Profile Mechanic - Scanner 1.0

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Introduction

Profile Mechanic - Scanner is a program for creating custom ICC color profiles for scanners and digital cameras.

Using a custom profile helps ensure accurate color and tonal reproduction when you scan photographic prints or tranparencies. Using a custom scanner profile takes the guesswork out of scanning and gives you accurate results every time without having to adjust curves or make color corrections.

Custom profiles for digital cameras can help you reproduce color accurately, but to make this work you must use the same lighting and camera settings (exposure, saturation, contrast, white balance, color space etc.) when photographing the test target as when photographing the subjects for which you want to use your profile. This makes digital camera profiles most useful for studio work, duping transparencies, copying artwork using a copy stand, table top or catalog photography, or other situations where lighting and exposure are carefully controlled.

A scanner profile is created by scanning or photographing a test target which has a number of color and gray patches each of which has been accurately measured with a spectrophotometer. The RGB values produced by the scanner or digital camera are then combined with reference values for the test target to produce a profile that a color management system can use to convert digital images from your input device to a standard color space.

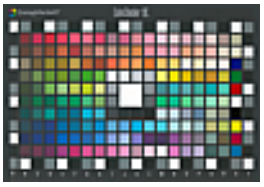
To make use of the color profiles *Profile Mechanic* generates, you need an image editing program such as Adobe's Photoshop or our Picture Window that supports color management.

Test Targets

A test target is the key to making a scanner or digital camera profile. *Profile Mechanic* currently supports four types of test targets:

IT8

HCT



ColorChecker DC

ColorChecker

Test targets are fragile and should be handled with care and kept clean. Avoid contact with the color patches, place it in its sleeve when not in use, and store it in a cool, dry dust-free location. Do not leave a transparency test target on a light table for any length of time as it may fade.

IT8

IT8 test targets have been an industry standard for quite a few years, and are manufactured by several sources including the major film suppliers: Kodak, Agfa and Fuji. They contain a large number of gray and color patches, are reasonably priced, and readily available in both print and transparency film versions from a number of suppliers. IT8 targets always come have an associated reference file that contains precise measurements of each color patch—you will need this reference file to create your profile. IT8 targets are a good choice for profiling transparency and flatbed scanners.

Macbeth ColorChecker DC

The ColorChecker DC is a new target designed especially for profiling digital cameras. One nice feature of this target is that there are redundant white patches around the edges and in the center that can be used to check for non-uniform lighting.

Macbeth ColorChecker

The original ColorChecker has been around for many years. You can make an adequate scanner or camera profile using it, but a target with more color patches may produce better results. ColorCheckers are available in a large 9”x12” version and in a convenient miniature version which is very convenient for field work.

ColorCheckers are made by applying specially prepared permanent pigments to a rigid cardboard backing. For this reason reference files are not required as there is little variation among targets. The rigid backing makes ColorCheckers easier to handle and lets them stand up by themselves. In addition, the pigmented surfaces are less shiny than printed IT8 targets and thus photograph with fewer reflections. For these reasons, ColorCheckers are a good choice for camera profiling. Wolf Faust also makes a letter-size IT8 target printed on matte paper with a rigid backing that is considerably less expensive than the ColorChecker DC.

HCT

The HCT from Hutcheson Consulting (www.hutchcolor.com) is the ultimate test target for high end scanners. It has more than twice the number of patches as an IT8 and comes in a variety of formats and media. Like the ColorChecker DC, it has redundant white patches around the edges and in the center to check for uneven lighting.

Color Negative Film

For a variety of reasons, no test targets are available for color negative film and it is not possible to use color negative film in a color managed environment.

Preparation

Before you can create a scanner or digital camera profile, you need to scan or photograph your test target and save the image as a TIFF file. Preparation is a little different for scanners and digital cameras.

Scanning your Test Target

Before you start, make sure your test target is clean.

If you are using a flatbed scanner, first clean the scanner glass; if you are using a film scanner, give it a blast of compressed air—this will save time later. retouching the image.

Set your scanner software to make no automatic adjustments to the color, contrast or brightness of the image. Also, make sure color management is turned off.

