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THERMAL CAMOUFLAGE OF FIXED INSTALLATIONS: PROJECT TIREX.(U)
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THERMAL CAMOUFLAGE OF FIXED INSTALLATIONS: PROJECT TIREX (U)

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I. Introduction

1. Camouflage of fixed installations is a special problem because:

   a. The facilities are static and their location and configuration are often well known.

   b. Individual structures may be quite large and groups of structures can cover an extensive ground area.

   c. Few fixed installations have been constructed or sited properly for the expedient addition of camouflage measures; similarly, new facilities seldom include camouflage in their design criteria.

   d. Very little attention has been focused on development of materials and concepts for camouflage of fixed installations since World War II.

Increased adversary air strength and advancements in target acquisition and terminal homing systems have placed a new premium on camouflage and deception at fixed installations. The Corps of Engineers is addressing this requirement in its fixed-installation camouflage research program.

2. The Corps research has considered a number of possible approaches for camouflaging a fixed installation. Any given approach must consider both camouflage technique and the scope of camouflage application. Technique concerns alternative camouflage methods such as tone-down, shape disruption, and decoys. Scope of application defines the degree to which camouflage is applied such as the number of structures or the proportion of the entire installation on which camouflage is used.

3. The most extensive application of camouflage would include an entire installation. This could involve a disguise of the presence of the installation (primarily to defeat surveillance systems) or to a lesser degree an overall reduction in the conspicuousness of the installation to defeat target-acquisition systems. A less extensive approach would be to apply camouflage only to the critical elements of the installation and those features in proximity to the critical elements that might be used to estimate their locations. Critical elements in this sense are those necessary for the survival of resources required to execute the operational mission of the installation or to retaliate after an attack. The latter approach lends itself specifically to the defeat of target acquisition and terminal homing devices used with manned fighter-bomber aircraft.

4. Manned fighter-bomber aircraft approaching at low altitudes and high rates of speed require a certain amount of time to locate specific targets and lock-on with a weapon system. This can be translated to distance; that is, the pilot, visually or with a target-acquisition aid, must detect and identify a specific target at a sufficient range from that target to allow lock-on and accurate firing or weapon release. It is against this threat that camouflage of fixed installations can provide the most cost effective counter and increase the survivability of an installation's critical resources. The Corps' ongoing research emphasizes the development of thermal camouflage measures against this threat to complement existing techniques used in the visual band.

5. Camouflaging structures to reduce their thermal contrast to the surrounding terrain is particularly difficult because of the significant and at times rapid variations in both target and background thermal infrared (IR) signatures. Targets can be warmer than the background during one portion of the day and cooler a few hours later. A change in the weather can reduce target-background contrast, eliminate it, or increase it within hours or a fraction of an hour. Since many target-acquisition systems utilize imaging sensors, the geometries (shape and texture) of the target and background are also important considerations. Terrain areas surrounding structures can vary considerably in their pattern and texture as perceived by thermal IR sensors. An area having variations in the percentage of grass cover and adjacent patches of trees may appear very uniform in tone with subtle boundaries at one time and heterogeneous with significant differences in tone and texture both between and within the areas of grass and trees at another time. Effective camouflage of a structure within such an area may require that the pattern and texture of the camouflage vary in phase with that of the background.

6. The growing threat posed by thermal IR imaging systems and heat seeking munitions and the almost complete dearth of information on thermal camouflage of fixed installations are the impetus for the Corps' research emphasis in this area. The interest in developing thermal camouflage

technology is shared by many of our NATO allies and formed the basis for the first major thermal camouflage field trial focused on fixed installations. This paper provides an overview of the field trial called Thermal Infrared Experiment (TIREX) and presents some preliminary results.

II. Overview of Project TIREX

A. Organization and Approach

7. In February 1979, members of NATO Working Group D of the Special Group of Experts on Concealment, Camouflage, and Deception (NATO AC/243 (CCD) WG(D)) agreed to cooperate in Project TIREX. One objective of the trial was to evaluate the potential of a variety of materials and material application concepts to reduce the vulnerability of critical elements at fixed installations to air attack by systems using thermal IR sensors.

