Observer 11	-900	-900	-400	-700
Observer 12	-900	-900	-300	-600
Observer 13	-900	-900	-300	-500
Observer 14	-900	-900	-300	-400
Observer 15	-900	-900	-300	-400
Median Detection Range	-1050	-1017	-480	-767

In Table 8, the median detection range for each dataset is shown at the bottom and is based on the detection range data adjusted by the uniform-spacing method. The first step in the process is to apply the Kruskal-Wallis test to determine if there is a difference among any of the datasets in the group. Using the adjusted detection range data, this test produces a p-value less than 0.0001, indicating that there is at least one difference within the group, i.e. at least one dataset (or group of datasets) that is different from the others. To locate the difference(s), the maximum likelihood method is next applied.

With the maximum likelihood method, one begins by ordering the datasets according to their associated median detection range. Going from longest median detection range to the shortest range, the sample data yields an order of net A, followed by net B, followed by net D and lastly by net C. As shown in Figure 7, there are three possible separation points: between the datasets for net A and net B, between the datasets for net B and net D and between the datasets for net D and net C. Each separation point divides the datasets into two groups. Within each group, all the detection range data of the datasets are combined into one large dataset and adjusted according to the uniform-spacing method. For separation point one, the dataset for net A is left in one group, while the data for nets B, D and C are combined. For separation point two, the data for nets A and B are combines in one group and the data for nets D and C are combined in the other group. Lastly, for separation point three, the data for nets A, B and D are combined in one group, while the net C data forms the second group.

The Wilcoxon two-sample test is used to calculate the p-value for each of the pairs of data groups formed by the separation points. The following results are obtained:

Separation Point 1 : p-value = 0.0027

Separation Point 2 : p-value = <0.0001

Separation Point 3 : p-value = <0.0001

Separation points two and three have the lowest p-values, which are equal in value. This indicates that both these separation points are equally good choices as the most likely separation points to use. In this case, the choice between separation point two and three is arbitrary. Separation point two is chosen.

The datasets have now been divided into two groups (net A + net B and net D + net C) that are known to have different median detection ranges. The next step is to test each of these data groups to determine if there are any differences between the datasets within the groups. As there are only two datasets in each group, the Wilcoxon two-sample test is applied with the following results:

Cam Net A versus Cam Net B : p-value = 0.5668
Cam Net D versus Cam Net C : p-value = 0.0264

The p-values obtained indicate that there is no statistically significant difference between cam nets in the first group (A and B), but there is a difference between cam nets in the second group (D and C). With this result, one would now apply the maximum likelihood method to determine the best separation point for the datasets in the second group. However, as there are only two datasets in the group, net D and net C, there is only one possible separation point, so the maximum likelihood method is not required. The median detection ranges for camouflage nets D and C have been shown to be different.

The overall results for the analysis of the detection range data for the four camouflage nets indicates that there is no statistically significant difference in the median detection ranges of net A and net B, net C and Net D are different from nets A and B and from each other.

7.5 INFLUENCE OF PARAMETERS ON DETECTABILITY

In some circumstances, the factors that may affect detectability of a camouflage treatment are of interest. For example, having collected information on the observers participating in the trial, one can investigate the relationship between observer age and experience on initial detection range of the target. One begins by establishing categories or ratings for the factors of interest and grouping the detection data by the associated factors' categories. To maintain the proper association between the covariate factors and the detection data, the detection data should be adjusted only by the single-spacing method. Having established the factor categories and having adjusted the associated detection data, one can apply the afore-described statistical tests to determine if the detection results are affected by the factors.

One concern to keep in mind when performing this type of analysis is the sample size. Each factor category under investigation can be considered a separate distribution or population. The data related to each factor category is a sample of the population. As was discussed earlier, ideally one should have at least 15 data values for each population being compared to provide reasonable confidence that true differences will be statistically discernable and good estimates for descriptive statistics can be obtained. If one collects detection data for a camouflage treatment using 15 observers, this will be adequate for comparing the detectability of this camouflage treat to others. However, if one then wishes to investigate if the detectability of the camouflage treatment is a function of the age of the observer, the sample size will be lower than the recommended level. If the observers are divided into two age groups (i.e. young and mature) then there will be less that eight data samples in one of the groups. At least one group will have a sample size much lower than the recommended level. If it is anticipated that this type of analysis will be conducted, the number of observers in the initial data should be increased to ensure that adequate sample sizes will be available for all components of the analysis.

