TR 33-2006

ASC X9 Technical Report —

Check Image Quality Assurance —

Standards and Processes

Accredited Standards Committee X9, Incorporated
Financial Industry Standards

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Contents

Page

Figures

Tables

Foreword

Publication of this *Technical Report* that has been registered with ANSI has been approved by the Accredited Standards Committee X9, Incorporated, 1212 West Street, Suite 200, Annapolis, MD 21401. This document is registered as a Technical Report according to the “Procedures for the Registration of Technical Reports with ANSI.” This document is not an American National Standard and the material contained herein is not normative in nature. Comments on the content of this document should be sent to: Attn: Executive Director, Accredited Standards Committee X9, Inc., 1212 West Street, Suite 200, Annapolis, MD 21401.

Under Check 21, image capture and processing provides an important role in supporting the creation of substitute checks and in supporting the evolution to electronic exchange of check information among institutions and their customers. This *Technical Report* provides a methodology to think about the issue of what constitutes image quality assurance and the tools available for implementing an assurance process. It reflects the learning process through which the industry is progressing and will be updated periodically to reflect the most recent developments.

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Introduction

This *Technical Report* conveys the state of the art in the industry's thinking about image quality from the perspective of developing common infrastructure and business practices. It is intended for bank managers, technical support personnel and vendors to the industry who are involved in the provision of image-supported check electronification.

Assuring and maintaining image quality is considered a critical concern for the financial industry and consumers, and is particularly important towards developing the confidence within the industry to proceed with the implementation of image-supported check electronification.

The conceptual framework presented (Clause 4) and the application of the image defect and usability tools to an image quality assurance process (Clause 5) will provide a thorough understanding of the tools and processes available.

The reality of the situation in 2006 is that check processing practices to a great extent reflect the legacy of the past, and this will take time to change. Understanding the operational considerations in implementing an Image Quality Assurance (IQA) practice in the next year, or so, will benefit from setting realistic expectations and working within the industry to address common problems through standards development, standards adoption, and the development of common business practices for dealing with images that may be unusable. Clause 6 on operational considerations reflects a decade of back room image capture and processing experience which is now being supplanted by the evolution of image capture in more distributed locations, and most noteworthy, in locations not being managed by the customers' financial institution. At this time, there is no common practice for setting up capture environments and industry-level discussion on the issues of calibration and certification of capture processes are just emerging.

Clause 7 on image business practices begins to address image exchange under Check 21. Inter-bank practices are gradually evolving among groups of exchange partners, but, in our opinion, do not reflect an industry-wide practice or assure interoperability in the sense of having a common set of definitions and procedures in place to assure that we all mean the same thing when we declare an exchanged image is usable or unusable.

The industry has learned a lot about the merits and challenges associated with the use of image quality assurance tools. Clause 8 provides a set of issues which the Work Group feels will need to be addressed before the industry can establish a cohesive and coordinated set of image quality assurance business practices.

Annex A is included as a tutorial on image capture and image processing techniques. It is included as a reference for those who wish to understand how the image process works "under the covers". We believe that Annex A can serve as a readily available reference for technical managers at financial institutions who wish to confirm impressions or verify statements from others. This Annex was prepared by a collaborative effort of the solution providers involved in this initiative.

Because we are in a state of rapid change based upon lessons learned during these exchanges, we expect to update this report periodically with emphasis on refreshing the Clauses dealing with operations and exchange. By the next revision, we expect that the industry's business practices will have evolved to the point where there might be automated options to replace or augment human assessment processes for "suspect" images. We also anticipate that business practices for using defect and usability assessment tools will have significantly changed. Other Clauses will be updated as necessary to provide useful information to the industry.

This *Technical Report* was created by a cadre of motivated individuals from financial institutions, solution providers, third party service providers and rule making organizations. A few of these individuals took on an inordinate share of the burden: Robert Klein of Unisys for many contributions and particularly Annex A, Carmen Nordstrand of Solutran for shepherding the Terms and Definitions, Steve Gibson-Saxty for overseeing the development of Annex A, Jude LeClerc of the Canadian Payments Association who took the independent sectional contributions and provided the framework for the entire document and to the final publication editor, James Doran.

In publishing a report such as this it is easy for a group to lose sight of the complete picture or to presume a level of understanding among the readers that isn't there. To the extent that this document suffers from any blind spots, please offer your suggestions for improvements and additions to X9, Inc., to the attention of Cindy Fuller at the address provided in the Foreword so that they may be reflected in future updates.

NOTE The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this *Technical Report*, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the standards developer.

Suggestions for the improvement or revision of this Standard are welcome. They should be sent to the X9 Committee Secretariat, Accredited Standards Committee X9, Inc., Financial Industry Standards, 1212 West Street, Suite 200, Annapolis, MD 21401 USA.

This *Technical Report* was processed and approved for publication by the Accredited Standards Committee on Financial Services, X9. Committee approval of the Standard does not necessarily imply that all the committee members voted for its approval.

The X9 committee had the following members:

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The X9B15 Image Quality group which developed this *Technical Report* had the following members:

Dexter Holt, Chairman and James Doran, Project Editor

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Wells Fargo Bank... Ann Kirk

This *Technical Report* addresses the processes that use image tests that can be registered in the registry supporting X9.100-40-2006. It also addresses how image quality assessment information can be conveyed in an image exchange using DSTU X9.37-2003 or ANS X9.100-180-2006.

The *Technical Report* acknowledges the challenges created by source document characteristics. Some of the characteristics are addressed by X9.7-1999 and emphasize the importance of compliance with that standard. Other source document characteristics relate to things such as the importance of consistent placement of fields and their printing characteristics that go beyond the current X9.7-1999 specification. It is expected that these issues will be addressed by X9B11 in its process of reviewing X9.7-1999.

ASC X9 Technical Report — Check Image Quality Assurance

1 Scope

1.1 Purpose

The purpose of this *Technical Report* is to provide a framework for assuring and assessing image quality to support the exchange of check images between financial institutions. It provides a detailed understanding of the problems and limitations associated with the image capture process, automated methods and systems that might be used to detect check quality problems (i.e., image defects and usability issues).

The following *Technical Report* provides:

a) a glossary of terms related to image quality;

b) a conceptual framework for image quality and its components;

c) an understanding of how to perform image quality assessments; and

d) a discussion around certain issues and considerations related to the operational reality of performing image quality assurance (IQA) assessments.

It is anticipated that this report will establish common terminology around check image quality so as to facilitate communication among operations and technical managers at financial institutions.

1.2 Problem statement

The enactment of the Check Clearing for the 21st Century Act (Check 21) has provided the financial services industry an opportunity to redefine the check clearing processes that have existed for decades. Check 21 makes an image-based substitute of the original check a legal equivalent provided it meets specific criteria, including conforming to the ANS X9.100-140-2004 standard developed by ASC X9.

Although financial institutions have been using image-based technology for years to support check truncation efforts, improve internal processes and provide enhanced services to customers, Check 21 only recently opened the door to leveraging imaging technology more broadly. This technology is now being used to improve the check clearing process through widespread image exchange supplemented by substitute check printing where image exchange is not possible. Since then financial institutions have begun exchanging images and shortening clearing timeframes by transmitting images and check data between processing sites, banks or intermediaries, and printing substitute checks for presentment to the paying entity if needed.

Prior to Check 21, clearing participants had frequently captured one or more digital or microfilm image(s) of each check as it passed through each of their systems. Because multiple parties imaged a check independently, a high number of redundant images were produced. This redundancy was helpful in cases where a party had a problem with their image and a source document was no longer available. On the other hand, as Check 21 is implemented, checks are imaged only once at the source and each clearing partner makes use of the same check image. Due to an image's uniqueness and the reliance of all parties on the one image, the quality of images has become essential; particularly given that when the check image is needed to support a business function, the original paper check has quite often already been destroyed, thus providing no opportunity to recapture the image.

Many variables can affect the quality of an image. Some key factors lay within the financial institutions' direct control, such as the type of technology, implementation and business practices used. Other factors, such as the customers' use of noncompliant check stock and their check writing practices, can be influenced through customer education and incentive. The ability to identify quality problems that affect the use of an image is thus critical in gaining the full benefits of Check 21 and image exchange.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANS X9.7-2006 (X9.100-110 and X9.100-30), *Bank Check Background and Convenience Amount Field Specification*

DSTU X9.37-2003 (X9.100-180-2006), *Specifications for Electronic Exchange of Check and Image Data*

ANS X9.100-20-2006 (X9.27-2000), *Print and Test Specifications for Magnetic Ink Printing (MICR)*

ANS X9.100-40-1-2006, *Specifications for Check Image Tests Part 1: Definition of Elements and Structures*

ANS X9.100-40-2-2006, *Specifications for Check Image Tests Part 2: Application and Registration Procedures*

ANS X9.100-140-2004, *Specifications for an Image Replacement Document – IRD. (Formerly published as DSTU X9.90)*

3 Terms and definitions[1]

3.1
A/D converter (Analog-to-Digital) (ASC X9 TR 33)
Hardware or software for converting analog data into digital data.

3.2
analysis (ASC X9 TR 33)
The process of extracting quantitative measurements from a check image.

3.3
arithmetic binary image compression (ABIC) (ASC X9 TR 33)
A proprietary lossless image compression algorithm, developed by IBM that can be applied to either bi-tonal or limited gray level images.

[1] The defining standard is listed in parentheses after each term. The first listing is the current defining standard and the second, if present, is the past or future defining standard.

3.4
artifact (ASC X9 TR 33)
A condition introduced into an image by the scanning process, the digital image preprocessing or the compression process.

3.5
assessment (ASC X9 TR 33)
The automated or subjective evaluation of a check image. Automated check image assessment combines measurements extracted during image analysis with a set of decision rules and thresholds to determine the presence (or absence) of a particular image defect or usability problem. Subjective check image assessments are generally performed by the human eye reviewing the check image and making a determination as to its legibility and/or usability for payment processing.

3.6
assurance (ASC X9 TR 33)
The procedures and systems used by a financial institution to ensure that a high degree of quality is being maintained for each check image that is being generated and/or processed.

3.7
binarization (ASC X9 TR 33)
The process of converting a grayscale or color image into a black and white image representation.

3.8
black and white image (ASC X9 TR 33)
A digital image rendition where each image pixel can be represented by a single binary bit. With a black and white image, each pixel value can be represented using one bit of information to indicate whether the image pixel is either black (1) or white (0). Sometimes black and white images are referred to as bi-tonal or binary images.

3.9
brightness (ASC X9 TR 33)
A measure of the grayscale intensity of a tonal image, a portion of a tonal image or an individual pixel. The lower the brightness value, the darker the image, image area or pixel; the higher the value, the lighter the image, image area or pixel.

3.10
calibration (ASC X9 TR 33)
A term used to describe a number of processes, including assuring consistent performance of a system, assessing differences in image appearance among different systems, and aligning output measurements from IQA systems.

3.11
camera analog video (ASC X9 TR 33)
The voltage signal generated by the image camera that is proportional to the light reflected off the document being imaged. The analog video signal is subsequently sampled and digitized to generate the individual pixel values contained in the document image.

3.12
camera subsystem (ASC X9 TR 33)
The sub-elements of the overall transport camera system, i.e., hardware and software elements of a document scanning system that are responsible for acquiring and generating digital images. Examples include such elements as document illumination, camera optics and electronics, and image preprocessing and compression hardware/software.

3.13
CCITT T.4 and T.6 compression (ASC X9 TR 33)
CCITT (International Consultative Committee on Telephony and Telegraphy) T.4 and T.6 are both internationally standardized lossless data compression algorithms. T.4 (Group 3) and T.6 (Group 4) were both originally developed to compress bi-tonal images generated by most document facsimile machines. These two image compression standards have been widely adopted for use in compressing bi-tonal check image renditions.

3.14
color image (ASC X9 TR 33)
A tonal digital representation of an original source document where the brightness and color values of image pixels are represented using multiple binary bits of information (typically ranging from 8 to 24 bits) to represent the red, green and blue color components of the image. Color images captured in red, blue and green (R, B, G) are typically transformed to luminance and chrominance components (Y, Cr, Cb) prior to image compression.

3.15
compressed image size (ASC X9 TR 33)
The file size (normally measured in bytes) of the compressed image pixel data, including any required compression parameter data defined by the image compression algorithm, but exclusive of any image header information.

3.16
contrast (ASC X9 TR 33)
A measurement of the difference in brightness between foreground and background information or data present in a tonal image.

3.17
convenience amount (ANS X9.7/X9.100-110)
The value of the check expressed in numbers, located within the convenience amount rectangle.

Note: It is sometimes also referred to as “courtesy amount”.

3.18
endorsement or indorsement (ANS X9.100-111/X9.53)
Information used to transfer a negotiable instrument from one holder to another. Endorsements are placed on a document by payee(s), by the Bank of First Deposit, and by institutions subsequently handling the document.

3.19
engine (ASC X9 TR 33)
In the context of software, a module that performs a specialized task, but is not a complete solution or application.

3.20
escape (ASC X9 TR 33)
The failure of an automated image quality assurance system to determine that a check image contains an image defect or usability problem. (Also referred to as a false negative.)

3.21
faithfulness (ASC X9 TR 33)
The accuracy and completeness of a digital representation of the information and graphic details contained within the source document. Typically image faithfulness is a function of capture DPI, image type (black and white, grayscale or color) and image compression algorithms.

3.22
false positive (ASC X9 TR 33)
The determination by an automated image quality assurance system of an image defect or usability problem when no defect or usability problem is actually present.

3.23
field of view (FOV) (ASC X9 TR 33)
The maximum document height (or width) that can be imaged by the document scanner. FOV is usually determined by the focal length of the camera lens, the number of sensors in the camera's CCD sensor, and the physical separation between the camera and the document being imaged.

3.24
fields of interest (ASC X9 TR 33)
Locations on a check and its image that contain transaction information, some of which are considered key to completing the payment.

3.25
filtering (ASC X9 TR 33)
The process or device that selectively separates or removes unwanted signals, data or noise. In the context of image filtering, a hardware or software process that modifies the original input image pixel values.

3.26
GIF (graphic interchange format) (ASC X9 TR 33)
A common format for image files that is especially suitable for images containing large areas of the same color. It is a common format for inline images placed in HTML documents.

3.27
gray level (or grayscale) image (ANS X9.7/X9.100-110)
As used in this report, a tonal image where each image pixel can represent a range of gray level values (typically 16 to 256) between white and black.

3.28
gray level resolution (ASC X9 TR 33)
The number of gray levels allowed between white and black for each image pixel. Grayscale resolution is typically measured in units of bits-per-pixel (bpp).

3.29
half-toning (ASC X9 TR 33)
A printing process based on halftone screens used by the printing industry. It effectively simulates shades of different density based on the number and density of dots in the image. The human eye perceives a combination of basic colors in the dots as a mixture or hue. In the case of a single color the human eye perceives a shade of the basic printed color that is dependent on dot size and spatial density.

3.30
horizontal streaks (ASC X9 TR 33)
The presence of one or more dark (for all images) or light (for grayscale and color images) horizontal lines or bands that extend across a specified percent of the image from leading to trailing edge.

3.31
image (ASC X9 TR 33)
A digital representation of all or part of a physical item, including any associated parameters required to interpret the digital representation. The digital representation is created by converting the light reflected from sub-areas of the document into a series of digital numbers that represent the brightness/darkness associated each sub-area of the document.

3.32
image compression (ASC X9 TR 33)
The application of data compression techniques to a digital image with the goal of reducing the image's file size to reduce subsequent image storage and transmission costs. A number of data compression techniques have been specifically designed and standardized for the compression of a variety of image representations (e.g., color, gray level, bi-tonal, etc.). See definitions associated with: Lossy and Lossless Data Compression, CCITT T.4, CCITT T.6, JBIG, and JPEG.

3.33
Image Defect Assessment (IDA) (ASC X9 TR 33)
The analysis of a document image based upon an established defect list. Defects will be assumed to be present in the image when defect metrics exceed industry established threshold values or limits. Image defect analysis is performed using a set of image defect metrics. These metrics may measure characteristics of the source document (e.g., size, folded corners, skew), or characteristics of the image itself (e.g., too dark, too light, streaks). Image defect assessment must be able to be performed reasonably accurately without reference to the source document or analysis of the information content from specific fields of interest.

3.34
image defect metrics (ASC X9 TR 33)
The set of measures used to quantify the overall likelihood that a digital check image has conditions that would render the information contained within the source document usable in the image.

3.35
image quality (ANS X9.100-140/X9.90)
As used in this report, the totality of image characteristics that bear on an image's ability to satisfy stated or implied needs.

3.36
image quality assurance (IQA) (ASC X9 TR 33)
A process for validating image quality.

3.37
image quality suspect (ASC X9 TR 33)
An image that fails one or more automated image defect or usability analyses.

3.38
image rendition (ASC X9 TR 33)
A term describing whether the check image is black and white, grayscale or color.

3.39
image replacement document (IRD) (ASC X9 TR 33)
A substitute check as defined by X9.100-140.; see 3.71 ‘substitute check’.

3.40
image scaling (ASC X9 TR 33)
The mathematical process of increasing or decreasing the number of pixels in the original document image, in order to create a larger or smaller image suitable for image display or print applications. Also see ‘pixel replication’ 3.59 and ‘pixel decimation’ 3.58.

3.41
Image Usability Assessment (IUA) (ASC X9 TR 33)
An analysis of selected information contained within an image to determine its usability. If the selected information is determined to be usable, then the image could be considered suitable as a substitute for the original document.

3.42
interchange wrapper (ASC X9 TR 33)
File formats for exchanging images.

3.43
joint bi-level image experts group (JBIG) (ASC X9 TR 33)
An international (ISO) image compression standard designed to more efficiently compress bi-tonal images, using a “lossless” data compression algorithm similar to IBM’s ABIC compression technology. JBIG typically yields image file size reductions of 15-30% compared to the older CCITT T.6 (Group 4) bi-tonal image compression standard.

3.44
joint photograph experts group (JPEG) (ASC X9 TR 33)
An international (ISO) image compression standard defined to compress gray level and color imagery using a “lossy” image compression technique. The JPEG baseline compression standard has been adopted by many vendors to compress both gray level and color check images.

3.45
legibility (ASC X9 TR 33)
As used in this report, distinctness that makes perception easy.

3.46
Lempel-Ziv-Welch (LZW) (ASC X9 TR 33)
A (patented) data compression algorithm that is commonly used to compress image data associated with GIF and TIFF files.

3.47
lossless data compression (ASC X9 TR 33)
A data compression algorithm that achieves data compression by removing redundancies in the original data set using an invertible mathematical technique or function. As such, when the data is decompressed, the original data is recovered without any losses.

3.48
lossy data compression (ASC X9 TR 33)
A data compression algorithm that achieves data compression by introducing some amount of distortion into the original data set. Therefore, when the data is decompressed, the resultant data does not match the original input data. The amount of data compression achieved is dependent upon the amount of distortion one can tolerate in the original data.

3.49
magnetic ink character recognition (MICR) (ASC X9 TR 33)
As used in this report, the common machine language specification for the paper-based payment transfer system. It consists of magnetic ink printed characters of a special design, called the E-13B font, which can be recognized by magnetic recognition equipment.

3.50
noise (ASC X9 TR 33)
Background or other information in an image that interferes with the legibility of pertinent data on the image.

3.51
normalization (image normalization) (ASC X9 TR 33)
A mathematical process whereby each image pixel undergoes some grayscale correction to correct for non-uniform document illumination and non-linearities that are associated with the digital camera's CCD sensor. Appropriate gray level correction factors are typically generated during a camera calibration procedure.

3.52
optical character recognition (OCR) (ANS X9.27/X9.100-20)
As used in this report, the technology or process in which an electronic device/software examines printed characters on paper and determines their shapes by detecting patterns of dark and light. Pattern matching with stored sets of characters is then used to translate the shapes into computer text.

3.53
optical filters (ASC X9 TR 33)
A piece of colored glass or plastic that is used to modify/filter the color of light illuminating the document, or used to modify/filter the light reflected from the document prior to detection by the image camera.

3.54
pattern recognition (ASC X9 TR 33)
The automatic finding, extraction and classification of shapes. Shapes can be characters, logos or other graphical elements on a digital image.

3.55
photo-sensor array (ASC X9 TR 33)
An electrical component that contains multiple sensors capable of converting light into an electrical charge or voltage.

