## Introduction

**SCAMAX®** document scanners are primarily used to digitize business documents and forms. Therefore, the standard calibrations of the devices are designed for the creation of compressed, clear color images, with the best possible qualitative conversion (*binarization*) into B/W images for subsequent processing, from a wide range of documents.

For some time now, the guidelines of international quality standards such as **ISO** (*International Organization for Standardization*) or **FADGI** (*Federal Agencies Digitization Guidelines Initiative*) have been used as assessment criteria for processing in the field of cultural assets (*archives, libraries, etc.*). Since these guidelines were developed for still image capturing by photo, reflected light or flatbed systems, it was previously considered unlikely that document scanners with rotating paper transport would be able to meet the necessary requirements.

Due to the excellent image quality of the cameras used and the precise transport system of the **SCAMAX®** document scanners, we are able to comply with the standard values of **ISO 19264-1 Level C** and **FADGI \*\*\***.

The following description contains all steps for the special calibration of the scanner and the determination of device-specific values to generate the necessary correction value tables.

## 1. Scanner Calibration

The following calibration should be accomplished by someone who has completed a technical training for this type of scanner, as access to the scanner's service menu is required and knowledge in handling the service tool **ScanDiag** is assumed. A clean sheet of InoTec white balance paper (*Art.No. s9100002 - please do **not** use other kind of paper!*) and the ScanDiag tool in **version 1.8.0.1** or higher is required.

The first step is to adjust the LED brightness (*PWM*) so that the camera threshold of 160 is no longer exceeded. To do this, the ScanDiag is started with an active scanner connected
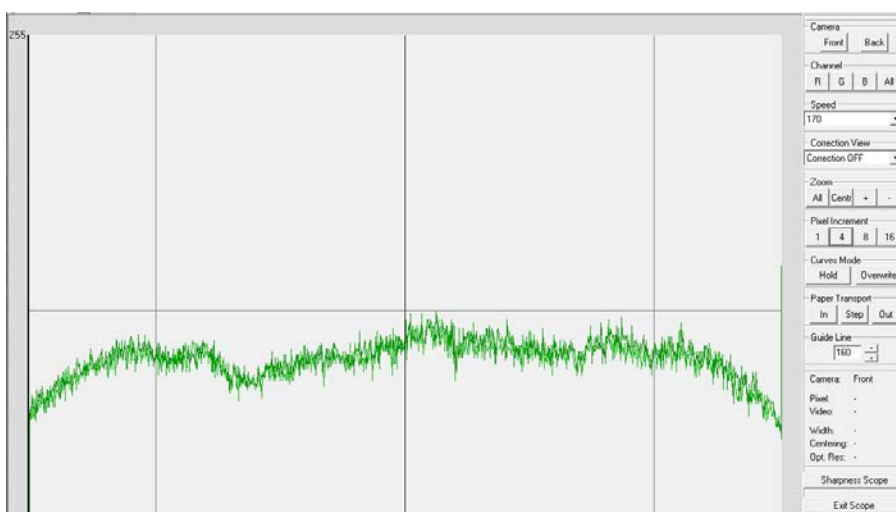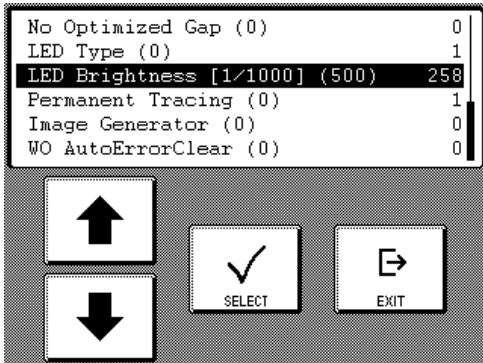


and the *Camera Scope* (*figure left*) is opened. The initially displayed green channel is sufficient for the adjustment, as it generates the highest values. In the menu on the right hand side **Correction OFF** must be selected as *Correction View*.

