DOT/FAA/AM-20/08
Office of Aerospace Medicine
Washington, DC 20591

Evaluation of a New Color Palette for ATC Displays

Kevin Gildea[1]
Ben Willems[2]
Seve Benincasa[3]
Dan G. Jack[4]
David L. Post[5]

[1] Civil Aerospace Medical Institute
Federal Aviation Administration
Oklahoma City, OK 73125

[2] William J. Hughes Technical Center
Federal Aviation Administration
Atlantic City, NJ 08405

[3] HSI Division of Oasis Systems
600 Maryland Avenue, SW, #820E
Washington, DC 20024

[4] Cherokee Nation 3-S
Oklahoma City, OK 73125

[5] ϕ
1333 Meadowlands Drive
Dayton, OH 45324

September 2020
Final Report

NOTICE

This publication and all Office of Aerospace Medicine technical reports are available in full-text from the Civil Aerospace Medical Institute's publications Web site: (www.faa.gov/go/oamtechreports)

<table>
<tr><td>1. Report No.
DOT/FAA/AM-20/08</td><td>2. Government Accession No.</td><td>3. Recipient's Catalog No.</td></tr>
<tr><td colspan="2">4. Title and Subtitle
Evaluation of a New Color Palette for ATC Displays</td><td>5. Report Date
September 2020
6. Performing Organization Code</td></tr>
<tr><td colspan="2">7. Author(s)
Gildea, K,[1] Willems, B,[2] Benincasa, S,[3] Jack, D,[4] Post, D[5]</td><td>8. Performing Organization Report No.</td></tr>
<tr><td colspan="2">9. Performing Organization Name and Address
[1] Civil Aerospace Medical Institute
[2] William J. Hughes Technical Center
[3] HSI Division of Oasis Systems
[4] Cherokee Nation 3-S
[5] ϕ</td><td>10. Work Unit No. (TRAIS)
11. Contract or Grant No.</td></tr>
<tr><td colspan="2">12. Sponsoring Agency name and Address
Office of Aerospace Medicine
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591</td><td>13. Type of Report and Period Covered
14. Sponsoring Agency Code</td></tr>
<tr><td colspan="3">15. Supplemental Notes</td></tr>
<tr><td colspan="3">16. Abstract
FAA HF-STD-010 (2017) provides a standard color palette for coding critical information on primary air traffic control (ATC) displays that accommodate air traffic controllers who have color vision deficiencies. We performed an initial evaluation to see whether applying the palette and other HF-STD-010 requirements to operational ATC displays would present difficulties, and we developed strategies for transitioning the colors used in operational ATC systems to comply with those requirements. Our findings have led to a refinement of the HF-STD-010 standard Red that has been incorporated into HF-STD-010A (2020). We found no noteworthy difficulties in applying the standard to existing air traffic automation systems for en route (En Route Automation Modernization; ERAM) or terminal radar air traffic control (Standard Terminal Automation Replacement System; STARS) and no objections to the new palette from ERAM and STARS controllers. We demonstrated ways to code weather severity on ERAM and STARS using the palette's weather colors that the controllers deemed acceptable. We recommend research to optimize color coding for STARS displays, a follow-on simulation study where controller participants can exercise the system using the new colors to further reduce the odds of encountering unforeseen implementation problems. We also recommend the development and refinement of display testing guidelines to ensure that new ATC displays reproduce the standard palette colors accurately.</td></tr>
<tr><td>17. Key Words
Keywords: Air traffic control, color code, color set, color vision deficiency, palette, reasonable accommodation, sRGB, standard, visual display, weather severity</td><td colspan="2">18. Distribution Statement
Document is available to the public through the Internet:
http://www.faa.gov/go/oamtechreports/</td></tr>
</table>

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	19	

Table of Contents

Table of Contents iv
Acronyms v
List of Figures vi
List of Tables vii
Acknowledgments viii
Introduction 1
Study 1: Revision to Red in the Standard Color Palette 2
  Study 1: Method 2
  Study 1: Results 3
  Study 1: Conclusions 4
Study 2: Simulation Task 5
  Study 2: Methods 6
  Study 2: Results 9
  Study 2: Conclusions 9
Discussion and Recommendations 9
References 11

