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CONSIDERATIONS FOR PREPARING CAMOUFLAGE, CONCEALMENT, AND DECEPTION (CCD) INSTALLATION GUIDANCE

by

Jonathan C. Duke, Jr., Bartley P. Durst
David L. Meeker, Gerardo I. Velazquez

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

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Jonathan C. Duke, Jr., Bartley P. Durst, David L. Meeker, Gerardo I. Velazquez

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The purpose of this report is to present considerations for use in preparing fixed-facility CCD design and implementation documentation. These considerations are supplemented by possible methods to improve manual CCD design procedures and to assist the CCD engineer in designing and evaluating a complete CCD plan for his installation. Importance is given to the materials descriptions and to the proper design of concepts and their demonstration. In addition, a procedure to collect visual, infrared, and radar baseline data is established to improve the application of CCD guidance.

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Contents

Preface

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The study was conducted by personnel of the U.S. Army Engineer Waterways Experiment Station (WES), under the general supervision of Dr. John Harrison, Chief, Environmental Laboratory, and Dr. Victor E. LaGarde III, Chief, Environmental Systems Division (ESD), and under the direct supervision of Mr. Malcolm Keown, Chief, Environmental Constraints Group (ECG), ESD, and Dr. Jonathan C. Duke, Jr., ECG, Technical Team Leader of the Camouflage Field Demonstration Team.

This report was prepared by Dr. Jonathan C. Duke, Mr. Bartley P. Durst, Mr. David L. Meeker, and Mr. Gerardo I. Velazquez, ECG, ESD. The WES laboratory team included Mr. Durst, Mr. Jesse B. Blalack, Mr. A. David Cook, and Mrs. E. Jeanette Farmer, all of the ECG.

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1 Introduction

Purpose

The primary purpose of this report is to present considerations for use in preparing fixed-facility camouflage, concealment, and deception (CCD) design and implementation documentation. These considerations are supplemented by possible methods to improve manual CCD design procedures.

Background

Two fundamental problems are associated with fixed-facility CCD: optimum design(s) development and military effectiveness evaluation. A subsequent problem, the application process, is considered secondary to the major problems of design and evaluation because CCD is generally implemented using relatively low-skilled labor.

For purpose of this paper, the terms *design* and *evaluation* are nearly synonymous for describing target signatures to be modified or duplicated and then down-selecting (evaluating) possible treatment solutions. CCD design without computer-assisted scene generation and sensor-image analysis is a fairly primitive manual process. However, this paper suggests several methods that may allow improvement of this procedure.

Properly, the term *design* would mean sensor-specific analyses of scenes containing untreated target/deception signatures through seasonal, diurnal, meteorological, and operational cycles and events to determine the optimum selection of materials as well as the appropriate tactics, techniques, and procedures. Evaluation would follow, with indicators of the military worth of the proposed defenses, e.g. increased sortie generation, increased circular error probable, etc. There is little likelihood that reasonable military worth evaluations can be developed until significantly more experimental and/or modeled data are available. Given the costs of testing and collecting data using manned aircraft and free-flight or tethered missilery, modeling of CCD effectiveness may prove the only viable, cost-effective solution. However, it is thought that significant improvement can be made in the current application guidance/considerations process by applying quantitative descriptors to the procedures.

In general, current CCD literature can be divided into four overlapping categories: material descriptions; concepts and their demonstration; sensor principles, performance, and evaluation and reporting; and CCD application guidance. Each of these categories is addressed in the succeeding paragraphs.

Material descriptions

Material descriptions, when available, are normally developed by materials manufacturers and may include limited application guidance. Material descriptions usually concentrate on spectral and physical properties, application rates, etc. Descriptions of the properties of CCD materials are often notably optimistic; however, because the applications engineer/designer will seldom have access to the test apparatus required to verify published spectral or physical properties, he is normally forced to rely on manufacturer's or Federal specifications or on data published in applications guidance.

Concepts and their demonstration

Concepts, demonstration of concepts, and reporting of demonstrations have inherent shortfalls. Concept journalism falls into three common classes: historical, conceptual, and adapted conceptual. As a rule, reporting of historical events and applications of CCD, normally from the two World Wars, lacks material descriptions, effectiveness, and scale of application information. Conceptual reporting, which ranges from notional to proof-of-principle reporting, frequently has limited laboratory or field data to support the concepts reported. Adaptation of historical concepts with modern materials is a fairly common literary event. The validity of this approach is limited by the capacity of the author/agency and the availability of suitable data, both from the historical application and from modern materials from which to draw conclusions. Reporting of the various concepts in application guidelines is not necessarily improper; however, current documentation often fails to discriminate between notional and demonstrated concepts, and suspected limitations are not fully addressed.

With the realization that there have been few demonstrations/applications of large-scale fixed-facility CCD (in the free world) since early to mid-World War II, the applications data derived from CCD demonstrations are based on a limited data set. Further, CCD demonstrations are customarily limited in duration, scale, and scope and are designed by one or more subject area specialists. Additionally, because of the cost and availability of data collection (i.e. airborne platforms, instrumentation, and scientific personnel), data acquisition has been curtailed, thereby limiting subsequent analysis reporting.

Sensor principles

A third potential source of information related to CCD lies with the review of the physical principles behind performance testing of various sensor systems. A review of each sensor principle allows definition of the fundamentals of detection and, in turn, methods to defeat or reduce the system's effectiveness. System performance and testing allow the development of detectability criteria and standards primarily as a function of environment, range, and target characteristics. Further, a review of reconnaissance, surveillance, and target acquisition (RSTA) systems fundamentals normally defines system performance modeling. Detailed threat sensor data are seldom available to CCD designers.

