INTERNET-DRAFT                                              R. Buckley
Fax Working Group                                     Xerox Corporation
April 9, 1999                                              D. Venable
draft-ietf-fax-TIFF-FX-00.txt                         Xerox Corporation
                                                            S. Zilles
                                                    Adobe Systems, Inc.
                                                          L. McIntyre
                                                      Xerox Corporation
                                                            G. Parsons
                                                      Northern Telecom
                                                            J. Rafferty
                                                  Human Communications
                                                            April 1999

                    File Format for Internet Fax (revised)


Status of this Memo:

    This document is an Internet-Draft and is in full conformance with
    all provisions of Section 10 of RFC2026.

    Internet-Drafts are working documents of the Internet Engineering
    Task Force (IETF), its areas, and its working groups.  Note that
    other groups may also distribute working documents as
    Internet-Drafts.

    Internet-Drafts are draft documents valid for a maximum of six
    months and may be updated, replaced, or obsoleted by other documents
    at any time.  It is inappropriate to use Internet- Drafts as
    reference material or to cite them other than as "work in progress."

    The list of current Internet-Drafts can be accessed at
    <http://www.ietf.org/ietf/1id-abstracts.txt>

    The list of Internet-Draft Shadow Directories can be accessed at
    <http://www.ietf.org/shadow.html>.

    A version of this draft document is intended for submission to the
    RFC editor as a Proposed Standard for the Internet Community.
    Discussion and suggestions for improvement are requested.


Copyright Notice

Abstract

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

   This RFC 2301 revision describes the TIFF (Tag Image File Format)
   representation of image data specified by the ITU-T Recommendations
   for black-and-white and color facsimile. This file format
   specification is commonly known as TIFF-FX. It formally defines
   minimal, extended and lossless 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. Files formatted according to this specification use
   the image/tiff MIME Content Type.

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
   draft:

       1.  specifies the structure of TIFF files for facsimile data,
       2.  defines ITU fax-compatible values for existing TIFF fields,
       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).

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 that is
   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 in 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. The MIME
   content type of the resulting file will be image/tiff, with an
   optional Application parameter [TIFF-REG]; see Section 9.

   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 draft

   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 describes the MIME content type image/tiff and the use of
   the optional Application parameter in connection with TIFF for
   facsimile. Sections 10, 11, 12 and 13 give Security Considerations,
   the ISOC Copyright Notice, References and Authors' Addresses. 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.

```
                          S (MH)
                          / \
               B&W       /   \  Color
           ------------      ----------
          /        \                  \
         /          F (MMR, MR)        C (JPEG)
        /                             / \
     J (JBIG)                       ----  \
                                   /       \
                                 L (JBIG)   \
                                             \
                                             M (MRC)
```
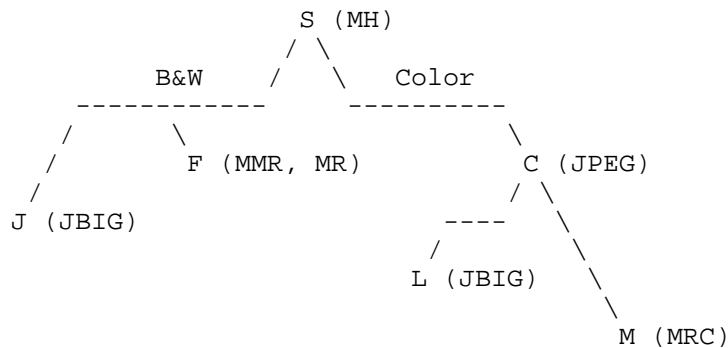
   A profile is based on a collection of ITU-T facsimile coding methods.

