Frequently Asked Questions

Quality Controlled Scanning

Abstract

Scanners and cameras can be used for digitizing documents, pictures, maps, fine art and more. The resulting digital images can be more or less accurate in terms of how well they reproduce the original record's tones, colors, details, and other features.

The characteristics of a digital image can be assessed by imaging systems quality analysis. In general, the achievable accuracy of digital reproductions depends on the nature of the original record and the performance of the imaging system and the applied system settings.

There are currently three technical specifications or guidelines, ISO 19264, FADGI and METAMORFOZE, which are explained in this document. The purpose of this document is to raise awareness about the necessity to evaluate the quality and the performance of the complete digitization system and not only an individual component.

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1. Confidentiality

Status	Interested Party	Source	PDF
Public Information	Image Access Support	Yes	Yes
	Authorized Service Providers	No	Yes
	Image Access Customers	No	Yes

2. Revision History

Date	Rev.	Name	Description of Change	Reason of Change
20.08.2017	1.0	TI	Initial Version	
06.10.2021	1.1	TI	Chapter 16.2	Revised FAGGI sharpening

3. Table of Contents

3.1. Table of Figures

4. References

Ref.	Document	Content
[1]	ISO 19264-1	ISO/TS 19264-1:2017 applies to scanners and digital cameras used for digitization of cultural heritage material and other documents.
[2]	iQ-Analyzer	The iQ-Analyzer, is the leading market solution in the image quality analysis domain. It can be used to measure all parameters in ISO 19264 and METAMORFOZE
[3]	Federal Agencies Digital Guidelines	The documents listed here have been drafted or are recommended by either the Still Image or Audio Visual Working Group, and range from guidelines recommending specific metrics to those describing more general processes or methodologies.
[4]	Technical Guidelines for the Still Image Digitization of Cultural Heritage Materials	This document, revised by the Still Image Working Group in 2015 and approved in September 2016, is an update of the 2010 Technical Guidelines for Digitizing Cultural Heritage Materials: Creation of Raster Image Master Files.
[5]	Technical Guidelines for Digitizing Cultural Heritage Materials (2016)	The Guidelines represents shared best practices for still image materials (e.g., textual content, maps, and photographic prints and negatives) followed by agencies participating in the Federal Agencies Digital Guidelines Initiative (**FADGI**).
[6]	OpenDICE and AutoSFR	OpenDice and AutoSFR (Digital Image Conformance Environment) targets and software. Together, these guidelines and the DICE testing and monitoring system provide the foundation for a **FADGI**-compliant digitization program.
[7]	Creative Commons	CC0 1.0 Universal Public Domain Dedication, legal code and license.
[8]	METAMORFOZE Preservation Imaging Guidelines	METAMORFOZE Preservation Imaging Guidelines Image Quality, Version 1.0, January 2012
[9]	Overview of FADGI & METAMORFOZE	Digital Transitions White Paper
[10]	Modulation Transfer Function (MTF)	MTF explained in Wikipedia

5. Introduction

The most highly regarded guidelines to date have been formulated out of a need to create objective requirements for digitization tasks contracted by government entities to 3rd party vendors. The two best known guidelines are Federal Agency Digitization Guidelines Initiative (FADGI) – a US based interagency government effort and METAMORFOZE – a venture between the National Library and National Archive of the Netherlands. These are known as FADGI and METAMORFOZE.

While the FADGI and METAMORFOZE guidelines are conceptually equal, they cannot be used interchangeably. There are differences in algorithms and criteria, in how the targets are designed and on the specified aims and tolerances. In addition, there are differences in the terminology applied by the two guidelines. These differences have caused confusion among users and manufacturers of image quality analysis systems. Further, this has slowed down the implementation of objective image quality analysis in digitization workflows. It is with this background, that stakeholders representing both guidelines decided to harmonize the different approaches and develop the ISO 19264 standard.

In general, their similarities are much greater than their differences. Many institutions have adopted these guidelines for their own in-house digitization and carefully scrutinize hardware, software, and workflows to ensure they meet or exceed the requirements set forth in these guidelines.

ISO 19264, FADGI and METAMORFOZE describe several tiers of quality. Loose equivalencies of these tiers are shown in the table on the next page.

6. Scope

This document describes methods for analyzing scanner quality used for scanning cultural heritage specimens, technical documents, fine art, and many other objects. The document intends to outline the procedures necessary to use and calibrate Scan2Net scanners to operate under image quality guidelines like ISO 19264, FADGI and METAMORFOZE. This document does not replace any calibration procedures and software tools. The intent is to provide an overview and to compare the three guidelines.

7. Practical Considerations

Initially, the FADGI and METAMORFOZE guidelines were not generally required standards for tenders and purchasing decisions except for very quality conscious organizations like the US National Archive and Records Administration.

This changed drastically when the ISO 19264-1 guidelines were published in April 2017. From this time on, each and every vendor claims to be compliant to all guidelines but many of them have not and still cannot offer any proof of this claim, at least not in the form of publicly available information.

We at Image Access have been reluctant to claim compliance to these guidelines until we could offer proof of our claims. Currently, since September 2017, we are adding scans of DICE and UTT targets of all of our scanners to our Internet site. Our customers and potential customers can analyze these scans at any time without us taking note of this.

At the very least, a vendor should be able to provide a scan of the appropriate test targets to allow customers to independently verify their claims.

NOTE!	**The vendor should be asked to prove their compliance claims via a scan or picture of the appropriate test target. Run it through the verification tools and make an educated decision.**

If you need help analyzing these scans or pictures, contact your sales representative or us directly.

7.1. Examples of Confusing Claims

It should be noted that ISO 19264, FADGI and METAMORFOZE are quality guidelines for digitization systems and procedures. To be compliant, the complete digitization workflow must be quality controlled, which includes not only the imaging device but also the document carriers/holders, the illumination, and the test targets.

NOTE!	**A vendor claims ISO 19264, FADGI and METAMORFOZE compliance for a simple digicam without any light and no document carrier being able to take pictures of any resolution. This is misleading to say the least.**

The company that publishes the above claims does not specify anywhere in their advertisement, under which illumination conditions and at which working distance the claimed compliance with the highest quality levels of all three guidelines has been obtained.

It is obvious that these claims are of no value.

8. Guideline Overview

Norm / Guideline		ISO 19264-1			FADGI			METAMORFOZE		
Quality Level		A	B	C	****	***	**	Strict	Light	Extra light
Resolution (claimed sampling rate)	ppi				400	300	300	300	300	300
Bit Depth (minimum)		8	8	8	16 or 8 (1)	8	8	16 or 8 (2)	8	8
Tone Reproduction (of gray scale @ image center)	ΔL*	± 2	± 3	± 4		± 5	± 8	± 2	± 2	± 2
Gain Modulation (Patches 95 and 85)	Gain	0,8-1,1	0,7-1,2	0,6-1,3				0,8-1,08	0,8-1,08	0,8-1,08
Gain Modulation (All other patches)	Gain	0,7-1,3	0,6-1,4	0,3-1,6				0,6-1,4	0,6-1,4	0,1-2,0
Noise (visual noise)	visual	< 5	< 6	< 7						
Noise	RMS				< 1	< 2	< 3	≤ 1,6	≤ 1,6	≤ 1,6
Dynamic Range (of gray scale @ image center)	D	≥ 2,3	≥ 2,1	≥ 1,9						
Banding (visual inspection)		none	none	slight				none	none	none
Defect Pixels (visual inspection)	ppm	none	0,1	1						
White Balance (over field)	ΔC*	≤ 2	≤ 3	≤ 5	≤ 2	≤ 4	≤ 6	≤ 2	≤ 2	≤ 2
Color Reproduction (Max)	ΔE*	≤ 10 CIE	≤ 15 CIE	≤ 15 CIE				≤ 10 CIE	≤ 18 CIE	≤ 18 CIE
Color Reproduction (Mean)	ΔE*	≤ 4 CIE	≤ 5 CIE	≤ 5 CIE	≤ 3 CIE	≤ 5 CIE	≤ 8 CIE	≤ 4 CIE	≤ 5 CIE	≤ 5 CIE
Sampling Rate (claimed/obtained)	%	≤ 2	≤ 3	≤ 4				≤ 2	≤ 2	≤ 2
Resolution @ MTF 10 (claimed/obtained)	%	≥ 85	≥ 80	≥ 70	> 90	> 80	> 70	≥ 85	≥ 85	≥ 85
MTF @ Nyquist (50% sampling frequency)	%				< 20	< 30	< 40			
MTF 50 (frequency @ MTF 10)	f	≥ 0,5	≥ 0,45	≥ 0,45				≥ 0,5	≥ 0,45	≥ 0,45
MTF 50 (MTF @ 25% sampling					≥ 45 ≤ 65	≥ 35 ≤ 75	≥ 25 ≤ 85			
Sharpening (max. SFR contrast value)		≤ 1,05	≤ 1,1	≤ 1,2	≤ 1,0	< 1,1	< 1,2	≤ 1,05	≤ 1,05	≤ 1,05
Illumination non-uniformity (≤ DINA3)	ΔL*	≤ 3	≤ 3	≤ 3	≤ 1%	≤ 3%	≤ 5%	≤ 3	≤ 3	≤ 3
Illumination non-uniformity (> DINA3 and ≤ DINA2)	ΔL*	≤ 4	≤ 5	≤ 5	≤ 1%	≤ 3%	≤ 5%	≤ 4	≤ 4	≤ 4
Illumination non-uniformity (> DINA2 and ≤ DINA1)	ΔL*	≤ 5	≤ 6	≤ 6	≤ 1%	≤ 3%	≤ 5%	≤ 5	≤ 5	≤ 5
Illumination non-uniformity (> DINA1 and ≤ DINA0)	ΔL*	≤ 5	≤ 6	≤ 6	≤ 1%	≤ 3%	≤ 5%	≤ 6	≤ 6	≤ 6
Color misregistration	pixels	≤ 0,40	≤ 0,70	≤ 1,0	< 0,33	< 0,50	< 0,80	< 0,33	< 0,50	< 0,80
Distortion	%	≤ ±1,5	≤ ±2	≤ ±5	≤ ±1	≤ ±2	≤ ±3	≤ ±2	≤ ±2	≤ ±2

(1) Some originals require 16bit.
(2) Originals with density > 1,5 require 16bit.

