

**W1.1: Image Quality of Printers
Guide for the Development of Standards**

The overall work of W1.1 will be divided among several task teams, each of which will focus on one or two major attributes. This is a draft guide for the task teams outlining the process to be followed in working on each of the print quality attributes. The guide describes the steps that should be taken to ensure that the developed standards are comprehensive and suitable for comparisons of print quality independent of printing technology or technical parameters.

This summary document is a work in progress. As the committee defines refinements in the process, the specific items listed here may be modified. This statement is a working draft and should be considered as a starting point for focused discussion.

1. Summary of overall procedure to be applied on each major attribute:

A. Define in a written statement the attribute and sub-attributes being studied.

B. Design one or more digital test targets suitable for characterizing all aspects of the attribute.

C. Produce hardcopy samples of the test targets which encompass all relevant printing technologies and all relevant levels and types of defects related to the attribute.

D. Digitize each hardcopy sample into a raster image (and/or other suitable digital representation, such as color measurements).

E. Establish subjective ratings of the attribute for each hardcopy sample. (Note: for the purposes of this activity, "subjective rating" refers to a visual, perceptual but nonetheless quantitative evaluation.)

F. Develop procedures for objective metrics to rate the digitized images or other representations created from the hardcopy samples. (Note: for the purposes of this activity, "objective metric" refers to an evaluation based on instrumental measurement.) Also generate computer code implementing each procedure.

G. Apply the objective metrics on the digitized images or other representations created from the hardcopy samples.

H. Correlate the outputs of the subjective evaluation (Step E) and the objective metrics (Step G). If they are not compatible, go back to Step F and define a more suitable procedure for objective metrics.

I. Independently confirm the validity of the procedures for objective metrics by repeating steps C, D, E and G, using an additional, independent set of hardcopy print samples.

The outcome of each significant step in the process will be posted on the W1.1 web site. A rapid response notice will be sent to the entire committee for review, comments and suggestions. Committee members will then have two weeks to make appropriate comments before the teams continue their work. In this way the various working teams will be able to participate in the standard as a whole and unity will be maintained in the form and content of the output.

2. Define Attributes (Step A in item 1)

It is critical that there is a common understanding of the attributes within each team and across the teams working on different attributes to ensure complete but not redundant coverage. To ensure that we have a common understanding of the attribute definitions, from the perspectives of all

relevant technologies, each team as a first priority will post a document that carefully defines the attribute they are addressing. In many cases the later work may be simplified by using two or more sub-attributes which together comprise that particular attribute. In such cases, these sub-attributes should also be defined at this step.

All documents should contain appearance-based definitions only, and there should be no technology-based definitions. As examples of technology-based definitions for Line Quality, electrophotographic toner scatter or inkjet satellite drops in the vicinity of a line may cause the line edges to appear blurred; inkjet bleed may cause the line to appear ragged; and so forth. The corresponding definitions should refer to appearance-based issues such as line edge blur and raggedness, not to technology-based issues such as toner scatter, satellite drops, and bleed. The attribute definitions must be suitable for all printing technologies and for comparisons between technologies.

In addition to the definition statements the document should contain a collection of scanned raster images (or other suitable digital representations) of hardcopy prints that illustrate actual print quality defects that pertain to the attribute. These images will be used only to illustrate the attribute definition, and are not the image set to be evaluated in Step C.

The posted document from each team will be reviewed by the entire W1.1 project before the team proceeds to the next stage.

3. Design digital test targets (Step B)

A digital test target is a digital document, or part of a digital document, suitable for evaluation of an attribute. A given test target may be suitable for evaluation of more than one attribute. Designing digital test targets appropriate for both objective and subjective evaluation is fundamental for the development of the standards.

Some considerations for designing the digital test targets:

3.1. The standard should be suitable for evaluating the image quality of all aspects of the printer system. Therefore, the test targets must be specified by a description of the fundamental image content, unmodified by specific applications. At least one valid implementation of the test target in an appropriate application program should also be provided.

3.2. The test target must be appropriate for the attribute being tested. For example, Text Quality test targets must be created using outline fonts rather than as raster images.

3.3. The test target must not be specific to a certain technology or technological parameter. For example, it should not contain raster images that assume a certain printer resolution (dpi). The test targets should be sensitive to all the visually significant characteristics of the images used in relevant technologies.