Acronyms

Acronym	Description
ARTS	Automated Radar Terminal System
ASR-9	Airport Surveillance Radar (generation 9)
ATC	Air Traffic Control
ATCOV	Air Traffic Color Vision
ATO	Air Traffic Organization
CHI	Computer-Human Interaction
DESIREE	Distributed Environment for Simulation, Rapid Engineering, and Experimentation
ERAM	En Route Automation Modernization
FAA	Federal Aviation Administration
IEC	International Electrotechnical Commission
NEXRAD	Next-Generation Radar
PET	Palette Evaluation Tool
PMO	Project Management Office
RDHFL	Research, Development, and Human Factors Laboratory
RGB	Red Green Blue
sRGB	Standard Red Green Blue
STARS	Standard Terminal Automation Replacement System
TRACON	Terminal Radar Approach Control Facility
Wx	Weather

List of Figures

Figure 1. From left to right: Original HF-STD-010 standard, ARTS/STARS, Ocean21, and ERAM Reds. 3
Figure 2. PET recognition accuracy scores for Reds. 3
Figure 3. Protan (red), deutan (green), and tritan (blue) confusion lines for the ARTS/STARS vs. Ocean21 Reds (points shown in triangle's upper right corner). 4
Figure 4. HF-STD-010-compliant rendition of ERAM with all 3 standard weather colors used to show severities 1 & 2, 3 & 4, and 5 & 6. 7
Figure 5. HF-STD-010-compliant rendition of STARS with all 3 standard weather colors plus black stippling used to show severities 1 through 6. 8

List of Tables

Table 1. 5
Table 2. 5
Table 3. 9
Table 4. 10

Acknowledgments

We thank the following individuals, who contributed significantly to the project. Svetlana McCarthy (FAA) coordinated the participation of the Terminal Computer-Human Interaction (CHI) Team. The simulation was prepared and run by DESIREE team members: Daniel D'Ascenzo, Laura Hamann (FAA), Alex Perez, Bryan Nunez, Keith Maggio, Laura Taneyhill, Samuel Isidoro, Tyler Reich, Valentina Strogonova, and Vincent Bryant (SAIC), plus Research, Development, and Human Factors Laboratory (RDHFL) personnel Albert Macias (FAA), Ed Little, and Slav Savov (SAIC). Contract support was provided through the Office of Research & Sponsored Programs at Wright State University. The grant was facilitated by Kevin B. Bennett of Wright State University’s Department of Psychology.

The research reported herein was conducted under the Air Traffic Program Directive/Level of Effort Agreement between the Human Factors Division (ANG-C1), FAA Headquarters, and the Aerospace Human Factors Research Division of the FAA Civil Aerospace Medical Institute.

Introduction

A need for a standard palette that accommodates color-deficient controllers was identified by the operational and research communities. The ensuing effort (Gildea, Milburn, & Post, 2018) supported the twofold goals of providing reasonable accommodation and supporting a more robust workforce by allowing a greater number of applicants with color vision deficiencies to qualify on medical grounds.

The previous phase of this research effort resulted in the development and publication of a new color standard, *Color Use in Air Traffic Control System Displays* (FAA HF-STD-010, 2017) that replaced a prior standard, *Baseline Requirements for Color Use in Air Traffic Control Displays* (FAA HF-STD-002, 2007). The new standard provides key display design requirements including a color palette for coding critical information on primary air traffic control (ATC) displays that accommodates air traffic controllers who have color vision deficiencies. The palette includes 11 colors for encoding foreground objects (white, gray, blue, aqua, green, yellow, orange, pink, red, purple, and brown) and 4 colors for encoding weather severity in the background (black, dark green, dark yellow, and dark red).

The current effort had two main objectives: 1) identify potential issues when applying the color palette and standard to ATC displays in the operational environment, 2) outline strategies for transitioning the palette to operational ATC systems. Fielded ATC systems present images that move, have overlapping items, and are otherwise more complex than was practical for the Gildea et al. (2018) experiments. Fielded systems have also used colors that are not part of the standard palette to code non-critical information. Therefore, it seemed possible that pragmatic obstacles not anticipated by Gildea et al.'s (2018) research might arise when implementing the standard palette on fielded systems. We wanted to experiment with implementation to identify any such obstacles and develop solutions.

To start, the research team enumerated the scientific foundations of the color standard that must be preserved when implementing the palette. These factors had largely been captured in the guidance included in FAA HF-STD-010 (2017). That guidance directed our subsequent development of mockups, simulator display design, and discussions with ATC personnel.

The team considered the problem of choosing colors to encode critical information. One of the major challenges was determining what information is critical and when it is critical. Certain information elements can be critical in some situations but not others, introducing an element of temporal complexity. Fortunately, the standard palette includes an example of each color the fielded-systems use presently to encode critical information (e.g., red and green), so it was obvious in most cases which standard palette color to substitute for each fielded-system color.