9. ISO 19264-1

ISO/TS 19264-1:2017 describes a method for analyzing imaging systems' quality for the purpose of cultural heritage imaging. This method analyzes multiple imaging systems' quality characteristics from a single image of a specified test target. The specification states which characteristics are measured, how they are measured, and how the results of the analysis need to be presented.

9.1. Standardization of Image Quality Analysis

While the FADGI and METAMORFOZE systems are conceptually equal, the systems cannot be used interchangeably. There are differences in algorithms and criteria, how the targets are designed, and on the specified aims and tolerances. In addition, there are differences in the terminology applied by the two systems. These differences have caused confusion among users and manufacturers of image quality analysis systems. Further, this has slowed down the implementation of objective image quality analysis in digitization workflows. It is with this background that stakeholders representing both systems decided to harmonize the different approaches and develop an ISO standard.

9.2. Three Quality Levels

ISO 19264-1 defines three quality levels of imaging, levels A, B and C. An A level relates to more consistent image quality but requires greater technical performance of both operator and imaging system to achieve. Conceptually, the three levels align with the FADGI star system (4, 3, and 2 stars) and the METAMORFOZE three tier system.

- Level C imaging is appropriate where there is no reasonable expectation of having the ability to achieve level B or A performance. These images will have informational value only and may or may not be suitable for OCR.
- Level B imaging defines a very good professional image capable of serving almost all use cases. This includes being suitable for OCR as well as for reprint on the best commercially available printers.
- Level A defines the best imaging practical today. Images created to level A represent the state of the art in image capture and are suitable for almost any use.

9.3. Comparison between ISO 19264-1, FADGI and METAMORFOZE

General Description	ISO 19264-1	FADGI	METAMORFOZE
Low Quality	Level C	Two Stars	Extra Light
Good Quality	Level B	Three Stars	Light
Best Possible Quality	Level A	Four Stars	(1)

(1) It should be called "strict" or "strong" but it is only called METAMORFOZE

The purpose of these levels is not to pass negative judgement on digitization executed at less than preservation grade quality. There are many use cases where there is no incremental value in accomplishing digitization at higher quality. For instance, neither color nor tonal accuracy is critical for scanning most books, newspapers, or magazines.

NOTE!	**A scan of good quality (level B) is significantly better and more accurate than a copy on a high-quality color copier.**

In addition, scanners are substantially better in almost every respect when compared to digital cameras. Only the most advanced and also, the most expensive digital cameras (Hasselblad, Phase One) can compete on this level.

9.4. Cost Implications

It should be noted that each star in the FADGI system involves more time at higher hourly rates and significantly higher equipment cost in total and per hour.

NOTE!	As a rule of thumb, the total cost triples with each additional level.

An example:
The following is a cost breakdown of a project to digitize 10000 pages of a historic newspaper which are bound in 20 books of 500 pages each.

Quality	Time	Labor (1)	Equipment (2)	Cost Per Page	Total Cost
Level C	80h	€1,200 @€15/h	€1,600 @€20/h	€0,28	€2,800
Level B	160h	€3,200@€20/h	€4,800 @€30/h	€0,80	€8,000
Level A	320h	€8,000 @€25/h	€16,000 @€50/h	€2,40	€24,000

(1) Each additional level requires twice the time but at a higher hourly rate due to higher qualification levels of the operators
(2) The equipment cost per hour is higher as better the equipment is. Level A compliant equipment sells at € 100.000 while a Level B compliant Bookeye 5V1A book scanner sells for under € 40,000.

9.5. Conclusion

Although it is always optimal from a technical point of view to have the best possible quality, this also comes at a price. Most projects can be successfully completed under the level B or even C guidelines, for which all Image Access scanners are suitable. The above mentioned project can most likely be completed to the customer's satisfaction under the "level B guidelines.

10. FADGI

Many cultural heritage institutions as well as the vendor community have implemented the FADGI guidelines, including the star ratings. For example, the National Agricultural Library and the Smithsonian Anthropological Archives engaged a FADGI expert consultant at their expense to implement the work at their institutions, and these engagements extended the overall development effort. The metrics in the FADGI set are one important input into a new ISO standards activity, intended to produce an international standard on imaging performance for the cultural heritage community. http://www.digitizationguidelines.gov/about/FADGI-impacts_20170126.pdf

FADGI is a collaborative effort started in 2007 by U.S. federal agencies to articulate common sustainable practices and guidelines for digitized and born digital historical, archival and cultural content. Two working groups study issues specific to two major areas, Still Image and Audio/Visual. The Still Image Group is involved in a cooperative effort to develop common digitization guidelines for still image materials, which are typically digitized by document scanners.

These guidelines originated in the U.S. but have been widely accepted by other nations. The guidelines are intended to be informative, not prescriptive.

10.1. FADGI Digitization Program

The FADGI digitization program consists of three elements:

- Technical Guidelines and Parameters
- Best Practices
- Digital Imaging Conformance Evaluation (DICE)

These three elements, when implemented together, form a FADGI compliant digitization environment. FADGI conformance is a process of continuous validation to known and accepted standards, best practices and adhering to the technical guidelines as detailed in this document [3]. While it is possible to create FADGI compliant images in a physical environment that does not conform to the recommendations in this document, conformance to FADGI recommendations related to the physical environment is highly recommended. [3]

10.2. The FADGI Star System

FADGI defines four quality levels of imaging, from 1 star to 4 stars. Higher star ratings relate to more consistent image quality, but require greater technical performance of both operator and imaging system to achieve. Conceptually, the FADGI four star system aligns with the METAMORFOZE[1] three tier system, with a fourth tier (1 star) on the lower end of the performance scale. [3]

- One star imaging should only be considered informational, in that images are not of a sufficient quality to be useful for optical character recognition or other information processing techniques. One star imaging is appropriate for applications where the intent is to provide a reference to locate the original, or the intent is textual only with no repurposing of the content.
- Two star imaging is appropriate where there is no reasonable expectation of having the capability of achieving three or four star performance. These images will have informational value only, and may or may not be suitable for OCR.
- Three star imaging defines a very good professional image capable of serving almost all use cases. This includes being suitable for OCR as well as for reprint on the best commercially available printers.
- Four stars define the best imaging practical today. Images created to a four star level represent the state of the art in image capture and are suitable for almost any use.

10.3. Comparison between FADGI, ISO 19264-1 and METAMORFOZE

General Description	FADGI	ISO 19264-1	METAMORFOZE
Very Low Quality	One Star	No equivalent	No equivalent
Low Quality	Two Stars	Level C	Extra Light
Good Quality	Three Stars	Level B	Light
Best Possible Quality	Four Stars	Level A	(1)

(1) It should be called “strict” or “strong” but it is only called METAMORFOZE

The purpose of these tiers is not to pass negative judgement on digitization executed at less than preservation grade quality. There are many use cases where there is no incremental value in accomplishing digitization at higher quality. For instance, neither color nor tonal accuracy is critical for scanning most books, newspapers or magazines.

NOTE!	**A scan of good quality (FADGI ***) is significantly better and more accurate than a copy on a high quality color copier.**

In addition, scanners are substantially better in almost every respect when compared to digital cameras. Only the most advanced and also the most expensive digital cameras, (Hasselblad, Phase One) can compete on this level.

10.4. Cost Implications

It should be noted that each star in the FADGI system involves more time at higher hourly rates and significantly higher equipment cost in total and per hour.

NOTE!	As a rule of thumb, the total cost triples with each additional star.

An example:
The following is a cost breakdown of a project to digitize 10.000 pages of a historic newspaper which are bound in 20 books of 500 pages each.

Quality	Time	Labor (1)	Equipment (2)	Cost Per Page	Total Cost
FADGI **	80h	$1,200 @$15/h	$1,600 @$20/h	$0,28	$2,800
FADGI ***	160h	$3,200 @$20/h	$4,800 @$30/h	$0,80	$8,000
FADGI ****	320h	$8,000 @$25/h	$16,000 @$50/h	$2,40	$24,000

(1) Each additional star requires twice the time but at a higher hourly rate due to higher qualification levels of the operators
(2) The equipment cost per hour is higher as better the equipment is. FADGI **** compliant equipment sells at $100.000 while a FAGDI *** compliant Bookeye 5V1A book scanner sells for under $40,000.

10.5. Conclusion

Although from a technical point of view it is always optimal to have the best possible quality, this also comes at a price. Most projects can be successfully completed under the “two star” or “three star” guidelines, for which all Image Access scanners are suitable. The above mentioned project can most likely be completed to the customer’s satisfaction under the “two star” guidelines.

11. METAMORFOZE

METAMORFOZE, the national program for preserving the paper heritage, is a joint venture between the National Library of the Netherlands (Koninklijke Bibliotheek or KB) and the National Archives. The program is the joint initiative of the Ministry of Education, Culture and Science and is being coordinated by Bureau METAMORFOZE.

The METAMORFOZE Preservation Imaging Guidelines are input oriented and relate exclusively to the image quality and metadata of the first file. All the desired output (derivatives) intended for print and/or the internet can be made from this first file. In these guidelines, this first file is referred to as the Preservation Master. The guidelines are intended for the digitalization of two dimensional materials such as manuscripts, archives, books, newspapers, and magazines. They may also be applied to digitalizing photographs, fine art, and technical drawings

11.1. Three METAMORFOZE Quality Levels

For every original, the quality of the technical image criteria referred to in these guidelines is significant. The tolerance level of the individual criteria is determined by the classification of the originals into one of the quality levels described below. Also, the technical test charts are used differently for each quality level.

METAMORFOZE

In this quality level of the guidelines, the color accuracy tolerance has been described very strictly. This high digitization quality level is intended for digitalizing originals that are considered works of art, such as letters with drawings by Vincent van Gogh or maps, photo collections and paintings.