3.56
piggyback (ANS X9.100-151/X9.40)
As used in this report, two items that appear as one, but the items are overlapped (i.e., offset in length or width). The front and back images represent two different items. See double documents for items that do not overlap.

3.57
pixel (ANS X9.7/X9.100-110)
A two-dimensional picture element that is the smallest non-divisible element of a digital image.

3.58
pixel decimation (ASC X9 TR 33)
A method of creating a smaller image (image down-scaling) by deleting pixels located in the original image.

3.59
pixel replication (ASC X9 TR 33)
A method of creating a larger image (image up-scaling) by repeating pixels located in the original image.

3.60
portable network graphics (PNG) (ASC X9 TR 33)
An image and graphic file format designed as the successor to GIF. It features compression, transparency, and progressive loading, as included in GIF, but is free of use restrictions associated with the LZW data compression algorithm.

3.61
print contrast signal (PCS) (ANS X9.7/X9.100-110)
The ratio of the print contrast of a specific printed point to the reflectance of its surrounding background.

3.62
raw check image (ASC X9 TR 33)
An image as it was originally captured, i.e., the original image pixel data obtained directly from the document scanner (e.g., image camera) prior to any digital image preprocessing or data compression operations being performed on the check image. Raw check images normally represent a full gray level or color rendition of the document image at the image camera's maximum spatial resolution.

3.63
scan line (ASC X9 TR 33)
A linear sequence of pixel values in the digital image representation of a document that spans either the width or height of the image. Scan lines can be oriented horizontally or vertically, based on the orientation of the camera optics to the source document during the scanning process. A collection of vertical or horizontal scan lines defines the entire area of the document image.

3.64
scanning geometries (ASC X9 TR 33)
Referring to the document scanning orientation used to acquire the pixel data present in the document image (e.g., a sequence of vertical scan lines, a sequence of horizontal scan lines).

3.65
scanning window (ASC X9 TR 33)
The opening in the document transport track wall that provides a slit or window through which the document is illuminated and imaged. On a flat bed scanner, the scanning window is the platen that you place the document on to be scanned.

3.66
security feature/technique (ANS X9.100-170/X9.51)
An addition to a document that will add complexity in its ability to be reproduced or changed.

3.67
skew (ANS X9.27/X9.100-20)
As used in this report, the tilt, or angle, of a document relative to the image camera's field of view.

3.68
smoothing (ASC X9 TR 33)
A filtering process, applied to image pixel data, which increases gray level or color uniformity in the document image while sharpening the edges of character strokes associated with printed or written information. Filtering is normally accomplished by applying a variety of computational techniques to the image pixel values that represent the brightness of the image at a particular location in the image.

3.69
source document (ASC X9 TR 33)
A check sized paper document such as a paper check, coupon, batch header or Image Replacement Document (IRD). An IRD is considered a source document just as the original check is a source document.

3.70
spatial resolution (ASC X9 TR 33)
Density of pixels horizontally and vertically in a digital image, typically measured in pixels or dots per inch (dpi). Increasing the spatial resolution generally causes finer document details (e.g., thin character stroke widths, smaller font sizes, etc.) to be visible in the image.

3.71
substitute check (ANS X9.100-140/X9.90)
A paper reproduction of an original check as defined by the Check 21 Act and Regulation CC.

Note: The reproduction, also known as an image replacement document (IRD), must comply with ANS X9.100-140-2004.

3.72
tagged image file format (TIFF) (ASC X9 TR 33)
A common image file format that stores image parameters and data associated with a document image. This specification was originally developed by Aldus and Microsoft and is now owned and administered by Adobe Systems.

3.73
threshold (ASC X9 TR 33)
The value at which a defect or usability metric, indicates the presence or absence of an image defect or usability problem (i.e., the pass/fail criteria associated with the defect or usability measurement).

3.74
trans-coding (ASC X9 TR 33)
The process of converting from one image format (e.g., image representation, image compression algorithm, etc.) to another.

4 Conceptual framework for assessing the quality of an image

4.1 General

To assist the industry in building a common understanding of image quality as a whole, this Clause describes a conceptual framework to illustrate how assessments of the image wrapper, image defects and image usability contribute to judgments on image quality. As noted in Figure 1, below, these assessments help predict the usability of an image in automated image processing applications and to what extent the image retains the information from the source document.

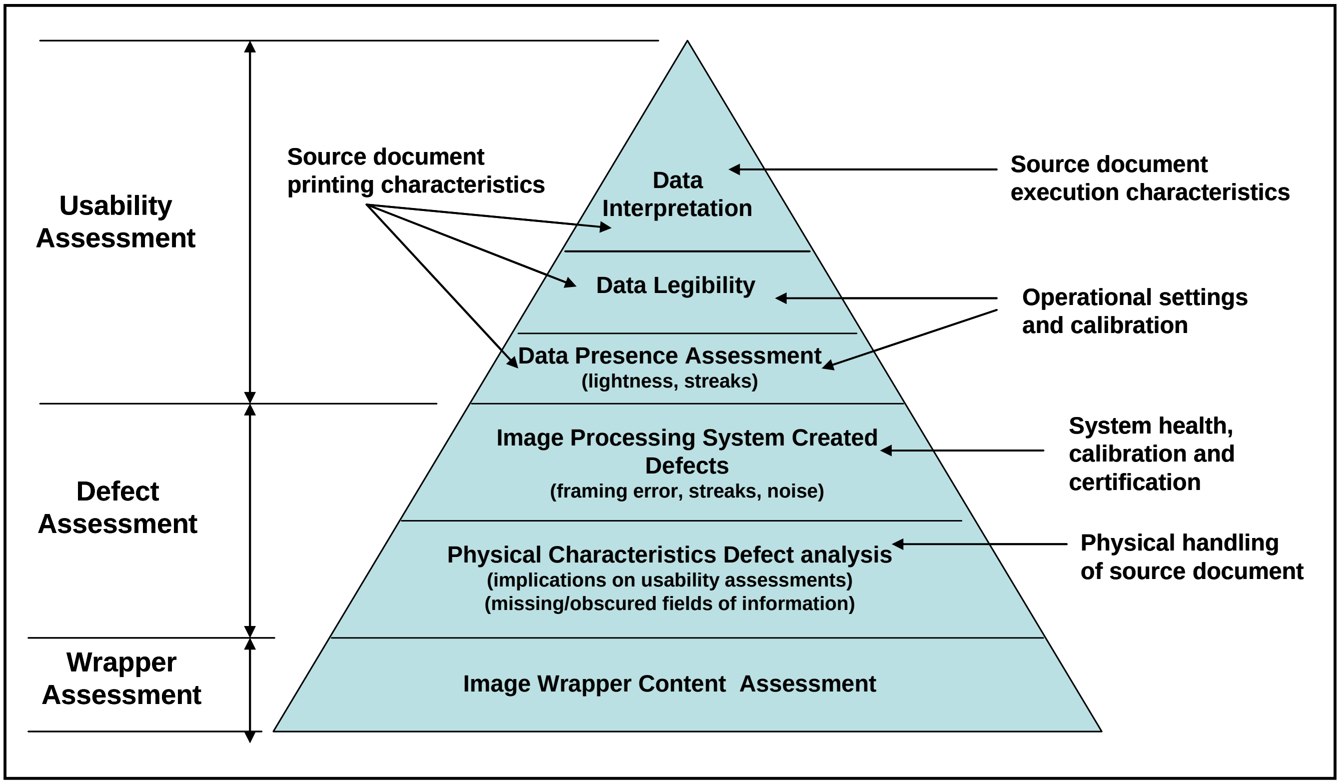


Figure 1 — Image quality: influencing factors

The key attributes of an image file are contained in an image wrapper. This information needs to be accurate and meet a minimal set of content requirements. Determining check image quality is a composite of looking at the three above attributes. This Clause will first focus on image defects and image usability, and then discuss the relationship between these two methods of Image Quality Assessment.

4.2 Image file wrapper characteristics

In order for an image to be interpretable (i.e., usable) for any purpose, its characteristics must be described. Some image systems use proprietary techniques until the image processing steps are complete.

In today's check image processing environment, most images being black and white are described in a wrapper called a tagged image file format (TIFF). The information in this wrapper needs to be accurate, contain the minimal set of information required and should comply with industry practice. There is more information on file format characteristics in Clauses 5.2, 7.4 and 7.5.

4.3 Image defects

An image defect is a condition within a check image that can be quantitatively assessed by standard technical measurements. Defects may result from either degradation of the original paper check or the resulting check image. Regardless of the cause, the result is a check image with a condition which may pose limitation on the use of the image.

The presence of one or more image defects can potentially impact the usability of fields on a check image. For example, if a corner of the paper check is folded when it is imaged, there is a potential for loss of data due to the corner of the document being either obscured or missing from the front and rear of check images. Likewise, an image that appears too dark may make the information on the check difficult or impossible to discern. These situations may limit the ability of the image to represent the truncated or converted check.

For example, the Financial Services Technology Consortium (FSTC) identified 15 image defect metrics. These are:

a) undersized image;

b) folded or torn document corners;

c) folded or torn document edges;

d) document frame errors;

e) excessive document skew;

f) oversize image;

g) piggybacked documents;

h) image too light;

i) image too dark;

j) horizontal streaks present in image;

k) below minimum compressed image size;

l) above maximum compressed image size;

m) excessive spot noise in the image;

n) front-rear image dimensions mismatch;

o) image out of focus (grayscale only).

Visit the FSTC's website at http://www.fstc.org/docs/prm/FSTC_Image_Defect_Metrics.pdf and http://www.fstc.org/docs/prm/IQ&U_P1_Final_Report.pdf for more information.

4.4 Image usability

Image usability is defined as the presence and legibility of the information in a digital representation of a source document necessary to perform a specific function. In other words, whether a check image is usable depends on:

a) the retention of information that is present in fields in a check image, e.g., payee name, convenience amount, legal amount, payor name, signature, date, endorsement, etc;

b) the legibility associated with information contained within the data fields; and

c) the requirements for the payment process at hand, e.g., collection, return, fraud prevention, customer use, etc.

In general, image usability problems are associated with the loss or degradation in the legibility of information present on the original paper check. Image usability assessment is thus a factor in determining whether a check image may be used as a substitute instrument for payment processing or not. It is important to note that check information that was absent on the original paper check, and hence not present in the resulting check image, may result in an image usability problem but the cause is attributable to a problem with the original paper check and not the imaging system. A similar situation can arise when checks are written with pastel-colored gel pens.

Image usability assessments have their own quality hierarchy, based upon the payment and data processing requirements and the degree to which data fields may be interpreted by either the human eye or automatically recognized by a character recognition engine.

Increased usability is thus generally associated with increased legibility. Some exceptions to this rule include the recognition of a signature for example, whereby in some cases the signature cannot be interpreted by either the human eye or an automated recognition system. In these situations image legibility is not the determining factor in establishing image usability, so much as the simple presence of the data.

4.5 Relationship between image defects and image usability

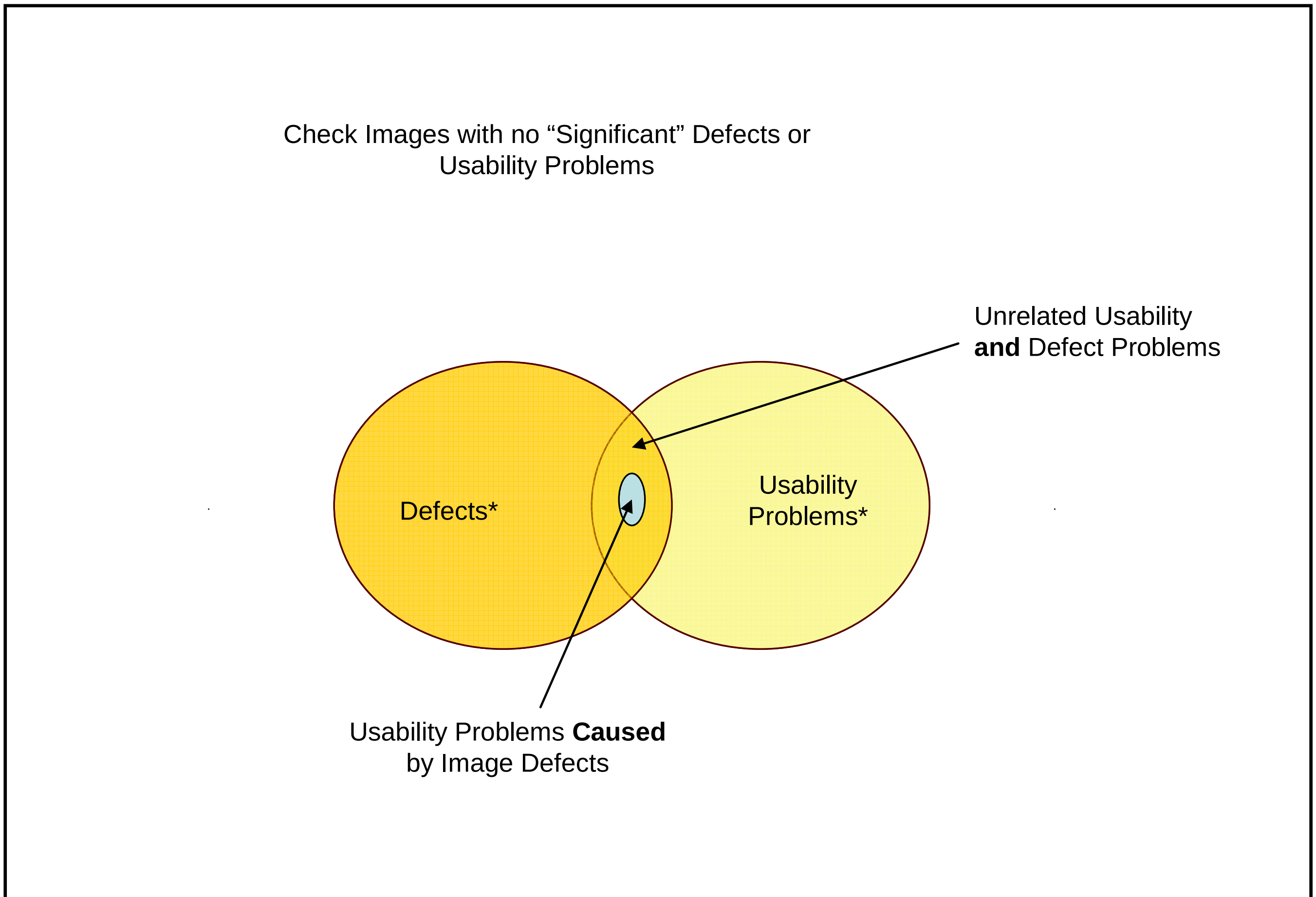
Although image defects have the potential to cause image usability problems, the presence of one or more of them does not necessarily lead to an image usability issue. Likewise the absence of an image defect does not ensure that the image is usable. The relationship between check images exhibiting defects and those with usability problems is illustrated in Figure 2 (next page) and provides a visual model of the relationship between four groups or sets of check images:

a) Check images with no significant image defect or image usability problems (i.e., images with good quality);

b) Check images with one or more image defects, but no apparent image usability problems;

c) Check images with one or more image usability problems, but no apparent image defects;

d) Check images with image usability problems due to the presence of one or more image defects.



*Relative sizes of ellipses are not proportional to actual occurrences, but are shown to illustrate relationships. It is believed that all quality problems combined represent less than 1% of checks processed.

Figure 2 — Image defect and image usability relationships

Referring to Figure 2, the background represents good quality images. The smaller left ellipse labeled "Defects" represents the group of check images that contain one or more image defects. Only a portion of the check images in this group contribute to image usability problems. This means that some check images will exhibit image defects in the absence of any image usability issues.

The smaller ellipse on the right labeled "Usability Problems" represents the group of check images that have one or more image usability problems. Only a portion of the check images in this group are due to the occurrence of one or more image defects. This means that some check images will exhibit some level of image usability problems in the absence of any image defects.

The area of intersection between these two ellipses labeled "Unrelated Usability and Image Defect Problems" represents the group of check images that contain both image defects and image usability problems that are in no way related to each other. A portion of this area labeled "Usability Problems Caused by Image Defects" represents the subset of images that have image usability problems caused by the presence of one or more image defects in the check image.

5 Automated Image Quality Assessment tools

5.1 Introduction

5.1.1 General

Clause 5 describes the elements of an image quality assurance process and how image record and file assessment, Image Defect Assessment and Image Usability Assessment tools work to make judgments on an image's usability.

It is helpful to have a conceptual understanding of how automated image defect and usability assessment systems function. In the following Clauses, generic Image Defect Assessment and Image Usability Assessment reference models are presented for consideration and review.

5.1.2 Analysis and assessment

Throughout this Clause, the terms "analysis" and "assessment" are used in conjunction with the words "image quality", "image defect" and "image usability".

a) "Analysis" refers to the process of extracting quantitative measurements from a check image.

b) "Assessment" refers to the automated or subjective evaluation of a check image. Automated check image assessment combines measurements extracted during image analysis with a set of decision rules and thresholds to determine the presence (or absence) of a particular image defect or usability problem. Subjective check image assessments are generally performed by the human eye reviewing the check image and making a determination as to its legibility and/or usability for payment processing. Assessments in the future will rely on more automated techniques and the use of risk-based alternate processing.

Image Quality Assurance (IQA) systems typically employ a combination of Image Defect Assessment (IDA), Image Usability Assessment (IUA) and human assessments to identify check images that exhibit quality problems (i.e., image quality suspects). In this context, IQA is an umbrella term that encompasses the combined tools, processes, and procedures that provide the total check image quality solution.

5.1.3 Overall image quality assurance.

IQA systems typically have used a combination of automated and manual assessments. IQA systems can include some or all of the following automated assessment processes:

a) Review of check image and exchange file format characteristics;

b) IDA;

c) IUA.

Additional assessments can be performed on the images judged to be suspects (See Clause 7). Figure 3, below, illustrates how these Image Quality Assessment processes might be used, either separately or in combination, to identify check images considered to exhibit suspect image quality.

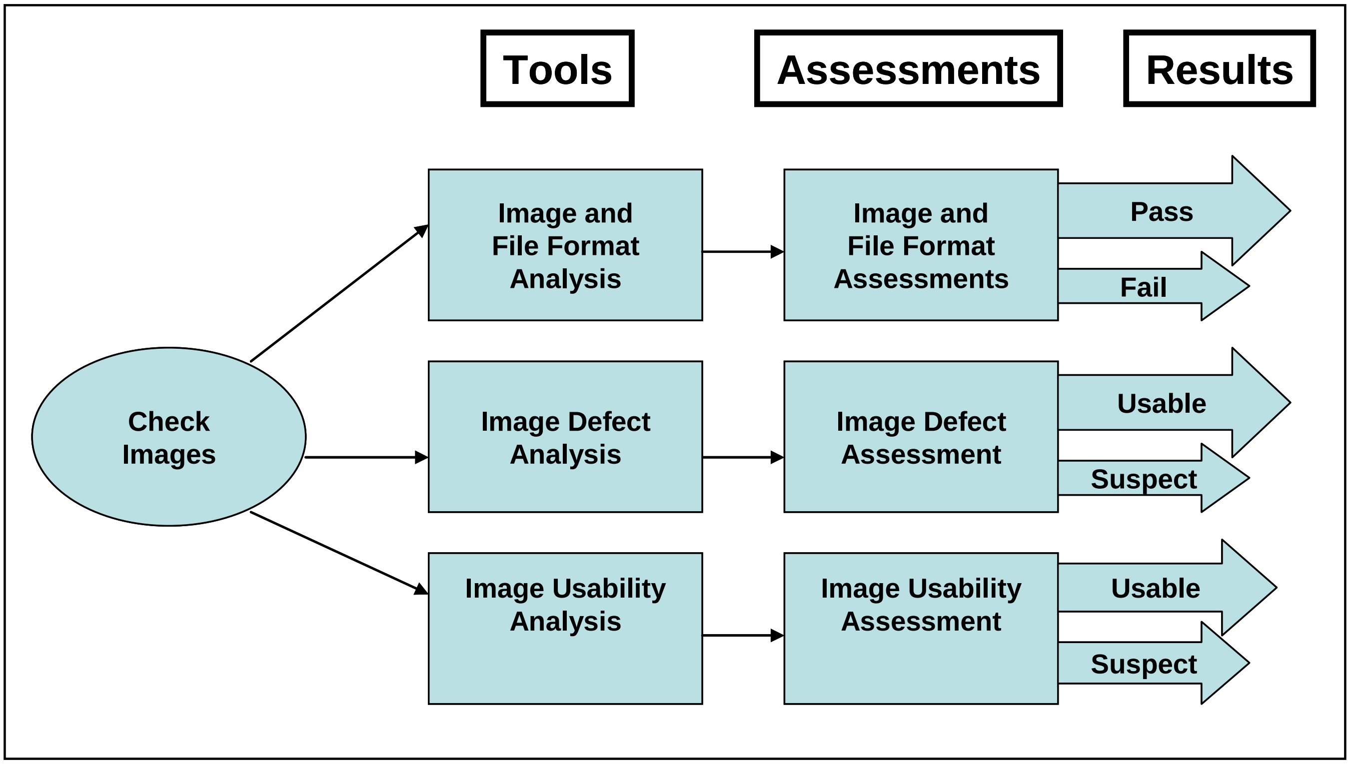


Figure 3 — Image Quality Assessment processes

The primary goal of applying the image quality tools is to identify check images that may be unusable. These image quality suspects may require that the check image be slated for special processing or be visually inspected by a person to determine whether or not the check image can be used to complete payment processing. This process will be described in Clause 7.