The research team worked with National Air Traffic Controllers Association (NATCA) Computer-Human Interaction (CHI) teams to obtain feedback and guidance on potential implementation challenges. At an initial meeting with NATCA, the researchers presented and discussed the results of the color palette research using static mockups of operational ATC displays, focusing on the Standard Terminal Automation Replacement System (STARS) and En Route Automation Modernization (ERAM) systems because they account for the majority of primary ATC displays. Additional meetings included a presentation of the color palette using STARS and ERAM simulations.

Study 1: Revision to Red in the Standard Color Palette

A group of current ATC personnel with normal color vision (color-normal) was shown the HF-STD-010 standard color palette at the initial NATCA meeting to obtain their opinions. The ATC color-normal group was satisfied with all the colors except Red, which they found overly pink. The group believed HF-STD-010 standard Red could be confused too easily with some current palette colors; further, they felt that the HF-STD-010 standard Red did not convey the sense of urgency that the more saturated Automated Radar Terminal System (ARTS), STARS, ERAM, and Ocean21 Reds conveyed. This finding demanded further attention because prompt recognition of Red is especially critical for alerting the controller that immediate action is needed to maintain aviation safety.

Changing ARTS/STARS, ERAM, and Ocean21 to the standard color palette to provide reasonable accommodation for color-deficient controllers must not compromise the broader (i.e., color-normal) controller population’s ability to maintain flight safety. That realization raised the question of whether the Red specified in the new standard is demonstrably better than the Reds used currently for color-deficient controllers. We concluded that further analysis of the data from Gildea et al. (2018) to answer that question was warranted. If the answer was “no,” the Red specified in the new standard should be changed to resemble the Reds in current use because they have been used without incident in operational practice by color-normal and color-deficient controllers alike.

Study 1: Method

Gildea et al. (2018) collected color-recognition accuracy data for the Red specified in the new standard using software called the *Palette Evaluation Tool* (PET; Gildea et al., 2018). The PET was derived from the Air Traffic Color Vision (ATCOV; Chidester et al., 2011 & 2013) assessment that is used to screen color-deficient air traffic controller candidates and uses visual tasks comparable to those used in the ATCOV. Gildea et al. (2018) also tested all participants using the ATCOV, which provided color-recognition accuracy data for the ARTS/STARS and Ocean21 Reds (the

ATCOV does not provide such data for the ERAM Red). The Reds are illustrated in Figure 1, where it can be seen that the ARTS/STARS, Ocean21, and ERAM Reds are difficult to distinguish.

Figure 1. *From left to right: Original HF-STD-010 standard, ARTS/STARS, Ocean21, and ERAM Reds.*

There is an inequity in making comparisons among these data: The PET required recognizing the Red specified in the new standard in a set containing 11 colors whereas the ATCOV required recognizing the ARTS/STARS and Ocean21 Reds in sets containing only 4 or 5 colors. The first is a harder task, so the HF-STD-010 standard Red is disadvantaged in these comparisons.

Study 1: Results

Figure 2 summarizes the results. Post-hoc paired comparisons using Fisher's Least Significant Difference test and alpha = 0.05 confirm what the figure suggests: Color deficients' recognition accuracy for the Ocean21 Red was reliably lower than for the other Reds; none of the other differences are statistically significant. (LSD critical difference = 1.7% for the color normals; = 4.1% for the color deficients.)