8. Project TIREX participants included Denmark, the Netherlands, the United Kingdom, the United States, and West Germany. The U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, U.S.A., had responsibility for overall coordination of project TIREX. Participation in the program involved contributing samples of thermal camouflage material for testing, supplying measurement teams for gathering field data, and supplying scientific personnel to analyze the data collected. The U.S. Air Force Base at Zweibruecken, West Germany, was selected as the site for the field trial. Because of the size of the installation and the diversity of its structures, no effort was made to examine and treat the whole installation or even significant parts of it. Instead, two general target categories were decided upon and several targets in each category were examined. The two categories considered were hot targets and cold targets. Hot targets were defined as buildings with internal heating and minimal insulation. Cold targets were unheated structures such as aircraft shelters and taxiways.

9. A two-pronged method of problem attack using a combination of computer modeling and field experiments was selected. The field experiment portion of the study was conducted in two phases. Phase 1 (Aug-Oct 79) involved the gathering of baseline temperature and thermal imagery data at the field site. Phase 2 (Sep-Nov 80) involved a side-by-side field comparison test of various potential thermal camouflage materials. Computer modeling will be used to extend the field test results to other climatic conditions, to other camouflage materials, and to other camouflage configurations. The final products will include initial guidance for the design and application of thermal camouflage for critical elements of fixed installations.

B. Test Structures

10. A variety of camouflage measures, some currently in use and others under development, were applied in different manners to four structures at the air base. The structures involved were a large metal building, an aircraft shelter, a hardstand, and a hardened concrete building. The hardened concrete building, the aircraft shelter, and the hardstand were considered cold targets. The large metal (corrugated) building was considered a hot target because of its internal heating and lack of insulation. These structures were not camouflaged completely. Instead, a number of different materials or combinations of materials were applied to each structure so that the performance of the various measures could be observed with respect to one another. In each case, a sizeable area of the structure was left uncamouflaged to provide a reference. The following paragraphs provide a brief description of the camouflage measures used on each structure.

11. Figure 1 is a photo showing the deployment of camouflage measures on the corrugated metal building east wall. Additional camouflage

Figure 1. Photo of corrugated metal building from the east

measures were applied to the roof and to the roof of the bunker in the foreground. The netting stretched over the chimney is the West German Far Infrared (FIR) net system. Next to it on the wall is the Dutch low emissivity net over a layer of bubble foil insulation. The bubble foil served as wall insulation which was attached to the outside of the wall rather than the inside. Next on the wall is a fairly large darker colored area. This area was painted with a U.S. camouflage paint having a high near-infrared reflectance in order to reflect away a portion of the sun's energy. The right half of this area also had fiberglass insulation installed inside the wall. Next on the wall is a somewhat lighter colored area. This was the untreated reference area. The dark material on the right corner of the building is the West German OGUS mat. The OGUS mat has a foam insulator sandwiched between an olive drab aluminized layer and an impregnated olive drab cloth layer. In the right center of the picture is a sloped surface. This is the east facing bunker roof which was mentioned previously. The left darker colored side is the untreated asphalt reference surface. On the right side is an area painted with U.K. near infrared reflecting (NIRR) paint.

12. The hardstand is a concrete pad typical of the hardstands used for aircraft parking and for equipment storage at Zweibruecken. Camouflage materials were applied to the entrance of the hardstand as shown in Figure 2. In the foreground, the darker area covering the entire bottom

