FSA User Sensitivity Study for Quality of National Agricultural Imagery Program (NAIP) Imagery - Interim Technical Report

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Table of Contents

I. Executive Summary 3
1. Introduction 4
1 Experimental Design 4
1.1 Mosaic Variations 5
1.2 Image Problem Attribute Series (Noise, Sharpness, Color registration) 6
1.3 Color Saturation Series 7
1.4 Color Balance Variations 8
1.5 Contrast and Clipping Variations 8
1.5.1 Contrast Variations 8
1.5.2 Clipping Variations 10
1.6 Workstation Characterization 13
2 Results 13
2.1 Mosaic Variations 13
2.2 Image Problem Attribute Series (Noise, Sharpness, Color registration) 18
2.3 Color Saturation Series 22
2.4 Color Balance Variations 24
2.5 Contrast and Clipping Variations 28
2.6 Workstation Setup 31
3 Discussion and Recommendations 32
4 References 33
Appendix A – Reference Imagery Detail 34
Appendix B – User Study Script 35
Appendix C – User Study Datasheet Example (Texas) 41
Appendix D. Monitor Characterization Target Examples 54

I. Executive Summary

This report documents a recent study to determine the sensitivity of FSA NAIP imagery users to variations in image quality. The study covered a range of attributes that included noise, sharpness, color registration, color saturation, color balance, and tonal variations. Users were most concerned with attributes that impacted the ability to discern boundaries for CLU determination and the ability to use color information to help identify crop type for compliance. Users were less sensitive to attributes that might affect the overall look of the imagery, without inhibiting boundary or edge determination. Specific results are given below:

- Noise, sharpness, and color registration mismatches were tolerated until levels obscured CLU definition and comments reflected levels beyond this would cause fatigue. Based on preliminary assessment of problematic NAIP imagery supplied by APFO, most imagery is within specification and is acceptable by the users.
- Color- neutral balance was preferred overall, with some small shifts in color being equivalent in preference. Large shifts in green were strongly not preferred. The color saturation level preferred by the users was neither unnaturally high nor washed out. Based on preliminary assessment of problematic NAIP imagery supplied by APFO, imagery has a wide variation in balance and saturation level and can be beyond levels considered optimum by the users.
- Tonal Variations– Higher contrast images (without clipping) were preferred over the reference. Clipping levels above 1% were preferred overall less than the reference images. Finally, low contrast images were rated consistently below the reference and all clipping variations. Users frequently commented on the ease of finding boundaries with the higher contrast imagery and concerns about fatigue if they had to use the lower contrast imagery. Based on preliminary assessment of problematic NAIP imagery supplied by APFO, imagery can have a wide variation in visual contrast and is sometimes clipped. Users frequently commented on imagery that they had received in current or past years that were difficult to use due to contrast issues.
- Monitor Setup – State and County office sites had monitors that were not set up for optimum image viewing conditions which impacted the perceived quality of the imagery used. Implementation of simple guidelines for viewing setup and monitor settings could help mitigate the observed variability, improve ease of use, and reduce user fatigue.

The overall conclusion is that optimum reproduction is one where colors and boundaries are most clearly delineated. This would mean higher contrast with minimal clipping and a moderately saturated and neutrally balanced image.

1. Introduction

The National Agricultural Imagery Program's (NAIP) primary application is agricultural regulation compliance by the Farm Service Agency (FSA) state and county field offices. This includes the definition of Common Land Use (CLU) boundaries to determine farm acreage and aiding in verification of crop type. NAIP imagery is also used by a variety of partner agencies, (e.g. Forest Service (USFS), National Resource and Conservation Service (NRCS), and the Geological Survey (USGS)), and private companies and individuals via the website.

This report documents a study completed to determine the sensitivity of FSA end users to various types of image quality problems thus identifying whether improvements in upstream production or quality control are warranted. In ITT's experience, in nearly every instance, users make do with what imagery they have—seldom are end consumers aware of "how good it could be" and thus often work less productively with lower contrast or un-enhanced data. This results in increased fatigue, longer than normal decision-making time, or less accuracy. It is only by characterizing these improvements in image quality which can lead to improvements in accuracy, throughput, confidence, or reductions in fatigue that image production systems are optimized for performance. These figures of merit establish a value and business case against which to consider the investments required to optimize upstream image chains and processes.

1 Experimental Design

In order to determine the attributes to vary in the study, APFO provided samples that represented a range of problem images to ideal images. Those images were sorted as to type of problem (e.g. exposure, color balance).

Once problem categories had been identified, the information was combined with information about end-user expectations and usage of the imagery to define the type and range of attributes produced for the study to determine sensitivity. The attributes identified were mismatch in mosaic tile attributes, noise, sharpness, color record registration, color saturation, color balance, clipping and contrast. The next step was to take a good quality starting image, and modify it accordingly to produce the required type and level of anomaly. Detailed descriptions of those modifications are given in the sections below. All users were shown variations of a 2 Meter Digital Ortho Quarter Quad (DOQQ) from Grady County, Oklahoma and an image that was from a user's geographic region. Details of the regional imagery used are given in Appendix A.

Once the attributes to be tested were determined and the imagery generated, ITT personnel visited user sites in four states. Seventeen users participated, as described in the table of the states and offices visited below. Users were shown imagery on a calibrated ITT LCD monitor, with a Gamma 2.0 tone scale and a color temperature of 6500K. The monitor response was checked at each user site to confirm that the calibration was maintained. Effort was made to keep the viewing conditions as similar as possible from site to site by reducing the room lighting to a lower ambient (4-25 fc) and situating the monitor so there was no glare on the screen.

Table 1. States and Offices Visited, with the number of users shown in parentheses

State	Office
New York	Monroe County (1)
Utah	State FSA (1)
Utah	Box Elder (2)
Utah	Cache County (1)
Kansas	State FSA (1)
Kansas	Pottawatomie County (1)
Kansas	Clay County (1)
Kansas	Riley County (1)
Texas	State FSA (1)
Texas	Waller County w/ representatives from Milam and Robertson County (3)
Texas	Burleson County w/ representatives from Washington and Fort Bend County (3)

Depending on the attribute, a person taking the test was asked to do different types of tasks with the test images. A description of the task-type is given in the appropriate sub-section below. The test was given according to a script, the full text of which is included in Appendix B. The complete data sheet is included in Appendix C.

1.1 Mosaic Variations

Using the 2 Meter DOQQ from Grady County, Oklahoma, a series of images were created to emulate a mismatch in mosaic tile attributes. These mismatches such as color balance, noise, exposure, and contrast were representative of problems identified in the image quality review. An example of how a mismatch would appear to the evaluator is shown in Figure 1.

Figure 2: Image Quadrants

1	2
4	3

The Grady image was broken into four quadrants using Adobe Photoshop CS2, as seen in Figure 2 at left. The four quadrants were converted to layers and had manipulations applied to them, as listed in Table 2 below. Once individual layers had changes applied, the layers were flattened and the image was saved as a TIFF file.

These flattened images were shown to end users as a subjective quality measure of user's sensitivity to said attributes when presented in a single image. Also qualified was relative

Figure 1: Example Mosaic Variation

impression, frequency of occurrence, and corrections (if any) that the user would make to improve image usability.

Table 2: Mosaic Variations Key

Grady County Oklahoma	Manipulated Attributes:	Changes: (Adobe Photoshop CS2)
n_3509864_ne_14_2_20060512_20060717	As delivered	No Changes
2-n_3509864_ne_14_2_20060512_20060717	Contrast - Curves	Layer 1 - None
		Layer 2 – digital counts (0-50), (255-200)
		Layer 3 – digital counts (255 - 150)
		Layer 4 - None
4-n_3509864_ne_14_2_20060512_20060717	Exposure	Layer 1, -1
		Layer 2 - +1
		Layer 3 - None
		Layer 4 - none
5-n_3509864_ne_14_2_20060512_20060717	Noise	Layer 1 - 15% Gaussian
		Layer 2 - None
		Layer 3 - None
		Layer 4 - 25% Gaussian
9-n_3509864_ne_14_2_20060512_20060717	Color Balance	Layer 1 - up 10% in the Red channel
		Layer 2- down 10% in the Red channel
		Layer 3 - Up 10% in the Green
		Layer 4 -Down 10% in the Green

1.2 Image Problem Attribute Series (Noise, Sharpness, Color registration)

In order to determine the minimum quality level that users could comfortably work with in their jobs for three image problem attributes (noise, sharpness and color registration) a series of images was created. The table below is a sample of the DOQQ for Grady County, Oklahoma that was used for the reference image for all participants. Table 3 below shows the key used for the user study.

Table 3: Simulation Key Example: DOQQ # 3509864 for Oklahoma

	Defect(s)					
Image #	**Uniform Noise**		**Gaussian Blur**		**Color Registration**	
1	Noise = 0	N0	Blur = 0	B0	Shift = 0 Pixel	I0
2	Noise = 4%	N4	Blur = .5	B.5	Shift = 1 Pixel Green	I1
3	Noise = 8%	N8	Blur = 1.0	B1.0	Shift = 2 Pixel Green	I2
4	Noise = 12%	N12	Blur = 1.5	B1.5	Shift = 3 Pixel Green	I3
5	Noise = 16%	N16	Blur = 2.0	B2.0		

The simulation to produce variations in uniform noise was performed on images as follows: In Adobe Photoshop the Filter > noise > Add Noise option(s) was used. In the Select Uniform Noise percentage option the following levels were used for the five Simulation Images (5 image builds)

- Image 1 - N0 = 0
- Image 2 - N4 = 4%
- Image 3 - N8 = 8%
- Image 4 - N12 = 12%
- Image 5 - N16 = 16%

Another image quality simulation was to use Gaussian blur to modify the sharpness of the images. The simulations of imagery were completed in the following manner: The base image was opened in Photoshop and the Filter > blur > Gaussian Blur option was used. The following was used for the blur pixel radius selection for the five Simulation Images (5 image builds)

- Image 1 - B0 = 0 px
- Image 2 - B.5 = .5 px
- Image 3 - B1 = 1.0 px
- Image 4 - B1.5 = 1.5 px
- Image 5 - B2 = 2 px

The last image quality simulation was a color registration series. The simulations of imagery were completed as follows: The base image was opened in Photoshop and the color channel navigation window was opened. The following was used for three green channel shifts. (4 image builds)

- Image 1 - I0 = 0 px
- Image 2 - I1 = 1 px
- Image 3 - I2 = 2 px
- Image 4 - I3 = 3 px

The test taker viewed the entire series and was asked to zoom in to the viewing level they used on a routine basis. The person was asked to go through the series and select the level where they felt the imagery would no longer be "usable." Usable was defined as not providing undue difficulty in obtaining necessary information from the images.

1.3 Color Saturation Series

Saturation variations were created in Adobe Photoshop 7.0 using the Adjustment/Variations/Saturation controls at the default and +1 level of saturation and de-saturation for the common image, and the default and -1 level of saturation and de-saturation for the regional images, for a total of five images in the series with the unmodified reference in the center. This corresponds to an approximately ±25% and ±50% variation for the common image and ±12.5% and ±25% for the regional images where the percentages refer to the value of the Image/Adjustments/Hue/Saturation slider that would give the same appearance. Note: the changes in the histograms for the two methods are not completely equivalent.

The images were presented to the user as a set. The user could only see one image at a time, but could go from image to image in the set. They were requested to rank the images in order 1 through 5 with 1 being the image they most preferred and 5 being the image they least preferred.

1.4 Color Balance Variations

The color balance variations were created in Adobe Photoshop 7.0 using the Adjustment/Variations/Saturation controls at the -1 and default level for mid-scale values. This corresponds to a difference between the appropriate RGB channels of approximately 15 and 30 digital counts respectively for a neutral patch. All images were verified using a neutral object, usually a road, contained in the picture.
The images were presented in pairs, with the user being asked to indicate whether they preferred the left or right picture on the screen. All permutations of the 9 variations were shown for a total of 36 pairs. The script used to display the pairs was modified so that not all users saw the same order, though the sets were not truly randomized. Interval scales were generated using Thurstone's Case V Solution according to the method described in Engeldrum. Confidence intervals were calculated using Montag's method.

1.5 Contrast and Clipping Variations

According to Falk, contrast is a measure of the variation in lightness in an image. If an image has high contrast, the difference between the lightest pixel and the darkest pixel in an image is great, tending to create an image that is vibrant and full of detail. If an image has low contrast, the difference between the lightest pixel and the darkest pixel in an image is small, tending to create an image that is "washed out" and lower in detail. Clipping is a term applied to pixels that have values at the minimum and maximum visible pixel value in an image. If some of the pixels within the image have been clipped, a user may perceive the contrast to be higher or might consider an image more pleasing. If many pixels within an image are clipped, an image will tend to have an artificial look, provide less information to the user, and would be less pleasing.

For this study, 6 images were created that exhibited contrast variations and 6 images were created exhibiting clipping variations, forming a total of 12 images.