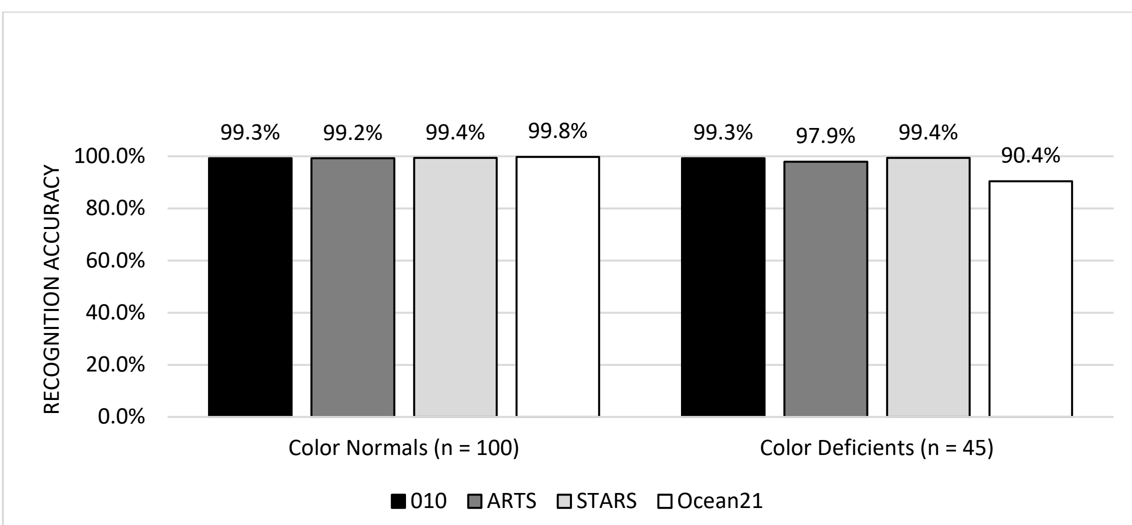

Figure 2. *PET recognition accuracy scores for Reds.*

Study 1: Conclusions

The difference between the Ocean21 Red versus the others for color deficients is puzzling because the ARTS/STARS and Ocean21 Reds have identical luminance and differ very little in chromaticity, as can be seen in Figure 3. Nonetheless, the confusion lines in Figure 3 show these two colors may look slightly different to protans and deutans. Further, the recognition accuracy scores demonstrate that the color deficients performed no better with the HF-STD-010 standard Red than they did with the others.

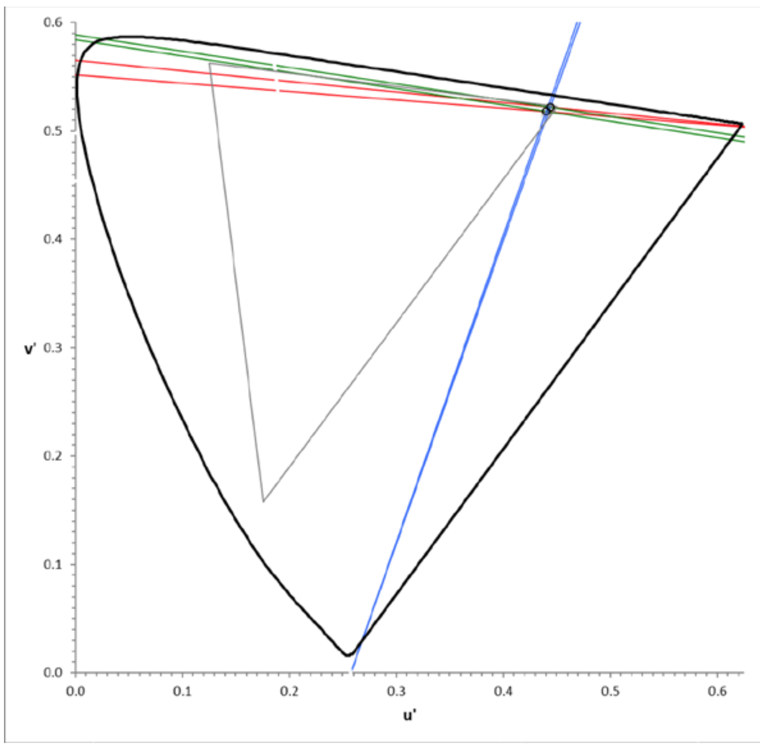

Figure 3. *Protan (red), deutan (green), and tritan (blue) confusion lines for the ARTS/STARS vs. Ocean21 Reds (points shown in triangle's upper right corner).*

The color-normals performed almost perfectly with all presented options, which included the HF-STD-010 standard Red that our controllers described as "too pink." This finding implies color-normal controllers *could* learn to recognize the Red specified in the new standard reliably. Given that recognition accuracy with the ARTS/STARS Red was very high for both color-normal and color-deficient individuals, though, there is no reason to change it. We therefore used the ARTS/STARS Red in the simulation studies reported here and it has been substituted for the original ("too pink") Red in FAA HF-STD-010A (2020). The standard color palette with the revised Red is shown in Table 1 and Table 2.

Table 1.

FAA Standard Color Palette with Revised Red: Foreground Colors

	Color name	u'	v'	%Y	sR	sG	sB	Hex Code
	White	0.1978	0.4683	100	255	255	255	FFFFFF
	Pink	0.266	0.418	41	246	132	216	F684D8
	Gray	0.1978	0.4683	45	179	179	179	B3B3B3
	Blue	0.17	0.348	28	94	141	246	5E8DF6
	Orange	0.294	0.541	42	254	147	13	FE930D
	Red	0.44	0.518	21.8	255	19	32	FF1320
	Green	0.13	0.54	55	35	225	98	23E162
	Yellow	0.193	0.55	80	223	243	52	DFF334
	Magenta	0.276	0.304	23	216	34	255	D822FF
	Aqua	0.142	0.428	50	7	205	237	07CDED
	Brown	0.241	0.519	34	197	149	91	C5955B

Table 2.

