WL-TM-91-315-FIGK



# DUAL COLOR AND SHAPE CODING IN THE VISUAL PERIPHERY: A Study of Joint Tactical Information Distribution System (JTIDS) Symbology

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WL/FIGK



AUGUST 1991



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# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



**1. AGENCY USE ONLY** *(Leave blank)*

**2. REPORT DATE**
Aug 91

**3. REPORT TYPE AND DATES COVERED**
Final March 1991-July 1991

**4. TITLE AND SUBTITLE**
Dual Color And Shape Coding In The Visual Periphery: A Study of Joint Tactical Information Distribution System (JTIDS) Symbology

**5. FUNDING NUMBERS**
PE: 62201F
PR: 2403
TA: 04
WU: 86

**6. AUTHOR(S)**

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**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
WL/FIGK (XPK)
WPAFB OH 45433-6553

**8. PERFORMING ORGANIZATION REPORT NUMBER**
WL-TM-91-315-FIGK

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

WL/FIGK (XPK)
WPAFB OH 45433-6553

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**

Unlimited

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

This research looked at four different dual color and shape coded Joint Tactical Information Distribution System (JTIDS) symbols on a color CRT located in the subject's periphery. Nighttime cockpit conditions were simulated. No subject could detect the 0.5° symbols in their periphery beyond 15°. Approximately 1/3 of the potential subject pool could not correctly identify symbol shape even at the lower end of the range under study: 5°. Subjects used only color to key in on the symbol's meaning; the symbol's shape did not matter at all during this recognition task, for symbol shape was harder to perceive than color in the periphery. Color and the symbol's meaning could both be perceived at approximately 12° off of the fovea, while shape had to be at 8° before subjects could perceive it. It is recommended that additional research in this area be accomplished. If findings are confirmed, it is suggested that a careful examination of the JTIDS dual coding be undertaken.

**14. SUBJECT TERMS**
Redundant coding, color coding, dual coding, shape coding, peripheral color vision, JTIDS symbology, color CRT.

**15. NUMBER OF PAGES**
22

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| UNCLASSIFIED | UNCLASSIFIED | UNCLASSIFIED | UL |

## FORWARD

This Technical Memorandum (TM) documents the results of the Joint Cockpit Office's JTIDS study, looking at dual color and shape coded symbology presented in the subject's visual periphery. The result will be used to improve upon existing color display symbology as well as for guiding color choice for future cockpit displays.

This Technical Memorandum has been reviewed and was approved.

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## 1.0 EXECUTIVE SUMMARY

This research looked at four different dual coded (color and shape) symbols used in the Joint Tactical Information Distribution System (JTIDS), presented peripherally on a color CRT representative of one found in a military cockpit. The symbols chosen were a cyan circle (own ship), a magenta triangle (enemy), a green diamond (neutral), and an yellow rectangle (unknown).

The objective of the study was to measure, in degrees off of the fovea, where in the subject's periphery the symbol's color, shape or meaning was first correctly perceived as the symbol traversed the subject's peripheral visual field towards the foveal region. Also of concern was the cognitive process used (i.e., utilization of both dual codes, or of only one) when subjects verbalized the peripherally presented symbol's meaning.

Subjects were exposed to three runs, two with randomly paired color/shape combinations using the four colors and shapes of the four JTIDS symbols under study, and one with the actual JTIDS color/shape combinations. For the randomly paired runs, subjects verbalized either symbol color or shape. For the actual JTIDS symbols, subjects named the meaning of the symbols.

Total visual range studied was from 15° to 5° off of the fovea along the X-axis. Nighttime cockpit conditions were simulated. No subject could detect the 0.5° symbols in their periphery beyond 15°. A pre-screen revealed that approximately 1/3 of the potential subject pool could not be used in this experiment for they could not correctly identify symbol shape at all in this range. The symbol needed to be closer than 5° before they could perceive its shape; all could perceive its color within the 15° to 5° range of this study.