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 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 and TIFF Technical Notes 1 and 2 [TTN1, 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 that 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 that either contain 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. While 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.

```
              +-----------------------+
              |        Header         |------------+
              +-----------------------+            | First IFD
              |     IFD (page 0)      |<-----------+ Offset
         +---|                       |------------+
  Value  |   +-----------------------+            |
  Offset +-->|     Long Values       |--+         |
             +-----------------------|  | Strip   |
             |     Image Data        |<-+ Offset  |
             |     strip 1 page 0    |  |         |
             +-----------------------+  |         |
             |          :            |  | :       |
                                                  |
              +-----------------------+           | Next IFD
              |     IFD (page 1)      |<-----------+ Offset
         +---|                       |------------+
  Value  |   +-----------------------+            |
  Offset +-->|     Long Values       |--+         |
             +-----------------------|  | Strip   |
             |     Image Data        |<-+ Offset  |
             |     strip 1 page 1    |  |         |
             +-----------------------+  |         |
             |     strip 2 page 1    |<-+         |
             +-----------------------+  |         |
             |          :            |  | :       |
                                                  |
              +-----------------------+           | Next IFD
              |     IFD (page 2)      |<-----------+ Offset
              |          :            |
```
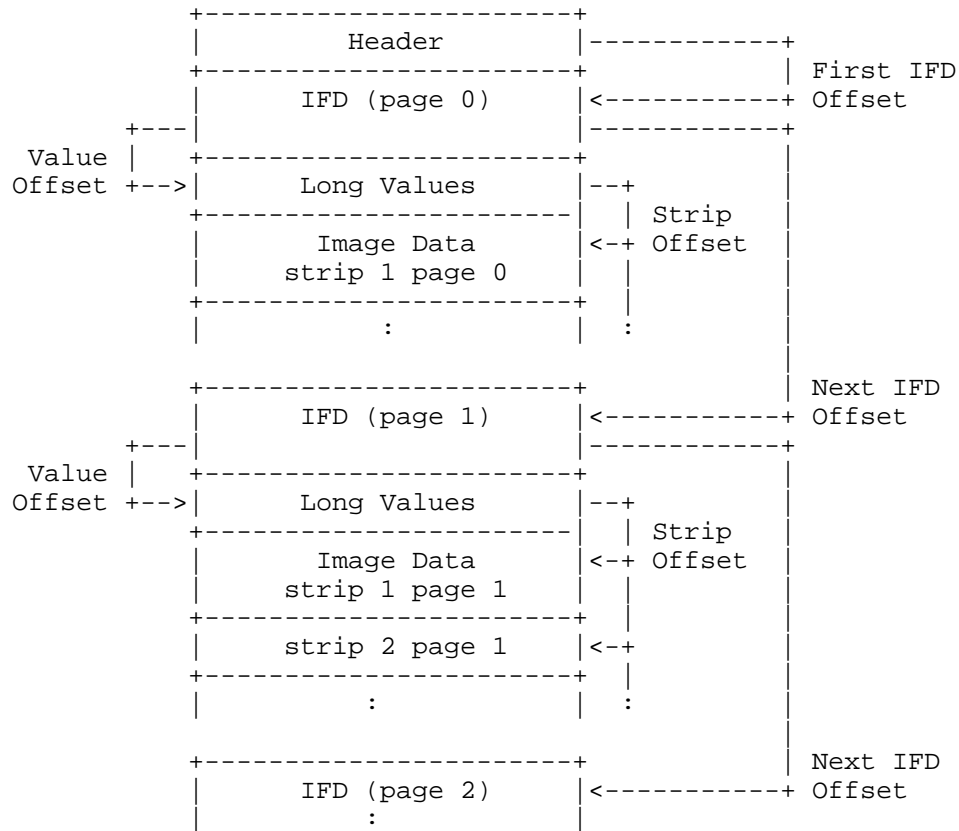
2.1.2 Image Structure

   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 gracefully add new compression schemes 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, then 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, which 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 which do depend on the profile. Section 2.2.3
lists
   the fields that are recommended for all profiles. Fields that are
   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 sub-sections for required and recommended fields;
each
   sub-section 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
draft
   is:

FieldName(TagValueInDecimal) = allowable values.               TYPE
     WhetherRequiredByTIFFforTIFFforFAX
     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
sub-
   section 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) which describe the profiles that uses 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 utilizes 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.

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.
    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. 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 how to convert from an ITU-T 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 will include this field to give a positive indication of
     the orientation, even if the value is the default. If the
     Orientation field is omitted, the reader SHALL assume a value of 1.

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, but their support is not expected for the minimal fax
profile
   described in Section 3. 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
which 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 sub- section 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
    using 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 scan lines 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 want
    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 sub-section.