FAA Standard Color Palette: Weather Colors

	Color name	Severity	u'	v'	%Y	sR	sG	sB	Hex Code
	Black	0	---	---	0.0	0	0	0	000000
	Wx-Green	1 & 2	0.15	0.5	3.2	23	57	40	173928
	Wx-Yellow	3 & 4	0.23	0.54	7.1	90	74	20	5A4A14
	Wx-Red	5 & 6	0.26	0.4	5.0	93	46	89	5D2E59

Study 2: Simulation Task

This activity demonstrated the implementation strategy by applying the new color palette to dynamic ATC simulation software that mimicked the user interface seen on fielded ATC displays. Additionally, the research team made recommendations for the implementation of brightness control algorithms and default color palettes on ERAM and STARS.

Although the new palette has been vetted in laboratory conditions, operational ATC displays present images that move and are more complex than could be used in the palette development project. Additionally, there are other untested (i.e., non-palette) colors used for noncritical information, which could cause confusion in discriminating and identifying information. Because of these complications, we wanted to perform a more realistic assessment of the palette using an ATC simulator so we could demonstrate images that are representative of fielded ATC systems.

Study 2: Methods

The Distributed Environment for Simulation, Rapid Engineering, and Experimentation (DESIREE) is an air traffic control simulator at the FAA's Research, Development, and Human Factors Laboratory (RDHFL) at the William J. Hughes Technical Center in Atlantic City. DESIREE emulates several ground-based ATC automation systems including ERAM and STARS. DESIREE is both a rapid prototyping environment and a high-fidelity ATC simulator. In conjunction with external prototype and operational automation systems, it is capable of creating realistic ATC environments that researchers and program offices use to evaluate new concepts and changes to automated systems before implementation on operational hardware and software.

For this demonstration, the DESIREE team verified the colors it used for the ERAM and the STARS environments exactly matched those used in the operational systems. The algorithms used to adjust the brightness of objects in these systems emulated the operational algorithms. To meet the HF-STD-010 requirements, the DESIREE team developed an alternative algorithm that adjusted object brightness as proportional to the object luminance rather than applying a ratio to the RGB (Red, Green, Blue) values. Where applying a ratio to the RGB values results in a chromaticity shift, this alternative method ensured the chromaticity of an object remains the same while the luminance changes. To achieve this, RDHFL personnel created display characteristics files by driving the displays with known values along the primary R, G, and B axes and measuring the u', v', and Y values output by the display. The display characteristics files were used in conjunction with Post and Goode's (2020) Palette Designer program to determine the transformation from u', v', and %Y coordinates to R, G, and B values. With that transformation, the DESIREE team created lookup tables containing R, G, and B values for every valid luminance level intended to represent every color by its chromaticity (u', v'). Only luminance values that resulted in R, G, and B values between 0 and 255 were valid. The use of display characteristics files ensures when we specify a color in u', v', and %Y for two individual displays, the resulting color output is identical even though the calculated R, G, and B values might be slightly different.

The authors used a simple mapping technique to apply the standard palette colors to ERAM and STARS. Legacy colors that shared similar color names as those in the new palette were simply replaced with the new palette's equivalent. For example: in ERAM, Full Data Block "Yellow" was replaced with the new palette "Yellow." An exception to this technique was required for the current ERAM and STARS depictions of Next-Generation Radar's (NEXRAD) weather because they differ from the Wx-Green, Wx-Yellow, and Wx-Red color-coding system the new palette provides. ERAM, for example, depicts NEXRAD using blue, cyan with a black checkerboard texture, and solid cyan to depict severities 1 and 2, 3 and 4, and 5 and 6, respectively (see Table 2). (ERAM has the ability to display ATC (Radar) weather also, using green hash marks and "H's" for severity.) We mapped Wx-Green, Wx-Yellow, and Wx-Red onto those three severity groups, respectively, as shown in Figure 4. STARS uses green and yellow plus three densities of white stippling (including none) to depict each of the six severities uniquely. We replaced STARS' legacy green and yellow with the new Wx-Green and Wx-Yellow to represent severities 1 and 3, and used Wx-Red to represent severity 5. Black stippling was added to each color to represent severities 2, 4, and 6, respectively, as shown in Figure 5. We used black stippling because it provides higher luminance contrast for foreground objects than the white stippling STARS uses presently, thereby increasing the readability of data blocks displayed over weather.