5.2 Image and file format characteristics

A first and relatively simple step in automatically assuring image quality is verifying that an image complies with a fundamental set of minimum requirements related to the type and format of the image. If any one of these minimum requirements is not met, the image is rejected due to inappropriate image type or format, and no additional image quality testing is performed.

Automated examination of image and file format characteristics attempts to insure that the image being captured, received, or presented meets some minimum image use requirements, and employs a file format and image compression method that is compatible to the financial organization’s check image systems and application software and will be compatible with industry or local exchange business practices. Image and file characteristics that should be examined include:

a) Range of image spatial resolution (for example: 200 or 240 dots per inch);

b) Type of image (for example: color, grayscale or black and white);

c) Image compression algorithm (for example: CCITT Group 4, JPEG, etc.);

d) Image view format (for example: TIFF 6.0, .JPG, .BMP, etc.);

e) Image interchange wrapper (for example: DSTU X9.37-2003, ANS X9.100-180-2006, etc.).

The above renditions, compression methods and image wrapper are the most commonly used in the check image processing environment today. Adoption of standard business practices to support a minimal set of characteristics is important to assure interoperability.

5.3 Automated Image Defect Assessment

5.3.1 Introduction

Automated Image Defect Assessment (IDA) attempts to quantitatively and objectively assess the presence of specific image defects that are known to negatively impact image usability. While many image defects have been defined, they tend to originate from the following sources:

a) Characteristics of the source document (scenic or patterned backgrounds, ink colors);

b) Damage to the source document (torn or folded corners, torn document);

c) Image capture system characteristics (illumination, camera limitations, paper handling);

d) Post-capture, image manipulation/generation (image scaling and zoom, IRD printing).

Clause 7 will provide more information on current thinking on the effectiveness and limitations of defect assessment as a predictor of usability.

5.3.2 IDA reference model

Automated IDA systems operate by extracting a set of measurements (or metrics) from each check image. Metrics are typically extracted independently for both the front and rear images of the paper check. These metrics are designed to identify a specific set of known image defects that might be present in the check image. By comparing the magnitude of these metrics against a set of image defect threshold values, an assessment can be made as to whether or not a particular image defect is present in the check image and whether or not this defect might affect check image usability. Check images containing defects of sufficient magnitude (i.e., significant defects) become image quality suspects possibly requiring further analysis and/or additional Image Quality Assessment.

Figure 4 identifies the major functional blocks used to identify defects that may exist in a check image. Given that automated IDA solutions may be implemented either during check image capture or as a post-image capture processing operation, the automated IDA reference model is capable of addressing both scenarios.

The major functional elements associated with an automated IDA system include:

a) Setting defect metric parameters and thresholds (i.e., establish operational settings);

b) Computing image defect metrics (i.e., defect analysis);

c) Computing image defect flags;

d) Reporting image defect results (i.e., metric values, thresholds, parameters, and flags).

Early indications are that some metrics are more reliable predictors of image usability challenges when used in combination.

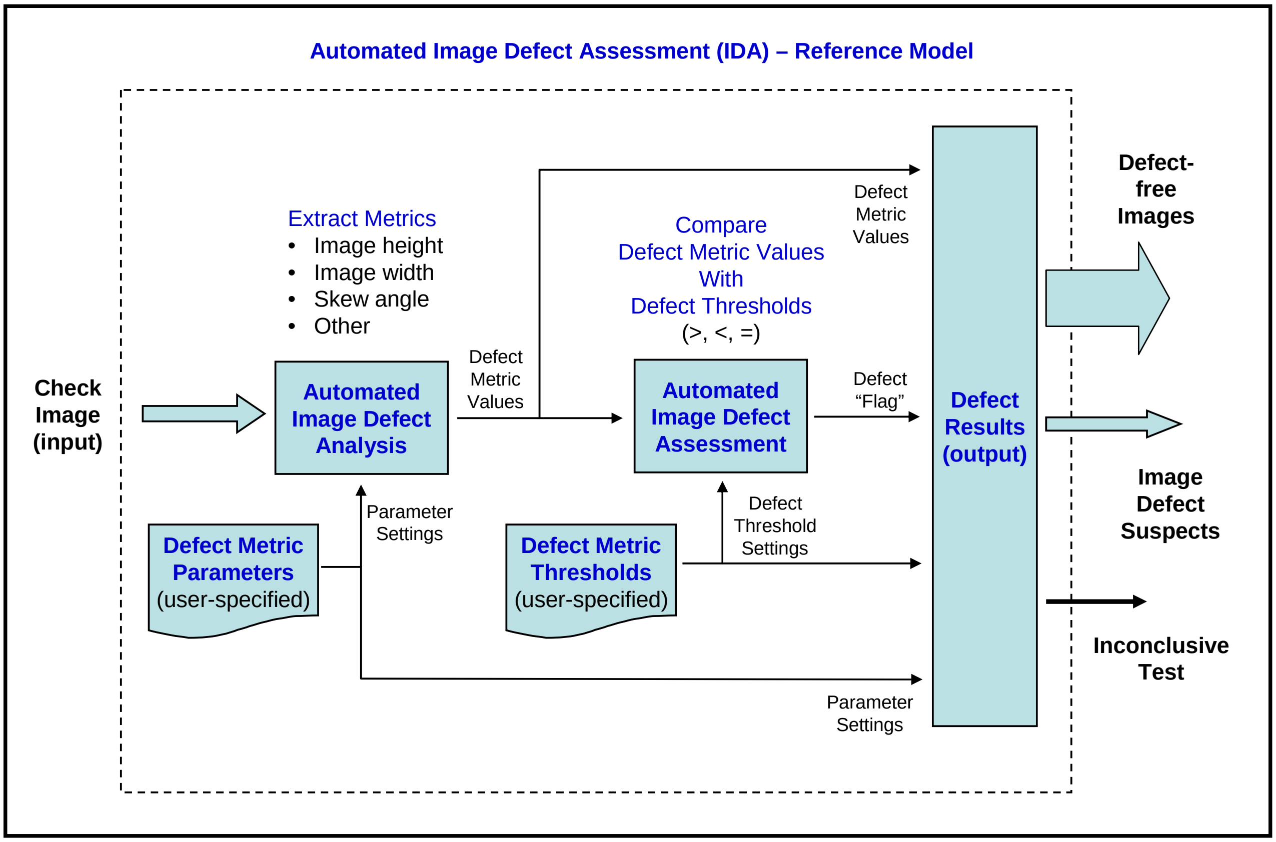


Figure 4 — Automated IDA reference model

5.3.3 Image defect analysis

The primary function of image defect analysis is to extract a set of defect metric values from the check image pixel data. Image defect analysis applies computational techniques to the check image pixel data, to detect and measure the magnitude of an image defect that might be present in a check image. Each image defect has a defined set of defect metrics that are used to quantify whether or not a specific image defect is present in the image, and if so, the magnitude of that image defect. Automatic detection of multiple image defects will therefore require that a variety of computations be performed and reported for an image. Therefore, the larger the number of image defects intended for automatic detection, the more time, cost and complexity required by IDA processing. Trade-offs in computational cost versus the benefits associated with a more robust image defect detection scheme should be considered when evaluating automated IDA implementations.

In order to provide some uniformity relative to which image defects should be detected, and what data should be reported, the financial industry needs to agree upon and implement a defined set of image defects (e.g., such as those defined in Clause 4.2) and a set of metrics to be reported for each image defect. Although the financial industry has defined a set of image defects to be detected, and adopted a standardized set of metrics and measurement definitions for calculating the magnitude (or size) of each image defect when present, the methods and techniques necessary to make the actual defect measurement is left to the implementer of the defect test. As an example, the standardized metrics associated with reporting a torn corner defect, may be to report the general location, the width and the height of the torn corner in units of one-tenth of an inch. While standardized metrics define how the image defect is to be calculated and reported, it does not tell you how to measure the value(s) of the torn corner from the image pixel data. This implies that image defect results may vary between vendors, depending upon the robustness and accuracy of their IDA implementation. To this end, the industry is seeking to have sufficient definitions and benchmarking so that significant variations do not occur across different implementations.

The metrics used to report the presence of a specific image defect generally depends on both the image defect and the image rendition (i.e., black and white, grayscale, color). Recognizing that some image defects are very simple to measure (e.g., image length too short), others are computationally complex and may involve proprietary and/or patented techniques (e.g., detection of horizontal streaks due to ink or debris on the image camera's scanning window).

5.3.4 Parameters and thresholds

A key element of an automated IDA system is the ability to control both the computation of defect metrics and the thresholds at which these metrics indicate that a defect is present in a check image.

Defect metric parameters control or influence how a specific defect measurement is made. As an example, when looking for horizontal black streaks in a black and white image, a parameter may control when a horizontal scan line should be considered part of a black streak. This might be accomplished by requiring that 98% or more of the pixels in each horizontal scan line must be black to be considered part of a horizontal streak. The 98% would be a parameter that affects how a streak is defined and measured in the image. It is understood that only some image defect metrics have parameters associated with the defect computations.

Image defect metric thresholds control or influence the number of image defects reported by the IDA process, as well as the number of check images identified as quality suspects. By modifying the defect metric threshold settings, only images containing image defect metric values that exceed the defect metric thresholds (i.e., significant defects) will be flagged by the IDA process as an image quality suspect. Defect metric threshold settings may be modified by either having the system administrator interactively modify the values via IDA utility software, or by providing a software application interface that allows the image application software to vary the defect metric thresholds as required.

Besides allowing the user or administrator to vary the IDA defect metric parameters and thresholds, parameters may also be available to provide the ability to enable or disable each image defect test. This feature allows the user to skip some portion of the IDA tests for specific sets of check images. In this *Technical Report*, parameters and thresholds are treated and discussed as separate entities. However, in ANS X9.100-40 *Specifications for Check Image Tests,* parameters are defined to include thresholds and other constants used to compute image test results for reporting purposes.

5.3.5 Computing image defect flags

At the core of any automated IDA process are the IDA decision rules. IDA decision rules establish the pass/fail criteria associated with detecting the presence/absence of a particular image defect. The IDA decision rules operate on two sets of data:

a) defect metric values that have been computed and extracted from the check image, and

b) a set of defect metric thresholds established by the user or the exchange community.

In other words, assessing whether or not a particular image defect is present in an image is accomplished by comparing the check's image defect metric values against a set of defect metric threshold settings. If the defect metrics associated with a particular image defect exceed the defect metric threshold values, the IDA process assumes a significant image defect is present in the check image and sets a flag accordingly. Definition of the IDA decision rules and the specification of the defect metric thresholds are thus essential to the success and robustness of an automated IDA process.

In order to minimize variation in IDA results, the industry is defining a standardized set of image defects (and associated metrics) to support a common IDA implementation by all vendors. Since the detection of a significant image defect is determined by one or more defect metric values exceeding established defect metric thresholds, adopting a uniform set of IDA parameters and defect metric threshold settings is required to insure that IDA results are consistent across all financial institutions and vendor implementations. Adopting a uniform set of IDA parameters and defect metric thresholds will allow financial institutions to establish a common image defect operating point, which will facilitate image interchange operations. Refer to Clause 7 for further discussion of the test registry and the manner of exchanging image assessment information.

5.4 Image Usability Assessment

5.4.1 Introduction

Automated IUA systems operate by applying a set of usability tests (or rules) to each check image. The goal of image usability testing is to automatically assess the legibility of the data fields present on the check image. Check images identified as having one or more image usability problems become image quality suspects possibly requiring further analysis and/or additional Image Quality Assessment.

5.4.2 IUA reference model

The major functional elements associated with an automated IUA system include:

a) Setting image usability parameters and thresholds (i.e., establish operational settings);

b) Computing usability test scores;

c) Computing usability test flags;

d) Reporting usability results (i.e., usability scores, thresholds, parameters, and flags).

Figure 5 (see next page) identifies the major functional blocks used to identify usability problems that may exist in a check image.

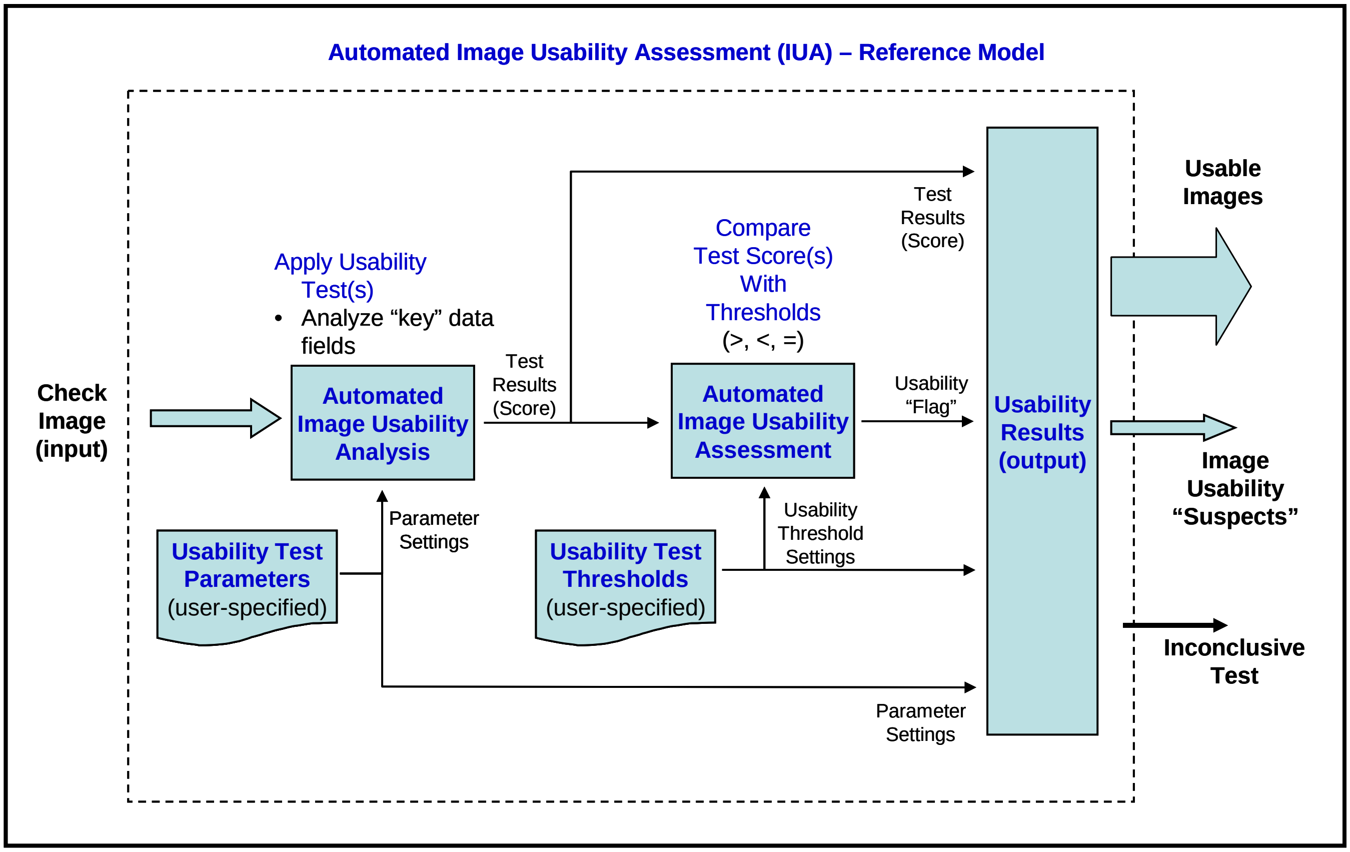


Figure 5 — Automated IUA reference model

5.4.3 Image usability analysis

Image usability tests typically apply character or pattern recognition technology to determine a proprietary set of metrics or scores that indicate the legibility of data fields within the check image. Although no standardized methods have been adopted for locating and measuring the legibility of fields located on a check, a number of data fields have been identified as candidates for usability assessments.

5.4.4 Image usability parameters and thresholds

Usability tests are typically designed to be controlled by specifying one or more parameters associated with the usability rules. Usability parameters allow the user to control or tune one or more of the automated measurements associated with the IUA process. In addition to the operational parameters associated with the usability tests, usability test results are also controlled by the specification of one or more usability thresholds. Usability thresholds establish the pass/fail criteria (or the level of usability measured) for each data field. In this *Technical Report*, parameters and thresholds are treated and discussed as separate entities. However, in ANS X9.100-40 *Specifications for Check Image Tests*, parameters are defined to include thresholds and other constants used to compute image test results for reporting purposes.

5.4.5 Image Usability Assessment

As usability tests analyze the data fields, each usability test produces a test result or test score. The test results are then compared to a set of usability threshold values (established by the administrator/operator) that determine the level of usability associated with the data field.

It has been difficult to uniformly and exactly quantify the usability of a data field. As such, the financial community has defined a subjective usability assessment scale. This scale defines four (4) levels of usability/legibility that can be applied to any data field present on a check image. Additionally, the condition where no data is present in a data field is also provided in the assessment. Table 1 below provides the scale and associated usability definitions.

Table 1 — Data field usability scale

Usability Description	Usability Definition
Absent	No data is present in the field or the field can not be located.
Illegible	Unable to interpret the intended meaning or characteristics of the data.
Mostly Illegible	Can only partially (with low reliability) interpret the intended meaning or characteristics with significant ambiguity.
Mostly Legible	Can reasonably interpret (reliably) the intended meaning or characteristics (in context) but with some ambiguity.
Legible	Able to unambiguously interpret the intended meaning or characteristics of the data (without context).
Note. As per interim assessment of the Financial Services Technology Consortium (FSTC).	

5.4.6 Usability scoring

Determining the precise usability of an image is not a straightforward task. This complexity occurs because of two major factors; first, the number of fields on a check which must be considered, and, secondly, the purposes for which the image will be used.

The financial industry has begun to address both aspects of this complexity. In the case of the number of fields on a check, the industry has identified those fields which are most critical to payment of a check, and prioritized those as the fields which will most commonly be assessed for usability. In addition, the industry has defined a scale of usability for an individual field. This scale (see Table 1 above) is related to the legibility of the field in the image, and can be applied to any field on the check.

In the case of understanding the purpose for which an image will be used, the industry, in the FSTC Image Quality initiatives, identified four broad classifications of use, and identified which fields were required for each of these uses. The uses defined were:

a) Collections, exchange and payment;

b) Exceptions and returns;

c) Fraud detection and loss prevention; and

d) Customer uses.

The specific check fields needed to support the business processes at each of these use levels was also identified and documented during the FSTC Image Quality projects, and may be found in the FSTC final report http://www.fstc.org/docs/prm/FSTC_IQ&U_Phase2_Final_Report.pdf.

By combining these two conditions—the overall level of usability required for the image, and the usability of individual fields of information in a check—it should be possible to develop a general scale that can be used to calculate the potential usability of the check. Agreement on the scale requires agreement on the fields to include, weighting of the importance of the fields, and the legibility of the information in each field.

The industry continues to work on developing a common measurement for check usability. As of the publication of this *Technical Report*, no such scale has been developed.

5.5 Comparison of IDA and IUA

5.5.1 Overview

A comparison of the IDA and IUA reference models displays many similarities. In general, the two reference models are identical with the appropriate substitution in the labeling of the block diagram. Table 2 on the next page summarizes the process and measurement substitutions between the two reference models.

