Network Working Group
Request for Comments: 3949
Obsoletes: 2301
Category: Standards Track

R. Buckley
D. Venable
Xerox Corporation
L. McIntyre
Consultant
G. Parsons
Nortel Networks
J. Rafferty
Brooktrout

February 2005

File Format for Internet Fax

Status of this Memo

Copyright Notice

Abstract

This document is a revised version of RFC 2301. The revisions, summarized in the list attached as Annex B, are based on discussions and suggestions for improvements that have been made since RFC 2301 was issued in March 1998, and on the results of independent implementations and interoperability testing.

This RFC 2301 revision describes the Tag Image File Format (TIFF) representation of image data specified by the International Telecommunication Union (ITU-T) Recommendations for black-and-white and color facsimile. This file format specification is commonly known as TIFF for Fax eXtended (TIFF-FX). It formally defines minimal, extended, and lossless Joint Bi-level Image experts Group (JBIG) profiles (Profiles S, F, J) for black-and-white fax and base JPEG, lossless JBIG, and Mixed Raster Content profiles (Profiles C, L, M) for color and grayscale fax. These profiles correspond to the content of the applicable ITU-T Recommendations.

Table of Contents

1. Introduction

This document describes the use of TIFF (Tag Image File Format) to represent the data content and structure generated by the current suite of ITU-T Recommendations for Group 3 facsimile. These recommendations and the TIFF fields described here support the following facsimile profiles:

S: Minimal black-and-white profile, using binary MH compression [T.4]
F: Extended black-and-white profile, using binary MH, MR, and MMR compression [T.4, T.6]
J: Lossless JBIG black-and-white profile, with JBIG compression [T.85, T.82]
C: Lossy color and grayscale profile, using JPEG compression [T.42, T.81]
L: Lossless color and grayscale profile, using JBIG compression [T.43, T.82]
M: Mixed raster content profile [T.44], using a combination of existing compression methods

Each profile corresponds to the content of ITU-T Recommendations shown and is a subset of the full TIFF for facsimile specification.

Profile S describes a minimal interchange set of fields, which will guarantee that, at least, binary black-and-white images will be supported. Implementations are required to support this minimal interchange set of fields.

With the intent of specifying a file format for Internet fax, this document

1. specifies the structure of TIFF files for facsimile data,
2. defines ITU fax-compatible values for existing TIFF fields, and
3. defines new TIFF fields and values required for compatibility with ITU color fax.

This specification of TIFF for facsimile is known as TIFF-FX (TIFF for Fax eXtended). References to the format described by this specification should always use the term "TIFF-FX", and some profiles in this specification may not be interpreted correctly by other TIFF applications.

1.1. Scope

This document defines a TIFF-based file format specification for enabling standardized messaging-based fax over the Internet. It specifies the TIFF fields and field values required for compatibility with the existing ITU-T Recommendations for Group 3 black-and-white, grayscale, and color facsimile. TIFF has historically been used for handling fax image files in applications such as store-and-forward messaging. Implementations that support this file format specification for import/export may elect to support it as a native format. This document recommends a TIFF file structure compatible with low-memory and page-level streaming implementations.

Unless otherwise noted, the current TIFF specification [TIFF] and selected TIFF Technical Notes [TTN1, TTN2] are the primary references for describing TIFF and defining TIFF fields. This document is the primary reference for defining TIFF field values for fax applications.

1.2. Approach

The basic approach to using TIFF for facsimile data is to insert the compressed fax image data into a TIFF file and use TIFF fields to encode the parameters that describe the image data. These fields will have values that comply with the ITU-T Recommendations.

This approach takes advantage of TIFF features and structures that bridge the data formats and performance requirements of both legacy fax machines and host-based fax applications. TIFF constructs for pages, images, and strips allow a TIFF file to preserve the fax data stream structure and the performance advantages that come with it. A TIFF-based approach also builds on an established base of users and implementors and ensures backward compatibility with existing TIFF-based IETF proposals and work in progress for Internet fax.

1.3. Overview of this Document

Section 2 gives an overview of TIFF. Section 2.1 describes the structure of TIFF files, including general guidelines for structuring multi-page TIFF files. Section 2.2 lists the TIFF fields that are required or recommended for all fax profiles. The TIFF fields used

only by specific fax profiles are described in Sections 3 - 8, which describe the individual fax profiles. These sections also specify the ITU-compatible field values (image parameters) for each profile.

The full set of permitted fields of TIFF for facsimile are included in the current TIFF specification, Section 2 of this document, and the sections on specific profiles of facsimile operation. This document defines profiles of TIFF for facsimile, where a profile is a subset of the full set of permitted fields and field values of TIFF for facsimile.

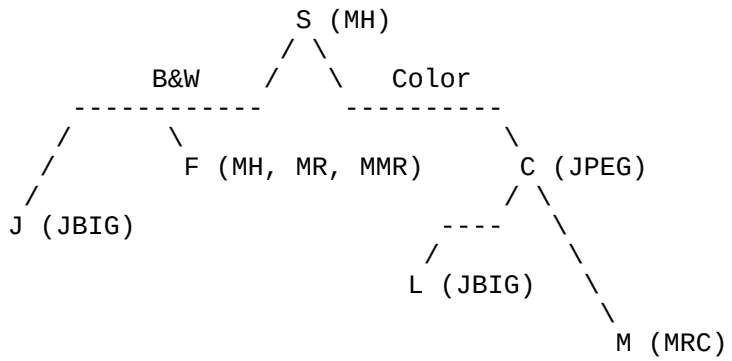
Section 3 defines the minimal black-and-white facsimile profile (Profile S), which is required in all implementations. Section 4 defines the extended black-and-white fax profile (Profile F), which provides a standard definition of TIFF-F. Section 5 describes the lossless black-and-white profile using JBIG compression (Profile J).

Section 6 defines the base color profile, required in all color implementations, for the lossy JPEG representation of color and grayscale facsimile data (Profile C). Section 7 defines the lossless JBIG color and grayscale facsimile profile (Profile L), and Section 8 defines the Mixed Raster Content facsimile profile (Profile M). Each of these sections concludes with a table summarizing the required and recommended fields for each profile and the values they can have.

Section 9 refers to the MIME content types used in connection with TIFF for facsimile. Sections 10 and 11 give Security Considerations and References, followed by Authors' Addresses and the Copyright Notice. Annex A gives a summary of the TIFF fields used or defined in this document and provides a convenient reference for implementors.

To implement only the minimal interchange black-and-white set of fields and values (Profile S), one need read only Sections 1, 2, 3, 9, and 10.

The following tree diagram shows the relationship among profiles and between profiles and coding methods.



A profile is based on a collection of ITU-T facsimile coding methods. For example, Profile S, the minimal profile, is based on Modified Huffman (MH) compression, which is defined in ITU-T Rec. T.4. Profile F specifies Modified Huffman (MH), Modified READ (MR), and Modified Modified READ (MMR) compressions, which are defined in ITU-T Rec. T.4 and T.6.

All implementations of TIFF for facsimile MUST implement Profile S, which is the root node of the tree. All color implementations of TIFF for facsimile MUST implement Profile C. The implementation of a particular profile MUST also implement those profiles on the path that connect it to the root node, and MAY optionally implement profiles not on the path connecting it to the root node. For example, an implementation of Profile M must also implement Profiles C and S and may optionally implement Profile F, J, or L. For another example, an implementation of Profile C must also implement Profile S and may optionally implement Profile F or J.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", " NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [REQ].

2. TIFF and Fax

2.1. TIFF Overview

TIFF provides a means for describing, storing, and interchanging raster image data. A primary goal of TIFF is to provide a rich environment within which applications can exchange image data. The current TIFF specification [TIFF] defines a commonly used core set of TIFF fields known as Baseline TIFF. The current specification, the set of Pagemaker TIFF Technical Notes [TTN1], and TIFF Technical Note 2 [TTN2] define several TIFF extensions. The TIFF-based specification for fax applications uses a subset of Baseline TIFF

fields, with selected extensions, as described in this document. In a few cases, this document defines new TIFF fields specifically for fax applications.

2.1.1. File Structure

TIFF is designed for raster images, which makes it a good match for facsimile documents, which are multi-page raster images. Each raster image consists of a number of rows or scanlines, each of which has the same number of pixels, the unit of sampling. Each pixel has at least one sample or component (exactly one for black-and-white images).

A TIFF file begins with an 8-byte image file header. The first two bytes describe the byte order used within the file. Legal values are "II" (0x4949) when bytes are ordered from least to most significant (little-endian), and "MM" (0x4D4D), when bytes are ordered from most to least significant (big-endian) within a 16- or 32-bit integer. Either byte order can be used, except in the case of the minimal black-and-white profile, which SHALL use value "II". The next two bytes contain the value 42, which identifies the file as a TIFF file and is ordered according to the value in the first two bytes of the header. The last four bytes give the offset that points to the first image file directory (IFD). This and all other offsets in a TIFF file are with respect to the beginning of the TIFF file. An IFD can be at any location in the file after the header but must begin on a word boundary.

An IFD is a sequence of tagged fields, sorted in ascending order by tag value. An IFD consists of a 2-byte count of the number of fields, a sequence of field entries, and a 4-byte offset to the next IFD. The fields contain information about the image and pointers to the image data. Each separate raster image in the file is represented by an IFD.

Each field entry in an IFD has 12 bytes and consists of a 2-byte Tag, 2 bytes identifying the field type (e.g., short, long, rational, ASCII), 4 bytes giving the count (number of values or offsets), and 4 bytes containing either the offset to a field value stored outside the IFD or, based on the type and count, the field value itself. Resolution and metadata such as dates, names, and descriptions are examples of "long" field values that do not fit in 4 bytes and therefore use offsets in the field entry. Details are given in the TIFF specification [TIFF].

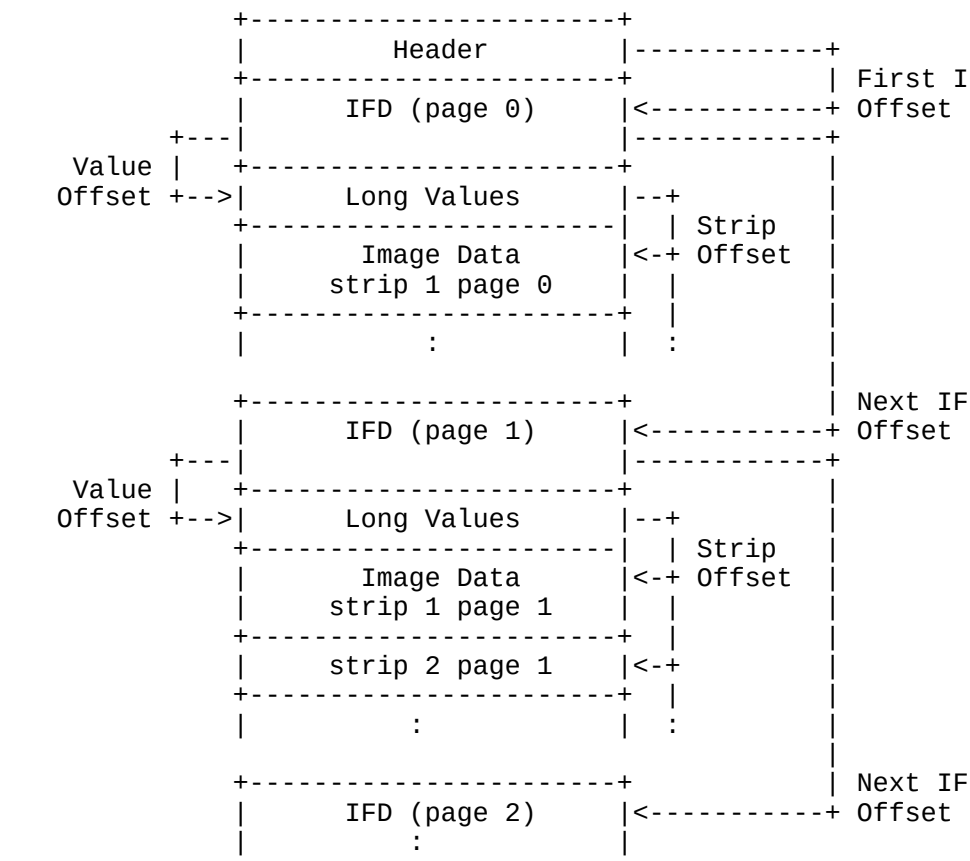
A TIFF file can contain more than one IFD, where each IFD is a subfile whose type is given in the NewSubfileType field. Multiple IFDs can be organized either as a linked list, with the last entry in

each IFD pointing to the next IFD (the pointer in the last IFD is 0), or as a tree, using the SubIFDs field in the primary IFD [TTN1]. The SubIFDs field contains an array of pointers to child IFDs of the primary IFD.

Child IFDs describe related images, such as reduced resolution versions of the primary IFD image. The same IFD can point both to a next IFD and to child IFDs, and child IFDs can themselves point to other IFDs.

All fax profiles represent a multi-page fax image as a linked list of IFDs, with a NewSubfileType field containing a bit that identifies the IFD as one page of a multi-page document. Each IFD has a PageNumber field, identifying the page number in ascending order, starting at 0 for the first page. Although a Baseline TIFF reader is not required to read any IFDs beyond the first, an implementation that reads the files that comply with this specification SHALL read multiple IFDs. Only the Mixed Raster Content fax profile, described in Section 8, requires the use of child IFDs.

The following figure illustrates the structure of a multi-page TIFF file.



2.1.2. Image Structure

An IFD stores an image as one or more strips, as shown in the preceding figure. A strip consists of 1 or more scanlines (rows) of raster image data in compressed form. An image may be stored in a single strip or may be divided into several strips, which would require less memory to buffer. (Baseline TIFF recommends about 8k bytes per strip, but existing fax usage is typically one strip per image.)

Each IFD requires three strip-related fields: StripOffsets, RowsPerStrip, and StripByteCounts. The StripOffsets field is an array of pointers to the strip or strips that contain the actual image data. The StripByteCounts field gives the number of bytes in each strip after compression. TIFF requires that each strip, except

the last, contain the same number of scanlines, which is given in the RowsPerStrip field. This document introduces the new StripRowCounts field that allows a variable number of scanlines per strip, which is required by the Mixed Raster Content fax profile (Section 8).

Image data is stored as uninterpreted, compressed image data streams within a strip. The formats of these streams follow the ITU-T Recommendations. The Compression field in the IFD indicates the type of compression, and other TIFF fields in the IFD describe image attributes such as color encoding and spatial resolution. Compression parameters are stored in the compressed data stream rather than in TIFF fields. This makes the TIFF representation and compressed data format specification independent of each another. This approach, modeled on [TTN2], allows TIFF to add new compression schemes gracefully as they become available.

Some attributes can be specified both in the compressed data stream and within a TIFF field. It is possible that the two values will differ. When this happens for values required to interpret the data stream, the values in the data stream take precedence. For informational values that are not required to interpret the data stream, such as author name, then the TIFF field value takes precedence.

2.1.3. TIFF File Structure for Fax Applications

The TIFF specification has a very flexible file structure that does not specify the ordering of IFDs, field values, and image data in a file. Individual applications may require or recommend an ordering.

This specification recommends that when using a TIFF file for facsimile, a multi-page fax document SHOULD be represented as a linked list of IFDs. It also recommends that a TIFF file for facsimile SHOULD order pages in a TIFF file in the same way that they are ordered in a fax data stream. In a TIFF file, a page consists of several elements: one or more IFDs (including subIFDs), long field values that are stored outside the IFDs, and image data (in one or more strips).

The minimal black-and-white profile (Profile S) specifies a required ordering of pages and elements within a page (Section 3.5). The extended black-and-white profile (Profile F) provides guidelines for ordering pages and page elements (Section 4.4.6). Other profiles SHOULD follow these guidelines. This recommendation is intended to simplify the implementation of TIFF writers and readers in fax applications and the conversion between TIFF file and fax data stream representations. However, for interchange robustness, readers SHOULD

be prepared to read TIFF files whose structure is consistent with [TIFF], which supports a more flexible file structure than is recommended here.

