

ColorPursuit™ 1.0



INTRODUCTION TO
ICC PROFILES
AND
COLOR QUALITY ASSESSMENT

17 April 2003

© ALWAN COLOR EXPERTISE 2003

Index

1. Abstract	3
1.1 ICC Profile specification	3
1.2 Color Quality assessment.....	6
1.3 About Quality Assessment Metrics	7
2. ColorPursuit Widgets	8
2.1 About Widgets	8
2.2 Color Widgets	9
2.3 Image Widgets	12
2.4 DVL Widgets	18
2.5 Color and Image Comparator.....	19
3. ColorPursuit Menus	21
3.1 Preferences:	21
3.2 File Menu:	24
3.3 Widgets Menu:	24
3.4 View menu:	25

1. Abstract

ICC color management is becoming increasingly popular as the vast majority of design and production software currently support ICC profiles and Apple® ColorSync® API on the Apple® platform.

Photographers, designers, production and prepress operators as well as press printers have now the ability to use ICC profiles to achieve accurate colors in their everyday job.

The used ICC profiles are generally made or supplied by:

- Hardware manufacturers of Digital cameras, scanners, printers, monitors...
- Developers of Graphics, Image editing, Layout, RIPs... software
- Users producing their own profiles with purchased profiling packages
- Users having their profiles built by service providers and color consultants

1.1 ICC Profile specification

The International Color consortium (www.color.org) was established in 1993 for the purpose of creating, promoting and encouraging the standardization and evolution of an open, vendor-neutral, cross-platform color management system architecture and components.

The first outcome of this co-operation was the development of the ICC profile specification.

The ICC profile contains the required data for an ICC color transformation.

ICC Device profiles

Device profiles provide color management systems with the information necessary to convert color data between native device color spaces and device independent color spaces.

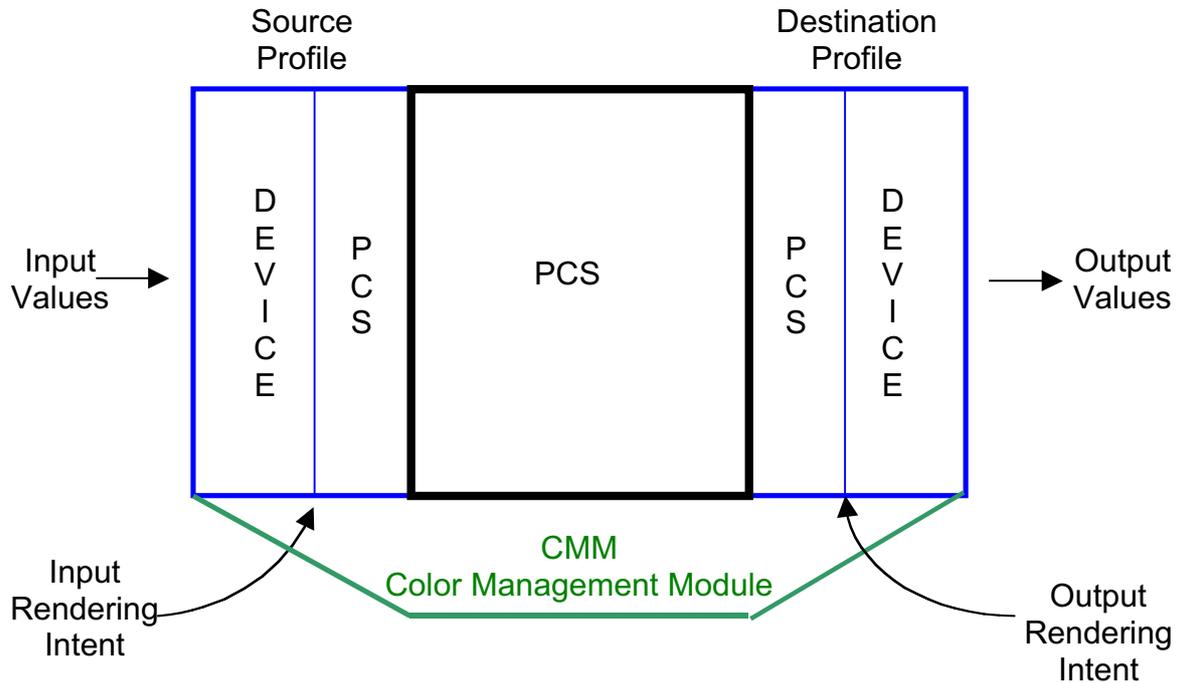
For each device profile, a series of base algorithmic models are described which perform the transformation between color spaces. These models provide a range of color quality and performance results. This required data provides the information for the color management framework default color management module (CMM) to transform color information between native device color spaces.

ICC Profile data include:

- Reference Illuminant: D50 (or other illuminant in ICC specification v4.0+)
- Media White: substrate...
- Device (RGB, CMYK...) to PCS (Profile Connection Space. CIELAB in most cases) LUTs (Look-up tables). Three tables corresponding to Three ICC defined Rendering Intents are embedded in the ICC profile
- PCS to Device LUTs: Three tables corresponding to Three ICC Rendering Intents are embedded in the ICC profile
- TRC (Tone Reproduction Curves) / Matrix... and other data which is not relevant for the purpose of this tutorial.

ICC Architecture

A representative architecture using ICC Profile components is illustrated below:



In most cases, Input and output Rendering Intents are identical.

ICC Profile Rendering Intents

In general, actual device gamuts will not be large enough to reproduce the desired color appearances communicated by the PCS values.

Four rendering intents (gamut mapping styles) are provided to address this problem. Each one represents a different compromise.

Relative Colorimetric Intent

The colorimetric intents preserve the relationships between in-gamut colors at the expense of out-of-gamut colors.

This intent is useful for colors that need no compression.

Absolute Colorimetric Intent

This intent is useful for spot colors and when simulating one medium on another (proofing).