Subjects used only the color cue to key in on the symbol's meaning; the symbol's shape did not matter at all during this recognition task, for symbol shape was harder to perceive than color in the periphery. Color and the symbol's meaning could both be perceived at approximately 12° off of the fovea, while shape had to be at 8° before subjects could perceive it. Questionnaire results coincide with this data, showing unanimously that subjects relied solely on one of the dual codes, symbol color, to determine the symbol's meaning.

JTIDS uses both shapes and colors to present the information to the pilot, but the colors and shapes are not unique for each symbol; hence, JTIDS does not employ an unique redundantly coded symbology set. A circle can be either green or blue. Green is used with both the circle as well as the diamond. For the case of non-unique shape coding, nothing need be done for pilots will rely solely on color for recognition. But, in the case of non-unique color usage, another color should be substituted, if additional research confirms these findings.

Under simulated nighttime conditions, the current quarter inch JTIDS symbols on a 5"x5" CRT, at a normal cockpit viewing distance of 28", could not be perceived at all beyond 15° in the horizontal periphery. If the JTIDS display of this size is in the pilot's foveal vision range, all symbols should fall within the pilot's visual field of view. But for peripheral viewing as well as for foveal viewing of larger displays, the situation may become problematic. For example, a 10"x10" display centrally located at a 28" viewing distance, covering 20° of the horizontal visual field, will have the display edges fall within the pilot's near periphery. With the pilot looking at one side of the display, the other far side's symbols may not even be noticeable by him/her because it will fall farther than 15° from the fovea. For these larger displays, it is recommended that the symbology size be increased or symbols altered (i.e., symbols filled in, drawn with triple line width)[1] and additional studies be performed.

With only a relatively small usable 30° field of view to detect the 0.25" colored JTIDS symbols at a normal cockpit viewing distance of 28", concern must be levied upon any condition that may cause the pilot's visual field to shrink. For instance, if the pilot is experiencing either high (stress) or low (relaxation) arousal levels, visual field narrowing phenomenon may occur (Ancman, 1991). With the onset of this phenomenon the pilot experiences "tunnel vision", i.e., the total visual field shrinks. Therefore, cues that could normally be perceived within the periphery, may not be noticeable under these circumstances. It is recommended that additional experimentation be accomplished in this area regarding the perception of the JTIDS symbology.

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[1] A study, soon to be published as a tech memo, will address these two potential fixes.

## 2.0 INTRODUCTION

Military cockpit displays utilize dual coding[2] to aid in the perceptual process. Joint Tactical Information Distribution System (JTIDS) symbology, is a good example of cockpit symbology using both color and shape to denote symbol meaning. JTIDS symbology, though dual color/shape coded, does not utilize uniquely redundant coding combinations. For instance, the color green is used with two shapes, a circle or a diamond. Also, a circle can be found with one of two colors, green or blue.

Examples of JTIDS symbology are shown in Table 2.0-1. This uniquely redundant coded subset of the dual coded JTIDS symbology set was used for this study.

| | |
|---|---|
| Own ship (cyan) |  |
| Enemy (magenta) |  |
| Unknown (yellow) |  |
| Neutral (green) |  |

Table 2.0-1: JTIDS symbology

Can non-unique redundant coding cause any perceptual problems if the symbols are viewed peripherally? Is color relied upon more than shape, equally with shape, or less than shape to denote the symbol's meaning when viewed peripherally?

### 2.1 Current Study

This study's objectives were (1) to measure perceptual recognition based on the angle off of the fovea in the subject's periphery where the symbol's color, shape or meaning was first correctly perceived; (2) to determine the cognitive process used (i.e., utilization of both dual codes, or of only one) when subjects verbalized the peripherally presented symbol's meaning.