For a better evaluation the *Pixel Increment* is set to **4** and the *Guide Line* is set to **160**.
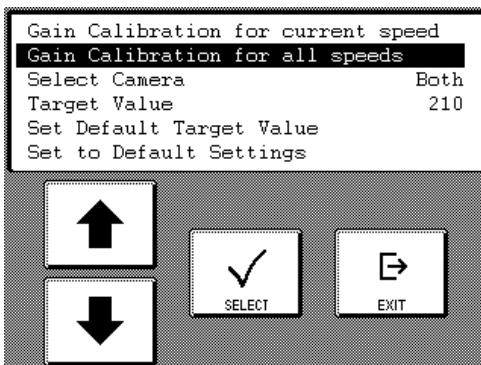
If the white balance paper is pulled in via *Paper Transport* -> **In**, the signal curve of the green channel will be considerably above 160.

A decrease of the signal is achieved by reducing the LED brightness. As a change of the LED brightness via ScanDiag would always mean leaving the Scope view, we recommend

```
No Optimized Gap (0)            0
LED Type (0)                    1
LED Brightness [1/1000] (500) 258
Permanent Tracing (0)           1
Image Generator (0)             0
WO AutoErrorClear (0)           0

       ↑
                    ✓        ⇥
       ↓          SELECT    EXIT
```
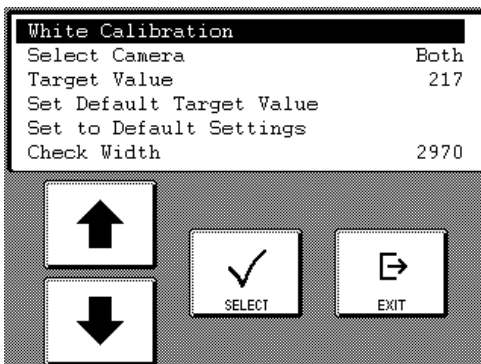
changing it via the menu *Parameter* inside the *Service Functions* on the scanner display. The value **LED Brightness** should be noted for safety reasons and successively reduced until the green signal curve in the Scope view no longer exceeds the *Guide Line* of **160**. Please note that the change of the value is only accepted by the scanner and therefore also visible in the Scope view, after confirming and leaving the menu *Parameter*. If double-sided scanning should be possible while keeping the desired quality guideline, the maximum value of 160 must also be kept in the Scope view of the backside camera. If the correct value was determined, the white balance paper is to be ejected and ScanDiag is to be terminated.
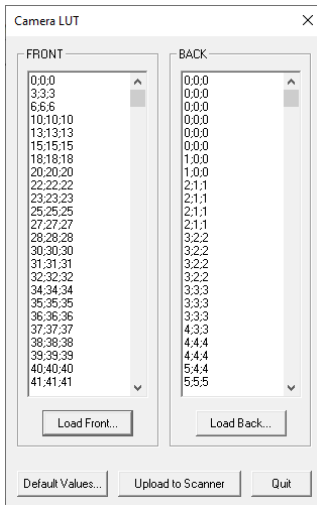
```
Gain Calibration for current speed
Gain Calibration for all speeds
Select Camera                 Both
Target Value                   210
Set Default Target Value
Set to Default Settings

       ↑
                    ✓        ⇥
       ↓          SELECT    EXIT
```

The next step is a Gain Calibration to a **Target Value** of **210** (*default is 240*). For this purpose, the according value has to be changed in the corresponding mask of the service functions. If the unit should be used with this type of calibration for a longer term, which is likely in a production environment, it is better to adjust the default target value immediately, so that the default value of 240 is not used again for a later Gain Calibration. This is possible via the item **Set Default Target Value**. Finally, the calibration is performed via the item **Gain Calibration for all speeds**.

```
White Calibration
Select Camera                 Both
Target Value                   217
Set Default Target Value
Set to Default Settings
Check Width                   2970

       ↑
                    ✓        ⇥
       ↓          SELECT    EXIT
```

Also the White Calibration, as the last step of this calibration, is performed with a lower target value of **217** (*default is 260*). Like at the gain calibration, this value must be entered for temporary use under **Target Value** and for the longer-term alternative it has to be used under **Set Default Target Value**, as the new default value. Then, as usual, perform the White Calibration with the paper provided for this purpose.