METAMORFOZE Light

In the second quality level of the guidelines, the color accuracy tolerance described is less strict. The second digitization quality level is intended for digitalizing originals, whereby color accuracy is slightly less significant. Examples include books, newspapers, magazines and handwritten material.

METAMORFOZE Extra Light

The third quality level is intended exclusively for digitizing books, newspapers, and magazines. For digitization projects needing only this quality level, digital cameras are used in most cases.

11.2. Comparison between METAMORFOZE, FADGI and ISO 19264-1

General Description	METAMORFOZE	FADGI	ISO 19264-1
Low Quality	Extra Light	Two Stars	Level C
Good Quality	Light	Three Stars	Level B
Best Possible Quality	(1)	Four Stars	Level A

(1) It should be called “strict” or “strong” but it is only called METAMORFOZE

The purpose of these levels is not to pass negative judgement on digitization executed at less than preservation grade quality. There are many use cases where there is no incremental value in accomplishing digitization at higher quality. For instance, neither color nor tonal accuracy is critical for scanning most books, newspapers, or magazines.

NOTE!	**A scan of good quality (METAMORFOZE light) is significantly better and more accurate than a copy on a high quality color copier.**

In addition, scanners are substantially better in almost every respect when compared to digital cameras. Only the most advanced and most expensive digital cameras, (Hasselblad, Phase One) can compete at this level.

11.3. Cost Implications

It should be noted that each step (METAMORFOZE extra light, METAMORFOZE light and METAMORFOZE) involves more time at higher hourly rates and significantly higher equipment cost in total and per hour.

NOTE!	**As a rule of thumb, the total cost triples with each additional step.**

An example:
The following is a cost breakdown of a project to digitize 10.000 pages of a historic newspaper which are bound in 20 books of 500 pages each.

Quality	Time	Labor (1)	Equipment (2)	Cost Per Page	Total Cost
Extra light	80h	€1,200 @€15/h	€1,600 @€20/h	€0,28	€2,800
Light	160h	€3,200@€20/h	€4,800 @€30/h	€0,80	€8,000
METAMORFOZE	320h	€8,000 @ €25/h	€16,000 @€50/h	€2,40	€24,000

(1) Each additional step requires twice the time but at a higher hourly rate due to higher qualification levels of the operators
(2) The equipment cost per hour is higher as better the equipment is. METAMORFOZE compliant equipment sells at € 100.000 while a METAMORFOZE light compliant Bookeye 5V1A book scanner sells for under € 35,000

11.4. Conclusion

Although from a technical point of view it is always optimal to have the best possible quality, this also comes at a price. Most projects can be successfully completed under the “extra light” or “light” guidelines, for which all Image Access scanners are suitable. The above mentioned project can most likely be completed to the customer’s satisfaction under the “extra light” guidelines.

12. Operating Scanners Under Defined Quality Guidelines

All Image Access Scanners are ISO 19264-1 level B compliant at a minimum, provided that the scanners are calibrated with the appropriate calibration sheets, verified via the recommended tools (iQ Analyzer [2]) and operated under appropriate light conditions in the scanning room. Flatbed scanners easily meet the ISO 19264-1 level A guidelines if operated and calibrated properly.

All Image Access Scanners are FADGI *** compliant at a minimum, provided that the scanners are calibrated with the appropriate calibration sheets, verified via the recommended tools (OpenDICE and AutoSFR [6]) and operated under appropriate light conditions in the scanning room. Flatbed scanners easily meet the FADGI **** guidelines if operated and calibrated properly.

All Image Access Scanners are METAMORFOZE light compliant a minimum, provided that the scanners are calibrated with the appropriate calibration sheets, verified via the recommended tools (iQ Analyzer [2]) and operated under appropriate light conditions in the scanning room. Flatbed scanners easily meet the METAMORFOZE guidelines if operated and calibrated properly.

12.1. Flatbed Scanner Operation

Flatbed scanners are the easiest to operate in a way that they produce compliant scan results. Flatbed scanners have a lid which makes them insensitive to ambient light. Image Access flatbed scanners WideTEK 12 and WideTEK 25 are suitable for ISO 19264, FADGI and METAMORFOZE compliant scanning and achieve the highest quality of all models. The CIS based flatbed scanners like the WideTEK 24F are almost as good as the CCD versions but much more affordable. Other large format scanners which are also compliant are part of the VERSASCAN family of scanners from SMA. For best results follow these steps.

- Keep the glass plate and the lid clean.
- Make sure the lid is closed and no light can enter the scanner during operation.

Obviously, flatbed scanners usually cannot be used for bound documents and flat documents which require contact free scanning.

12.2. Sheetfeed Scanner Operation

Sheetfeed scanners are also fairly simple to operate as ISO 19264, FADGI and METAMORFOZE compliant, as long as the document's condition permits being fed through a sheetfeed scanner. The Image Access wide format scanners WideTEK 36, WideTEK 44 and WideTEK 48 are suitable for ISO 19264, FADGI and METAMORFOZE compliant scanning and achieve results almost as good as the flatbed scanners. Fragile or hard to feed documents can be scanned with the help of the clear envelope, which removes any stress from the document during feeding. The stiffness of this envelope also helps to achieve the highest possible geometric accuracy. For best results follow these steps.

- Keep the glass plate and the transport drums clean.
- Make sure that the documents can be fed safely. If necessary, turn on the safe drive function.
- Use the clear envelope if documents are precious originals, fragile, dirty, or partially destroyed.

12.3. Book Scanner Operation

Planetary scanners are also called book scanners and they pose the least impact on the object to be scanned. However, they are the most difficult to operate with respect to various ambient light conditions and product features. Since book scanners operate in an open environment, care must be taken to guarantee adequate ambient conditions. The following is a list of steps which must be taken to ensure consistent quality for ISO 19264, FADGI and METAMORFOZE compliant results.

- The ambient light must be at a low level, neutral, diffuse, and consistent.
- No spotlights are allowed, fluorescent lights directly above the scanner must also be avoided.
- No direct or indirect sunlight is allowed since it is not consistent over time.
- Monitors should not send any significant light toward the scanning object.
- The operator must be dressed in neutral colors, a dark gray is preferable.
- The operator should not be able to produce a shadow on the scanning bed.
- The scanner's light source temperature should be 5000K, CRI 90 and above.
- The scanner's light intensity must be at least 10 times the ambient level. Light levels at the scanning positions should be at least 5.000lux.

The Bookeye family of scanners from Image Access can be operated ISO 19264, FADGI and METAMORFOZE compliant if the above conditions are met and if the scanners are calibrated at their final position. The models range from the A3+ model Bookeye 5V3, the A2+ model Bookeye 5V2 and the largest member, the Bookeye 5V1A. The main feature which guarantees tonal and color accuracy in normal ambient light conditions is the fact that a bar of bright, high quality CRI>90 LED light moves in sync over the scanning surface, minimizing the impact over time on the scanning object. Because the light level at the scanning position is far over 5.000 Lux, the influence of ambient light is very small.

NOTE!	**All *real book scanners* on the market today have one or two high output, high quality LED light bars which are moved over the document while scanning.**

12.4. Book Camera Operation

There are digital cameras on the market that are mounted on a neck with or without internal lights which would more correctly be called "***book cameras"***. Some vendors call these digicams "***book scanners***", trying to resemble the quality level that can be achieved only by real book scanners.

The list of preconditions for book cameras are the same as for book scanners. But there are additional problems:

The biggest problem is light. Since it is mandatory for good results to have at least 10 times more controlled light than the ambient light level, there are only two ways to overcome this with book cameras.

- The first option is operating in a very concealed room with an extremely low ambient light level and an illumination of the whole area with extremely bright light at the time of exposure.

- The second option is an operation with a flash known from digital cameras.

Both options are extremely strenuous for the operator.

One vendor claims that they can work without internal light. This can be compared to taking a picture of a person in the early morning, at noon and at sunset. No one would expect a high degree of similarity between these pictures and equipment that relies on ambient or natural light will not meet all quality criteria, even at the lowest level.

The second problem is the low resolution for larger scanning areas. A high-end Phase One 100MP camera has 50 million green, 25 million blue and 25 million red pixels. The smallest Bookeye scanner, selling for a fraction of the price of a Phase One camera, already has 70 million green, 70 million red and 70 million blue pixels. Only the most advanced book cameras can meet the requirements set forth in the ISO 19264, FADGI and METAMORFOZE guidelines for larger formats. The products from Digital Transitions for example, can meet even FADGI **** and they need two cameras for larger documents, but they also carry an appropriate price tag.

Another problem with digital cameras is the fact that the lenses are optimized for photography and not for flat images. Also, the calibration process takes so much time that the only benefit compared to scanners – shorter exposure time – fades away when all tasks are considered.

NOTE!	**A book camera has an area sensor, also called matrix, one shot etc. All *real book scanners* have line sensors and scan line by line while only illuminating the area to be scanned with high quality LED light.**

13. Calibrating a Scanner's Compliance with the FADGI Guidelines

This document explains how a Scan2Net® scanner, whether it is a Bookeye® book scanner or a WideTEK® sheetfeed or flatbed scanner, needs to be operated to form a FADGI compliant digitization environment. The document also presents validation measurements performed with the tools OpenDICE and AutoSFR recommended in the guidelines.

To calibrate or verify a scanner, three things are needed.