Table 2 — IDA and IUA reference model comparison

IDA Process		IUA Process
Defect Metric Parameters	→	Usability Test Parameters
Image Defect Analysis	→	Image Usability Analysis
Defect Metric Thresholds	→	Usability Test Thresholds
Image Defect Assessment	→	Image Usability Assessment
Defect Results	→	Usability Results
Image Defect Tests	→	**Image Usability Tests**
Compute Metrics	→	Compute usability test scores
Defect Metric Values	→	Test Scores
Compare Defect Metric Values with Defect Thresholds	→	Compare Test Score(s) with Thresholds
Defect Flags	→	Usability Flags

5.5.2 Image quality tests and image quality suspects

As discussed above, image quality tests involve the computation of metrics based entirely on image data. The metrics, which may be global properties based on the whole image, or more localized characteristics, are compared to defect/usability thresholds to enable a pass/fail condition to be reported. The results of image quality tests relate to actual image defect or usability problems with varying levels of approximation. Some image quality test results correspond exactly to image quality defect or usability conditions while others produce results that only approximate the conditions that form part of the conceptual hierarchy.

Given that Image Quality Assessments are intended to identify suspect images (i.e., images suspected of carrying a problem), some of the images set aside in a suspect batch will truly manifest a defect or usability problem while others will not. In addition, some systems could fail to identify certain images with defects or usability problems. For example, the test for “image data size too small” should produce a result that corresponds narrowly to a defect for which everyone has agreed on, i.e., a minimum data size. The test for a “torn or folded corner”, on the other hand, may only report a damaged corner 80% of the time. And even when a test correctly identifies a damaged corner, it may incorrectly report the extent of the fold or tear. Given that the success rate in detecting a defect depends on the specifics of the images and the software implementation, discrepancies can exist in the precision of IQA system reports.

As automated image quality tests can in some cases report defects and usability problems only in an approximate manner, the results from such assessments can fall into the following categories:

a) Correct positives – Images that have no image quality problems and pass all the image quality tests;

b) Correct negatives – Images have a defect or usability problem that a test correctly identifies;

c) False positives – Images that fail a particular test but do not in fact carry the corresponding defect or usability problem;

d) Escapes (False negatives) – Images that carry a defect or usability problem but pass the corresponding image quality test.

5.6 Integration of image assessment tools with X9 standards

Image assessment tools provide data about conditions that can affect the quality of an image. ANS X9 standards provide a uniform way to convey or exchange the information generated by image assessment tools. The Image View Analysis Record (Type 54) in DSTU X9.37 was the industry's first attempt to provide a facility to convey image test results in an image exchange standard. Record 54 conveyed image quality (defect) and image usability information for several Image Quality Assessment tests. The image quality tests in the Type 54 record comprise partial image, excessive image skew, piggyback image, too light or too dark, streaks and or bands, below minimum image size, and exceeds maximum image size.

The Record 54 image usability tests include Image-Enabled Proof of Deposit (POD), Source Document Bad, and usability tests for each area of interest on the front and back of an item. Each Record 54 test result is conveyed as a single tri-state value (test not done, condition present, condition not present).

Record 54 suffered from the shortcoming that there was no provision to convey additional information about the test outcome (e.g., metrics, confidence levels, etc.) that might enable users to more intelligently interpret and respond to the reported result. Another issue with the Type 54 Record was that since each test was explicitly defined and enumerated within the standard, new tests could not be added without changing and re-balloting DSTU X9.37.

The Work Group responsible for creating ANS X9.100-180 (the replacement for DSTU X9.37) was challenged with rectifying the limitations inherent in the Type 54 Record. Three actions were taken: remove the detailed check image test definitions from the standard; create an application and registration process so that organizations can apply to have image quality tests registered and updated as technology advances; and create a generic template within the standard for conveying more comprehensive test information generated by image assessment tools.

To facilitate this new approach, a new two-part standard ANS X9.100-40 *Specifications for Check Image Tests* was created. Part 1 defines the generic elements and structures for check image tests. Part 2 of the standard establishes the application and registration procedures used to register specific check image tests that conform to Part 1 of the standard. Interested parties are able to apply to have new check image tests approved and registered following the procedures established in Part 2.

An X9 Registration Management Group for Check Image Tests has been created to manage the application process and determine whether image tests that are submitted for registration meet the acceptance criteria. X9, Inc. will act as the Registration Authority.

ANS X9.100-40 defines two new check image test structures—image test detail and image test summary. The Image Test Detail structure is used to convey the outcome of one specific image test. The Image Test Summary structure contains summary data for a group of one of more image tests (as conveyed in the corresponding Image Test Detail structures). ANS X9.100-180 implements the Image Test Detail Structure as the Type 56 Record, and the Image Test Summary structure as the Type 55 record. Similar structures are contained in the XML-based DSTU X9.100-182 *Specifications for Bulk Data and Image Delivery.*

The Image Test Detail structure supports the following data elements for each conveyed test outcome:

a) Image test number

b) Image test version

c) Image test method

d) Image test flag (quad state)

e) Test results (optional)

f) Test parameters (optional)

g) User test data

The data conveyed in the Image Test Detail structure represents a much richer set of information about the outcome of executing a check image test compared to the limited information available in the Type 54 record.

The detailed image test definitions are contained in the Registry, which is publicly accessible from www.X9.org. When using X9.100-180, the outcome from executing a specific check image quality test using an image assessment tool is conveyed by populating the appropriate fields in the Type 56 Record in accordance with the detailed Registry definition for the test.

6 Environmental considerations

6.1 General

This Clause discusses the environment in which IQA practices are employed, including the legal and regulatory issues, source document concerns, state of industry adoption and use, current industry operating point and causes for failure in an imaging environment. It lays the groundwork and the context for implementation of IQA practices to be described in Clause 7.

6.2 Legal and regulatory environment

Check 21 legislation went into effect in October, 2004. While it prescribed a new legal document—the Substitute Check—it paved the way for broader use of images to support the clearing process. In an interpretation for the Federal Reserve Board of Governors, it was declared that an image must be an accurate representation of the source document and retain all information on that document.

Judgments on the legibility of the information contained in the fields on a check image contribute to the assessment of whether the image provides an accurate representation. Other information that can contribute to whether an image is an accurate representation includes such attributes as legends, security features, etc.

Image quality is an overarching term, which encompasses various factors used to convey how closely an image resembles the source document. In the context of Check 21, the assessment of an accurate representation can be based upon:

a) Determining the presence or absence of image defects (IDA) and

b) Determining the presence or absence of check data and, when present, the assessed usability of that data.

An accurate representation is influenced by the characteristics of the source document (see 6.3 below), the resolution of image capture, the amount of resolution retained after processing and the amount of color or shading information retained. The industry's current operating point for image capture and processing is adequate from a spatial resolution perspective but will fail to retain all data based up the industry's reliance on black and white images. Nevertheless, industry experience indicates that most images are suitable for clearing and subsequent use.

The objective of performing the composite assessment of image defect and image usability testing is to determine to what extent an image may be used as a substitute for the original item for business and personal purposes.

The industry's objective is not to obtain an accurate representation, as it is not considered necessary to strive for an image that looks exactly like the original source document. An accurate representation reflects the interdependency among check printing characteristics, check writing and execution, and the check image processing system.

6.3 Source documents and associated quality issues

6.3.1 General

It is clear that check usage is declining as electronic payments become more broadly used. Current trends indicate that the decline is more pronounced for personal checks than for business checks. Therefore, the challenges associated with capturing a usable image will only become greater over time unless the industry addresses compliance with current and future printing standards.

An expected outcome from lessons learned through industry experience and formal studies is that it will be useful for the X9B Subcommittee to consider updating the current X9.7 standard to reflect the challenges that face image assessment algorithms in accurately locating and analyzing field content in fields that currently do not have printing guidelines to optimize retention of information. It is expected that such a work effort will be launched in the second quarter of 2006.

Even with the most reliable of imaging and IQA systems, some check images may still exhibit quality issues. In assessing how to most effectively manage image quality, it is thus helpful to understand the issues related to the amount and type of information retained in an image and how the industry's operational practices contribute to the notion of what constitutes an accurate representation.

Given that image quality metrics are computed from the image data alone, image quality tests say nothing about data that are absent from the image. For example, an image quality test cannot determine if a field is empty because the maker of the check did not fill it in, or because the writing instrument did not produce a line dark enough to be picked up by the imaging system. Systems that use automated image quality testing cannot automatically segregate all source document problems from image capture problems. Suspect images that are generated due to source document deficiencies are thus processed along with image quality suspects resulting from other causes.

6.3.2 Source document creation

The printers that produce the great majority of checks are active in the check design work in X9B and their products comply with X9B standards. Bankers are aware, however, that some customers prefer to use check stock that is not compliant. In many cases, we expect that these customers are unaware of the implications on the utility of the images of their checks, so an educational process is clearly warranted. Poorly produced, non-compliant checks have historically cost the industry time and money. In an environment where an increasing percentage of items are imaged, exception processing will become even more costly. This is becoming a large enough issue for banks to begin to consider charging some sort of fee or premium to customers who knowingly insist on using non-compliant checks.

The movement to image exchange is prompting banks to consider image survivable deterrence techniques. The FSTC has just concluded a work effort that has been passed to the X9B Subcommittee to create, or incorporate into existing standards, requirements to support interoperable verification of check security features. The X9B effort will include a messaging standard and incorporating requirements on the check printing standard to enable voluntary incorporation of a security mark onto the check.

The implications of such initiatives on IUA are not known. It is also true that some traditional check security features (such as security patterns) can be applied in a way that is not compliant with X9.7 and which can significantly affect the appearance and usability of images of those items.

Source document creation standards that focus on ways to control the location and printing characteristics for the creation of conventional checks currently exist.[2] With the increased reliance of the industry on images, these standards are under review to assess how the standard could best support check electronification and image business requirements prompted by the passage of Check 21 legislation. Because IUA systems perform field level analysis, being able to locate fields in order to assess their legibility may be an important asset. Today, no guidelines for the placement and location of payment information on business checks exist. Without the implementation of placement and location specifications, IQA processes may create a considerable amount of false positive rejects which may be unacceptable for certain financial institutions. Due to the high level of rejects, the extent to which IUA processes are used may be limited.

In some cases, certain check design features that have traditionally been used in the backgrounds of check stock may result in undesirable and/or unintended consequences on the usability of an image or its overall quality when captured. The application of certain design patterns on source documents can significantly increase the resulting image's record size or make the information on the image more difficult to read with an intelligent character recognition (ICR) engine, e.g., improperly executed repeating patterns, bold scenic backgrounds, etc.

Unfortunately, many consumers and corporations remain unaware of the implications of using check stock that is not standard-compliant and/or image-friendly. In general, issues that lead to unacceptable images in personal checks have been associated with backgrounds and font size, while corporate check problems have been most commonly associated with inconsistent placement of fields, font size, faint printing, and security features with repeating patterns.

6.3.3 Source document completion

With consumer checks, source document completion remains an issue as the general public continues to write payment information on checks with writing instruments having light colors and fine line widths. Because imaging systems rely on the ability to detect contrast between payment information and the check's background, the ability to detect presence of information may be compromised if writing instruments used by consumers are not appropriate. To this end, the public is continuously advised to use writing instruments with blue or black ink and medium line widths.

For completion of corporate check source documents, it is preferable that high contrast exists between the ink used to fill in the check and the background color of the check. For example, it is best to avoid the use of a medium blue background and a light blue ink to print information. In addition, given that print densities can wash out over time, it is important to uphold proper maintenance of ink supplies and ribbons.

[2] ANS X9.7-1999 *Bank Check Background and Convenience Amount Field Specification* is under revision.

Corporate check processing may utilize various processes that use ICR for verification of issue information (payee, check number, amount, etc.). The font size, style and case are very important for reliable recognition. The standards group working on a revised check printing standard will be reviewing and likely revising the standard to reflect these issues.

6.3.4 Source document processing

It is recognized that situations can occur during check handling and processing that will eliminate or obscure payment information on the source document, subsequently causing usability issues. Examples of such situations include improper placement of overlay stamps, tearing or folding corners of source documents, feeding multiple documents at one time in the image capture system (i.e., causing piggyback images), documents entering the capture system skewed, etc. Some of these situations can cause serious usability problems while others do not.

6.3.5 Security features on source documents

In some cases, certain check security features that have traditionally been used for protecting the check stock against fraud may result in undesirable and/or unintended consequences on the usability of an image or its overall quality. The application of certain safety patterns on source documents that are not compliant with X9.7 can significantly increase the resulting image's record size or make the data field in the image more difficult to read with an ICR engine. In addition, the location of certain security features may hinder the legibility of fields on an image. In certain cases, photochromatic techniques used to prevent photocopying can appear on an image, causing information on the check to be unreadable in an image or raise questions regarding the legitimacy of the transaction for clearing agents downstream.

For these reasons, from an IQA perspective, it is best that the check security features be as image compatible as possible. If used, security features should be selectively placed on the source document so as not to interfere with the legibility of check information. Key fields on the check where use of certain security features should be avoided unless they are image compatible include the convenience amount, MICR band, as well as date, payee, dollar, and signature lines. More details on each of these fields are available in ANS X9.7-1999.

6.3.6 Carrier documents

Carrier documents are generally used to accommodate the processing of non-machinable items (i.e., items that are ripped, with staples, etc.). In an imaging environment however, it seems that carrier documents are not easily processed as their design and manufacture tends to either obscure required information from the source document or make the information somewhat illegible once scanned and captured into a digital image. For this reason, it is advisable that carrier documents be used solely for the transport of a physical document and that electronic alternatives for processing non-machinable items be developed that do not rely on traditional carriers.

6.3.7 Image replacement document (IRD)

IRDs or substitute checks are created from images of conventional checks and inherit any limitations in the image captured from the check. This problem becomes even worse when images are created from IRDs. The number of IRDs continues to climb as the number of organizations that wish to send checks electronically grows more quickly than the number of organizations willing to receive electronically.

The standard for IRDs (ANS X9.100-140) specifies a precise location in which the check image must be placed on the IRD. In accordance with this standard, business checks are usually shrunk to approximately two thirds of their original size. As a result, the legibility of small font information on original checks can create problems when IRDs are created from such items.

Due to the increasing proportion of corporate checks along with the lack of standardization of corporate checks, IRDs with legibility problems are likely to become more common.

6.4 The image capture process and associated quality issues

6.4.1 General

The amount of information captured and retained in an image affects the way an image looks to the human eye as well as the amount of information it retains that can be discerned by image character recognition systems. For this reason, understanding the image capture process and its associated quality issues is essential in understanding how to improve these areas.

Figure 6, below, provides an overview of the image capture process and typical conditions that generally lead to the perception of poor image quality.

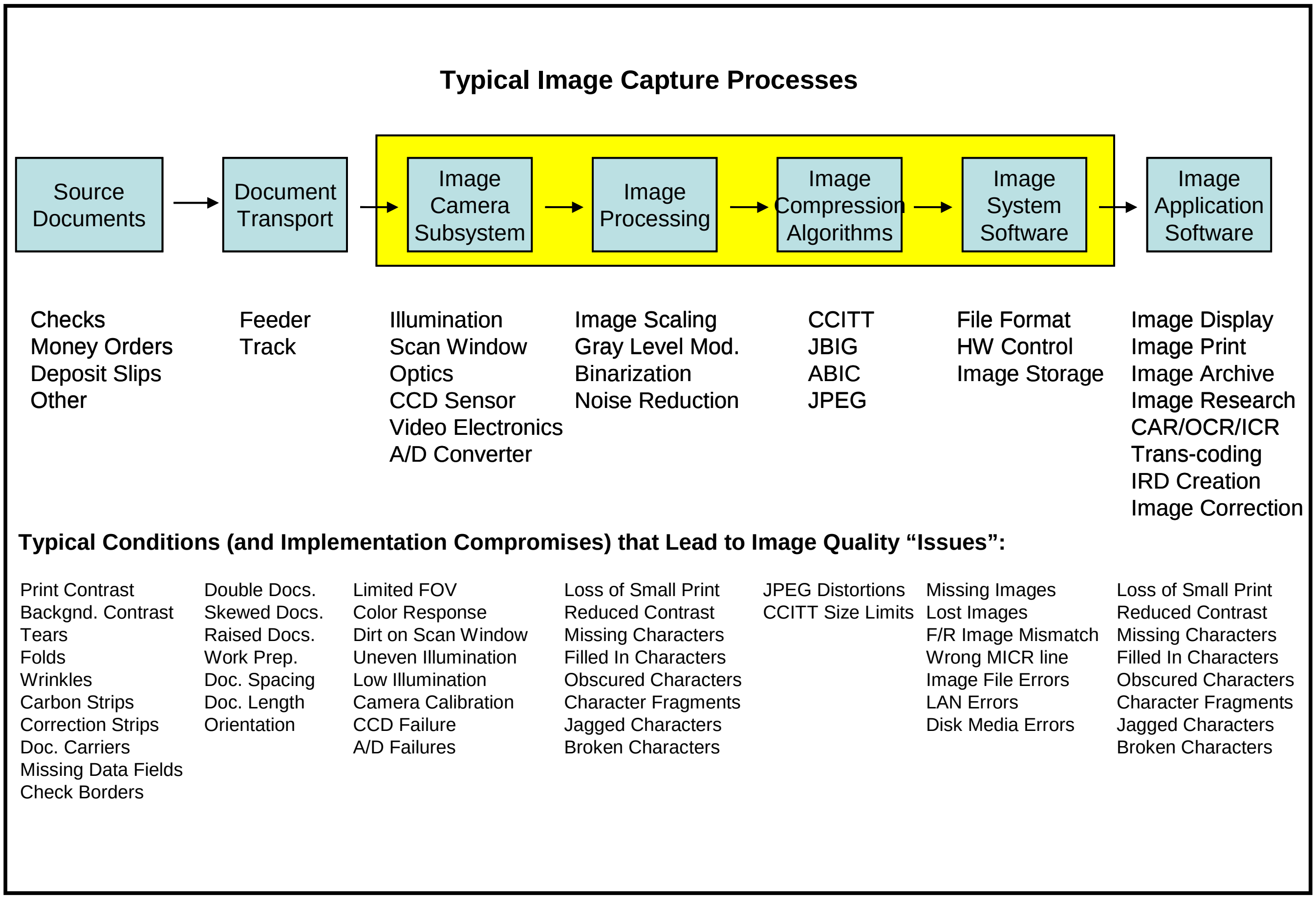


Figure 6 — Overview of image capture process and typical quality issues

6.4.2 Camera output variability

Due to the different technologies available and the wide range of imaging system implementations, variations in camera output exist. It is recognized that even the same image capture platform employed across an organization can produce different representations. For this reason, the industry continues to discuss managing this variability by performing various tests to assess camera output. The use of a system calibration process with standard physical and virtual test decks is an example of practices that continue to become more common in an effort to minimize variability.

6.4.3 Calibration

Calibration is a term used to address various issues, including assuring consistent performance within a system, assessing differences in image appearance among different systems, and aligning output measurements from different IQA systems.

Calibration of image systems is typically performed by manufacturers prior to shipping. In some cases, calibration may remain consistent, needing only to be verified if a significant operational issue surfaces. Nevertheless, implementing an internal calibration process to assure that images produced by an image system remain within acceptable tolerances should become more common. Test documents and software currently exists in the marketplace to perform these assessments, and it is expected that more will be developed should the industry see a need for them.

For calibration issues due to image systems drifting from factory settings after prolonged operation, see 6.5.3 Image system performance degradations.

6.4.4 Image resolution and associated quality issues

6.4.4.1 Image resolution and spatial density

Although black and white images are most commonly exchanged among financial institutions in the U.S., images may be captured in black and white, grayscale or color with varying resolution. Generally, color is expressed in bits per pixel (bpp) and resolution is expressed in dots per inch (dpi).

As a rule, higher spatial resolutions (e.g., 200 dpi to 300 dpi) allow for the differentiation and retention of smaller line features and stroke widths on a check image. Higher color and grayscale resolutions (e.g., 8 bpp or 16 bpp) allow for the differentiation and retention of small changes in contrast or color.