Scan using the maximum bit depth your scanner supports. Some scanners can produce 48-bit color scans (16 bits per channel) while others, even if they internally scan at more than 8 bits per channel can only save 24-bit color images (8 bits per channel). You will get better results profiling with 16 bits per channel than with 8.

Select a scanner resolution that yields at least 1000-pixels across the longer dimension of the part of the image covered by the target.

The profile generated from the scan will only work for subsequent scans made using the same identical bit depth, color, contrast and brightness settings you use to scan the target, so make sure you record this information for future reference.

If you are profiling a transparency scanner, you will get more accurate results if you use a test target made using the same film type you will be scanning - use a Kodak target for Ektachromes or a Fuji target for Velvia/Provia/Astia/Sensia. The differences are subtle, but worth taking into account if you want the most accurate possible results.

If you are profiling a flatbed scanner, if you can, place a sheet of black paper, cardboard or velvet behind your test target covering the entire scanner bed. This helps reduce brightness variations resulting from flare light reflected from the white underside of the scanner lid.

Once you have captured a good image of your test target, use your image editing software to clean up any dirt or scratches as any nonuniformity in the color patches can result in incorrect readings.

Finally save the file in TIFF format with a name that includes the type of scanner or camera, any custom settings, and the date. *Profile Mechanic* can read either 24-bit or 48-bit color TIFF files.

Photographing your Test Target

Before you start, make sure your test target is clean.

Strictly speaking, the profile you create will only be valid for the exact lighting conditions and camera settings in effect when you photographed the target. A camera profile created with the correct white balance setting for the light illuminating the test target will however be more or less generic for the camera. Getting a good image from a test target is a lot harder with a digital camera than with a scanner. Here are some of the variables you need to control:

Uniform Lighting

The entire target must be evenly lit. Photographing the target under sunlight or an overcast sky is a good way to get uniform lighting. It is very hard to get uniform lighting indoors or with a flash. Try to avoid placing the target near bright objects that may be reflecting light onto the target.

White Balance

The color temperature of the light illuminating the target must be consistent with the white balance setting of your camera. If you use a copy stand with tungsten lights, make sure you use the corresponding white balance setting on your camera. If you shoot outdoors, it makes a big difference if the target it is in the sun, in the shade, if it is overcast, or if it is near sunrise or sunset.

Reflections

Avoid reflections from the target. In particular, do not use an on-camera flash as it will produce a hot spot in the center of the image.

Distortion

If the image of the target is too distorted, *Profile Mechanic* may have problems reading some of the color patches. A little care when photographing the target will save a lot of trouble later. If necessary, keep the target flat by taping its corners to a

flat surface, but be careful not to get tape near any of the color patches. Line up the camera square with the target, and center the target in the viewfinder. Avoid using wide angle zoom settings as they are prone to barrel distortion. Unless you have a low resolution camera (which will probably not profile very well anyway), don't try to fill the frame with the target as this will produce more distortion than using just the central area. This will also minimize any light falloff in the corners of the frame. Try to get 1000-2000 pixels across the target. Don’t save the image as a JPEG - use TIFF or some other uncompressed file format.

Exposure

The image of the test target needs to have reasonable values for the darkest and lightest patches. The lightest patch should come out slightly darker than pure white and the dark patch a little lighter than pure black. Try bracketing your exposures and select the one that keeps the gray patches centered in the tonal range. Once you get a good exposure, use your image editing software to expand the dynamic range of the image to run all the way from full black to full white.

Sharpening

Turn off in-camera sharpening.

Clean-up

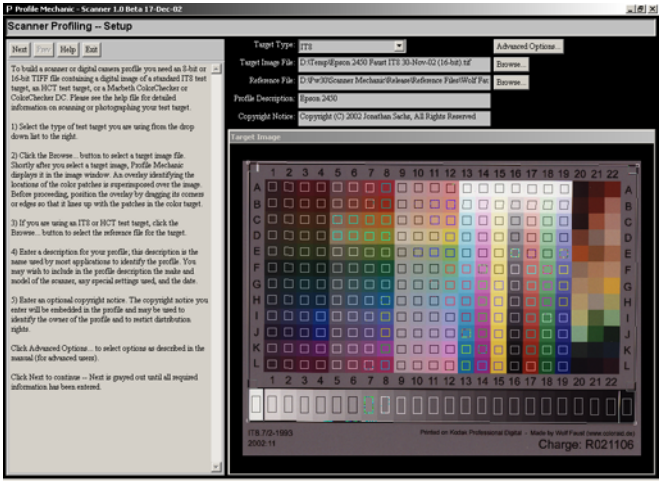
Once you have captured a good image of your test target, use your image editing software to clean up any specks in the image.