Perceptual Intent

The exact gamut mapping of the perceptual intent is vendor specific and involves compromises such as trading off preservation of contrast in order to preserve detail throughout the tonal range. It is useful for general reproduction of images, particularly pictorial or photographic-type images.

Saturation Intent

The exact gamut mapping of the saturation intent is vendor specific and involves compromises such as trading off preservation of hue in order to preserve the vividness of pure colors. It is useful for images which contain objects such as charts or diagrams.

Perceptual, Relative Colorimetric and Saturation are embedded in the ICC profile LUTs. The fourth RI, Absolute Colorimetric, is calculated using the Relative Colorimetric RI table and the Profile media white point.

ICC Profile/Device Class

ICC specification defines 7 classes of device profiles:

- Input device profile: scanner, digital camera...
- Display profile: monitor, projector, RGB space...
- Output device profile: printer, film recorder...
- DeviceLink profile: special device-to-device
- ColorSpace conversion profile: CIELAB, CIEXYZ...
- Abstract profile: specific effects
- Named color profile: Pantone®, TrueMatch®...

The first five categories of these ICC profiles are the most widely produced and used.

The Need for Quality Assessment

As you can see, an ICC profile contains a significant amount of information and data regarding your device.

The quality and pertinence of this data depends on the profile maker and on its ability to build accurate and robust ICC Profiles.

A good profile will allow you to achieve consistent, predictable and reproducible colors.

A poor profile can cause color shifts, monitor mismatch, proof mismatch, poor color separation that can be very frustrating and may take endless time to understand and to solve

Before using an ICC profile that you have produced or that has been supplied to you, you may want to make sure the ICC **Profile**, the **Device** it describes as well as the resultant **Reproduction** quality suit your purposes and expectations.

This is reason behind the development of Alwan ColorPursuit®.

1.2 Color Quality assessment



ICC Profile Quality

Profile accuracy can be calculated using the error which is introduced by the profile tables in color transformation operations.

Colorimetric and Perceptual tables are used for this evaluation.

The average ΔE error for each of these tables is calculated.

The maximum ΔE error for each of these tables is also calculated.

The resulting data is used to calculate the Profile QI (Quality Index).



Device Quality

Device quality can be calculated using the device gamut which is measured from the device profile.

Colorimetric gamut and Perceptual gamut are calculated.

Colorimetric Gamut corresponds to the range of colors that can be reproduced by the physical device. This gamut is calculated using the Profile Colorimetric table. It contains the device in-gamut colors.

Perceptual Gamut corresponds to the range of colors that can be mapped into the physical device gamut. This gamut is calculated using the Profile Perceptual table. It contains in-gamut as well as some out of gamut colors.



Color Reproduction Quality

A given Device and Profile allow you to achieve a specific reproduction of a source color or image.

The quality of this reproduction can be evaluated by calculating the error between the chosen source image and colors and their predicted reproduction.

1.3 About Quality Assessment Metrics

The metrics implemented in Alwan ColorPursuit® are quite sophisticated and include comprehensive quality calculations and evaluations that have been confirmed by practical experience and correlations with visual assessments.

Nevertheless, ICC Profile assessment techniques are relatively new and are improving thanks to the works of companies like Alwan Color Expertise among others and organizations like the ICC which has now a specific working group named PAWG (Profile Assessment Working Group) working exclusively on this issue.

This is why new versions of Alwan ColorPursuit® may include metrics that are slightly different from previous versions.

- **Note 1**

Make sure you are using the latest version of Alwan ColorPursuit by regularly visiting our web site page

<http://www.alwancolor.com/english/products/colorpursuit.html>

Application version can be seen in the **About ColorPursuit** dialog from the **ColorPursuit** menu.

Quality Index version can be seen when putting the mouse arrow on the quality index values displayed in the *Information* tab of an image Widget.

- **Note 2**

This introduction to ICC profiles and color quality assessment does not contain practical examples. For more hands-on and tutorials about Alwan ColorPursuit, please visit our web site page

<http://www.alwancolor.com/english/products/colorpursuit.html> and download the available hands-on and tutorials PDFs.

- **Note 3**

If you would like to know more about color, ICC profiles and Color Management, please visit our web site pages:

-Training programs: <http://www.alwancolor.com/english/services/training.html>

-Resources: <http://www.alwancolor.com/english/ressources/profiles.html>

ColorPursuit is © ALWAN COLOR EXPERTISE 2002-2003

ALWAN COLOR EXPERTISE
31 chemin du plan du loup
F-69110 Ste-Foy-les-Lyon
Tel : (33) 4 72 16 08 82
Fax : (33) 4 72 16 95 87

<http://www.alwancolor.com>

2. ColorPursuit Widgets

2.1 About Widgets

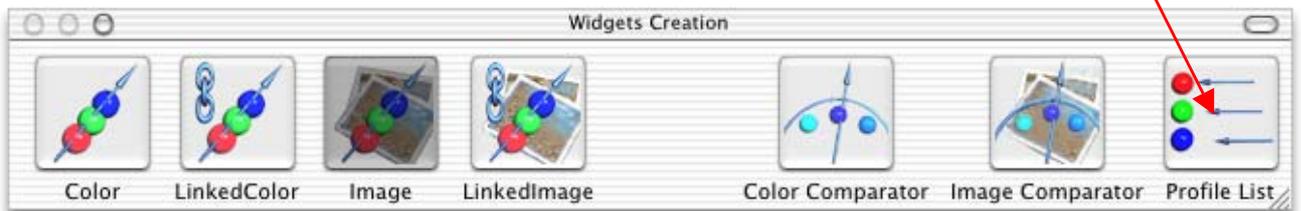
What is a Widget?

Alwan ColorPursuit™ allows you to open what is called "**Widgets**", i.e. windows in which you can select images, documents or colors with associated ICC device, color space or DeviceLink profiles.

Each widget can represent a device or a color space. Thus, linking Widgets enables you to build your ICC/ColorSync workflow(s) comprising your various devices and working spaces.