1.5.1 Contrast Variations

To perform contrast variations, a lookup table was used to transform the imagery. A lookup table is a way to transform one image into another by replacing each individual pixel value in the input image f(x,y) with a corresponding pixel value in the output image g(x,y) specified by the table, as seen in Figure 3.

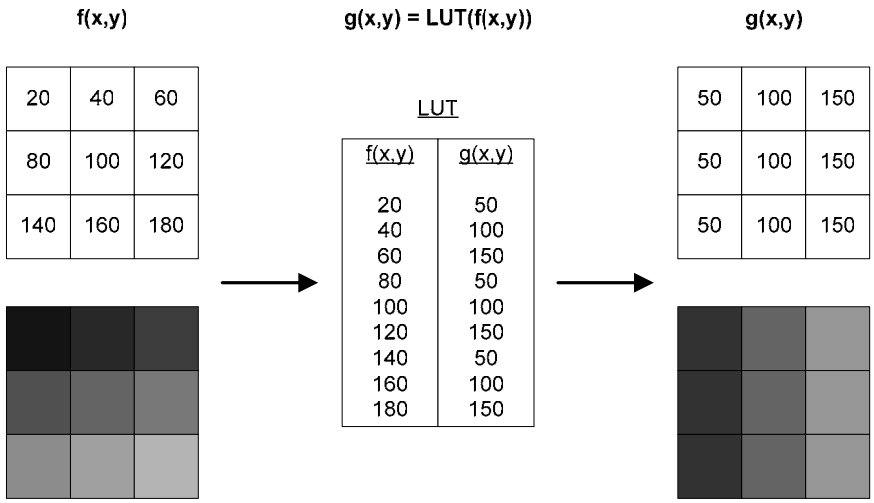


Figure 3. Lookup table operation

To create images that have varying levels of contrast, a sigmoidal lookup table was applied to each color channel of the reference image. A sigmoidal lookup table is based on the sigmoid function, as seen in Equation 1.

$$DC_{out(R|G|B)} = \left\lfloor 255 \frac{1}{1+e^{-b\left(\frac{DC_{in(R|G|B)}}{255}-0.5\right)}} \right\rfloor \tag{1}$$

$DC_{in(R|G|B)}$ represents the input digital count in the red, green, and blue color channel respectively; b represents an arbitrary scaling parameter; and $DC_{out(R|G|B)}$ represents the output digital count in the red, green, and blue color channel. By varying b, one can influence how much contrast is apparent in the output image. For low values of b ($b < 4$), the input image loses contrast and appears gray. For high values of b ($b > 4$), the input images gains contrast. An example of how the parameter controls contrast can be seen in Figure 4.

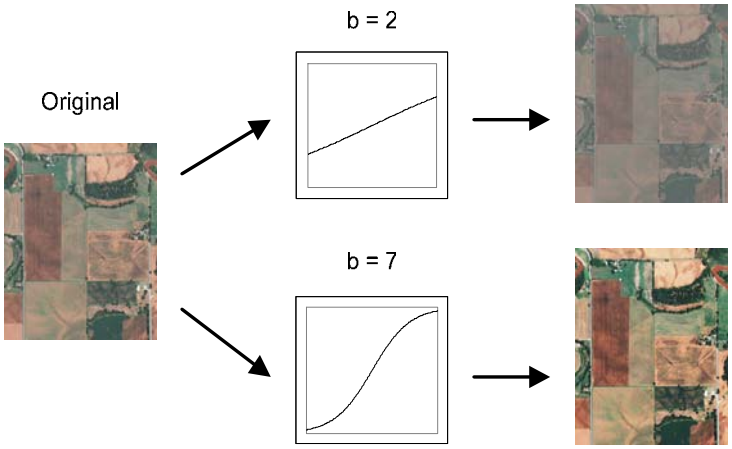


Figure 4. Contrast control through scaling parameter selection

To generate the lookup table for each color channel, DC_{out} values were calculated based on all possible input DC_{in} values for an arbitrary scaling parameter. For this study, DC_{in} fell into the range of 0 to 255.

For the imagery used in the study, the scaling parameter was in the interval of 2 to 7 in one-step increments, forming 6 images for each state.

1.5.2 Clipping Variations

To perform contrast variation with clipping, pixels were chosen in a controlled manner to have their values transformed to the minimum or maximum visible pixel value. The process to do so can be seen in Figure 5.

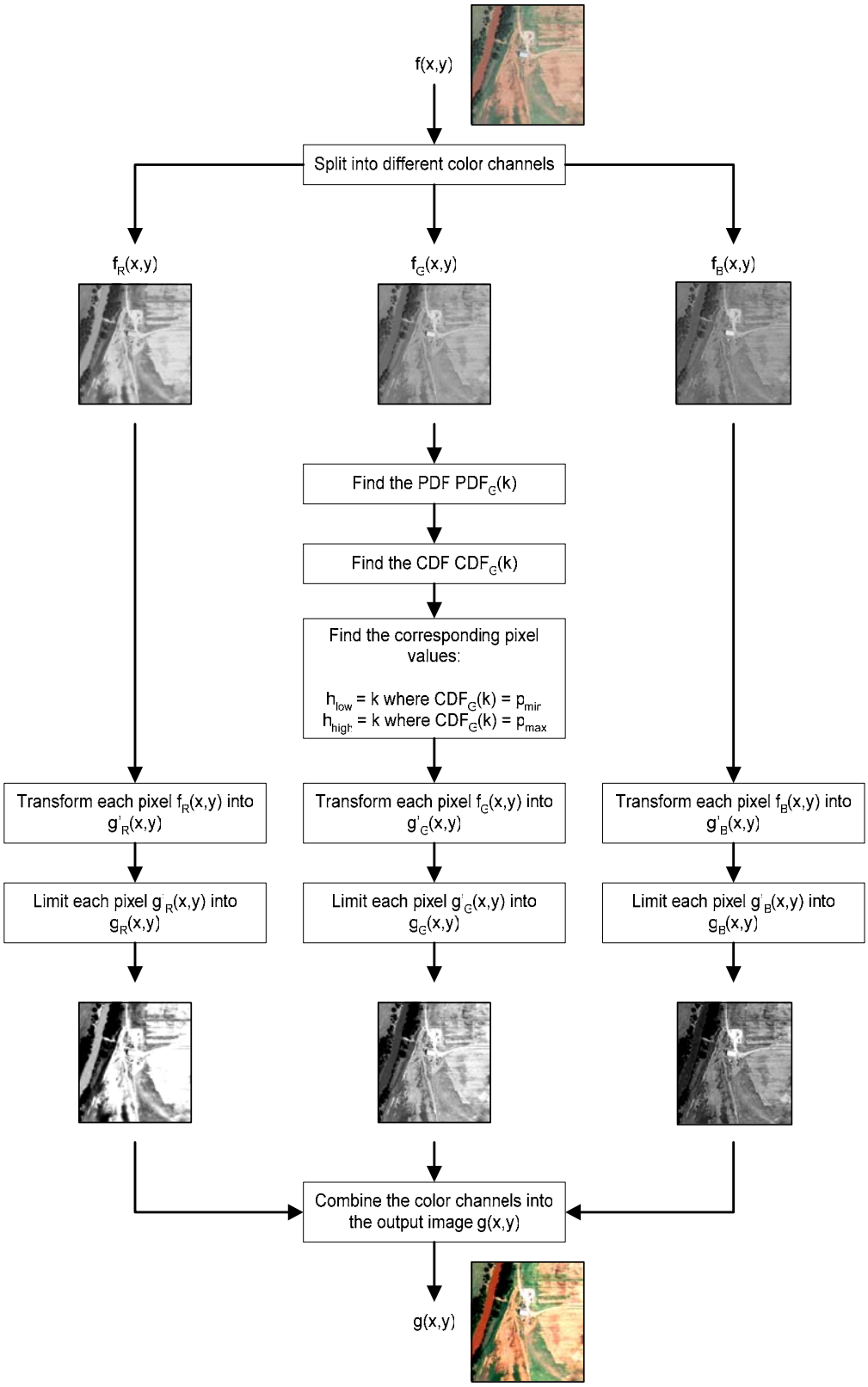


Figure 5. Clipping variation in imagery

To start, an input color image f(x,y) is broken into its constituent color channels: the red channel $f_R(x,y)$, the green channel $f_G(x,y)$, and the blue channel $f_B(x,y)$. Second, the probability distribution function of the green channel $PDF_G(k)$ is found using Equation 2.

$$PDF_G(k) = \frac{n_{G,k}}{N} \tag{2}$$

N represents the total number of pixels in the input image while $n_{G,k}$ represents the number of pixels that have the pixel value k. Next, the cumulative distribution function for the green channel $CDF_G(k)$ is found using Equation 3.

$$CDF_G(k) = \sum_{i=1}^{k} PDF_G(i) \tag{3}$$

Once the cumulative distribution function has been found, the pixel values that correspond to an arbitrary limit h_{low} and h_{high} are found. This requires the definition of two parameters: p_{min} and p_{max}. p_{min} represents the percentage point where clipping ends on the dark end of an image's pixel values. This scalar value can range from 0% to 50%. p_{max} represents the percentage point where clipping begins on the bright end of an image's pixel values. This scalar value can range from 50% to 100%. If one would like to introduce no clipping to image, p_{min} would be 0% and p_{max} would be 100%, for example. To find h_{low} and h_{high}, Equations 4 and 5 are employed.

$$h_{low} = k \text{ where } CDF_G(k) = p_{\min} \tag{4}$$

$$h_{high} = k \text{ where } CDF_G(k) = p_{\max} \tag{5}$$

By selecting the endpoints in this fashion, there was some variability in the nominal percentage of clipped pixels. Next, each color channel in the input image is clipped and contrast stretched using Equation 6.

$$g'_{R|G|B}(x,y) = \left\lfloor 255 \frac{f_{R|G|B}(x,y) - h_{low}}{h_{high} - h_{low}} \right\rfloor \tag{6}$$

$g'_{R|G|B}(x,y)$ represents the clipped pixel in the red, green, or blue color channel respectively while $f_{R|G|B}(x,y)$ represents the input image pixel in the red, green, or blue color channel. As some pixels will now have values that lie outside the viewable dynamic range, the pixels must be limited using Equation 7.

$$g_{R|G|B}(x,y) = \begin{cases} 0 & g'_{R|G|B}(x,y) < 0 \\ g'_{R|G|B}(x,y) & 0 \le g'_{R|G|B}(x,y) \le 255 \\ 255 & g'_{R|G|B}(x,y) > 255 \end{cases} \tag{7}$$

Once each color channel has been limited, the channels are recombined to form the output image g(x,y). For this study, six sets of parameters were defined to form 6 output images: $[p_{min},p_{max}]$ = [0%, 97%], [0%, 99%], [2%, 100%], [3%, 100%], [1%, 99%], [2%, 98%]. These parameters were selected such that all possible contrast changes would be accounted for: images that were clipped bright, images that were clipped dark, and images that were clipped both light and dark. Moreover, these parameters were selected to give approximately equal visual changes when clipping occurred.

1.6 Workstation Characterization

At each site, the monitor used most often to view imagery was characterized. The ambient light levels with the colorimeter pointed at the monitor screen with the monitor off, at the keyboard, and behind the monitor were measured. The luminance response of the monitor was determined using a seven point gray scale. A Briggs target was also used to characterize spatial resolution. Sample targets are included in Appendix D.

2 Results

2.1 Mosaic Variations

Overall impression of NAIP imagery to date:
Users were satisfied with the improvement seen over the years of NAIP collections. Previous data have been problematic causing a deficiency in clear definitions of CLU line placement and shifting CLU boundaries across multiple collection datasets. There is a definitive preference for higher resolution and higher contrast datasets; users would like to see the trend of improvement continue.

Image Variations Tile Series:
Many people indicated that using degraded imagery as shown in this test affects their ability to do their jobs well. This signifies that greater time is dedicated to studying a single degraded image as opposed to a well processed one. This additional time needed causes eye strain, fatigue, reduced productivity, and an overall reduction in accuracy of CLU boundaries.

Users are generally not aware that monitor set up affects how images are displayed and viewed on a system. Those that are aware try to adjust monitor settings as they see fit. Users have not had specialized training to this end and should be trained as such. Once such training occurs, systems should be locked to prevent changes or manipulations of a calibrated system thereby providing a known base system for constant and reliable processing.

A great impact in usability across Compressed County Mosaics (CCMs) was noted, as there was an increased perception of differences in color, contrast and lightness/darkness of adjacent images or on image seams. Consistency across DOQQs and County/State boundaries is necessary to promote efficient use of analyst's time.

Most noticeable was visible differences in noise. Mosaic variations with an inconsistency in noise across the panel scored the lowest, with an average rating 1.36. Note that for quality ratings a scale with "5" being best and "1" being worst was used. This mismatch in mosaic tile attributes renders this image not useable. Very strict recommendations should be made and included in vendor CCM/DOQQ deliverable specifications to prevent this type of imagery from being sent to the USDA APFO office.