To a certain extent, some trade-offs between spatial resolution and grayscale resolution can be made with minimal impact on check image usability and legibility. For example, grayscale check image systems generating JPEG image formats tend to operate at a reduced spatial resolution of 100 or 120 dpi, while black and white check image systems generating CCITT image formats tend to operate at a 200 or 240 dpi level. Although there is a loss of spatial resolution with JPEG image renditions, the color or grayscale resolution is usually higher (e.g., 8 bpp for grayscale vs. 1 bpp for black and white images) and therefore the grayscale may provide more image detail. It should be noted that grayscale may also make key data elements harder to recognize due to the surrounding background shading.

Comparing check images with equivalent spatial resolution (e.g., 200 dpi) has shown that color image renditions tend to exhibit a higher degree of faithfulness to the original (physical) document than grayscale image renditions, and that grayscale image renditions in turn exhibit a higher degree of faithfulness to the original document than black and white image renditions. Likewise, assuming equivalent color or grayscale resolution, images with higher spatial resolution (200, 240 and 300 dpi) exhibit higher degree of faithfulness to original documents than the lower spatial resolution image renditions (e.g., 80, 100, and 120 dpi).

It is important to note that the design of cameras, digital image preprocessing and some image data compression techniques (which irreversibly manipulate and modify the original source document image pixel data) can have a direct impact on image spatial and color or grayscale resolution.

6.4.4.2 Converting grayscale to black and white

Given that black and white images are the most commonly exchanged images among financial institutions in the U.S., images are typically captured in a grayscale format and subsequently converted to black and white images. The process of creating a black and white image from the captured grayscale image involves the conversion (i.e., binarization) of gray level data to either white or black pixels. For images to remain as accurate as possible within the conversion process, essential information must be retained (and thus converted into black pixels) while backgrounds and un-required information from the original check must be suppressed (and thus converted into white pixels).[3]

One challenge identified with this conversion process is that distinguishing between complete loss of information and information that was not originally on the source document can be very difficult and at times impossible. In addition, the industry needs to continue to work towards establishing an accord on what constitutes information that should be retained and what information an image system can suppress without liability or loss of usability.

6.5 Other general processes and associated quality issues

6.5.1 General

According to industry experience thus far, the root cause of some image quality problems may also lie with processes other than those related to the source document or the basic image capture process. Another root cause may be related to image processing system-created defects and image system performance degradations (i.e., maintenance-related issues).

6.5.2 Image processing system-created defects

Defective quality conditions may be caused by the image processing hardware/firmware/software system itself such as the introduction of spots of information (noise) that were not on the source document. Proper selection of camera user settings and options is also important. Qualification or benchmark testing using test decks or calibration documents can be used to select settings that should be implemented and maintained consistently.

6.5.3 Image system performance degradations

A properly performing image system can begin to produce images that are less useful due to issues associated with gradual or fatal image component failure as well as with lack of required maintenance (e.g., cleaning of optics). The types of situations just described can be monitored and flagged through internal image systems monitoring and/or later in the process through image quality analysis systems or calibration/benchmarking techniques.

Illumination changes, camera focus, and dust and debris on camera optics can also affect the raw image and the resulting processed image. Image systems require regular maintenance, and an image quality assurance environment should be able to recognize systemic degradations and failures by monitoring results. Capture systems should be stopped when the rate of occurrence of defect conditions begins to deviate from long-term averages. The industry's ability to manage the overall level of quality will depend on a commitment by the industry and its agents to operate image capture devices according to manufacturers' recommendations and accepted industry practice.

6.6 Technical standards

The X9 Subcommittee has a number of work efforts that will affect the quality of images, assurance of their integrity and the manner in which quality assurance results are conveyed among exchange partners. These efforts include notable work items such as (1) source document redesign to acknowledge the need to be able locate and assess key fields of information as part of the IUA process, (2) the provision of a process for

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[3] It is expected that the X9.7 *Bank Check Background and Convenience Amount Field Specification* will be amended to reflect check design that optimizes information retention and legibility assessments.

interoperable verification of image-survivable check security features[4], and (3) the X9/ANSI approval of X9.100-180, which is a revision to DSTU X9.37.

These efforts, and others, will offer the potential to improve check electronification operations and effectiveness. The key to achieving payback for these efforts will be industry education resulting in compliance with new printing requirements and the coordinated adoption of new processes. Clauses 7 and 8 describe implementation and identify some issues.

6.7 Industry initiatives

There are many private discussions and some public high-profile discussions. The FSTC is particularly active and may sponsor projects that will assist the industry in establish benchmarks, calibration tests, and/or improved processes.

Active industry forums such as the ECCHO/Federal Reserve forum on image quality may also help pave the way for trusted processes among exchange partners.

6.8 Evolving solution marketplace

The current image defect and usability product set, in our judgment, is in an early stage of development as measured by their ability to meet evolving industry needs. There are many vendors and processors employing a wide variety of products to analyze defects. Until recently, there has been no attempt to unify the process to assure interoperability in an exchange. Each of these products may perform the same tests as other products and measure the results differently. Judgments made by the image capture organizations with respect to the usability of images reviewed can vary as well.

Intuition, as well as scientific studies performed in 2005, confirm that defect assessment tools must be used very carefully. The industry needs to agree upon which tools to use for image exchange, standardize the tests to be used for that purpose, use common thresholds and set expectations for all parties in an exchange.

7 Image business practices

7.1 General

Implementation of the IQA tools described in Clause 5 can take a number of forms and has significant operational and exchange partner implications. This Clause describes implementation approaches, selection of key fields upon which to perform IUA, handling of images suspected of being unusable, how IQA tools are supported within X9, how IQA systems support the clearing process and how results from these IQA tools can be conveyed to trading partners during image exchange.

How different IDA and IUA technologies and implementations may impact IQA performance and consistency of results will also be discussed.

7.2 Implementation overview

The complexity, time and effectiveness associated with automated IQA processes can vary greatly, directly impacting the final IQA solution. Figure 7 illustrates the relationship between image characteristics, defect,

[4] Building from a FSTC study and recommendations.

usability and manual assessment processes, their associated level of complexity, and the level of quality assurance provided. By employing both automated and manual image assessment processes, most check image quality problems can be detected.

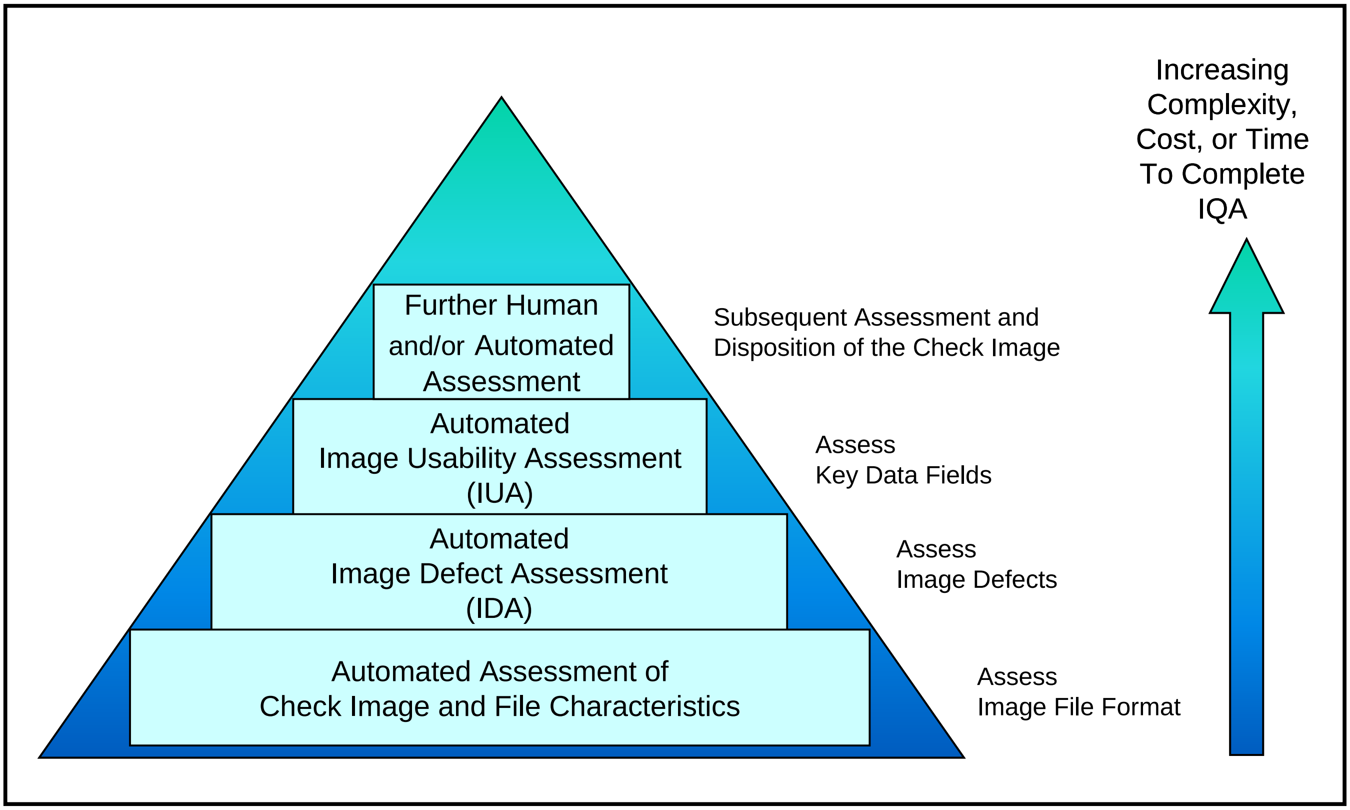

Figure 7 — Image quality assurance pyramid

Even if human review is not implemented, IDA or IUA problems trigger alternate processing decisions for the document (e.g., process the check in a normal paper stream or retain a higher resolution image).

7.3 IQA tools and human assessment

To minimize the amount of time and labor required in assessing check image quality, multiple automated IQA processes are generally implemented. With the exception of the human assessment, all of the IQA processes listed above may be automated.

When performing automated IQA processes, it is important to recognize that the number of images identified as having an image defect or usability issue (i.e., being classified as an image quality suspect), depends upon IDA and IUA threshold and parameter settings.

Although time consuming and expensive, many IQA processes provide for human review of images considered suspect by automated processes. Suspect check images can originate from a variety of processes associated with an image-based check processing system, including the manual review of image quality suspects identified by the automated IQA processes. Industry opinion is that human review provides the highest level of verifying image usability—particularly when images are readily interpretable. However, when check images contain only partial or faint information, it is known that reviewers will vary more in their interpretations. These variations reflect individual differences as well as amount and type of training received.

7.4 Implementation of IQA processes

The high level model above does not address how the automated assessments are applied (sequentially or in parallel; dependently or independently). Figure 8 below builds upon Figure 3 in Clause 5 to address which operational alternatives emerge from the use of image quality assurance tools.

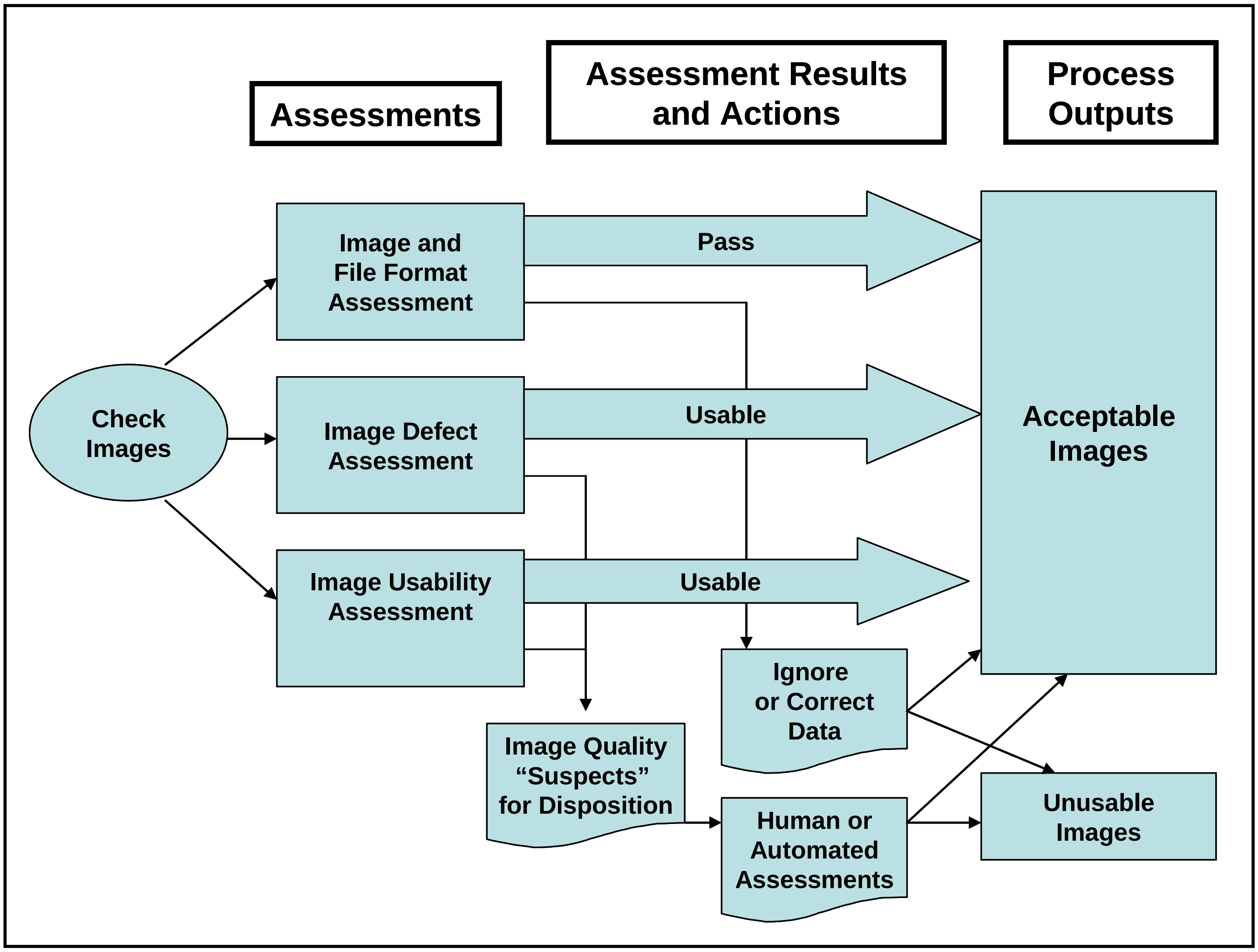

Figure 8 — Implementation of automated assessment processes

7.5 Validation of check image and format characteristics

7.5.1 Introduction

Electronic exchange of check and image data needs to be done in a standard manner by the industry. The process for formatting an image as it completes processing in the camera system also needs to be standardized. Fortunately, the industry can and does use existing standards.

For image and check data exchange, the relevant standard in use is DSTU X9.37-2003. The industry primarily uses either the Fed's or SVPCo's implementation, and these organizations have worked together to assure interoperability. A core set of DSTU X9.37 format compliance requirements should be defined as the minimal set that should become standard business practice for organizations exchanging images under the standard.

The check image industry has settled on the use of the Aldus/Adobe TIFF 6.0 format for black and white images. Check image usage of TIFF, relative to the tags used and the acceptable values within those tags, will require specification of the way this industry wishes to implement and use this broad de facto standard. An industry work group sponsored by the Federal Reserve and ECCHO is negotiating common practices and is expected to produce its recommendation this year.

Performing edit checks on the contents of exchange files and image wrappers is an effective and necessary first level process. There is no common industry practice associated with what to do with images or files containing errors. In part, this is because the implications of these errors on downstream applications will differ from organization to organization. The industry needs to consider the value of setting a high quality hurdle for files or images that were formed improperly or contain errors.

7.5.2 Editing examples

The TIFF record provides tags for specifying information about an image. The operating points below are considered standard business practice in early 2006. Assuming a check image meets the required image type and format criteria as specified by the receiving organization or multi-national agreement, the check image is then accepted for further IQA processing.

Examples of minimum image interchange or import requirements include the following:

a) X and Y Resolution Tags (#282 and #283): Black and white images cannot have a spatial resolution below 200 pixels per inch;

b) Compression Tag (#259): Black and white images must be compressed using the CCITT Group 4 compression algorithm;

c) Image Width Tag (#256): Should not exceed a width larger than the largest check plus some tolerance).

7.6 Image Defect Assessment

The financial industry can choose among many suppliers of image quality tools. Each provider can use the same or different metrics as other providers, and parameters supporting the metrics may differ. This situation supports the contention that the industry should agree upon common practices that identify a set of tests and defines how output is expressed. By doing so, the industry can become confident that a suspect identified by one supplier's system would be a suspect in another supplier's system.

The FSTC's metric list (referenced in Clause 4) is intended to provide that common practice. The FSTC has taken a second step to assess the relationship between defects and usability in black and white images. Information on the results of that effort is also available on the FSTC web site (http://www.fstc.org/docs/prm/FSTC_IQ&U_Phase2_Final_Report.pdf). The FSTC study concludes that two defects (too light and too dark) are effective predictors of potential image usability problems, but the majority of defects are not good predictors. This outcome suggests that results from image defect testing need to be used in appropriate ways, some for best practices associated with process quality control and others to convey specific defect information. It is acknowledged that there will still be escapes with the application of these metrics at the recommended threshold settings.

We expect that vendor-unique metrics will continue to be used for some time. This situation arises partly from vendor inertia and partly from a lack of clear indications from banks that they wish to coalesce defect testing around the FSTC's approach. There is significant movement among key industry solution providers to move in that direction, but the reality is that there is likely to be variability in the tools used and the results that they generate.

7.7 Image Usability Assessment

7.7.1 Key data fields

IUA analyses are performed on fields considered important to the image exchange process. Key data fields that should be examined in an IUA include:

a) Convenience amount and/or legal amount;

b) Payee names;

c) MICR code line data;

d) Maker of the check (name and address block of the account owner); and

e) Signature.

7.7.2 Other data fields

The above fields influence judgments made on the suitability for clearing. Other fields that a financial institution may want to assess are:

a) Issue date;

b) Payee endorsement; and

c) Bank of First Deposit.

The design and use of image usability tests depend on the fields being assessed, resulting in a different set of tests typically being applied to the fields associated with the front and rear images of the check.

7.8 Conveying assessment results

7.8.1 Introduction

Presenting IDA and IUA results may be done in a variety of ways. The simplest method of reporting IDA results is to provide a pass/fail flag for each image defect condition being tested. The benefit of this image quality reporting method is that only a single binary bit needs to be stored and examined to communicate the results of each IDA test. Although this approach requires the storage and transmission of a minimum amount of information, it does not convey any insight into the numerical value of the defect metrics and/or IDA defect metric threshold and parameter values used.

An extension of this approach was adopted in DSTU X9.37, *Specifications for Electronic Exchange of Check and Image Data,* whereby an Image View Analysis Record (Type 54) is provided to carry image defect information associated with the check image. To this end, a tri-state defect flag was defined to convey the results associated with each image defect test. The following values were defined for this record:

a) Defect flag value = 0, the IDA test was not performed;

b) Defect flag value = 1, the IDA test was performed, and the defect was present;

c) Defect flag value = 2, the IDA test was performed, and the defect was not present.

Further discussion of the use of standards to convey test results is contained in Clause 7.9.

7.8.2 Considerations related to conveying Image Defect Assessment results

In addition to the flag results associated with individual image defects, a global image defect flag provides global information as to whether any individual image defect tests detected a defect. By examining the global image defect flag, systems can quickly ascertain whether or not any image defects are present.

As an alternative to just flagging defect problems, IDA processes may also provide the numerical value of the defect metric(s) measured, as well as the IDA parameters and defect metric threshold settings used for each image defect test. This approach provides additional quantitative insight into the magnitude of the image defects. Providing the value of the defect metric(s) associated with each image defect detected allows post-capture image applications to review IDA measurements and possibly apply different pass/fail criteria. This approach is beneficial if a common set of IDA decision rules have not been established and universally adopted for each image defect, and/or the post-capture image application has defined a set of decision rules that can utilize the defect metrics, parameters and threshold settings provided by the image capture process.

7.8.3 Considerations related to conveying IUA results

Because each solution provider's IUA and legibility prediction process uniquely reflects its proprietary approach, as an addition to flagging problems, IUA processes may also provide the actual value and confidence level of the test result on each field assessed, as well as the IUA parameters and threshold settings associated with each image usability test.

7.9 Implementation of X9B standards

Products from solution providers need to be registered processes so that senders can specify and receivers can know what type of process made the judgment on image defects and/or usability.