4. Creation of hard copy test samples (Step C)

One of the key advantages of an approach that focuses on attributes is that it allows a direct comparison of image quality independent of technology or engineering design variables. To enable this, the objective metrics (Step F) must be applicable to the various relevant technologies, and be robust against defects in the image other than the attribute being measured. An example of the challenge in this regard, is the presence of high frequency noise when measuring low frequency noise. Care must be taken to devise robust metrics.

The hardcopy test samples generated for this study must support these objectives. In particular, the sample set must be sufficiently diverse among printing technologies, and cover a suitable range of image quality for each of these technologies, to demonstrate that the attribute definitions and measurements apply across all technologies. Input for the sample set will be solicited from the entire W1.1 project. A rapid response will be requested of those wishing to participate.

5. Digitizing images (Step D)

The objective measurements made on test images must be specified in terms of well-defined physical quantities, independent of any particular measurement instrument. To ensure the results are not convoluted by characteristics of the measurement device, we must make sure the hardcopy samples are digitized with a device that does not compromise the quality of the digitized image.

5.1. The spatial resolution and accuracy must far exceed what is necessary for evaluation of the attribute. The necessary resolution may be different from one attribute to another.

5.2. The color resolution (e.g., bit depth) and accuracy must far exceed what is necessary for evaluation of the attribute. The color must be represented by colorimetric quantities such as CIELAB as appropriate for the attribute.

6. Subjective evaluation (Step E)

A subjective rating of the hardcopy sample set from section 4 should be conducted. For the purposes of this activity, "subjective rating" refers to a visual, perceptual, quantitative evaluation. This subjective rating will form the basis for testing the procedures developed in Step F. The accuracy of these procedures will be verified by applying them on independent hardcopy samples of the defined test targets as discussed in Step G.

There needs to be a uniformity of process across attributes, and the exact procedures to be used in subjectively evaluating the images should be defined. The final scaling method selected will certainly require more observers than the number of committee workers developing the standard. After the subjective evaluation procedure is defined, it can be carried out at multiple sites covering of the W1.1 project.

7. Developing objective metrics (Step F)

Procedures should be developed for objective metrics to rate the digitized images or other representations created from the hardcopy samples. For the purposes of this activity, "objective metric" refers to an automated evaluation based on instrumental measurement.

The objective metrics are intended to numerically represent the image quality pertaining to the given attribute or sub-attribute, as quantified by the subjective evaluation (Step E). In keeping with the nature of the attributes, the metrics should be appearance-based. Known characteristics of the human visual system should be taken into account wherever possible in their design.

At least one instance of computer code for each procedure should be implemented in an appropriate programming language, and made available to the entire W1.1 project.

8. Applying objective metrics (Step G)

The objective metrics developed in Step F should be applied to the digitized images or other representations created from the hardcopy samples, to

determine numerical values signifying the measured quality of the hardcopy images.

9. Correlating objective and subjective ratings (Step H)

The performance of objective metrics applied in Step G should be correlated with the subjective rating determined in Step E. Any correlation factors necessary may be determined at this stage. If the correlation is inadequate, steps F, G and H should be repeated until adequate correlation is achieved.

10. Testing performance of objective metrics (Step I)

Finally, the validity of the objective metrics should be independently verified. Since the metrics would be developed using the hardcopy samples of Step C and their subjective evaluations of Step E, these should not be reused here. A new set of hardcopy samples, solicited from the entire W1.1 project, should be generated and subjective evaluations again conducted on them. These new hardcopy samples should also be digitized and their quality predicted by the objective metrics. These predictions should be tested against the subjective evaluations. The objective metrics may not be adjusted in any way at this point. If this test is unsuccessful the entire process may need to be repeated.

11. Summary

The output from each team working on a specific attribute will include:

11.1 A detailed definition of the major attribute and all sub-attributes being considered.

11.2 Test patterns suitable for evaluating each of the sub-attributes.

11.3 Hardcopy print samples of these test patterns, covering the necessary range of technologies and quality levels.

11.4 Results of a visual analysis of the hardcopy print samples.

11.5 An objective measurement procedure and results for each of the sub-attributes unless this is impractical.

11.6 Testing of the objective measurement.

At this stage of the work on the standard, the exact format of the data and results have not yet been defined.

Diagram Illustration of
Guide for the Development of Standards

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