7.5.1 Example of Factor Analysis

To demonstrate this type of analysis the data shown in Table 8 will be used. For conciseness only 15 data samples will be used. This sample size will be sufficient to demonstrate the technique, but would be much too small to be used in practice.

During the hypothetical detection trial for camouflage X, each observer is required to complete a questionnaire indicating their age and previous experience at target detection. The results are shown in Table 9. Examination of the ages of the observers indicates that the median age of the group was 37. This value was used to divide the observers into two age groups, Young for observers under 37 years of age and Mature for observers 37 years of age and older. The data on experience level naturally divides into two categories. With these factor categories, one can now test to determine if detection range is related to observer age or experience. To statistically test for the effect of observer age on detection range, begin by separating the detection range data into a group associated with Young observers and another related to Mature observers. Analyzing the detection data based on age category indicates that the median detection range for Young observers is -800 m and for Mature observers, it is -1050 m. The Wilcoxon (Mann-Whitney) two-sample test can be used to determine if the perceived difference in median detection range between the age groups is statistically significant. The Wilcoxon test is the appropriate statistical test as all the data are independent. The resulting p-value from the Wilcoxon test is 0.6943, indicating there is no statistically significant difference in the detection performance between the observer age groups. The input data and results for this analysis (and the analyses that will be discussed below) using the Analyse-it software are contained in the file ‘Age_Experience_Tests.xls’ on this CD-Rom, on the RTO Website and in Annex A.9.

The same statistical procedure can be used to test for the effect of observer experience on detection performance. Again, the detection data are separated in two groups based on the categories of experience, Yes and No. The two sets of detection range data are then compared using the Wilcoxon test. Here, the median detection range for observers with no experience is -650 m, while for experienced observers the median detection range is -1200 m. The p-value from the Wilcoxon test is 0.0120, indicating that there is a statistically significant difference in the detection results for the two categories of observer experience.

Table 9: Detection Results for Camouflage Treatment X

Observer Session	Age	Age Category	Experienced	Adjusted Detection Range (m)
1	38	Mature	Yes	-1050
2	40	Mature	Yes	-1150
3	32	Young	No	-1700
4	36	Young	No	-950
5	28	Young	No	-650
6	36	Young	No	-450
7	37	Mature	No	-850
8	38	Mature	Yes	-1250
9	38	Young	Yes	-1350
10	38	Mature	Yes	-1700
11	33	Young	Yes	-1150
12	37	Mature	No	-750
13	25	Young	No	-550
14	32	Young	No	-650
15	37	Mature	No	-350

Lastly, one can also check if there is an effect on target detection for the interaction between age and experience. To do this a set of groupings must be created for the combinations of age and experience categories. Here there are two age categories, Young and Mature, and there are two categories of experience, Yes and No. This produces four combinations of age and experience: Young-No, Young-Yes, Mature-No and Mature-Yes. Having established the applicable interaction categories, the detection results are grouped under the appropriate categories. For the detection range data being analyzed here, the median detection ranges for the four Age-Experience categories are: -650 m for the Young-No category, -1250 m for Young-Yes, -750 m for Mature-No and -1200 m for the category of Mature-Yes. As there are more than two groups of independent data, the Kruskal-Wallis test is applied. The results of the Kruskal-Wallis test indicate a p-value of 0.0835, revealing that there is no statistically significant difference in the detection results for the combined age-experience factor. However, as the p-value is between 0.05 and 0.10, this suggests that there is some evidence for an age-experience effect.

Chapter 8 – CONCLUDING REMARKS

Using military observers in the field to evaluate camouflaged targets is the preferred method. However, it is also the most time consuming, labor intensive, logistically difficult and expensive procedure to use. In order to provide a reasonable alternative, the procedures outlined in these guidelines describe an approach to improve the reliability and repeatability of visual trials.