## 3.0 METHOD

### 3.1 Subjects

The subjects for this study were twelve Air Force civilian/ military volunteers with non-corrected 20/20 visual acuity and full color vision. An all male, 23 to 34 year old subject pool was

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[2] The term "dual coding" was used throughout this report instead of "redundant coding" due to the nature of the symbology set under study, JTIDS. It does not employ a truly unique redundant coding system.

used. During a pre-screen, it was determined if subject's visual field fit the criteria of this study: be wide enough to be able to detect both color and shape of a 0.5° symbol within the range of 15° to 5° off of fovea along the X-axis. If they could not, they were not used as a subject. Approximately 1/3 of the potential subjects did not meet this criteria. Their visual field was narrower than 5° with reference to symbol shape. All could perceive symbol color within the range of interest.

### 3.2 Design

This study employed a within subjects design with one independent variable: perceptual recognition. A counterbalanced design was used to alternately test subjects for the "color" and "shape" runs first, followed by the "meaning" run. The Experimental Matrix used in this study can be found in Appendix A. A color naming/reaction time task was utilized.

### 3.3 Experimental Runs

Three different perceptual recognition runs were studied: 1)"color" run: naming the color of randomly paired color/shape combinations, 2)"shape" run: naming the shape of the randomly paired color/shape combinations, 3)"meaning" run: naming the meaning of four unique JTIDS color/shape combinations.

**3.3.1 Subjects Named Symbol's Color.** This run recorded perceptual recognition in the periphery for the symbol's color only, regardless of the symbol's shape. Randomly paired colors with shapes were presented to the subjects.

As soon as the subjects could perceive the color of the symbol slowly moving from their peripheral to foveal vision, they responded by calling out the color. Subjects were told to disregard the symbol's shape; they were to rely solely on one type of coding: color.

**3.3.2 Subjects Named Symbol's Shape.** This run was the same as the previously described run, except subjects verbalized the moving symbol's shape as soon as it could be perceived during its trek across the subject's visual field. Again, randomly paired color/shape combinations were used. Subjects were to rely solely on one type of coding: shape.

**3.3.3 Subjects Named Symbol's Meaning.** For this run, the four uniquely redundant coded JTIDS symbols (see Table 2.0-1) were used to promote the utilization of the dual color/shape coding. Subjects were told:

- all circles would be cyan and to respond with the correct "meaning" for this symbol as soon as they could perceive it: "own" (for own ship)
- all triangles would be magenta and to respond with the correct "meaning" for this symbol as soon as they could perceive it: "enemy"
- all diamonds would be green and to respond with the correct "meaning" for this symbol as soon as they could perceive

it: "friendly"[3]

- all squares would be yellow and to respond with the correct "meaning" for this symbol as soon as they could perceive it: "unknown"

In a post-test questionnaire (see Appendix B), subjects were asked if they relied upon just color coding, just shape coding, or a combination of both during this perceptual recognition task of determining the symbol's meaning.

**3.4 Apparatus**

Figure 3.4-1 shows the experimental set-up for this study. Apparatus on the far end of the table: color monitor on stand. Apparatus on the near end of the table: chin rest with clamps and computer mouse. A small white light source, blocked in the photograph by the monitor, was taped to the wall.