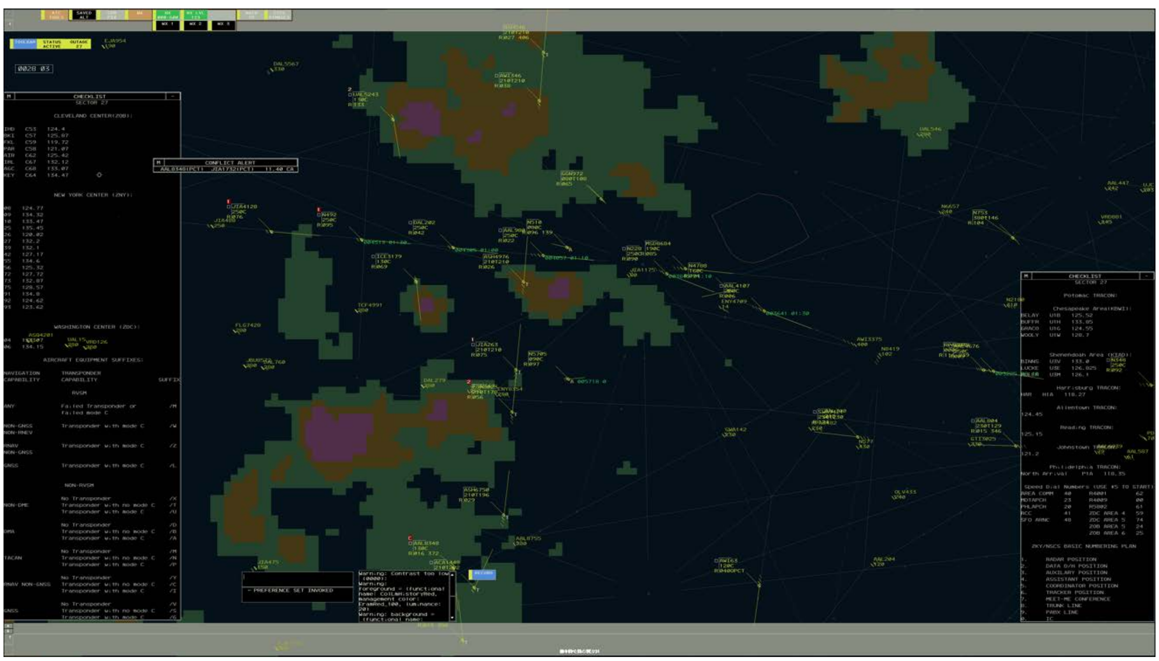

***Figure 4**. HF-STD-010-compliant rendition of ERAM with all 3 standard weather colors used to show severities 1 & 2, 3 & 4, and 5 & 6.*