- A scanner that generates images with an embedded ICC profile. The profile used can be either the default profile of the scanner or an individually generated profile using an IT8 test target or a ColorChecker SG.
- A Dice test target which is used by OpenDice and AutoSFR.
- The OpenDice and AutoSFR are free tools under a BSD license which can be found at Chapter 4, References [6]

13.1. Scanner with ICC Profile

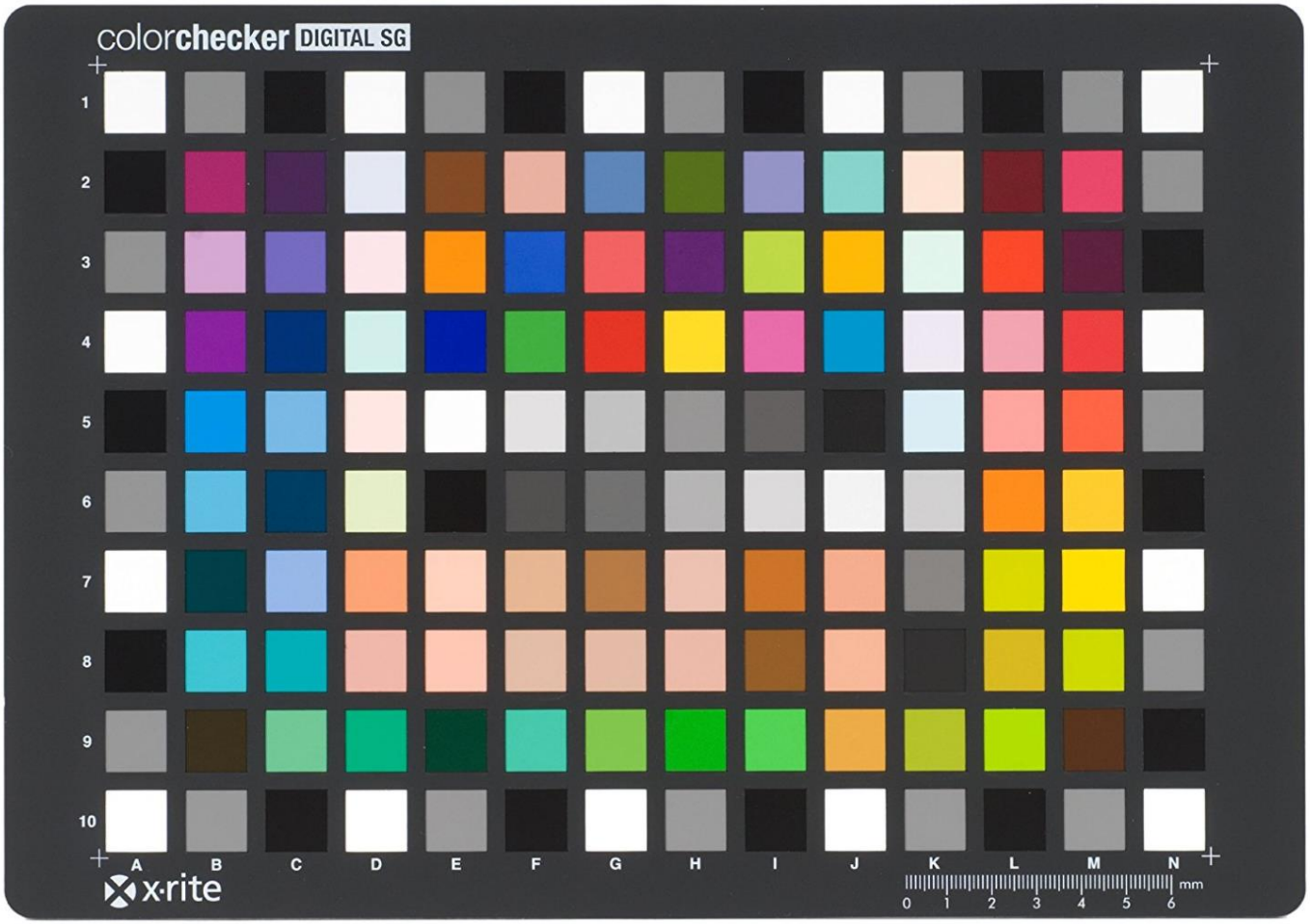

Fig. 1: ColorChecker SG from x-rite

Image Access scanners all have a built in ICC profile, which is generated individually for each scanner family. Most standard ICC profiles are good enough to be FADGI *** compliant. If the test fails, generate a new individual ICC profile using Scan2ICC.

Optionally, all Image Access scanners are shipped with an IT8 test target which is used to individually generate ICC profiles via our Scan2ICC option.

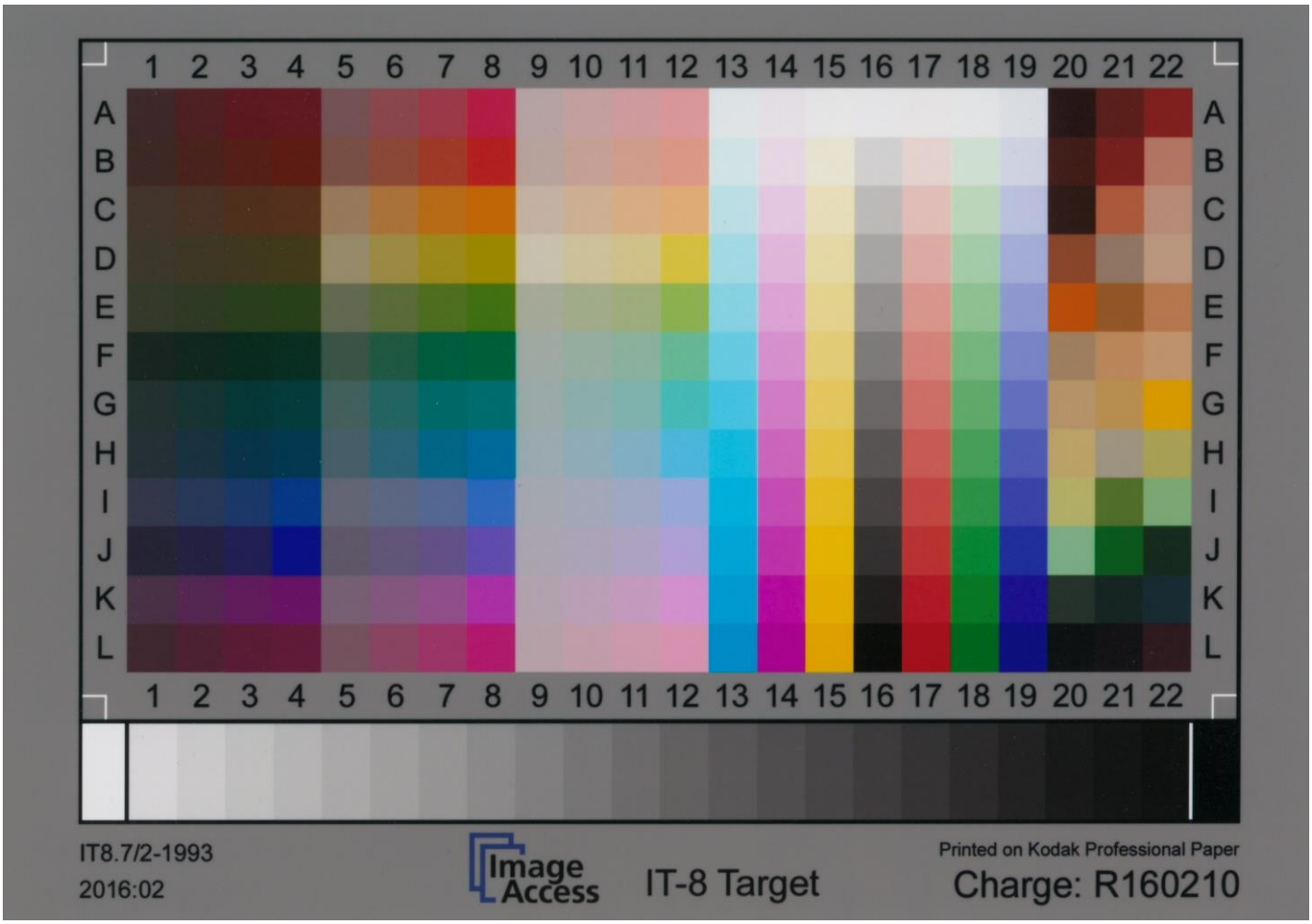

Fig. 2: IT8-chart

NOTE!	**The built in ICC profile of an Image Access scanner is most likely good enough to satisfy the FADGI *** requirements. If the target is not met, use Scan2ICC to recalibrate.**