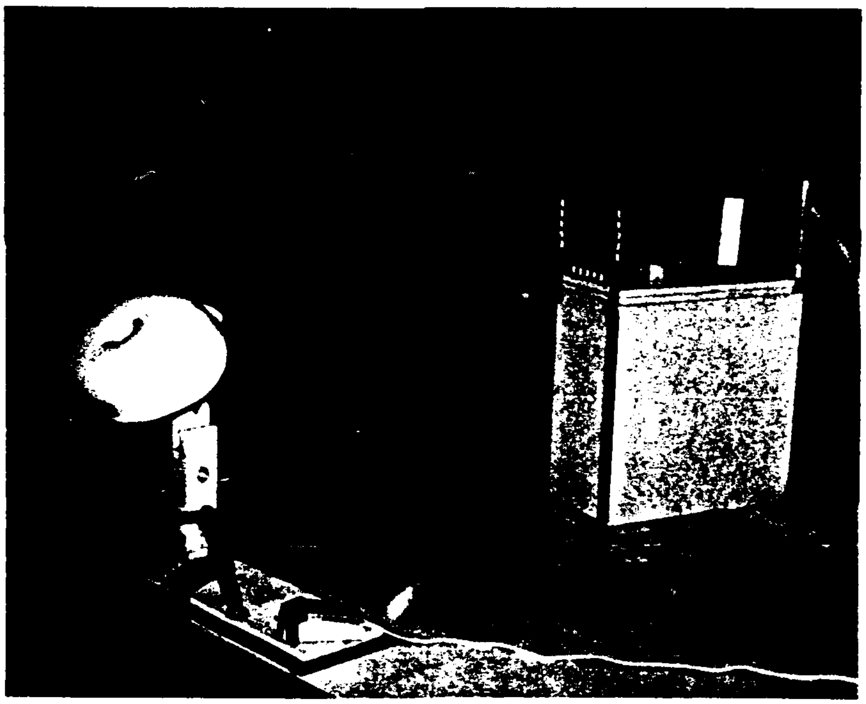

Figure 3.4-1: Experimental Set-up

[3] The liberty of using the meaning of "friendly" for the green diamond was taken. Actual JTIDS meaning would be "neutral". "Friendly" in JTIDS symbology would be a green circle.

### 3.5 Procedure

Subjects were seated in a chair with their chin on the chin rest providing both vertical as well as horizontal support. Each subject received a standardized briefing to explain the purpose and mode of operation for the experiment.

The subject focused on a spot of white light set directly in front of him. A 5"x5" monitor screen was placed 28"[4] away from the subject's right eye to cover a 15° to 5° arc[5] of the subject's vision off of the fovea along the x-axis. This comprised the total range under study for the experiment. 0.5° symbols (screen height of 0.25") continuously moved at the rate of 2.3° per second from the right to left of the screen (subject's far to near periphery) along the X-axis.

The subjects were told to verbalize their response and depress a mouse button as soon as they "recognized" the color, shape, or meaning of the symbol slowly moving towards the center of their visual field, traversing across the monitor off-set to the right. If the right color, shape, or meaning was named, the experimental operator hit the space bar on the computer keyboard. This function stopped the trek of the current symbol across the screen and replaced it with the next symbol after a 1.5 sec delay. If the subject called out the wrong color, shape or meaning, the experimental operator made note of the wrong color, shape, or meaning on the subject's matrix sheet and did not hit the space bar on the computer keyboard. By not hitting the space bar, the symbol continued to travel towards the subject's foveal vision range until the correct color, shape or meaning was named. When the correct color, shape or meaning was verbalized, the symbol disappeared from the screen and another started it's trek across the monitor after a 1.5 sec delay. Each time the subject hit the mouse button or the experimental operator hit the computer space bar, the computer recorded the exact location of the symbol in degrees off the X-axis of the subject's fovea, normal to the wall.

All lights were turned off in the room and the experimental area was dark, with the exception of the instrumentation lumination. The monitor was adjusted to simulate a nighttime environment cockpit lighting for stroke symbology using the F-15E nighttime color scheme. Raster only was used on the high resolution monitor, with an IRIS to drive the display. Therefore, a quality raster simulation of the aircraft stroke symbology was presented.

For each of the three runs, a representative practice session was initiated. For the "meaning" run, the practice session was not terminated until the subject proved to be proficient at naming the correct symbol meanings (i.e., no errors for at least 10 symbols in

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[4] Normal cockpit viewing distance.

[5] This 10° range corresponds to the total visual area covered by a 5"x5" monitor set at 28" away and off-set from dead center by 5°.

a row; subjects answered affirmatively to the question, "..do you now feel confident that you know the meanings of the symbols and can rapidly call them out as soon as you can recognize them?").

Prior to leaving, subjects were given a questionnaire tc subjectively rate their feelings of which color, shape, or meaning was easier to perceive and if they used color, shape, or the combination of both when perceiving the meaning of the symbols.