Save the TIFF file

Finally save the file in TIFF format with a name that includes the type of scanner or camera, any custom settings, and the date. *Profile Mechanic* can read either 24-bit or 48-bit color TIFF files.

Using Profile Mechanic

Armed with your target image file, you are ready to create a profile, so start up *Profile Mechanic*. It will display the following screen:



While you can resize the main window if you wish, *Profile Mechanic* is designed to run maximized to use the full screen. Instructions are displayed in the panel at the left. The controls in the upper right panel let you select or enter the information necessary to build a profile:

Target Type

The Target Type drop down list lets you select the type of target you are using (*IT8*, *ColorChecker DC*, *ColorChecker* or *HCT*). If you select one of the ColorCheckers, the *Reference File* control is automatically filled in as the reference files for these targets are built into *Profile Mechanic*.

Advanced Options

When you click the *Advanced Options...* button, *Profile Mechanic* displays its *Advanced Options* dialog box. The available options are described in Appendix C of this manual. In most cases the best results will be obtained with the default settings.

Target Image File

Click the *Choose...* button to select the image of your test target. Shortly afterwards, the image will be displayed in the window below.

Target Image Overlay

Once you select a target image, an overlay is displayed superimposed on the image indicating the locations of the gray and color patches. It is important that you select the correct *Target Type* (see above) so that the overlay matches the target image. Before proceeding, align the overlay with the patches in the target image. You can adjust the overlay by dragging its corners, edges, or its interior. Examples of proper alignment for each target type are given below:

Reference File

If you are using an *IT8* or *HCT* target, click the *Choose...* button to select the reference file for your target. It is very important to use the correct reference file for your target. Your target should be labeled with a batch number that identifies the

corresponding reference file. *Profile Mechanic* comes with a collection of reference files that were available at the time the software was released, but if you have a more recent target, its reference file may not be included. In this case you should either have a reference file that came with your target or you should be able to download one. The following table lists locations on the internet from which you can download reference files for certain test targets:

Kodak IT8	ftp://ftp.kodak.com/gastds/q60data
Wolf Faust IT8	http://www.targets.coloraid.de
HCT	http://www.hutchcolor.com/HCT_data.htm

Profile Description

The description you enter here will be embedded in the profile you create. Most color management applications identify profiles by their description and not by their filename, so be sure to enter enough information in the description so you can recognize your profile later. At a minimum you should include the make and model number of your scanner or camera. You might also want to include the date and any special conditions under which the target image was created.

A profile description is required and the *Next* button remains grayed out until you enter one.

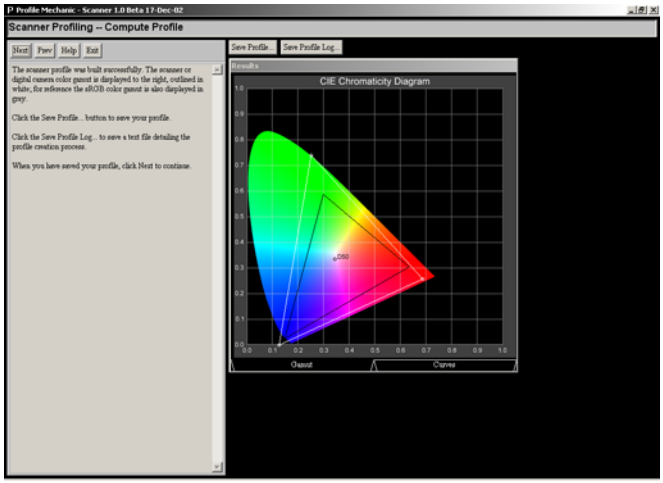
Copyright Notice

A copyright notice is optional. You may choose to include a copyright notice if you need to establish legal ownership of the profile you are creating or to limit its redistribution rights.