3.4.1. RTC Exclusion

    Implementations which wish 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 which 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 which do not include RTCs and SHOULD be able to
process files which do include RTCs.

3.5. File Structure

   The TIFF header, described in Section 2.1.1, contains two bytes which
   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 that offset to the first IFD is 8. The headers 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 it has
   offsets to 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 contains 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, etc.
   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.

```
                    +----------------------+
                    |        Header        |------------+
                    +----------------------+            | First IFD
                    |     IFD (page 0)     | <----------+ Offset
              +---| |                      |------------+
              |   | |                      |--+         |
       Value  |   | +----------------------+  |         |
       Offset +-->|      Long Values      |  |         |
                  +----------------------  |  | Strip   |
                  |  Image Data (page 0)  |<-+ Offset   |
                  +----------------------+    | Next IFD
                  |     IFD (page 1)     | <----------+ Offset
              +---| |                      |------------+
              |   | |                      |--+         |
       Value  |   | +----------------------+  |         |
       Offset +-->|      Long Values      |  |         |
                  +----------------------  |  | Strip   |
                  |  Image Data (page 1)  |<-+ Offset   |
                  +----------------------+    | Next IFD
                  |     IFD (page 2)     | <----------+ Offset
                  +----------------------+
                  |          :           |
```
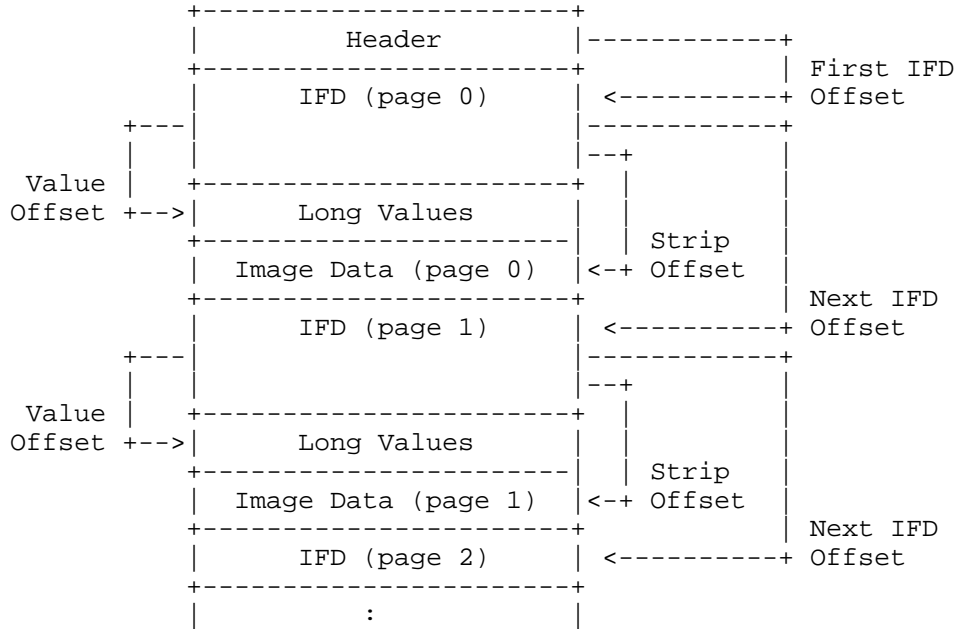
Using this file structure may reduce the memory requirements in
implementations. It is also provides some support for streaming, in
which a file can be processed as it is received and before the entire
file is received.

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

The table below summarizes the TIFF fields that comprise 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 in the table, certain fields which
have a value that is a sequence of flag bits are shown taking integer
values that correspond 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<br>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 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 use
   of TIFF-F. 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 usage 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"
   which 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 which 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 which 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, 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 measures.
    Default = 2 (field may be omitted if this is the value)

SamplesPerPixel(277) = 1.                                     SHORT
    RequiredByTIFFBaseline
    1 = monochrome, bilevel 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 size [T.30].

| XResolution x YResolution | ImageWidth | | |
|---|---|---|---|
| 200x100, 204x98<br>200x200, 204x196<br>204x391 | 1728 | 2048 | 2432 |
| 300 x 300 | 2592 | 3072 | 3648 |
| 408 x 391, 400 x 400 | 3456 | 4096 | 4864 |
|  | Letter,A4<br>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 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

    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 scan lines. A

"good" scan line is defined as a line that, when decoded, contains
the correct number of pixels. Conversely, a "bad" scan line is
defined as a line that, when decoded, comprises an incorrect number
of pixels.