This specification introduces an optional new GlobalParametersIFD field, defined in Section 2.2.4. This field has type IFD and indicates parameters describing the fax session. While it is often possible to obtain these parameters by scanning the file, it is convenient to make them available together in one place for fast and easy access. If the GlobalParametersIFD occurs in a TIFF file, it SHOULD be located in the first IFD, immediately following the 8-byte image file header.

2.2. TIFF Fields for All Fax Applications

The TIFF specification [TIFF] is organized as a baseline set and several extensions, including technical notes [TTN1, TTN2] that will be incorporated in the next release of TIFF. The baseline and extensions have required and optional fields.

Facsimile applications require (and recommend) a mixture of baseline and extensions fields, as well as some new fields that are not part of the TIFF specification and that are defined in this document. This sub-section lists the fields that are required or recommended for all profiles. In particular, Section 2.2.1 lists the fields that are required by all profiles and that have values that do not depend on the profile. Section 2.2.2 lists the fields that are required by all profiles and that have values that do depend on the profile. Section 2.2.3 lists the fields that are recommended for all profiles. Fields required or recommended by some but not all profiles are given in the section (Section 3 - 8) that describes that profile. The sections for each fax profile have subsections for required and recommended fields; each subsection organizes the fields according to whether they are baseline, extension or new.

The fields required for facsimile have only a few legal values, specified in the ITU-T Recommendations. Of these legal values, some are required and some are optional, just as they are required (mandatory) or optional in fax implementations that conform to the ITU-T Recommendations. The required and optional values are noted in the sections on the different fax profiles.

This section describes the fields required or recommended by all fax profiles. The pattern for the description of TIFF fields in this document is as follows:

FieldName(TagValueInDecimal) = allowable values.
TYPE

WhetherRequiredByTIFForTIFFforFAX
Count = (omitted if =1) = (if not in current spec but available)
Explanation of the field, how it's used, and the values it can have. Default value, if any, as specified in [TIFF].

When a field's default value is the desired value, that field may be omitted from the relevant IFD unless specifically required by the text of this specification.

2.2.1. TIFF fields required for all fax profiles

The TIFF fields listed in this section SHALL be used by all fax profiles but have field values that are not specified by the ITU standards, i.e., the fields do not depend on the profile. The next subsection lists the fields that SHALL be used by all fax profiles, but which do have values specified by the ITU-specified or profile-specific values. Fields that SHALL be used by some but not all profiles are given in the Sections (3 - 8) that describe the profiles that use them.

ImageLength(257)
SHORT or LONG
RequiredByTIFFBaseline
Total number of scanlines in image.
No default, must be specified.

PageNumber(297)
SHORT
RequiredByTIFFforFAX, TIFFExtension
Count = 2
The first number represents the page number (0 for the first page); the second number is the total number of pages in the document. If the second value is 0, then the total page count is not available.
No default, must be specified

```
   RowsPerStrip(278)
   SHORT or LONG
      RequiredByTIFFBaseline
      The number of scanlines per TIFF strip, except for the last strip.
      For a single strip image, this is the same as the value of the
      ImageLength field.
      Default = 2**32 - 1 (meaning all scanlines in one strip).

   StripByteCounts(279)
   SHORT or LONG
      RequiredByTIFFBaseline
      Count = number of strips
      For each strip, the number of bytes in that strip after
      compression.
      No default, must be specified.

   StripOffsets(273)
   SHORT or LONG
      RequiredByTIFFBaseline
      Count = number of strips
      For each strip, the byte offset from the beginning of the file to
      the start of that strip.
      No default, must be specified.
```

2.2.2. Additional TIFF fields required for all fax profiles

The TIFF fields listed in this section SHALL be used by all fax profiles, but the values associated with them depend on the profile being described and the associated ITU Recommendations. Therefore, only the fields are defined here; the values applicable to a particular fax profile are described in Sections 3 - 8. Fields that SHALL be used by some but not all profiles are given in the section (3 - 8) describing the profile that uses them.

```
   BitsPerSample(258)
   SHORT
      RequiredByTIFFBaseline
      Number of bits per image sample.
      Default = 1 (field may be omitted if this is the value).

   Compression(259)
   SHORT
      RequiredByTIFFBaseline
      Compression method used for image data.
      Default = 1 (no compression, so may not be omitted for FAX).
```

FillOrder(266)
SHORT
RequiredByTIFFforFax
The default bit order in Baseline TIFF per [TIFF] is indicated by FillOrder=1, where bits are not reversed before being stored. However, TIFF for Fax typically uses the setting of FillOrder=2, where the bit order within bytes is reversed before storage (i.e., bits are stored with the Least Significant Bit first). Default = 1 (field may be omitted if this is the value) Facsimile data appears on the phone line in bit-reversed order relative to its description in the relevant ITU compression Recommendation. Therefore, a wide majority of facsimile implementations choose this natural order for storage.

Nevertheless, all readers conforming to this specification must be able to read data in both bit orders, except in the case of Profile S, which only requires support for FillOrder=2 (Least Significant Bit first).

ImageWidth(256)
SHORT or LONG
RequiredByTIFFBaseline
The number of pixels (columns) per scanline (row) of the image No default, must be specified.

NewSubFileType(254)
LONG
RequiredByTIFFforFAX
A general indication of the kind of data contained in this IFD Bit 1 is 1 if the image is a single page of a multi-page document. Default = 0 (no subfile bits on, so may not be omitted for FAX).

PhotometricInterpretation(262)
SHORT
RequiredByTIFFBaseline
The color space of the image data.
No default, must be specified.

ResolutionUnit(296)
SHORT
RequiredByTIFFBaseline The unit of measure for resolution. 2 = inch, 3 = centimeter; Default = 2 (field may be omitted if this is the value)

SamplesPerPixel(277)
SHORT
RequiredByTIFFBaseline
The number of color components per pixel; SamplesPerPixel is 1 for a black-and-white, grayscale or indexed (palette) image. Default = 1 (field may be omitted if this is the value).

XResolution(282)
RATIONAL
RequiredByTIFFBaseline
The horizontal resolution of the image in pixels per resolution unit. The ITU-T Recommendations for facsimile specify a small number of horizontal resolutions: 100, 200, 300, 400 pixels per inch, and 80, 160 pixels per centimeter (or 204, 408 pixels per inch). The allowed XResolution values for each profile are given in the section defining that profile. Per [T.4], it is permissible for applications to treat the following XResolution values as being equivalent: <204, 200> and <400,408> in pixels/inch. These equivalencies were allowed by [T.4] to permit conversions between inch and metric based facsimile terminals. To ensure interoperability, if an application accepts any member of the pairs then T.4 requires it to accept both (e.g., accept 204 if 200 pixels per inch is accepted). TIFF for Facsimile Writers SHOULD express XResolution in inch-based units, for consistency with historical practice and to maximize interoperability. See the table below for information on how to convert from an ITU-T metric value to its inch-based equivalent resolution.
No default, must be specified

YResolution(283)
RATIONAL
RequiredByTIFFBaseline
The vertical resolution of the image in pixels per resolution unit. The ITU-T Recommendations for facsimile specify a small number of vertical resolutions: 100, 200, 300, 400 pixels per inch, and 38.5, 77, 154 pixels per centimeter (or 98, 196, 391 pixels per inch). The allowed YResolution values for each profile are given in the section defining that profile. Per [T.4], it is permissible for applications to treat the following YResolution values as being equivalent: <98, 100>, <196, 200>, and <391, 400> in pixels/inch. These equivalencies were allowed by [T.4] to permit conversions between inch- and metric-based facsimile terminals. To insure interoperability, if an application accepts any member of the pairs, then T.4 requires it to accept both (e.g., accept 98 if 100 pixels per inch is accepted). TIFF for Facsimile Writers SHOULD express YResolution in inch-based units, for consistency with historical practice and to maximize

interoperability. See the table below for information on converting from the metric value to its inch based equivalent resolution.
No default, must be specified.

XResolution		YResolution	
ResolutionUnit =2 (inch)	ResolutionUnit =3 (cm)	ResolutionUnit =2 (inch)	ResolutionUnit =3 (cm)
100		100	
204 200	80	98 100	38.5
204 200	80	196 200	77
204	80	391	154
300		300	
408 400	160	391 400	154

2.2.3. TIFF fields recommended for all fax profiles

The TIFF fields listed in this section MAY be used by all fax profiles. However, Profile S writers (the minimal fax profile described in Section 3) SHOULD NOT use these fields. Recommended fields that are profile-specific are described in Sections 3 - 8.

DateTime(306)
ASCII
OptionalInTIFFBaseline
Date/time of image creation in 24-hour format "YYYY:MM:DD HH:MM:SS". No default.

DocumentName(269)
ASCII
OptionalInTIFFExtension(DocumentStorageAndRetrieval)
The name of the scanned document. This is a TIFF extension field, not a Baseline TIFF field. No default.

ImageDescription(270)
ASCII
OptionalInTIFFBaseline
A string describing the contents of the image.
No default.

Orientation(274) = 1 - 8.
SHORT
OptionalinTIFFBaseline 1: 0th row represents the visual top of the image; the 0th column represents the visual left side of the image. See the current TIFF spec [TIFF] for further values; Baseline TIFF only requires value=1. Default = 1.
Note: It is recommended that a writer that is aware of the orientation include this field to give a positive indication of the orientation, even if the value is the default. Writers should not generate mirror images, because many readers will not properly reverse the image before display or print.

Software(305)
ASCII
OptionalInTIFFBaseline
The name and release number of the software package that created the image.
No default.

2.2.4. New TIFF fields recommended for fax profiles

The new TIFF fields listed in this section MAY be used by all fax profiles. However, Profile S writes (the minimal fax profile described in Section 3) SHOULD NOT use these fields. In addition, support for these new TIFF fields has not been included in historical TIFF-F readers described in Section 4 and [TIFF-F]. These fields describe "global" parameters of the fax session that created the image data. They are optional, not part of the current TIFF specification, and are defined in this document.

The first new field, GlobalParametersIFD, is an IFD that contains global parameters and is located in a Primary IFD.

GlobalParametersIFD (400) IFD or LONG

An IFD containing global parameters. It is recommended that a TIFF writer place this field in the first IFD, where a TIFF reader would find it quickly.

Each field in the GlobalParametersIFD is a TIFF field that is legal in any IFD. Required baseline fields should not be located in the GlobalParametersIFD but should be in each image IFD. If a

conflict exists between fields in the GlobalParametersIFD and in the image IFDs, then the data in the image IFD shall prevail.

Among the GlobalParametersIFD entries is a new ProfileType field that generally describes information in this IFD and in the TIFF file.

ProfileType(401)
LONG
The type of image data stored in this IFD.
0 = Unspecified
1 = Group 3 fax
No default

The following new global fields are defined in this document as IFD entries for use with fax applications.

FaxProfile(402) = 0 - 6.
BYTE
The profile that applies to this file; a profile is subset of the full set of permitted fields and field values of TIFF for facsimile. The currently defined values are:
0: does not conform to a profile defined for TIFF for facsimile
1: minimal black & white lossless, Profile S
2: extended black & white lossless, Profile F
3: lossless JBIG black & white, Profile J
4: lossy color and grayscale, Profile C
5: lossless color and grayscale, Profile L
6: Mixed Raster Content, Profile M

CodingMethods(403)
LONG
This field indicates which coding methods are used in the file. A value of 1 in a bit location indicates the corresponding coding method is used. More than one bit set to 1 means more than one coding method is used in the file.
Bit 0: unspecified compression
Bit 1: 1-dimensional coding, ITU-T Rec. T.4 (MH - Modified Huffman)
Bit 2: 2-dimensional coding, ITU-T Rec. T.4 (MR - Modified READ)
Bit 3: 2-dimensional coding, ITU-T Rec. T.6 (MMR - Modified MR)
Bit 4: ITU-T Rec. T.82 coding, using ITU-T Rec. T.85 (JBIG)
Bit 5: ITU-T Rec. T.81 (Baseline JPEG)
Bit 6: ITU-T Rec. T.82 coding, using ITU-T Rec. T.43 (JBIG color)
Bits 7 - 31: reserved for future use

Note: There is a limit of 32 compression types to identify standard compression methods.

VersionYear(404)
BYTE
Count: 4
The year of the standard specified by the FaxProfile field, given as 4 characters, e.g., '1997'; used in lossy and lossless color profiles.

ModeNumber (405)
BYTE
The mode of the standard specified by the FaxProfile field. A value of 0 indicates Mode 1.0; used in Mixed Raster Content profile.

3. Profile S: Minimal Black-and-White Fax Profile

This section defines the minimal black-and-white subset of TIFF for facsimile. This subset is designated Profile S. All implementations of TIFF for facsimile SHALL support the minimal subset.

Black-and-white mode is the binary fax application most users are familiar with today. This mode is appropriate for black-and-white text and line art. Black-and-white mode is divided into two levels of capability. This section describes the minimal interchange set of TIFF fields that must be supported by all implementations in order to assure that some form of image, albeit black-and-white, can be interchanged. This minimum interchange set is a strict subset of the fields and values defined for the extended black-and-white profile (TIFF-F or Profile F) in Section 4, which describes extensions to the minimal interchange set of fields that provide a richer set of black-and-white capabilities.

3.1. Overview

The minimal interchange portion of the black-and-white facsimile mode supports 1-dimensional Modified Huffman (MH) compression, with the original Group 3 fax resolutions, commonly called "standard" and "fine."

To assure interchange, this profile uses the minimal set of fields with a minimal set of values. There are no recommended fields in this profile. Further, the TIFF file is required to be "little-endian", which means that the byte order value in the TIFF header is "II". This profile defines a required ordering for the pages in a fax document and for the IFDs and image data of a page. It also requires

that a single strip contain the image data for each page; see Section 3.5. The image data may contain RTC sequences, as specified in Section 3.4.

3.2. Required TIFF Fields

Besides the fields listed in Section 2.2.1, the minimal black-and-white fax profile requires the following fields. The fields listed in Section 2.2.1 and the fields and fax-specific values specified in this subsection must be supported by all implementations.

3.2.1. Baseline fields

BitsPerSample(258) = 1.
SHORT
RequiredByTIFFBaseline
Binary data only.
Default = 1 (field may be omitted if this is the value)

Compression(259) = 3.
SHORT
RequiredByTIFFBaseline
3 = 1- or 2- dimensional coding.
The value 3 is a TIFF extension value [TIFF]. The T4Options field must be specified, and its value specifies that the data is encoded with the Modified Huffman (MH) compression of [T.4].

FillOrder(266) = 2.
SHORT
RequiredByTIFFBaseline
2 = Least Significant Bit first

NOTE: Baseline TIFF readers are only required to support FillOrder 1, where the lowest numbered pixel is stored in the MSB of the byte. However, because many devices, such as modems, transmit the LSB first when converting the data to serial form, it is common for black-and-white fax products to use the second FillOrder = 2, where the lowest numbered pixel is stored in the LSB. Therefore, this value is specified in the minimal black-and-white profile.