The content of these guidelines contains the collective knowledge of SCI-095 gathered over the span of the four years of the task group and provide a framework for the user to conduct an assessment. These guidelines address a typical situation where comparison between different camouflage treatments is desired, as opposed to determination of an absolute range. The statistical analysis procedures presented in these guidelines are a minimal set of descriptive statistics that produce acceptable results. More exhaustive analytical techniques exist and are left to the user to investigate.

The observer detection data presented in this report are fictitious and have been defined to adhere to the proposed guidelines and efficiently demonstrate the recommended statistical analysis procedures. While fictitious, the data have been based on past trials conducted by the participating nations in SCI-095. As such, the values listed as observer detection ranges are typical and representative of the detection ranges that would be expected for similar camouflage assessment trials.

Results from past trials (field observer, traditional photosimulation and digital photosimulation) have been found to be largely independent of observer characteristics. Generally, observer background (military trade or occupation), age, gender and target detection experience do not have a significant impact on the detection ranges obtained in trials. There is some evidence that employing very young observers (relatively new recruits) with associated limited experience at viewing military targets in field conditions can produce shorter detection ranges. Likewise, specialized military personnel trained in target detection, such as reconnaissance troops, can obtain longer detection ranges. However, these trends have not been found to be consistent. In general, any mature military person should be suitable as an observer for a camouflage assessment trial.

The use of a practice imagery series is very important in a photosimulation trial. It overcomes any potential learning effect on observers, allowing unbiased results to be obtained for the imagery of interest. Consistent use of the same warm-up imagery provides a mechanism to confirm that different trials have been conducted in the same consistent manner and that it is valid to compare detection results between these trials that may have been conducted at different times and/or in different geographic regions. Use of the Coyote imagery series, described here, and included in a separate folder in the digital version of these guidelines, has yielded a median detection range of 950 meters with a 95 percent confidence interval of 850 – 1067 meters for fifteen observers. Future photosimulation trials employing this imagery series should expect to obtain similar results.

Based on a comparative digital photosimulation trial conducted by SCI-095 in 2004 and similar trials carried out over the previous four years, it can be stated conclusively that following the procedures recommended in this report and paying careful attention to the experimental set-up will produce consistent, reproducible target detection results that can be compared across different observer trials.

Chapter 9 – REFERENCES

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ANNEX

A.1 FIELD TRIAL: BRIEFING OF OBSERVERS

My name is ....

There is a need for an investigation of the camouflage capabilities of different camouflage nets. The result of this investigation will be used for decisions on the future purchase of camouflage nets. Both from a military and an economical point of view the correct decision will be of great importance to………………..

It is important that the investigation results in an objective and accurate evaluation of the camouflage effectiveness of the camouflage nets. To achieve this it is necessary to run a field trial to collect the information needed and you are participating in this trial. It is of the utmost importance that you make your own personal observations, independent of all other observers. You will observe a background against which a number of target vehicles, camouflaged and uncamouflaged, have been placed within an area that has been clearly marked with signs. You will move along an observation path leading towards the background. The observation path is marked with markers. Each marker defines an observation post from which an observation is to be made. The background is divided into five sections with signs, which are clearly visible. Within each section there may or may not be placed a target. Before you start, you will receive an observation form on which you mark your detections with a cross. The form is divided into five columns corresponding to the background sections. Each of these columns is subdivided into 3 sub columns. The observation points are printed on the form by their ranges from the background.

When you detect a target, you must mark the detection on the form. You do this by putting a cross in the sub column corresponding to the observation post at which you are standing. You estimate in which third of a given background section you have detected the target and put your cross in the corresponding sub column of the form. Further, at each observation post you are to mark with a cross whether the sun was shining or not during the observation. When you have finished your observations at an observation post, you will move to the next observation post, where you repeat the procedure. There is no time limit for your observations at each observation post, but you are not allowed to gather during the observations and you are not allowed to communicate in any way with the other observers. Your observation form will be collected and checked at the end of the observation path. In case of doubt as to your filling in of the form, you may be asked for clarification. I want to stress that we are only interested in your personal observations. This is very important for the results of the trial. That is the reason why you are not allowed to talk with other observers during the observations or to discuss the trial with other observers before the whole trial is completed. Finally, this is not a test of your personal capabilities as an observer and your name will not be recorded with the processing of the data.