The industry needs to establish common practices about how to use the image quality records Type 54 in DSTU X9.37 or Type 55/56 in X9.100-180 image exchange standards.

7.10 IQA systems and clearing

7.10.1 General

The way organizations choose to implement their image business practices will impact the effectiveness of image-supported electronic exchanges. In the Check 21 environment, the likelihood increases that images are captured by organizations that have no relationship to the financial institution that manages the customer relationship. Early detection of situations that can cause downstream image usability issues and correcting those conditions while the source document is still available will become increasingly important.

For example, consider an item in the image cash letter. What are the consequences if the amount of that item cannot be read from either the convenience amount or legal amount in the front image because that image is too light? If the "image too light" defect test, or the "amount fields" usability tests, effectively identified this item as a suspect, then business rules, possibly combined with human review or alternate exception processing, could result in the check being cleared via the paper route with very little chance that the item be returned. On the other hand, if exchanged as an image, there would be a strong possibility that the item would be returned on the basis that it is an unusable image.

7.10.2 Sources of problems

When an item is returned due to an image quality issue, financial institutions may want to know how an item with that problem was sent in as an image cash letter. Some the potential answers are:

a) Escape (false negative) – the image has an image usability problem that testing performed after capture failed to flag;

b) Marginal problem but a subsequent process aggravated the situation – for example, IRD production from a marginal image resulted in an image quality problem;

c) The image is not a problem for clearing of the item but the image quality does not support day-two process requirements – for example image quality does not allow the issue date to be read;

d) False positive – the paying bank automatically returned an item that was actually usable.

7.10.3 Responses to an unusable image

In any case the sending bank has several options for dealing with image quality returns. These include:

a) Clearing the paper or photocopy (if it has been retained);

b) Clearing a recoverable image, e.g., a higher quality image retained from the original capture run, an image enhanced through certain algorithms, or a new image captured from the retained paper, an IRD; or

c) Writing off the value of the item.

In addition, the institution may consider improvements to its image quality assurance system. For escapes, for example, the sending institution may tighten test thresholds, or add new tests, with the understanding that these actions could result in an increase in the number of false positives. An institution may also implement calibration procedures that would improve capture quality and reduce image defects that typically would not result in image usability problems. If secondary processes are aggravating marginal image quality problems, then those processes may need review, or additional image quality tests may be required within those processes. Quality issues that revolve around the paying bank's day-two processes may be addressed through inter-bank exchange agreements.

Table 3 (next page) shows examples of image quality tests and related sources for detected problems. This kind of table may be a useful analysis tool by helping to identify areas where specific risk reduction strategies might apply.

Table 3 — Image quality test failures and related sources

Tests		Sources			
		Source document	Camera system	Processing system	Application
Image defects	Too light	Maybe	Maybe	Maybe	Unlikely
	Too dark	Maybe	Maybe	Maybe	Maybe
	Streak	Maybe	Maybe	Unlikely	No
	Damaged corner	Yes	No	No	No
	...				
Image usability problems	MICR	Maybe	Maybe	Maybe	No
	Convenience amount	Maybe	Maybe	Maybe	No
	Legal amount	Maybe	Maybe	Maybe	No
	...				

7.11 Clearing participants and IQA systems

7.11.1 General

The following provides a brief overview of how players in the payment process flow may use IQA systems to mitigate risks associated with clearing images.

7.11.2 The truncating bank and IQA systems

The truncating bank or its designee captures images of truncated checks. Given that the capture process provides the best opportunity to reduce the occurrence of unusable images entering the payment processing system, a truncating Bank may adopt appropriate measures to identify unusable images with software image analysis such as the use of an IQA system. The truncating bank may also employ a calibration and performance monitoring practice that assesses capture performance. An IQA system and performance monitoring can be effective components for building a quality check image capture process.

Many image defects can be attributed to document characteristics, condition, scanning and mechanical handling issues. It is recommended that truncating banks inspect images during the capture phase, correct any defects, and rescan the items to capture a better image. However, while this approach may be ideal for low volume capture, inspection of flagged items may not be feasible when dealing with high volumes. To this end, exception handling of items flagged with severe defects may be considered, such as retaining those checks for a period of time that would allow research or re-scanning if needed. Likewise, saving the originally captured grayscale image may also provide access to a more usable image if the need arises. In most cases, if the MICR line is good, no issues will be raised.

7.11.3 The paying bank and IQA systems

Paying banks must rely on incoming check images for payment processing and therefore expect to receive usable images. An IQA system can thus be an effective component of image verification, particularly if no agreements exist between the truncating and paying bank regarding what constitutes an acceptable quality level of image capture. Indeed, IQA assessment can give the paying bank the required confidence that the images were captured with an acceptable quality process.

In cases where not all items are verified, inspection processes could be established to flag images with severe defects. Such inspection processes could be dependent on the value of the item, the severity of the defect detected, or related to the service level given to the particular account.

As unusable images are often caused by poor source documents, the Paying Bank could also use an IQA system to track occurrences of quality issues related to specific accounts. Further analysis might reveal that the image quality problems are in fact related to the account holder’s check design or check writing practices. The Paying Bank could then use this information to implement changes to these accounts.

7.11.4 Image exchange and IQA systems

Clearing houses and intermediary exchange service providers may consider using IQA systems. This can be useful if some financial institutions have not implemented quality image capture processes using industry-standard IQA business practices. A clearing house or exchange service could then use standard IQA tests for all incoming images received from members and pass on related information to the receiving/paying banks.

By the same token, clearing houses or exchange services could reject any item that failed an IQA test and notify the originator. Clearing houses or exchange services could ensure that all cleared images are of high quality with a low incidence rate of image quality defects that could create usability issues. That being said, clearing houses or exchange services should be cautious in using IQA system outputs to automatically reject items, as many rejected items may be usable images.

8 Open issues

8.1 Introduction

The intent of this clause is to make a statement on the state of the industry, taking into consideration the current assessment tools and their likely evolutionary direction, the environmental issues and the business practice issues.

8.2 Defect metrics

As discussed in Clause 6, the market place offers solutions from a number of providers for determining defects. However, how the solutions are implemented can and does differ. This means that how defects are detected is inconsistent. Thus the FSTC worked with some banks and vendors to determine a common acceptable definition of each of more than a dozen defects and the units of measurement and output for these defects. If all exchange partners use software from vendors that complies with the FSTC definitions, variability between analyses caused by different analysis techniques will shrink.

There has been little implementation of software using these new definitions, but implementation is anticipated in 2006. We are uncertain as to the rate of adoption in terms of which organizations or how much volume will be subjected to more uniform business practices. We can anticipate, therefore, confusion about failure limits in the determination of defects is likely to continue through 2006 but is expected to become gradually less of an issue in 2007 and beyond. It may also be reasonable to expect that some metrics may have multiple implementations (both FSTC and vendor unique) because certain techniques are more effective at accurately assessing a particular defect.

Defect analysis appears to have two uses. The first use appears to be as a good first-level check to be performed on an on-going basis that internal image processing systems are working consistently. This use will require maintaining statistics and performing analysis to spot long term deviations. This practice is not in general use today, and analysis will become more difficult by changes or upgrades in image assessment software. The second use is in an image exchange where selected defects exceeding a specified level are considered suspect and become eligible for any of a number of disposition processes.

Using defect assessment as a predictor of true image usability appears to be useful only for a very limited number of metrics, according to FSTC studies. Two defect conditions (too dark, too light) are reasonable predictors of possible image usability suspects if the condition exceeds moderate threshold values. Those and other conditions provide a clear indication of a usability suspect if the metric value exceeds an extreme (high or low) threshold. In addition to employing the most useful defect metrics for images included in exchanges, it will be desirable for the industry to establish common failure thresholds.

While the FSTC has recommended initial settings, threshold values for specific metrics have not yet been adopted. It is likely that some institutions will begin to use the FSTC thresholds to gain experience and either validate them or propose changes to them. Establishing common threshold values will take time to mature. The FSTC study also demonstrated the risk of using defect screening as the only quality tool because images with usability problems may escape. Better results are expected if usability assessments are used along with defect assessments to screen for unusable images.

8.3 The use of “true” image usability metrics

The use of field level assessment tools is far less common than defect analysis. Knowledgeable individuals agree that the output from this type of assessment tool can be much more useful than global judgments made by defect assessment tools on the entire image. Some have expressed concern that field level analysis takes longer or uses more computing power to perform than defect analysis. This contention appears to be have delayed broad adoption of field level assessment tools. The current solutions are proprietary. While proprietary processes are not problematic in themselves, concerns about interoperability arise as a byproduct of this uniqueness. Another consequence of the uniqueness of each solution is that there are currently no common usability threshold values. Until these issues are addressed by the industry, adoption of field level analysis will be slow.

Some have expressed concern about the level of false positives that are expected to be higher, (much higher some believe) than defect analysis. Exception processing on false indications of problems from the assessment tool worries users who are already concerned about the cost of exception processing from defect assessment alone.

8.4 Source document issues

As stated above, IUA is done at the field element level. There are many business-sized checks where fields cannot be reliably located because the guidelines for field placement on larger checks are not as thoroughly detailed as on personal checks.

We are also aware that some checks are not printed in compliance with X9.7. In many cases, these non-compliant checks create less readily usable images, putting a cost burden on all processors.

Finally, the widespread adoption of image exchange and the reliance on images have put more emphasis on preserving information in more check fields than has been true historically. The current version of X9.7 does not require that all fields which are of interest to banks be printed in an image friendly manner. It is expected that the revision to X9.7 will address this shortcoming as well as provide for more consistent field placement on all checks. However, revising the current standard may take 12 or more months to complete, so we cannot anticipate any near-term improvement except by banks working with users of non-compliant check stock.

8.5 Conveying the results of image defect and usability assessments in image exchange

As explained in Clause 5, DSTU X9.37 and its replacement ANS X9.100-180 have records to indicate which tests were performed and the judgment of the assessment tool on any particular defect or usability assessment. X9.100-180 goes a step further in allowing the actual output score to be conveyed. Today very few organizations provide this information in an exchange. There is some question how important this capability will be as the industry moves forward.

Many judge that the improvement in image quality records is one of the more important attributes of the X9.100-180 standard. We agree that this capability may be important, especially in the nearer term while industry practices are maturing. However, the industry has focused its efforts on adopting the DSTU. It is unclear how quickly the users of this exchange standard will migrate to something newer; at a minimum, there will be a period of time when some will be using the older standard while others are using a new standard.

When one or more images are considered suspect, or are confirmed by subsequent review to be unusable, the current default position is not to include them in an image exchange and instead to forward them for payment in the paper check payment stream. This low risk approach will function well enough as long as physical check exchange remains efficient, but resorting to traditional processes will become more cumbersome over time.

Because the Image View Record (Type 54) record in exchanges supported by DSTU X9.37 are generally not used in today’s image exchange environment, it is typically not clear to the receiver of an image cash letter, from the exchange itself, if every item in an exchange has been checked for quality. It is definitely not clear which tests have been performed and what thresholds have been applied to assess whether an image is usable. Even when an Image View Record is included in the exchange, it is not clear when a suspect image has been subsequently reviewed and judged to be usable. This condition leads to a business model where exchanging partners rely upon one another to perform due diligence and only object when the exchanging partner’s performance fails to meet overall expectations. When exchanging partners are known to one another, this model seems to work well, but it does not support broader exchange scenarios.

All of the preceding gives rise to the notion of exchanging even known suspect or unusable images and automatically initiating exception process to assure that a better image (perhaps a grayscale version) or the original check is retained for a longer period of time. This “better image” or “better copy” can be requested when needed. No exception notification and request processes have been socialized enough for trial use at this time.

Some organizations that perform image assessments on incoming cash letters do not perform any sort of suspect disposition review of suspect items, but simply reject them.

Image capture output from any given platform can (and currently does) vary substantially. Inasmuch as image assessment tools must respond to what is retained, there will always be some variability in the apparent performance of assessment tools that has nothing to do with the tool itself, but rather with the way in which the image was captured. The need for a standardized calibration process is an understood need that may be pursued by the FSTC or others.

X9.100-180 will augment this process by adding a flag that indicates if human review has been performed and the image was in fact judged acceptable or if the image was felt to be a potential problem and that a better image rendition or the original item is available on request. With this information, even if an item that fails incoming IQA can be accepted with confidence that the item really is usable or, if a problem were to occur, a backup is available.

Annex A
(Informative)

Detailed image capture process and IQA systems

A.1 Introduction

This Annex is provided as a handy reference to the operation of image capture systems that can be used by anyone who wishes to understand the technical elements of the process as context for understanding the implications on image quality.

A.2 Document image capture devices

A.2.1 General

Documents can be imaged using a variety of optical scanners. Over the years, a number of scanning geometries and mechanisms have been utilized. In some low-volume applications, documents or film have been attached to a rotating drum and then scanned using a single photo-sensor that acquires a single pixel of the image at a time as the sensor is translated across the rotating drum. Some page imaging applications place a stationary document on a table and use an overhead electronic camera fitted with a two-dimensional photo-sensor array to acquire an image of the entire document during a single exposure.

More recently, flatbed scanners have been introduced into the home and office that support scanning of various sized documents positioned on a flat glass scan window. Document scanning is accomplished by translating a one-dimensional photo-sensor array that spans the width of the flatbed scanner, over the entire length of document. As the photo-sensor array moves over the length of the document, a sequential set of scan line data is collected and concatenated to generate the document image. Alternatively, rather than move a one-dimensional photo-sensor array over a stationary document, scan line data can be collected by moving a document past a stationary one-dimensional photo-sensor array. Financial institutions commonly use the latter scanning method to acquire check images from document transports.

A.2.2 Reader/Sorters

Since the 1960s and the adoption of magnetic ink character recognition (MICR) code lines, check processing has become automated by the introduction and use of document processors typically known as a reader/sorter. The primary function of any reader/sorter is to mechanically transport checks down a track so that the MICR code line data can be read from each check. In the 1980s, check imaging was introduced into the document transport platforms to further automate and reduce the processing times and costs associated with check processing. Given that most check image capture systems today are integrated into a reader/sorter platform, it is recognized that the reader/sorter itself can create problems that may impact check image quality.

Reader/sorters vary greatly in both size and speed. High speed reader/sorters can read checks at rates exceeding 2,000 items per minutes and be 50 feet long filling a small room. Low speed reader/sorters may be the size of a shoe box and sit on a desk top, reading checks at a rate of 30 items per minute; other document transport devices may be embedded within an Automatic Teller Machine (ATM). For purposes of this discussion, the term “document transport” is used regardless of the size and speed of a specific device.

The three primary elements of any document transport platform are the document input mechanism, the track, and the document output mechanism. Operation of the transport starts with the input mechanism. In the case of a medium or high speed device, this would involve extracting documents from a hopper that could contain hundreds of documents, while for a document transport embedded within an ATM, this could involve extracting a single item from a hand feed slot. Once accepted by the input mechanism the check is moved down a track where a variety of optional processing operations may be performed (e.g., MICR read, OCR read, check endorsement, microfilming, imaging, etc.). For purposes of this discussion, the minimum processing operations performed are MICR read and imaging. Depending on the optional processing modules present, the track length can vary from a few inches to several tens of feet. After all operations have been completed, the check is then presented to the output mechanism for final disposition. On a small ATM embedded device, this may be as simple as ejecting the check through a slot. On other document transports, one or more output pockets may be present, and each item will be directed to a specific pocket based on various processing criteria.

Accelerating and translating a paper check down the mechanical track of a transport can introduce problems that impact check imaging. Typical problems include feeder problems that generate piggybacked items and mechanical design issues that sometimes lead to excessive document skew, improper document spacing and document jams.

Since check image capture is normally performed while the document is in motion within a track, variations in document position and motion can negatively impact the image of the check. Non-uniform motion of the document past the image camera can introduce image warping artifacts in the check image. Checks improperly positioned at the bottom of the transport track may cause the top portion of the document to fall outside the image camera's field of view, resulting in a check image missing the top portion of the check. Checks that are skewed relative to the bottom of the transport track will cause a rotated rendition of the check image to be generated. Highly skewed checks may result in a corner of the check not being imaged by the camera, since the corner of the paper document is outside the image camera's field of view.

Finally, improper work preparation of the checks prior to insertion into a transport document hopper can create feeder problems that can result in an increased frequency of document jams, piggybacked documents, and/or poor document spacing, resulting in a variety of feeder exception conditions. Imaging piggybacked checks yields a check image where one document is overlapped with another, obscuring data on one check and often truncating data on the other. Damage to paper checks resulting from transport jam conditions can create one or more of the source document problems discussed in the previous Clause.

Therefore, a portion of the image quality problems observed today can be directly attributed to the problems associated with mechanical document handling problems induced by the document transport.

A.2.3 Flatbed scanners

Although the majority of check images are generated by document transports, a small percentage of check images are created using flatbed scanner technology. Flatbed scanners may be used to image mutilated checks that cannot be physically handled on a document transport, or to perform imaging of documents that require exception handling.

A.3 Image capture processes

A.3.1 General

Check image capture is accomplished in a document transport by the addition of an image capture subsystem. The major elements of image capture include the following major components:

a) Image camera subsystem;

b) Digital image preprocessing;

c) Digital image compression;

d) Image system software.

These four major operational components are identified in Figure A1 as the collection of four functional blocks that are labeled “Typical Image Capture Processes”. A description of each of these functional blocks and their impact on image quality is discussed in the following paragraphs.

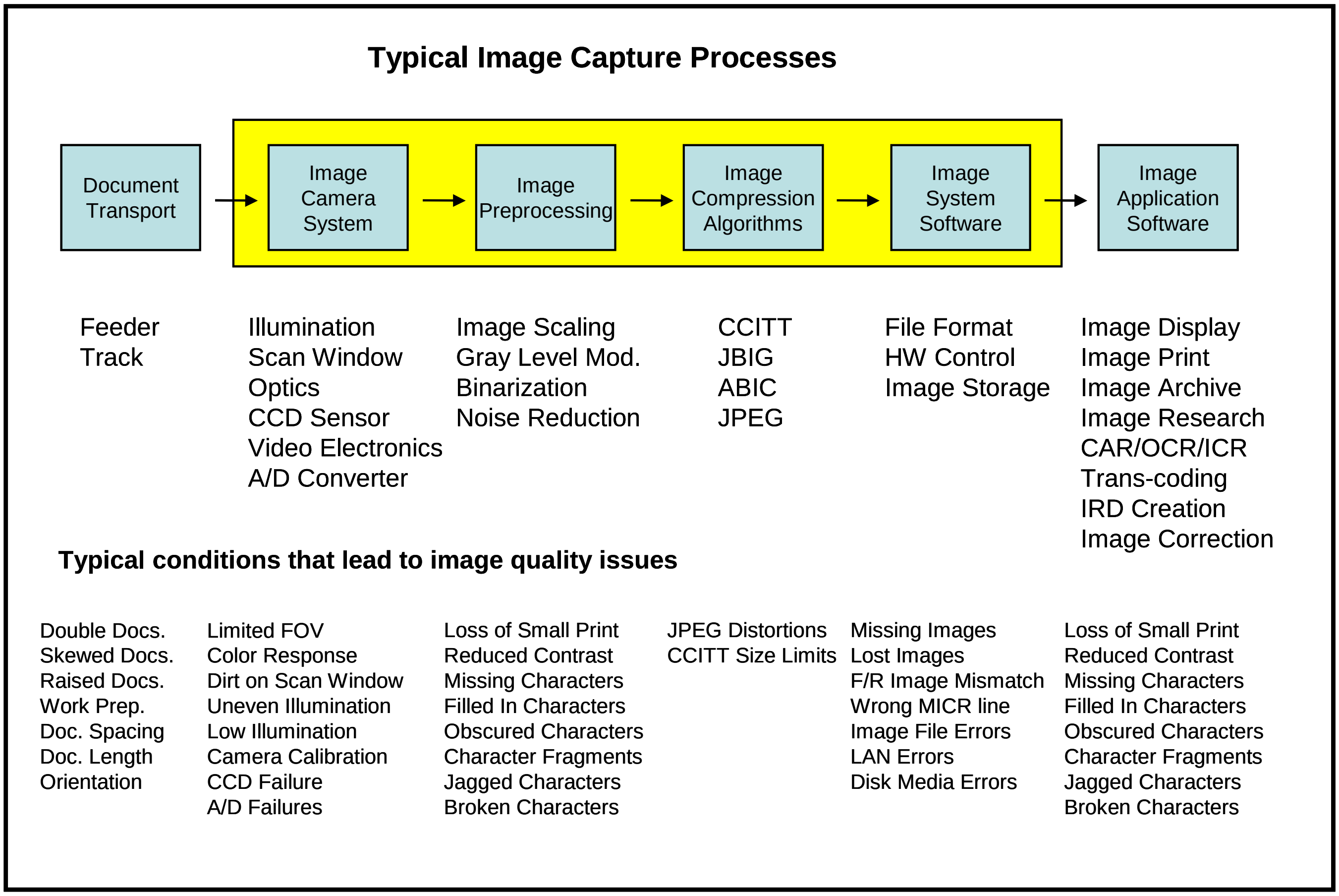

Figure A1—Check image capture reference model

A.3.2 Image camera subsystem

A.3.2.1 Attributes

A.3.2.1.1 Introduction

The primary function of the image camera subsystem is to scan the original paper check and create a digital image representation that can be electronically processed. The three primary attributes associated with any image camera subsystem that influence the overall quality of the resultant check image:

a) The camera’s field of view (FOV);

b) The camera's spatial scanning resolution;

c) The camera's gray level or color resolution.