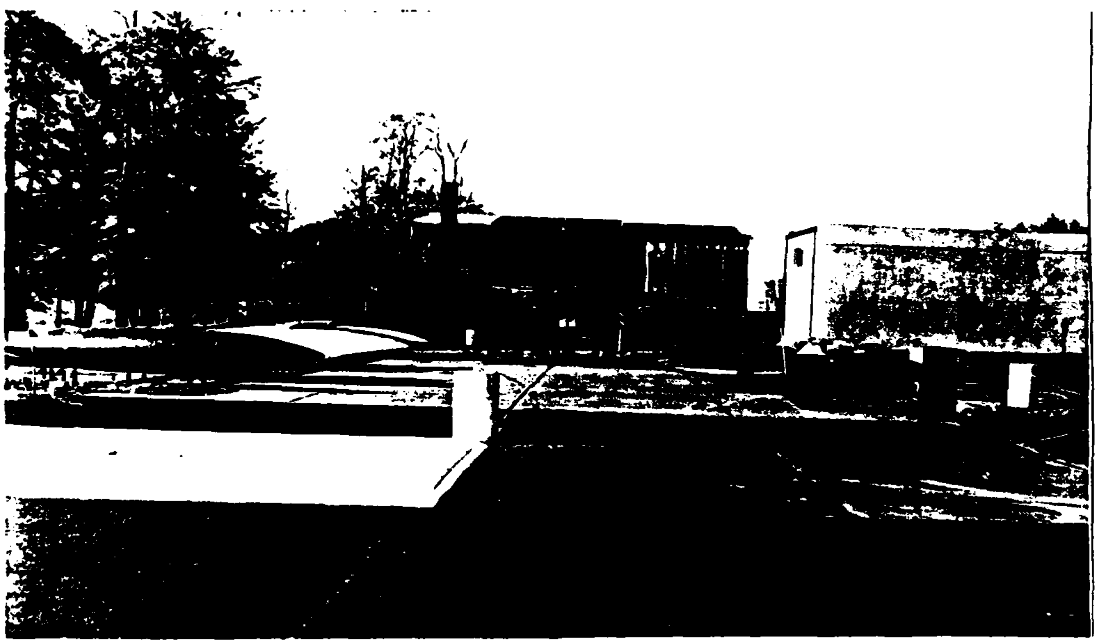

Figure 2. Photo (from west) of hardstand with camouflage measures tested

of the picture is the Danish texture mat, a synthetic carpetlike material. The light-colored area in the left center of the picture is covered with yellow paint. The yellow paint is used for taxiway marking, centerline stripes, and so on. It is highly reflecting in the solar band thus preventing heating of a surface on which it is placed. Next to the yellow paint is an area with U.S. green camouflage paint and to the right of it is an area with tan U.S. camouflage paint. Beyond the white square the dark area at the left center of the picture is another of 3M Company black paint. This was painted on the hardstand to serve as a hot reference surface with known surface properties (emissivity and absorptivity) for the aerial thermal imagery. The dark area to the right of the 3M paint is covered with Dutch low emissivity paint. The area beyond the barrel in the left center of the picture is the untreated concrete which served as the reference surface.

13. Camouflage materials were applied over the entire roof arch of the aircraft shelter so that the north wall, the roof, and the south wall were covered by strips of material. Figure 3 is a photo of the site as seen from the south side. Starting from the left, the first camouflage measure which is seen is the Dutch low emissivity paint. It shows in the photo as a lighter colored area. Instead of simply applying a strip of the paint, an effort was made to also apply a pattern with the paint. This shows as the bulge at the base of the shelter. Moving toward the