Do you have any questions?

A.2 FORM FOR FIELD OBSERVATIONS

DATE OBSERVER ....

SUBTRIAL ....

BACKGROUND ....

BACKGROUND SECTION — ILLUMINANCE

OBSERVATION DISTANCE	1			2			3			4			5			Sun	Over cast
2000																	
1800																	
1600																	
1400																	
1200																	
1100																	
1000																	
900																	
800																	
700																	
600																	
500																	
400																	
300																	
200																	

A.3 PHOTOSIMULATION TRIAL BRIEFING TO OBSERVERS

Part 1 (For all observers)

Welcome and thank you for participating in this visual camouflage trial.

Introduce ourselves.

The ultimate purpose of this work is to improve the effectiveness of Canada's and NATO's land forces through the improvement and validation of camouflage. Our results are shared with similar results from our NATO allies, allowing all to benefit.

Each of you will be asked to act as an observer looking for tactical military vehicles such as trucks, tanks or armored personnel carriers. As in real life, the vehicles may or may not be camouflaged. You will individually view 2 different sets of slides. The first set of slides has 16 images and you must scan the entire image, looking for the target or targets. The second set has 20 images and the target or targets are located between two sets of large white markers that you will see in the centre of the image. In each case there will be a series of photographic slides, which start at long range and gradually decrease down to short range.

The basic idea is to determine the range at which you detect the target vehicles. We do this by noting the slide on which you first detect the targets. Remember that we show the slides starting from a very long range and then proceed to shorter and shorter ranges. We allow ample time to view each slide – 14 seconds.

We will give you a pointer to use while viewing the slides. If at any time you detect a target, point it out with the pointer, describe the target and if you can, tell us what it is. **Please do not guess.** If you see the same target on other slides, mention it again and give any added details that you can.

To confirm: a series of slides will be presented, starting from long range and steadily decreasing. Study each slide and describe any military tactical vehicles you detect. If you wish to change your mind about either the detection or description of an earlier target, please do so. This is not a problem and in fact helps us to determine the camouflage effectiveness. We want to know when you detect a target and when you recognize the type or class of vehicle, such as tracked vehicle, truck, etc.

This camouflage trial is not a test of your personal ability. It is a test of the camouflage materials. Your name will not be recorded in any way.

If you have any questions, you may ask them now or when you come in for your turn.

Part 2 (In the viewing room)

You will be shown two sets of slides. The first set of slides has 16 images and you must scan the entire image, looking for the target or targets. The second set has 20 images and the target or targets are located between two sets of large white markers that you will see in the centre of the image. If at any time you detect a target, point it out with the laser pointer, describe the target as best you can and if you can, tell us what it is. Furthermore, if you see the same target on other slides, mention it again and give any added details that you can.

After the warm-up set has been shown:

For this set of slides, we ask that you focus on the white panels. If at any time you detect a target in the area between the white panels, point it out with the pointer, describe the target and if you can, tell us what it is.

A.4 DEMOGRAPHIC QUESTIONNAIRE

Thank you for participating in this NATO camouflage effectiveness experiment. We request that you take a few minutes to provide us with answers to some questions that will help us to properly analyze camouflage effectiveness. The long-term goal is to provide sound advice to Canadian and NATO forces on the effectiveness of tactical camouflage.

CONFIDENTIALITY

No participant will be named in any part of this experiment and no personal information other than that relating to camouflage effectiveness will be collected. Any information gathered will be used exclusively for the stated purpose and will not be disseminated further for any reason.