ImageWidth(256) = 1728.
SHORT or LONG
RequiredByTIFFBaseline
This profile only supports a page width of 1728 pixels. This width corresponds to North American Letter and Legal and to ISO A4 size pages. No default, must be specified.

```
   NewSubFileType(254) = (Bit 1=1).
   LONG
      RequiredByTIFFforFAX
      Bit 1 is 1 if the image is a single page of a multi-page document.
      Default = 0 (no subfile bits on, so may not be omitted for fax).

   PhotometricInterpretation(262) = 0.
   SHORT
      RequiredByTIFFBaseline
      0 = pixel value 1 means black.
      No default, must be specified.

   ResolutionUnit(296) = 2.
   SHORT
      RequiredByTIFFBaseline
      The unit of measure for resolution. 2 = inch.
      Default = 2 (field may be omitted if this is the value).

   SamplesPerPixel(277) = 1.
   SHORT
      RequiredByTIFFBaseline
      The number of components per pixel; 1 for black-and-white.
      Default = 1 (field may be omitted if this is the value).

   XResolution(282) = 200, 204.
   RATIONAL
      RequiredByTIFFBaseline
      The horizontal resolution of the image is expressed in pixels per
      resolution unit.  In pixels/inch, the allowed values are 200 and
      204, which may be treated as equivalent.  See Section 2.2.2 for
      inch metric equivalency.  No default, must be specified.

   YResolution(283) = 98, 100, 196, 200.
   RATIONAL
      RequiredByTIFFBaseline The vertical resolution of the image is
      expressed in pixels per resolution unit.  In pixels/inch, the
      allowed values are 98, 100, 196, and 200; 98 and 100 may be
      treated as equivalent, and 196 and 200 may be treated as
      equivalent.  See Section 2.2.2 for inch metric equivalency.  No
      default, must be specified.
```

3.2.2. Extension fields

T4Options(292) = (Bit 0 = 0, Bit 1 = 0, Bit 2 = 0, 1)
LONG
RequiredTIFFExtension (when Compression = 3)
Bit 0 = 0 indicates MH compression.
Bit 1 must be 0.
Bit 2 = 1 indicates that EOLs are byte aligned, = 0 EOLs not byte aligned.
Default is all bits are 0 (applies when EOLs are not byte aligned)

Note: The T4Options field is required when the Compression field has a value of 3. Bit 0 of this field specifies the compression used (MH only in this profile). MH coding requires the use of EOL (End of Line) codes: Bit 2 indicates whether the EOL codes are byte-aligned or not. See Section 3.4 for details.

3.2.3. New Fields

None.

3.3. Recommended TIFF Fields

None.

3.4. End of Line (EOL) and Return to Control (RTC)

TIFF extensions for fax, used in this specification, differ from Baseline TIFF in the following ways:

- A 12-bit EOL sequence MUST precede each line of MH-compressed image data. (Baseline TIFF does not use these EOL sequences.)
- The EOL sequence MAY be byte-aligned, in which case fill bits are added so that the EOL sequence ends on a byte boundary, and any subsequent image data begins on a byte boundary.
- If the EOL codes are not byte aligned, the image data MAY be followed by an RTC (Return to Control) sequence, consisting of 6 consecutive EOLs.

In conventional fax, an MH-compressed fax data stream for a page consists of the following sequence:
EOL, compressed data (first line), EOL, compressed data, ... ,
EOL, compressed data (last line), RTC (6 consecutive EOL codes)

Baseline TIFF does not use EOL codes or Return to Control (RTC) sequences for MH-compressed data. However, the TIFF extension field T4Options used in this specification for MH compression (Compression = 3) requires EOLs.

Furthermore, Bit 2 in the T4Options field indicates whether or not the EOL codes are byte aligned. If Bit 2 = 1, indicating the EOL codes are byte aligned, then fill bits have been added as necessary before EOL codes so that an EOL code always ends on a byte boundary, and the first bit of data following an EOL begins on a byte boundary. Without fill bits, an EOL code may end in the middle of a byte. Byte alignment relieves application software of the burden of bit-shifting every byte while parsing scanlines for line-oriented image manipulation (such as writing a TIFF file). Not all TIFF readers historically used for fax are able to deal with non byte aligned data.

While TIFF extension requires EOL codes, TIFF in fax applications has traditionally prohibited RTC sequences. Implementations that seek common processing and interfaces for fax data streams and Internet fax files would prefer that the TIFF data include RTC sequences.

To reconcile these differences, RTCs are allowed in cases where EOL codes are not byte aligned and no fill bits have been added to the data. This corresponds to situations where the fax data is simply inserted in a strip without being processed or interpreted. RTCs should not occur in the data when EOLs have been byte aligned. This is formally specified in the next subsection.

3.4.1. RTC Exclusion

Implementations that seek to maintain strict conformance with TIFF and compatibility with the historical use of TIFF for fax SHOULD NOT include the RTC sequence when writing TIFF files. However, implementations that need to support "transparency" of T.4-generated image data MAY include RTCs when writing TIFF files if the flag settings of the T4Options field are set for non byte aligned data, i.e., Bit 2 is 0. Implementors of TIFF readers should be aware that there are some existing TIFF implementations for fax that include the RTC sequence in MH image data. Therefore, minimal set readers MUST be able to process files that do not include RTCs and SHOULD be able to process files that do include RTCs.

3.5. File Structure

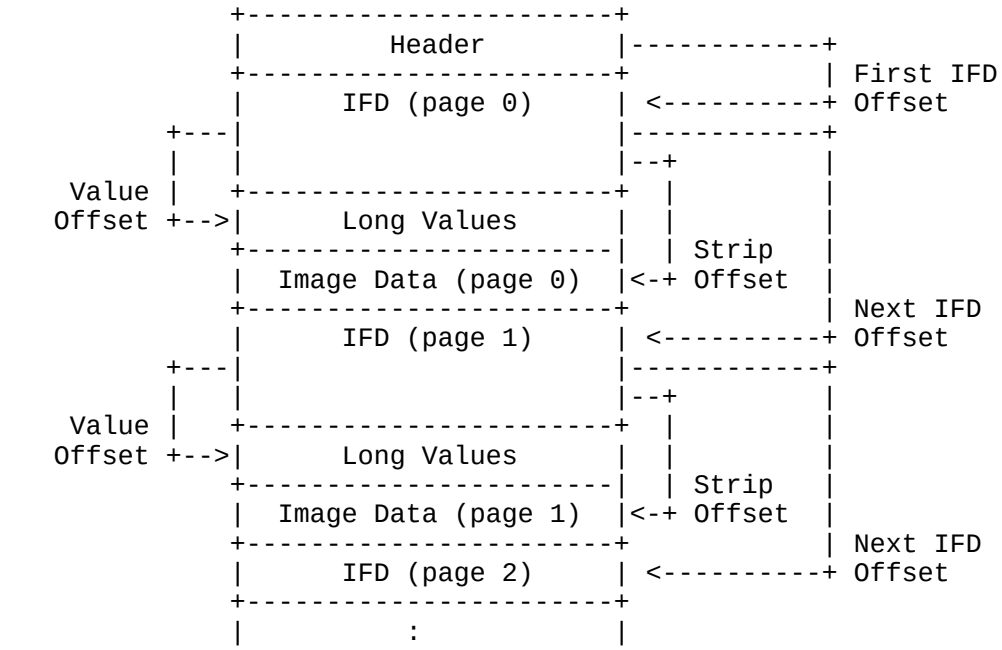
The TIFF header, described in Section 2.1.1, contains two bytes that describe the byte order used within the file. For the minimal black-and-white profile, these bytes SHALL have the value "II" (0x4949), denoting that the bytes in the TIFF file are in LSByte-first order (little-endian). The first or 0th IFD immediately follows the header, so offset to the first IFD is 8. The header values are shown in the following table:

Offset	Description	Value
0	Byte Order	0x4949 (II)
2	Identifier	42 decimal
4	Offset of 0th IFD	0x 0000 0008

The minimal black-and-white profile SHALL order IFDs and image data within a file as follows: (1) There SHALL be an IFD for each page in a multi-page fax document; (2) the IFDs SHALL occur in the same order in the file as the pages occur in the document; (3) the IFD SHALL precede the image data to which it has offsets; (4) the image data SHALL occur in the same order in the file as the pages occur in the document; (5) the IFD, the value data, and the image data to which it has offsets SHALL precede the next image IFD; and (6) the image data for each page SHALL be contained within a single strip.

As a result of (6), the StripOffsets field will contain the pointer to the image data. With two exceptions, the field entries in the IFD contain the field values instead of offsets to field values located outside the IFD. The two exceptions are the values for the XResolution and YResolution fields, both of which are type RATIONAL and require 2 4-byte numbers. These "long" field values SHALL be placed immediately after the IFD which containing the offsets to them, and before the image data pointed to by that IFD.

The effect of these requirements is that the IFD for the first page SHALL come first in the file after the TIFF header, followed by the long field values for XResolution and YResolution, followed by the image data for the first page, then the IFD for second page, and so on. This is shown in the following figure. Each IFD is required to have a PageNumber field, which has value 0 for the first page, 1 for the second page, and so on.



Using this file structure may reduce the memory requirements in implementations. It also provides some support for streaming, in which a file can be processed as it is received and before the entire file is received.

3.6. Profile S: Minimal Black-and-White Profile Summary

The table below summarizes the TIFF fields that compose the minimal interchange set for black-and-white facsimile. The Baseline and Extension fields and field values MUST be supported by all implementations. For convenience, certain fields that have a value that is a sequence of flag bits are shown with integer values corresponding to the flags that are set. An implementation should test the setting of the relevant flag bits individually, however, to allow extensions to the sequence of flag bits to be appropriately ignored. (See, for example, T4Options below.)

Baseline Fields	Values
BitsPerSample	1
Compression	3: 1D Modified Huffman coding set T4Options = 0 or 4

FillOrder	2: least significant bit first
ImageWidth	1728
ImageLength	n: total number of scanlines in image
NewSubFileType	2: Bit 1 identifies single page of a multi-page document
PageNumber	n,m: page number n followed by total page count m
PhotometricInterpretation	0: pixel value 1 means black
ResolutionUnit	2: inch
RowsPerStrip	number of scanlines per strip = ImageLength, with one strip
SamplesPerPixel	1
StripByteCounts	number of bytes in TIFF strip
StripOffsets	offset from beginning of file to single TIFF strip
XResolution	204, 200 (pixels/inch)
YResolution	98, 196, 100, 200 (pixels/inch)
Extension Fields	
T4Options	0: MH coding, EOLs not byte aligned 4: MH coding, EOLs byte aligned

4. Profile F: Extended Black-and-White fax profile

This section defines the extended black-and-white profile or Profile F of TIFF for facsimile. It provides a standard definition of what has historically been known as TIFF Class F and now as TIFF-F. In doing so, it aligns this profile with current ITU-T Recommendations for black-and-white fax and with existing industry practice. Implementations of this profile include implementations of Profile S.

This section describes extensions to the minimal interchange set of fields (Profile S) that provide a richer set of black-and-white capabilities. The fields and values described in this section are a superset of the fields and values defined for the minimal interchange set in Section 3. In addition to the MH compression, Modified READ (MR) and Modified Modified READ (MMR) compression, as described in [T.4] and [T.6] are supported.

Section 4.1 gives an overview of TIFF-F. Section 4.2 describes the TIFF fields that SHALL be used in this profile. Section 4.3 describes the fields that MAY be used in this profile. In the spirit of the original TIFF-F specification, Sections 4.4 and 4.5 discuss technical implementation issues and warnings. Section 4.6 gives an example of TIFF-F use. Section 4.7 gives a summary of the required and recommended fields and their values.

4.1. TIFF-F Overview

Though it has been in common use for many years, TIFF-F has previously never been documented in the form of a standard. An informal TIFF-F document was originally created by a small group of fax experts led by Joe Campbell. The existence of TIFF-F is noted in [TIFF], but it is not defined. This document serves as the formal definition of the F application of [TIFF] for Internet applications. For ease of reference, the term TIFF-F will be used throughout this document as a shorthand for the extended black-and-white profile of TIFF for facsimile.

Up until the TIFF 6.0 specification, TIFF supported various "Classes" that defined the use of TIFF for various applications. Classes were used to support specific applications. In this spirit, TIFF-F has been known historically as "TIFF Class F". Previous informal TIFF-F documents [TIFF-F0] used the "Class F" terminology. As of TIFF 6.0 [TIFF], the TIFF Class concept has been eliminated in favor of the concept of Baseline TIFF. Therefore, this document updates the definition of TIFF-F as the F profile of TIFF for facsimile, by using Baseline TIFF as defined in [TIFF] as the starting point and then adding the TIFF extensions to Baseline TIFF that apply for TIFF-F. In almost all cases, the resulting definition of TIFF-F fields and values remains consistent with those used historically in earlier definitions of TIFF Class F. Where some of the values for fields have been updated to provide more precise conformance with the ITU-T [T.4] and [T.30] fax recommendations, these differences are noted.

4.2. Required TIFF Fields

This section lists the required fields and the values they must have to be ITU-compatible. Besides the fields listed in Section 2.2.1, the extended black-and-white fax profile SHALL use the following fields.

4.2.1. Baseline fields

BitsPerSample(258) = 1.
SHORT
RequiredByTIFFBaseline
Binary data only.
Default = 1 (field may be omitted if this is the value)

Compression(259) = 3, 4.
SHORT
RequiredByTIFFBaseline
3 = 1- or 2- dimensional coding, must have T4Options field This is a TIFF Extension value [TIFF].
4 = 2-dimensional coding, ITU-T Rec. T.6 (MMR - Modified Modified READ, must have T6Options field)) This is a TIFF Extension value.
Default = 1 (and is not applicable; field must be specified)

NOTE: Baseline TIFF permits use of value 2 for Modified Huffman compression, but data is presented in a form that does not use EOLs, and so TIFF for facsimile uses Compression=3 instead. See Sections 4.4.4, 4.5.1, and 4.5.2 for more information on compression and encoding.

FillOrder(266) = 1 , 2.
SHORT
RequiredByTIFFBaseline
Profile F readers must be able to read data in both bit orders, but the vast majority of facsimile products store data LSB first, exactly as it appears on the telephone line.
1 = Most Significant Bit first.
2 = Least Significant Bit first.

ImageWidth(256)
SHORT or LONG
RequiredByTIFFBaseline
This profile supports the following fixed page widths: 1728, 2592, 3456 (corresponding to North American Letter and Legal and ISO A4 paper sizes), 2048, 3072, 4096 (corresponding to ISO B4 paper size), and 2432, 3648, 4864 (corresponding to ISO A3 paper size).
No default; must be specified.

NOTE: Historical TIFF-F did not include support for the following widths related to higher resolutions: 2592, 3072, 3648, 3456, 4096, and 4864. Historical TIFF-F documents also included the following values related to A5 and A6 widths: 816 and 1216. Per the most recent version of [T.4], A5 and A6 documents are no longer supported in Group 3 facsimile, so the related width values are now obsolete. See section 4.5.2 for more information on inch/metric equivalencies and other implementation details.

NewSubFileType(254) = (Bit 1=1).
LONG
RequiredByTIFFforFAX
Bit 1 is 1 if the image is a single page of a multi-page document.
Default = 0 (no subfile bits on, so may not be omitted for fax).

NOTE: Bit 1 is always set to 1 for TIFF-F, indicating a single page of a multi-page image. The same bit settings are used when TIFF-F is used for a one-page fax image. See Section 4.4.3 for details on multi-page files.

PhotometricInterpretation(262) = 0, 1.
SHORT
RequiredByTIFFBaseline
0 = pixel value 1 means black, 1 = pixel value 1 means white.
This field allows notation of an inverted or negative image.
No default, must be specified.

ResolutionUnit(296) = 2, 3.
SHORT
RequiredByTIFFBaseline
The unit of measure for resolution. 2 = inch, 3 = centimeter; =
TIFF-F has traditionally used inch-based measurement.
Default = 2 (field may be omitted if this is the value).

SamplesPerPixel(277) = 1.
SHORT
RequiredByTIFFBaseline
1 = monochrome, bi-level in this case (see BitsPerSample).
Default = 1 (field may be omitted if this is the value).

XResolution(282) = 200, 204, 300, 400, 408
RATIONAL
RequiredByTIFFBaseline
The horizontal resolution of the image is expressed in pixels per resolution unit. In pixels/inch, the allowed values are 200, 204, 300, 400, and 408. See Section 2.2.2 for inch metric equivalency.
No default, must be specified.