13.2. The Dice Test Target

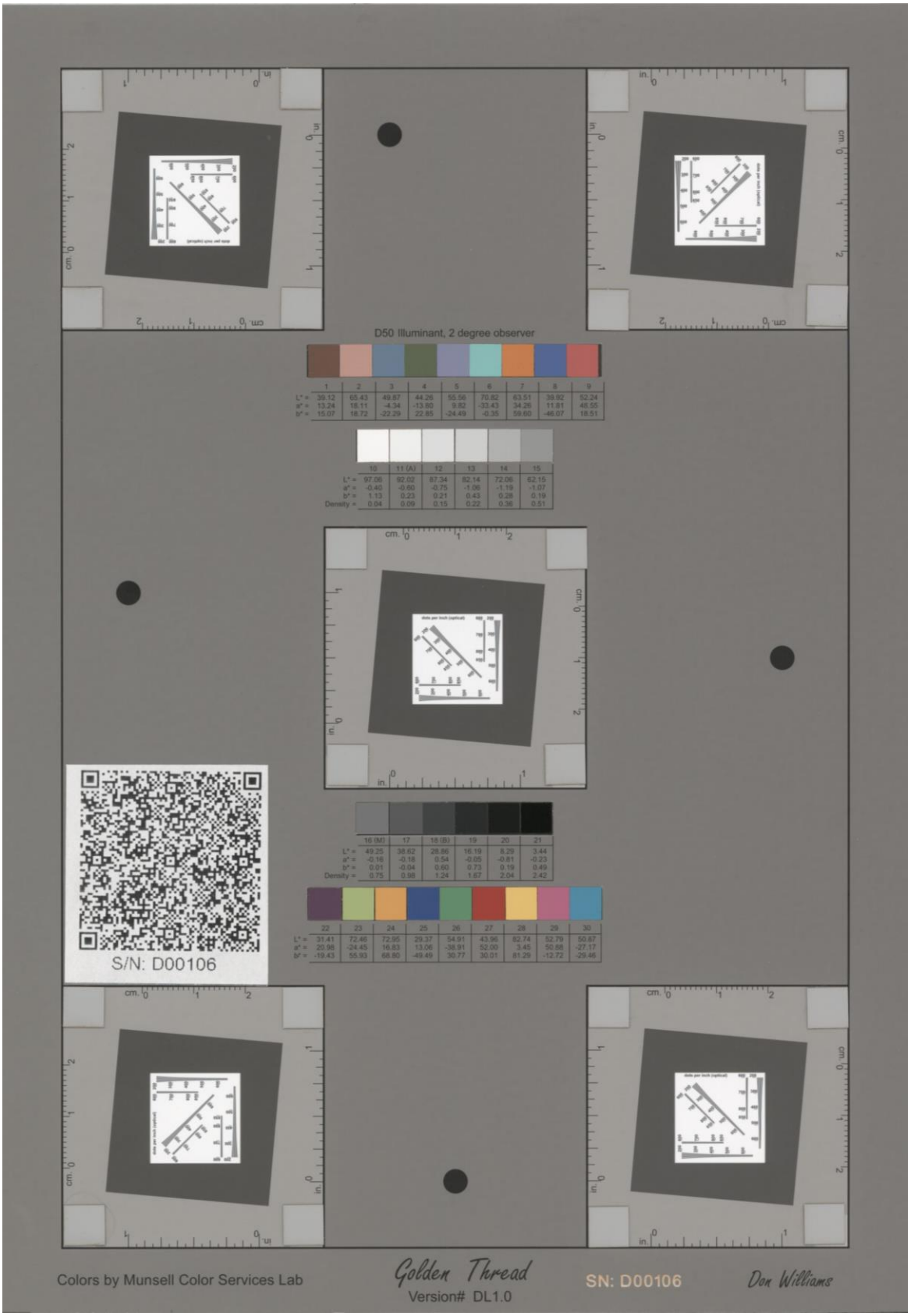

Fig. 3: Dice test target

13.3. Calibrate White Point Using the DICE Test Target

One of the most important things to do is to calibrate the white point. It might not be obvious that it matters much if the image is darker or lighter, but the tonal response curve is checked by the openDICE verification tool, and the error bandwidth is very small. On the dark side, things are slightly relieved because black is the absence of light and can be controlled rather easily in comparison with the white point.

Patch #10 of the DICE target marked on figure 2 shows the L*a*b* values of 97,06, -0,4, 1,14 and a density value of 0,04. This is the same on any DICE target, which basically means that these values are controlled during manufacturing of the target and not measured after manufacturing, as with other targets.

These values translate to RGB values of 246, 246, 244 in the 24bit color domain. The tonal response curve required in the FADGI guidelines can only be met if the scanner returns these RGB values on this patch as close as possible. If the first measurement by OpenDICE is not satisfactory although the patch #10 returns the required values, you can still tweak it a little higher or lower to get the tonal response curve completely inside the tolerance boundaries.

Step 1: Start ScanWizard and select the ISO 19264-FAGDI template. This template is available on all scanners with the firmware level 6.72 and higher.

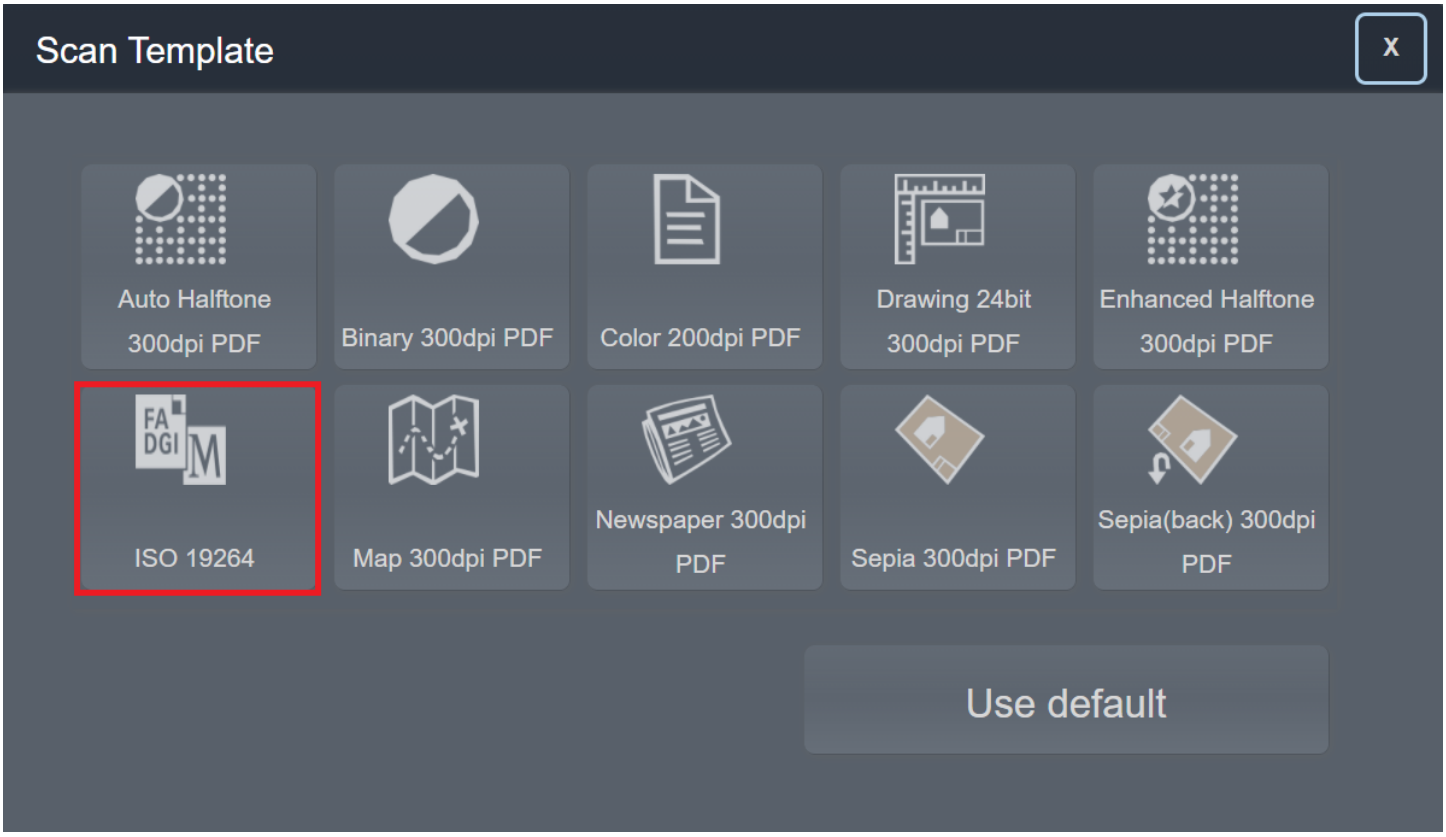

Fig. 4: Select FADGI template

Step 2: Scan DICE target and mark the area containing patch 10.

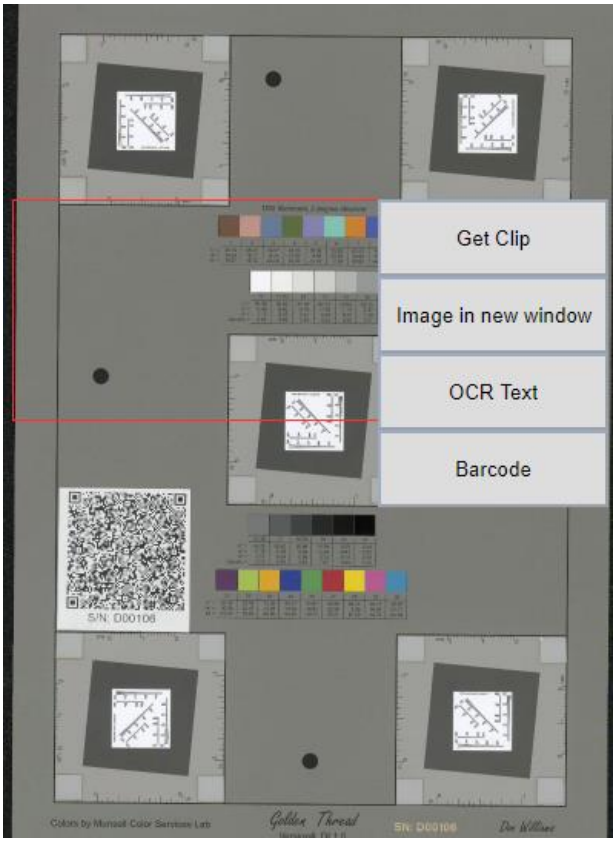

Fig. 5: Mark area including patch10

Step3: Mark patch10 (use the right mouse button to draw a rectangle) and select “Color Calculation”

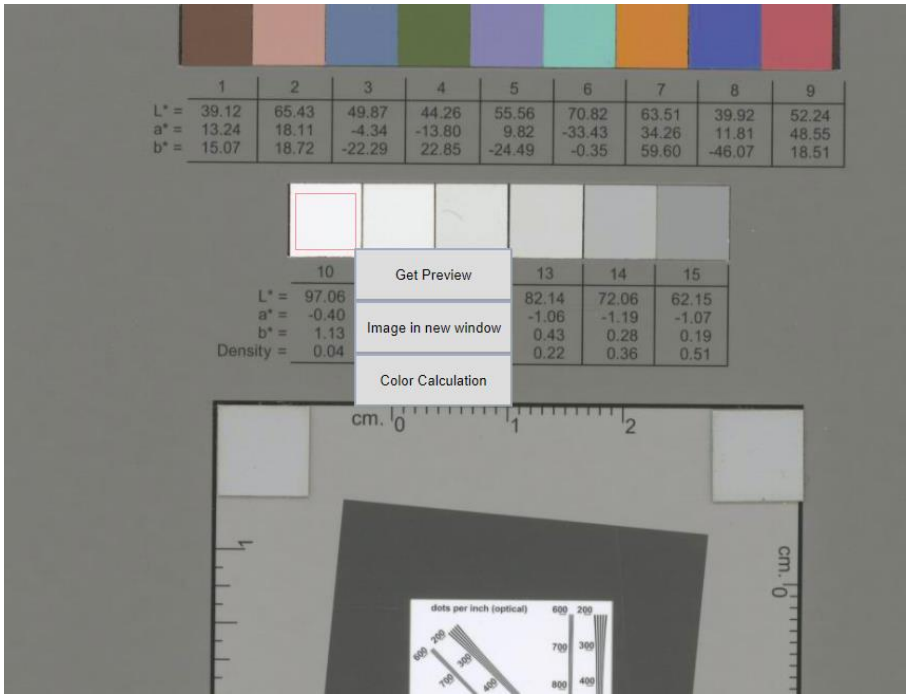

Fig. 6: Mark patch10 and select Color Calculation

Step 4: Enter the target reference values for patch 10, which are printed below the patch.