1. What is your Military Occupation Code? ____________________

2. What is your age? ____________________

3. What is your sex? ____________________

4. Do you have normal 20 / 20 vision or better in both eyes?

[ ] Good vision in both eyes
[ ] Good vision in both eyes with glasses or contacts
[ ] No If no, please explain. ___________________________

5. Are you color blind?

[ ] No
[ ] Yes
[ ] Don't know

6. Have you had any training or experience in locating and identifying military vehicles in the field?

[ ] No
[ ] Yes If yes, please explain. ________________________________

7. Have you ever participated in this sort of evaluation before?

[ ] No
[ ] Yes If yes, please explain. ________________________________

A.5 FORM FOR PHOTOSIMULATION EXPERIMENTS

Obsvr # __5___

OBSERVATION FORM

IMCAVS CALIBRATION SLIDES

Date: _21_ Jan 03

Series: 20 Aug 98 Run 1, Coyote BARE

Range	Target	False	Comments
2500	X		
2250	X		
2000	X	F	Bushes at bottom of slide
1800	X	F	Brown patch in tree line
1600	X		
1400	X		
1200	X		
1100	X	F	Something at bottom left of slide
1000	X		
900	D		Vehicle
800	R		Wheeled vehicle
700	“		8 wheels
600	“		
500	I		Coyote
400	“		
300	“		
TGT	“		

A.6 DIGITAL SIMULATION TRIAL BRIEFING TO OBSERVERS

Welcome and thank you for participating in this visual camouflage trial.

The ultimate purpose of this work is to improve the effectiveness of Canada's and NATO's land forces through the improvement and validation of camouflage. Our results are shared with similar results from our NATO allies, allowing all to benefit.

You are asked to act as an observer looking for tactical military vehicles such as trucks, tanks or armored personnel carriers. As in real life, the vehicles may or may not be camouflaged. You will view a set of 18 images on a laptop computer. The images start at a very long range and gradually decrease down to short range.

The basic idea is to determine the range at which you detect the target or targets. I do this by noting the image on which you first detect the target or targets. Remember that you are shown the images starting from a very long range, proceeding to shorter and shorter ranges. You are allowed ample time to view each image – 14 seconds.

You will have a pointer to use while viewing the images. If at any time you detect a target, point it out with the pointer and if you can, tell me what it is. If you see the same target on subsequent images, point it out again and give any added details that you can.

To confirm: a series of images will be presented, starting from long range and steadily decreasing. Study each image and point out and describe any military tactical vehicles you detect. If you wish to change your mind about either the detection or description of an earlier target please do so. This is not a problem and in fact helps us to determine the camouflage effectiveness. I want to know when you detect a target and when you recognize the type or class of vehicle, such as tracked vehicle, truck, etc.

This camouflage trial is not a test of your personal ability. It is a test of the camouflage materials. Your name will not be recorded on the result sheet.

Thank you again for your co-operation. For familiarization purposes, you will now see an image similar to those that you will be seeing later and you can take some time to adjust the laptop screen viewing angle and your chair to best suit yourself. If you have any questions, please feel free to ask.

A.7 EXAMPLE OF A DATA SHEET

SCI-095 Camouflage Assessment Trial 2004

LAPTOP ONLY

Nation:	
Prepared by:	

					Calibration Imagery		CAT Imagery			
							Bare Target		Camouflage Net	
Observer	Age (Yrs)	Sex (M/F)	Color Blind (Y/N/Unk)	Target Detection Experience (Y/N)	Slide No. when Detction Occurred	Detection Range (m)	Slide No. when Detction Occurred	Detection Range (m)	Slide No. when Detction Occurred	Detection Range (m)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

LAPTOP

1. 14 inch (35 cm) diagonal display
2. 1020 x 768 resolution
3. 16 bit colour
4. 60 Hz

INSTRUCTIONS

1. Use MS Power Point and at least 15 observers
2. Use 14 second interval and briefing provided
3. Show IMCAVS calibration imagery first
4. Use SUNNY series of images after calibration series
5. Use digitalsimulation guidelines in SCI-095 draft report

Please record any suggestions for the improvement of procedures

A.8 VALUES FOR α(N) FOR FIRST PERCENTILE CALCULATION

This Annex gives the expected value of the first order statistic of a standardized Normal distribution, denoted by α(N), for use in the calculation of the first percentile of a set of camouflage data. The value depends only on N, the total number of observations in the dataset being evaluated.