When you have entered all the necessary information, click the *Next* button at the top of the instructions panel to compute the profile and continue to the next screen.

Computing the Profile

If everything is OK, *Profile Mechanic* computes the profile and displays the results in a screen such as the following:

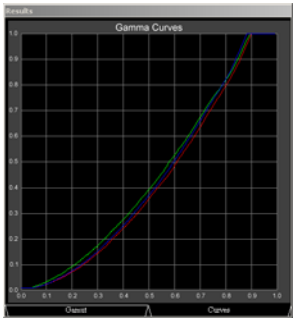


If errors are detected while computing your profile, *Profile Mechanic* displays an error message and returns to the previous screen. The most common problem is misalignment of the overlay or some other problem that makes one or more of the color or gray patches non-uniform. If this occurs, problem patches will be identified with an X on the overlay when you return.

Once your profile has been computed, *Profile Mechanic* displays a diagram illustrating the color gamut of your scanner or camera as a white triangle. For reference purposes, the *sRGB* color gamut is displayed as a dark gray triangle.

Using the tabs at the bottom of the *Results* window, you can also switch the display from the scanner gamut to the gamma curves that linearize the scanned data (see below). It is a good idea to check these curves to make sure they are smooth as irregularities in the curves may indicate problems with the gray patches in the tar-

get. If this occurs, you may want to check one of the *Smooth Gamma Curves* radio buttons in the *Advanced Options* dialog box and rebuild the profile.



To save your profile, click the *Save Profile...* button and select a pathname for your profile. By default, the profile will be saved in your system profile folder so it can be used by other programs.

To save a detailed report of the profile generation process as a text file, click the *Save Profile Log...* button and select a pathname for your report. For information on profile logs, see Appendix A.

Once you have saved your profile, click *Next* to return to the startup screen from which you can build additional profiles if desired or click *Exit* to terminate *Profile Mechanic*.

System Requirements

Profile Mechanic can create profiles for RGB flatbed or film scanners or digital cameras. It does not support CMYK scanners.

Operating System

Windows 95/NT or later (this includes Windows 95, 98, 98 SE, ME, NT, 2000 and XP).

Mac OS/9 or OS/X.

Appendix A - How to Read the Profile Log

The profile log is a text file containing detailed information about the profile you just created. The information in the log is organized as follows:

Date -- the date the log was created.

Target Type -- the type of target used to create the profile.

Description -- the profile description.

Copyright -- the profile copyright notice.

Red, Green and Blue Primaries

Estimated CIE XYZ and CIE xy values for the red, green and blue primaries are given. The CIE xy values define the vertices of the gamut triangle displayed in the chromaticity diagram in the *Results* window. The white point for scanner profiles is always specified as D50.

The reported primary values are estimates and not direct measurements as there is no way to create a test target with pure red, green and blue color patches—consequently the values may not be accurate and should only be used for making relative comparisons between different scanners. In addition, slightly different values are computed depending on whether you use a CIE XYZ or a CIE Lab model. While scanner primaries are included in the scanner profile, they do not affect conversions from the scanner color space to the working color space as this is done using lookup tables.

Dmin and Dmax RGB values

These are the measured RGB values of the darkest and lightest gray patches in the target on a scale from 0.00% (black) to 100.00% (white).

For scanners, the Dmax value should be a little above 0.00% and the Dmin should be a little below 100.00%, indicating that none of the gray patches has been clipped. Since the darkest patch generally reflects (for flatbed scanner) or transmits (for a film scanner) some light, its measured value will usually not be 0%. Similarly, the lightest patch will absorb some light and its measured value will not be 100%. This is perfectly normal and not a cause for concern. If you are seeing values of 0% or 100%, this means that you are losing some shadow or highlight detail and need to rescan. As long as you leave the *Stretch Contrast* option on, the profile will handle the determination of the correct black and white points automatically.