Actions to achieve the quality criteria for digital images according to FADGI with a SCAMAX® 4x3 series document scanner

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## 2. Reference Image in the sRGB Color Range

After performing the calibration, a reference image for each camera used has to be created with this scanner. For this purpose, default correction values are first loaded onto the scanner via a so-called Lookup Table (*LUT*), so that the device works in the sRGB range. We provide these for download as a file called ***sRGB.csv*** together with this description To use this CSV file as a ***LUT*** on the scanner, it must first be transferred to the unit via ScanDiag. If the tool is connected to the scanner, the dialog shown on the left is opened with the menu item *Settings->Camera LUT Values*. Via the ***Load Front…*** button the CSV file containing the correction values can be loaded as LUT for the front side camera. The loaded values are displayed in the left column ***Front***. The button ***Upload to Scanner*** loads the LUT to the scanner, where it is directly used for future processing without restarting the scanner. If double-sided scanning should be possible while keeping the desired quality guideline, the LUT must be loaded via ***Load Back...*** before the upload to the scanner.

A measured target must be used as a template for the reference image(s). In our example we refer to a DICE target from *Image Science Associates.* This targets must be handled with care, because only a clean target will give correct values. Reference images must always be saved as uncompressed color images in Tiff format. This can be done directly using an image editing program like ***GIMP*** (*see next chapter*) or a scanning solution like ***SCAMAX scan*** that can receive and save uncompressed images. The scanner should be turned on *several minutes* before scanning reference images so that it is already at *operating temperature!* From now, the *Input Mode* of the scanner should be changed to ***Manual***, to protect the templates which still have to be scanned.
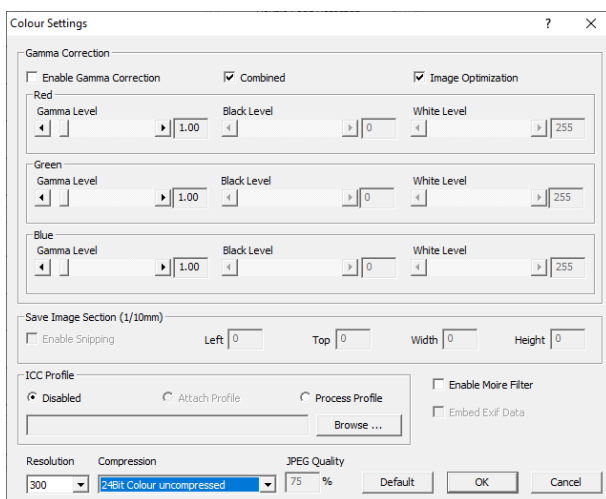
In the scanner settings, the resolution which is used in the later processing (*here 300 dpi*), should be selected now as well. The front side color image must be marked and in the *Colour Settings*, the *Image Optimization* must be ***activated*** and the *Compression* must be changed to ***24Bit Color uncompressed***. At the paper settings, the middle area of the driver's main dialogue, an *Output Format* selection of ***Maximum Scan Area*** and ***Portrait*** is recommended. The *Input Orientation* must be set to ***Top Edge First***. Via driver dialog or the scanner display the *Scan Speed* should be set to ***90 ppm*** or (*with Slow Mode Option*) even slower. With these settings, the present target must be scanned. Please make sure that the target is pulled in as straight as possible. When using SCAMAX scan, the scanned image can now be saved via *File->Save As* or *CTRL-S*. In the corresponding dialog, any path and file name can be specified for saving the image. ***Tiff single pages*** has to be selected as *File type* and *Color* must set to ***Uncompressed*** via at the button *Options*.

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## 3. Creation of Correction Value Tables