A.3.2.1.2 Field of view

The camera's field of view refers to the physical area that the camera sees when in operation. In order for the camera to acquire a complete image of the original paper check, the entire check document must reside in the camera's field of view. Any portion of the paper check that falls outside the camera's field of view will not be scanned. The field of view is dependent upon a number of design parameters associated with the camera's illumination, optics and sensor electronics, all of which will be discussed in subsequent paragraphs. When imaging checks in a document transport environment, the field of view is representing a portion of the transport track's document scan window and is normally expressed in units of inches.

A.3.2.1.3 Scanning resolution

The camera's scanning resolution refers to the actual spatial area that each pixel in the digital image represents on the original paper check. Since a check image is a two-dimensional collection (or mosaic) of individual pixels that are concatenated together to create an image, the spatial resolution refers to the geometric size of each pixel in the image. Normally camera systems are designed to generate square pixels that have the same spatial resolution in both the vertical and horizontal direction. Spatial resolution is normally expressed in units of pixels or dots per inch (dpi) with typical operating values ranging from 200 to 300 dpi. The camera's scanning resolution determines the smallest feature on the original paper check (e.g., thinnest character stroke or font) that can be resolved and accurately rendered in the check image. In general, the higher the scanning resolution, the higher the amount of fine detail preserved in the raw check image representation.

A.3.2.1.4 Gray level or color resolution

The final attribute associated with any camera subsystem is the camera's gray level or color resolution. The gray level or color resolution refers to the number of brightness levels that are defined, between white and black, for each pixel. A black and white image only allows two levels of brightness for each image pixel, white or black. A continuous tone monochrome image generally defines at least 256 shades of gray (between white and black) for each pixel in the image. A color image generally defines a triplet of red, blue and green pixels, each of which can have 256 shades or hues of red, blue and green. Image gray level resolution is normally expressed in bits per pixel (bpp) which indicates the precision of the binary value associated with each image pixel. Check images that are captured with 256 shades of gray will have a gray level resolution of eight (8) bpp, since an 8-bit binary number can take on 256 different values. By contrast, a black and white image requires only one (1) bpp to represent pixels that are white (0) or black (1). Camera subsystems that generate monochrome check image renditions typically operate at 7 or 8 bpp of gray level resolution. Camera subsystems that generate color check image renditions typically operate at 24 bpp (8 bpp for each color component—red, blue and green).

A.3.2.2 Sub-elements

A.3.2.2.1 General

The image camera subsystem is comprised of three sub-elements, all of which can affect image quality.

a) Document illumination system;

b) Camera optics;

c) Digital camera electronics.

A.3.2.2.2 Document illumination system

Check imaging begins with the illumination of the paper check. Checks are illuminated and imaged in a document transport track by cutting a vertical slit and placing a window into the track wall in front of the image camera. As the check passes by the scanning window, a vertical strip of the document is illuminated and the reflected light collected by the image camera. Each vertical strip of the document image is referred to as a scan line. As the check moves past the scan window, additional scan lines are collected and concatenated to create the final two-dimensional check image.

Since the scan window is generally a vertical rectangular slit cut into the document transports track wall, a line of light is required to illuminate the check as it passes the scanning window. In general, the illumination system is designed to provide document lighting that meets or exceeds the camera’s field of view. Sources of illumination vary depending on the design of the camera subsystem and the design constraints associated with the document transport. Typical illumination sources include fluorescent bulbs, halogen lamps, and light emitting diodes (LEDs). Since the illumination must be provided uniformly over a rectangular scan window, fiber optic and light pipes are often used to convert a spot of light generated by a bulb into a line of light suitable for illuminating the source document.

Inadequate check illumination can create check images that are too dark, thus obscuring data. Over illumination can create digital check images that are too white, yielding washed out data. Additionally, non-uniform check illumination can introduce shading variations. These shading variations typically manifest themselves as horizontal bands or streaks in a gray level or color rendition of the check image. If the check image is being converted to a bi-tonal (black and white) representation, the shading variations may cause horizontal bands of the check image to be either washed out (turned to white) or obscured (turned to black) by the black and white image binarization process. Dirt, dust or debris on the scanning window can affect image quality by blocking the reflected light from the check from reaching the image camera. The result is a check image containing one or more gray or black horizontal streaks that may obscure or degrade data.

A.3.2.2.3 Camera optics

Light reflected from a check is collected by the camera’s optical system and focused on to a photo-sensor where the light is converted into an electrical signal. Defects or design limitations associated with the camera optical system can directly impact check image quality. Variation in lens magnification can impact image resolution (dpi) in the vertical direction, variation in the lens focal length can affect camera focus, and design characteristics associated with the lens can introduce a variety of other optical aberrations into the check image.

Besides the camera lens, one or more optical filters are typically added to the optical system to modify the spectral response (i.e., color response) of the capture system. The goal of spectral filtering is to have the capture system detect colors present on the check in a manner identical to the color perceived by the human eye. Transforming the color response of the camera to match the color response of the human eye can be accomplished by adding a photopic filter into the optical path of the image camera. A photopic filter is a special color filter that only permits light that is in the visible spectrum (wavelengths of 700 nm to 400 nm, red through violet) to be detected by the camera’s photo-sensor. Improper spectral filtering can impact image quality by optically enhancing, eliminating or degrading, specific ink colors, resulting in a loss or obscuration of data.

A.3.2.2.4 Digital camera electronics

As described in the previous paragraphs, light reflected off a check is optically filtered and focused by a lens on to the photo-sensor. A photo-sensor is an electrical component that converts light energy into electrical charge. The amount of electrical charge produced by the photo-sensor is proportional to the amount of light impacting the sensor. Dark areas of the check reflect little light and therefore generate little charge at the photo-sensor. However, white areas of the check reflect a great deal of light and therefore generate a lot of electrical charge at the photo-sensor.

Since check scanning is performed by imaging vertical slices of the document, most check imaging cameras typically use a line scan array component to convert the light reflected off the check into an electrical signal. The line scan array packages 1024 or 2048 photo-sensors into an electronic chip that becomes the primary sensor array for the image camera. Image camera electronics are required to extract the electrical charge from the sensor array and to control the rate at which vertical scan lines are collected as the check moves past the transport scanning window. As electrical charges are extracted from the sensor array, the charge from each photo-sensor is converted into a voltage that is proportional to the amount of light received. The collection of voltages extracted from the sensor array is commonly referred to as the camera analog video signal.

The camera analog video signal is then converted to a digital video signal by a process called analog-to-digital or A/D (pronounced A-to-D) conversion. During A/D conversion the line scan photo-sensor data is converted into digital pixel values that form a vertical scan line of the check image. The camera A/D converter electronics determines the grayscale resolution, or the number of gray levels allowed between white and black. Grayscale resolution is typically measured in bits-per-pixel (bpp). A 1-bit per pixel grayscale resolution results in a bi-tonal (black and white) image rendition with each pixel being represented by a single binary bit that has a value of 0 (white) or 1 (black). A 6-bit per pixel image supports an image grayscale range of 0-63, or 64 gray levels. Likewise, an 8-bit per pixel image supports an image grayscale range of 0-255, or 256 gray levels.

Check image quality can be impacted if any portion of the camera electronics, such as the line scan photo-sensor, video processing circuitry or A/D converter, experiences a hardware failure. Failure of one or more photo-sites in the sensor array can create black horizontal streaks or bands in the check image. Failure of the sensor array control electronics that dictate the rate at which vertical scan lines are acquired can affect the horizontal resolution (dpi) of the check image. Failure in the photo-sensor video processing electronics that converts the electrical charge to a voltage signal can impact the image quality by increasing the level of noise in the check image. Failure of the A/D converter can cause errors associated with the generation of pixel gray level values, that can effect overall check image brightness and contrast levels.

In summary, the image camera sub-system is responsible for creating a stream of digitized pixel data that forms the check image. Poor design or failure of critical image camera sub-system components (e.g., document illumination, camera optics, or camera electronics) can manifest a number of image defects, any of which are capable of affecting check image quality.

Figure A2 (next page) summarizes the elements of an image capture sub-system.

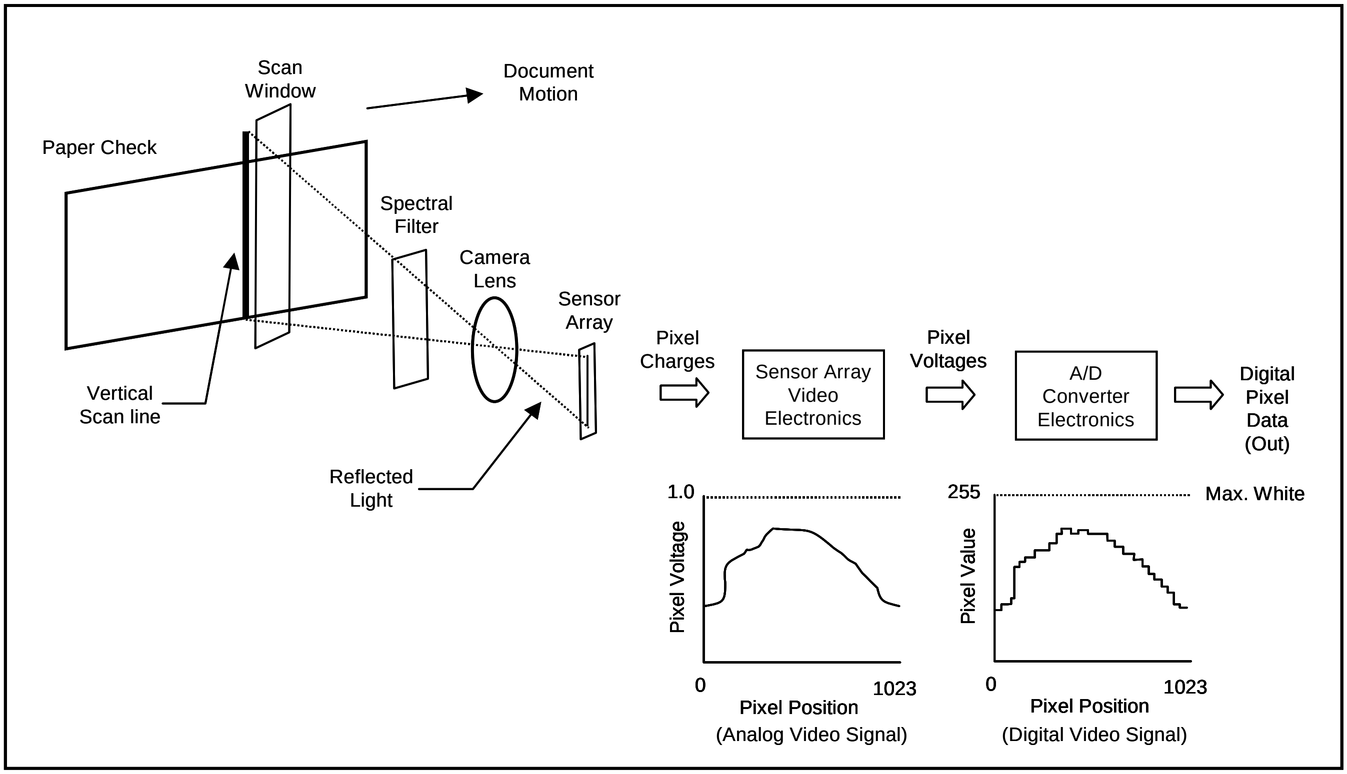

Figure A2—Elements of an image camera subsystem

A.3.2.3 Contact image sensors

All image camera subsystems contain the following primary elements: illumination, lenses, photo-sensor and electronics. Packaging and arrangement of these elements can vary depending on the sensor technology utilized and the design requirements associated with the overall image camera design. One example of a pre-packaged image camera subsystem is the contact image sensor (CIS). Due to their low cost, size and performance characteristics, CIS devices have been used to add image capture functionality to many of the low-speed document transports. CIS devices integrate the primary elements of an image capture subsystem into a single compact electro-optical package. A requirement associated with all CIS devices is that the document being scanned should be in direct contact with the CIS scan window in order to avoid blurred images.

A.3.2.4 Monochrome vs. color image capture

The simplest digital images are black and white. In these images there is one bit of information for each pixel. Black and white images are adequate for many document processing applications.

More information can be conveyed in a gray level image. Gray level images typically use one of 256 levels to describe the image intensity at each pixel. These gray level images require one byte of information for each pixel.

The data to describe a color image can be arranged in several ways. One way is to have three color planes, each like a gray image for a particular color. The color planes typically used are red, green and blue (RGB). Each color plane consists of one byte per pixel representing the intensity (256 levels) of the color in question (red, green or blue) at a particular point in the image. In this arrangement each pixel in the image has three byte sized numbers (a total of 24 bits) associated with it, representing the intensities of red, green and blue.

Another useful scheme for storing color image information is a method based on luminance and chrominance. In this scheme the luminance component, usually one byte, represents the intensity or brightness of the image at a particular pixel. The chrominance is a two dimensional quantity (one byte each for hue and saturation) that describes the color information for a pixel. This method is useful because the luminance part of the image data is in fact a gray level image and so can be easily used alone when a gray level image is required.

A.3.3 Digital image preprocessing

A.3.3.1 General

The second major functional element in any image capture subsystem is the image preprocessing. The goal of image preprocessing is to modify, filter and/or enhance the original gray level or color image (e.g., original pixel values) generated by the image camera subsystem. Modification of the original digital image pixel values is accomplished by applying a variety of computational and predictive algorithms to the individual pixel values that form the check image. Modification of the digital pixel values results in a modified check image. In general, multiple image preprocessing operations are applied to the original or raw check image, with each image preprocessing operation performing one or more specific functions. Image preprocessing computations are typically performed during check image capture either by dedicated image preprocessing electronics or image preprocessing software that is executing on one or more PCs. Figure A3 illustrates the conceptual model for image preprocessing.

Since digital image preprocessing involves changing the original source document image pixel values, it is clear that image preprocessing operations can introduce artifacts, distortions or degradations into the document image. Typical examples of image preprocessing operations applied to check images today include the following:

a) Image normalization;

b) Image framing;

c) Image contrast enhancement;

d) Image binarization;

e) Image filtering;

f) Image scaling;

g) Image transposition.

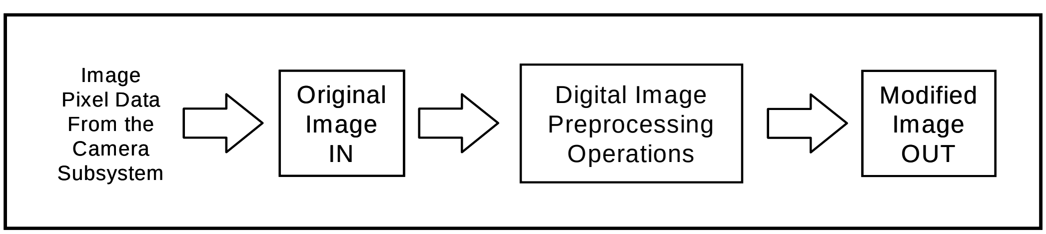

Figure A3 — Digital image preprocessing reference model

A.3.3.2 Image normalization

Image normalization preprocessing is generally the first image processing operation applied to the source document image generated by the camera subsystem. The goal of image normalization is to correct the original source document image for known defects typically introduced by the document illumination system and design limitations associated with the camera electronics. Normalization processing utilizes data collected during a camera calibration procedure to compute a pixel gray level (or color) correction factor for each photo-site in the sensor array. As pixel scan line data is generated and collected from the camera subsystem, separate correction factors are applied to each pixel value of the scan line.

The goal of normalization processing is to insure that the camera subsystem is generating identical pixel values (i.e., uniformly shaded pixels) over the entire scan line (e.g., 1024 pixels) when the camera is imaging a uniformly shaded target or document. Therefore, normalization processing attempts to remove variations in the image due to non-uniform document illumination, variation in lighting due to aging of the light source and variation in photo sensor sensitivity.

Normalization can impact check image quality if the camera calibration procedure is performed using a dirty reference document or target, which then yields erroneous correction factors for one or more pixels in the scan line. Failure of the normalization processing electronics can also cause computational errors. Image quality defects due to computational errors in normalization processing typically manifest themselves as one or more horizontal streaks in the check image, or images that are too dark or too light.

A.3.3.3 Image framing

Image framing is the process of extracting only the relevant check image data from the image collected by the camera subsystem. Since checks have varying document heights, the camera subsystem is normally designed to scan a height that exceeds the height of the maximum size document. In most check imaging systems the scan height (also referred to as the camera's FOV) is between 4.0 and 5.0 inches to accommodate business checks that may contain a correction strip or checks in carrier envelopes. Therefore, the scan line data generated by the camera subsystem generally contains over-scan pixels. The over-scan pixels contain an image of the transport track wall that extends above the check. To insure that the entire length of the check is imaged, the camera subsystem normally begins collecting scan line data prior to the leading edge of the check being positioned in the scan window (pre-scan data). Collection of image scan lines continues for a short time after the trailing edge of the check passes the scan window (post-scan data) to insure that the entire length of the check was imaged.

Image framing is typically accomplished by examining the pixel data in the original image in order to locate the position of the check image. Once the check image is located, coordinates of the circumscribing rectangle containing only the check image are then computed. The portion of the original image containing the over-scan, pre-scan, and post-scan pixel data is then discarded from the original image.

Any error in computing the boundaries of the actual check image pixel data can lead to missing information or the retention of extraneous image data (i.e., over-scan data) in the final check image. Common causes of image framing errors include: dark borders on the perimeter of checks, excessive document skew, and folds/tears that may be present on the original document.

A.3.3.4 Image contrast enhancement

Check images are represented as a two-dimensional array (or mosaic) of pixel values. The actual physical size of the sub-area, represented by a single pixel in the image, is referred to as the image resolution and is expressed in pixels or dots per inch (dpi). The digital value of each pixel conveys the brightness associated with a small sub-area of the original paper check. Altering the digital pixel values in an image will directly affect the brightness and contrast of the check image.

By using a variety of automated image analysis and mathematical techniques, pixel values in the image can be modified to provide an altered image rendition that exhibits increased readability. By modifying the overall image brightness and contrast, written and printed information can often be visually separated from the check's patterned or scenic background.

Although the goal of image contrast enhancement is to improve overall check image legibility, automated image enhancement processing techniques can sometimes lead to image degradation. In these situations modification of the image pixel data can negatively impact the resultant check image quality.

A.3.3.5 Image binarization

A special case of image contrast enhancement is image binarization. The goal of image binarization is to convert the original multi-gray level or color image into a black and white, or bi-tonal, image rendition. The conversion of an image from grayscale to black and white is accomplished by comparing the gray level of each pixel located in the image to a threshold value. The threshold value is actually a digital value that is selected somewhere between the white and black range. Pixels whose gray level values are darker than the threshold value are turned to black, while pixels with gray level values that are lighter than the threshold are turned to white.

A common example of image binarization occurs when using an office copying machine. Black and white copies of a document are created regardless of the gray level or color content of the original document. The colors or gray shades retained in the copy are controlled by adjusting the dark setting on the copying machine. In this example the dark setting is the image threshold for the document being scanned and copied. Since only one dark setting can be selected for the entire document, this type of binarization is referred to as a fixed image threshold.