The Widgets Creation Toolbar

Displays your profile list (and useful information such as date, profile creator...)



different types of Widgets

You can customize this toolbar by choosing **Customize Toolbar...** from the **View** menu.

2.2 Color Widgets

Color Widget



To create a Color Widget, you can use either the **Widget** menu or the **Color** button from the **Widget Creation Toolbar**.

The following information is available from the Color Widget interface:

Each Widget is identified by its number

Device/Color Space represented by the Widget according to the selected profile

ICC profile of this Widget

switches between the different color values options

Click on CIE lab to display CIE lch values



Displayed CIE Lab* (40,7/44,2/34,9) color correspond to the Scanner/Camera RGB (160/40/40) value.

CIE Lab* (with a star) means that the CIELAB color has been calculated using the Device values and ICC profile Relative Colorimetric Rendering Intent. This applies always for Display and scanner profiles.

CIE Lab (without a star) means that the CIELAB color has been calculated using the Device values and ICC profile Absolute Colorimetric Rendering Intent. This applies for Printer Profiles

The selected ICC profile automatically determines the type of device (scanner, display, printer etc...) and the relevant device color mode (RGB, Lab, CMYK...)

LinkedColor Widget



To create a LinkedColor Widget, you can use either the **Widget** menu or the **LinkedColor** button from the **Widget Creation Toolbar**.

The following information is available from the LinkedColor Widget interface:

Indicates the source of colors of this widget. In this example, *Widget 2 is linked to Widget 1*. This means that Widget 2 CMYK values are calculated using Widget 1 CIELAB colors and the chosen *Sheetfed PV glossy* profile and Rendering Intent

Rendering Intent

Selected profile class

TAC : Total Area Coverage

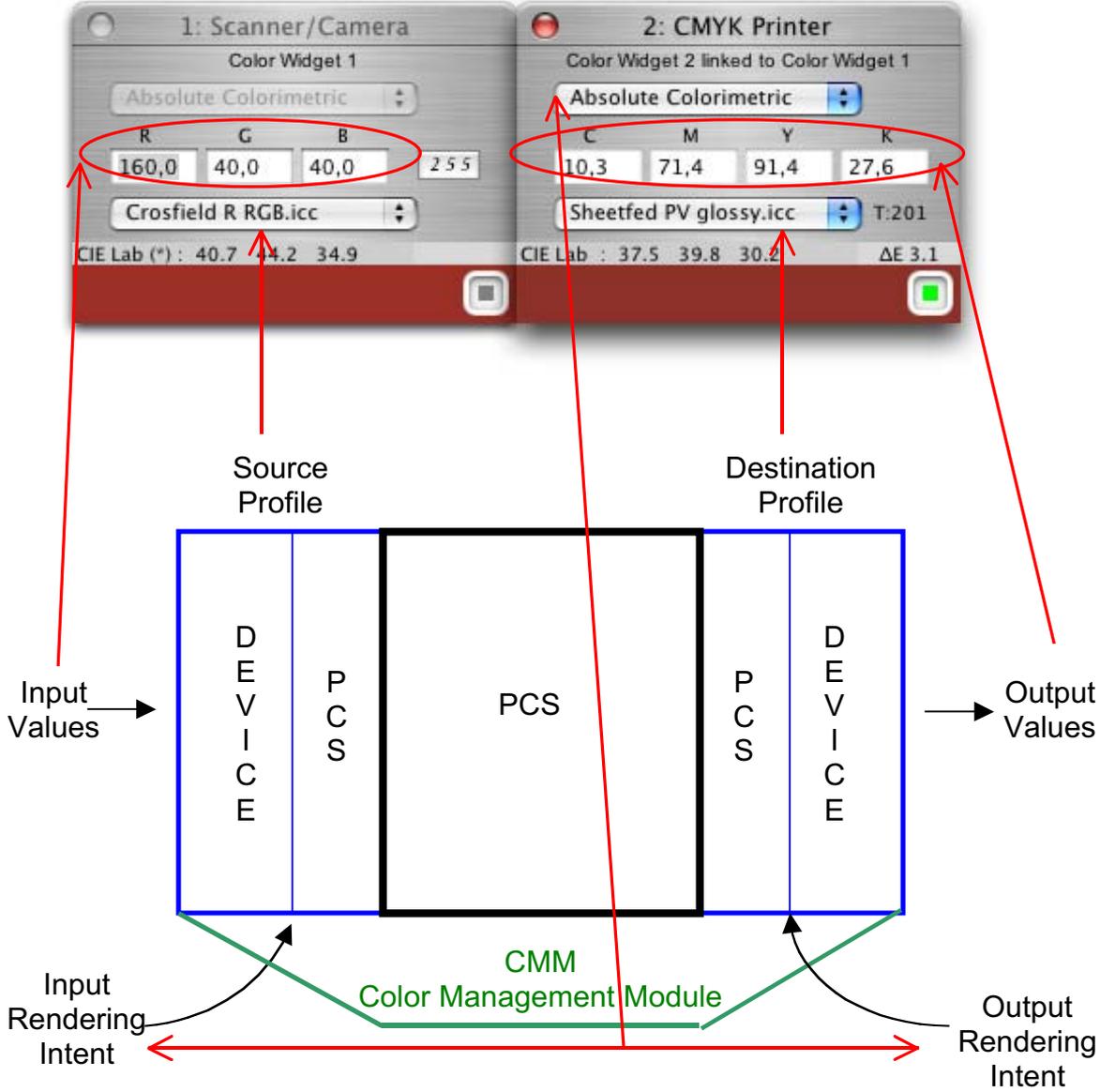
ΔE_T indicates the error/color shift introduced by the specified Transformation (ICC Profiles and Rendering Intent) See page 21 for more information about ΔE_T and ΔE^*_T

Color accuracy indicator, with the following meaning:

ICC profile of this Widget

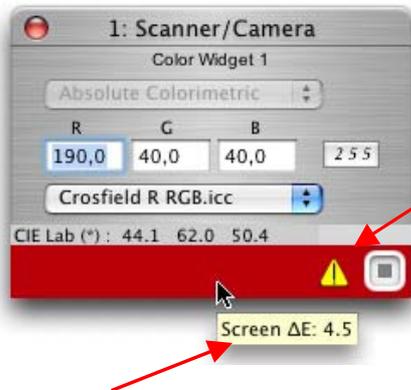
- No accuracy calculations, for source colors
- $\Delta E <$ Preferences value (Default $\Delta E = 4.0$)
- $\Delta E \geq$ Preferences value (Default $\Delta E = 4.0$)

Alwan ColorPursuit allows you to do any color transformation based on the ICC architecture described in page 4.
 See below how nicely Alwan ColorPursuit fits into this architecture.