With the previously created reference image, a correction value table is generated in the next step which is calculated based on measured values and loaded onto the scanner again as a so-called Lookup Table (*LUT*) via ScanDiag. The necessary measured values must be determined from the grayscale patches 10 to 21, which are located in the center of the target, from the data of the so-called Lab color space.
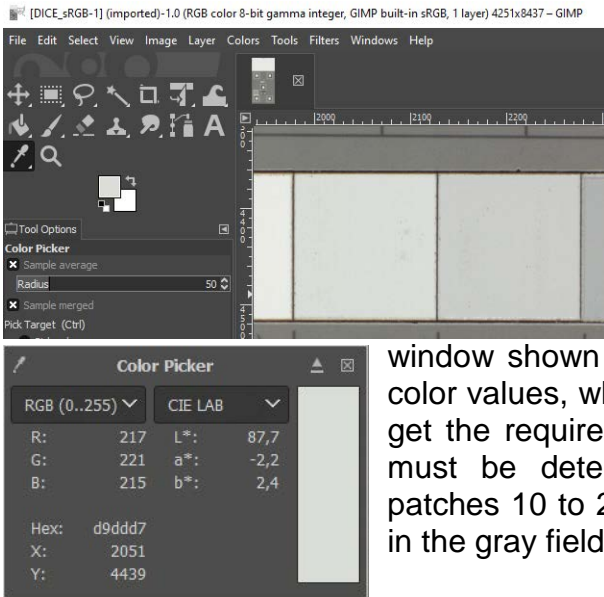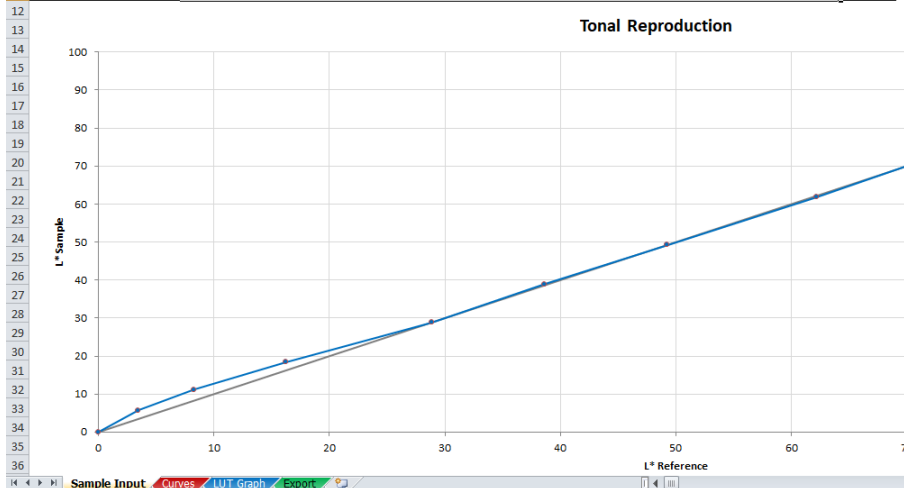
For this we use the free image editor **GIMP**. This shows the image with a built-in sRGB profile by default and is able to list average values for **L\*a\*b\*** from a pre-defined sampling area by the *Color Picker* function. We recommend to choose an area size that covers at least 70% of one gray field's height. As soon as the activated Color Picker is clicked into the loaded image for the first time, the additional window shown on the left appears, offering two selections for color values, where **CIE LAB** must be selected at least once to get the required values. Using these settings, the Lab values must be determined from the above-mentioned grayscale patches 10 to 21. The sampling area should always be placed in the gray fields as centred as possible.

These values are required for the Excel workbook *TonalCorrection-DICE-Lab*, which is provided with this description and consists of four tables. At the table *Sample Input*, the reference values from the grayscale patches **10** to **21** of the used DICE target must be entered in the lines **6 - 8**. Into lines **9 - 11** of the *Sample* section, the values determined with **GIMP** have to be entered. The graph below the input area shows the tonal deviation of reference and measurement from the theoretical ideal line. After entering the two ranges of values, the workbook should be saved under a new name in order to avoid having to re-enter the values for further tests.
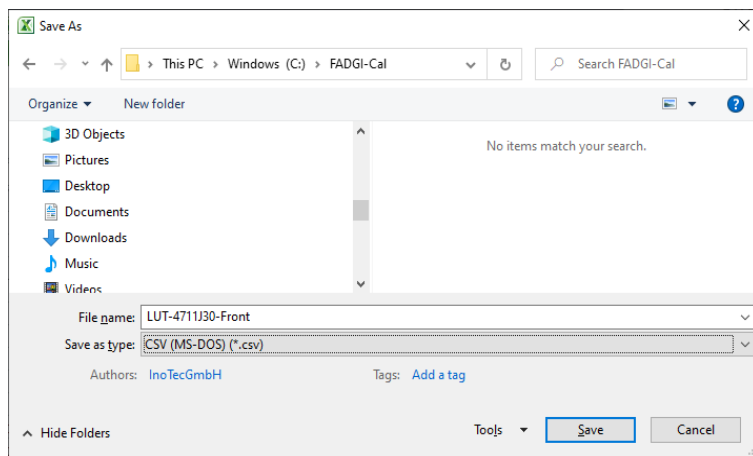
**Sample Input**