BadFaxLines(326)                                      SHORT or LONG
   The number of "bad" scan lines 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 if "bad" lines encountered during reception are stored in
   the data, or if "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 if 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, thus 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, a wide majority of 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 that 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 common
practice 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, historical TIFF-F has required readers and writers to
   be able to handle multi-page TIFF-F files.  Based on the experience
   of various TIFF-F implementors, it has been seen that the
   implementation of 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
   page of the document.  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 strip offsets for each strip of image are defined from
   within each IFD.   Where possible, another simplifying guideline for
   the writing of TIFF-F files is to specify 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). The use of a single
   image strip per page is very useful 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 which require the use of "streaming"
   techniques (see section 4.4.7).  In the event 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 that are related to
   strips.

   A third simplifying guideline is that each IFD SHOULD be placed in
   the TIFF-F file structure at a point which precedes the image which
   the IFD describes.

   In addition, a fourth simplifying guideline for TIFF-F writers and
   readers is to place the actual image data in a physical order within
   the TIFF file structure which is consistent with the logical page
   order.  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 at the top of the
page.

TIFF-F writers MAY make a fifth 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
(writers MAY rather than SHOULD use it) compared to the other
guidelines given here to reflect past practices for TIFF-F.

In the case of the minimal profile, which is also the minimal subset
of
Profile F, the SHOULD's and MAY's of these guidelines become SHALL's
(see Section 3.5).

So, a TIFF-F file which is structured using the guidelines of this
section will essentially be composed of a linked list of IFDs,
presented in ascending page order, which in turn each point 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 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.  While TIFF-F may also possibly
be used as a file format for cases such as streaming applications,
assumptions may be required that differ from those provided in this
section (e.g., the entire size and number of pages within the image
are not known in advance).  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. This means that 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 that wish to have the maximum flexibility in reading
   TIFF-F files should support all three of these compression methods
   (MH, MR and MMR).

   For the case of resolution, 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, 400 x 400 in dots per
   inch based units.  At the same time, support was added for metric
   dimensions which are 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, since 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 to not
   support the use of these higher resolutions.

   Per [T.4], it is permissible for applications to treat the following
   XResolution values as being equivalent: <204,200> and <400,408>.  In
   a similar respect, the following YResolution values may also be
   treated as being 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.

   In a similar respect, the optional support of metric based
   resolutions in the TIFF-F reader (i.e. 77 x 38.5 cm) is included for
   completeness, since 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 such 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], facsimile documents encoded
   with Modified Huffman begin with an EOL, which in TIFF-F may be byte-
   aligned. The last line of the image is not terminated by an EOL.  In
   a similar 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 which wish 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 which need 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 which include the RTC sequence in MH/MR image
   data. Therefore, TIFF-F readers MUST be able to process files which
   do not include RTCs and SHOULD be able to process files which do
   include RTCs.

4.5.6 Use of EOFB for T.6 Compressed Images

   TIFF-F pages which are 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 [VPIM2].  Voice messaging systems
   can often handle fax store-and-forward capabilities in addition to
   tradi- tional 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|
    +--------------------------+------------------------------+
```

| Field | Description |
|---|---|
| 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 | |

| Field | Description |
|---|---|
| T4Options | 0**: required if Compression is Modified Huffman, EOLs are not byte aligned<br>1: required if Compression is 2D Modified Read, EOLs are not byte aligned<br>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<br>1: "bad" lines exist, but were regenerated by receiver<br>2: "bad" lines exist, but have not been regenerated |
| ConsecutiveBadFaxLines* | Max number of consecutive "bad" lines received |

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

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

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 = ITU-T Rec. T.82 coding, applying ITU-T Rec. T.85 (JBIG). This is
    a TIFF extension value.
    Default = 1 (and is not applicable; field must be specified).

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

1999

   Same fields as those in Section 2.2.1.

## 5.2.3. New fields

   None.

## 5.3. Recommended TIFF Fields

   See Section 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    |
+-------------------------+-------------------------------+
| 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 or Profile C of TIFF for
   facsimile. Implementations of this profile are required to also
   implement Profile S.

   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, 12.                                     SHORT
    Count = SamplesPerPixel
    The base color fax profile requires 8 bits per sample, with 12 as an
    option. 12 bits per sample is not baseline TIFF.

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 using 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 Sec. 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: 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|   B4    |    A3    |
                                   | Legal   |         |          |
                                   +-----------------------------------+
                                   |           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,
    A 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, either 8 or
    12. For example, when n=8, 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 12, 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.

                    +-------------------------------------------------+
                    | ITU-T Rec. T.42  |          Decode          |