ΔE screen error

If you put your mouse on the color in the lower part of the Widget, Screen ΔE error appears. (ColorPursuit active Window often offers such contextual information zone named tooltips) :



If this warning appears, it means that the color is out of the gamut of your monitor. The ΔE error for display can be defined in **ColorPursuit/Preferences/SoftProof** tab (default $\Delta E = 2$).

ΔE error between the color and the monitor display.

This information is relevant only if your monitor is calibrated.

- **Note** : For more information about monitor calibration, please visit our web site pages:

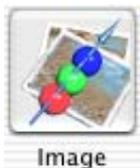
-Monitor Expert Calibrator:

<http://www.alwancolor.com/english/products/mec.html>

-Resources: <http://www.alwancolor.com/english/ressources/profiles.html>

2.3 Image Widgets

2.3.1 Image Widget



To create an Image Widget, you can use either the **Widget** menu or the **Image** button from the **Widget Creation Toolbar**.

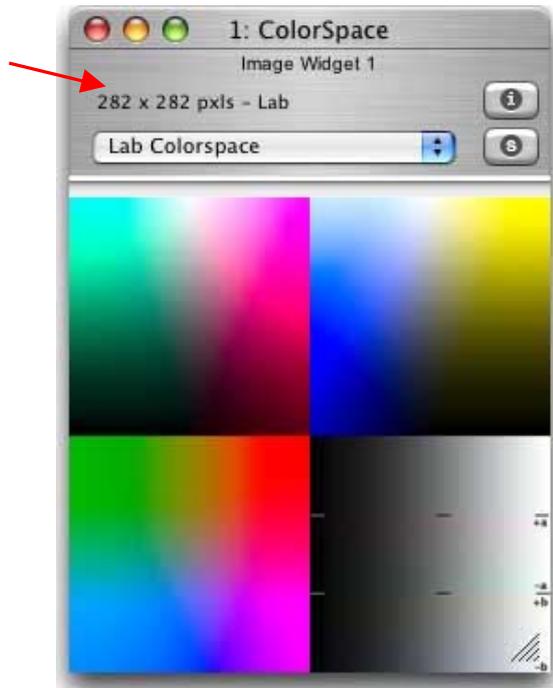
Depending on your **ColorPursuit/Preferences.../Image Widget tab/Startup Image** choice, the following window will appear (default Preferences setting **Choose on Opening**).



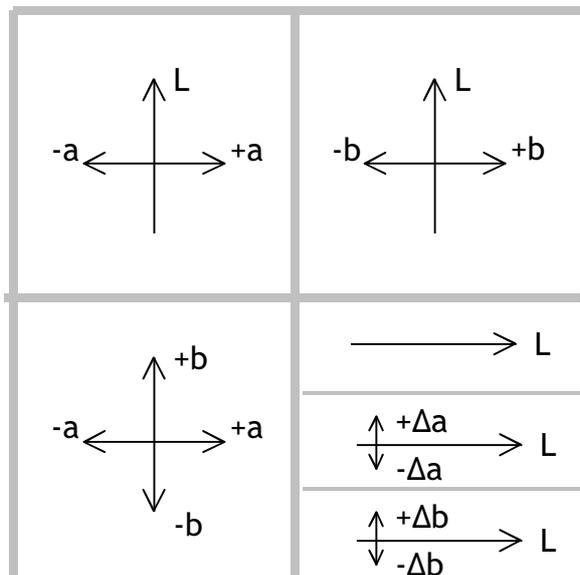
- **Default Lab Image Widget**

If you choose Lab, the following Widget appears:

Source image pixel size

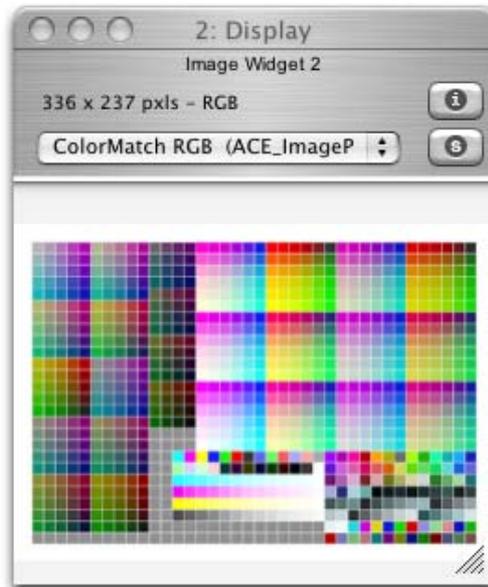


The default CIELAB image represents four zones corresponding to different slices in the CIELAB color space:



- **Default RGB Image Widget**

If you choose RGB, the following Widget appears:



- **Default CMYK Image Widget**

If you choose CMYK, the following Widget appears:



- **Loading your own Image**

If you want to use one of your images, you can load it by choosing **Load Image...** from the **File** menu or by **double-clicking** on the Widget image, or by using **Drag and Drop**.

You can use any image file format supported by Mac OS X (tiff, jpeg, png , pict, bmp...).