|  |  |  | Patch 21 | Patch 20 | Patch 19 | Patch 18 | Patch 17 | Patch 16 | Patch 15 | Patch 14 | Patch 13 | Patch 12 | Patch 11 | Patch 10 |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ideal | L* | 0,00 | 5,00 | 10,00 | 15,00 | 30,00 | 40,00 | 50,00 | 60,00 | 70,00 | 80,00 | 85,00 | 90,00 | 95,00 | 100,00 |
|  | a* | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
|  | b* | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Reference | L* | 0,00 | 3,44 | 8,29 | 16,19 | 28,86 | 38,62 | 49,25 | 62,15 | 72,06 | 82,14 | 87,34 | 92,02 | 97,06 | 100,00 |
|  | a* | 0,00 | -0,23 | -0,81 | -0,05 | 0,54 | -0,18 | -0,16 | -1,07 | -1,19 | -1,06 | -0,75 | -0,60 | -0,40 | 0,00 |
|  | b* | 0,00 | 0,49 | 0,19 | 0,73 | 0,60 | -0,04 | 0,01 | 0,19 | 0,28 | 0,43 | 0,21 | 0,23 | 1,13 | 0,00 |
| Sample | L* | 0,00 | 5,70 | 11,20 | 18,40 | 28,80 | 38,90 | 49,20 | 61,80 | 72,30 | 82,00 | 87,70 | 92,80 | 97,20 | 100,00 |
|  | a* | 0,00 | 0,90 | 0,20 | -0,20 | -0,90 | -1,30 | -1,30 | -1,20 | -1,30 | -1,20 | -2,20 | -1,80 | -1,70 | 0,00 |
|  | b* | 0,00 | 0,40 | 0,40 | 0,00 | 0,40 | 0,50 | 0,50 | 0,80 | 0,50 | 0,90 | 1,50 | 2,40 | 2,60 | 2,10 |

**Tonal Reproduction**

(Graph: L* Sample vs. L* Reference)

Tabs: Sample Input | Curves | LUT Graph | Export

The second spreadsheet *Curves*, contains calculation fields in different blocks, which finally lead to a linear correction table for the scanner. The input field *Factor*, which is preset with the value **100**, should **not** be changed, as otherwise correction values might be determined which possibly lead to a non-compliance with the quality specifications. In the table *LUT Graph*, the colour gradient of the 1024 correction values per colour channel is graphically illustrated.
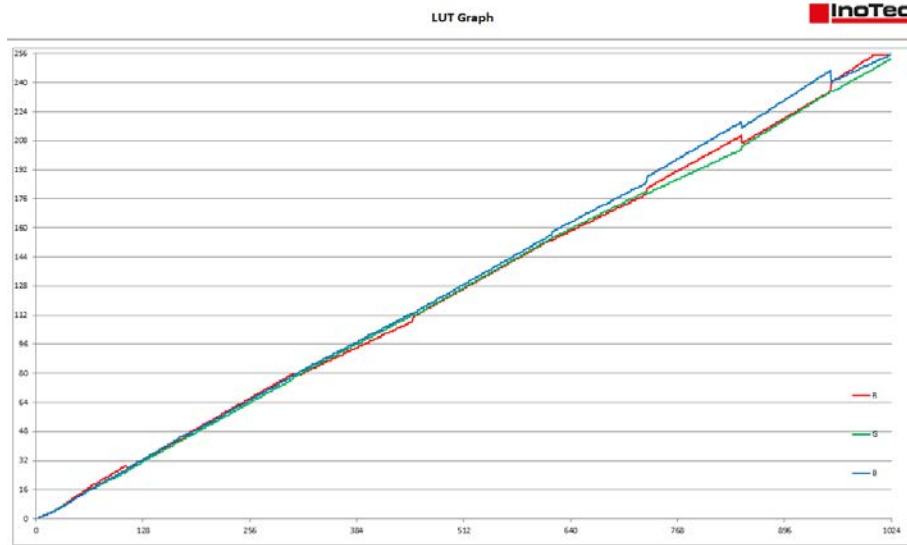
The last table *Export* contains the correction values which must be saved as a CSV file for further use. For that, you have to switch to this table to make it the "active" one. By pressing the **F12** key, the *Save As* dialog opens, in which the desired path and file name is to be entered. **CSV (MS-DOS)** must be selected as type. The two messages which are displayed during the following saving process must be confirmed with **OK** and **Yes**. Afterwards the workbook should be closed without saving it again.
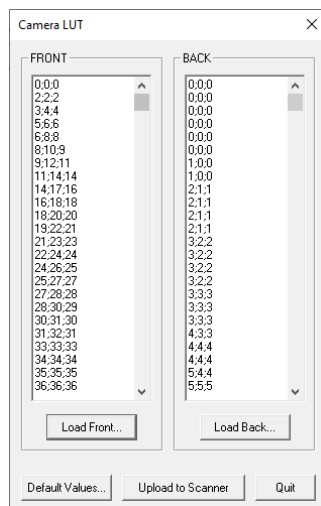