N	α(N)	N	α(N)	N	α(N)	N	α(N)
1	–	26	-1.982	51	-2.256	76	-2.406
2	-0.564	27	-1.998	52	-2.263	77	-2.411
3	-0.846	28	-2.013	53	-2.271	78	-2.416
4	-1.029	29	-2.028	54	-2.278	79	-2.421
5	-1.163	30	-2.042	55	-2.285	80	-2.425
6	-1.267	31	-2.056	56	-2.292	81	-2.43
7	-1.352	32	-2.069	57	-2.299	82	-2.434
8	-1.424	33	-2.082	58	-2.305	83	-2.439
9	-1.485	34	-2.094	59	-2.312	84	-2.443
10	-1.539	35	-2.106	60	-2.318	85	-2.447
11	-1.586	36	-2.118	61	-2.324	86	-2.451
12	-1.629	37	-2.129	62	-2.331	87	-2.456
13	-1.668	38	-2.14	63	-2.337	88	-2.46
14	-1.703	39	-2.15	64	-2.342	89	-2.464
15	-1.736	40	-2.16	65	-2.348	90	-2.468
16	-1.766	41	-2.17	66	-2.354	91	-2.472
17	-1.794	42	-2.18	67	-2.36	92	-2.476
18	-1.82	43	-2.189	68	-2.365	93	-2.48
19	-1.844	44	-2.198	69	-2.371	94	-2.483
20	-1.867	45	-2.207	70	-2.376	95	-2.487
21	-1.889	46	-2.216	71	-2.381	96	-2.491
22	-1.909	47	-2.224	72	-2.386	97	-2.495
23	-1.929	48	-2.232	73	-2.392	98	-2.498
24	-1.947	49	-2.24	74	-2.397	99	-2.502
25	-1.965	50	-2.248	75	-2.401	100	-2.505

A.9 EXAMPLES OF SPREADSHEETS FOR STATISTICAL ANALYSIS

Wilcoxon Example.xls

Det Range for Camouflage Type

Det Range by Camouflage Type	
A	B
-1733	-1700
-1667	-1150
-1167	-1075
-1133	-1050
-1075	-1025
-1050	-983
-1025	-967
-980	-950
-960	-933
-940	-917
-920	-850
-875	-750
-850	-650
-825	-567
-750	-533

analysed with: Analyse-it + General 1.71

Test	**Mann-Whitney test**
	Det Range for Camouflage Type
Alternative hypothesis	Det Range by Camouflage Type: A ≠ B
Performed by	ChristopherG
Date	20 May 2004

n	30

Det Range by Camouflage Type	n	Rank sum	Mean rank	U
A	15	207.5	13.83	137.5
B	15	257.5	17.17	87.5

Difference between medians	-75.0	
95.5% CI	-283.0 to 67.0	(exact)

Mann-Whitney U statistic	137.5	
2-tailed p	**0.3245**	(exact tables used, 33% ties)

Wilcoxon_Paired_Example.xls

Det Range for Camouflage Type

Det Range by Camouflage Type		
Observer	Cam A	Cam B
1/16	-1050	-950
2/17	-1150	-950
3/18	-1700	-1150
4/19	-950	-850
5/20	-950	-950
6/21	-950	-1050
7/22	-850	-1700
8/23	-1050	-750
9/24	-1050	-650
10/25	-1700	-550
11/26	-1150	-1050
12/27	-750	-950
13/28	-850	-950
14/29	-950	-550
15/30	-850	-1050

analysed with: Analyse-it + General 1.71

Test	**Wilcoxon signed ranks test**		
	Det Range for Camouflage Type		
Alternative hypothesis	Det Range by Camouflage Type: Cam A ≠ Cam B		
Performed by	ChristopherG	Date	20 May 2004

n	15

Difference between pairs	n	Rank sum	Mean rank
Positive	5	33.0	6.60
Negative	9	72.0	8.00
Zero	1		

Difference between medians	-100.000	
95.2% CI	-325.000 to 100.000	(exact)

Wilcoxon's W statistic	33	
2-tailed p	0.2412	(exact tables used, 71% ties)