For digital cameras, the situation is more complicated since an outdoor scene may include deep shadows that are darker than the darkest target patch or highlights lighter than the lightest patch. For studio photography, this should be less of a problem as the range of densities of the target should be representative of subject brightness values. In any case your target image should have Dmax at or very close to 0.00% and Dmin at or very close to 100.0%. If not, go back and adjust the target image to use the full range from pure black to pure white.

White, Gray and Black RMS Nonuniformity.

These are measures of the variability of the redundant white, gray and black patches scattered around the target (ColorChecker DC and HCT only). Values greater than 5% to10% indicate uneven target illumination.

Gray and Color Uniformity, Regression errors, and Delta E

These tables list the RMS uniformity, regression errors, and Delta E for each gray and color patch in the target.

The regression error is only reported for CIE XYZ profiles and corresponds to the RMS error in XYZ between the measured target values and those predicted by the regression model. When creating CIE Lab profiles, the regression error and Delta E are the same thing.

If the uniformity error for a given patch is large (> 5%), this indicates that the image of that patch may be noisy, include specks or be uneven for some reason.

The regression error indicates how far the measurement of a given patch differs from the predicted value based on the regression model. A large number (> 5%) may indicate some nonlinearity in the scanner, a problem reading the patch, uneven target lighting, problems with the spectral properties of the scanner light source, or simply an inconsistency between the target and the reference file. These inconsistencies can arise from variations among individual targets in a batch, aging of the target, dirt on the target, or abrasion of its surface. In some cases, regression errors are reduced considerably when creating a custom reference file by measuring all the patches with a spectrophotometer, or by using a different target with a more accurate reference file. This means that errors may be a result of target inconsistency and not scanner nonlinearity. For this reason, *Eliminate All Residuals* (see Appendix C) is turned off by default since there is no point in modelling errors in the reference file. If you are using a custom measured reference file, you may want to select *Eliminate All Residuals* to increase the accuracy of the profile. In this case, *Profile Mechanic* still reports the regression errors from the regression model even though these are all reduced to zero in the final profile.

Even if your target has a few regression errors in the 5-10 Delta E range, this does not mean there is anything significantly wrong with the profile your created as the regression process averages the response over all the patches and normally still produces very accurate results even if a few errors are large. Errors larger than 10-20 Delta E may indicate a some kind of problem with the input image, reference file, target or scanner.

The Delta E values represent the color differences between the values predicted by the regression model and the reference values expressed in standard CIE Lab ΔE units. Delta E values may be larger or smaller than the regression errors which are the errors in the CIE XYZ color space due to differences in the way these color spaces are defined.

Appendix B - Error Messages

This section lists *Profile Mechanic* error messages listed alphabetically and explains what they mean and what you can do about them.

Cannot profile negative images

If *Profile Mechanic* determines that the brightness of the gray patches is reversed, it assumes you are attempting to create a profile using a negative image which is not supported.

Illegal reference file: <pathname>

Before reading a reference file, *Profile Mechanic* does a few simple tests to see if it is a valid file. If these tests fail, this message is displayed indicating that an improper or corrupted reference file has been specified or that the reference file is for a different type of target than the one you have specified.

Nonuniform target illumination detected

Some targets include redundant white, gray and black patches in various locations intended to be used as a check for nonuniform target lighting. *Profile Mechanic* examines these patches and issues this warning if it finds significant variation among these extra patches. If you are profiling a digital camera, this may indicate that the target was unevenly lit when you photographed it. If you are profiling a scanner, it may indicate that the scanner light source is not uniform over the scanning area. This is a warning and not a fatal error.

One of more gray patches not in increasing brightness order. Target lighting may be uneven.

Profile Mechanic examines the gray patches in the target to make sure the measured values of each progressively lighter patch are higher than those of the previous patch. If any of the values is out of sequence, this may indicate that the target was unevenly illuminated or that the target image is noisy. For targets such as the HCT which has many very closely spaced gray patches, this is not uncommon. If you are getting this warning, try selecting one of the *Smooth Gamma Curves* options in *Advanced Options* (see Appendix C) to reduce noise in the gray measurements.