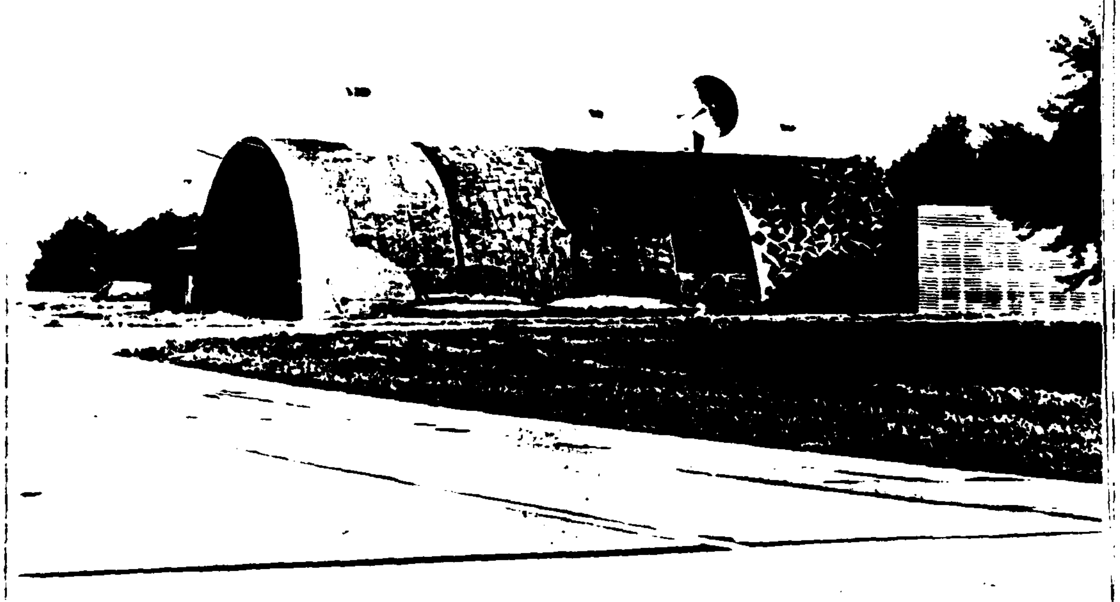

Figure 3. Photo of camouflage materials on aircraft shelter

right, the next area seen is the untreated reference area. The next camouflage measure was a combination of an old U.S. jute camouflage net with water trickling over it. The darker area to the right of the jute net is an area of untreated concrete shelter with water trickling over it. The next material with the white rope crosses on it is the Danish texture mat. The remainder of the shelter to the right was covered by a U.K. camouflage net that was sparsely garnished. This material added some elements of texture to the surface. The left half of this netted area was a combination measure. Before the netting was put in place, a U.K. low emissivity foil was applied on the surface.

14. The hardened concrete structure was chosen as representative of an aboveground hardened facility. Camouflage materials were applied to the roof and to the west wall. Some of the roof materials overlapped the east wall somewhat. Figure 4 is a photo of the site which shows the west wall. On the left side of the wall is the sparsely garnished U.K. camouflage net. This measure was staked out about 5 m from the wall and formed a sloping structure. The right half of this structure was cooled by water sprinkling. The next camouflage measure was an effort at cooling the wall by semiforced convection. This shows as the area of 3 m x 3 m squares. A frame was attached to the wall and slats were inserted into the frame in a way similar to a venetian blind except that the angle of the slats was fixed. Some of the slats were inclined downward and some were inclined upward. Two types of slats were used. The three darker squares had green painted wooden slats and the six lighter squares had asbestos slats.