The created CSV file must first be transferred to the scanner as a **LUT** via the ScanDiag tool, as described in Chapter 2. Here, too, a separate LUT must be created and transmitted for both cameras if double-sided scanning is required in compliance with the desired quality guideline.
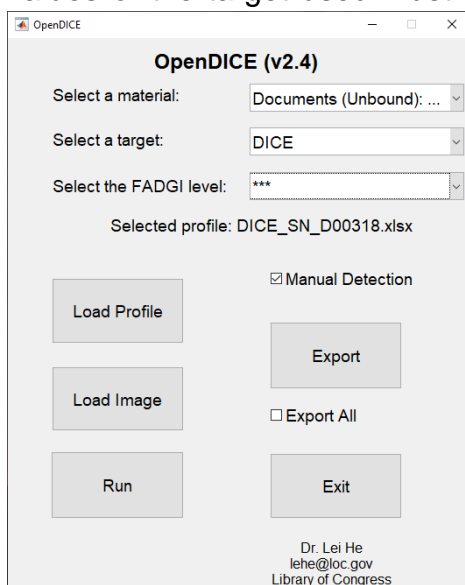
## 4. Checking the Effectivity via OpenDICE

In the final step, it must be checked whether the previously performed scanner calibration, in conjunction with the correction values of the LUT, is sufficient to meet the requirements of FADGI ***. For this check, an uncompressed color image in Tiff format must be created again from the target used, with the scan settings which already has been described in *Chapter 2*.

In practice, the **GoldenThread** analysis software from the target manufacturer *Image Science Associates* is used to check the reference images or, as in our example, the open source solution **OpenDICE**. This solution can be downloaded together with a description, a material table (*Config_materials.xlsx*) and an example of a reference file for the used target from the official FADGI website - see:
http://www.digitizationguidelines.gov/guidelines/digitize-OpenDice.html

After installing **OpenDICE**, a reference file according to the downloaded example with the values of the target used must be created and stored in the path of the reference image together with the material table. After starting the tool a dialog appears (*see left*), where in the first field the material must be changed to *Documents (Unbound): General Collections*. By that, a window opens for selecting the material table. Afterwards the used *target* (*here DICE*) and the desired *FADGI level* have to be selected. The activation of *Manual Detection* isn't required according to the description, but our experience shows that an automatic detection of the evaluation zones often leads to a hint to use it after all. Now the button *Load Profile* is used to load the created table with the reference values and then the button *Load Image* must be clicked to load the last created reference image. When *Manual Detection* is activated, the loaded reference image is now displayed in a viewer, with the option to first define the detection area and then, in a new display, to correct the placement of the detection zones. Further details can be found in chapters 5 and 6 of the OpenDICE description. After correcting the zones, the evaluation is started, while the viewer stays open, via the button *Run* in the main dialog and the result is displayed in several overview windows. An explanation of these overviews and the various export options can be found in the description of the software.

We strongly recommend to follow the sequence of steps described here, otherwise the OpenDICE software may behave incorrectly. If an analysis has to be performed several times on the basis of different reference images, e.g. due to optimizations (see next chapter) or for front and back sides, it is sufficient to close all overview windows and load the new reference image in the main dialog.