NOTE: The values of 200 and 408 have been added to the historical TIFF-F values, for consistency with [T.30]. Some existing TIFF-F implementations may also support values of 80 pixels/cm, which is equivalent to 204 pixels per inch. See section 4.5.2 for information on implementation details.

YResolution(283) = 98, 100, 196, 200, 300, 391, and 400
RATIONAL
RequiredByTIFFBaseline
The vertical resolution of the image is expressed in pixels per resolution unit. In pixels/inch, the allowed values are 98, 100, 196, 200, 300, 391, and 400 pixels/inch. See Section 2.2.2 for inch metric equivalency.
No default, must be specified

NOTE: The values of 100, 200, and 391 have been added to the historical TIFF-F values, for consistency with [T.30]. Some existing TIFF-F implementations may also support values of 77 and 38.5 (cm), which are equivalent to 196 and 98 pixels per inch, respectively. See section 4.5.2 for more information on implementation details.

NOTE: Not all combinations of XResolution, YResolution, and ImageWidth are legal. The following table gives the legal combinations and corresponding paper sizes [T.30].

XResolution x YResolution	ImageWidth		
200x100, 204x98 200x200, 204x196 204x391	1728	2048	2432
300 x 300	2592	3072	3648
408 x 391, 400 x 400	3456	4096	4864
	Letter,A4 Legal	B4	A3
	Paper Size		

4.2.2. Extension fields

T4Options(292) = (Bit 0 = 0 or 1, Bit 1 = 0, Bit 2 = 0 or 1)
LONG
RequiredTIFFExtension (when Compression = 3)
T4Options was also known as Group3Options in a prior version of [TIFF].
Bit 0 = 1 indicates MR compression, = 0 indicates MH compression.
Bit 1 must be 0.
Bit 2 = 1 indicates that EOLs are byte aligned, = 0 EOLs not byte aligned.
Default is all bits are 0 (applies when MH compression is used and EOLs are not byte aligned) (See Section 3.2.2.) The T4Options field is required when the Compression field has a value of 3. This field specifies the compression used (MH or MR) and whether the EOL codes are byte aligned or not. If they are byte aligned, then fill bits have been added as necessary so that the End of Line (EOL) codes always end on byte boundaries. See Sections 3.4, 4.5.3, and 4.5.4 for details.

T6Options(293) = (Bit 0 = 0, Bit 1 = 0).
LONG
RequiredTIFFExtension (when Compression = 4)
Used to indicate parameterization of 2D Modified Modified READ (MMR) compression. T6Options was also known as Group4Options in a prior version of [TIFF]. Bit 0 must be 0.
Bit 1 = 0 indicates uncompressed data mode is not allowed; = 1 indicates that uncompressed data is allowed (see [TIFF]). Default is all bits 0. For FAX, the field must be present and have the value 0. The use of uncompressed data where compression would expand the data size is not allowed for FAX.

NOTE: MMR compressed data is two-dimensional and does not use EOLs. Each MMR encoded image MUST include an "end-of-facsimile-block" (EOFB) code at the end of each coded strip; see Section 4.5.6.

4.2.3. New fields

None.

4.3. Recommended TIFF fields

4.3.1. Baseline fields

See Section 2.2.3.

4.3.2. Extension fields

See Section 2.2.3.

4.3.3. New fields

See Section 2.2.4 and optional fields below.

Three new, optional fields, used in the original TIFF-F description to describe page quality, are defined in this specification. The information contained in these fields is usually obtained from receiving facsimile hardware (if applicable). They SHOULD NOT be used in writing TIFF-F files for facsimile image data that is error corrected or otherwise guaranteed not to have coding errors. Some applications need to understand exactly the error content of the data. For example, a CAD program might wish to verify that a file has a low error level before importing it into a high-accuracy document. Because Group 3 facsimile devices do not necessarily perform error correction on the image data, the quality of a received page must be inferred from the pixel count of decoded scanlines. A "good" scan line is defined as a line that, when decoded, contains the correct number of pixels. Conversely, a "bad" scanline is defined as a line that, when decoded, contains an incorrect number of pixels.

BadFaxLines(326)
SHORT or LONG
The number of "bad" scanlines encountered by the facsimile device during reception. A "bad" scanline is defined as a scanline that, when decoded, comprises an incorrect number of pixels. Note that PercentBad = (BadFaxLines/ImageLength) * 100.
No default.

CleanFaxData(327) = 0, 1, 2.
SHORT
Indicates whether "bad" lines encountered during reception are stored in the data, or whether "bad" lines have been replaced by the receiver.
0 = No "bad" lines
1 = "bad" lines exist but were regenerated by the receiver,
2 = "bad" lines exist but have not been regenerated.
No default.

NOTE: Many facsimile devices do not actually output bad lines. Instead, the previous good line is repeated in place of a bad line. Although this substitution, known as line regeneration, results in a visual improvement to the image, the data is nevertheless corrupted. The CleanFaxData field describes the error content of the data. That

is, when the BadFaxLines and ImageLength fields indicate that the facsimile device encountered lines with an incorrect number of pixels during reception, the CleanFaxData field indicates whether these bad lines are actually still in the data or whether the receiving facsimile device replaced them with regenerated lines.

ConsecutiveBadFaxLines(328)
LONG or SHORT
Maximum number of consecutive "bad" scanlines received. The BadFaxLines field indicates only the quantity of bad lines. No Default.

NOTE: The BadFaxLines and ImageLength data indicate only the quantity of bad lines. The ConsecutiveBadFaxLines field is an indicator of the distribution of bad lines and may therefore be a better general indicator of perceived image quality. See Section 4.4.5 for examples of the use of these fields.

4.4. Technical Implementation Issues

4.4.1. Strips

In general, TIFF files divide an image into "strips", also known as "bands". Each strip contains a few scanlines of the image. By using strips, a TIFF reader need not load the entire image into memory, enabling it to fetch and decompress small random portions of the image as necessary.

The number of scanlines in a strip is described by the RowsPerStrip value and the number of bytes in the strip after compression by the StripByteCount value. The location in the TIFF file of each strip is given by the StripOffsets values.

Strip size is application dependent. The recommended approach for multi-page TIFF-F images is to represent each page as a single strip. Existing TIFF-F usage is typically one strip per page in multi-page TIFF-F files. See Sections 2.1.2 and 2.1.3.

4.4.2. Bit Order

The current TIFF specification [TIFF] does not require a Baseline TIFF reader to support FillOrder=2, i.e., lowest numbered 1-bit pixel in the least significant bit of a byte. It further recommends that FillOrder=2 be used only in special purpose applications.

Facsimile data appears on the phone line in bit-reversed order relative to its description in ITU-T Recommendation T.4. Therefore, most facsimile applications choose this natural order for data in a file. Nevertheless, TIFF-F readers must be able to read data in both bit orders and support FillOrder values of 1 and 2.

4.4.3. Multi-Page

Many existing applications already read TIFF-F-like files but do not support the multi-page field. Since a multi-page format greatly simplifies file management in fax application software, TIFF-F specifies multi-page documents (NewSubfileType = 2) as the standard case.

It is recommended that applications export multiple-page TIFF-F files without manipulating fields and values. Historically, some TIFF-F writers have attempted to produce individual single-page TIFF-F files with modified NewSubFileType and PageNumber (page one-of-one) values for export purposes. However, there is no easy way to link such multiple single-page files together into a logical multiple-page document, so this practice is not recommended.

4.4.4. Compression

In Group 3 facsimile, there are three compression methods which had been standardized as of 1994 and are in common use. The ITU-T T.4 Recommendation [T.4] defines a one-dimensional compression method known as Modified Huffman (MH) and a two-dimensional method known as Modified READ (MR) (READ is short for Relative Element Address Designate). In 1984, a somewhat more efficient compression method known as Modified Modified READ (MMR) was defined in the ITU-T T.6 Recommendation [T.6]. MMR was originally defined for use with Group 4 facsimile, so that this compression method has been commonly called Group 4 compression. In 1991, the MMR method was approved for use in Group 3 facsimile and has since been widely utilized.

TIFF-F supports these three compression methods. The most commonly used is the one-dimensional Modified Huffman (MH) compression method. This is specified by setting the Compression field value to 3 and then setting bit 0 of the T4Options field to 0. Alternatively, the two dimensional Modified READ (MR) method, which is much less frequently used in historical TIFF-F implementations, may be selected by setting bit 0 of the T4Options field to 1. The value of Bit 2 in this field is determined by the use of fill bits.

Depending upon the application, the more efficient two-dimensional Modified Modified READ (MMR)compression method from T.6 may be selected by setting the Compression field value to 4 and then setting

the first two bits (and all unused bits) of the T6Options field to 0. More information to aid the implementor in making a compression selection is contained in Section 4.5.2.

Baseline TIFF also permits use of Compression=2 to specify Modified Huffman compression, but the data does not use EOLs. As a result, TIFF-F uses Compression=3 instead of Compression=2 to specify Modified Huffman compression.

4.4.5. Example Use of Page-quality Fields

Here are examples for writing the CleanFaxData, BadFaxLines, and ConsecutiveBadFaxLines fields:

1. Facsimile hardware does not provide page-quality information: MUST NOT write page-quality fields.

2. Facsimile hardware provides page-quality information, but reports no bad lines. Write only BadFaxLines = 0.

3. Facsimile hardware provides page-quality information and reports bad lines. Write both BadFaxLines and ConsecutiveBadFaxLines. Also write CleanFaxData = 1 or 2 if the hardware's regeneration capability is known.

4. Source image data stream is error corrected or otherwise guaranteed to be error free such as for a computer-generated file: SHOULD NOT write page-quality fields.

TIFF Writers SHOULD only generate these fields when the image has been generated from a fax image data stream where error correction, e.g., Group 3 Error Correction Mode, was not used.

4.4.6. Practical Guidelines for Writing and Reading Multi-Page TIFF-F Files

Traditionally, TIFF-F has required readers and writers to be able to handle multi-page TIFF-F files. The experience of various TIFF-F implementors has shown that implementing TIFF-F can be greatly simplified if certain practical guidelines are followed when writing multi-page TIFF-F files.

The structure for a multi-page TIFF-F file will include one IFD per document page. In this case, this IFD will define the attributes for a single page. A second simplifying guideline is that the writer of TIFF-F files SHOULD present IFDs in the same order as the actual sequence of pages. (The pages are numbered within TIFF-F beginning with page 0 as the first page and then ascending (i.e., 0, 1,

2, ...). However, any field values over 4 bytes will be stored separately from the IFD. TIFF-F readers SHOULD expect IFDs to be presented in page order but be able to handle exceptions.

Per [TIFF], the exact placement of image data is not specified. However, the offsets for each image strip are defined from within each IFD. Where possible, another guideline for TIFF-F writers is that the image data for each page of a multi-page document SHOULD be contained within a single strip (i.e., one image strip per fax page). A single image strip per page further simplifies TIFF-F file writing for applications such as store and forward messaging, where the file is usually prepared in advance of the transmission, but other assumptions may apply for the size of the image strip for applications that require "streaming" techniques (see section 4.4.7). If a different image strip size guideline has been used (e.g., constant size for image strips that may be less than the page size), this will immediately be evident from the values/offsets of the fields related to strips.

Another simplifying guideline is that each IFD SHOULD be placed in the TIFF-F file structure at a point preceding the image that the IFD describes.

In addition, placing the image data in a physical order within the TIFF file structure which is consistent with the logical page order simplifies TIFF-F file writing and reading. In practice, TIFF-F readers will need to use the strip offsets to find the exact physical location of the image data, whether or not it is presented in logical page order.

If the image data is stored in multiple strips, then the strips SHOULD occur in the file in the same order that the data they contain occurs in the facsimile transmission, starting from the top of the page.

TIFF-F writers MAY follow another simplifying guideline, in which the IFD, the value data and the image data to which the IFD has offsets precede the next image IFD. However, this guideline has been relaxed compared to the others given here.

In the case of the minimal profile, which is also the minimal subset of Profile F, the SHOULDs and MAYs of these guidelines become SHALLs (see Section 3.5).

A TIFF-F file structured using the guidelines of this section will essentially consist of a linked list of IFDs, presented in ascending page order, each pointing to a single page of image data

(one strip per page), where the pages of image data are also placed in a logical page order sequence within the TIFF-F file structure. (The pages of image data may themselves be stored in a contiguous manner, at the option of the implementor).

4.4.7. Use of TIFF-F for Streaming Applications

TIFF-F has historically been used for handling fax image files in applications such as store and forward messaging, where the entire size of the file is known in advance. Although TIFF-F may also be used as a file format for cases such as streaming applications, assumptions differing from those provided in this section (e.g., the entire size and number of pages within the image are not known in advance) may be required. As a result, a definition for the streaming application of TIFF-F is beyond the scope of this document.

4.5. Implementation Warnings

4.5.1. Uncompressed data

TIFF-F requires the ability to read and write at least one-dimensional T.4 Huffman ("compressed") data. Uncompressed data is not allowed. The "Uncompressed" bit in T4Options or T6Options must be set to 0.

4.5.2. Encoding and Resolution

Since two-dimensional encoding is not required for Group 3 compatibility, some historic TIFF-F readers have not been able to read such files. The minimum subset of TIFF-F REQUIRES support for one-dimensional (Modified Huffman) files, so this choice maximizes portability. However, implementors seeking greater efficiency SHOULD use T.6 MMR compression when writing TIFF-F files. Some TIFF-F readers will also support two-dimensional Modified READ files. Implementors who wish to have the maximum flexibility in reading TIFF-F files should support all three of these compression methods (MH, MR, and MMR).

Almost all facsimile products support both standard (98 dpi) vertical resolution and "fine" (196 dpi) resolution. Therefore, fine-resolution files are quite portable in the real world.

In 1993, the ITU-T added support for higher resolutions in the T.30 recommendation, including 200 x 200, 300 x 300, and 400 x 400 in dots per inch-based units. At the same time, support was added for metric dimensions equivalent to the following inch-based resolutions: 391v x 204h and 391v x 408h. Therefore, the full set of inch-based equivalents of the new resolutions are supported in the TIFF-F

writer, as they may appear in some image-data streams received from Group 3 facsimile devices. However, many facsimile terminals and older versions of TIFF-F readers are likely not to support these higher resolutions.

Per [T.4], it is permissible for applications to treat the following XResolution values as equivalent: <204,200> and <400,408>. Similarly, the following YResolution values may also be treated as equivalent: <98, 100>, <196, 200>, and <391, 400>. These equivalencies were allowed by [T.4] to permit conversions between inch- and metric-based facsimile terminals.

The optional support of metric-based resolutions in the TIFF-F reader (i.e., 77 x 38.5 cm) is included for completeness, as they are used in some legacy TIFF-F applications, but this use is not recommended for the creation of TIFF-F files by a writer.

4.5.3. EOL byte-aligned

The historical convention for TIFF-F has been that all EOLs in Modified Huffman or Modified READ data must be byte-aligned. However, Baseline TIFF has permitted use of non byte-aligned EOLs by default, so that a large percentage of TIFF-F reader implementations support both conventions. Therefore, the minimum subset of TIFF-F, or Profile S, as defined in Section 3, includes support for both byte-aligned and non-byte-aligned EOLs; see Section 3.2.2.

An EOL is said to be byte-aligned when Fill bits have been added as necessary before EOL codes so that EOL always ends on a byte boundary, thus ensuring an EOL sequence of a one byte preceded by a zero nibble: xxxx0000 00000001.

Modified Huffman compression encodes bits, not bytes. This means that the end-of-line token may end in the middle of a byte. In byte alignment, extra zero bits (Fill) are added so that the first bit of data following an EOL begins on a byte boundary. In effect, byte alignment relieves application software of the burden of bit-shifting every byte while parsing scan-lines for line-oriented image manipulation (such as writing a TIFF file).