If your image has an embedded profile, it is automatically recognised and used by Alwan ColorPursuit

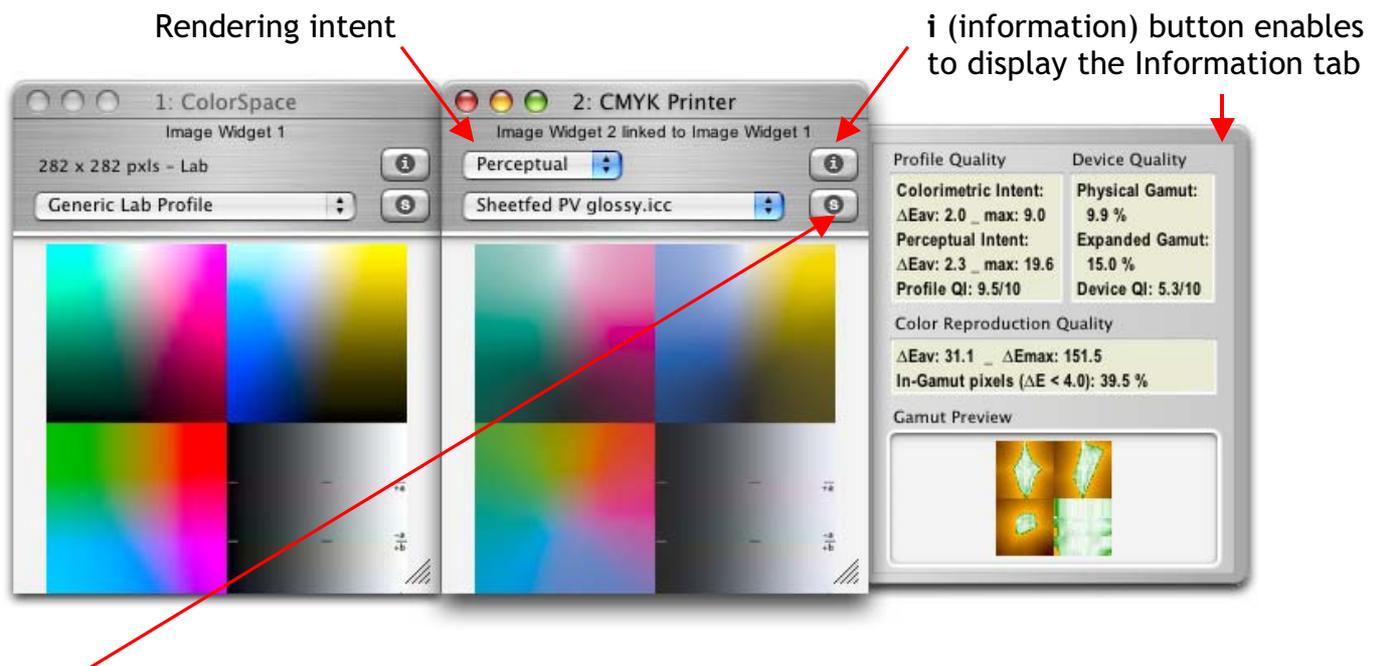


2.3.2 LinkedImage Widget



To create a LinkedImage Widget, you can use either the **Widget** menu or the **LinkedImage** button from the **Widget Creation Toolbar**.

The new Widget is automatically linked to the front most Widget (in the foreground)



The **s** (shadow) button allows you to remove the shadow of the window, enabling you to overlap colors from different Widgets for visual assessment of differences.

- **Profile quality (Profile dependant)**

Profile accuracy is calculated using the error which is introduced by the profile tables in color transformation operations.

Colorimetric and Perceptual tables are used for this evaluation.

The average ΔE error for each of these tables is calculated.

The maximum ΔE error for each of these tables is also calculated.

The resulting data is used to calculate the Profile QI (Quality Index) on a scale of 10.

- **Device quality (Device and Profile dependant)**

Device quality is calculated using the device gamut which is measured from the device profile.

Colorimetric gamut and Perceptual gamut are calculated.

Colorimetric Gamut corresponds to the range of colors that can be reproduced by the physical device. This gamut is calculated using the Profile Colorimetric tables. It contains in-gamut colors.

Perceptual Gamut corresponds to the range of colors that can be mapped into the physical device gamut. This gamut is calculated using the Profile Perceptual tables.

- **Color Reproduction Quality (Image, Device and profile dependant)**

A given Device and Profile allow you to achieve a specific reproduction of a source color or image.

The quality of this reproduction can be evaluated by calculating the error between the chosen source image and colors and their predicted reproduction.

In-Gamut pixels indicates the percentage of image pixels source colors that will be accurately reproduced within the error specified in the **ColorPursuit/preferences.../Reproduction accuracy**

- **Gamut Preview**

The **Gamut Preview** image displayed in the information tab shows the source image colors which are reproduced within and those which are out of tolerance for the chosen Device and Rendering Intent.