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## 5. Improvements

Test series have shown that FADGI *** is sometimes not achieved at the first attempt, since the *Tonal Response* limits are not met for very light or very dark shades of gray

| Measurements | Pass/Fail | Lower Limit | Value | Upper Limit |
|---|---|---|---|---|
| Tone Response | | | | |
| Patch #10 Red | Fail | 239.5 | 251.7 | 249.5 |
| Patch #10 Green | Fail | 239.5 | 252.7 | 249.5 |
| Patch #10 Blue | Pass | 239.5 | 248.3 | 249.5 |
| Patch #11 Red | Pass | 227.1 | 236.7 | 237.1 |
| Patch #11 Green | Fail | 227.1 | 237.3 | 237.1 |
| Patch #11 Blue | Pass | 227.1 | 233.0 | 237.1 |
| Patch #12 Red | Pass | 213.0 | 221.8 | 223.0 |
| Patch #12 Green | Fail | 213.0 | 223.4 | 223.0 |
| Patch #12 Blue | Pass | 213.0 | 220.6 | 223.0 |

(*patches 10-12 or 19-21*). In the figure you can see that the RGB values of patch 10 to 12 are very close to the upper limit or even exceed it This can be prevented by manually adjusting the measured **L\*** values of these patches in **line 9** of the table **Sample Input**. The change of the corresponding **L\*** values must be in the **same** direction as the deviation. Thus, if the values are exceeded, like in the figure, they must be raised, and if they are fallen short of, they must be lowered. To get a feel for the effect, we recommend starting with a change in the amount of 1.0. A CSV file must be created again from the Excel worksheet and loaded onto the scanner (*see end of Chapter 3*). Finally, carry out the steps from this **Chapter 4** again.

In addition to Tonal Response, *White Balance* compliance may also fail. This can occur directly or as an interaction of an adjustment of the values for the Tonal Response. However, errors at the White Balance are corrected by adjusting the values of **a\*** or **b\***. In the White

| Measurements | Pass/Fail | Lower Limit | Value | Upper Limit |
|---|---|---|---|---|
| White Balance | | | | |
| Patch #10 Green - Blue | Fail | -4.0 | 4.4 | 4.0 |
| Patch #10 Green - Red | Pass | -4.0 | 1.0 | 4.0 |
| Patch #10 Blue - Red | Pass | -4.0 | -3.4 | 4.0 |
| Patch #11 Green - Blue | Fail | -4.0 | 4.3 | 4.0 |
| Patch #11 Green - Red | Pass | -4.0 | 0.6 | 4.0 |
| Patch #11 Blue - Red | Pass | -4.0 | -3.7 | 4.0 |

Balance section shown, you can see that the green/blue values in patches 10/11 have exceeded the upper limit, while the green/red values are okay and the blue/red values are borderline in the lower range. Thus, it can be assumed that the blue content is too low and must be increased. To ensure this, the values **a\*** and **b\*** of the relevant patches must be determined again from the reference image that was analyzed with OpenDice (*see Chapter 3*). These values must be compared with the reference values of the corresponding patches in **line 7/8** of the table **Sample Input**. In case of a significant deviation, the associated sample value must be adjusted in the reverse procedure. If the measured value is higher than the reference value, the corresponding sample value in **line 11** of the table **Sample Input** is also *increased* to compensate the deviation. If the measured value is below the reference value, the corresponding sample value must be *reduced*. Please note here that **a\*** and **b\*** can also contain negative values. In such cases a measured value of **-1.5** isn't *higher* than a reference value of **-0.5**, but *lower*. The corresponding sample value must therefore be **reduced**.

Since the values of **a\*** and **b\*** represent a coordinate in a three-dimensional color space, the effect of a deviation is influenced by the respective other value. If one of the measured values is very close to the corresponding reference value, the deviation of the other value does not have as strong an effect as if both values deviate significantly. Therefore, it may be necessary and useful to adjust both values in such a case. Furthermore, it is recommended to check the values of the adjacent patches, since an alignment of the values also affects these patches.

After adjusting the sample values in **line 11** of the table **Sample Input**, a CSV file has to be created again from the Excel worksheet and loaded onto the scanner (*see end of Chapter 3*). Finally, carry out the steps from this **Chapter 4** again.

If the test is performed with a lower resolution than 400 dpi and without **Deskew** enabled, it is very likely that the limits of the horizontal resolution will be exceeded. This is due to the very high sharpness of the optics used in these resolution ranges. Although this is not a disadvantage in terms of quality, it still ensures that the test is not passed. If this is considered an issue, the sharpness can be artificially reduced for resolutions lower than 400 dpi by scanning with a *Main Resolution* of **400 dpi** and saving the color image with a *reduced resolution*. This can be selected in the *Colour Settings* of the driver dialog if a higher main resolution was **previously** set.
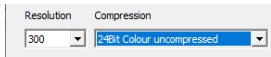
In case of doubt or for further assistance, please contact our support.