Differences in exposure across a scene also had significant impact on the usability of an image. Most people commented that it would be difficult to do their job and would prefer not to use it. Although this type of image variation causes a reduction in performance and usability, most people tested said there are few instances of adjacent images with drastic exposure shifts; this issue is not frequently seen. As such, recommendations should be captured to prevent this type of image from being delivered in the future.

An image with distinct areas of contrast difference allows users to do their tasks, but causes fatigue and increases throughput time. CCMs exhibit these issues frequently, "All the time…" in Monroe County NY, and "up to half the time" in Utah. Therefore this issue should also be addressed, detailing specific metrics related to contrast, dynamic range, and with emphasis on consistency.

Small color balance differences across images did not have an impact on the usability of images. A 10% shift in red and green channels went unnoticed by some.

Image Name	Manipulated Attributes:	Average Score
2-n_3509864_ne_14_2_20060512_20060717	Contrast - Curves	3.1
4-n_3509864_ne_14_2_20060512_20060717	Exposure	2.8
5-n_3509864_ne_14_2_20060512_20060717	Noise	1.4
9-n_3509864_ne_14_2_20060512_20060717	Color Balance	3.6

A summary of the comments received for each variation is given below:

2-n_3509864_ne_14_2_20060512_20060717, Contrast Curves:
On a scale of one to five, overall this image received and average of 3.117, Usable -This image would provide the information for me to do the type of job I do, but could be improved.

User Sensitivity:
8 of 17 users (47%) identified fatigue as being a primary issue in using images with low contrast, stating that it would be more difficult to perform necessary tasks:

- Monroe County, NY, Kim: "quad 3 is dark, useable but pretty dark. Not easy on the eyes. Close to not useable"

- State Office UT, Jim: "There is no way to determine accurately the crop type in the areas that are real dark. It would require a lot more time to interpret"
- Clay County KS, Jeanie: "The overlaps make it hard to see the information around the bordering areas"
- Burleson County TX, Wayne: "Using the upper right hand corner would tire *me* out" (have to concentrate more)"
- State Office TX, Danny and Kevin: "*I* could still use it but it would make *my* job much harder. If *I am* looking at the light/dark areas, *I* cannot do crop identification."
- Washington County TX, Paula: "It would be hard to tell the lines"
- Washington County TX, Steven: "It would be hard to tell the lines"
- Fort Bend County TX, Wayne: "It would be hard to tell the boundaries"

Corrective Actions:
Corrective actions to improve contrast include: Nothing, adjusting colors through software, zooming in, or adjusting monitor settings.

- 5 of 17 users (29%) Indicate doing nothing to correct imagery
- 3 of 17 (18%) Depend on software (ESRI ARCMap) functionality to lighten or adjust contrast.
- 2 of 17 (12%) Zoom in
- 1 of 17 (6%) Adjust monitor settings

Frequency of Occurrence:

- Monroe County NY, Kim "All the time…"
- Utah: Answers range from Infrequently to Quite often, or up to 50%
    - Cache County UT, Dixie Beesely: "Current imagery less than half the time. Do see it regularly"
    - State Office, UT, Rodney: "Lot of inconsistency. Quite often"
- Kansas: Not very often
- Texas: Approximately 15% of the time

4-n_3509864_ne_14_2_20060512_20060717, Exposure:
On a scale of one to five this image received and average of 2.85; 2- Somewhat usable, this image would provide some information with some effort, but is not what I'd prefer using.

This type of image variation causes a reduction in performance and usability. The user community tested said there are instances of adjacent images with drastic exposure shifts; and in some cases is seen frequently. As such, recommendations should be captured to prevent this type of image from being delivered in the future.

User Sensitivity:
10 of 17 (59%) of those tested claimed it would be more difficult to perform necessary tasks:

- Pottawatomie County KS, Debbie: "Hard for the user's eyes to focus in, the farmers would have a real problem with the light and the dark. The office could get what they need but the farmers might not"
- Riley County KS, Nikki: "It would make the job difficult"
- Milem County TX, Alan: "*I* cannot distinguish lines in the bright areas (the bright area makes it hard to see the shape file lines in Arc)"
- Robertson County TX, Lewis: "The contrast is difficult to work with when finding boundaries"
- Waller County TX Sandra: "If you were looking at a similar crop, it would be hard to identify the crop"
- Washington County TX, Paula: "Too dark in the one part…"
- Washington County TX, Steven: "Too dark in the one part…"
- Box Elder County UT, Jim: "Contrast obscures the lines…too bright. Other parts too dark. Can still use it but it might be hard"
- Cache County UT, Dixie Beesely: "Bottom section across is pretty good. Upper right side is way too bright. Upper right side is dark but would cause a lot of eye strain"
- State Office UT, Rodney: "Split fields; not sure if the lines are field delineations or image artifacts."

Corrective Actions:
8 of 17 (47%) of End Users indicate they could do nothing to improve the usability of this image.
3 of 17 (18%) users indicate they would try to adjust their monitor

- Robertson County, TX, Lewis: "Try to make the whole image like the upper right quadrant. He would adjust the monitor first then do something with the software, if possible."
- Washington County TX, Paula: "Try to change the brightness on the monitor"
- Washington County TX, Steven: "Try to change the brightness on the monitor"

2 of 17 (12%) people try to manipulate the imagery using available software

- Robertson County, TX, Lewis: "Try to make the whole image like the upper right quadrant. He would adjust the monitor first then do something with the software, if possible."
- Waller County TX Sandra: "Do a standard deviation change in the Properties window of the layer in ArcMap"

Frequency of Occurrence:
Utah: Answers range from Infrequently to Quite often, or up to 50%

- Box Elder County UT, Dave Davis: "See it often enough"
- State Office UT, Jim: "2004 lack of contrast often"

Kansas:

- State Office KS, Scott: "Never seen one this exaggerated. 1% or 5% of the time."

Texas:

- Waller County TX, Sandra: "In 2005, half would be darker and too green"

- Burleson County TX, Wayne: "There were a couple of panels that were darker and muddy in 2005 but 2006 was better."

5-n_3509864_ne_14_2_20060512_20060717, Noise:
Everyone tested scored this image very poorly; it received a rating of 1.36. On our scale a score of 1 indicates an image is not usable: This image would be difficult to get information from to do the type of job I do.

Those tested stated images with noise are not frequently seen, and also said they felt they could do nothing to improve the imagery.

User Sensitivity:
11 of 11 tested (100%) said this image would be problematic and very hard to distinguish land boundaries.

- Clay County KS, Jeanie: "The boundaries are not distinct"
- Pottawatomie County, KS, Debbie: "The crop lines are there but it is real grainy, hard to read. The farmer probably would not be able to tell where the lines lie."
- State Office KS, Scott: "Again, it would present a problem for mapmaking"
- Monroe County NY, Kim: "*I* don't like this one at all…Looks pixilated….noisy"
- Burleson County TX, Wayne: "Making measurements would be very difficult and everything seems to blur together"
- State Office TX, Danny and Kevin: "*I* cannot distinguish what is there"
- Washington County TX, Paula: "Cannot really find the lines."
- Washington County Office TX, Steven: "Cannot really find the lines."
- Cache County UT, Dixie Beesely: "(Left) Bad side of it would be unusable…not able to see what was planted there. *I would have a* hard time telling what we would be taking out...inclusions/houses"
- State Office UT, Rodney: "Going to draw field boundaries…can't tell where the homestead or grainery is…as far as an overall image you couldn't use this image in your project"

Corrective Actions:
1 of 5 (20%) of End Users indicate they would do try to sharpen the image
3 of 5 (60%) would do nothing
1 of 5 (20%) said they would reproject the image.

Frequency of occurrence:

- Monroe County NY, Kim "See images look like this….this looks like NAIP last time we had it, 2004 – less is better."
- Riley County KS, Nikki: "Not very often"
- Washington County TX, Paula: "Not at all."

9-n_3509864_ne_14_2_20060512_20060717, Color Balance:
Image 9-n_3509864_ne_14_2_20060512_20060717 received an average rating of 3.653. It was found to be useable and very useable across those who took the test. A 10% color

shift in the green and red channels across the norm was noticed by 4 of 7 (57%) users, and does not impact one's ability to do their job well.

User Sensitivity:

9 of 11 (81.8%) people tested said they saw no problems with this image and would have no problems using it.

1 of 11 (9%) said they thought it was washed out,

- Cache County UT, Dixie Beesely: "No issues…a little washed out."

1 of 11 (9%) thought the image was grainy

- State Office UT, Rodney: "A lot of lossy data in fields that are sparsely plowed. Lot of areas …without clarity. Grainier than 1m…"

Corrective Actions:

None needed. Users did indicate that any correction would be performed or needed.

2.2 Image Problem Attribute Series (Noise, Sharpness, Color registration)

Noise Analysis:

Based on the data in table 4, the average threshold for noise for states in the study was between image 3 and 4. One could conclude that the threshold for noise was ~10%. This would mean that the equivalent of a uniform noise pattern on any image of 10% or greater would be unacceptable. Similarly, any uniform noise less than 10% could be tolerated or acceptable for the USDA offices to complete their tasks. The statistical data shown in table 5 and figure 6 also back this conclusion. The standard deviation function was used as a noise metric for the image analysis.

Table 4. Mean image number selected for image problem attribute series

Series / Defect	Common image / 17	Regional Image /8	Color IR Image / 8	All Natural Color Images/26
Noise (1-5 Images)	3.53	4.00	3.75	3.65
Sharpness (1-5 Images)	3.09	3.06	3.25	3.08
Color registration (1-4 Images)	2.47	2.75	2.625	2.63

To analyze the data further, the reference Oklahoma image was used. The sample size is 17. All 17 testers used this image as a baseline reference. The noise metrics and Statistics of the reference Oklahoma image break down as shown in table 5:

Table 5 - Oklahoma Reference Image

Uniform Noise (%)	Band (Color)	std dev
0	0	2.576227
0	1	2.975187
0	2	2.38669

4	0	6.418881
4	1	6.674878
4	2	6.468731
8	0	12.12577
8	1	12.15056
8	2	11.90328
12	0	18.41578
12	1	18.5829
12	2	18.63562
16	0	23.66428
16	1	23.95222
16	2	24.20083

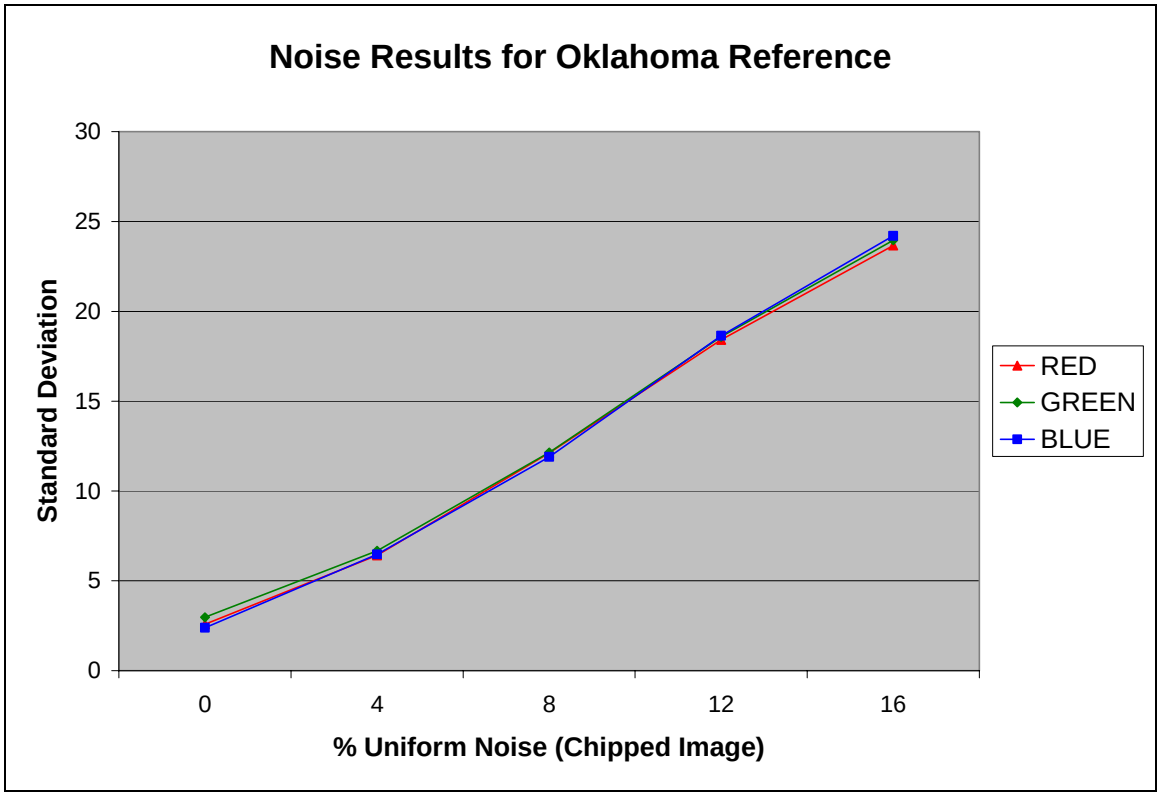


Figure 6. Standard deviation vs. added percent noise applied to the image via Photoshop.