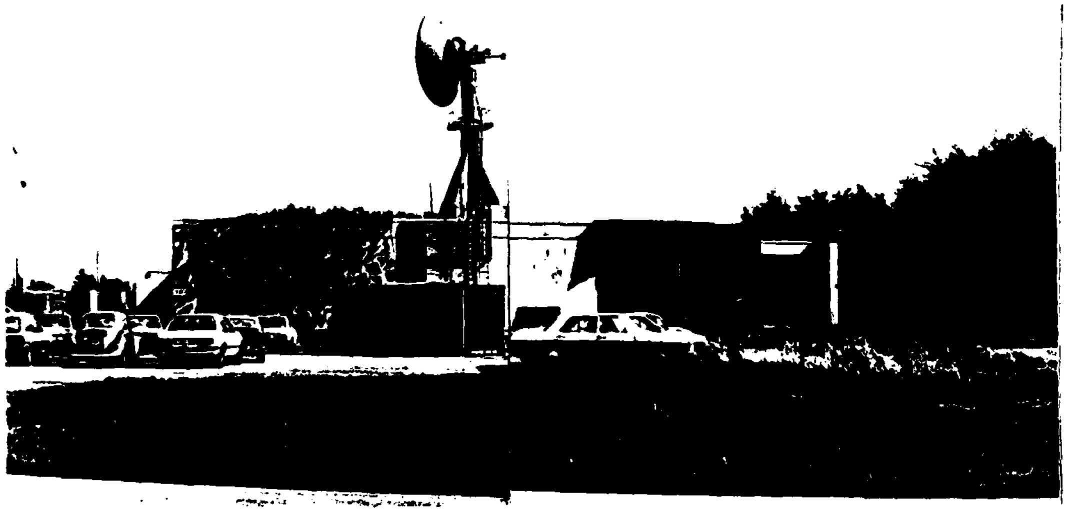

Figure 4. Application of camouflage materials on hardened concrete building

15. The light-colored area to the right of the slats was the untreated wall reference area. Next to it is a combination measure. The top half of the wall was painted with Dutch low emissivity paint. Then half of this area was covered by a Dutch camouflage net which was suspended vertically at a distance of about 1 m from the wall. The lower half of the wall was covered by Danish texture mat which was attached directly to the wall. Next to this measure is another combination measure. Beneath the Dutch camouflage netting seen in the photo is a U.S. furnished mat made up of space blankets, a commercially available thermal blanket. The space blankets were hung with the shiny side facing out in order to form a low emissivity surface. The last measure on the west wall was also a combination measure. A U.S. thermal blanket was draped down next to the wall and then a U.S. camouflage net was stretched out over it away from the wall. This measure appears in the photo immediately to the right of the white wall column next to the trees.

C. Ground Measurements

16. The ground measurements were made to characterize site conditions, thermal characteristics of the camouflaged and uncamouflaged structures, and background features over diurnal cycles and in different weather conditions. Four types of ground data were obtained: weather, feature temperature, feature reflectance, and imagery.

17. The weather data consisted of measurements of solar insolation, wind speed, wind direction, relative humidity, and air temperature. Measurements were recorded every 30 minutes with each value representing an average value for the previous 30 minutes. Measurements were recorded on magnetic tape cassettes for subsequent analysis.

18. Contact surface temperature measurements were made for most camouflage measures, uncamouflaged reference areas, and adjacent background areas using thermistors attached to the material surfaces. The thermistors were attached to data logger and recorder systems similar to the one used for the weather data. Temperature values were recorded every 30 minutes for the duration of the experiment.

19. Radiometric temperature values were obtained manually by use of an AGA Thermopoint TPT 80 Radiation Thermometer, a Wahl Heatspy Radiation Thermometer, and a Barnes Engineering Instatherm hand-held measurement device. A digitron Model 1751 Contact Thermometer was used to supplement these devices. Radiation temperatures were obtained over selected diurnal cycles spaced over the extent of the field data collection. Periodic measurements were made of the surface radiometric temperatures of the individual camouflage materials, uncamouflaged reference areas, and background features adjacent to the structures camouflaged.

20. Optical reflectance measurements for the individual camouflage materials (in situ), reference areas, and background features were made periodically by the various scientific teams. Additional material properties were determined through laboratory analyses by IABG Corporation, West Germany. The optical reflectance measurements were made with an integrating quantum radiometer/photometer providing hemispherical reflectance for solar (.4 to 1.2 μm), near infrared (0.67 to 0.85 μm), and visual (standard response of the human eye) bands.

21. Thermal IR imagery was obtained from preestablished ground stations by two West Germany teams (FfO and IABG) and teams from the Netherlands, Denmark, and the United States. The thermal IR imagery was acquired with modified AGA Thermovision Systems (Denmark and West Germany), Inframetric (United States), and a privately designed system used by the Netherlands team.

22. The image information was recorded on magnetic tape for most of the systems with the exception of the IABG system, which used an analog to digital converter to generate digital records of the imagery. All measurements were made in the 8- to 14-μm spectral band with the exception of those made by the Netherlands, which were made in both the 3- to 5-μm and 8- to 14-μm spectral bands. The various scientific teams acquired imagery over selected diurnal cycles to provide relatively uniform coverage over the full period of the field data acquisition. Since all teams acquired images from the same positions and at approximately the same times during the diurnal cycle, the imagery collected form a compatible data set that can be used to examine the performance of the respective camouflage measures over diurnal cycles and for a variety of weather conditions that span the 15 Sep to 10 Nov time period.