## 4.0 RESULTS

Data was analyzed using the Multivariate Analysis of Variance (MANOVA) subprogram of the Statistical Package for the Social Sciences (SPSS) (Hull and Nie, 1981). A further analysis of the results was performed using the Finite Intersection Test (FIT). FIT, a simultaneous comparison test for both univariate and multivariate data, was used to determine what level of the independent variable most affected the dependent variable (Cox, Krishnaiah, Lee, Reising, and Schuurman, 1980).

### 4.1 Perceptual Recognition

A main effect for the independent variable, perceptual recognition, was found ($F(2,22) = 59.43$; $p<0.001$). The FIT test showed differences between the "color" run and the "shape" run ($F(1,33) = 20.97$; $p<0.05$) and the "meaning" run and the "shape" run ($F(1,33) = 15.67$; $p<0.05$). (See Figure 4.1-1)

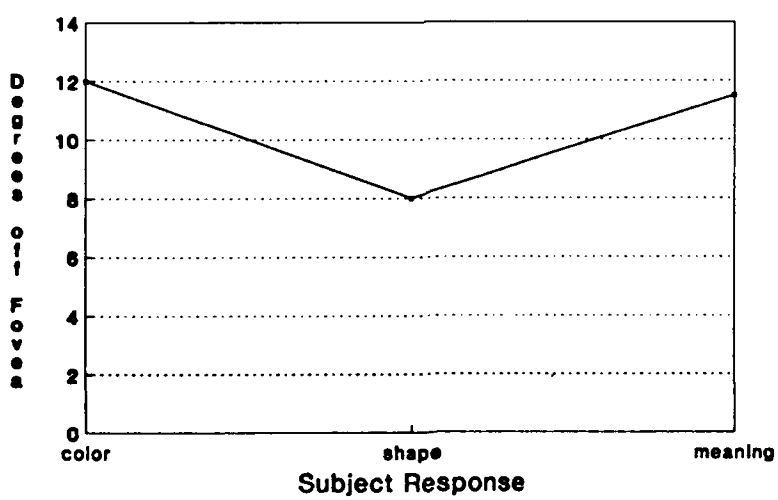


Figure 4.1-1: Perceptual Recognition Main Effect

## 4.2 Cognitive Process

Questionnaire responses unanimously showed subjects used the symbol's color cue and not the shape cue to determine the meaning of peripherally presented, dual coded symbols. The FIT test showed the lack of significance between the "color" run and "meaning" run data (see Figure 4.1-1). This supports the subjective data that color was primarily used when identifying symbol meaning.

# 5.0 DISCUSSION

## 5.1 "Color", "Shape" and "Meaning" via Peripheral Vision

Subject's perceptual recognition of symbol color and meaning did not differ; both the symbol's color and meaning were first perceived correctly at approximately 12° off of the fovea (see Figure 4.1-1). Perceptual recognition of symbol shape was not as extensive; on the average, a subject could not perceive the symbol's shape until it was fell within 8° of the fovea (see Figure 4.1-1).

None of the subjects could detect the 0.5° symbols' color or meaning correctly further in the periphery than 15°. Recorded data showed approximately 14.3° to be the furthest value in the periphery obtained for any subject. Approximately 1/3 of the potential subject pool the symbol needed to be closer than 5° before they could perceive its shape. Would 1/3 of the pilots currently flying have problems perceiving shape too?

Potential problems may be confounded with the advent of larger cockpit displays. For instance, a 10"x10" display centrally located at a 28" viewing distance, covers 20° of the horizontal visual field; therefore, the pilot will have its edges fall within his/her near periphery. With the pilot looking at one side of the display, the other far side's symbols may not even be noticeable by him/her for it will fall farther than 15° from the fovea.

## 5.2 Singular Reliance on Color Coding

When confronted with dual coding (color and shape) of symbology peripherally presented, all subjects chose a cognitive process utilizing solely a single code (color) to determine symbol meaning. Both the perceptual recognition data collected and the questionnaire results confirmed this finding.