Kruskal-Wallis_Example.xls

Detection Range for Camouflage Type

Det Range by Camouflage Type		
A	B	C
-1733	-1700	-1900
-1667	-1150	-1267
-1167	-1075	-1233
-1133	-1050	-1067
-1075	-1025	-1033
-1050	-983	-980
-1025	-967	-960
-980	-950	-940
-960	-933	-920
-940	-917	-880
-920	-850	-860
-875	-750	-840
-850	-650	-820
-825	-567	-767
-750	-533	-733

analysed with: Analyse-it + General 1.71

Test	**Kruskal-Wallis ANOVA**		
	Detection Range for Camouflage Type		
Comparison	Det Range by Camouflage Type: A, B, C		
Performed by	ChristopherG	Date	21 May 2004

n	45

Det Range by Camouflage Type	n	Rank sum	Mean rank
A	15	302.5	20.17
B	15	378.5	25.23
C	15	354.0	23.60

Kruskal-Wallis statistic	1.16	
p	0.5588	(chisqr approximation, corrected for ties)

Friedman_Example.xls

Det Range for Camouflage Type

	Det Range by Camouflage Type		
Observer	Cam A	Cam B	Cam C
1/16/31	-1050	-950	-1050
2/17/32	-1150	-950	-750
3/18/33	-1700	-1150	-950
4/19/34	-950	-850	-1050
5/20/35	-950	-950	-1300
6/21/36	-950	-1050	-950
7/22/37	-850	-1700	-950
8/23/38	-1050	-750	-850
9/24/39	-1050	-650	-1300
10/25/40	-1700	-550	-1900
11/26/41	-1150	-1050	-850
12/27/42	-750	-950	-850
13/28/43	-850	-950	-950
14/29/44	-950	-550	-750
15/30/45	-850	-1050	-850

analysed with: Analyse-it + General 1.71

Test	Friedman ANOVA		
	Det Range for Camouflage Type		
Comparison	Det Range by Camouflage Type: Cam A, Cam B, Cam C		
Performed by	ChristopherG	Date	27 May 2004

n 15

Det Range by Camouflage Type	n	Rank sum	Mean rank
Cam A	15	29.0	1.93
Cam B	15	32.0	2.13
Cam C	15	29.0	1.93

Friedman's statistic	0.4364
p	0.8040 (chisqr approximation, corrected for ties)

Age_Experience_Tests.xls

analysed with: Analyse-it + General 1.71

Test	**Mann-Whitney test**
	Detection Range for Observer Age and Experience
Alternative hypothesis	Det Rng by Experience: No ≠ Yes
Performed by	ChristopherG
Date	31 May 2004

n	15

Det Rng by Experience	**n**	**Rank sum**	**Mean rank**	**U**
No	9	93.5	10.39	5.5
Yes	6	26.5	4.42	48.5

Difference between medians	550.0	
95.0% CI	300.0 to 800.0	(exact)

Mann-Whitney U statistic	5.5	
2-tailed p	0.0120	(exact tables used, 40% ties)

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Apparent temperature
Background discrimination
Bitmap image format
CAMAELEON software
Camouflage
Concealment
Conspicuity
Countermeasures
Cumulative probability curve
Deception
Degradation factor (imagery multiplication factor)
Descriptive statistics
Detectability
Detection range
Digital techniques
Emissivity
Field of view
Field tests
First percentile
Identification range
Image processing
Live observation trial
Local energy
Local orientation
Luminance
Magnification
Median
Multispectral
Operational effectiveness
Optical countermeasures
Overlap
Photosimulation
p-value
Recognition range
Signal processing
Statistical analysis
Texture
TIF image format

14. Abstract

The objective of SCI-095 was to advance alternative techniques for determining the camouflage effectiveness of military systems reliably at reduced cost. SCI-095 produced "Guidelines for Camouflage Assessment Using Observers" which is a standardized methodology for observer-based tests and statistical analysis. A comparative trial concluded that following the recommended procedures as described in this standardized methodology and with careful attention to experimental setup, produces consistent, reproducible target detection results for comparison across trials.

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