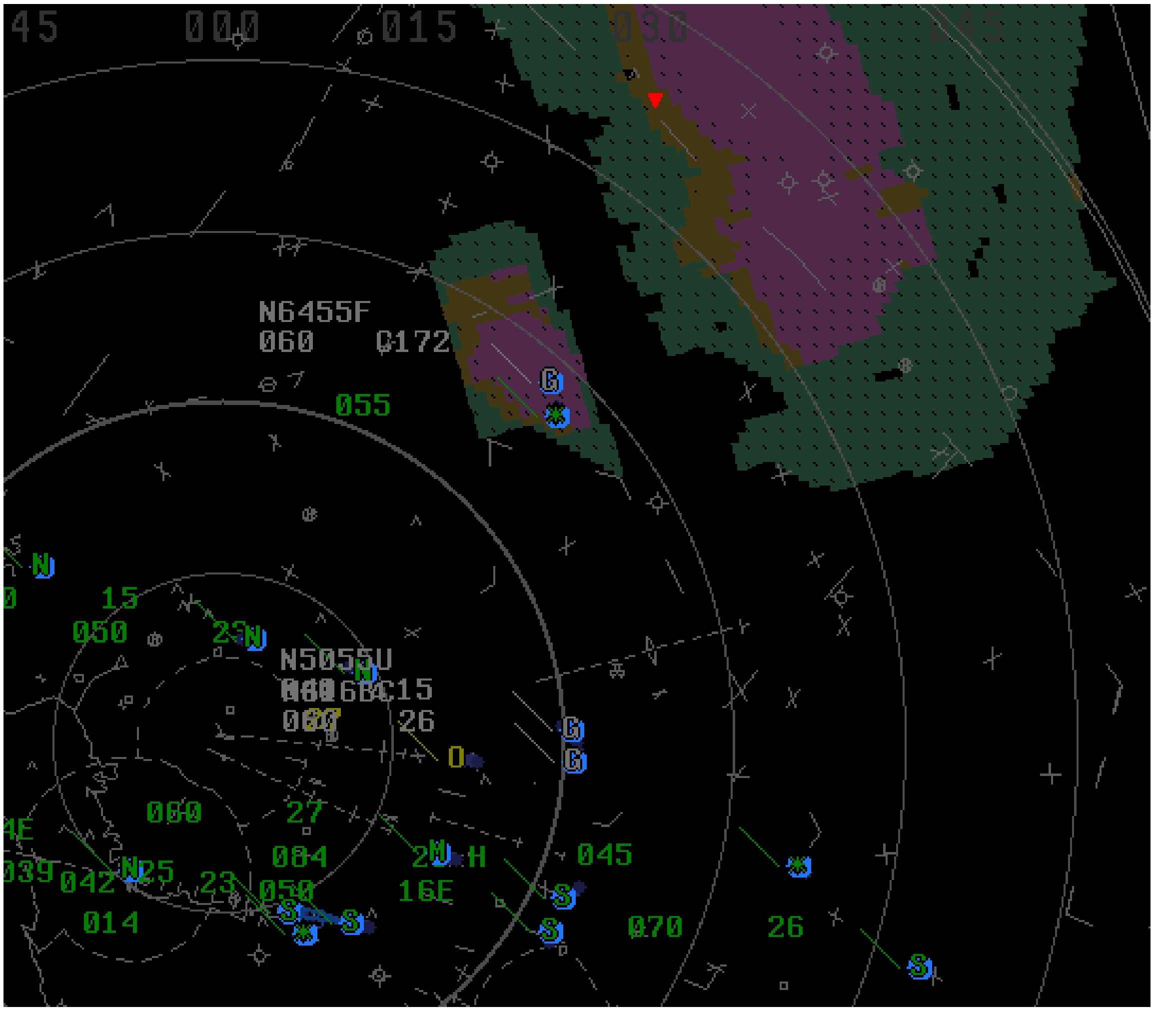

Figure 5. *HF-STD-010-compliant rendition of STARS with all 3 standard weather colors plus black stippling used to show severities 1 through 6.*

Participants in the demonstrations were able to use either the legacy brightness adjustment or an HF-STD-010-compliant method. To implement the latter, the DESIREE team developed an algorithm that compared foreground/background luminance contrast and issued a warning when a brightness adjustment resulted in less than a 3:1 contrast ratio, which is the minimum allowed by HF-STD-010. That arrangement allowed participants to adjust contrast ratios below the 3:1 minimum, but provided feedback that the lower contrast might impair the legibility of characters and symbols.

To minimize preparation time, we repurposed airspace adaptations and traffic samples used in other studies. To assess the revised STARS color palette, we used a STARS airspace adaptation and video maps from the Northern California Terminal Radar Control (TRACON) facility. The DESIREE team modified the airspace adaptation to ensure automated tools would trigger alarms, alerts, and notifications that used colors. To provide background shading, we created depictions of the FAA's current airport surveillance radar (ASR-9) system's weather data underneath the traffic flows that comply with HF-STD-010.

To assess the revised ERAM palette, we used a New York Air Route Traffic Control Center ERAM airspace adaptation. We used traffic samples created for another En Route study. To provide background shading, we created HF-STD-010-compliant depictions of NEXRAD weather data underneath the traffic flows.

Study 2: Results

A small team of Terminal controllers from the Terminal CHI team and supporting staff from the FAA's Air Traffic Organization's (ATO) Project Management Office (PMO) participated in the simulated demonstrations of the color palette. Members of the ERAM CHI team did not participate. Overall, the Terminal CHI team participants were receptive to the changes demonstrated using the DESIREE software. The participants indicated that the simple one-for-one color mapping was effective by displaying colors coded in a way that they found familiar. Impressions were also positive with the altered depictions of weather severities. It was noted in the debriefing with the controllers that reducing contrast ratios below 3:1 did indeed impair legibility appreciably, thereby validating the HF-STD-010 minimum requirement for contrast ratio. Although the ERAM CHI team did not participate in the demonstrations, they were briefed on the upcoming changes using static screenshots.