Regression error

The regression process *Profile Mechanic* performs to attempt to model the scanner's response has failed. Normally this means there is a serious problem with the target image file or the reference file. If both files are OK, you can try changing to a different regression model (see Appendix C).

Some gray or color patches are non-uniform. Bad patches will be identified with an X when you click OK.

Profile Mechanic samples each color patch at 111 different points and averages the results. It also computes the standard deviation of the measurements and displays this error when that values exceeds a preset threshold. Generally patches may be nonuniform if the target image has dirt on it or if the image is unusually noisy. If the image is basically OK, you can increase its uniformity by applying a median or blur to it using your image editing software and retrying.

Target file is not a 24-bit or 48-bit color image: <pathname>

The target image must be scanned as a 24-bit or 48-bit color TIFF file. This error indicates that the image needs to be rescanned using the proper settings.

Appendix C - Advanced Options

This section describes the options available in *Profile Mechanic*'s *Advanced Options* dialog box.

Regression Model

Regression Color Space (*Use CIE XYZ / Use CIE Lab*)

ICC scanner profiles can use either of two color spaces: CIE XYZ or CIE Lab. As a rule, CIE Lab is the preferable choice as it more closely models the characteristics of the human visual system, and thus the Lab equivalents of two colors whose XYZ values are very close can be much further apart. For this reason, regression using CIE Lab color space tends to produce smaller errors as measured in units of Delta-E which is a mathematical approximation of visual difference.

Regression Type (*Linear / Quadratic / Cubic*)

Profile Mechanic can perform linear, quadratic or cubic regression to model the behavior of the input device. If the test target has a sufficient number of color patches and the reference file is accurate, cubic regression will produce the most accurate results. The *Macbeth ColorChecker* target does not have enough patches to perform meaningful cubic regression. When this target is selected, quadratic regression is used when you specify cubic.

Residual Handling (*Eliminate All Residuals*)

Normally a profile's color lookup tables are generated by using a linear, quadratic or cubic model of the response of the scanner or digital camera. In most cases, the regression model, especially cubic regression, is a close approximation to the measured color response. You can check how well the model fits the data by looking at the *Delta-E* errors in the profile log. If all or nearly all the values are small (less about 2.0 or 3.0), the regression model is a good fit to the measured data. If any values are larger, this means either that the values in the reference file do not correspond accurately to the target or that the scanner or digital camera has nonlinear characteristics that are not fully modelled.

When you select *Eliminate All Residuals*, *Profile Mechanic* applies a nonlinear model to the residual errors from the regression model when creating the profile. This distorts the color lookup tables in the profile so as to precisely match all patches in the target to their corresponding reference values, but can introduce artifacts in the profile if the regression errors are due to inconsistencies between the target image and the reference file or if you are using a target with a small number of patches.

Stretch Target Image Contrast

When *Stretch Target Image Contrast* is checked, the target image data corresponding to the *Dmin* and *Dmax* gray patches in the target are adjusted to run from pure black to pure white. Unless you are profiling a digital camera it is recommended that you leave this setting unselected.

If you are profiling a digital camera, you should select this option if you want the range of brightness values represented by the target to use the full range from black to white.

Stretch Reference Data Contrast

When *Stretch Reference Data Contrast* is checked, the *Dmin* and *Dmax* gray patches in the target are adjusted to run from pure black to the D50 white point. In most cases it is recommended that you leave this setting selected.

If you have reason to believe that the *Dmin* and *Dmax* patches do not represent the darkest and lightest possible image data for a given scanner or digital camera, you can turn off *Stretch Reference Data Contrast* and *Profile Mechanic* will use unadjusted values to compute the profile. The resulting profile will then not use the full range from 0% to100% when applied to the target image.

Smooth Gamma Curves

When *Smooth Gamma Curves* is selected, the sequence of measured gray patches is smoothed using sophisticated cubic spline smoothing techniques. This can be very helpful in reducing wiggles in the gray curve that can arise if you are using a target such as the *HCT* that has many closely spaced gray patches. Select the smallest amount of smoothing (*None*, *Light*, *Moderate*, or *Heavy*) that produces a curve without kinks. Smoothing is not recommended for targets such as the *ColorChecker* that have a small number of widely spaced gray patches.