The data collected showed non-significance between the degrees off of the fovea where subjects correctly identified symbol color during the "color" run and symbol meaning during the "meaning" run. Therefore, the addition of shape coding had no significant effect on improving symbol recognition further out in the visual periphery. Also, with an average color field of 12° and an average shape field of 8° (see Figure 4.1-1), subjects could correctly perceive the symbol's color prior to perceiving its shape by approximately 4°. This would account for why subjects relied on the symbol's color to derive its meaning, for they could not even perceive its shape as far in the periphery as its color.

For JTIDS symbology, where the color green is used for two different shapes (i.e., circle and diamond) to denote two different symbol meanings (i.e., friendly and neutral), confusion could exist when viewed peripherally.

Due to the singular usage of the symbols' color coding, further discussion is warranted on the perception of individual color fields as well as percent error associated with each JTIDS color studied. Sections devoted to these topics follow.

**5.2.1 Individual Color Fields.** The average values of the individual color fields along the X-axis are shown in Table 5.2-1.

| Color | Avg. Degrees Off of Fovea |
|---|---|
| Magenta | 12.5° |
| Green | 12.1° |
| Cyan | 11.9° |
| Yellow | 11.5° |

Table 5.2-1: Average Color Fields

Magenta, the easiest color to perceive in the periphery, could be seen correctly the furthest away from the fovea. Yellow was the hardest to perceive; symbols of this color had to be closer than 11.5° before subjects could correctly identify their color.

Questionnaire responses showed that 75% of the subjects reported perceiving magenta the easiest with the remaining 25% stating the easiest color to perceive peripherally was cyan. 66% of the subjects reported that yellow was the hardest to perceive, while 25% gave this distinction to green. One person (8%) thought cyan was the hardest to perceive.

**5.2.2 Color Perception Error.** The error associated with each color during the color naming task can be found in Table 5.2-2.

| | % of Time Incorrectly Perceived As | | | | Total |
|---|---|---|---|---|---|
| Actual Color | Cyan | Yellow | Green | Magenta | Error |
| Cyan | -- | 0 | 2% | 1% | 3% |
| Yellow | 0 | -- | 8% | 1% | 9% |
| Green | 1% | 3% | -- | 1% | 5% |
| Magenta | 3% | 1% | 0 | -- | 4% |

Table 5.2-2: Color Naming Error

Yellow was the color confused most often when seen in the periphery. 9% of the time the subjects thought they were perceiving a color other than yellow; 8% of the time, subjects thought they were perceiving a green symbol. Unanimously, subjects reported that yellow was easily confused with green in the questionnaire.

For JTIDS symbology, this confusion may be off-set through dual color/shape coding when viewed foveally; but, as shown in Figure 4.1-1, the redundancy supplied through shape coding, is not of an advantage unless the symbol is 8° or closer to the fovea.

### 5.3 JTIDS Symbology

**5.3.1 Dual Coding.** JTIDS uses both shapes and colors to present the information to the pilot, but the colors and shapes are not unique per symbol. Since color is relied upon more than shape to determine peripherally located symbol's meaning, the pilot may encounter more problems determining whether a green symbol is a circle or a diamond than if the circle is green or blue. For the former case, it is recommended that the symbology be changed. One must also keep in mind what the connotation of this symbology is and if it is "okay" to be uncertain of its meaning until it is closer to the pilot's foveal range. For the above mentioned case, a green circle means friendly while a green diamond means neutral. If they are confused, how detrimental may the effect be?

It is also recommended that the yellow hue chosen for nighttime flying be changed to one more easily differentiated from the green used for nighttime flying, thereby, reducing the 8% confusion factor (see Table 5.2-2). Since JTIDS uses different color for its symbology for both daytime and nighttime flying, additional studies should be performed to look at the yellow hue chosen for daytime conditions versus the green daytime hue choice.

**5.3.2 Effects of Pilot Psychological State.** With only a relatively small usable 30° field of view to detect the quarter inch colored JTIDS symbols at a normal cockpit viewing distance of 28", concern must be levied upon any condition that may cause the pilot's visual field to shrink. For instance, if the pilot is experiencing either high (stress) or low (relaxation) arousal levels, visual field narrowing phenomenon may occur (Ancman, 1991). With the onset of this phenomenon the pilot experiences "tunnel vision", i.e., the total visual field shrinks. Therefore, cues that could normally be perceived within the periphery, may not be noticeable under these circumstances. It is recommended that additional experimentation be accomplished in this area regarding the perception of the JTIDS symbology.