Note: The Standard Deviation is directly related to the Noise in the image sample. A Standard Deviation below 12 is preferred based on customer feedback. This corresponds to the acceptance level dropping off at the third and fourth images in the test. (Between 8% and 10% added Uniform Noise or Standard Deviation greater than 12)

The final result of the above user test are listed below and illustrated in figure 7:

- Tolerant to noise until level obscures CLU definition
- High noise fatigue factor identified by users

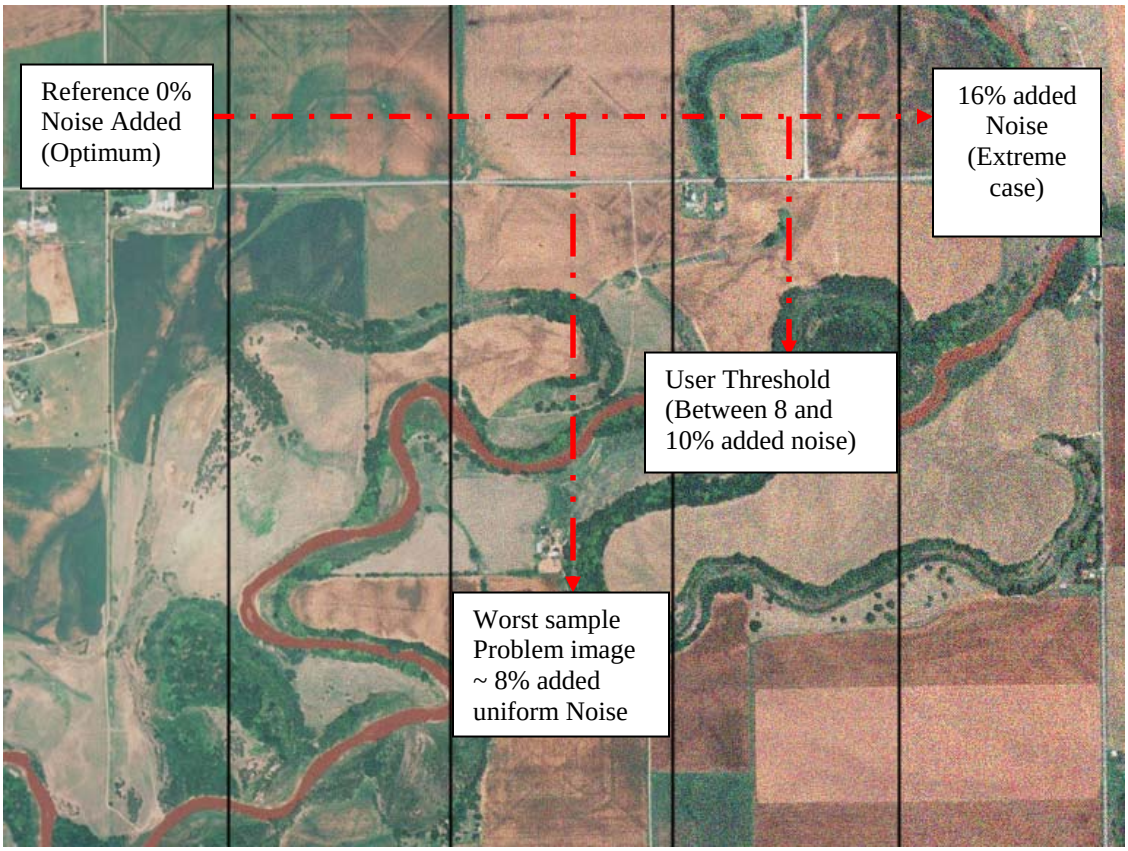


Figure 7. Illustration of noise levels used in the study

Sharpness Analysis:
Degradation in sharpness was the least tolerated image quality problem of the threshold series used for this study. Any image with blur added that included more than 0.5 pixels was not acceptable overall. This result illustrates the need for sharp imagery for data analysis.

The Relative Edge Response (RER) measurement (Leachtenauer) was used to better quantify the required sharpness level and the results are shown in Table 6. Clearly testers will only tolerate an image with an RER between 0.5-1.0 (50-100%). In cases where the RER metric was under 50% of the optimum, the image was deemed non-usable. It is also important to note that the RER metric could not be run on actual imagery due to the lack of sharp edges available for calculations. RER depends on edges, such as houses, buildings etc. with sharp definition for the calculation. Instead a simulated image consisting of alternating white and black blocks was used to calculate the RER relative percentages by applying the same Gaussian blur manipulations as on the image series used for the study. See the table below for the approximate RER's based on the metrics used for analysis.

Table 6 - Sharpness (RER) Results

	Simulated Check	Oklahoma Reference Image

Gaussian Blur (Pixels)	Band (Color)	Relative Edge Response (RER)	~ Delta %RER (100%-25%)
0.0	Green	0.910	~91%
0.5	Green	0.518	~52%
1.0	Green	0.343	~34%
1.5	Green	0.251	~25%
2.0	Green	0.246	~25%

The final result of the above user test was the users are listed below and illustrated in Figure 8:

- Low tolerance to poor sharpness
- Impacts CLU definition

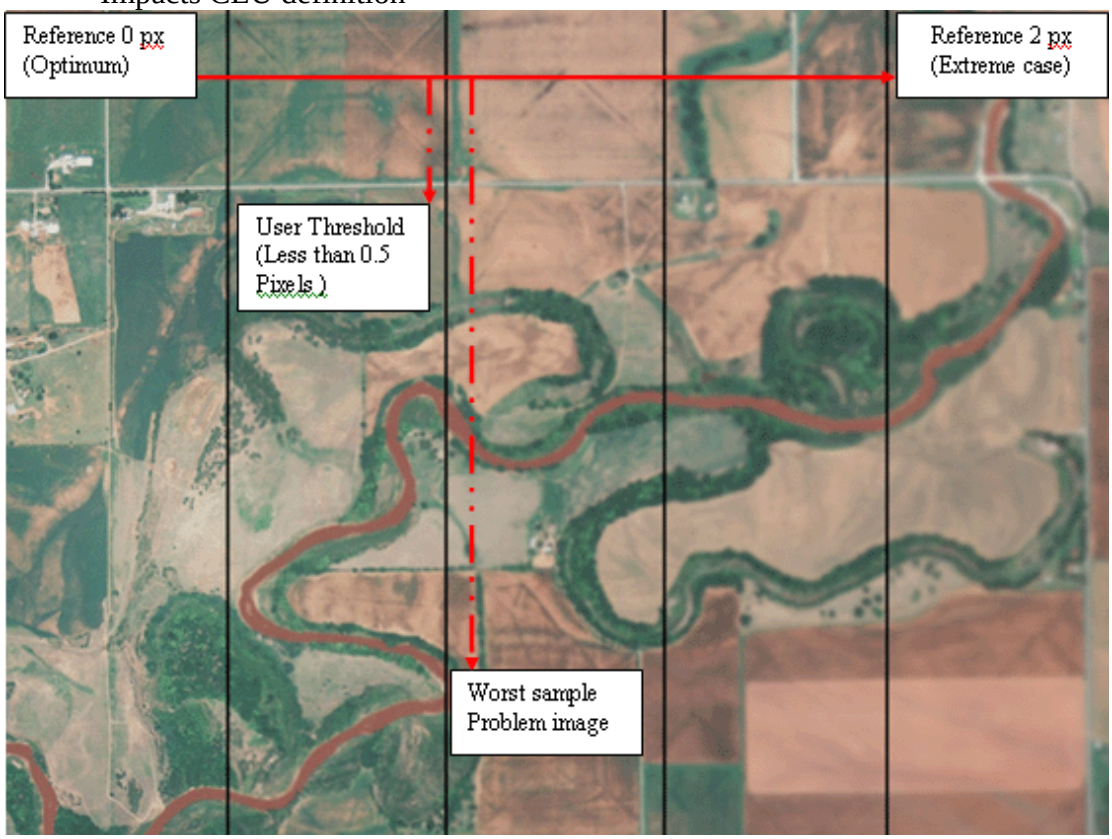


Figure 8. Illustration of blur levels used in the study

Color registration Analysis:

Lastly, the color registration series seems to have a narrow threshold as well. Any image with a two pixel shift or greater was not acceptable. Again, this is most likely due to the blur or ghosting created by the de-stagger of the color channels. Sensor alignments are critical and as a result, any post processing will need to account for any registration issues. The green channel was analyzed being it was the most significant color channel for the analysis. The result of the user test:

- A two-pixel shift was found to make an image too difficult to use without strain for the users. (See figure 9)

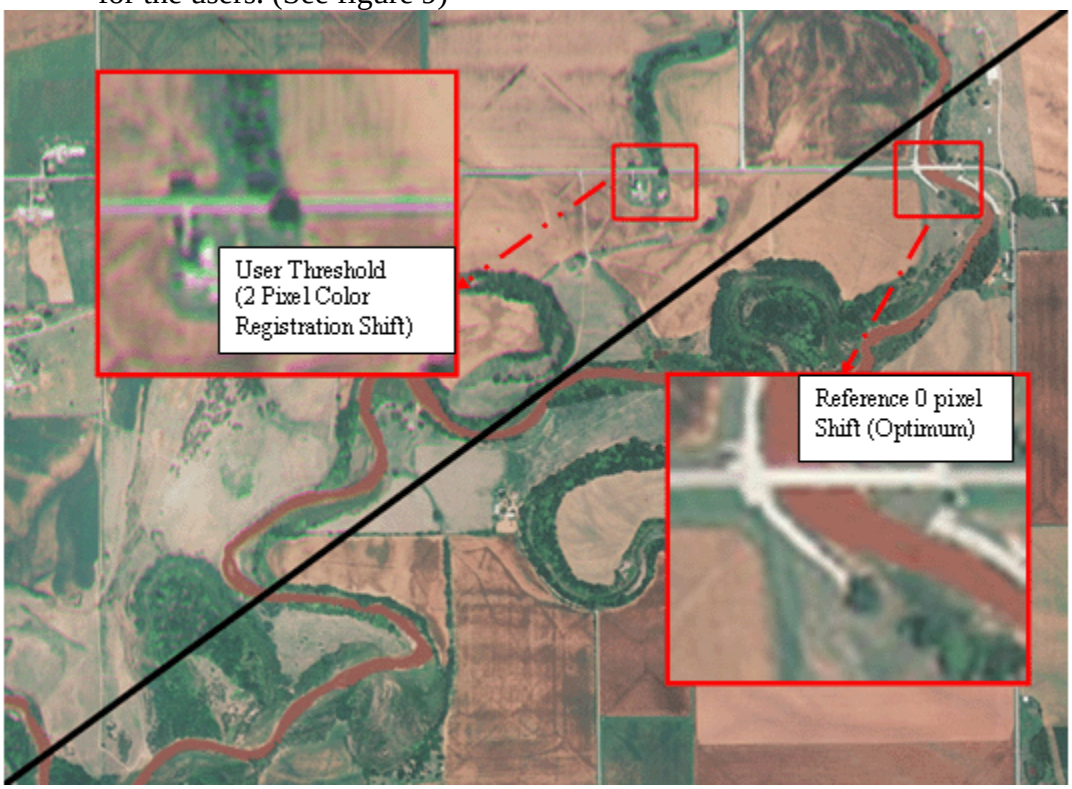


Figure 9. Illustration of color registration mismatch

2.3 Color Saturation Series

The results for the color saturation are given in Figure 10 and Table 7. The results are consistent for the common and regional images with the preference being for a saturation level equivalent to up to 25% higher than the reference. For both the common image and regional images, the mean rank of the reference through the 25% level is within the 95% confidence interval ranges. Both sets do show a trend towards decreasing preference at the 25% level, so the ideal is probably in the reference to 12.5% range.

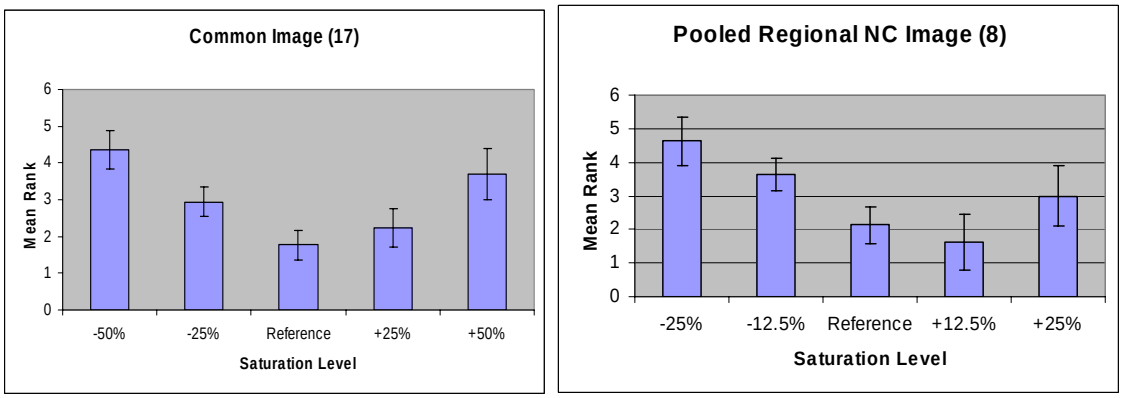


Figure 10. Mean Rank for saturation series of A) the common image shown to all test takers and B) the pooled results for the Utah and Kansas regional images natural color (NC) images.