Black and white check images are generated by applying an image binarization process to the grayscale (or color) check image. Recognizing that checks have background patterns and scenes that vary between and within documents, the use of a fixed threshold often produces black and white check images with missing or obscured data fields over large areas of the check image. To avoid this problem, many check image binarization implementations utilize an adaptive threshold. Adaptive thresholding is a process whereby a separate threshold is computed for every pixel in the check image. Determining the value for the adaptive threshold is accomplished by comparing the gray level of the pixel to be thresholded with the gray level values of neighboring pixels. A pixel that has about the same gray level as its neighboring pixels is normally judged to be part of the check background and is thresholded to white. Pixels whose gray level value is significantly darker than the gray level of neighboring pixels are judged to be writing or printing and are thresholded to black. By adaptively adjusting the threshold in the image pixel-by-pixel, patterned and scenic check backgrounds can be effectively eliminated, while retaining the preprinted and written information. Although most adaptive thresholding techniques are effective, they are not perfect. Therefore, using an improper adaptive threshold can lead to eliminating or obscuring data in the black and white image. For black and white image renditions, this is the primary cause for loss of image quality and legibility.

Improper binarization manifests itself as a variety of image defects; however, the two most common image quality problems are either the retention of background scenes and patterns (that appear as spot noise or black blobs) or the elimination of low contrast printing or writing. Both can result in the loss of data by causing written or printed characters to disappear or to become filled in, obscured, or fragmented.

Image binarization is an irreversible process. Once an image has been converted from grayscale to black and white, it is not possible to recreate the original grayscale image from the resultant black and white image.

A.3.3.6 Image filtering

Recognizing that a digital image is nothing more than a two-dimensional array of numbers, various two-dimensional digital signal processing techniques can be applied to the check image data. Signal processing filters can perform a number of image modifications and/or enhancements. Examples include image smoothing and edge enhancement filters, as well as a variety of image spot noise removal filters.

Image smoothing and edge enhancement filters can be applied to gray level (or color) images to increase the gray level uniformity of the check background while sharpening the edges of character strokes associated with printed and/or written information. The result is an enhanced gray level image with improved legibility. In a similar manner, noise removal filters can be applied to black and white images to eliminate spot noise that may remain in the image after performing image threshold processing. Spot noise filters attempt to identify and remove isolated groups of black pixels that are not part of character strokes. Eliminating spot noise in black and white images can improve the overall appearance of the black and white check image and its perceived quality.

A.3.3.7 Image scaling

Image scaling operations can be performed to reduce (or increase) the effective spatial resolution (i.e., dpi) of the check image. Image down-scaling can be used to create a re-sized version of the check image that may be more suitable for image display/print applications or to reduce the physical storage requirements associated with the original image file. When viewed by a human being, spatial resolution (dots-per-inch) and gray level resolution (bits-per-pixel) can often be traded off. Images that contain 256 or more gray levels can be presented for human viewing at a lower spatial resolution without seriously impacting check image quality and legibility. In comparison, presentation of black and white images for human recognition generally requires a higher spatial resolution.

Image scaling (up or down) can be accomplished by using a variety of mathematical techniques. The quality of the up-scaled or down-scaled image is usually directly proportional to the computational complexity of the image scaling algorithm employed.

Up-scaling an image involves creating pixels and scan line data that are not present in the original image. A computationally efficient method of up-scaling an image is pixel replication. During pixel replication, the image pixels and scan lines being created are generated by copying the values of adjacent pixels or scan lines. Down-scaling an image involves reducing the number of pixels and scan lines from the original image. A computationally efficient method of down-scaling an image is pixel decimation. During pixel decimation, image pixels and scan lines are periodically removed from the original image. Although pixel replication and decimation algorithms are computationally fast, the scaled-up or scaled-down image will typically exhibit some visual artifacts and therefore degraded image quality.

In order to eliminate the visual artifacts induced by pixel replication and decimation, image scaling generally uses data interpolation. Data interpolation involves computing a weighted average of neighboring pixel values to create a pixel in an up-scaled image or eliminate a pixel in a down-scaled image. Interpolation techniques that attempt to create or eliminate pixels using a linear model and adjacent pixels are commonly referred to as bi-linear interpolation methods. Bi-linear interpolators minimize the introduction of visual artifacts into the up- or down-scaled image, while minimizing the computational complexity associated with the scaling process.

Since image scaling is either creating or removing pixel and scan line data from the original image, image scaling processes have the potential to impact check image quality and legibility. Image down-scaling results in a loss of spatial resolution and introduces a slight image blur, both of which can negatively impact the legibility of small character fonts and certain features in the check image. Excessive image up-scaling can lead to the magnification of defects that are present in the original source document image, since image up-scaling is equivalent to an image zooming process.

A.3.3.8 Image transposition

As most image camera systems generate check images by collecting vertical scan lines from the camera subsystem, the pixel and scan line sequence obtained during the image capture process may not be suitable for software imaging applications that involve image display and print operations. Therefore, the check image may need to undergo image transposition processing, whereby the vertical scan line capture format is converted into a rasterized image format. A rasterized image format is one where the image pixel data is presented as a collection of horizontal scan lines, typically progressing sequentially from the top of the document to the bottom. The pixel data contained in each scan line is presented as a pixel sequence that progresses horizontally from left to right across the document image. This rasterized image format is generally preferred.

A.3.3.9 Summary of implications of preprocessing on image quality

In summary, any image preprocessing operation performed on the check image pixel data has the potential to impact the quality and legibility of the resultant check image. In general, most image preprocessing techniques used in today's check processing systems have undergone extensive testing to insure that the image processing techniques employed are robust and result in a check image exhibiting a high degree of quality and legibility.

A.3.4 Digital image compression

As a digital check image is a two-dimensional array of pixels, it is easy to compute the number of pixels in a typical check image. Because personal checks are 2.75 by 6.0 inches and most business checks are 3.25 inches by 8.50 inches, the area of these checks in square inches is 16.50 and 27.63 respectively. Scanning these checks at a resolution of 200 dpi (vertically and horizontally) yields 660,000 pixels for the personal check image and 1,105,000 pixels for the average business check image. If a 256 gray level image is being retained, one byte per pixel will be required to store the gray level value associated with each pixel, yielding a raw check image file size of 660 KB or 1105 KB respectively. Binarizing the 256 gray level image renditions to a black and white rendition, requiring only one binary bit per pixel, still presents image file sizes that are approximately 83 KB and 138 KB respectively. Given the large amount of data associated with digital images, data compression techniques are typically employed to reduce the storage and transmission bandwidths.

In general there are two major classes of data compression techniques, lossless and lossy. Lossless data compression uses mathematical algorithms that attempt to identify and eliminate redundant information that may be present in a collection of data or signals. Lossless data compression methods are designated lossless since the compression process is completely reversible.

In contrast, lossy data compression uses mathematical algorithms and transformations that attempt to trade off data compression and data distortion. Lossy data compression methods are designated lossy since the compression process introduces some level of distortion artifacts into the original data. Types of distortion artifacts depend on the data compression technique. The magnitude of the distortion artifacts is directly proportional to the degree of data compression. Images that have been compressed using a lossy data compression algorithm do not present the complete and full original document image to the viewer after the image is decompressed.

A number of lossless and lossy data compression algorithms have been designed to compress image data. Most image compression techniques are based on international standards. Some of the more widely used international image compression standards are listed below:

— CCITT T.4

— CCITT T.6

— Joint Photographic Experts Group (JPEG)

— Joint Bi-level Image experts Group (JBIG)

— JPEG 2000

Additional industry developed and adopted image compression techniques include:

— Arithmetic Binary Image Compression (ABIC, from IBM)

— Lempel Ziv Welch (LZW, from Unisys)

— Portable Network Graphics (PNG)

It should be noted that the JPEG image compression standard defines a variety of lossy and lossless image compression techniques that support both gray level and color imagery. The most commonly adopted form of JPEG compression is the JPEG Baseline. JPEG Baseline is a lossy image compression technique that can compress both color and gray level imagery. It is the JPEG Baseline technique that has been widely adopted in consumer camera products as well as check imaging platforms. The degree of compression achieved using JPEG baseline is controlled by modifying a set of parameters (Quantization Matrices, or the Q-factor) associated with the JPEG algorithm.

Lossless image compression techniques (e.g., CCITT T.4 and T.6, ABIC, LZW, JBIG, PNG, etc.) are normally used when the number of gray levels in the image is low (four gray levels or less). Lossy image compression techniques (e.g., JPEG, JPEG2000, etc.) are normally used to compress full gray level and/or color imagery. In general, lossless image compression algorithms lose their compression effectiveness when applied to images containing a high number of gray levels. Likewise, lossy image compression algorithms are not effective in compressing black and white images. Therefore, the data compression technique selected is highly dependent upon the image rendition to be compressed.

Since the CCITT compression algorithms are lossless, the image compression process itself does not directly impact check image quality. However, in order to utilize the CCITT compression algorithm, a black and white image rendition is required. Therefore, the impact to check image quality occurs during image binarization, where background patterns or scenes located on the original paper check are eliminated, and replaced with a white background.

Applying lossy data compression algorithms (e.g., JPEG) to check images can also potentially impact check image quality and legibility. As discussed previously, lossy image compression algorithms achieve compression by introducing some amount of distortion into the original image. The rate of distortion is proportional to the rate of compression desired. An image with a high degree of compression will exhibit increased image distortion compared to an image compressed a lesser amount. Therefore the application of lossy image compression algorithms to check images requires that a suitable operating point be established to insure that the amount of distortion does not negatively impact check image legibility and usability.

In general, check images with a spatial resolution of 100 dpi that are compressed using the JPEG standard result in files around 15-20 KB for personal checks and 20-30 KB for business checks. This compression rate provides image quality and legibility suitable for most check image applications. If the resolution of the gray level or color image is increased above 100 dpi, the amount of data compression delivered by the JPEG algorithm will need to be reduced (i.e., yielding a larger image file size) in order to maintain the equivalent image quality (i.e., rate of distortion).

Although lossy algorithms such as JPEG introduce distortions into the original pixel data during the compression process, distortions are generally quite small. In reality, JPEG compressed check images can be generated that appear visually lossless compared to the original uncompressed check image, while still delivering compression ratios (reduction in data) in the 5-to-1 range. Only when JPEG compression ratios are extreme (>20:1) does the distortion in the check image begin to impact quality and legibility. As a reference point, the majority of consumer digital cameras employ JPEG compression in order to reduce photo storage requirements without introducing noticeable amounts of image distortion.

A.3.5 Image system software

A.3.5.1 General

Control of the image capture electronics is accomplished by providing image system software that normally runs on a PC or server attached to the image capture hardware. Besides providing a control interface to the image capture electronics, the image system software also provides a software interface to the check imaging application software. Therefore, the image system software acts as the conduit between the image capture system and the back-end check image application software.

Operations and functions normally handled by the image system software include the following:

a) Run-time control of the image capture electronics;

b) Image data acquisition;

c) Image file creation;

d) Temporary image storage;

e) Image configuration utilities;

f) Image quality assurance.

A.3.5.2 Run-time control

At run-time, the image system software is responsible for extracting and receiving compressed image data from the image capture electronics. The compressed image data is temporarily cached in the PC memory and then written into an image file along with a set of parameters that describe attributes of the check image (e.g., scanning resolution, pixels per scan line, scan lines per image, compression technique, etc.). The layout and format of the check image file is handled by the image system software. The resultant check image file is then temporarily stored where it can be accessed by one or more of the back-end check image applications. In addition, check image files are normally available for viewing by image utility software provided with the image system software.

A.3.5.3 Image data acquisition

The run-time functionality embedded in the image system software can vary depending on the architecture of the check imaging platform. In a low-speed (<200 dpm) check processing environment, the image system software might be responsible for performing all or some of the image preprocessing and image compression algorithms, after extracting the raw image data from the image camera subsystem. In a medium-to-high speed (>200 dpm) check processing environment, the image system software might only be responsible for acquiring the compressed image data from the image capture electronics and creating the temporary check image files.

A.3.5.4 Image file creation

One of the primary functions of the image system software is to create check image files that can be used by various document imaging software applications. A check image file basically contains two blocks of data: a set of data parameters, and the compressed image data itself. The encapsulation and data structure of the image data parameters and the compressed image data is commonly referred to as the image file format.

A number of image file formats have been defined by the industry for use with various image software applications. Some image file formats use a predefined image compression algorithm to limit the size of the image file. As an example, the graphic interchange format (GIF) was defined to support the display of web photos and graphics and uses a compression algorithm known as Lempel Ziv Welch (LZW). The Image Object Content Architecture (IOCA) file format was developed by IBM to support a variety of image and compression types. IOCA uses a fixed field record structure to carry attributes and information associated with the document image. The JPEG interchange format (JPG) supports color photographs using the JPEG compression algorithm. The Tag Image File Format (TIFF) has the flexibility to store either black and white, gray level or color images using a variety of compression algorithms (e.g., CCITT, JPEG, LZW, etc.). A feature of the TIFF image file format is the large set of predefined image parameters (referred to as tags) that are useful in supporting imaging applications. In addition to the predefined image tags, the TIFF format has provisions for assigning private image tags to carry user-defined data.

Designation of the image file format is denoted by appending the proper three character extension on to the image filename. The filename extensions, .GIF, .JPG, and .TIF, are used respectively to denote either the graphic interchange format, JPEG interchange format, or Tag image file format. Due to TIFF's robust set of predefined image parameters, flexible data structure layout, and support for multiple image compression algorithms, many check image capture systems and check image applications have adopted the TIFF image file format.

A.3.5.5 Temporary image storage

Check image files are temporarily stored on a hard disk system where they are available to check image processing software applications (e.g., proof of deposit, image archive, image exchange, etc.). After the check images have been extracted or used by the image application software, check image files are normally deleted from the temporary disk storage system.

A.3.5.6 Image configuration utilities

In addition to controlling the image capture electronics at run-time, the image system software may also provide image configuration utility software to manage the image capture hardware when off-line. Image utilities would include such functions as:

a) Image camera calibration;

b) Check image viewing software;

c) Image hardware diagnostics.

A.3.5.7 Image Quality Assurance

Finally, image system software can provide IQA functionality. Automated analysis of the check image pixel data can detect a number of check image defects. Analysis of the image data can either be performed by the image capture electronics or the image system software. Regardless of where the assessment computations are performed, image system software stores assessment results. These results are then made available to the check image application software.

As the image system software is responsible for controlling the image electronics, receiving the check image data from the camera electronics, handling the image parameters, formatting the image file and transfer of the image file to disk storage, one or more design defects in the image system software can precipitate image quality problems. Image quality problems often attributed to design problems include the following:

a) Missing or lost check images;

b) Improper camera calibration;

c) Mismatch of front and rear images of the check;

d) Mismatch of the check's MICR code line data with the check image;

e) Image file format errors;

f) Image file data corruption.

A.4 Post image capture processes

A.4.1 General

After the initial image capture and processing further procedures may be performed, such as:

a) Image display;

b) Image printing;

c) Trans-coding the data;

d) Image security features;

e) Other post-capture image manipulation.

A.4.2 Image display

Factors that may affect the apparent quality of a displayed image include screen resolution, image size and pixel manipulations. The resolution of many display screens is lower than that of the image capture device, and/or the viewing window size determined by the application may be smaller than the captured image size. These factors often make it necessary to reduce the resolution of the captured image by removing pixels. A common technique employed to reduce the resolution of an image is "scale to gray", whereby information from several adjacent pixels are mapped into a single grayscale pixel.

A.4.3 Image printing

Similar to displays, resolution-related factors may affect the apparent quality of a printed image. Printers typically have a higher resolution than the captured image resolution. The size of each pixel in the printer is typically significantly smaller (3x – 12x) than the size of each pixel in the captured image. For example, an image captured at 200dpi and printed at 600dpi would appear one third the size of the original item. To prevent this shrinkage it is necessary to increase the resolution of the captured image by adding pixel data to match the resolution of the printer. In the case of grayscale images, a translation must occur in order to print them in black and white. A common technique is "half-toning" whereby a single gray pixel is printed as multiple adjacent black and white pixels.

A.4.4 Trans-coding the data

A.4.4.1 General

The implications of trans-coding vary depending on the specific process. Trans-coding functions include:

a) wrapper (file format) changes;

b) color or grayscale to black and white conversion;

c) compression algorithm changes.

While trans-coding from any source format to any destination format may be technically possible, careful consideration of the resultant image quality should be made before performing the trans-code process. The following Clauses discuss some of the more common trans-code processes.

A.4.4.2 Wrapper (file format) changes

Image files generally consist of a wrapper (or header) and the image data. The wrapper contains information about the characteristics of the image data such as: size, resolution, compression algorithms, and orientation.

Examples of wrapper changes are:

TIFF to IOCA,

JPEG to TIFF.

Trans-coding algorithms that alter only the wrapper portion of the image file will not alter image usability, but they may affect file characteristics if not performed accurately.

A.4.4.3 Color or grayscale to black and white conversion

Although trans-coding of previously binarized and compressed color or grayscale images to black and white images is technically possible, the image quality of the resultant black and white image may be negatively impacted by trans-coding.

In order to reduce storage requirements, color and grayscale images are commonly compressed using lossy compression algorithms and typically have a resolution of 120dpi or less. On the other hand, black and white images typically utilize lossless compression algorithms and maintain a resolution of 200 or 240dpi. The compression losses and reduced resolution of color or grayscale images are compensated by the larger palette size not present with a black and white image. The compression loss and resolution reduction of the color or grayscale images cannot be precisely reversed by trans-coding. The resultant black and white image will inherit those traits with the disadvantage of a reduced black and white palette, thus potentially rendering an image of lesser quality than the source color or grayscale image.

It is not possible to trans-code a black and white image to either a color or a grayscale image.

A.4.4.4 Compression algorithm changes

Image compression routines can be either lossless or lossy (see clause A.3.4 Digital image compression). In order to evaluate the impact a particular compression algorithm will have on image quality, the source and destination compression algorithms must be determined.

In today’s operating environment, the most likely combinations are as follows:

Table A1 — Conversion risks

Conversion Method		Risk of Conversion
From	To	
Lossless (e.g., CCITT G4)	Lossless (e.g., ABIC)	None
Lossy (e.g., JPEG)	Lossless (e.g., CCITT G4)	Some
Lossless (e.g., ABIC)	Lossy (e.g., JPEG)	Some
Lossy (e.g., JPEG)	Lossy (e.g., Q factor changes)	Could be significant

The image data contains the actual compressed or uncompressed digital representation of the captured image. Trans-coding algorithms that alter image data may introduce distortions in addition to distortions present in the original image and inherited by the trans-coded image.

A.4.5 Image security features

Two fundamental forms of security may be applied to the image and its associated data: the image may be protected against unauthorized creation and changes; and the image may be protected against unauthorized viewing. In either case, image quality is not compromised.

To protect against unauthorized creation and changes, digital signatures utilizing public key infrastructure (PKI) may be used. The authorized creator of the image calculates the digital signature for the image data using a private key known only to the creator and supplies this digital signature with the image data. A matching public key can be issued to and used by all parties receiving that image data to validate the digital signature against the data and confirm the source and integrity of the image data.

To protect against unauthorized image viewing, the image data can be encrypted by the creator of the image, the decryption keys are then only made available to parties authorized to view that image.

A.4.6 Other post capture image manipulation

A.4.6.1 General

In addition to processes described above, numerous types of image manipulation may be performed on the image data such as:

a) Defect removal

b) Scaling

c) Image enhancement.

In many cases these processes modify the source image data and can impact the image quality. Security features that may have been added to the original image should be reviewed since they may no longer be valid for the manipulated image. Consideration should be given to maintaining the original image data in addition to the manipulated image data.

A.4.6.2 Defect removal

Many defects (e.g., skew and streaks) can be successfully removed by image manipulation. However, good image data may be unintentionally modified or removed along with the defect and subsequently lower the image quality of the manipulated image.

A.4.6.3 Scaling

Scaling typically refers to a reduction in image resolution (i.e., 200dpi to 100dpi). This is usually performed to reduce the image size for long term archiving. The resultant lower resolution image may be of sufficient quality for the archive business purposes such as image statement printing or web page viewing. However, it may not be of suitable quality for operations that typically require a higher resolution image such as OCR recognition, IRD printing and automated signature verification.

A.4.6.4 Image enhancement

Image enhancement procedures are typically performed to make specific fields of interest clearer for a particular purpose. For example, the signature field could be enhanced through the removal of background noise to make signature verification easier. This process could, however, remove background security features that would render the image unsuitable for other purposes.