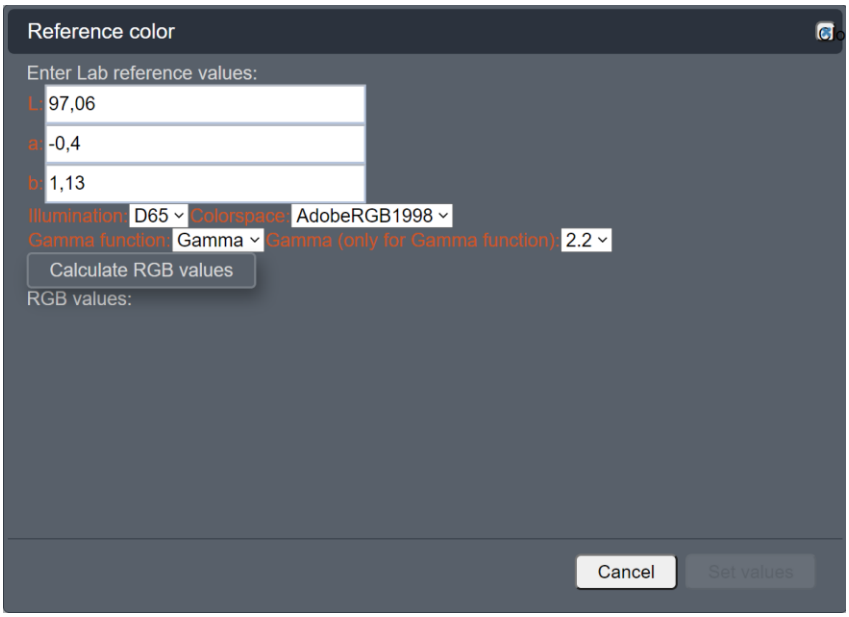

Fig. 7: Calculate RGB values and gains

Step 5: Tap “Calculate RGB values”. The calculated RGB reference values and the actual RGB image values are displayed.

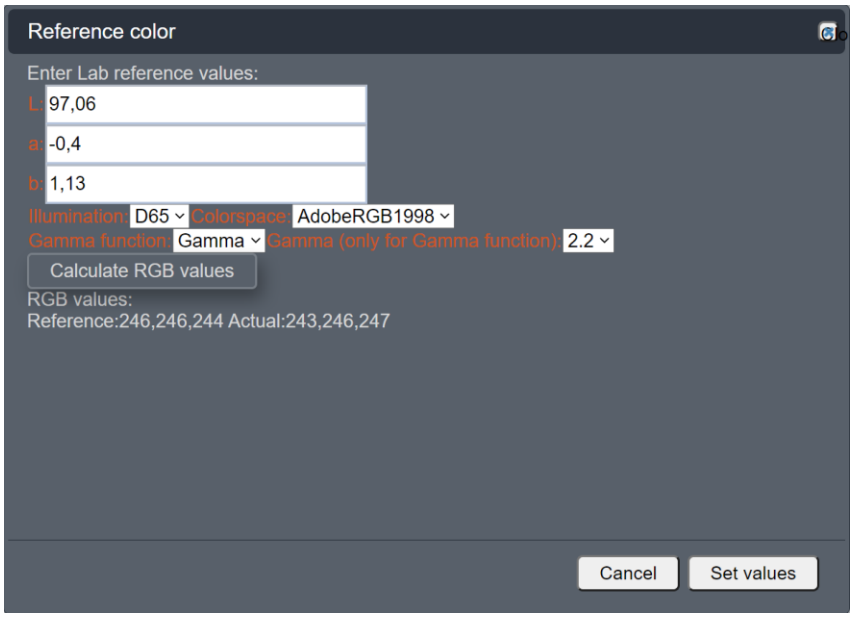

Fig. 8: Reference and actual image values

Step 6: Tap “Set values” to store the calculated gains (based on the calculated RGB values) in the scanner and work with these values.

NOTE!	**After this procedure is performed, a temporary new white reference point is stored until the scanner is turned off. To make this change permanent, a new template needs to be generated.**

14. Calibrating to the ISO 19264-1 or METAMORFOZE Guidelines

The UTT test chart is designed to evaluate the imaging system's quality of scanners and other digital input devices used to create digital images of documents, photos, and other reflective media. Individual measurements and regular checks of the target ensure that the results obtained from the measurements are reliable.
The idea behind the UTT test chart was to have a universal target for visual and automatic evaluation that covers all the basic aspects of imaging systems quality and at the same time is scalable. Therefore, a variety of features have been implemented that will be explained in the following sections.

All structures designed to be neutral grey at different brightness levels should have a spectral reflectance as uniform as possible over the visual spectrum. In order to reduce the cost of the target, a compromise for spectral non-uniformity needs to be made and it must be kept in mind for the production process. The patches shall appear uniform under typical halogen, tungsten, and fluorescent lighting. The measured a* and b* values for all patches (D50, 2° observer) shall not exceed the ± 4 range.

14.1. The Universal Test Target (UTT)

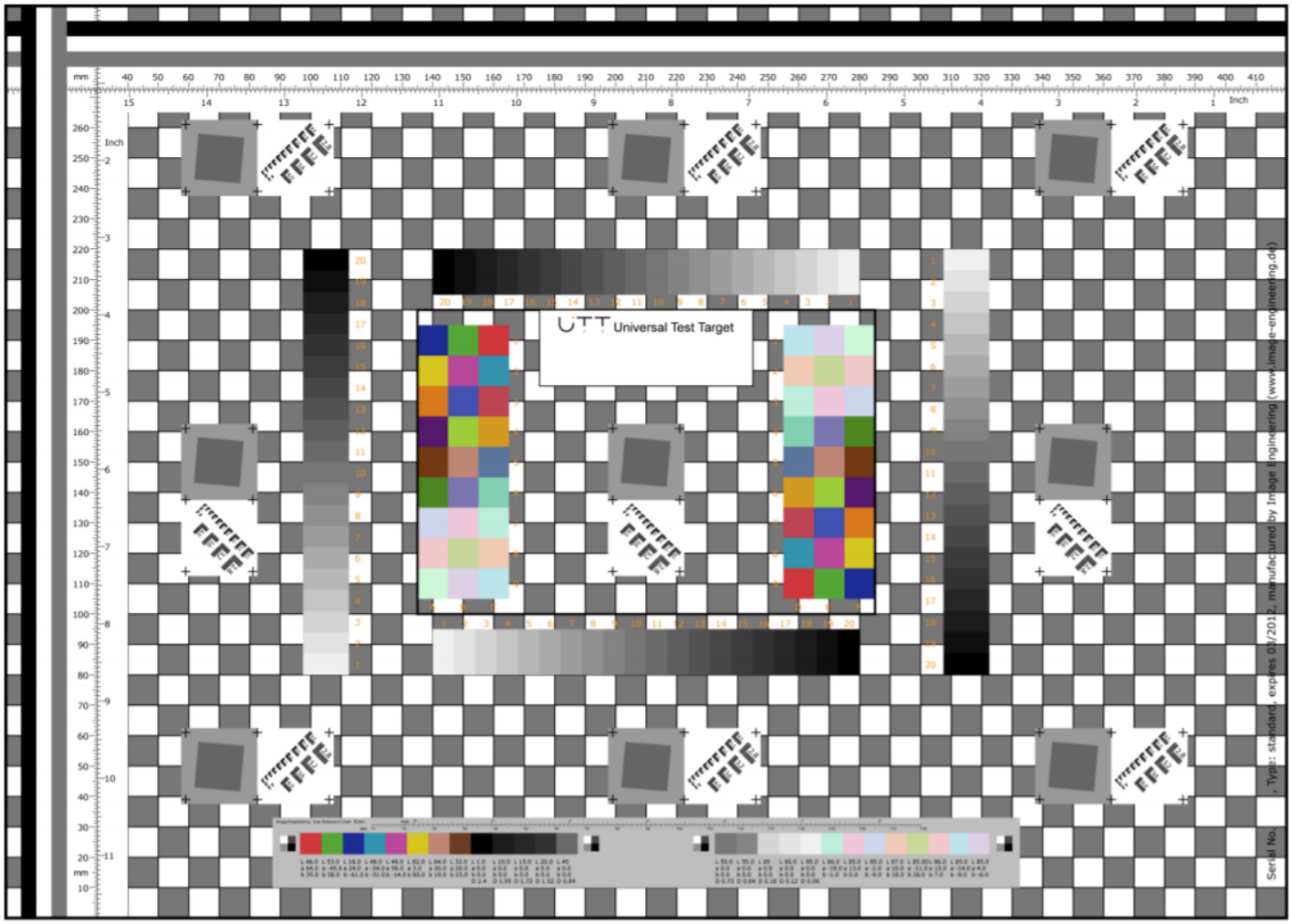

Fig. 9: Universal Test Target (UTT)

14.2. Calibrate White Point using the UTT

One of the most important things to do is to calibrate the white point. It might not be obvious that it matters much if the image is darker or lighter, but the tonal response curve is checked by the iQ Analyzer verification tool and the tolerable error bandwidth is very small. On the dark side, things are slightly relieved because black is the absence of light and can be controlled rather easily in comparison with the white point.

The patch 1 of each grayscale bar is the reference white for the tonal response curve required in the ISO 19264 and METAMORFOZE.