For Modified READ compression, each line is terminated by an EOL and a one-bit tag bit. Per [T.4], the value of the tag bit is 0 if the next line contains two-dimensional data and 1 if the next line is a reference line. To maintain byte alignment, fill bits are added before the EOL/tag bit sequence so that the first bit of data following an MR tag bit begins on a byte boundary.

4.5.4. EOL

As illustrated in FIGURE 1/T.4 in [T.4], MH-encoded facsimile documents begin with an EOL, which in TIFF-F may be byte-aligned. The last line of the image is not terminated by an EOL. Similarly, respect, images encoded with Modified READ two-dimensional compression begin with an EOL, followed by a tag bit.

4.5.5. RTC Exclusion

Aside from EOLs, TIFF-F files have historically only contained image data. This means that applications seeking to maintain strict conformance with the rules in [TIFF] and compatibility with historical TIFF-F SHOULD NOT include the Return To Control sequence (RTC) (consisting of 6 consecutive EOLs) when writing TIFF-F files. However, applications intended to support "transparency" of [T.4] image data MAY include RTCs if the flag settings of the T4Options field are set for non byte aligned MH or MR image data. Implementors of TIFF readers should also be aware that there are some existing TIFF-F implementations that include the RTC sequence in MH/MR image data. Therefore, TIFF-F readers MUST be able to process files that do not include RTCs and SHOULD be able to process files that do include RTCs.

4.5.6. Use of EOFB for T.6 Compressed Images

TIFF-F pages encoded with the T.6 Modified Modified READ compression method MUST include an "end-of-facsimile-block" (EOFB) code at the end of each coded strip. Per [TIFF], the EOFB code is followed by pad bits as needed to align on a byte boundary. TIFF readers SHOULD ignore any bits other than pad bits beyond the EOFB.

4.6. Example Use of TIFF-F

The Profile F of TIFF (i.e., TIFF-F content) is a secondary component of the VPIM Message, as defined in [VPIM 2]. Voice messaging systems can often handle fax store-and-forward capabilities in addition to traditional voice message store-and-forward functions. As a result, TIFF-F fax messages can optionally be sent between compliant VPIM systems and may be rejected if the recipient system cannot deal with fax.

Refer to the VPIM Specification for proper usage of this content.

4.7. Profile F: Extended Black-and-white Fax Profile Summary

Recommended fields are shown with an asterisk (*).

Required fields or values are shown with a double asterisk (**). If the double asterisk is on the field name, then all the listed values are required of implementations; if the double asterisks are in the Values column, then only the values suffixed with a double asterisk are required of implementations.

Baseline Fields	Values
BitsPerSample	1**
Compression	3**: 1D Modified Huffman and 2D Modified READ coding 4: 2D Modified Modified READ coding
DateTime*	{ASCII}: date/time in 24-hour format "YYYY:MM:DD HH:MM:SS"
FillOrder**	1: most significant bit first 2: least significant bit first
ImageDescription*	{ASCII}: A string describing the contents of the image.
ImageWidth	1728**, 2048, 2432, 2592, 3072, 3456, 3648, 4096, 4864
ImageLength**	n: total number of scanlines in image
NewSubFileType	2**: Bit 1 identifies single page of a multi-page document
Orientation	1**-8, Default 1
PhotometricInterpretation **	0: pixel value 1 means black 1: pixel value 1 means white
ResolutionUnit**	2: inch 3: centimeter

RowsPerStrip**	n: number of scanlines per TIFF strip
SamplesPerPixel	1**
Software*	{ASCII}: name & release number of creator software
StripByteCounts**	<n>: number or bytes in TIFF strip
StripOffsets**	<n>: offset from beginning of file to each TIFF strip
XResolution	200, 204**, 300, 400, 408 (written in pixels/inch)
YResolution	98**, 196**, 100, 200, 300, 391, 400 (written in pixels/inch)
Extension Fields	
T4Options	0**: required if Compression is Modified Huffman, EOLs are not byte aligned 1: required if Compression is 2D Modified READ, EOLs are not byte aligned 4**: required if Compression is Modified Huffman, EOLs are byte aligned
T4Options (continued)	5: required if Compression is 2D Modified READ, EOLs are byte aligned
T6Options	0: required if Compression is 2D Modified Modified READ
DocumentName*	{ASCII}: name of scanned document
PageNumber**	n,m: page number followed by total page count

New Fields	
BadFaxLines*	number of "bad" scanlines encountered during reception
CleanFaxData*	0: no "bad" lines 1: "bad" lines exist, but were regenerated by receiver 2: "bad" lines exist, but have not been regenerated
ConsecutiveBadFaxLines*	Max number of consecutive "bad" lines received
GlobalParametersIFD*	IFD: global parameters IFD
ProfileType*	n: type of data stored in file
FaxProfile*	n: ITU-compatible fax profile
CodingMethods*	n: compression algorithms used in file

5. Profile J: Lossless JBIG Black-and-White Fax profile

This section defines the lossless JBIG black-and-white profile of TIFF for facsimile, designated Profile J. Implementations of this profile are required to implement Profile S as well.

The previous section described the extended interchange set of TIFF fields for black-and-white fax, which provided support for the MH, MR, and MMR compression of black-and-white images. This section adds a profile with JBIG compression capability.

5.1. Overview

This section describes a black-and-white profile that uses JBIG compression. The ITU-T has approved the single-progression sequential mode of JBIG [T.82] for Group 3 facsimile. JBIG coding offers improved compression for halftoned originals. JBIG compression is used in accordance with the application rules given in ITU-T Rec. T.85 [T.85].

This profile is essentially the extended black-and-white profile with JBIG compression used instead of MH, MR, or MMR.

5.2. Required TIFF Fields

This section lists the required fields and the values they must have to be ITU-compatible. Besides the fields listed in Section 2.2.1, the extended black-and-white fax profile requires the following fields.

5.2.1. Baseline fields

The TIFF fields that SHALL be used in this profile are the same as those described in Section 4.2.1 for the extended black-and-white profile, with two exceptions: the following text replaces the text in Section 4.2.1 for the Compression and FillOrder fields.

Compression(259) = 9.
SHORT
RequiredByTIFFBaseline
9 = JBIG coding. This is a TIFF extension value.
Default = 1 (and is not applicable; field must be specified).
Profile J uses ITU-T T.85 profile of T.82; see T82Options field.

FillOrder(266) = 1, 2.
SHORT
RequiredByTIFFBaseline
1 = Pixels are arranged within a byte such that pixels with lower values are stored in the higher-order bits of the byte, i.e., most significant bit first (MSB).
2 = Pixels are arranged within a byte such that pixels with lower column values are stored in the lower-order bits of the bytes, i.e., least significant bit first (LSB).
Profile J readers must be able to read data in both bit orders.

5.2.2. Extension fields

Same fields as those in Section 2.2.1.

5.2.3. New fields

T82Options(435) = 0
LONG
Required when Compression = 9
Individual bits are set to indicate the applicable profile of JBIG coding; all bits set to 0 indicates ITU-T T.85 profile of T.82; Other values are for further study.
Default is all bits 0, and field may be omitted if this is the value. (Field may be omitted in Profile J files.)

Note: A T.82 decoder can decode a T.85-encoded image when it handles the NEWLE marker code as described Corrigendum 1 in [T.85].

5.3. Recommended TIFF Fields

See Sections 2.2.3 and 2.2.4.

5.4. Profile J: Lossless JBIG Black-and-white Fax Profile Summary

Recommended fields are shown with an asterisk (*).

Required fields or values are shown with a double asterisk (**). If the double asterisk is on the field name, then all the listed values are required of implementations; if the double asterisks are in the Values column, then only the values suffixed with a double asterisk are required of implementations.

Baseline Fields	Values
BitsPerSample	1**
Compression	9**: JBIG coding
DateTime*	{ASCII}: date/time in 24-hour format "YYYY:MM:DD HH:MM:SS"
FillOrder**	1: most significant bit first 2: least significant bit first
ImageDescription*	{ASCII}: A string describing the contents of the image
ImageWidth	1728**, 2048, 2432, 2592, 3072, 3456, 3648, 4096, 4864
ImageLength**	n: total number of scanlines in image
NewSubFileType**	2: Bit 1 identifies single page of a multi-page document
Orientation	1**-8, Default 1
PhotometricInterpretation **	0: pixel value 1 means black 1: pixel value 1 means white

ResolutionUnit**	2: inch 3: centimeter
RowsPerStrip**	n: number of scanlines per TIFF strip
SamplesPerPixel**	1
Software*	{ASCII}: name & release number of creator software
StripByteCounts**	<n>: number of bytes in TIFF strip
StripOffsets**	<n>: offset from beginning of file to each TIFF strip
XResolution	200, 204**, 300, 400, 408 (written in pixels/inch)
YResolution	98**, 196**, 100, 200, 300, 391, 400 (written in pixels/inch)
Extension Fields	
DocumentName*	{ASCII}: name of document scanned
PageNumber**	n,m: page number followed by total page count
New Fields	
GlobalParametersIFD*	IFD: global parameters IFD
T82Options**	0: T.85 profile of T.82
ProfileType*	n: type of data stored in file
FaxProfile*	n: ITU-compatible fax profile
CodingMethods*	n: compression algorithms used in file

6. Profile C: Base Color Fax profile

6.1. Overview

This section defines the lossy color profile of TIFF for facsimile, designated Profile C. Implementations of this profile are required to also implement Profile S as well.

This is the base profile for color and grayscale facsimile, which means that all applications that support color fax must support this profile. The basic approach is the lossy JPEG compression [T.4, Annex E; T.81] of L*a*b* color data [T.42]. Grayscale applications use the L* lightness component; color applications use the L*, a* and b* components.

This profile uses a new PhotometricInterpretation field value to describe the L*a*b* encoding specified in [T.42]. This encoding differs in two ways from the other L*a*b* encodings used in TIFF [TIFF, TTN1]: it specifies a different default range for the a* and b* components, based on a comprehensive evaluation of existing hardcopy output, and it optionally allows selectable range for the L*, a* and b* components.

6.2. Required TIFF Fields

This section lists the required fields, in addition to those given in Section 2.2.1, and the values they must support to be compatible with ITU-T Rec. T.42 and Annex E in ITU-T Rec. T.4.

6.2.1. Baseline Fields

ImageWidth(256).
SHORT or LONG
This profile supports the following fixed page widths: 864, 1024, 1216, 1728, 2048, 2432, 2592, 3072, 3456, 3648, 4096, 4864.

NewSubFileType(254) = (Bit 1=1).
LONG
RequiredByTIFFforFAX
Bit 1 is 1 if the image is a single page of a multi-page document.
Default = 0 (no subfile bits on, so may not be omitted for fax).

BitsPerSample(258) = 8.
SHORT
Count = SamplesPerPixel
The base color fax profile requires 8 bits per sample.

Compression(259) = 7.
SHORT
Base color fax profile uses Baseline JPEG compression. Value 7 represents JPEG compression as specified in [TTN2].

FillOrder(266) = 1 , 2.
SHORT
RequiredByTIFFBaseline
Profile C readers must be able to read data in both bit orders, but the vast majority of facsimile products store data LSB first, exactly as it appears on the telephone line.
1 = Most Significant Bit first.
2 = Least Significant Bit first.

PhotometricInterpretation(262) = 10.
SHORT
Base color fax profile requires pixel values to be stored with the CIE L*a*b* encoding defined in ITU-T Rec. T.42. This encoding is indicated by the PhotometricInterpretation value 10, referred to as ITULAB. With this encoding, the minimum sample value is mapped to 0, and the maximum sample value is mapped to (2^n - 1), i.e., the maximum value, where n is the BitsPerSample value. The conversion from unsigned ITULAB-encoded samples values to signed CIE L*a*b* values is determined by the Decode field; see Section 6.2.3.

NOTE: PhotometricInterpretation values 8 and 9 specify encodings for use with 8-bit-per-sample CIE L*a*b* [TIFF] and ICC L*a*b* [TTN1] data, but they are fixed encodings, which use different minimum and maximum samples than the T.42 default encoding. As currently defined, they are not able to represent fax-encoded L*a*b* data.

ResolutionUnit(296) = 2.
SHORT
The unit of measure for resolution. 2 = inch.
ITU-T standards only specify inch-based resolutions for color fax.
Default = 2 (field may be omitted if this is the value).

SamplesPerPixel(277) = 1, 3.
SHORT
1: L* component only, required in base color profile
3: L*, a*, b* components
Encoded according to PhotometricInterpretation field

XResolution(282) = 100, 200, 300, 400.
RATIONAL
YResolution(283) = 100, 200, 300, 400.
RATIONAL
The resolution of the image is expressed in pixels per resolution unit. In pixels per inch, allowed XResolution values are 100, 200, 300, and 400. The base color fax profile requires the pixels to be square, hence YResolution must equal XResolution. Base resolution is 200 pixels per inch and SHALL be supported by all implementations of this profile.

NOTE: The functional equivalence of inch-based and metric-based resolutions is maintained, per Annex E.6.5 in [T.4]. See table in Section 2.2.2.

NOTE: Not all combinations of XResolution, YResolution and ImageWidth are legal. The following table gives the legal combinations for inch-based resolutions and the corresponding paper sizes [T.30].

XResolution x YResolution	ImageWidth		
100 x 100	864	1024	1216
200 x 200	1728	2048	2432
300 x 300	2592	3072	3648
400 x 400	3456	4096	4864
	Letter,A4 Legal	B4	A3
	Paper Size		

6.2.2. Extension Fields

The JPEG compression standard allows for the a*b* chroma components of an image to be subsampled relative to the L* lightness component. The extension fields ChromaSubSampling and ChromaPositioning define the subsampling. They are the same as YCbCrSubSampling and YCbCrPositioning in [TIFF] but have been renamed to reflect their applicability to other color spaces.

ChromaSubSampling(530).
SHORT
Count = 2
Specifies the subsampling factors for the chroma components of a L*a*b* image. The two subfields of this field, ChromaSubsampleHoriz and ChromaSubsampleVert, specify the horizontal and vertical subsampling factors respectively.

SHORT 0: ChromaSubsampleHoriz = 1, 2.
1: equal numbers of lightness and chroma samples horizontally,
2: twice as many lightness samples as chroma samples horizontally,

SHORT 1: ChromaSubsampleVert = 1, 2.
1: equal numbers of lightness and chroma samples vertically,
2: twice as many lightness samples as chroma samples vertically,

The default value for ChromaSubSampling is (2,2), which is the default for chroma subsampling in color fax [T.4, Annex E]. No chroma subsampling, i.e., ChromaSubSampling = (1,1), is an option for color fax.

ChromaPositioning(531) = 1.
SHORT
Specifies the spatial positioning of chroma components relative to the lightness component.
1: centered, value of 1 means chrominance samples are spatially offset and centered with respect to luminance samples. See the current TIFF specification under YcbCr positioning for further information.
Default = 1, which is what ITU-T T.4, Annex E specifies.

6.2.3. New Fields

Decode(433).
SRATIONAL
Count = 2 * SamplesPerPixel
Describes how to map image sample values into the range of values appropriate for the current color space. In general, the values are taken in pairs and specify the minimum and maximum output value for each color component. For the base color fax profile, Decode has a count of 6 values and maps the unsigned ITULAB-encoded sample values (Lsample, asample, bsample) to signed L*a*b* values, as follows:

L* = Decode[0] + Lsample x (Decode[1]-Decode[0])/(2^n -1)
a* = Decode[2] + asample x (Decode[3]-Decode[2])/(2^n -1)
b* = Decode[4] + bsample x (Decode[5]-Decode[4])/(2^n -1)

where Decode[0], Decode[2] and Decode[4] are the minimum values for L*, a*, and b*; Decode[1], Decode[3] and Decode[5] are the

maximum values for L*, a*, and b*; and n is the BitsPerSample. When n=8,=20 L*=Decode[0] when Lsample=0 and L*=Decode[1] when Lsample=255.