D. Aerial Data

23. Aerial overflights were made to acquire both visual and thermal IR imagery. The visual imagery consisted of conventional panchromatic aerial photography. Two types of thermal IR imagery were obtained: vertical line scan imagery and forward-looking infrared (FLIR) imagery. Vertical line scan imagery was acquired by U.S. Air Force tactical reconnaissance aircraft. FLIR imagery was acquired by the West German FfO team using a Honeywell mini-FLIR system. The team acquired simulated FLIR imagery with the Inframetrics imaging system mounted in a helicopter. A limited amount of FLIR imagery was acquired in 1979 prior to the application of camouflage materials by a U.K. aircraft. The FLIR imagery was obtained at different times of day and along preselected flight paths.

III. Data Analysis

A. Analysis Approach

24. The major objectives of the data analysis were to (1) evaluate the performance of the various camouflage materials for contrast reduction, both visual and thermal IR; and (2) evaluate the potential of the various camouflage measures (materials applied in specific ways) to reduce the detectability of specific types of structures for a variety of time and weather conditions. The analysis of contrast reduction potential is being accomplished primarily with the ground radiometric temperature, reflectance, and contact temperature data. The analysis of detectability reduction potential is being accomplished primarily with imagery data supplemented by modeling and simulation techniques.

25. Analyses of the data collected during the 1979 and 1980 field trials has been ongoing by scientific teams from each nation. The analysis of contrast and reduction potential is largely completed, while the analysis of detectability reduction potential is ongoing. Because of the sheer volume of data collected by the various scientific teams, it is practical only to present a few example or representative analyses in this paper. The analyses presented are those accomplished by WES personnel on the U.S. ground based radiometric temperatures, reflectance, and contact temperature data for the aircraft shelter.

B. Analyses of Radiation Temperature Data

26. For each data point (set of instrument readings), an average temperature of the material being examined was computed by adding the temperature readings from the various instruments together and dividing by the number of instruments used. Next, the absolute value of the temperature difference between the camouflage or reference material and its appropriate background material (grass or trees) was calculated. Two measures of camouflage effectiveness were calculated based on these absolute value calculations. The first of these measures was a daily sum of the absolute values for each camouflage measure and each reference surface. This provides a measure of the total daily temperature differences between the camouflage or reference material and its background. The second of these measures was the daily sum for each camouflage material divided by the daily sum for its appropriate reference material. This quotient was subtracted from one. This measure compares the camouflage and reference materials. If the result of this calculation is one, then the camouflage is perfect. However, if the result of this calculation is less than zero, then the camouflage material is less effective than the untreated reference surface. Table 1 presents the results from the aircraft shelter for three data collection days. The last columns in the table provide overall measures for all three days. Based on these data the wet concrete and wet

Table 1

Radiation Temperature Measures of Effectiveness (MOE) for Camouflage Materials for Aircraft Shelter