The ideal lab values are defined as 95 0 0 and a density value of 0.06. If you have a photometrically measured UTT target, the manufacturer will have delivered a reference file with it. The reference file is used by the verification program but is also needed here. The only value of importance is the measure value for patch 1

Step 1: Start ScanWizard and select the ISO 19264 template. This template is available on all scanners with the firmware level 6.72 and higher.

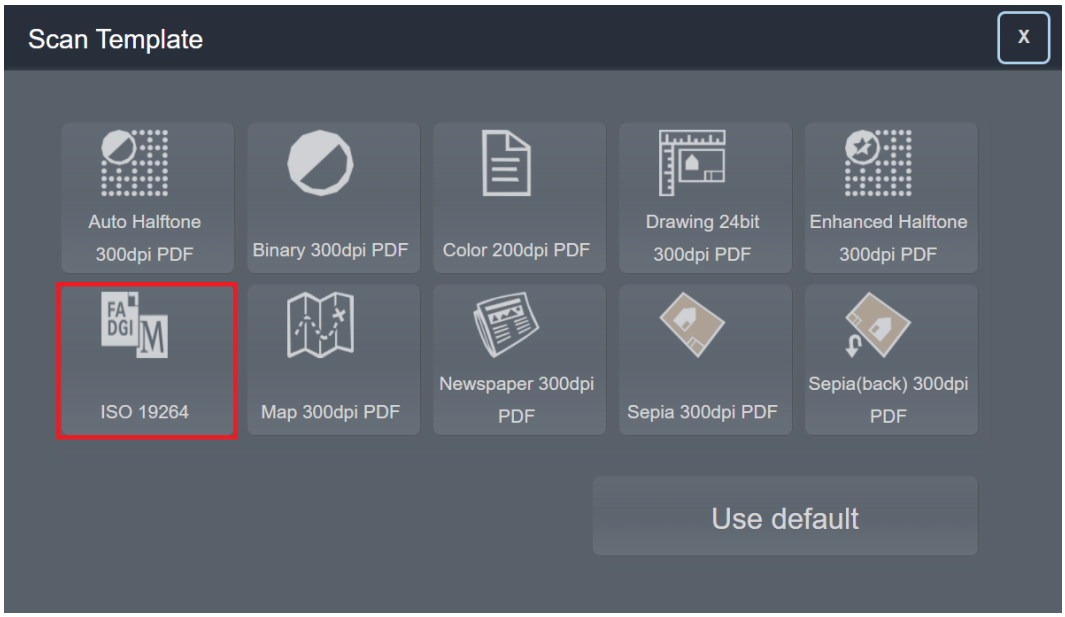

Fig. 10: Select ISO 19264 template

Step 2: Scan UTT target and mark the area containing patch1.

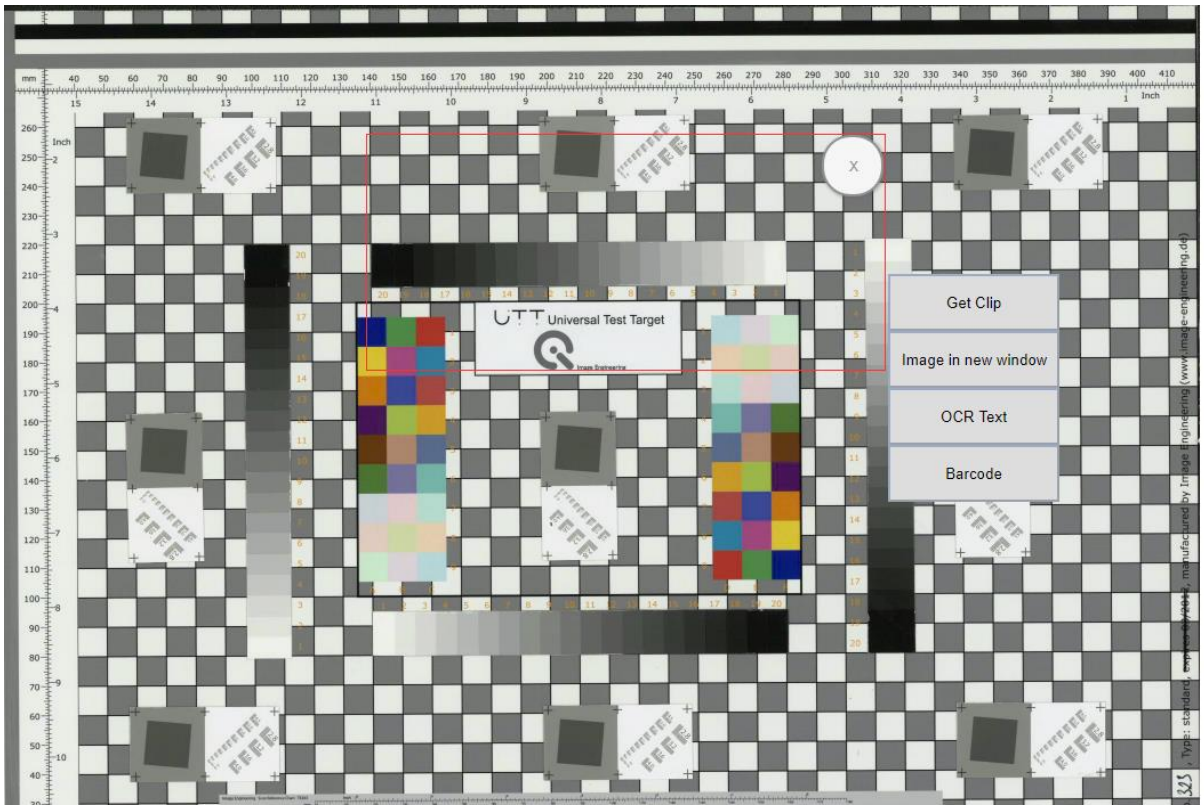

Fig. 11: Mark area around grayscale bar including patch 1

Step3: Mark Patch1 (use right mouse button to draw rectangle) and select “Color Calculation”

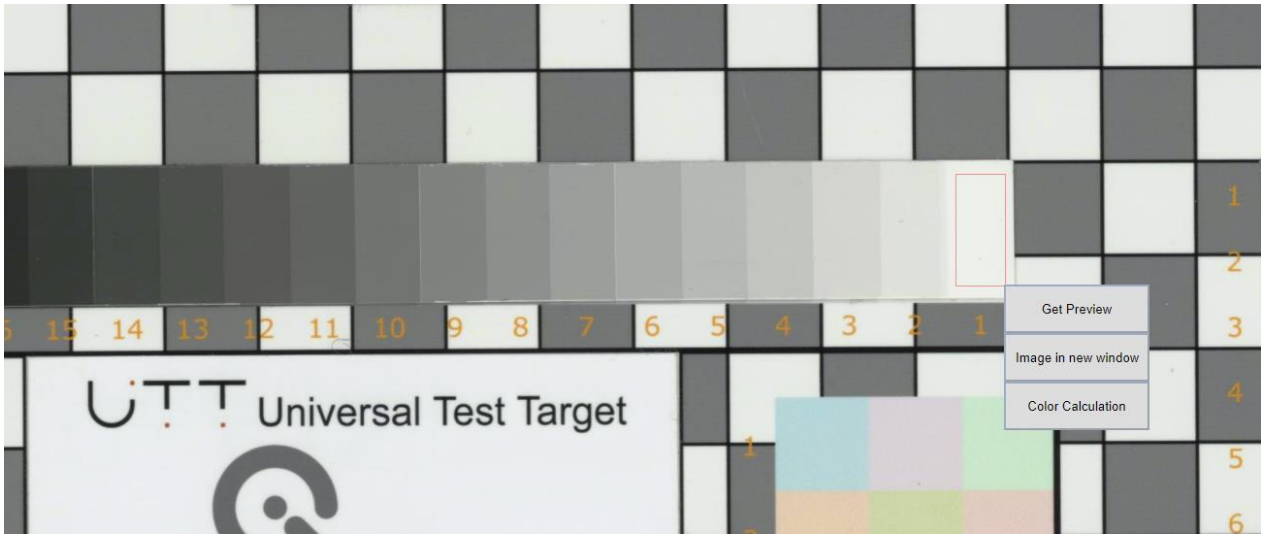

Fig. 12: Mark Patch1 and select Color Calculation

Step 4: Enter Target reference values for Patch 1

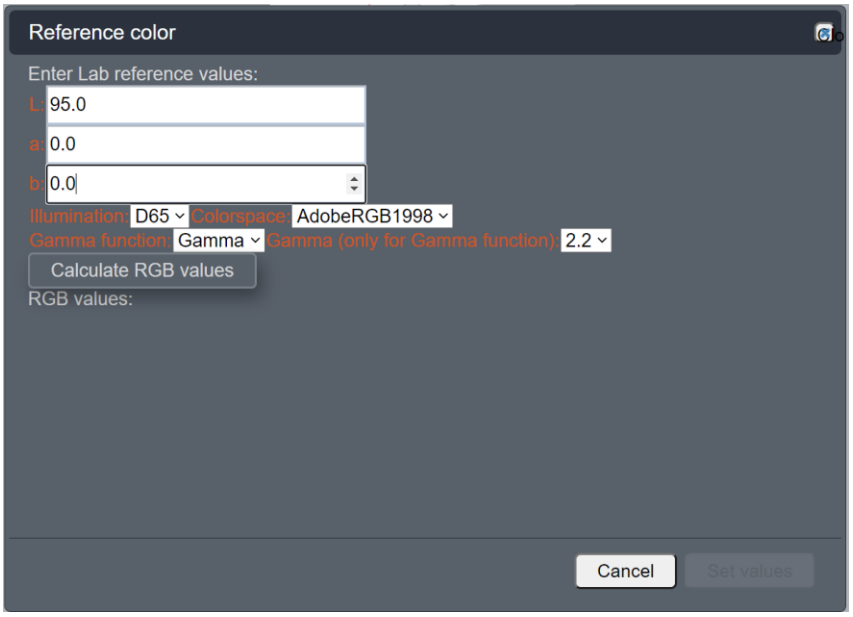

Fig. 13: Calculate RGB values and gains

Step 5: Tap “Calculate RGB values”. The calculated RGB reference values and the calculated RGB image values are displayed.