ITU-T Rec. T.42 specifies the ITULAB encoding in terms of a range and offset for each component, which are related to the minimum and maximum values as follows:

minimum = - (range x offset) / 2^n - 1
maximum = minimum + range

The Decode field default values depend on the color space. For the ITULAB color space encoding, the default values correspond to the base range and offset, as specified in ITU-T Rec. T.42 [T.42]. The following table gives the base range and offset values for BitsPerSample=8, and the corresponding default minimum and maximum default values for the Decode field, calculated using the equations above when PhotometricInterpetation=10.

Refer to ITU-T Rec. T.42 [T.42] to calculate the range and offset, and hence the minimum and maximum values, for other BitsPerSample values.

BitsPer -Sample	Component	ITU-T Rec. T.42 base values		Decode default values	
		Range	Offset	Min	Max
8	L*	100	0	0	100
	a*	170	128	-21760/255	21590/255
	b*	200	96	-19200/255	31800/255

For example, when PhotometricInterpretation=10 and BitsPerSample=8, the default value for Decode is (0, 100, -21760/255, 21590/255, -19200/255, 31800/255). For guidelines on the use of the Decode field, see section 5.2.2 of [GUIDE].

6.3. Recommended TIFF Fields

See Sections 2.2.3. and 2.2.4.

6.4. Profile C: Base Color Fax Profile Summary

Recommended fields are shown with an asterisk (*).

Required fields or values are shown with a double asterisk (**). If the double asterisk is on the field name, then all the listed values are required of implementations; if the double asterisk is in the Values column, then only the values suffixed with a double asterisk are required of implementations.

Baseline Fields	Values
BitsPerSample	8**: 8 bits per color sample
Compression**	7: JPEG
DateTime*	{ASCII}: date/time in 24-hour format "YYYY:MM:DD HH:MM:SS"
FillOrder**	1: most significant bit first 2: least significant bit first
ImageDescription*	{ASCII}: A string describing the contents of the image
ImageWidth	864, 1024, 1216, 1728**, 2048 2432, 2592, 3072, 3456, 3648 4096, 4864
ImageLength**	n: total number of scanlines in image
NewSubFileType**	2: Bit 1 identifies single page of a multi-page document
Orientation	1**-8, Default 1

PhotometricInterpretation	10**: ITULAB
ResolutionUnit**	2: inch
RowsPerStrip**	n: number of scanlines per TIFF strip
SamplesPerPixel	1**: L* (lightness) 3: LAB
Software*	{ASCII}: name & release number of creator software
StripByteCounts**	<n>: number or bytes in TIFF strip
StripOffsets**	<n>: offset from beginning of file to each TIFF strip
XResolution	100, 200**, 300, 400 (written in pixels/inch)
YResolution	100, 200**, 300, 400 (must equal XResolution)
Extension Fields	
DocumentName*	{ASCII}: name of scanned document
PageNumber**	n,m: page number followed by total page count
ChromaSubSampling	(1,1), (2, 2)** (1, 1): equal numbers of lightness and chroma samples horizontally and vertically (2, 2): twice as many lightness samples as chroma samples horizontally and vertically
ChromaPositioning	1**: centered

New Fields	
Decode**	minL, maxL, mina, maxa, minb, maxb: minimum and maximum values for L*a*b*
GlobalParametersIFD*	IFD: IFD containing global parameters
ProfileType*	n: type of data stored in TIFF file
FaxProfile*	n: ITU-compatible fax profile
CodingMethods*	n: compression algorithms used in file
VersionYear*	byte sequence: year of ITU std

7. Profile L: Lossless Color Profile

This section defines the lossless color profile of TIFF for facsimile, designated Profile L. Implementations of this profile are required to also implement Profiles S and C as well.

7.1. Overview

This profile, specified in [T.43] and [T.4] Annex G, uses JBIG to code three types of color and grayscale images losslessly: one bit per color CMY, CMYK, and RGB images; a palettized (i.e., mapped) color image; and continuous tone color and grayscale images. The last two are multi-level and use the L*a*b* encoding specified in [T.42].

7.1.1. Color Encoding

While under development, ITU-T Rec. T.43 was called T.Palette, as one of its major additions was palettized color images. Baseline TIFF only allows RGB color maps, but ITU-T Rec. T.43 requires L*a*b* color maps, using the encoding specified in ITU-T Rec. T.42. Palette color images are expressed with indices (bits per sample) of 12 bits or less, or optionally 13 to 16 bits, per [T.43] and Annex G in [T.4]. Profile L files use the color table in the T.43 data stream rather than the TIFF ColorMap field.

Enabling T.43 color maps in TIFF requires the extension field Indexed, as defined in [TTN1], and the PhotometricInterpretation field value 10, as defined in Section 6.2.1. The following table shows the corresponding PhotometricInterpretation, SamplesPerPixel, BitsPerSample, and Indexed field values for the different T.43 image types.

Image Type	PhotometricInterpretation	Samples Per Pixel	Bits Per Sample	Indexed
RGB	2=RGB	3	1	0
CMY	5=CMYK	3	1	0
CMYK	5=CMYK	4	1	0
Palette	10=ITULAB	1	n	1
Grayscale	10=ITULAB	1	2-8, 9-12	0
Color	10=ITULAB	3	2-8, 9-12	0

7.1.2. JBIG Compression

T.43 uses the single-progression sequential mode of JBIG, defined in ITU-T Rec. T.82. (Other compression methods are for further study.) To code multi-level images using JBIG, which is a bi-level compression method, an image is resolved into a set of bit-planes, and each bit-plane is then JBIG compressed. For continuous-tone color and grayscale images, Gray code conversion is used. The Gray code conversion is part of the data-stream encoding and is therefore invisible to TIFF.

7.2. Required TIFF Fields

This section lists the required fields, in addition to those in Section 2.2.1, and the values they must have to be compatible with ITU-T Rec. T.43.

7.2.1. Baseline Fields

ImageWidth(256).
SHORT or LONG
Same page widths as the base color profile; see Section 6.2.1.
NewSubFileType(254) = (Bit 1=1).
LONG
RequiredByTIFFforFAX
Bit 1 is 1 if the image is a single page of a multi-page document.
Default = 0 (no subfile bits on, so may not be omitted for fax).

BitsPerSample(258) = 1, 2 - 8, 9 - 12.
SHORT
Count = SamplesPerPixel
RGB, CMY, CMYK: 1 bit per sample
Continuous tone (L*a*b*): 2 - 8 bits per sample, 9 - 12 bits optional. Palette color: 12 or fewer bits per sample.
Note: More than 8 bits per sample is not baseline TIFF.

Compression(259) = 10.
SHORT
10: ITU-T Rec. T.43 representation, using ITU-T Rec. T.82 (JBIG) coding

FillOrder(266) = 1 , 2.
SHORT
RequiredByTIFFBaseline
Profile L readers must be able to read data in both bit orders, but the vast majority of facsimile products store data LSB first, exactly as it appears on the telephone line.
1 = Most Significant Bit first.
2 = Least Significant Bit first.

PhotometricInterpretation(262) = 2, 5, 10.
SHORT
2: RGB
5: CMYK, including CMY
10: ITULAB
Image data may also be stored as palette-color images, where pixel values are represented by a single component that is an index into a color map using the ITULAB encoding. This color map is specified by the color palette table embedded in the image data stream. To use palette-color images, set the PhotometricInterpretation to 10, SamplesPerPixel to 1, Indexed to 1, and use the color map in the data stream. See Section 7.1.1 for discussion of the color encoding.

ResolutionUnit(296) = 2.
SHORT
The unit of measure for resolution. 2 = inch.
ITU-T standards only specify inch-based resolutions for color fax.
Default = 2 (field may be omitted if this is the value).

SamplesPerPixel(277) = 1, 3, 4.
SHORT
1: Palette-color image, or L*-only if Indexed = 0 and
PhotometricInterpretation is 10 (ITULAB).
3: RGB, or L*a*b*, or CMY if PhotometricInterpretation is 5
(CMYK).
4: CMYK.

XResolution(282) = 100, 200, 300, 400.
RATIONAL
YResolution(283) = 100, 200, 300, 400.
RATIONAL
The resolution of the image is expressed in pixels per resolution unit. In pixels per inch, allowed XResolution values are 100, 200, 300, and 400. The lossless color fax profile requires the pixels to be square, hence YResolution must equal XResolution. Base resolution is 200 pixels per inch.

7.2.2. Extension Fields

Indexed(346) = 0, 1.
SHORT
0: not a palette-color image.
1: palette-color image.
This field is used to indicate that each sample value is an index into an array of color values specified in the image data stream. Because the color map is embedded in the image data stream, the ColorMap field is not used in Profile L. Lossless color fax profile supports palette-color images with the ITULAB encoding. The SamplesPerPixel value must be 1.

7.2.3. New Fields

Decode(433)
SRATIONAL
Decode is used in connection with the ITULAB encoding of image data; see Section 6.2.3.

7.3. Recommended TIFF Fields

See Sections 2.2.3. and 2.2.4.

7.4. Profile L: Lossless Color Fax Profile Summary

Recommended fields are shown with an asterisk (*).

Required fields or values are shown with a double asterisk (**). If the double asterisk is on the field name, then all the listed values are required of implementations; if the double asterisks are in the Values column, then only the values suffixed with a double asterisk are required of implementations.

Baseline Fields	Values
BitsPerSample	1: Binary RGB, CMY(K) 8**: 8 bits per color sample 9 - 12: optional
Compression	10**: JBIG, per T.43
DateTime*	{ASCII}: date/time in the 24-hour format "YYYY:MM:DD HH:MM:SS"
FillOrder**	1: Most significant bit first 2: Least significant bit first
ImageDescription*	{ASCII}: A string describing the contents of the image
ImageWidth	864, 1024, 1216, 1728**, 2048, 2432, 2592, 3072, 3456, 3648, 4096, 4864
ImageLength**	n: total number of scanlines in image
NewSubFileType	2**: Bit 1 identifies single page of a multi-page document

Orientation	1**-8, Default 1
PhotometricInter-pretation	2: RGB 5: CMYK 10**: ITULAB
ResolutionUnit**	2: inch
RowsPerStrip**	n: number of scanlines per TIFF strip
SamplesPerPixel	1**: L* (lightness) 3: LAB, RGB, CMY 4: CMYK
Software*	{ASCII}: name & release number of creator software
StripByteCounts**	<n>: number or bytes in TIFF strip
StripOffsets**	<n>: offset from beginning of file to each TIFF strip
XResolution	100, 200**, 300, 400 (pixels/inch)
YResolution	equal to XResolution (pixels must be square)
Extension Fields	
DocumentName*	{ASCII}: name of scanned document
PageNumber**	n,m: page number followed by total page count
Indexed	0: not a palette-color image 1: palette-color image
New Fields	
Decode	minL, maxL, mina, maxa, minb, maxb: minimum and maximum values for L*a*b*
GlobalParameters IFD*	IFD: global parameters IFD

ProfileType*	n: type of data stored in TIFF file
FaxProfile*	n: ITU-compatible fax profile
CodingMethods*	n: compression algorithms used in file
VersionYear*	byte sequence: year of ITU fax std

8. Profile M: Mixed Raster Content Profile

This section defines the Mixed Raster Content profile of TIFF for facsimile, designated Profile M. Implementations of this profile are required to implement Profiles S and C and may optionally implement Profiles F, J and L.

8.1. Overview

Unlike previous fax profiles, which use a single coding method and resolution for an entire fax page, Mixed Raster Content [T.44] enables different coding methods and resolutions within a single page. For example, consider a page that contains black-and-white text, which is best coded with MMR or JBIG; a color bar chart, best coded with JBIG; and a scanned color image, best coded with JPEG. Similarly, although spatial resolution of 400 pixels per inch may be best for the black-and-white text, 200 pixels per inch is usually sufficient for a color image.

Rather than applying one coding method and resolution to all elements, MRC allows multiple coders and resolutions within a page. By itself, MRC does not define any new coding methods or resolutions. Instead it defines a 3-layer image model for structuring and combining the scanned image data. The MRC 3-layer model has been applied here with the TIFF format to yield a data structure that differs from [T.44], though it applies the same coding methods, uses the same compressed image data streams, and is consistent with the TIFF principle of a single IFD per image.

8.1.1. MRC 3-layer model

The 3 layers of the MRC model are Foreground and Background, which are both multi-level, and Mask, which is bi-level. Each layer may appear only once on a page and is coded independently of the other two layers. The final image is obtained by using the Mask layer to determine whether output pixels come from the Foreground layer or the Background layer. When the Mask layer pixel value is 1, the

corresponding pixel from the Foreground layer is selected; when it is 0, the corresponding pixel from the Background layer is selected. Details are given in the Introduction of [T.44].

In our earlier example, the shape of the black-and-white text and the mask for the color chart could be in the Mask layer, the color of the chart and text in the Foreground layer, and the color image in the Background layer. If a Mask layer pixel has a value of 1, the final image pixel will be, depending on the pixel location, from either the color chart or text color in the Foreground layer. If a Mask layer pixel has a value of 0, the final image pixel will be from the color image in the Background layer.

Each layer is an image and, when present, is represented by at least one IFD in a TIFF file. This is consistent with TIFF, which provides fields to define the attributes, such as resolution, image size, bits per sample, etc., of a single image or layer. The distribution of content among layers is determined by the writer, as is the choice of coding method, color encoding, and spatial resolution for a layer.

Not all pages, and not all parts of a page, require 3 layers. If a page has of only one layer, then that layer is the primary image whether it is a Background, Mask, or Foreground layer. If there is more than one layer, then the Mask must be one of the layers, in which case it is the primary image. In all cases, the primary image must be page size.

MRC [T.44] allows a page to be transmitted as a series of stripes, each consisting of 1, 2 or 3 layers. The number of scanlines in each stripe can vary over the page. Although [T.44] does not allow overlap between images of a single layer, the MRC profile permits overlapping IFDs when one of the IFDs is used only to define a default image color. According to [T.4] Annex H, stripes having more than 1 layer SHOULD NOT be more than 256 lines in length unless the capability to receive longer stripes has been negotiated.

Furthermore, color fax also requires the spatial resolutions of Background and Foreground images to be legal fax values that are also integer factors of the Mask image resolution. For example, if the Mask-Layer resolution is 400 pixels per inch, then allowable resolutions for the Foreground and Background layers are 100, 200, or 400 pixels per inch; if the Mask is at 300 pixels per inch, then allowable values are 100 and 300. The Foreground and Background layer resolutions can be set independently of each other.

8.1.2. A TIFF Representation for the MRC 3-layer model

In the TIFF representation of the 3-layer MRC model, each page is represented by a single IFD, called the Primary IFD. The nextIFD offset associated with a Primary IFD will point to the Primary IFD of the next page. If the page consists of a single layer, then the Primary IFD represents that layer. If more than one layer is present, the Primary IFD represents the Mask layer and the other layers are represented by a set of child IFDs that are referenced through the SubIFD extension field [TTN1] of the Primary IFD. To distinguish MRC-specific SubIFDs from other SubIFDs, the NewSubFileType field MUST have Bit 4 ON, indicating an MRC-related IFD. A new ImageLayer field is also introduced that consists of two values that identify the layer (Foreground, Background, or Mask) and the order within the layer (first, second, ... image of the layer); see Section 8.2.3.

In Profile M, the Primary IFD represents a complete layer and corresponds to the primary image described in Section 8.1.1. There must be no other MRC-related IFDs or SubIFDs that contain image data corresponding to the layer represented by the Primary IFD.