Study 2: Conclusions

The controllers', based on their review of the mockups and simulator examples, deemed the new weather depictions acceptable and noted the increased foreground to background contrast between full data blocks and weather was an improvement over the legacy blue and cyan colors.

Discussion and Recommendations

Our results indicate that user acceptance of the FAA standard color palette, as embodied in FAA HF-STD-010A (2020) and this report, are suitable. A simple mapping of the standard palette colors onto legacy ones, based on similarity of color names, will be satisfactory. For ERAM's and STARS' depictions of NEXRAD weather, the mappings we demonstrated (shown in Table 3 and Table 4) are promising.

Table 3.

Suggested NEXRAD Color Mapping for ERAM.

Severity Level	Legacy Color	Standard Palette Color
1 & 2	Blue	Wx-Green
3 & 4	Checkerboarded Cyan	Wx-Yellow
5 & 6	Cyan	Wx-Red

Table 4.

Suggested NEXRAD Color Mapping for STARS.

Severity Level	Legacy Colors	Standard Palette Color
1 & 2	Green; Light-Stippled Green	Wx-Green
3 & 4	Medium-Stippled Green; Yellow	Wx-Yellow
5 & 6	Light & Medium-Stippled Yellow	Wx-Red

For STARS to code each weather-severity level uniquely, the mapping in Table 4 must be expanded a bit, which raises some minor issues. We used the presence or absence of black stippling to distinguish weather-severity Levels 1 versus 2, etc., but another texture might prove to be better. If black stippling is used, how large and how dense should the stipples be to ensure they are readily visible without obscuring the background colors? Other textures would raise equivalent questions. We recommend choosing a weather texture for STARS by performing a laboratory experiment that compares alternatives and identifies promising candidates, followed by an email survey asking controllers to evaluate images showing static versions of those candidates.

The simple evaluation we performed revealed no difficulties in applying the standard color palette or other HF-STD-010 requirements to ERAM and STARS or objections from controllers. We recommend, therefore, performing a more thorough evaluation, involving more complex simulations and participation by a larger number of ERAM and STARS controllers. Such an evaluation would increase the likelihood of detecting any latent problems that may exist, so they could be addressed before implementing the palette in the field.

An important challenge to implementation is rendering the colors accurately in the colorimetric sense on fielded ATC systems. HF-STD-010 includes standard Red Green Blue (sRGB) values for each color, but for those values to produce the colors accurately, fielded displays must be calibrated to conform to the International Electrotechnical Commission (IEC) sRGB standard (1999). HF-STD-010 includes this requirement, which has the major advantage of allowing computer programmers to use the same set of red, green, and blue digital values to produce the intended colors accurately on all displays. The requirement leaves the FAA in need of guidelines for testing conformance to IEC (1999). We recommend that the FAA develop such guidelines for incorporation into ATC display procurement contracts and for in-house use during display acceptance testing.

References

Chidester, T., Milburn, N., Lomangino, N., Baxter, N., Hughes, S., & Peterson, L. Sarah (2011). *Development, Validation, and Deployment of an Occupational Test of Color Vision for Air Traffic Control Specialists* (DOT/FAA/AM-11/8). Washington, DC: US Federal Aviation Administration.

Chidester, T., Milburn, N., Peterson, L. S., Gildea, K., Roberts, C., & Perry, D. (2013). *Development, Validation, and Deployment of a Revised Air Traffic Color Vision Test: Incorporating Advanced Technologies and Oceanic Procedures and En Route Automation Modernization Systems* (DOT/FAA/AM-13/18). Washington, DC: US Federal Aviation Administration.

FAA HF-STD-002 (2007). *Baseline requirements for color use in air traffic control displays.* Washington, DC: US Federal Aviation Administration.

FAA HF-STD-010 (2017). *Color use in air traffic control displays.* Washington, DC: US Federal Aviation Administration.

FAA HF-STD-010A (2020). *Color use in air traffic control displays.* Washington, DC: US Federal Aviation Administration.

Gildea, K., Milburn, N., & Post, D. L. (2018). *Development of a standard palette for color coding ATC displays* (DOT/FAA/AM-18/22). Washington, DC: Federal Aviation Administration.

IEC (1999). *Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management – Default RGB colour space – sRGB* (IEC 61966-2-1:1999). Geneva, Switzerland: International Electrotechnical Commission.

Post, D. L., & Goode, W. E. (2020). Palette Designer: A color-code design tool. *Displays, 61,* 1-6.