Table 7. Mean ranks for the saturation level images

Image	Saturation Level	Mean Rank	Confidence Interval
common	-50%	4.35	0.42
	-25%	2.94	0.32
	reference	1.76	0.32
	+25%	2.24	0.44
	+50%	3.71	0.55
Pooled regional	-25%	4.63	0.74
	-12.5%	3.63	0.47
	reference	2.13	0.57
	+12.5%	1.63	0.83
	+25%	3.00	0.91
Texas CIR	-25%	3.38	1.48
	-12.5%	2.63	1.09
	reference	1.88	0.98
	+12.5%	3.00	1.43
	+25%	4.13	1.50

Figure 11 shows the results for the Texas color IR (CIR) regional image. While the natural color imagery shows a clear preference, the CIR image does not. This may be because the CIR imagery is inherently highly saturated due to the fact that foliage has a large IR reflectance. This produces a highly colored red image and therefore the variations are not as pronounced as for the natural color imagery that had a broader range of tones.

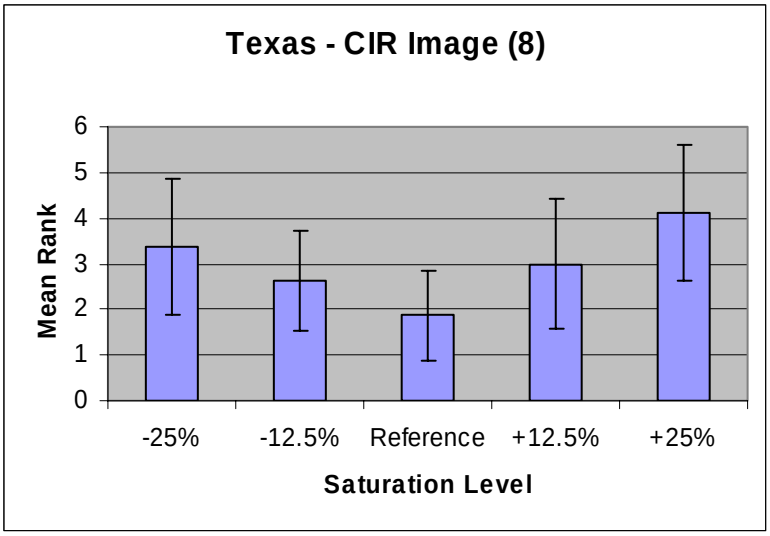


Figure 11. Mean Rank for CIR image saturation series

2.4 Color Balance Variations

According to the method described by Engeldrum, an interval scale was calculated by separating the results of the paired comparison tests into 4 categories:

- All paired comparison results for the Oklahoma image
- Paired comparison results for the local county image excluding Texas subjects
- Paired comparison results for the local county image for Texas subjects
- All paired comparison results excluding the observations of the Texas subjects for the local county image.

A 95% two-tailed confidence interval was calculated for each category using the method described by Montag. The results can be seen in Figures 12 through 15, respectively. The numerical results can be seen in Tables 8 through 11.

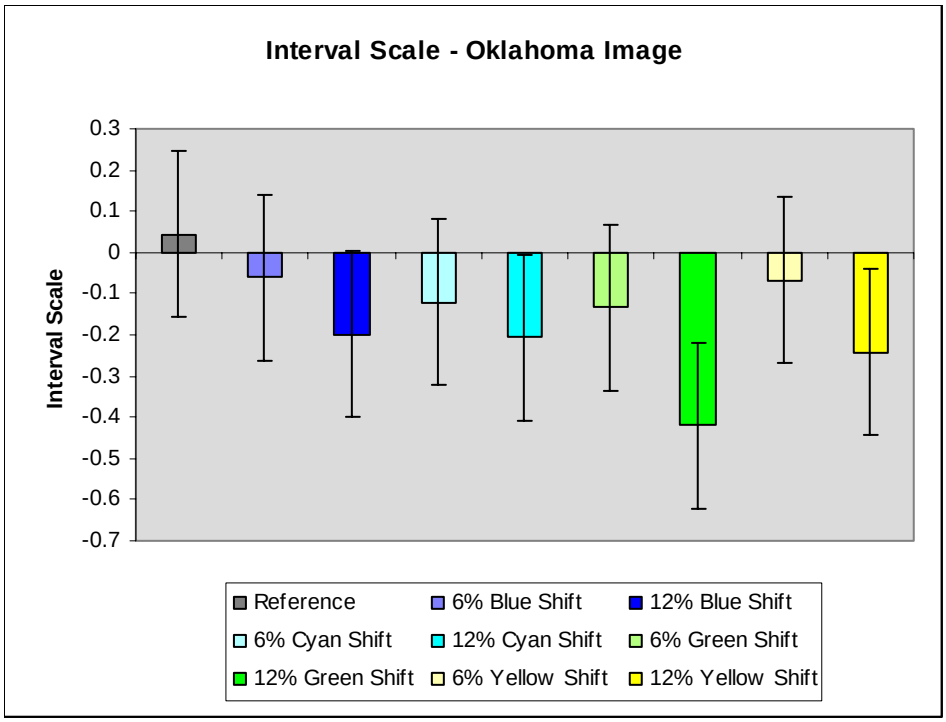


Figure 12. Interval scale for Oklahoma observations

Table 8. Interval scales for Oklahoma observations

Image	Scale Value	Confidence Interval (±)
Reference	0.04	0.20
6% Blue Shift	-0.06	0.20
12% Blue Shift	-0.20	0.20
6% Cyan Shift	-0.12	0.20
12% Cyan Shift	-0.21	0.20
6% Green Shift	-0.13	0.20
12% Green Shift	-0.42	0.20
6% Yellow Shift	-0.07	0.20
12% Yellow Shift	-0.24	0.20

As shown in Figure 12, the reference image was preferred the most. It is also important to note that the scale values for the small color shifts all lie within the error interval for the reference image. This could indicate that there is a tolerance for a color imbalance within an image. Moreover, when compared to the reference image, the large color shifts were disliked almost equally. The notable exception is the large green color shift. From spoken observations, the large green shift is indicative of a loss of contrast in the image, resulting in the lower preference.

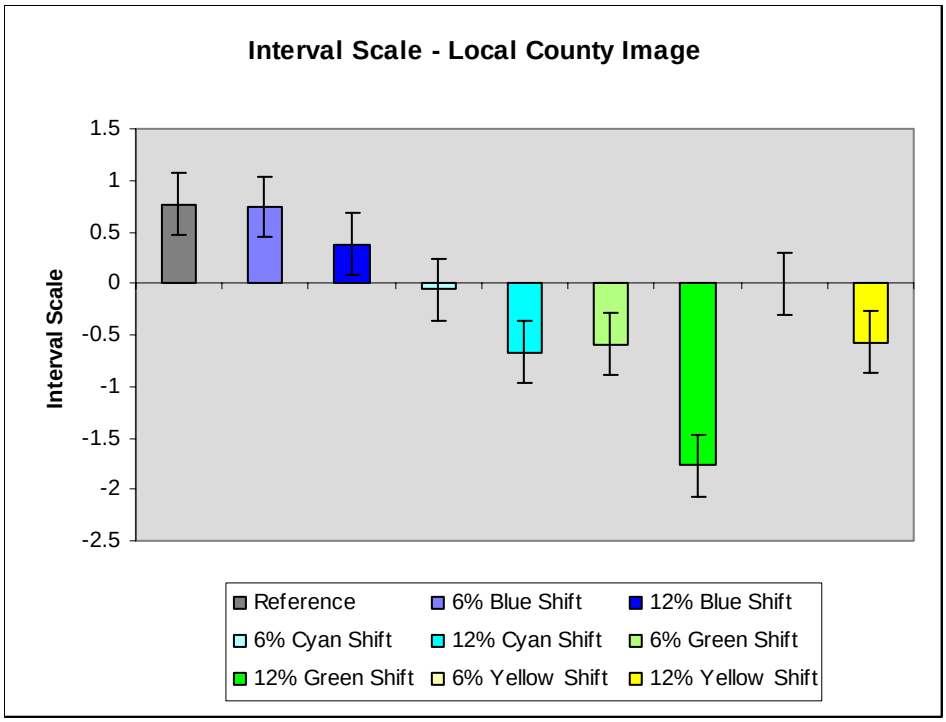


Figure 13. Interval scale for local county observations for natural color images

Table 9. Interval scales for local county observations for natural color images

Image	Scale Value	Confidence Interval (±)
Reference	0.77	0.30
6% Blue Shift	0.74	0.30
12% Blue Shift	0.38	0.30
6% Cyan Shift	-0.06	0.30
12% Cyan Shift	-0.67	0.30
6% Green Shift	-0.59	0.30
12% Green Shift	-1.77	0.30
6% Yellow Shift	0.00	0.30
12% Yellow Shift	-0.57	0.30

When considering results from the tests using natural color imagery, one sees that the small blue color shift was preferred just as much as the reference image. This could be explained by the slight yellow color shift present in the reference image. Some users would prefer the slight blue shift because that would counteract the original slight yellow shift, forming a more neutral image. After the reference image and small blue shift, the results become more differentiated. In order of most preference to least preference, users preferred a large blue shift, a small cyan and yellow shift, a small green and large cyan and yellow shift, ending with a large green shift.

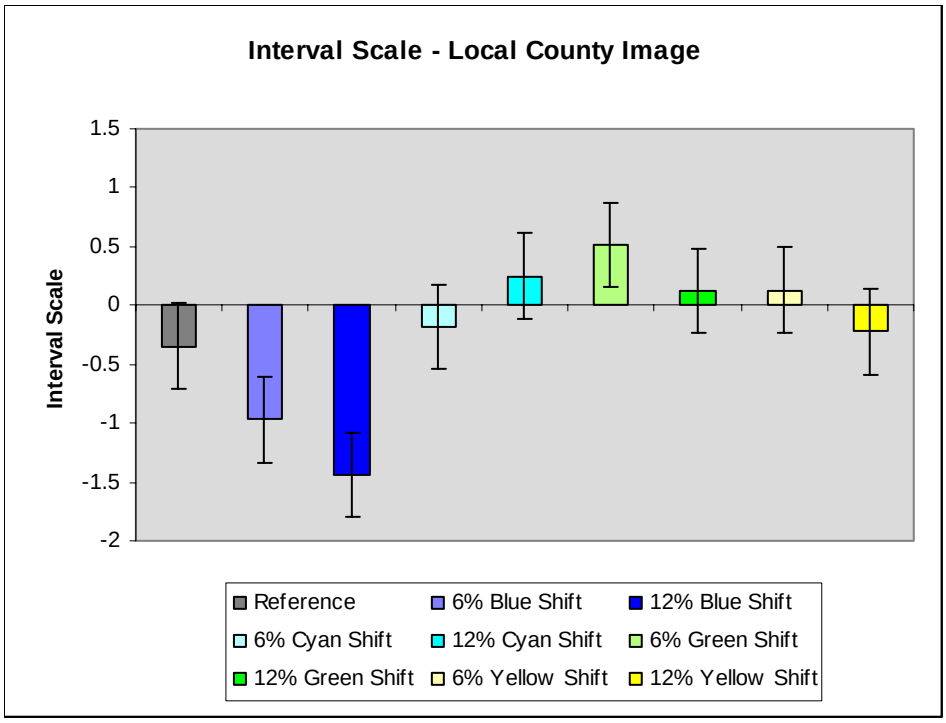


Figure 14. Interval scale for local county observations for color infrared images

Table 10. Interval scales for local county observations for color infrared images

Image	Scale Value	Confidence Interval (±)
Reference	-0.35	0.36
6% Blue Shift	-0.97	0.36
12% Blue Shift	-1.44	0.36
6% Cyan Shift	-0.18	0.36
12% Cyan Shift	0.25	0.36
6% Green Shift	0.52	0.36
12% Green Shift	0.12	0.36
6% Yellow Shift	0.13	0.36
12% Yellow Shift	-0.22	0.36

As stated before, the observer data from the color infrared images was kept separate from all other local county image data. It was unknown if the different analysis methodology for color infrared imagery would affect the results. From the results, one could definitively say that the results differed from other states. First, some color shifts were preferred over the reference image. This may be explained by an apparent reported increase in contrast of the color infrared imagery. From the data obtained, it was difficult to ascertain which color shift was preferred. However, it is clear that any blue shift is not preferable in the imagery. From spoken observations, imagery associated with a blue shift has lower contrast and makes a user's job more difficult.