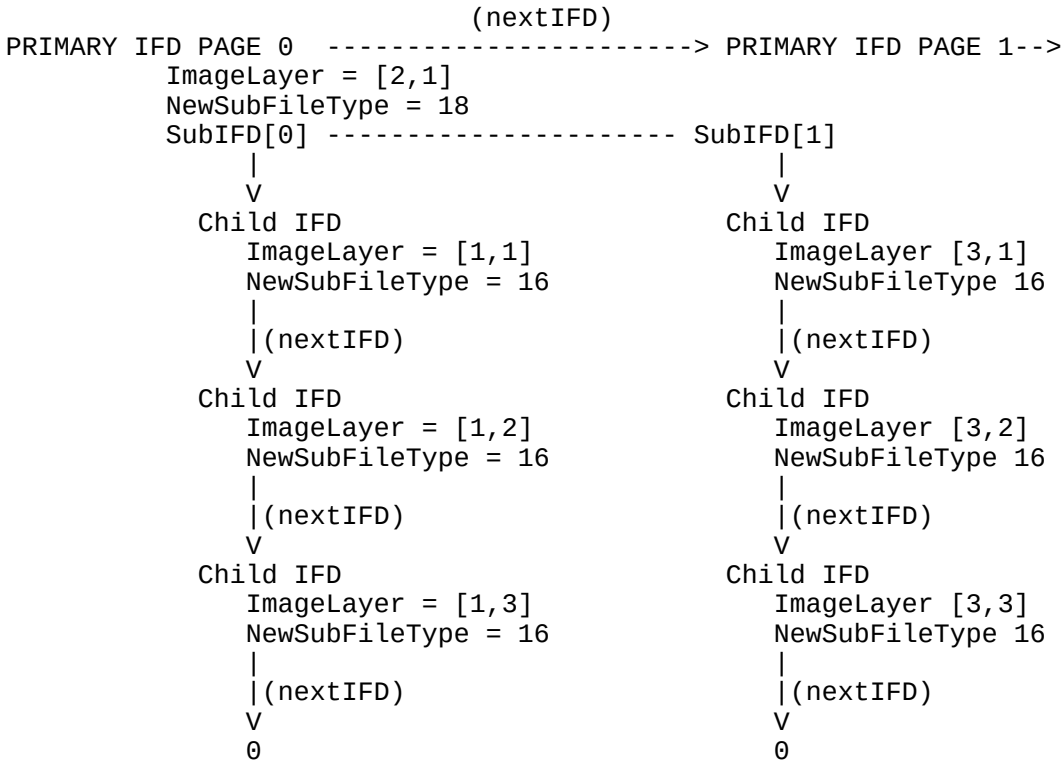
MRC [T.44] allows a page to be transmitted as a series of stripes. A strip within an IFD in a Profile M file represents a stripe in a [T.44] data stream. The [T.44] stripes of the Primary image are represented by a single, multiple-strip IFD; the [T.44] stripes of other layers are represented as multiple, single-strip IFDs.

The layer represented by the Primary IFD may consist of strips of image data, but all the strips must be part of the single Primary IFD. For example, if the page consisted of only the Background layer, then all strips associated with the Background layer must be treated as a single image. Because MRC allows stripes with variable numbers of scanlines, a reader MUST support StripRowCounts field, as a writer may use it in place of the RowsPerStrip field to support a variable number of scanlines in each strip of the Primary IFD. In accordance with [TTN2], each strip shall be independently encoded, but coding parameters may not change between strips.

Layers other than the layer represented by the Primary IFD store each strip as a separate IFD, allowing the coding parameters to change from strip to strip as described by the MRC standard [T.44]. In all cases, if the Mask layer exists, it shall be represented by a single IFD and a single set of coding parameters.

The use of SubIFDs to store child IFDs is described in [TTN1]. When the Mask is the primary image, the Background and Foreground layer images are represented with child IFDs referenced by the SubIFDs

field in the Primary IFD. There are multiple ways to organize the images of the Background and Foreground layer images: (1) the SubIFD field of the Primary IFD is an array of pointers to all child image IFDs, one entry per child image; (2) the SubIFD field is a single pointer to a linked list of all child image IFDs; (3) the SubIFD field is an array of two pointers, where the first pointer is to a linked list of all Background layer image IFDs, and the second pointer is to a linked list of all Foreground layer image IFDs. A Profile M writer SHOULD structure the Background and Foreground layer images by using (3), as shown in the example below. Furthermore, the child IFDs representing the images of the Background and Foreground layers SHOULD be ordered in the file in the same order as they occur on the page. However, a Profile M reader must scan all available child IFDs to locate and identify IFDs associated with MRC layers.



The XPosition and YPosition TIFF fields specify the offset to the upper left corner of the IFD in resolution units, which are inches in Profile M; see Section 8.2.2. The Primary IFD must not use XPosition or YPosition fields.

MRC [T.44] allows the specification of a default image color that is to be applied in the event no image data is transmitted for a given stripe and layer. The new field ImageBaseColor is used to store default image color specifications in Profile M, see 8.2.3. By setting the StripByteCounts array to zero values, an IFD defining a default color but containing no encoded image data can be specified. ImageBaseColor can also be used in IFDs that contain encoded image data. In that case, the fields of the IFD must accurately reflect the encoding of the image data. If the StripByteCount entry for a given strip is 0, then the ImageBaseColor is used for that strip. If the encoded image data is ITU L*a*b, the ImageBaseColor is interpreted with the encoding parameters of the image data. If the image data is not ITU L*a*b*, the ImageBaseColor is interpreted as 8-bit ITU L*a*b*; see Section 8.2.3.

8.2. Required TIFF Fields

This section describes the TIFF fields required, in addition to those in Section 2.2.1, to represent MRC fax images. Since MRC stores fax data as a collection of images corresponding to layers or parts of layers, the coding methods, color encodings, and spatial resolutions used by previous profiles apply to Profile M. Therefore, the descriptions here will typically reference the appropriate earlier sections. Fields and values specific to Profile M are pointed out.

8.2.1. Baseline Fields

ImageWidth(256).
SHORT or LONG

Same page widths as Profile C, the base color profile; see Section 6.2.1. In Profile M, the width of a Foreground or Background image in the coded data stream may be less than the page width, unless the Background or Foreground is the primary image, in which case the width of the coded data stream is the page width. The ImageWidth field will always store the actual width of the coded data.

NewSubFileType(254) = 16, 18.
LONG

For Profile M, the NewSubFileType field has two bits that are required. Bit 1 indicates a single page of a multi-page document and must be set for the Primary IFD; Bit 4 indicates the MRC imaging model as described in ITU-T Recommendation T.44 [T.44] and must be set for Primary IFDs and all MRC-specific child IFDs.

BitsPerSample(258) = 1, 2-8, 9-12
SHORT
SamplesPerPixel(277) = 1, 3, 4.
SHORT
Compression(259) = 1, 3, 4, 7, 9, 10.
SHORT
For Mask layer, see Sections 4.2.1 and 5.2.1. For Foreground and Background layers, see Sections 6.2.1 and 7.2.1 Compression=1 is not used by previous profiles. An IFD used only to specify the default image color for a layer and strip will not have any encoded image data associated with it, i.e., the StripByteCounts field will contain a 0. Since no image data exists in the IFD, the Compression field shall be set to 1, indicating no compression. A Compression field value of 1 is not allowed for any other IFDs.

FillOrder(266) = 1 , 2.
SHORT
RequiredByTIFFBaseline
Profile M readers must be able to read data in both bit orders, but the vast majority of facsimile products store data LSB first, exactly as it appears on the telephone line
1 = Most Significant Bit first.
2 = Least Significant Bit first.

PhotometricInterpretation(262) = 0, 2, 10.
SHORT
For Mask layer, 0. For Foreground and Background layers, see Sections 6.2.1 and 7.2.1.

ResolutionUnit(296) = 2.
SHORT
The unit of measure for resolution. 2 = inch.
ITU-T standards only specify inch-based resolutions for color fax
Default = 2 (field may be omitted if this is the value).

StripByteCounts(279)
SHORT or LONG
In Profile M, it is permissible for the StripByteCounts value for a given strip to have a zero entry. This means there is no encoded image data corresponding to that strip. Instead, the current default image color should be used for the strip. The standard default image colors are black for the Foreground layer and White for the Background layer. The ImageBaseColor field can be used to specify other default colors; see Section 8.2.3.

XResolution(282) = 100, 200, 300, 400.
RATIONAL
YResolution(283) = 100, 200, 300, 400.
RATIONAL
The resolution of the image is expressed in pixels per resolution unit. In pixels per inch, allowed XResolution values for all layers are 100, 200, 300, and 400. Color fax requires the pixels to be square, hence YResolution must equal XResolution for all layers. The resolution of Background and Foreground layers must each be an integer factor of the Primary image, which is the Mask layer, when it is present; see Section 8.4.

8.2.2. Extension Fields

ChromaSubSampling(530).
SHORT
ChromaPositioning(531).
SHORT
For Foreground and Background layers, see Section 6.2.2.

Indexed(346) = 0, 1.
SHORT
For Foreground and Background layers: 1 indicates a palette-color image; see Section 7.2.2.

T4Options(292) = 0, 1, 4, 5.
SHORT
T6Options(293) = 0.
SHORT
For Mask layer, see Section 4.2.2.

SubIFDs(330).
IFD
Count = number of child IFDs. Each value is an offset from the beginning of the TIFF file to a child IFD [TTN1].

XPosition(286).
RATIONAL
YPosition(287).
RATIONAL
Specifies the horizontal and vertical offsets of the top left of the IFD from the top left of the Primary IFD in resolution units. For example, if the Primary IFD is at 400 pixels per inch, and a foreground layer IFD is at 200 pixels per inch and located at pixel coordinate (345, 678) with respect to the Primary IFD, the XPosition value is 345/400 and the YPosition value is 678/400 in inches.

The Primary IFD does not use the XPosition or YPosition fields. The XPosition and YPosition values must be specified for MRC child IFDs; there is no default value.

8.2.3. New Fields

Decode(433).
SRATIONAL
For Foreground and Background layers, see Section 6.2.3.

T82Options(435)
LONG
For Mask layer, see Section 5.2.3.

ImageBaseColor(434).
SHORT
Count = SamplesPerPixel

In areas of an image layer where no image data is available (i.e., where no strips are defined, or where the StripByteCounts entry for a given strip is 0), the color specified by ImageBaseColor will be used.

If the ImageBaseColor field is used in an IFD that contains image data encoded in ITU L*a*b*, then the ImageBaseColor will be interpreted with the color-encoding parameters of the image data (i.e., color gamut, illuminant, bit/sample, and decode). If the ImageBaseColor field is used in an IFD that contains image data that is not encoded in ITU L*a*b, then the ImageBaseColor SHALL be interpreted as 8 bits/sample, 3 samples/pixel ITU L*a*b*. If the ImageBaseColor field is used in an IFD that contains no encoded image data, then the ImageBaseColor SHALL be interpreted as 8 bits/sample, 3 samples/pixel ITU L*a*b*. If the fax data stream requires a different encoding, then transferring the default color value between a TIFF file and fax data stream requires a color conversion.

A [T.44] stripe may contain a Foreground or Background image less than full stripe size, with the rest of the stripe assuming a default image color. In this case, the default image color is imaged first, followed by the image data. In Profile M, this is represented as a child IFD containing no encoded image data but specifying the default image color in the ImageBaseColor field. A second child IFD contains the image data. To ensure the default image color is imaged first, the order value in the ImageLayer field of the IFD defining the ImageBaseColor field MUST have a lower value than the order value in the ImageLayer field of the IFD defining the image data.

To define a child IFD specifying a ImageBaseColor but containing no encoded image data, create an IFD with the following settings.

ImageLayer[0]:	specified layer
ImageLayer[1]:	less than any other IFDs corresponding to the same layer and strip.
RowsPerStrip:	strip height
ImageLength:	strip height
ImageWidth:	full image width
BitsPerSample:	8
PhotometricInterpretation:	10 (ITULAB)
SamplesPerPixel:	3
Compression:	1 (none)
X/YResolution:	that of the Primary IFD
XPosition:	0
YPosition:	the offset from the top of the page to the beginning of the strip in the resolution units of inches
StripByteCounts:	single 0 value
StripOffsets:	single 0 entry
NewSubFileType:	bit 4 O (MRC)
ImageBaseColor:	desired color in 8 bit ITULAB

For the Foreground layer image, the default value for the ImageBaseColor field is black. For other cases, including the Background layer image, the default value is white.

StripRowCounts(559).
LONG
Count = number of strips.
The number of scanlines stored in a strip. Profile M allows each fax strip to store a different number of scanlines. For strips with more than one layer, the maximum strip size is either 256 scanlines or full page size. The 256 maximum SHOULD be used unless the capability to receive longer strips has been negotiated. This field replaces RowsPerStrip for IFDs with variable-size strips. Only one of the two fields, StripRowCounts and RowsPerStrip, may be used in an IFD.

ImageLayer (34732).
LONG
Count = 2.
Image layers are defined such that layer 1 is the Background layer, layer 3 is the Foreground layer, and layer 2 is the Mask layer, which selects pixels from the Background and Foreground layers. The ImageLayer tag contains two values, which describe the layer to which the image belongs and the order in which it is imaged.

ImageLayer[0] = 1, 2, 3.
1: Image is a Background image, i.e., the image that will appear whenever the Mask contains a value of 0. Background images typically contain low-resolution, continuous-tone imagery.
2: Image is the Mask layer. In MRC, if the Mask layer is present, it must be the Primary IFD and be full page in extent.
3: Image is a Foreground image, i.e., the image that will appear whenever the Mask contains a value of 1. The Foreground image generally defines the color of text or lines but may also contain high-resolution imagery.

ImageLayer[1]:
1: first image to be imaged in this layer
2: second image to be imaged in this layer
3: ...

In Profile M, more than one image can exist in a single layer. ImageLayer[1] specifies the order in which images within a single layer are to be imaged. This insures that overlapping images within a single layer are imaged correctly.

If an IFD contains no encoded image data and is used only to specify the ImageBaseColor field, the value of ImageLayer[1] must be less than that of any other IFD corresponding to the same layer and strip to ensure the image data is interpreted as on top of the default color.

In Profile M, it is possible to have only a single layer. For example, if a page contains only a single continuous-tone photograph, then only the Background layer would occur. In this case, the Background layer will be stored as the Primary IFD. ImageLayer[0] will be 1, indicating Background; ImageLayer[1] will be 1, as there can be no other IFDs associated with that layer. No Mask layer will exist.

8.3. Recommended TIFF Fields

See Sections 2.2.3. and 2.2.4.

8.4. Rules and Requirements for Images

Profile M defines a fundamental set of rules for images in the 3 layer representation.

1. If more than one layer exists, then the binary Mask layer SHALL be present and be the primary image. The Mask layer SHALL support the binary data representations defined in Section 3 and MAY support those defined in Sections 4 and 5, with the exception that PhotometricInterpretation MUST be 0. If only one layer exists, then the image corresponding to that layer is the primary image.

2. The Primary IFD defines and extends to the entire page boundary; all attached model images cannot extend beyond the Primary image. Resolution differences may cause some pixels to "hang over" the page boundary, but no new pixels should exist completely beyond the page extent.

3. The Background and Foreground images SHALL support the color representations defined in Section 6 and MAY support those defined in Section 7. These images MAY optionally cover only a portion of the strip or page.

4. Each Primary IFD and each MRC-specific SubIFD must have an ImageLayer field to specify which layer the IFD belongs to, and the imaging order of that IFD within the layer.

5. Each Primary IFD must have a NewSubFileType field value set to 18, indicating a single page of a multi-page document (bit 1) and MRC (bit 4).