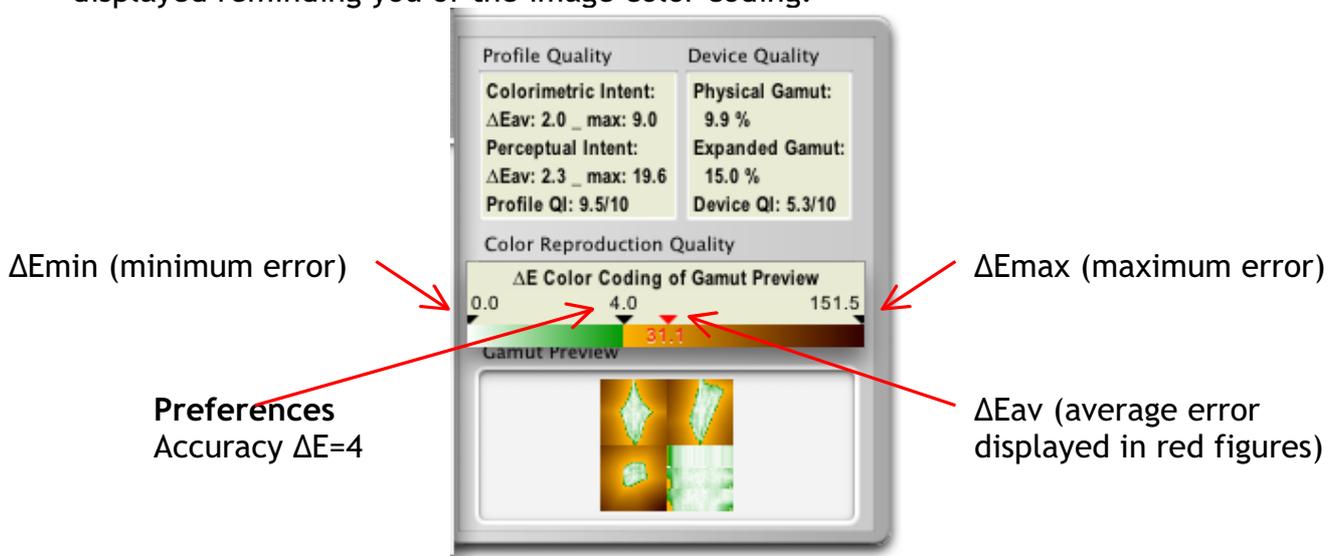
Image colors which are displayed in white are those reproduced with a ΔE of 0.

Image colors which are displayed in green are those reproduced with a ΔE less than the **Preferences** value (Default $\Delta E = 4.0$).

Image colors which are displayed in orange are reproduced with a ΔE greater than the **Preferences** value (Default $\Delta E = 4.0$) ..

Image colors which are displayed in brown are reproduced with ΔE_{max} .

If you put your mouse cursor on the **Gamut Preview** image, a scale of colors will be displayed reminding you of the image color coding:



- **Note** : For more information about the Information tab, please refer to Alwan ColorPursuit's hands-on and tutorial documentation available from <http://www.alwancolor.com/english/products/colorpursuit.html> .

2.4 DVL Widgets

DVL stands for “DeviceLink”.

To create DVL Widgets, you need first to customize your **Widget Creation Toolbar** and add them to your toolbar buttons. To do that, select **Customize Toolbar** from the **View** menu.

Color(DVL) Widget



Color(DVL)

To create a Color(DVL) Widget supporting DeviceLink Profiles, choose the **Color (DVL)** button from the **Widget Creation Toolbar**.

LinkedColor(DVL) Widget



LinkedColor(DVL)

To create a LinkedColor Widget supporting DeviceLink Profiles, choose the **LinkedColor (DVL)** button from the **Widget Creation Toolbar**.

Image(DVL) Widget



Image(DVL)

To create an Image(DVL) Widget supporting DeviceLink Profiles, choose the **Image(DVL)** button from the **Widget Creation Toolbar**.

LinkedImage(DVL) Widget



LinkedImage(DVL)

To create a LinkedImage(DVL) Widget supporting DeviceLink Profiles, choose the **LinkedImage(DVL)** button from the **Widget Creation Toolbar**.

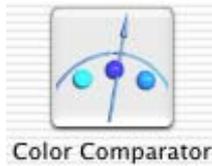
Note : For more information about DeviceLink profiles, please visit our web site pages :

-LinkProfiler : <http://www.alwancolor.com/english/products/linkprofiler.html>

-Resources: <http://www.alwancolor.com/english/ressources/profiles.html>

2.5 Color and Image Comparator

Color Comparator

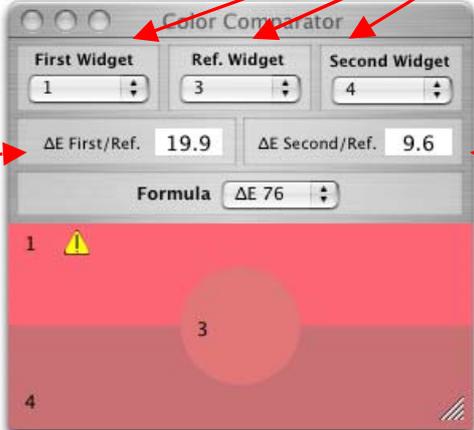


Color Comparator allows you to evaluate visually and numerically the differences between three colors of three Color Widgets. To display a Color Comparator, you can use either the **Widget menu** or the **Color Comparator** button from the **Widget Creation Toolbar**.

ColorWidget number of the three colors displayed below

ΔE between ColorWidget 1 and ColorWidget 3

ΔE between ColorWidget 4 and ColorWidget 3



If your Color Comparator is the active window, these indications will appear when you put your mouse on the different fields (tooltips).

- **Note** : The most widely known and used ΔE formula is $\Delta E_{CIE\text{LAB } 1976}$. This formula gives good error calculations in most situations and for most colors. But in some regions of the color space, CIELAB ΔE 1976 show some limitations in terms of uniformity and correlation with visual assessment of differences. This is the reason why other ΔE formulae have been developed by the CIE (Commission Internationale de l'Eclairage) among which ΔE 1994 formula which is implemented in Alwan ColorPursuit 1.0.

Image Comparator

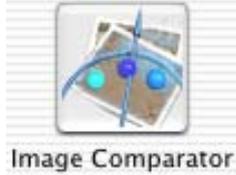


Image Comparator allows you to evaluate visually and numerically the differences between images of two ImageWidgets. To display an Image Comparator, you can use either the **Widget** menu or the **Image Comparator** button from the **Widget Creation Toolbar**.