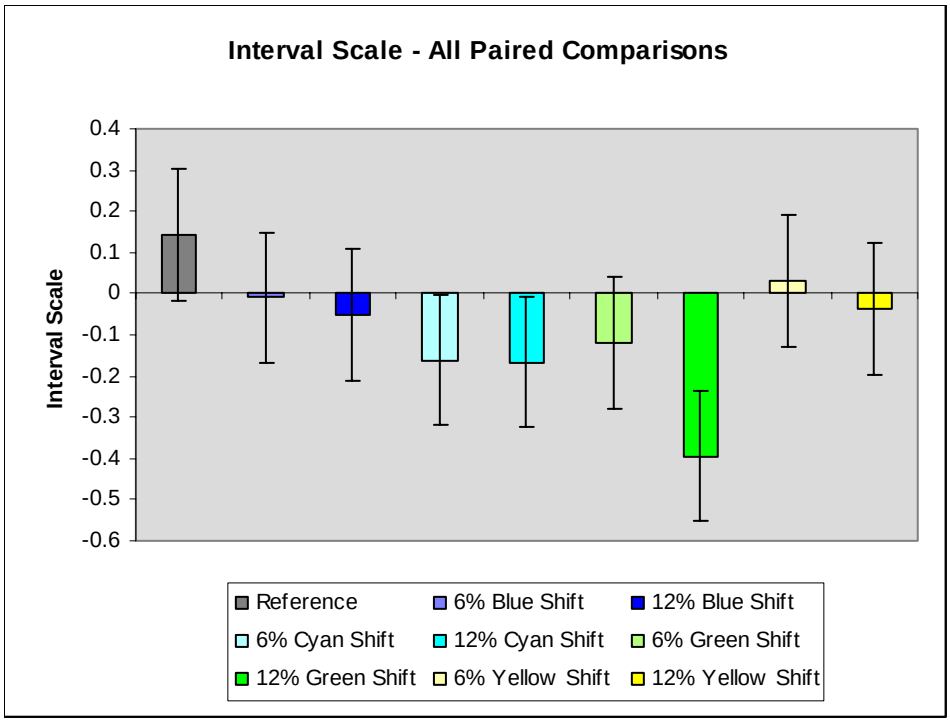


Figure 15. Interval scale for all paired comparison observations

Table 11. Interval scales for all paired comparison observations

Image	Scale Value	Confidence Interval (±)
Reference	0.14	0.16
6% Blue Shift	-0.01	0.16
12% Blue Shift	-0.05	0.16
6% Cyan Shift	-0.16	0.16
12% Cyan Shift	-0.17	0.16
6% Green Shift	-0.12	0.16
12% Green Shift	-0.39	0.16
6% Yellow Shift	0.03	0.16
12% Yellow Shift	-0.04	0.16

When all of the paired comparison observer data was combined, the reference was slightly preferred. Additionally, a small blue or yellow shift is within the error, indicating that there is a tolerance for this type of color imbalance. After the slight blue and yellow color shift, the large blue and yellow color shift was preferred just the same as cyan and small green color shifts. Coinciding with previous results, a large green color shift is not preferred.

2.5 Contrast and Clipping Variations

The mean rating for the six contrast variations, six clipping variations, and the reference are given in Table 12. The exact order varied somewhat depending how the images were pooled. However, some general trends are apparent. The reference image was never the

top ranked image; the higher contrast Sigma 5, 6, and 7 images occupied the top spots. The lowest even clipping level was ranked near the reference, the other clipping levels varied a bit by grouping, although the darkest images tended to fare worst. Some of the variability in judging was probably due to the variability in nominal clipping percent introduced as the result of the simulation algorithm. However, statistical analysis indicated that very little of the experimental results could be explained by which image was being judged. Consistently, the two lowest contrast Sigma 2 and 3 images were ranked at the bottom.

Table 12. Mean Rank of clipping and contrast variations for all natural color images, the Oklahoma common image, and the Regional images.

ALL		Common		Regional	
Variation	**Mean Rank**	**Variation**	**Mean Rank**	**Regional**	**Mean Rank**
Sigma 5	3.88	Sigma 6	3.85	Sigma 5	4.13
Sigma 6	3.77	Sigma 5	3.76	Sigma 6	3.44
Sigma 7	3.50	Sigma 7	3.62	Sigma 7	3.31
Clip at 1%,99% (even clip, low level)	3.25	Clip at 1%,99% (even clip, low level)	3.38	Sigma 4	3.25
Sigma 4	3.12	Clip at 0%,99% (highlight clip, low level)	3.18	Reference	3.13
Reference	3.10	Reference	3.09	Clip at 1%,99% (even clip, low level)	2.88
Clip at 0%,99% (highlight clip, low level)	2.88	Sigma 4	3.00	Sigma 3	2.88
Clip at 2%,100% (shadow clip, low level)	2.58	Clip at 0%,97% (highlight clip, high level)	2.65	Clip at 2%,100% (shadow clip, low level)	2.75
Clip at 0%,97% (highlight clip, high level)	2.46	Clip at 2%,98% (even clip, high level)	2.41	Clip at 0%,99% (highlight clip, low)	2.25
Clip at 2%,98% (even clip, high level)	2.38	Clip at 2%,100% (shadow clip, low level)	2.35	Clip at 2%,98% (even clip, high level)	2.25
Clip at 3%,100% (shadow clip, high level)	2.31	Clip at 3%,100% (shadow clip, high level)	2.18	Clip at 3%,100% (shadow clip, high level)	2.25
Sigma 3	2.23	Sigma 3	1.88	Clip at 0%,97% (highlight clip, high level)	2.13
Sigma 2	1.42	Sigma 2	1.41	Sigma 2	1.50

In order to determine which variations were statistically different, a Tukey analysis was performed. The results of this analysis are shown in Figure 16. Any points that are within a box are statistically equivalent and groups in overlapping boxes cannot be distinguished from each other. As can be seen, the only clearly distinct variations in preference are the group consisting of the reference and higher sigma values and a group consisting of the lower sigma values and the highest level of dark clipping.

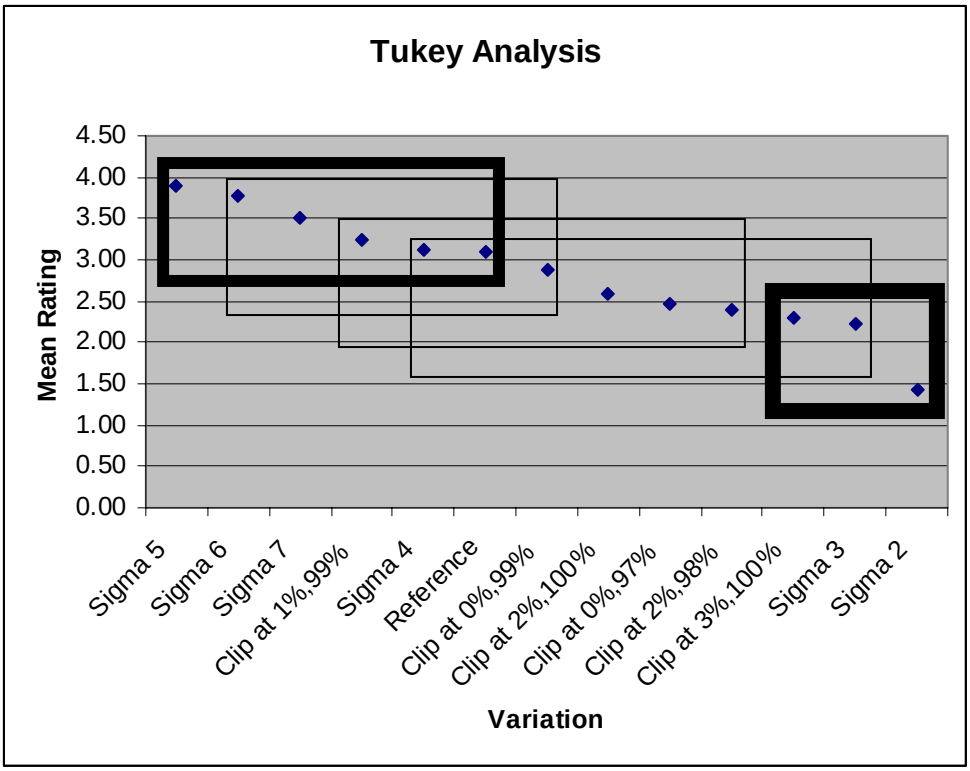


Figure 16. Results of Tukey analysis for clipping and contrast variations

The data was further analyzed by grouping the images by similar perceptual category. A high contrast group consisted of the Sigma 5, 6, and 7 images. A medium contrast group consisted of the Sigma 4, and low level of even clip (1%, 99%). A low contrast group consisted of the Sigma 2 and 3 variations and finally a loss-of-detail group consisted of the rest of the clipping variations. A Tukey analysis by group with respect to the reference determined that the high contrast group is preferred at a 95% confidence level over the reference, the medium contrast was equivalent, the loss-of-detail group was not preferred at a 95% confidence level and the low contrast group was less preferred than all other groups.

The comments made by users during the test were consistent with a preference for higher contrast imagery. This imagery was thought to be easier to find lines and field boundaries. The lower contrast images were frequently commented to be too hard to use without getting tired. The clipping variations did provide a higher contrast look, though at the expense of information loss in the shadow or highlight areas. There was a lot of variability in the user's judgments as to whether the clipped images were good because they had high contrast or bad because it was hard to see in the shadow or highlight areas.

For the CIR image, the preference was much less clear except that the lowest contrast image was not preferred. Intrinsically higher contrast imagery might explain the lack of clear preference for clipping level or contrast level. If CIR imagery were to be used more extensively, more investigation would be necessary to define the preferred tone scale type.

2.6 Workstation Setup

All workstations examined indicated an "out of the box" default set up. All were at 9300K color temperature, many at a fairly low refresh rate (60Hz). The 60Hz refresh can cause an obvious flicker to many users and eye strain when used over a long period of time.

The ambient light levels were higher than usually recommended for image viewing and the lighting was standard office fluorescent at between 4000-5000K color temperature rather than recommended 6500K.

The monitor responses are shown below in Figure 17. As is evident, there is no consistent response. This is to be expected as no calibration or verification program was used at any of the sites visited and monitors drift over time. The large variability in response produces a large variability in apparent image contrast. The above study results show a preference for higher contrast imagery. Viewing conditions that have a large amount of ambient glare and responses that are low in contrast will tend to negate improved image contrast and so minimize the benefit that processing improvements might give the end user.

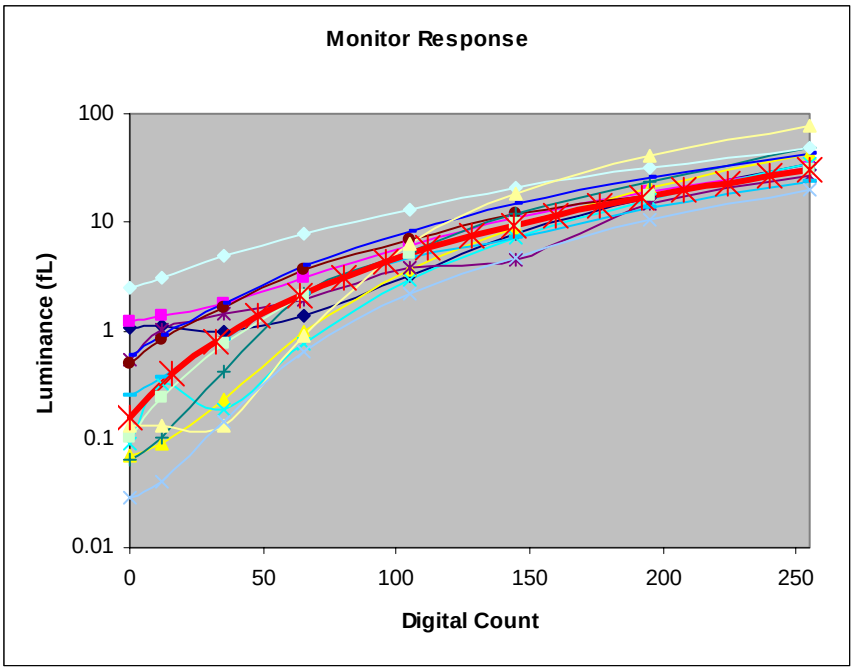


Figure 17. Monitor response from a seven point gray scale for all user sites visited. The thick red line is the aim used for the monitor provided for the user study.

3 Discussion and Recommendations

The results described above indicate that the users are most sensitive to attributes that affect the ability to quickly and easily discern boundaries and edges. They were less sensitive to attributes that might affect the overall look of the imagery, but did not inhibit boundary or edge determination. The optimum reproduction is one where colors and boundaries are most clearly delineated. This would mean higher contrast with minimal clipping and a moderately saturated and neutrally balanced image.

For the image problem series (noise, sharpness, color registration) natural color and color IR imagery gave equivalent results. However, for color (balance and saturation) and tonal variations, there were distinct differences in how the imagery was rated. The sample size was not large enough in this study to draw any firm conclusions, but it is evident that more detailed study would be required to determine optimum rendering of CIR imagery for use by FSA offices.