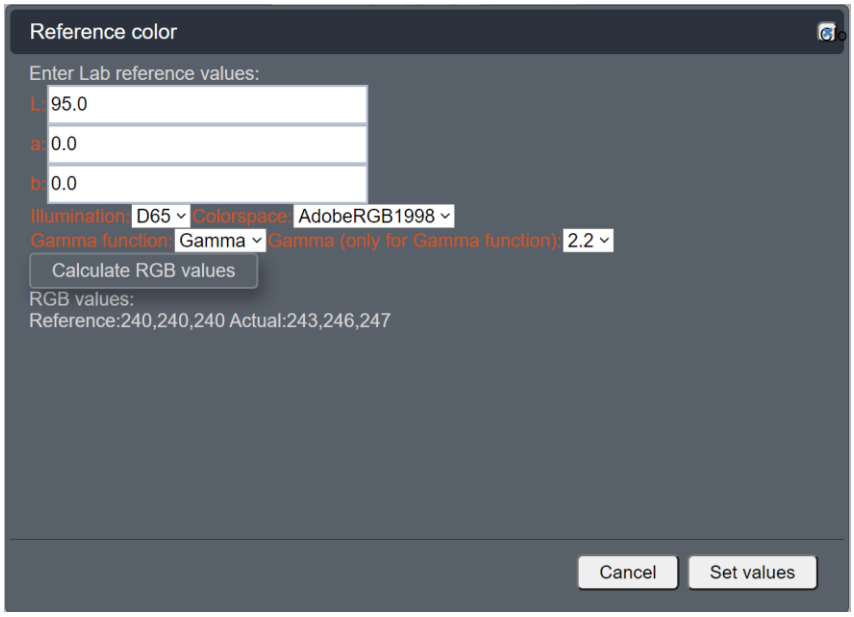

Fig. 14: Reference and actual image values

Step 6: Tap “Set values” to store the calculated gains (based on the calculated RGB values) in the scanner and work with these values.

NOTE!	**After this procedure is performed, a temporary new white reference point is stored until the scanner is turned off. To make this change permanent, a new template needs to be generated.**

15. Create a New Template with Individual White Point

The calibration to FADGI, ISO 19264 or METAMORFOZE can be done after the appropriate template is selected. Aside from the white reference point which needs to be calibrated, all other parameters in the template are set so that the scanner passes the compliance test. Occasionally, it might be necessary to fine tune some parameters to meet the criteria set forth in the guidelines. One example is the level of sharpness applied to the image, which might cause a failure in the test software, so that the operator has to make the image blurrier. Details are explained in the next chapter.

The best approach to this is possibly to ignore some of the fails (like the one caused by the scanners producing images that are too sharp) and use the default values of the scanner to achieve crisp and clean images.

The default templates cannot be changed, therefore all changes made after invoking the default template (FADGI or ISO) are lost as soon as the scanner is powered down. It is therefore advisable to duplicate the template and disable the default one.

Step 1: Open the FADGI or the ISO 19264 template.

Step 2: Duplicate the template and add “(cal)” for calibrated or something similar to the existing name.

Step 3: Disable the visibility of the default template, enable the visibility for the copy.

Step 4: After calibration and other settings have been performed and the compliance is tested, tap on “Save current Settings” to store all settings in the template.

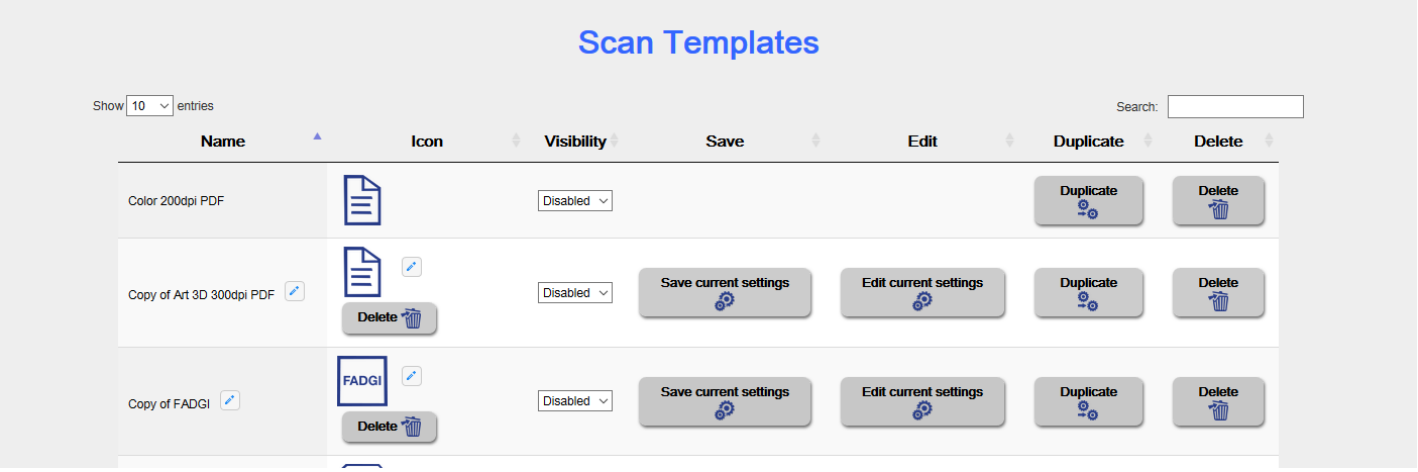

Fig. 15: Scan templates menu

16. Sharpness

16.1. Overshoot

ISO 19264-1, FADGI and METAMORFOZE all require different measurements and requirements for the Modulation Transfer Function MTF [10]. There is a limit for overshoot, which varies among the guidelines and quality levels which range from 5% to 20%. Overshoot typically is caused by applying sharpening algorithms to the digital image. All digital cameras need to do this because their claimed resolution is significantly lower than advertised due to the Bayer pattern effect. The sharpness and details of a real RGB scan of 50Mp is comparable to a 70Mp picture taken by an expensive digital camera without sharpening applied. This gap can be made smaller only with excessive sharpening, at the cost of generating artifacts. This is the reasoning behind the strict overshoot limitations in all guidelines.

16.2. MTF

The requirements for the spread of the MTF are also very different. The common ground is that the MTF10 frequency (MFT10 = 10% modulation) should be close to half of the sampling frequency (Nyquist frequency) and the MFT50 should also be in a certain range.
All Image Access scanners are real scanners – not digicams - and produce real RGB pixels. All scanners also have a sharpness setting which ranges from -7 to +7. All values between -1 and -6 apply blurring to the image while +7 actually bypasses any modification. Values between 0 and +7 sharpen the image. A value of 0 only compensates the MTF of the lens and produces crisp and sharp images but does not always meet some of the older FADGI verification tools because the resulting MTF is better than allowed. The image still meets even the strictest overshoot criteria; therefore it is not considered sharpening by the guidelines but since the MFT is too high for some of these verification tools, it would report to fail the criteria set forth in the various guidelines. Therefore, from time to time, the sharpness of an Image Access scanner has to be negative for these verification tools to report acceptance, but the MTF looks like a digital picture taken by a digicam. The image looks much better without blurring the image just to satisfy these verification tools.

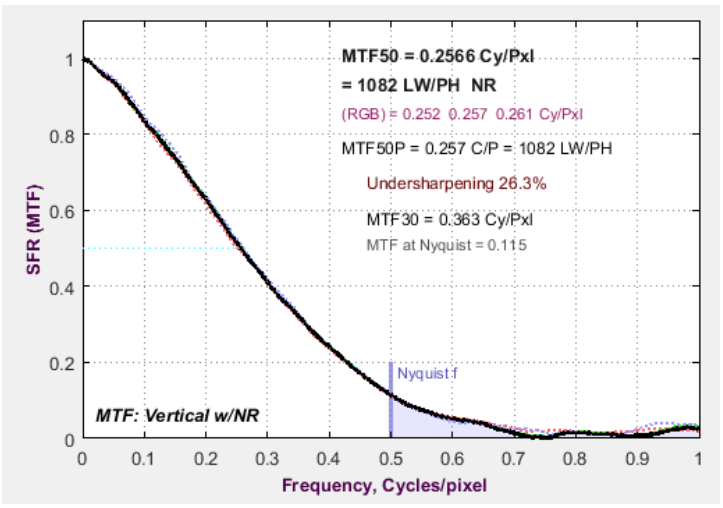

Fig. 16: MTF of WT25 reduced, passes older FADGI

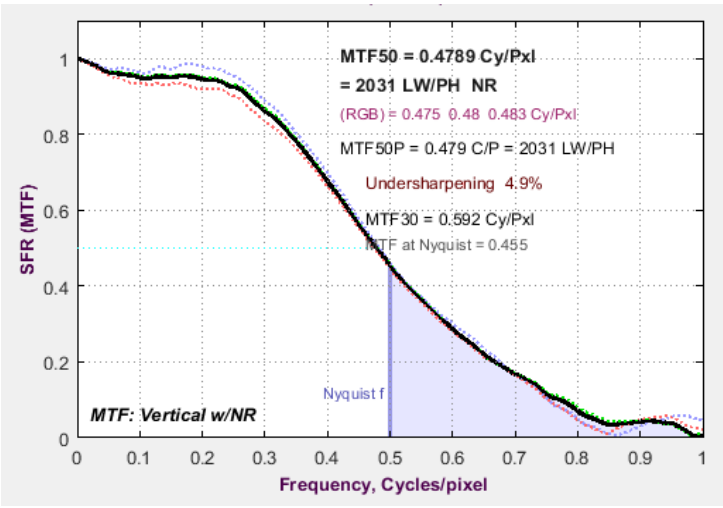

Fig. 17: MTF of WT25, too good for older FADGI

NOTE!	We recommend setting sharpness to a value of 0 to get more crisp images at the expense of failing the MTF10 or MTF50 criteria of some validators.