## 6.0 CONCLUSION

This study's scenario corresponded to a 5"x5" display centrally located in the cockpit with the pilot focusing at a point 5° off of the display along the X-axis. But real world situations may differ greatly, requiring the pilot to rely on information presented on displays located even further out in his/her visual field. One case in point would be the F-15E, where the JTIDS color CRT display lies within the pilot's periphery at 40° off of the fovea when the pilot is in a head-up mode. Also, with several smaller CRTs in a row, if the pilot is studying the far one, another may appear within his/her far periphery. With a larger 10"x10" display, even with the pilot staring directly at it, the edges will appear in the pilot's periphery.

For the case of JTIDS' non-unique shape coding, nothing need be done for pilots will rely solely on color for recognition via their peripheral vision. But, in the case of non-unique color usage, another color should be substituted, if additional research confirms these findings. Also additional studies should be accomplished to determine which hue, if any, can reduce the 9% color naming error associated with nighttime yellow. As displays get larger, it is recommended that the symbology size be increased or symbols altered (i.e., symbols filled in, drawn with triple line width)[6] and additional studies be performed.

## 7.0 REFERENCES


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[6] A study, soon to be published as a tech memo, will address these two potential fixes.

# APPENDIX A:

# Experimental Matrix

Color: 1 - Blue
2 - Yellow
3 - Red
4 - Green

Shape: A - 
B - 
C - 
D - 

## MATRIX FOR COLOR AND SHAPE RUNS: Latin Squares

4 x 4 Latin Squares

| | | | |
|---|---|---|---|
| 1 | 2 | 4 | 3 |
| 2 | 3 | 1 | 4 |
| 3 | 4 | 2 | 1 |
| 4 | 1 | 3 | 2 |