The impact of dealing with non-optimal imagery was re-iterated in the comments users gave as how hard it would be to find lines or to tell what crop was present without strain in problem images. Also, at sites that had received NAIP imagery that would be similar to the Sigma 2 variation or low saturation level, comments were made that they couldn't use the imagery for that year very much. By ensuring that this type of imagery does not reach FSA offices more accurate and efficient utilization of the imagery can be achieved.

In order to ensure that optimal imagery is received by NAIP, it is important that the image chain be optimized through its vendor partners. A set of recommendations will be provided in a subsequent report as to how to achieve this goal.

As well as ensuring optimum input, it was also apparent from the work done for this study that the output display systems need to be more optimized. The lack of consistent viewing environment and response contributes to not being able to utilize imagery effectively. Monitors were set up in environments with a large amount of screen glare and non-optimal settings. By seeking to minimize glare through more careful placement of the monitor and utilization of visors, using more optimal settings, and checking the monitor response on a periodic basis, the imagery users see will be more consistent, easier to glean information from, and viewing fatigue will be reduced.

Another output issue that was commented on at some of the sites was the difficulty of obtaining printed output that was consistent with the monitor. This problem can be addressed by first ensuring a stable and optimum monitor response and then by characterizing and maintaining the printer systems to ensure consistent output. Printer profiles could potentially be generated once the input (display) and output (printer) systems are known.

Overall, the users were very positive in their experiences to date with NAIP imagery. The work done for this study indicates that this imagery can prove to be even more valuable to the users by implementing practices that provide images of good contrast,

saturation, and balance on a consistent basis as well as ensuring the display allows the most information to be gained from the image.

4 References

Engeldrum, P. G. Psychometric scaling: a toolkit for imaging systems development. Winchester: Imcotek Press, 2000.

Falk, D., D. Brill, and D. Stork. Seeing the light: optics in nature, photography, color, vision, and holography. New York: John Wiley and Sons, 1986.

Montag, E. D. Empirical formula for creating error bars for the method of paired comparison. Journal of Electronic Imaging: 15, 1, 010502-1-3. (2006)

J. C. Leachtenauer, W. Malila, J. Irvine, L. Colburn, and N. Salvaggio, General Image-Quality Equation: GIQE , Appl. Opt. **36**, 8322-8328 (1997)

Appendix A – Reference Imagery Detail

State	DOQQ Name	DOQQ Number
Oklahoma	Verden NE	3509864.ne
New York	Mikado NE	4408329.ne
Utah	Brigham City NW	4111232.nw
Kansas	La Sita NW	3909633.nw
Texas	Hicks NW	3009625.nw

Appendix B – User Study Script

Initial Setup and Site Documentation

Set up the laptop and Dell LCD test monitor in a location that is away from windows and preferably in a place where the lights can be dimmed like a conference room. With the LCD off and the lights dimmed, measure and record the ambient light in the following areas:

Pointed at the screen
Pointed at the Keyboard/desk
Pointed at the Wall

At the users desktop PC also take these measurements:

Pointed at the screen (black flat panel or off)
Pointed at the Keyboard/desk
Pointed at the Wall

Record color temperature and type of ambient lights
Record Make and Model, and approximate age of Workstation monitor(s)

At the users desktop PC, display the "Grey Scale" target with the Viewer software and measure the 6 steps. Record the readings on the data sheet.

Record if a calibration software package is used and settings (e.g. *default*, custom settings if applicable).

Display the V T-8 target and record info on data sheet.

Record Monitor Settings on data sheet.

User Test Setup

1. Make sure the calibration LUT is loaded on the laptop (double click LutLoaderAutoDowload)
2. Launch VIEWER
3. Open up the "Task 1" folder on the CD and load all the images.

Intro Question

Read the following: *Today you will see images with varying levels of common problems which you may or may not have already encountered in NAIP imagery. We will ask your opinion of the images in regards to overall quality and usability for the type of tasks you perform in your job. This information will be used to improve the quality of the imagery delivered for future NAIP.*

What has been your overall impression to date of images you have received from NAIP?

Task 1 (Subjective Quadrant Set)

Display the first quandrant variation image. Show the test taker how to zoom and roam and let them do so if desired. Ask the following:

1) What is your overall impression of the image? How would you rank this for usability on a 1 to 5 scale? (Show the user the scale)

2) There are some non-uniformities introduced into the image. What kind of problems, if any, do you think this non-uniformity would present in your ability to use this image in your work?

3)What areas do you consider more usable?

4) What areas do you consider less usable?

If the test taker has trouble identifying regions that are lower quality, zoom in and go to different sections. Allow the test taker to zoom in and out if desired.

5) What would you do to try to correct the problems you see in this image?

6) How often do you see images with the same type of problem?

Task 2

1) Load in the noise series in Flicker Mode. Check that the images are in the correct order and the best (reference) image is displayed.

Read the following to the test taker:

Please roam through the image to find an area of interest and zoom to a magnification that would be similar to how you would normal use it. You will be shown a series of images that vary in the level of grain or noisiness in the image. Please choose a level where you would consider the imagery no longer usable for your application.

Record magnification level and rough area chosen by the test taker. Record image chosen. Load in the next OK image and repeat the judging, then repeat for the home county image.

2) Load in the reference image in the mis-registration series

Read the following to the test taker:

Please roam through the image to find an area of interest and zoom to a magnification that would be similar to how you would normal use it. You will be shown a series of images that vary in the level of mis-registration of the color records in the image. Please

choose a level where you would consider the imagery no longer usable for your application.

Record magnification level and rough area chosen by the test taker. Record image chosen. Load in the home county image and repeat the judging.

3) Load in the reference image in the sharpness series.

Read the following to the test taker:

Please roam through the image to find an area of interest and zoom to a magnification that would be similar to how you would normal use it. You will be shown a series of images that vary in the level of sharpness in the image. Please choose a level where you would consider the imagery no longer usable for your application.

Record magnification level and rough area chosen by the test taker. Record image chosen. Load in the home county image and repeat the judging.

4) Load in the reference image in the saturation series.

Read the following to the test taker:

Please roam through the image to find an area of interest and zoom to a magnification that would be similar to how you would normal use it. You will be shown a series of images that vary in the level of saturation or colorfulness in the image. For this series we will ask you to do something different then the previous series. Please rank them in order 1-5 with 1 being the best image and 5 being the worst image for overall usability.

Record magnification level and rough area chosen by the test taker. Load in the home county image and repeat the judging.

Task 3

Load the first image in the Clipping/Tone scale series into Flicker Mode. Read the following to the test taker:

Please roam through the image to find an area of interest and zoom to a magnification that would be similar to how you would normal use it. You will be shown a series of images that vary in the lightness, darkness, or contrast. Please rate each image on a scale of 1 to 5 for usability in the type of job you do where the numbers are defined as follows:

1 – Not Usable

This image would be difficult to get information from to do the type of job I do

2- Somewhat Usable

This image would provide some information with some effort, but is not what I'd prefer using.

3 – Usable

This image would provide the information for me to do the type of job I do, but could be improved

4- Very Usable

It is easy to find information in this image to do the type of job I do

5- Best Image

This image is optimum for finding information for the type of job I do. I'd like all images to look like this.

You may zoom in and zoom out as much as you'd like to make a judgment, but may only judge each image once.

Record the rating for each image in the series for the OK image and the home county image

Task 4

Load in the first pair sets into Flicker Mode. Make sure they are in order.

Read the following to the test taker:

You will be shown pairs of image that vary in their overall color balance. Please pick which image you prefer on the basis of what would be more usable for your job.

Circle the choice on the data sheet for each pair.

Final Questions:

1) Are there any problems that you commonly see that you don't think have been present in the images you saw today?

2) Do you have any examples of imagery you feel was particularly low quality and difficult to use?

If time and interest allow, do Task 5

Task 5

Take the top rated couple images for the home county from the Task 4 rating task and display them on the user's monitor. Ask them to re-rate the images on a 1-5 scale.

On the Dell reference monitor, load the same images and switch the aim to the IDEX aim, a Gamma 2.2 aim, the LDim Aim, then reset for a linear aim. At each point ask the user if they think the image is better or worse.

Comments:

Appendix C – User Study Datasheet Example (Texas)

Setup Info
Test Monitor Meaurements
Pointed at the screen _____fL
Pointed at the Keyboard/desk _____fL
Pointed at the Wall _____fL
User Monitor Measurements
Pointed at the screen (black flat panel or off) _____fL
Pointed at the Keyboard/desk _____fL
Pointed at the Wall _____fL
Color temperature of ambient lights_____
Type of ambient lights_____
Record Make and Model of Workstation monitor(s)_____
Approximate age of monitor? _____

Large Grey Scale measurements

Step	fL
1	
2	
3	
4	
5	
6	
7	
8	

Calibration software used? Y N

If yes record software package and settings (e.g. default, custom settings if applicable).

V T-8 target.
Can you see Delta 1 black? Y N
Delta 1 white? Y N
Delta 1 midscale gray? Y N
If no, record delta where score Brigg's score is greater than 4.

Monitor Settings:
Resolution_____
Refresh rate_____

True Color? Y N
Color Temp setting?_____
If LCD, check if screen is scaled, Y N Can’t tell

What has been your overall impression to date of images you have received from NAIP?

Task 1, Image 1_____(record name)

1) What is your overall impression of the image? How would you rank this for usability on a 1 to 5 scale? (Show the user the scale)

Comments

2) There are some non-uniformities introduced into the image. What kind of problems, if any, do you think this non-uniformity would present in your ability to use this image in your work?

Comments

3)What areas do you consider more usable?

Comments

4) What areas do you consider less usable?

Comments

5) What would you do to try to correct the problems you see in this image?

Comments

6) How often do you see images with the same type of problem?

Comments

Task1, Image 2_____(record name)

1) What is your overall impression of the image? How would you rank this for usability on a 1 to 5 scale? (Show the user the scale)

Comments

2) There are some non-uniformities introduced into the image. What kind of problems, if any, do you think this non-uniformity would present in your ability to use this image in your work?

Comments

3)What areas do you consider more usable?

Comments

4) What areas do you consider less usable?

Comments

5) What would you do to try to correct the problems you see in this image?

Comments

6) How often do you see images with the same type of problem?

Comments

Task1, Image 3_____(record name)

1) What is your overall impression of the image? How would you rank this for usability on a 1 to 5 scale? (Show the user the scale)

Comments

2) There are some non-uniformities introduced into the image. What kind of problems, if any, do you think this non-uniformity would present in your ability to use this image in your work?

Comments

3)What areas do you consider more usable?

Comments

4) What areas do you consider less usable?

Comments

5) What would you do to try to correct the problems you see in this image?

Comments

6) How often do you see images with the same type of problem?

Comments

Task1, Image 4_____(record name)

1) What is your overall impression of the image? How would you rank this for usability on a 1 to 5 scale? (Show the user the scale)

Comments

2) There are some non-uniformities introduced into the image. What kind of problems, if any, do you think this non-uniformity would present in your ability to use this image in your work?

Comments

3)What areas do you consider more usable?

Comments

4) What areas do you consider less usable?

Comments

5) What would you do to try to correct the problems you see in this image?

Comments

6) How often do you see images with the same type of problem?

Comments

Task 2

Noise Series

Image	ID for threshold	Mag/Comments
OK3509864	1 2 3 4 5	
Home County	1 2 3 4 5	

Misregistration Series

Image	ID for threshold	Mag/Comments
OK3509864	1 2 3 4 5	
Home County	1 2 3 4 5	

Sharpness Series

Image	ID for threshold	Mag/Comments
OK3509864	1 2 3 4 5	
Home County	1 2 3 4 5	

Saturation Series

Image	ID	Rank	Mag/Comments
OK3509864	1		
	2		
	3		
	4		
	5		
Home County	1		
	2		
	3		
	4		
	5		

Task 3

Image	Rating
OK3509864-1	1 2 3 4 5
2	1 2 3 4 5
3	1 2 3 4 5
4	1 2 3 4 5
5	1 2 3 4 5
6	1 2 3 4 5
7	1 2 3 4 5
8	1 2 3 4 5
9	1 2 3 4 5
10	1 2 3 4 5
11	1 2 3 4 5
12	1 2 3 4 5
13	1 2 3 4 5
Home county-1	1 2 3 4 5
2	1 2 3 4 5
3	1 2 3 4 5
4	1 2 3 4 5
5	1 2 3 4 5
6	1 2 3 4 5
7	1 2 3 4 5
8	1 2 3 4 5
9	1 2 3 4 5
10	1 2 3 4 5
11	1 2 3 4 5
12	1 2 3 4 5
13	1 2 3 4 5

Task 4

OK – 1

Pair Number	A	B	Choice	
1	'n_3509864_ne_y1.tif'	'n_3509864_ne_b1.tif'	A	B
2	'n_3509864_ne_y1.tif'	'n_3509864_ne_c1.tif'	A	B
3	'n_3509864_ne_y1.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
4	'n_3509864_ne_y1.tif'	'n_3509864_ne_g1.tif'	A	B
5	'n_3509864_ne_y1.tif'	'n_3509864_ne_g2.tif'	A	B
6	'n_3509864_ne_y1.tif'	'n_3509864_ne_c2.tif'	A	B
7	'n_3509864_ne_y1.tif'	n_3509864_ne_y2.tif'	A	B
8	'n_3509864_ne_y1.tif'	'n_3509864_ne_b2.tif'	A	B
9	'n_3509864_ne_b1.tif'	'n_3509864_ne_c1.tif'	A	B
10	'n_3509864_ne_b1.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
11	'n_3509864_ne_b1.tif'	'n_3509864_ne_g1.tif'	A	B
12	'n_3509864_ne_b1.tif'	'n_3509864_ne_g2.tif'	A	B
13	'n_3509864_ne_b1.tif'	'n_3509864_ne_c2.tif'	A	B
14	'n_3509864_ne_b1.tif'	n_3509864_ne_y2.tif'	A	B
15	'n_3509864_ne_b1.tif'	'n_3509864_ne_b2.tif'	A	B
16	'n_3509864_ne_c1.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
17	'n_3509864_ne_c1.tif'	'n_3509864_ne_g1.tif'	A	B
18	'n_3509864_ne_c1.tif'	'n_3509864_ne_g2.tif'	A	B
19	'n_3509864_ne_c1.tif'	'n_3509864_ne_c2.tif'	A	B
20	'n_3509864_ne_c1.tif'	n_3509864_ne_y2.tif'	A	B
21	'n_3509864_ne_c1.tif'	'n_3509864_ne_b2.tif'	A	B
22	'n_3509864_ne_14_2_20060512_20060717.tif'	'n_3509864_ne_g1.tif'	A	B
23	'n_3509864_ne_14_2_20060512_20060717.tif'	'n_3509864_ne_g2.tif'	A	B
24	'n_3509864_ne_14_2_20060512_20060717.tif'	'n_3509864_ne_c2.tif'	A	B
25	'n_3509864_ne_14_2_20060512_20060717.tif'	n_3509864_ne_y2.tif'	A	B
26	'n_3509864_ne_14_2_20060512_20060717.tif'	'n_3509864_ne_b2.tif'	A	B
27	'n_3509864_ne_g1.tif'	'n_3509864_ne_g2.tif'	A	B
28	'n_3509864_ne_g1.tif'	'n_3509864_ne_c2.tif'	A	B
29	'n_3509864_ne_g1.tif'	n_3509864_ne_y2.tif'	A	B
30	'n_3509864_ne_g1.tif'	'n_3509864_ne_b2.tif'	A	B
31	'n_3509864_ne_g2.tif'	'n_3509864_ne_c2.tif'	A	B
32	'n_3509864_ne_g2.tif'	n_3509864_ne_y2.tif'	A	B
33	'n_3509864_ne_g2.tif'	'n_3509864_ne_b2.tif'	A	B
34	'n_3509864_ne_c2.tif'	n_3509864_ne_y2.tif'	A	B
35	'n_3509864_ne_c2.tif'	'n_3509864_ne_b2.tif'	A	B
36	n_3509864_ne_y2.tif'	'n_3509864_ne_b2.tif'	A	B

OK - 2

Pair Number	A	B	Choice	
1	'n_3509864_ne_b1.tif'	'n_3509864_ne_c1.tif'	A	B
2	'n_3509864_ne_b1.tif'	'n_3509864_ne_y1.tif'	A	B
3	'n_3509864_ne_b1.tif'	'n_3509864_ne_y2.tif'	A	B
4	'n_3509864_ne_b1.tif'	'n_3509864_ne_c2.tif'	A	B
5	'n_3509864_ne_b1.tif'	'n_3509864_ne_g1.tif'	A	B
6	'n_3509864_ne_b1.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
7	'n_3509864_ne_b1.tif'	'n_3509864_ne_g2.tif'	A	B
8	'n_3509864_ne_b1.tif'	'n_3509864_ne_b2.tif'	A	B
9	'n_3509864_ne_c1.tif'	'n_3509864_ne_y1.tif'	A	B
10	'n_3509864_ne_c1.tif'	'n_3509864_ne_y2.tif'	A	B
11	'n_3509864_ne_c1.tif'	'n_3509864_ne_c2.tif'	A	B
12	'n_3509864_ne_c1.tif'	'n_3509864_ne_g1.tif'	A	B
13	'n_3509864_ne_c1.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
14	'n_3509864_ne_c1.tif'	'n_3509864_ne_g2.tif'	A	B
15	'n_3509864_ne_c1.tif'	'n_3509864_ne_b2.tif'	A	B
16	'n_3509864_ne_y1.tif'	'n_3509864_ne_y2.tif'	A	B
17	'n_3509864_ne_y1.tif'	'n_3509864_ne_c2.tif'	A	B
18	'n_3509864_ne_y1.tif'	'n_3509864_ne_g1.tif'	A	B
19	'n_3509864_ne_y1.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
20	'n_3509864_ne_y1.tif'	'n_3509864_ne_g2.tif'	A	B
21	'n_3509864_ne_y1.tif'	'n_3509864_ne_b2.tif'	A	B
22	'n_3509864_ne_y2.tif'	'n_3509864_ne_c2.tif'	A	B
23	'n_3509864_ne_y2.tif'	'n_3509864_ne_g1.tif'	A	B
24	'n_3509864_ne_y2.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
25	'n_3509864_ne_y2.tif'	'n_3509864_ne_g2.tif'	A	B
26	'n_3509864_ne_y2.tif'	'n_3509864_ne_b2.tif'	A	B
27	'n_3509864_ne_c2.tif'	'n_3509864_ne_g1.tif'	A	B
28	'n_3509864_ne_c2.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
29	'n_3509864_ne_c2.tif'	'n_3509864_ne_g2.tif'	A	B
30	'n_3509864_ne_c2.tif'	'n_3509864_ne_b2.tif'	A	B
31	'n_3509864_ne_g1.tif'	'n_3509864_ne_14_2_20060512_20060717.tif'	A	B
32	'n_3509864_ne_g1.tif'	'n_3509864_ne_g2.tif'	A	B
33	'n_3509864_ne_g1.tif'	'n_3509864_ne_b2.tif'	A	B
34	'n_3509864_ne_14_2_20060512_20060717.tif'	'n_3509864_ne_g2.tif'	A	B
35	'n_3509864_ne_14_2_20060512_20060717.tif'	'n_3509864_ne_b2.tif'	A	B
36	'n_3509864_ne_g2.tif'	'n_3509864_ne_b2.tif'	A	B

TX - 1

Pair Number	A	B	Choice	
1	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_c1.tif'	A	B
2	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_b2.tif'	A	B
3	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_y1.tif'	A	B
4	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
5	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
6	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
7	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
8	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
9	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_b2.tif'	A	B
10	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_y1.tif'	A	B
11	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
12	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
13	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
14	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
15	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
16	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_y1.tif'	A	B
17	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
18	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
19	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
20	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
21	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
22	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
23	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
24	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
25	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
26	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
27	'tx_cir_HicksNW_2M_c2.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
28	'tx_cir_HicksNW_2M_c2.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
29	'tx_cir_HicksNW_2M_c2.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
30	'tx_cir_HicksNW_2M_c2.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
31	'tx_cir_HicksNW_2M_ref.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
32	'tx_cir_HicksNW_2M_ref.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
33	'tx_cir_HicksNW_2M_ref.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
34	'tx_cir_HicksNW_2M_g1.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
35	'tx_cir_HicksNW_2M_g1.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
36	'tx_cir_HicksNW_2M_g2.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B

TX - 2

Pair Number	A	B	Choice	
1	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_c1.tif'	A	B
2	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
3	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
4	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_y1.tif'	A	B
5	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_b2.tif'	A	B
6	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
7	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
8	'tx_cir_HicksNW_2M_b1.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
9	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_g2.tif'	A	B
10	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
11	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_y1.tif'	A	B
12	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_b2.tif'	A	B
13	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
14	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
15	'tx_cir_HicksNW_2M_c1.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
16	'tx_cir_HicksNW_2M_g2.tif'	'tx_cir_HicksNW_2M_y2.tif'	A	B
17	'tx_cir_HicksNW_2M_g2.tif'	'tx_cir_HicksNW_2M_y1.tif'	A	B
18	'tx_cir_HicksNW_2M_g2.tif'	'tx_cir_HicksNW_2M_b2.tif'	A	B
19	'tx_cir_HicksNW_2M_g2.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
20	'tx_cir_HicksNW_2M_g2.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
21	'tx_cir_HicksNW_2M_g2.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
22	'tx_cir_HicksNW_2M_y2.tif'	'tx_cir_HicksNW_2M_y1.tif'	A	B
23	'tx_cir_HicksNW_2M_y2.tif'	'tx_cir_HicksNW_2M_b2.tif'	A	B
24	'tx_cir_HicksNW_2M_y2.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
25	'tx_cir_HicksNW_2M_y2.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
26	'tx_cir_HicksNW_2M_y2.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
27	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_b2.tif'	A	B
28	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
29	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
30	'tx_cir_HicksNW_2M_y1.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
31	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_ref.tif'	A	B
32	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
33	'tx_cir_HicksNW_2M_b2.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
34	'tx_cir_HicksNW_2M_ref.tif'	'tx_cir_HicksNW_2M_g1.tif'	A	B
35	'tx_cir_HicksNW_2M_ref.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B
36	'tx_cir_HicksNW_2M_g1.tif'	'tx_cir_HicksNW_2M_c2.tif'	A	B

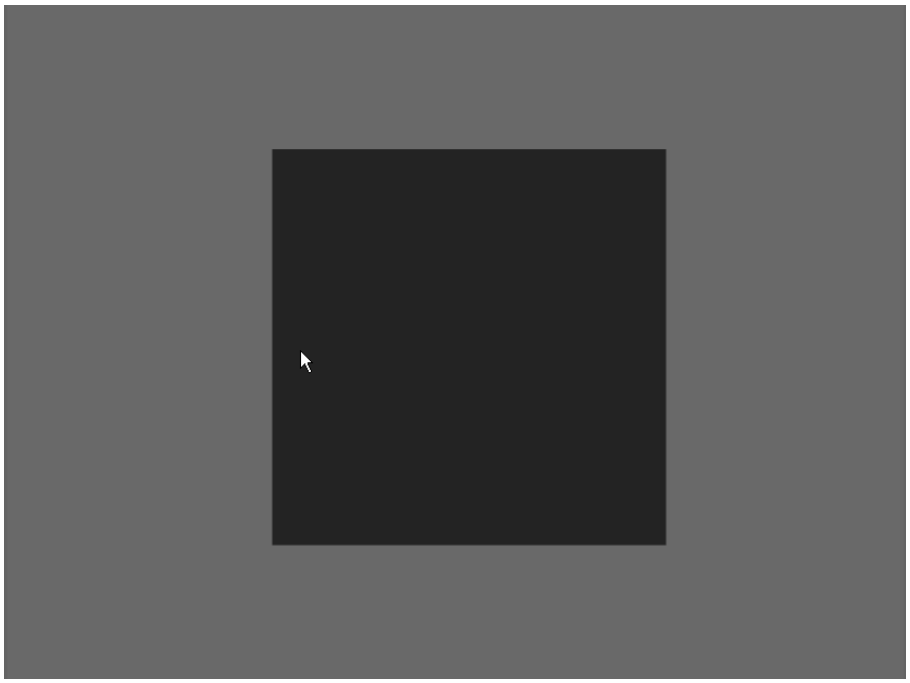
Task 5

IDEX Aim	Better	Worse
Gamma 2.2	Better	Worse
LDim	Better	Worse
Linear	Better	Worse

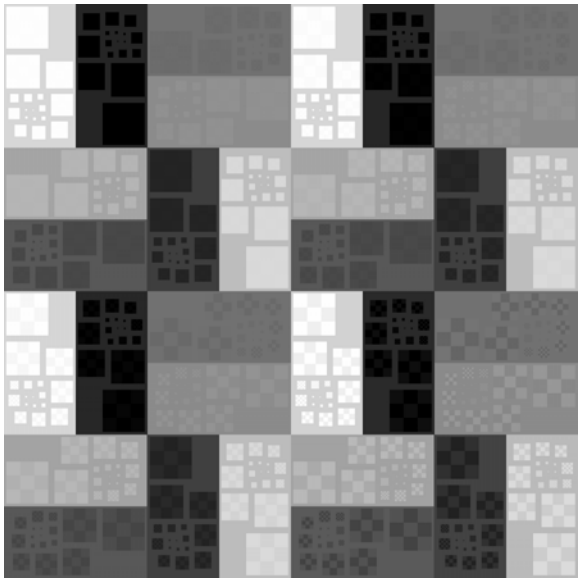
Question 1 Comments

Question 2 Comments

Appendix D. Monitor Characterization Target Examples



Typical target for measuring monitor response. For this study, eight targets were used with an internal square value of 0, 12, 35, 65, 105, 145, 195, and 255 digital code value.



A BTP#4 Briggs target used to test monitor resolution. The layout of this target was developed by Boeing Aerospace Company.(S. J. Briggs, Document D180-25066-1, January 1979)