Camouflage or Reference Material	1 Oct 80		25 Oct 80		31 Oct 80		Summary	
	MOE#1	MOE#2	MOE#1	MOE#2	MOE#1	MOE#2	MOE#1	MOE#2
North Wall								
Net (U.K.)	4.1	0.2	0.8	-0.3	3.7	-0.2	8.6	0
Screen and Net (U.K.)	5.9	-0.2	2.5	-3.2	14.6	-3.9	23.0	-1.7
Mat (Denmark)	3.5	0.3	1.2	-1.0	4.6	-0.5	9.3	-0.1
Wet Concrete	3.6	0.3	0.6	0	1.4	0.5	5.6	0.3
Wet Jute (U.S.)	3.1	0.4	1.2	-1.0	1.8	0.4	6.1	0.3
Reference Wall	5.0	0	0.6	0	3.0	0	8.6	0
LE* Paint (Netherlands)	6.4	-0.3	1.6	-1.7	1.9	0.4	9.9	-0.2
Reference West Hardstand	10.4	0	1.5	0	5.6	0	17.5	0
West Hardstand LE Paint	16.6	-0.6	3.3	-1.2	25.9	-3.6	45.8	-1.6
South Wall								
LE Paint (Netherlands)	11.1	0.6	2.8	-3.7	8.0	0.8	21.9	0.7
Reference Wall	31.3	0	0.6	0	36.9	0	68.8	0
Wet Jute (U.S.)	14.7	0.5	1.3	-1.2	19.5	0.5	35.5	0.5
Wet Concrete	15.8	0.5	0.7	-0.2	23.1	0.4	39.6	0.4
Mat (Denmark)	41.9	-0.3	2.1	-2.5	41.6	-0.1	85.6	-0.2
Screen and Net (U.K.)	16.7	0.5	4.7	-6.8	20.7	0.4	42.1	0.4
Net (U.K.)	7.6	0.8	1.3	-1.2	8.8	0.8	17.7	0.7

Note: $MOE\#1 = \Sigma|C-B|$ and $MOE\#2 = 1 - (\Sigma|C-B|)/(\Sigma|R-B|)$

where C = temperature of camouflage material
B = temperature of background (grass or trees)
R = temperature of untreated reference surfaces

*LE = low emissivity

jute (old U.S. camouflage net) were the most effective camouflage measures deployed on the north wall. On the south wall, the British camouflage net was the most effective camouflage measure, followed closely by the Dutch low emissivity paint. The result for the British net may be misleading because it was shaded from direct sunlight during portions of the day.

C. Analyses of Reflectance Data

27. A fairly simple performance analysis technique was also used for the reflectance data. First, an appropriate natural background material (grass) was selected. Second, reasonable bounds were determined for the solar, near IR, and visual reflectances of grass. These bounds were determined by selecting the minimum and the maximum grass reflectances measured. The bounds established were as follows: solar reflectance, 19 to 34 percent; near IR reflectance, 27 to 37 percent; visual reflectance, 5 to 9 percent. The third step in the analysis process was to examine the reflectances of the materials to assign them into two categories, those materials judged to have camouflage potential and those judged to be camouflage deficient.

28. Materials with camouflage potential had to meet three requirements. Their average reflectance had to be within the established reflectance bounds of the background, their average reflectance had to be higher than that of the reference for the solar and/or near IR bands and lower for the visual band. These requirements lead to materials which have camouflage potential in both the thermal and the visual portions of the spectrum. Materials with high solar and near IR reflectances will usually absorb less of the sun's energy. Thus, they will stay cooler and be good for thermal camouflage. Materials with low visual reflectance will reflect less of the incident sunlight back to the observer and hence will be good for visual camouflage. Table 2 is the summary table for the aircraft shelter reflectance data. From the table one can see that only the Dutch low-emissivity paint was judged to have overall camouflage potential. Generally, the other materials were judged deficient because their solar and near IR reflectances were too low.

D. Analyses of Contact Temperature Data

29. The analysis method used for the contact temperatures was nearly the same as that used for the radiometric temperatures. However, there were several differences. The temperature of the background material was not grass temperature, but rather air temperature measured at each site. Air temperature is a reasonable approximation of natural background temperatures (e.g. trees and grass). For the contact temperature devices, 48 data points per day were collected and contact temperatures were collected on 55 days. For each data point (temperature sample), an average temperature of the material being examined was computed by adding the

Table 2

Spectral Reflectance Performance of Thermal Camouflage Materials

Material	Solar Performance	Near IR Performance	Visual Performance	Overall Performance
Dutch Low Emissivity Paint	+	-	+	+
Reference	-	-	-	-
Jute Camouflage Net	-	-	-	-
British Camouflage Net	-	-	+	-
British Low Emissivity Screen and Net	-	-	+	-