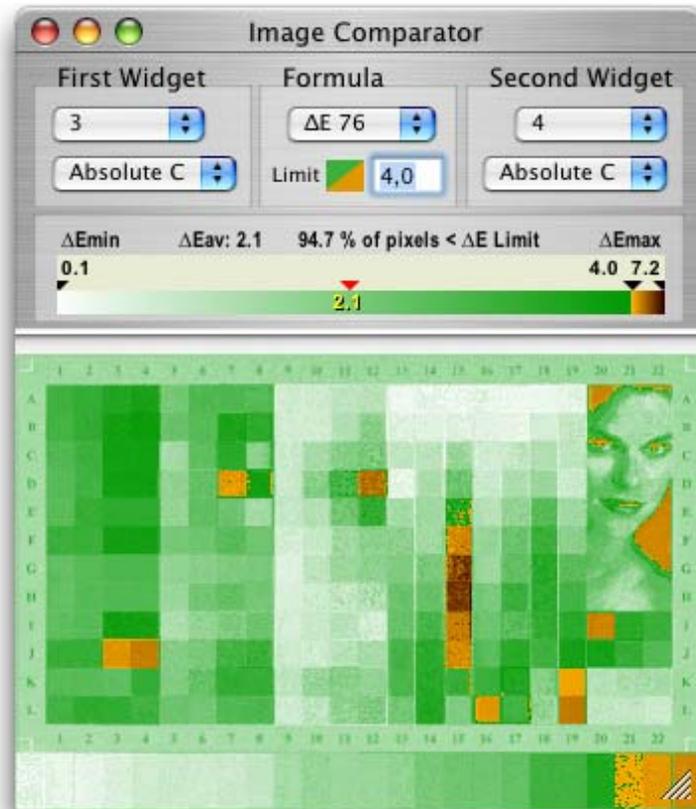


Image colors which are displayed in white are those reproduced with a ΔE of 0.
Image colors which are displayed in green are those reproduced with a ΔE less than the **Preferences** value (Default $\Delta E = 4.0$).
Image colors which are displayed in orange are reproduced with a ΔE greater than the **Preferences** value (Default $\Delta E = 4.0$) ..
Image colors which are displayed in brown are reproduced with ΔE_{max} .

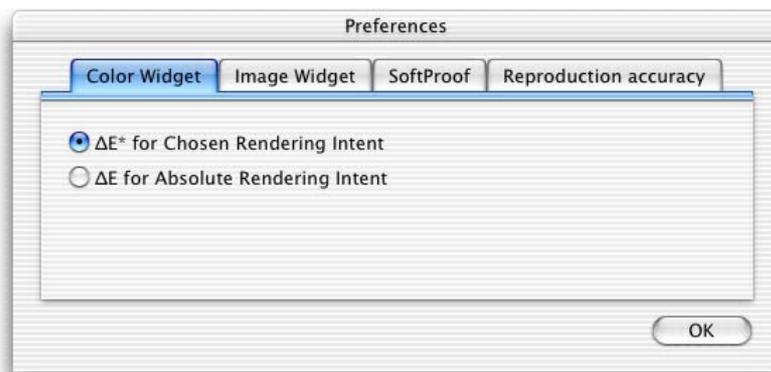
3. ColorPursuit Menus

3.1 Preferences

Choose Preferences... from ColorPursuit menu. The following tabs are available

- Color Widget

This Preferences Tab sets Color Widgets properties :



ΔE^*_T for Chosen Rendering Intent

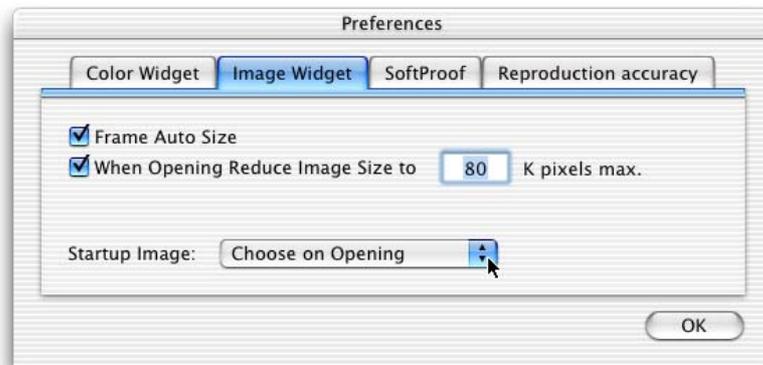
The ΔE^*_T indicates the error/color shift introduced by the chosen ICC Profiles and Rendering Intent which are used for the ICC color transformation.

ΔE_T for Absolute Rendering Intent

The ΔE_T indicates the error/color shift introduced by the chosen ICC Profiles but with Absolute Colorimetric Rendering Intent.

- **Image Widget**

This **Preferences** Tab sets Image Widgets properties :



Frame Auto Size: The Widget size depends on the opened image size.

When Opening Reduce Image Size to: Max size of displayed images. Useful to limit unnecessary long calculation time for large images.

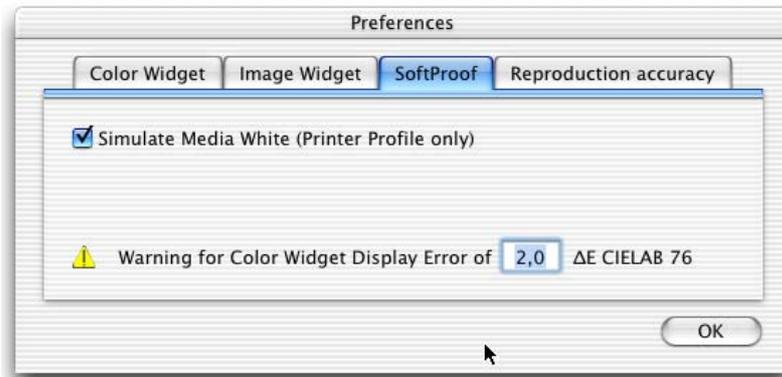
Startup Image: You can choose one of the following charts to be your default startup image: **RGB IT8.7-3 based**, **CMYK IT8.7-3**, **CIELAB**.

You can also select **Choose on Opening** which lets you decide on the fly which chart and colorspace you would like to use for your new Image Widget or Image workflow.

- **Note :** You can modify the default chart and choose your own images anytime by double clicking on the corresponding Image Widget or by dragging your image on the Widget or by choosing **Load images** from the **File menu**.