```
+---------+-----------+ base values  |     default values        |
| BitsPer + Component +-----------------+---------------------------+
| -Sample |           | Range | Offset |     Min     |    Max      |
+---------+-----------+-------+--------+-------------+-------------+
|    8    |    L*     |  100  |   0    |     0       |    100      |
|         +-----------+-------+--------+-------------+-------------+
|         |    a*     |  170  |  128   | -21760/255  | 21590/255   |
|         +-----------+-------+--------+-------------+-------------+
|         |    b*     |  200  |   96   | -19200/255  | 31800/255   |
+---------+-----------+-------+--------+-------------+-------------+
|   12    |    L*     |  100  |   0    |     0       |    100      |
|         +-----------+-------+--------+-------------+-------------+
|         |    a*     |  170  |  2048  | -348160/4095| 347990/4095 |
|         +-----------+-------+--------+-------------+-------------+
|         |    b*     |  200  |  1536  | -307200/4095| 511800/4095 |
+---------+-----------+-------+--------+-------------+-------------+
```

For example, when PhotometricInterpretation=10 and BitsPerSample=8, the default value for Decode is (0, 100, -21760/255, 21590/255, -19200/255, 31800/255).

## 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 asterisks are 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  |
|                           | 12: optional 12 bits/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 or Profile L of TIFF for
   facsimile. Implementations of this profile are required to also
   implement Profiles S and C.

7.1. Overview

   This profile, defined in [T.43], uses JBIG to losslessly code three
   types of color and grayscale images: 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 palette or mapped 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]. 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, defined in [TTN1], and the PhotometricInterpretation field
    value 10, 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 |PhotometricIn| Samples  | Bits Per | Indexed |
|            |-terpretation| PerPixel | Sample   |         |
|------------+-------------+----------+----------+---------|
|    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. 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, 9-16.                        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, 13-16 bits optional
    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 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

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)<br>8**: 8 bits per color sample<br>9-16: optional |
| Compression | 10**: JBIG, per T.43 |
| DateTime* | {ASCII}:  date/time in the 24-hour<br>format "YYYY:MM:DD HH:MM:SS" |
| FillOrder** | 1: Most significant bit first<br>2: Least significant bit first |
| ImageDescription* | {ASCII}: A string describing the<br>contents of the image. |
| ImageWidth | 864, 1024, 1216, 1728**, 2048, 2432,<br>2592, 3072, 3456, 3648, 4096, 4864 |
| ImageLength** | n: total number of scanlines in image |
| NewSubFileType | 2**: Bit 1 identifies single page of<br>a multi-page document |

| | |
|---|---|
| Orientation | 1**-8, Default 1 |
| PhotometricInter- | 2: RGB |

| pretation            | 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: global parameters IFD       |
| 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 or Profile M
   of TIFF for facsimile. 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, while spatial resolution of 400 pixels per inch may be
   best for the black-and- white text, 200 pixel 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 using the TIFF format to yield a data
   structure which 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 if 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 consists 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
with each stripe 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 allowed
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
allowed values are 100 and 300. The Foreground and Background layer
resolutions can be independently set 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
because 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 that are referenced by the
SubIFDs field in the Primary IFD.  There are many possible ways to
represent 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 using (3), as shown in the example below. Furthermore,
the child IFDs representing the Background and Foreground layer
images 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.