Note: + denotes camouflage potential
- denotes camouflage deficiency

temperature readings from 30 consecutive one-minute samples together and dividing by 30. Next, the absolute value of the temperature difference between the camouflage or reference material and its appropriate background material (air temperature) was calculated. Two measures of camouflage effectiveness were calculated based on these absolute value calculations. The first of these measures was a daily sum of the absolute values for each camouflage measure and each reference surface. This provides a measure of the total daily temperature differences between the camouflage or reference material and its background. The second of these measures was closely related to the first measure. The daily sum for each camouflage material was divided by the daily sum for its appropriate reference material and then this quotient was subtracted from one. This measure compares the camouflage and reference materials. If the result of this calculation is one, then the camouflage is perfect. However, if the result of this calculation is less than zero, then the camouflage material is less effective than the untreated reference surface.

30. Table 3 shows the contact temperature results. Only 4 of the 55 days are shown in the table. These days were carefully chosen from the entire data set to span the weather conditions experienced during the 1980 field trial. Data were selected from the sunniest, the cloudiest, the coldest, and the wettest days. From the table one can see that the best camouflage measure for both MOE#1 and MOE#2 was the wet jute camouflage net. However, the wet concrete and the British LE Screen also provided an improvement in thermal camouflage over the untreated reference surface.

Table 3

Contact Temperature Measures of Effectiveness (MOE) for

Camouflage Materials for the Aircraft Shelter

Camouflage or Reference Material	Sunniest 18 Sept 80		Wettest 11 Oct 80		Coldest 3 Nov 80		Cloudiest 5 Nov 80		Summary	
	MOE#1	MOE#2	MOE#1	MOE#2	MOE#1	MOE#2	MOE#1	MOE#2	MOE#1	MOE#2
South Wall										
LE Paint (Netherlands)	294	-0.2	48	-0.8	203	-0.3	46	-0.5	591	-0.3
Reference Wall	246	0	27	0	162	0	31	0	466	0
Wet Jute (U.S.) Camouflage Net	88	0.6	21	0.2	114	0.3	41	-0.4	264	0.4
Wet Concrete	116	0.5	37	-0.4	143	.1	36	-0.2	332	.3
Mat (Denmark)	385	-0.6	62	-1.3	283	-0.7	81	-1.7	811	-0.7
LE Screen (U.K.)	263	-0.1	39	-0.5	100	0.4	41	-0.4	443	0.1

Note: $MOE\#1 = \Sigma|C-B|$ and $MOE\#2 = 1 - (\Sigma|C-B|)/(\Sigma|R-B|)$

where C = temperature of camouflage material
B = temperature of background (grass or trees)
R = temperature of untreated reference surfaces

IV. Concluding Remarks

31. This paper has presented an overview of Project TIREX as well as a sampling of some of the results for one of the structures on which camouflage materials were tested. The examples presented were limited to analyses of contrast reduction potential in both the visual and thermal IR bands. The results are indicative of the results of the complete data set. Few materials exist that offer an ability to completely reduce the contrast of a structure to its natural surround. While many materials offer significant thermal or visual contrast reductions, none were ideal for simultaneously providing the desired reduction in both bands. This indicates a continuing need to develop better materials and applications concepts.

32. While the results of ground-based data analyses may appear discouraging, when coupled with the initial imagery analyses the picture is not so bleak. Structures that are not extremely hot targets, such as aircraft shelters and hardened concrete structures, are detectable primarily by their individual shapes. The clever use of many of the existing materials to accomplish shape disruption can be very effective in reducing the detectability of those structures. The ground-based data provide a valuable quantitative data base to aid in the design of material application concepts. These concepts will allow use of these materials for modifying the appearance of structures to reduce their vulnerability to attack by thermal IR devices. Combinations of materials may provide significant reduction in the vulnerability of structures to both visual and thermal IR target acquisition aids. Insulating materials can have a significant impact on the detectability of hot targets such as the heated corrugated metal building investigated.

33. Project TIREX will provide the first available systematic guidance for thermal camouflage design. While a considerable amount of developmental work is still required, a very substantial foundation will be available to proceed rapidly to the full camouflage capability needed to address the modern threat.


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