6. Each MRC-specific child IFD must have a NewSubFileType field value set to 16, indicating MRC (bit 4).

7. In MRC fax, each layer is transmitted as a sequence of strips. If the page consists of a single layer, then all strips shall be stored in the single Primary IFD. In this case, coding parameters cannot change between strips. If the page consists of more than one layer, then all strips of the Mask layer shall be stored in the single Primary IFD. All strips of the Foreground/Background layers SHALL be stored in separate IFDs, referenced by the Primary IFD’s SubIFD field, containing an ImageLayer field with ImageLayer[0] identifying either Background (layer 1) or Foreground (layer 3), and Imagelayer[1] identifying order in which images within a single layer are to be imaged. The TIFF XPosition and YPosition fields are used to indicate the placement of these images with respect to the primary image.

8. When the Mask image is present, the resolution of Background and Foreground images must each be an integer factor of the Mask image. For example, if the Mask image is 400 pixels/inch, then the Background or Foreground image may be at 400 pixels/inch (400/1), 200 pixels/inch (400/2), or 100 pixels/inch (400/4).

8.5. Profile M: MRC Fax Profile Summary

Recommended fields are shown with an asterisk (*).

Required fields or values are shown with a double asterisk (**). If the double asterisk is on the field name, then all the listed values are required of implementations; if the double asterisk is in the Values column, then only the values suffixed with a double asterisk are required of implementations.

Baseline Fields	Values
BitsPerSample	1**: binary mask, RGB, CMY(K) 2 - 8**: bits per color sample 9 - 12: optional 12 bits/sample
Compression	1: None (ImageBaseColor IFD only) 3**: Modified Huffman and Modified READ 4: Modified Modified READ 7**: JPEG 9: JBIG, per T.85 10: JBIG, per T.43
DateTime*	{ASCII): date/time in the 24-hour format "YYYY:MM:DD HH:MM:SS"
FillOrder**	1: Most significant bit first 2: Least significant bit first
ImageDescription*	{ASCII}: A string describing the contents of the image.
ImageWidth	864, 1024, 1216, 1728**, 2048, 2432, 2592, 3072, 3456, 3648, 4096, 4864 Note: legal widths for the Primary IFD.
ImageLength**	n: total number of scanlines in image
NewSubFileType**	16, 18: Bit 1 indicates single page of a multi-page document on Primary IFD Bit 4 indicates MRC model

Orientation	1**-8, Default 1
PhotometricInterpretation	0**: WhiteIsZero (Mask Layer) 2: RGB 10**: ITULAB
ResolutionUnit**	2: inch
RowsPerStrip	n: number or scanlines per strip
SamplesPerPixel	1**: L* (lightness) 3: RGB, LAB, CMY 4: CMYK
Software*	{ASCII}: name & release number of creator software
StripByteCounts**	<n>: number or bytes in each strip
StripOffsets**	<n>: offset from beginning of file to each TIFF strip
XResolution	100, 200**, 300, 400 (written in pixels/inch)
YResolution	equal to XResolution (pixels must be square)
Extension Fields	
T4Options	0**: required if Compression is Modified Huffman, EOLs not byte aligned 1: required if Compression 2D Modified READ, EOLs are not byte aligned 4**: required if Compression Modified Huffman, EOLs byte aligned 5: required if Compression 2D Modified READ, EOLs are byte aligned
T6Options	0: required if Compression is 2D Modified Modified READ
DocumentName*	{ASCII}: name of scanned document
PageNumber**	n,m: page number followed by total page count

ChromaSubSampling	(1,1), (2, 2)** (1, 1): equal numbers of lightness and chroma samples horizontally & vertically (2, 2): twice as many lightness samples as chroma horizontally and vertically
ChromaPositioning	1: centered
Indexed	0: not a palette-color image 1: palette-color image
SubIFDs	<IFD>: byte offset to FG/BG IFDs
XPosition	horizontal offset in primary IFD resolution units
YPosition	vertical offset in primary IFD resolution units
New Fields	
Decode	minL, maxL, mina, maxa, minb, maxb: minimum and maximum values for L*a*b*
ImageBaseColor	a,b,c: background color in ITULAB
StripRowCounts	<n>: number of scanlines in each strip
ImageLayer	n, m: layer number, imaging sequence (e.g., strip number)
T82Options	0: T.85 profile of T.82 coding
GlobalParameters IFD*	IFD: global parameters IFD
ProfileType*	n: type of data stored in TIFF file
FaxProfile*	n: ITU-compatible fax profile
CodingMethods*	n: compression algorithms used in file
ModeNumber*	n: version of T.44 standard
VersionYear*	byte sequence: year of ITU fax standard

9. MIME content-types image/tiff and image/tiff-fx

The MIME content-types image/tiff and image/tiff-fx are used for TIFF-FX encoded image data, as defined in this document. [TIFF-REG] and [TIFF-FX-REG] describe the registration of these MIME content-types.

10. Security Considerations

This document describes a file format for Internet fax, which is a series of profiles of TIFF for facsimile. As such, it does not create any security issues not already identified in [TIFF-REG], in its use of fields as defined in [TIFF]. There are also new TIFF fields defined within this specification, but they are of a purely descriptive nature, so no new security risks are incurred.

Further, the encoding specified in this document does not in any way preclude the use of any Internet security protocol to encrypt, authenticate, or non-repudiate TIFF-encoded facsimile messages.

11. References

11.1. Normative References

[REQ] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[T.4] ITU-T Recommendation T.4, Standardization of group 3 facsimile apparatus for document transmission, October 1997.

[T.6] ITU-T Recommendation T.6, Facsimile coding schemes and coding control functions for group 4 facsimile apparatus, November 1988

[T.30] ITU-T Recommendation T.30 - Procedures for Document Facsimile Transmission in the General Switched Telephone Network, June 1996

[T.42] ITU-T Recommendation T.42, Continuous-tone colour representation method for facsimile, February 1996

[T.43] ITU-T Recommendation T.43, Colour and gray-scale image representations using lossless coding scheme for facsimile, February 1997

[T.44] ITU-T Recommendation T.44, Mixed Raster Content (MRC), April 1999.

[T.81] ITU-T Recommendation T.81, Information technology - Digital compression and coding of continuous-tone still images - Requirements and guidelines, September 1992

[T.85] ITU-T Recommendation T.85, Application profile for Recommendation T.82 - Progressive bi-level image compression (JBIG coding scheme) for facsimile apparatus, August 1995

[T.82] ITU-T Recommendation T.82, Information technology - Coded representation of picture and audio information - Progressive bi-level image compression, March 1995

[TIFF] Tag Image File Format, Revision 6.0, Adobe Developers Association, June 3, 1992, http://partners.adobe.com/public/developers/en/tiff/TIFF6.pdf

The TIFF 6.0 specification dated June 3, 1992 specification (c) 1986-1988, 1992 Adobe Systems Incorporated. All Rights Reserved.

[TIFF-F0] TIFF Class F specification, Apr 28, 1990, ftp://ftp.faximum.com/pub/documents/tiff_f.txt

[TIFF-REG] Parsons, G. and J. Rafferty, "Tag Image File Format (TIFF) - image/tiff MIME Sub-type Registration", RFC 3302, September 2002.

[TTN1] Adobe PageMaker 6.0 TIFF Technical Notes, Sept. 14, 1995, http://partners.adobe.com/public/developers/en/tiff/TIFFPM6.pdf

[TTN2] Draft TIFF Technical Note 2, Replacement TIFF/JPEG specification, March 17, 1995, ftp://ftp.uu.net/graphics/jpeg/

[TIFF-FX-REG] McIntyre, L., Parsons, G., and J. Rafferty, "Tag Image File Format Fax eXtended (TIFF-FX) - image/tiff-fx MIME Sub-type Registration", RFC 3250, September 2002.

11.2. Informative References

[GUIDE] Cancio, V., Moldovan, M., Tamura, H., and D. Wing, "Implementers Guide for Facsimile Using Internet Mail", RFC 3249, September 2002.

[TIFF-F] Parsons, G. and J. Rafferty, "Tag Image File Format (TIFF) - F Profile for Facsimile", RFC 2306, March 1998.

[VPIM 2] Vaudreuil G. and G. Parsons, "Voice Profile for Internet Mail - version 2 (VPIMv2)", RFC 3801, June 2004.

Annex A: Summary of TIFF Fields for Internet Fax

This annex includes tables which list by profile the TIFF fields used in the proposed fax file format. The fields are organized into 3 categories:

1) TIFF Baseline Fields
2) TIFF Extension Fields
3) New Fields.

The tables include the allowed values for each fax profile. Entries other than explicit numbers are described by:

- n - single number
- n, m - 2 numbers
- a, b, c - 3 numbers
- r - rational number
- <n> - array of numbers
- <b> - byte sequence
- {ASCII} - string
- IFD - IFD byte offset
- <IFD> - array of IFD byte offsets

A blank entry in the table indicates that the field is not used by that particular fax profile.

Table A.1 TIFF Baseline Fields

	Fax Profile					
TIFF Field	Minimal B&W S	Extended B&W F	JBIG B&W J	Lossy Color C	Lossless Color L	Mixed Raster Content M
BitsPerSample	1	1	1	8	1, 2-8 9-12	1, 2-8 9-12
Compression	3	3, 4	9	7	10	3, 4, 7 9,10
DateTime		{ASCII}	{ASCII}	{ASCII}	{ASCII}	{ASCII}
FillOrder	2	1, 2	1, 2	1, 2	1, 2	1,2

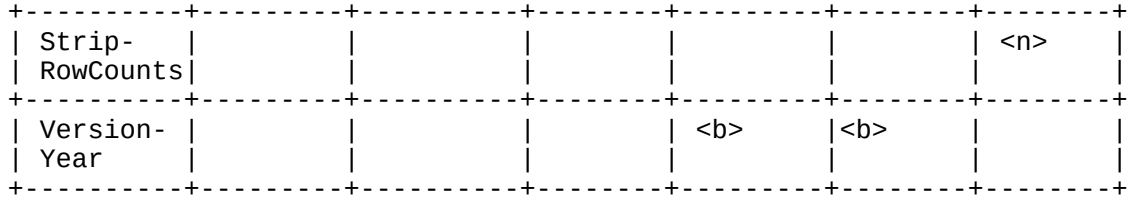
ImageDes-cription		{ASCII}	{ASCII}	{ASCII}	{ASCII}	{ASCII}
Image-Length	n	n	n	n	n	n
Image-Width	1728	1728, 2048, 2432 2592, 3072, 3456 3648, 4096, 4864 Note, for the Mixed Raster Content M profile these widths apply to the Primary IFD.		864, 1024, 1216, 1728, 2048, 2432, 2592, 3072, 3456, 3648, 4096, 4864		
NewSub-FileType	2	2	2	2	2	16, 18
Orien-tation	1	1-8	1-8	1-8	1-8	1-8
Photo-metric-Interp-retation	0	0, 1	0, 1	10	2, 5, 10	0, 2, 10
Resolu-tionUnit	2	2, 3	2, 3	2, 3	2, 3	2, 3
RowsPer-Strip	n	n	n	n	n	n
Samples-PerPixel	1	1	1	1, 3	1, 3, 4	1, 3, 4
Software		{ASCII}	{ASCII}	{ASCII}	{ASCII}	{ASCII}
Strip-Byte-Counts	n	<n>	<n>	<n>	<n>	<n>
Strip-Offsets	n	<n>	<n>	<n>	<n>	<n>
XResolu-tion	204 200	200, 204, 300 400, 408		100, 200, 300, 400		
YResolu-tion	98, 196 100,200	98, 196, 100, 200 300, 391, 400		100, 200, 300, 400		

Table A.2 TIFF Extension Fields

	Fax Profile					
TIFF Field	Minimal B&W S	Extended B&W F	JBIG B&W J	Lossy Color C	Lossless Color L	Mixed Raster Content M
Chroma-Positioning				1		1
Chroma-SubSampling				<1, 1> <2, 2>		<1, 1> <2, 2>
Document-Name		{ASCII}	{ASCII}	{ASCII}	{ASCII}	{ASCII}
Indexed					0,1	0,1
Page-Number	n, m	n, m	n, m	n, m	n, m	n, m
SubIFDs						<IFD>
T4Options	0, 4	0, 1, 4, 5				0, 1, 4, 5
T6Options		0				0
XPosition						r
YPosition						r

Table A.3 New Fields

	Fax Profile					
TIFF Field	Minimal B&W S	Extended B&W F	JBIG B&W J	Lossy Color C	Lossless Color L	Mixed Raster Content M
BadFax-Lines		n				
CleanFax-Data		0, 1, 2				
Coding-Method			n	n	n	n
Consecu-tiveBad-FaxLines		n				
Decode				<r>	<r>	<r>
Fax-Profile			n	n	n	n
Global-Parame-tersIFD		IFD	IFD	IFD	IFD	IFD
Image-Layer						n, m
T82-Options			n			n
Image-BaseColor						<n>
Mode-Number						n
Profile-Type			n	n	n	n



Annex B: List of technical edits to RFC2301

This Annex lists technical differences between this document and RFC 2301, the Proposed Standard File Format for Internet Fax.

No.	Section	Technical Edit
1.	5.2.1	Added FillOrder=1 to Profile J
2.	6.2.1 7.2.1 8.2.1	Constrained ResolutionUnit to 2 (i.e., inch) for all color profiles, per ITU-T Recommendations
3.	7.2.1 7.4	Deleted ColorMap field; it re-encoded the color palette already in the T.43 data stream
4.	7.2.2	Changed TAG value of Indexed field from 364 to 346 to agree with Section 8.2.2 and Ref. [TTN1]
5.	8.2.1	Added text clarifying the use of ImageWidth when Background or Foreground layer is Primary IFD
6.	8.2.3	Changed field name from DefaultImageColor to ImageBaseColor;
7.	8.2.1	Added Compression=1 for ImageBaseColor IFDs
8.	5.2.1 5.2.3	Redefined compression = 9 to be T.82 (JBIG); added T82Options field, with a default value (0) corresponding to the T.85 application profile
9.	4.3.3 4.7	Added GlobalParametersIFD, ProfileType, FaxProfile and CodingMethod to the New Fields portion of Profile F, per Sec. 2.2.4

10.	6.2.1 6.2.3,6.4 Table A.1	Deleted BitsPerSample=12 as an option when Compression=7 due to lack of interop testing.
11.	8.2.1,8.4 Table A.1	Deleted PhotometricInterpretation=5 in Profile M due to insufficient interop testing.
12.	7.2.1,7.4 8.2.1,8.5 Table A.1	Deleted BitsPerSample=13-16 for Palette-color due to lack of interop testing.
13.	Annex B	Deleted Annex B due to discontinued use of application parameter; Annex C renamed Annex B

Authors' Addresses

Robert Buckley
Xerox Corporation
Mailstop 0128-30E
800 Phillips Road
Webster, NY 14580, USA

Phone: +1-585-422-1282
Fax: +1-585-422-2636
EMail: rbuckley@crt.xerox.com

Dennis Venable
Xerox Corporation
Mailstop 0128-27E
800 Phillips Road
Webster, NY 14580, USA

Phone: +1-585-422-3138
Fax: +1-585-422-6117
EMail: dvenable@crt.xerox.com

Lloyd McIntyre
10328 S. Stelling Road
Cupertino, CA 95014 USA

Phone: +1-408-725-1624
EMail: lloyd10328@pacbell.net or
Lloyd_McIntyre@Dell.com

Glenn W. Parsons
Nortel Networks
P.O. Box 3511, Station C
Ottawa, ON K1Y 4H7, Canada

Phone: +1-613-763-7582
Fax: +1-613-967-5060
EMail: gparsons@nortel.com

James Rafferty
Brooktrout Technology
410 First Avenue
Needham, MA 02494 USA

Phone: +1-781-433-9462
Fax: +1-781-433-9268
EMail: jraff@brooktrout.com

Full Copyright Statement

Intellectual Property

Acknowledgement

Funding for the RFC Editor function is currently provided by the Internet Society.