```
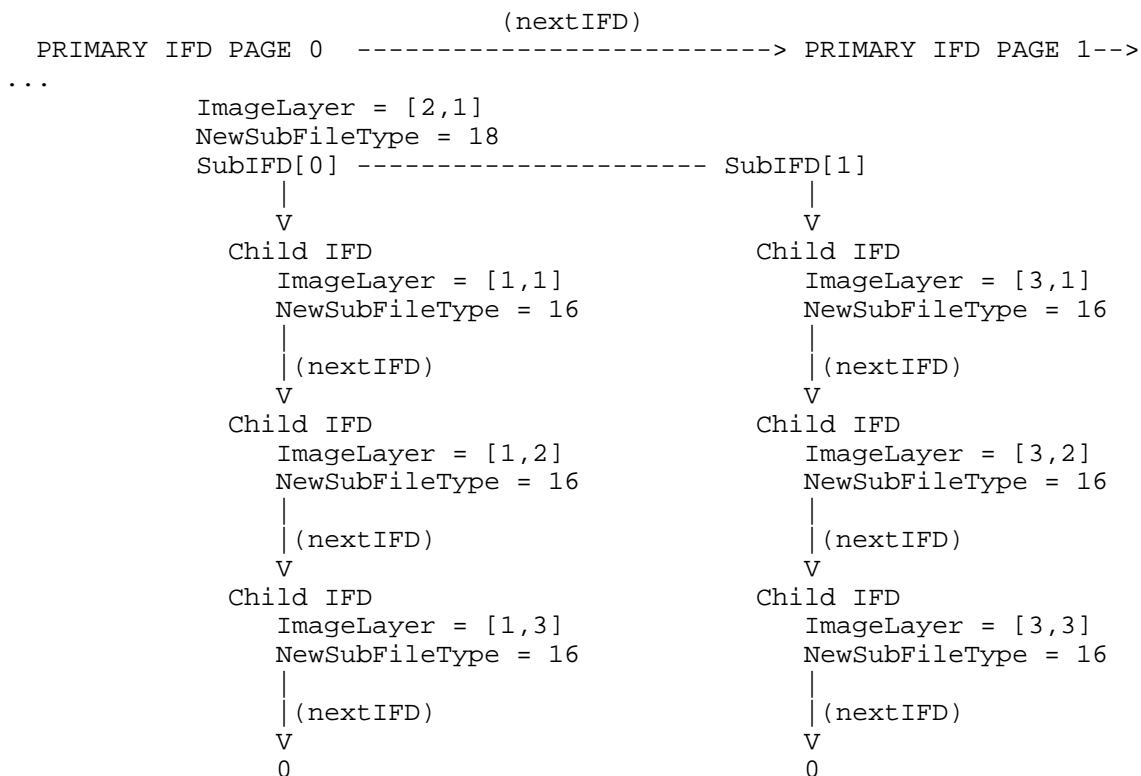                                   (nextIFD)
   PRIMARY IFD PAGE 0  ------------------------> PRIMARY IFD PAGE 1-->
...
            ImageLayer = [2,1]
            NewSubFileType = 18
            SubIFD[0] --------------------- SubIFD[1]
               |                                |
               V                                V
            Child IFD                        Child IFD
               ImageLayer = [1,1]               ImageLayer = [3,1]
               NewSubFileType = 16              NewSubFileType = 16
               |                                |
               |(nextIFD)                       |(nextIFD)
               V                                V
            Child IFD                        Child IFD
               ImageLayer = [1,2]               ImageLayer = [3,2]
               NewSubFileType = 16              NewSubFileType = 16
               |                                |
               |(nextIFD)                       |(nextIFD)
               V                                V
            Child IFD                        Child IFD
               ImageLayer = [1,3]               ImageLayer = [3,3]
               NewSubFileType = 16              NewSubFileType = 16
               |                                |
               |(nextIFD)                       |(nextIFD)
               V                                V
               0                                0
```

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 LayerBaseColor 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.
LayerBaseColor 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 LayerBaseColor is used for that strip. If
the encoded image data is ITU L*a*b, the LayerBaseColor is
interpreted using the encoding parameters of the image data.  If the

image data is not ITU L*a*b*, the LayerBaseColor is interpreted as
8-bit ITU L*a*b*; see Section 8.2.2.

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, 9-16                                 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, 5, 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 LayerBaseColor field can be used to
   specify other default colors, see 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.

LayerBaseColor(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 LayerBaseColor will be
    used.

    If the LayerBaseColor field is used in an IFD that contains image
    data encoded in ITU L*a*b*, then the LayerBaseColor will be
    interpreted with the color encoding parameters of the image data
    (i.e., color gamut, illuminant, bit/sample, and decode). If the
    LayerBaseColor field is used in an IFD that contains image data that
    is not encoded in ITU L*a*b, then the LayerBaseColor SHALL be
    interpreted as 8 bits/sample, 3 samples/pixel ITU L*a*b*.  If the
    LayerBaseColor field is used in an IFD that contains no encoded
    image data, then the LayerBaseColor 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 LayerBaseColor field.  A second child IFD
contains the image data. To insure the default image color is imaged
first, the order value in the ImageLayer field of the IFD defining
the LayerBaseColor 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 LayerBaseColor 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 ON (MRC)
    LayerBaseColor:              desired color in 8 bit ITULAB
```