CCD application guidance

Currently available literature in the fourth category, CCD application guidance, attempts to amalgamate all pertinent CCD information into a document that can be readily assimilated by a variety of user audiences. Almost without exception, the resulting product provides qualitative and general considerations only, with very limited quantitative implementation or design criteria.

This rather extensive background has been offered to identify the source, contents, and current status of fixed-facility CCD design and applications information with the intent of suggesting procedures to improve available literature.

2 Considerations for Improved CCD Application Guidance

This chapter provides considerations for improving CCD application guidance. A rudimentary requisite for optimal placement of CCD is the ability to analyze target signatures and CCD measures being considered. Although there is a shortage of RSTA modeling that allows evaluation of CCD in measures of military worth, there is an adequate selection of sensor (system) models to allow the relative ranking of target detectability with and without CCD. This ranking can be accomplished with some degree of confidence for many target and CCD combinations. Such an analysis proves relatively straightforward with a computer-assisted image analysis environment, particularly if using calibrated data. The problem becomes more complex and less accurate when performed using manual methods and uncalibrated data-imagery, though meaningful estimates can certainly still be developed.

Possible Methods for Manual CCD Design Improvements

To develop quantitative estimates of CCD effectiveness manually, three procedures must be modified or improved: data collection, image analysis, and target-sensor modeling. These procedures are discussed below in light of the equipment and data limitations of field operating agencies.

Data collection

Collection of aerial data for analysis is critical to CCD design and evaluation. Current guidance for camoufleurs collecting data for analysis and design is limited. The available procedures for collection of data for CCD design purposes are far too generic. Significantly more data acquisition guidance should be added to the literature, particularly if manual methods are applied for data analysis. Several points are noted. Current literature emphasizes collecting data by flying ingress routes. This procedure may not provide the information required for design because it is unanticipated by the camoufleur. Additionally, data collection hardware limitations make ingress data collection difficult. In many cases camoufleurs will not have forward-looking visual and thermal infrared imagery unless it is collected using a tactical system. When available, tactical imagery also presents a problem because the quality of the imagery is marginal for design purposes.

Most visual CCD design information is collected from helicopters using video, 35-mm, and medium-format cameras. A preferred procedure for collection of nonforward-looking data is flying circles, or arcs, at differing ranges and altitudes around the centroid of the target area. The technique yields a large and flexible database of imagery and simplifies any subsequent data analysis. The procedure for data acquisition utilizing this method needs to be formalized.

Along the same lines, the procedures (profiles, ranges, altitudes, etc.) for collection of tactical imagery need to be defined to allow uniform methods of data analysis for radar, forward-looking, and line scan systems. With standard procedures defined, many of the well-known photographic analysis techniques can be adapted without extensive training or research requirements.

Image analysis

Modeling for manual analysis procedures requires discussion of at least three subjects: the nature of the data analyzed, the type of models selected, and the precision and accuracy of the modeling.

Fixed-facility CCD designs against an aerial threat mandate extensive use of aerial imagery. If one allows the standard assumption that color (with exceptions) is a relatively unimportant factor in the aerial target acquisition process, then gray-level (monochrome) analysis becomes a powerful tool. This is particularly true for targeting the use of electro-optical sensors.

An inherent disadvantage of manual analysis of gray-level data is the inability of the eye to distinguish gray tones. While sensor systems usually are capable of imaging/formatting data at greater than 100 gray levels, the unaided eye is limited to discerning somewhat less that 20 gray tones accurately. If one assumes that target-background relationships are probabilities, and indeed they are, then this loss of resolution is probably not significant. Of necessity, there must be objects of known values for calibration of collected imagery, a task sometimes difficult to achieve in practice unless aerial data collection times can be closely coordinated. With defined procedures, the use of gray-level image analysis form areas and gray-scale rulers can provide camoufleurs significant information. These procedures need to be defined.

Radar data as imagery does provide vital information. The value of these data can be improved by using corner reflectors of varying size while maintaining constant gain and threshold settings. Simultaneous recording of distance data to targets while maintaining constant radar settings could allow designers to backtrack into the radar equations and estimate target radar cross sections. Such a rough method would certainly prove better than examining collected imagery alone.

Modeling

With defined procedures, the worth of information provided by collected target and scene data is great. These data can become more valuable, even using manual methods, if appropriate analysis tools are available. The military effectiveness of CCD is largely undetermined; however, relative ranking of measures can be developed with simplified modeling.

Perhaps the most useful tools that could be applied for manual analysis would be families of curves and nomographs based on the performance of standardized sensor systems. Later versions applying to systems with different specifications could also be developed. The use of families of curves and a nomographic code is an accepted norm in military engineering practice; thus, most users would be familiar with this approach versus computer codes. Also curves and nomographs can be generated and updated for field use and are much easier to implement than software packages. An additional advantage to nomograms is that relatively complex modeling can be solved for varying unknowns.

For the procedures described, accuracy is dependent upon the quality and interpretation of the data, as well as modeling content. For the most part, precision will depend upon the quality and interpretation of the data analyzed.

3 Summary

This report provides an overview of the CCD documentation currently available and those considerations that could aid in the development of improved CCD placement and planning guidance. Considerations such as placement to allow data to be collected by flying circles around the target area will aid the process of analysis. The simultaneous recordings of distance, constant radar settings, and the use of corner reflectors should be included in planning for comprehensive camouflage, concealment, and deception plans.