- **SoftProof**

This Preferences Tab sets SoftProof properties :

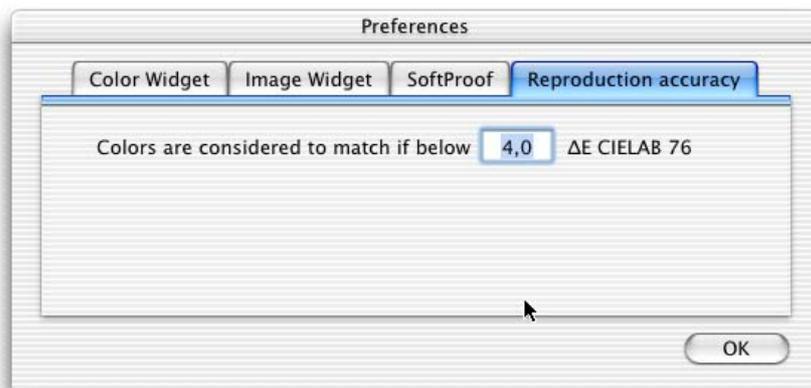


Simulate Media White (Printer Profile only): If checked, output colors are displayed in Absolute Colorimetric Rendering Intent. If not checked, output colors are displayed in Relative Colorimetric RI.

Warning for Color Widget Display Error of: the yellow warning is displayed in the color zone at the bottom of a Color Widget if the color is out of the gamut of the monitor. You can choose the ΔE value for this out of gamut warning.

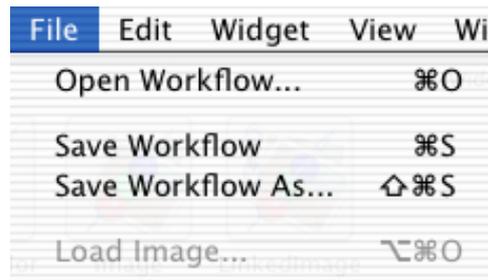
- **Reproduction accuracy**

This Preferences Tab allows you to set the accepted ΔE in your workflow. This value affects Image Comparators and color reproduction assessments.



Colors which are reproduced with a ΔE below the chosen value are considered to be acceptable matches the originals. The default value for this ΔE is 4.0.

3.2 File Menu



Open Workflow lets you open a saved Color and/or Image workflow

Save Workflow lets you save a new workflow or to save changes to an opened workflow.

After saving be careful if you move the used image files or profiles because Alwan ColorPursuit does not save them, it only saves their path.

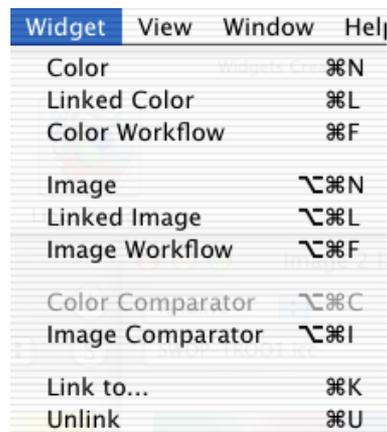
Save Workflow as... lets you save the workflow under another name

Load Image... lets you change your source Image Widget image.

You can choose any file format supported by Mac OS X (tiff, jpeg, png, pict, bmp...)

3.3 Widgets Menu

The Widgets menu allows you to create, link and arrange color and image Widgets.



Color: creates a new color Widget

Linked Color: creates a new color Widget which is linked to the Widget currently in the foreground

Color workflow : creates a set of 4 linked Color Widgets. If an Image workflow is created previously and the first Image Widget is on the foreground, than the Color Workflow will have the same profiles as the workflow Image. The first Color Widget is linked to the first Image Widget.

Image: creates a new Image Widget

Linked Image: creates a new Image Widget which is linked to the Image Widget currently in the foreground

Image workflow: creates a set of 4 linked Image Widgets.

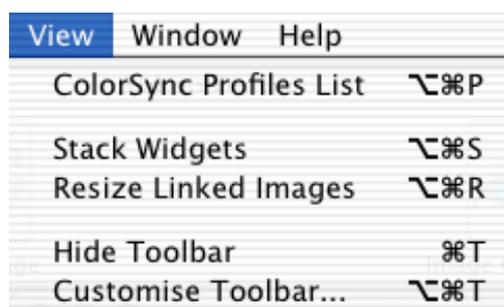
Color Comparator: a tool you can use to visually and numerically compare the colors of 3 chosen Color Widgets

Image Comparator: a tool you can use to visually and numerically compare the color reproduction of two chosen Image Widgets

Link to...: lets you link the active Widget to any other opened Widget. A list of the compatible and opened Widgets is displayed in the validation dialogue.

Unlink: breaks the existing link between two currently linked Widgets.

3.4 View menu



ColorSync Profiles List displays your ColorSync folders ICC profiles list with useful information such as their date of creation, profile maker...

Stack Widgets puts the Widgets next to each other to optimize screen space. You can Stack Widgets anytime to arrange the desktop.

Resize linked Image: If a source Image Widget is resized on the screen, all Image Widgets that are linked to this Image Widget are resized accordingly

Hide Toolbar hides the Widget creation toolbar

Customize toolbar lets you choose the buttons you want to include in the toolbar. You can also choose to have the name of the buttons displayed too.

All mentioned products and marks are the property of their respective owners :
Apple, ColorSync, Mac OS X: © Apple Computer Inc.
Irina's picture: © Studio Didier Créte
Adobe RGB, ColorMatch RGB: © Adobe Systems Incorporated
Best RGB and Don RGB: © Don Hutcheson
ECI-RGB: © ECI (European Color Initiative)

ColorPursuit is © ALWAN COLOR EXPERTISE 2002-2003

ALWAN COLOR EXPERTISE
31 chemin du plan du loup
F-69110 Ste-Foy-les-Lyon
Tel : (33) 4 72 16 08 82
Fax : (33) 4 72 16 95 87
<http://www.alwancolor.com>