| | | | |
|---|---|---|---|
| A | B | D | C |
| B | C | A | D |
| C | D | B | A |
| D | A | C | B |

Subject 1: 1A 2B 4D 3C 2C 4A 3D 1B 4B 3A 1C 2D 3B 1D 2A 4C

Subject 2: 2A 3B 1D 4C 3C 1A 4D 2B 1B 4A 2C 3D 4B 2D 3A 1C

Subject 3: 3A 4B 2D 1C 4C 2A 1D 3B 2B 1A 3C 4D 1B 3D 4A 2C

Subject 4: 4A 1B 3D 2C 1C 3A 2D 4B 3B 2A 4C 1D 2B 4D 1A 3C

Subject 5: 1A 2B 4D 3C 2C 4A 3D 1B 4B 3A 1C 2D 3B 1D 2A 4C

Subject 6: 2A 3B 1D 4C 3C 1A 4D 2B 1B 4A 2C 3D 4B 2D 3A 1C

Subject 7: 3A 4B 2D 1C 4C 2A 1D 3B 2B 1A 3C 4D 1B 3D 4A 2C

Subject 8: 4A 1B 3D 2C 1C 3A 2D 4B 3B 2A 4C 1D 2B 4D 1A 3C

Subject 9: 1A 2B 4D 3C 2C 4A 3D 1B 4B 3A 1C 2D 3B 1D 2A 4C

Subject 10: 2A 3B 1D 4C 3C 1A 4D 2B 1B 4A 2C 3D 4B 2D 3A 1C

Subject 11: 3A 4B 2D 1C 4C 2A 1D 3B 2B 1A 3C 4D 1B 3D 4A 2C

Subject 12: 4A 1B 3D 2C 1C 3A 2D 4B 3B 2A 4C 1D 2B 4D 1A 3C

## MATRIX FOR MEANING RUN: Random Order

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject 1: | 4D | 4D | 3C | 1A | 3C | 4D | 2B | 2B | 3C | 1A | 2B | 1A | 4D | 1A |
| | 2B | 3C | | | | | | | | | | | | |
| Subject 2: | 4D | 3C | 2B | 3C | 4D | 2B | 1A | 1A | 2B | 4D | 3C | 4D | 2B | 3C |
| | 1A | 1A | | | | | | | | | | | | |
| Subject 3: | 1A | 2B | 1A | 3C | 4D | 4D | 4D | 2B | 1A | 2B | 3C | 4D | 3C | 1A |
| | 2B | 3C | | | | | | | | | | | | |
| Subject 4: | 3C | 3C | 2B | 1A | 1A | 2B | 3C | 1A | 2B | 4D | 3C | 4D | 4D | 1A |
| | 2B | 4D | | | | | | | | | | | | |
| Subject 5: | 4D | 4D | 3C | 1A | 3C | 4D | 2B | 2B | 3C | 1A | 2B | 1A | 4D | 1A |
| | 2B | 3C | | | | | | | | | | | | |
| Subject 6: | 4D | 3C | 2B | 3C | 4D | 2B | 1A | 1A | 2B | 4D | 3C | 4D | 2B | 3C |
| | 1A | 1A | | | | | | | | | | | | |
| Subject 7: | 1A | 2B | 1A | 3C | 4D | 4D | 4D | 2B | 1A | 2B | 3C | 4D | 3C | 1A |
| | 2B | 3C | | | | | | | | | | | | |
| Subject 8: | 3C | 3C | 2B | 1A | 1A | 2B | 3C | 1A | 2B | 4D | 3C | 4D | 4D | 1A |
| | 2B | 4D | | | | | | | | | | | | |
| Subject 9: | 4D | 4D | 3C | 1A | 3C | 4D | 2B | 2B | 3C | 1A | 2B | 1A | 4D | 1A |
| | 2B | 3C | | | | | | | | | | | | |
| Subject 10: | 4D | 3C | 2B | 3C | 4D | 2B | 1A | 1A | 2B | 4D | 3C | 4D | 2B | 3C |
| | 1A | 1A | | | | | | | | | | | | |
| Subject 11: | 1A | 2B | 1A | 3C | 4D | 4D | 4D | 2B | 1A | 2B | 3C | 4D | 3C | 1A |
| | 2B | 3C | | | | | | | | | | | | |
| Subject 12: | 3C | 3C | 2B | 1A | 1A | 2B | 3C | 1A | 2B | 4D | 3C | 4D | 4D | 1A |
| | 2B | 4D | | | | | | | | | | | | |

## CONDITION ORDER

| Subject # | Set 1 | Set 2 | Set 3 |
|---|---|---|---|
| 1 | C | S | M |
| 2 | S | C | M |
| 3 | C | S | M |
| 4 | S | C | M |
| 5 | C | S | M |
| 6 | S | C | M |
| 7 | C | S | M |
| 8 | S | C | M |
| 9 | C | S | M |
| 10 | S | C | M |
| 11 | C | S | M |
| 12 | S | C | M |

KEY

C = Subject calls out color of symbol
S = Subject calls out shape of symbol
M = Subject calls out JTIDS' meaning of symbol

APPENDIX B:

Post Test Questionnaire

## QUESTIONNAIRE

1. Was there any color that was easier to perceive? If so, which? ____________

2. Was there any color that was harder to perceive? If so, which? ____________

3. Was there any shape that was easier to perceive? If so, which? ____________

4. Was there any shape that was harder to perceive? If so, which? ____________

5. Was there any symbol that was easier to perceive the meaning of? If so, which? ____________

6. Was there any symbol that was harder to perceive the meaning of? If so, which? ____________

7. Was any color brighter than the rest? ____________

8. Were any colors easily confused? ____________

9. Were any shapes easily confused? ____________

10. Did you use mainly color, shape or the combination when perceiving the meaning of the symbols? ____________

11. How would you change the symbols, if at all? ____________

12. Is there anything about the experiment you would change? ____________

13. Comments: