GoldenThread™

The Gold Standard of image quality specification and verification

A Comprehensive Set of Image Quality Metrics …

GoldenThread™ is the product of years of research and development conducted for the Federal Agencies Digitization Guidelines Initiative*. Fully compliant with existing ISO standards, **GoldenThread™** measures:

- Grayscale and Color Response
- Resolution, Sampling Frequency, and Spatial Frequency Response (SFR)
- White Balance
- Color Channel Registration
- Noise
- Color Encoding Accuracy
- Lighting Uniformity

* For more information, visit: www.digitizationguidelines.gov/stillimages/organizations.html

… Designed for Digital Archiving

GoldenThread™ was designed to facilitate total image quality management in digital imaging workflows, and is ideally suited to work in libraries, museums, archives and galleries. Features include:

- Easy-to-use operator interface
- Simplified method to create, share, and test performance specifications (e.g. NARA guidelines, Metamorfoze, Geheugen van Nederland)
- Pass/Fail reporting based on user defined test profiles
- Automatic mode for batch processing
- Data stored to Microsoft Excel® and Access® facilitating trend analysis and forecasting

The GoldenThread™ System - Targets

GoldenThread™ includes two targets for two distinct situations: (1) fully qualifying an imaging *device* such as a camera or scanner and (2) capturing information during the digitization event of an *object*. The **device** target has expanded functionality to maximize the information for a system. The **object** target captures critical information with the smallest footprint possible to enable its integration into an actual workflow.

Target Design

- ✓ Slanted-edge resolution features are created on high-resolution silver halide paper by **Applied Image**, the world leader in image quality targets.
- ✓ Sheets of Munsell color patches are purchased directly from **X-Rite**, laser-cut and assembled below the surface to protect them from damage.
- ✓ Target components are mounted on anodized aluminum sheets to maintain flatness and protect the targets from damage
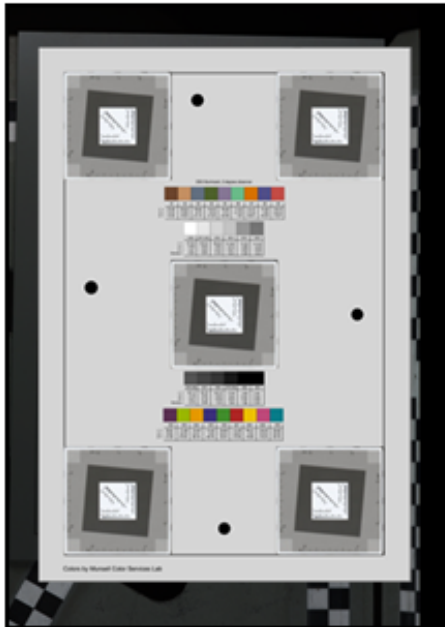
Target used for full Field-of-View
Image Quality Analysis
"Device-Level Target"

Target used for *In-situ*
Image Quality Analysis
"Object-Level Target"

The GoldenThread™ System - Software

GoldenThread™ software can accept images with either object or device-level targets in the image. Operators simply select a region around the target to start analysis. If targets are placed consistently, automatic mode can be used to process images without user input. Setting up test parameters and measurement aims is facilitated with a profile setup wizard to guide operators.

Software Design

- ✓ **LabVIEW**'s powerful imaging library has been leveraged with **Excel** and **Access** programs to optimize the program's utility and stability
- ✓ Built-in feature detection greatly simplifies operator involvement
- ✓ Fully documented with online Help screens to guide users through the analysis process and provide in-depth test descriptions.
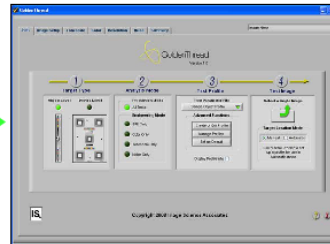
The Graphical User Interface was designed so operators can confidently run the software "out of the box". Test results are displayed clearly.

User Interface Front Panel

Open Image

Select Region

Pass/Fail Summary
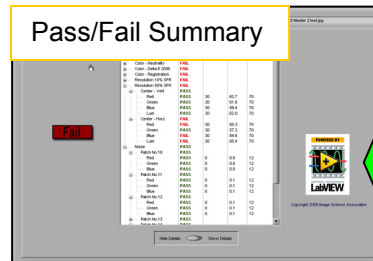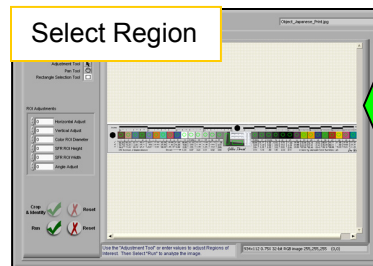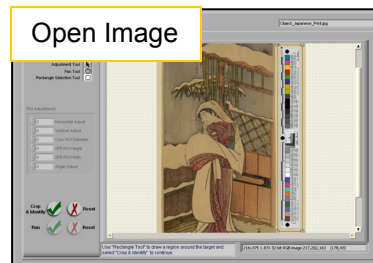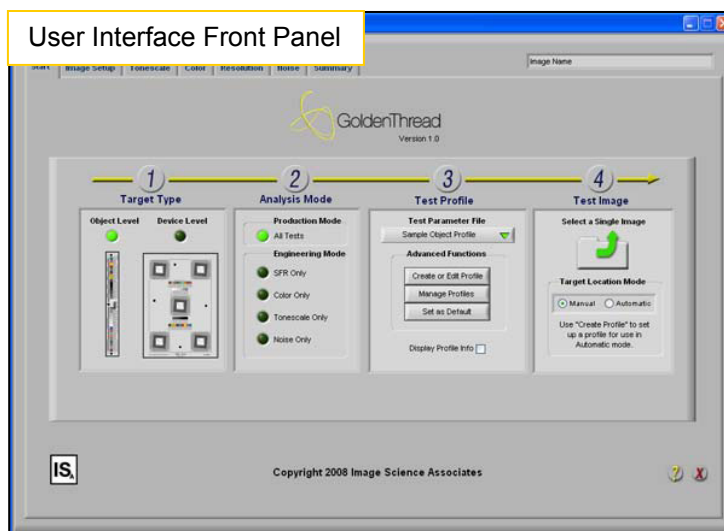
GoldenThread™ is increasingly accepted as the measurement and communication standard for image quality among all components of the digital archiving industry.
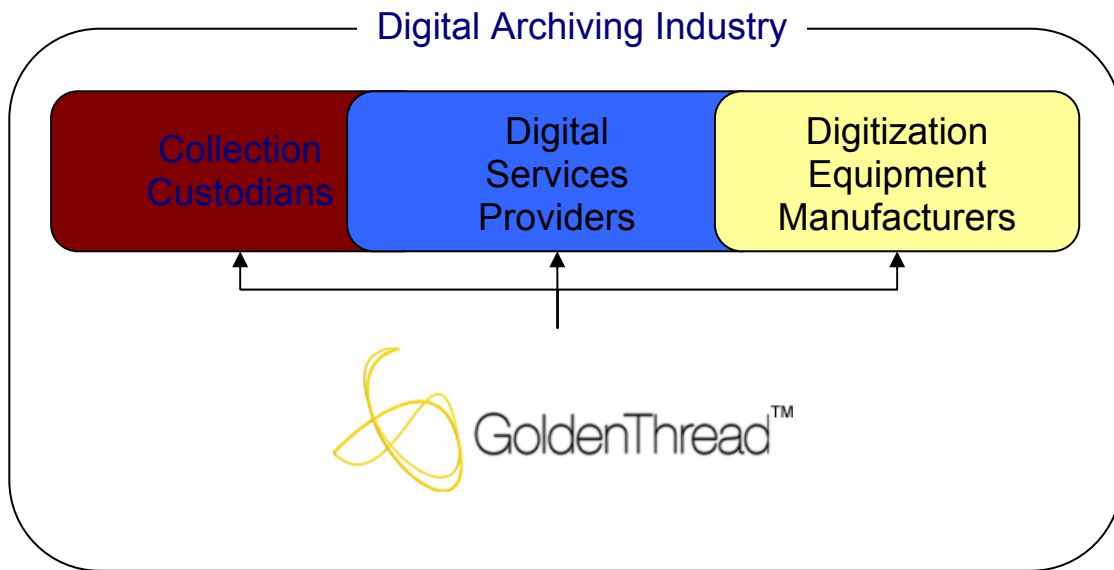
Collection Custodians: Specifying the use of GoldenThread™ with your suppliers and using it to verify compliance of the received product will ensure that your collections are properly preserved for future use. Don't get stuck with a collection of digital images that are out of focus, noisy or off color. We provide a method to quantify your specifications and communicate them clearly to your suppliers.
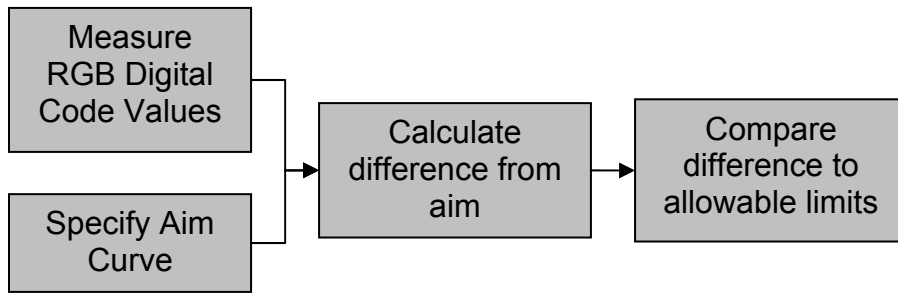
Digital Services Providers: GoldenThread™ reduces the ambiguity of the quoting process by explicitly communicating image quality specifications. With GoldenThread, you'll reduce cost and rework by ensuring that the job is done right the first time. Just as important, GoldenThread™ is used for quality control throughout the production process. At the end of a job, you'll be able to prove 100% compliance to your customer specifications.

Digitization Equipment Manufacturers: Accurately assessing your system components for Spatial Frequency Response, noise and tonescale will allow you to fit the cost of your product to the needs of the customer. You will be able to demonstrate that a customer's image quality performance specifications are achievable with your equipment. You'll reduce time spent on customer assistance, align your products more accurately to customer needs and your customers will be confident that your equipment is up to the task.

Tonescale Analysis

Achieving the desired tonescale in a system and making sure it stays on aim are critical components of image quality. GoldenThread™ goes beyond just measuring and reporting the RGB values. We allow an aim curve to be specified with custom limits to explicitly measure if a system meets specification.

Measure RGB Digital Code Values		
Specify Aim Curve	Calculate difference from aim	Compare difference to allowable limits

Built-in NARA and UCB aims allow for quick analysis against these standards. Or build a custom aim using our gamma, gain and offset adjustments

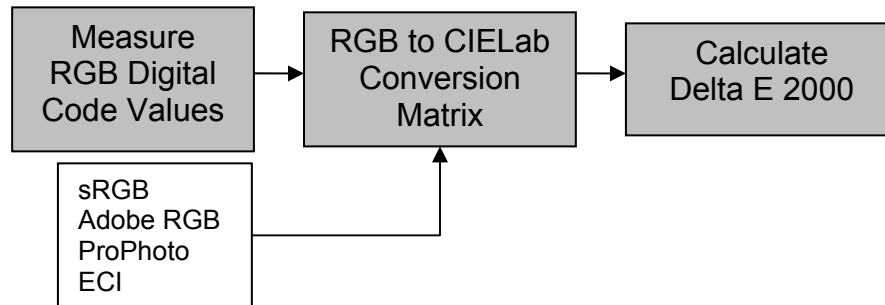12 neutral patches offer an expanded, more detailed mapping of the Tonescale response of your system.

Munsell	Patch	Density
N 9.5		0.04
N 9		0.09
N 8.5		0.15
N 8		0.22
N 7		0.36
N 6		0.51
N 4.75		0.75
N 3.75		0.98
N 2.75		1.24
N 1.75		1.67
N 1		2.04
N 0.5		2.42
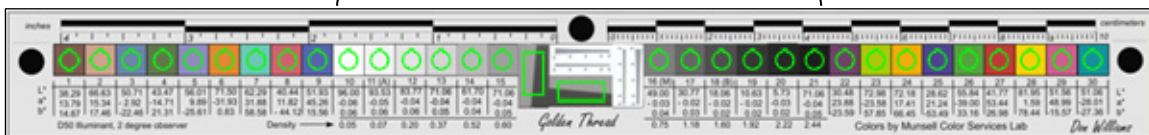
Color Analysis

GoldenThread™ includes the most advanced methods to analyze the color accuracy of a system. This involves converting the captured RGB digital values from the scanner to L*a*b* and calculating the difference in color from the known L*a*b* using the "Delta E 2000" method.

```
┌─────────────────┐    ┌─────────────────┐    ┌─────────────────┐
│    Measure      │    │  RGB to CIELab  │    │                 │
│  RGB Digital    │──▶ │   Conversion    │──▶ │   Calculate     │
│  Code Values    │    │     Matrix      │    │  Delta E 2000   │
└─────────────────┘    └─────────────────┘    └─────────────────┘
       ┌─────────────────┐      ▲
       │    sRGB         │      │
       │   Adobe RGB     │──────┘
       │   ProPhoto      │
       │    ECI          │
       └─────────────────┘
```

The key step in this process is the conversion of RGB to L*a*b*, which requires the color model and lighting conditions to be specified for your specific capture system. Using the tonescale and color techniques enabled by GoldenThread™, you can be confident that your system is performing to world-class standards.

Our targets include a wide gamut of colors representing flesh tones, foliage, and sky as well as standard color patches.
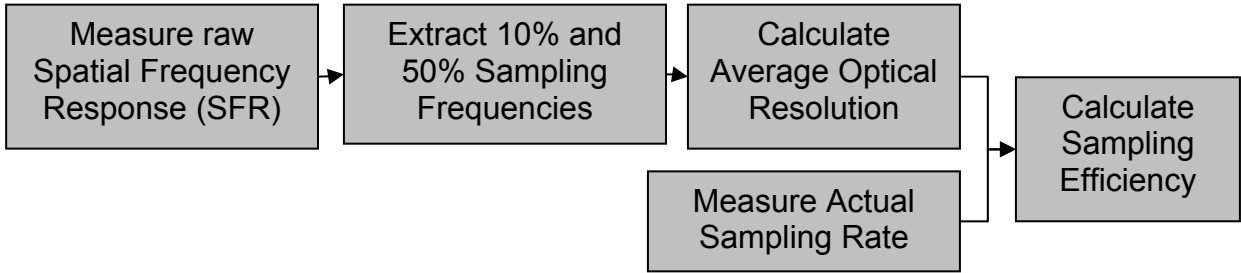
Munsell	Color	L*	a*	b*
3YR		39.12	13.24	15.07
2.2YR		65.43	18.11	18.72
4.3PB		49.87	-4.34	-22.29
6.7GY		44.26	-13.80	22.85
9.7PB		55.56	9.82	-24.49
2.5BG		70.82	-33.43	-0.35
5YR		63.51	34.26	59.60
7.5PB		39.92	11.81	-46.07
2.5R		52.24	48.55	18.51
5P		31.41	20.98	-19.43
5GY		72.46	-24.45	55.93
10YR		72.95	16.83	68.80
7.5PB		29.37	13.06	-49.49
0.25G		54.91	-38.91	30.77
5R		43.96	52.00	30.01
5Y		82.74	3.45	81.29
2.5RP		52.79	50.88	-12.72
5B		50.87	-27.17	-29.46

Color accuracy for a system is specified by setting the maximum allowable Delta E for any patch and the maximum allowable *average* Delta E for all 30 patches.   Calculated L*, a*, b* as well as Delta E values are all stored to the database for each image.
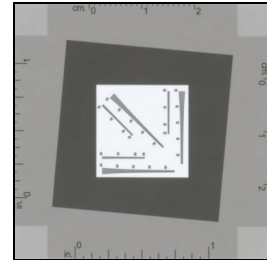
Resolution Analysis

GoldenThread™ has implemented ISO 12233 for the measurement of resolution. Since this specification was authored by Don Williams, we are confident in its correct implementation. Both targets are measured for horizontal and vertical resolution for all color channels.

Measure raw Spatial Frequency Response (SFR)	→	Extract 10% and 50% Sampling Frequencies	→	Calculate Average Optical Resolution	
				Measure Actual Sampling Rate	→ Calculate Sampling Efficiency

In order to specify resolution performance, Spatial Frequency Response (SFR) curves are analyzed for 10% and 50% frequency positions. These are further distilled to the average optical resolution and, finally, the sampling efficiency is calculated based on the measured spatial resolution of the image.

Resolution features for both targets include visual analysis checks to allow crossover from existing methods.

Raw SFR curves are displayed and saved to Excel for all ten features of the device target and both features of the object target
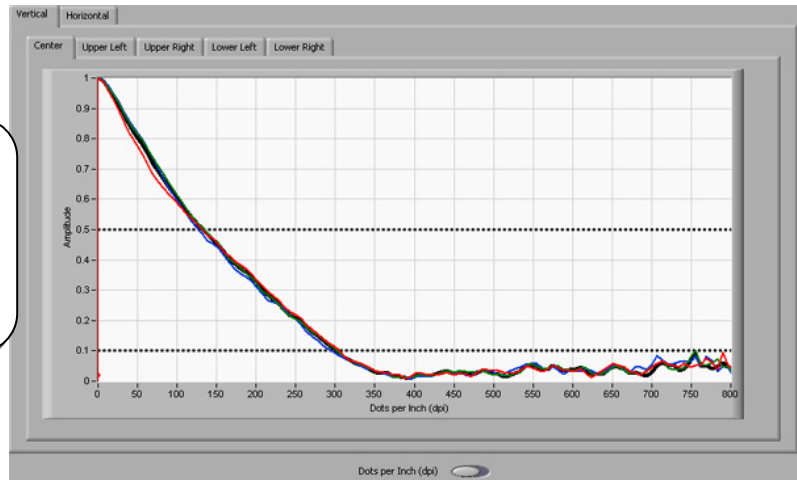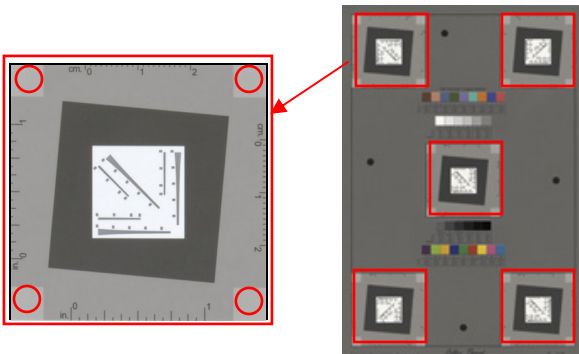
Registration Analysis

Registration
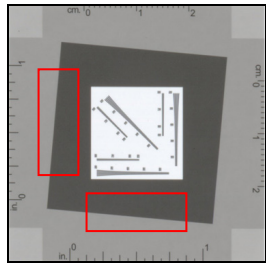
Registration of the color planes are performed as part of the resolution analysis. The degree (in pixels) to which the red and blue planes are not co-planar with the green plane is reported as mis-registration. Aims are set for both horizontal and vertical directions in units of pixels.

Uniformity Analysis

Uniformity is measured on the device-level target only. Four patches are measured for each of the five resolution feature locations. The peak difference is the ratio of the difference between the lightest and darkest patches to the average of all patches. Uniformity is calculated for red, green blue and visual channels

Neutrality and Noise Analysis

For each of the twelve neutral patches, neutrality and noise are measured and compared to specifications. Neutrality is measured as the difference in average code value between the green channel and the red or blue. Noise is the standard deviation of the code values in these same areas.
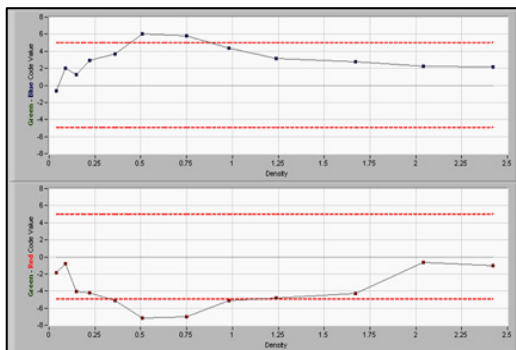
Neutrality
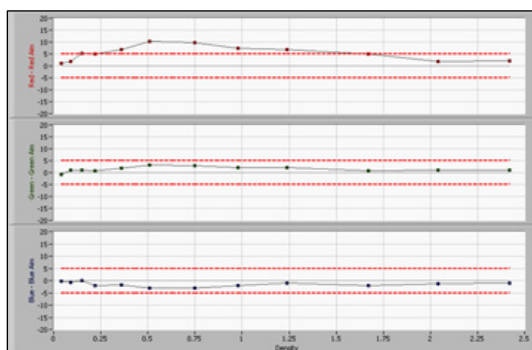
Noise

Data are saved to a Microsoft Access database to facilitate quality control analysis. The database has a user interface that allows users to quickly filter, extract and plot data. For additional analysis or to generate reports, filtered data can be exported to Excel.

Data can be sorted (filtered) based on the information provided in the test profile, such as camera, operator, system description or date range.

Viewing raw data in tabular form allows for inspecting exact measurement values. These data values can be exported to Excel for further analysis.


Viewing the data in a chart allows for quick confirmation that critical performance characteristics are not drifting out of specification.

Data from each image is also saved to individual Excel files. This is done to capture raw data, such as the SFR curves, that don't fit the database model and also to record acceptance limits for a particular scan. Each file is built from an Excel template with charts that replicate the GoldenThread user interface. Aims are also included from the selected profile.
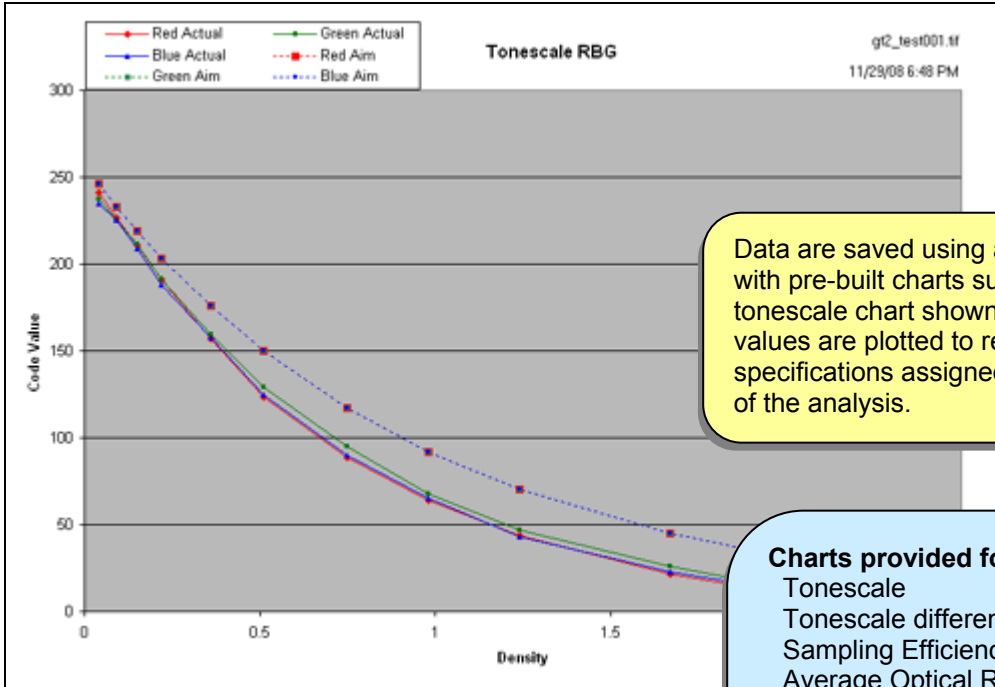
Data are saved using a template with pre-built charts such as the tonescale chart shown here. Aim values are plotted to record the specifications assigned at the time of the analysis.

Charts provided for:
Tonescale
Tonescale difference from aim
Sampling Efficiency
Average Optical Resolution
10% SFR Summary
50% SFR Summary
Delta E 2000
Luminance
Noise
Registration
Neutrality
All SFR Curves
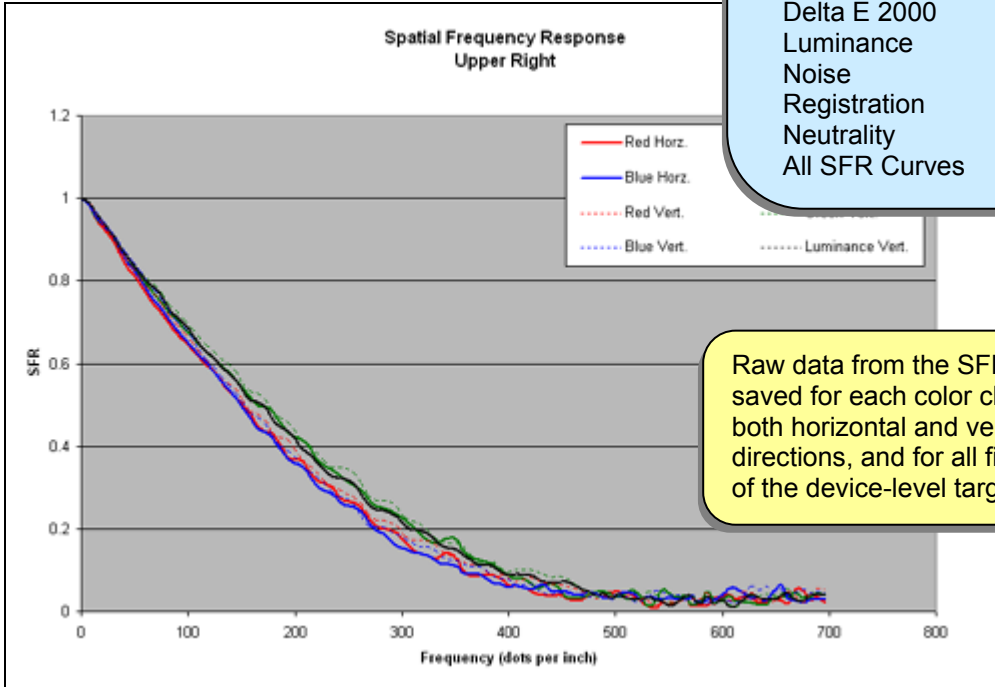
Raw data from the SFR analysis are saved for each color channel, in both horizontal and vertical directions, and for all five locations of the device-level target.

Interested?

Visit our website at
www.ImageScienceAssociates.com to
sign up for an informational Webex seminar.

Or call us tool free at1-888-801-6626

Other Products from Image Science Associates

Micro and Nano Color Palettes

The Micro-Check Color Palette Kit includes two 30-patch color targets and analysis software. These targets are intended for extremely small field-of-view applications where color accuracy is required. The colors are identical to those used in the GoldenThread system.

Target sizes are: 1 5/8" x 1 3/8" and 9/16" x 13/16"

Individual SFR Targets

This stand-alone system measures the resolution and SFR metrics from individual SFR targets (4) supplied with the kit. This kit is especially useful for evaluating resolution over large fields of view (A2 – 4A0) where resolution is likely to vary significantly. The operator places multiple targets anywhere in the field they wish to evaluate.

X-Large and X-small Object Targets

Object level targets are also available in 4.6" and 18.5" width versions for extra-small and extra-large fields of view.   These targets are identical to the standard object target except for their size.