For the Foreground layer image, the default value for the
LayerBaseColor 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-sized 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, describing 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 to only specify
      the LayerBaseColor field, the value of ImageLayer[1] must be less
      than that of any other IFD corresponding to the same layer and strip
      to insure 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 since 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 the binary data representations 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 the color
   representations 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 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 mask<br>2-8**: bits per color sample<br>9-16: optional 12 bits/sample |
| Compression | 1: None (LayerBaseColor IFD only)<br>3**: Modified Huffman and Modified Read<br>4: Modified Modified Read<br>7**: JPEG<br>9: JBIG, per T.85<br>10: JBIG, per T.43 |
| DateTime* | {ASCII): date/time in the 24-hour format<br>"YYYY:MM:DD HH:MM:SS" |
| FillOrder** | 1: Most significant bit first<br>2: Least significant bit first |
| ImageDescription* | {ASCII}: A string describing the<br>contents of the image. |
| ImageWidth | 864, 1024, 1216, 1728**, 2048, 2432,<br>2592, 3072, 3456, 3648, 4096, 4864 |
| ImageLength** | n: total number of scanlines in image |
| NewSubFileType** | 16, 18:<br>Bit 1 indicates single page of a multi-<br>page document on Primary IFD<br>Bit 4 indicates MRC model |

| Orientation | 1**-8, Default 1 |
|---|---|
| PhotometricInterpretation | 0**:  WhiteIsZero  (Mask Layer)<br>2:  RGB<br>5:  CMYK<br>10**: ITULAB |
| ResolutionUnit** | 2: inch |
| RowsPerStrip | n: number or scanlines per strip |
| SamplesPerPixel | 1**: L* (lightness)<br>3: RGB, LAB, CMY<br>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<br>1: required if Compression 2D Modified Read, EOLs are not byte aligned<br>4**: required if Compression Modified Huffman, EOLs byte aligned<br>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)**<br>(1, 1): equal numbers of lightness and chroma samples horizontally & vertically<br>(2, 2): twice as many lightness samples as chroma horizontally and vertically |
| ChromaPositioning | 1: centered |
| Indexed | 0: not a palette-color image<br>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*     |
+-----------------+-------------------------------------------+
|  LayerBaseColor | 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)                      |
+-----------------+-------------------------------------------+
|  GlobalParameters | IFD: global parameters IFD              |
|  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-type image/tiff

   [TIFF-REG] describes the registration of the MIME content-type
   image/tiff to refer to TIFF encoded image data. When transported by
   MIME, the TIFF content defined by this document must be encoded
   within an image/tiff content type. In addition, an optional
   "application" parameter is defined for image/tiff to identify a
   particular application's subset of TIFF and TIFF extensions for the
   encoded image data, if it is known. Typically, this would be used to
   assist the recipient in dispatching a suitable rendering package to
   handle the display or processing of the image file.

9.1 Refinement of MIME content-type image/tiff for Facsimile
    Applications

   Since this document defines facsimile specific profiles of TIFF, it
   is useful to note an appropriate application parameter for the

image/tiff MIME content-type.

The two values of the image/tiff application parameter as defined for facsimile are shown below, separated by a comma:

    faxbw, faxcolor

The "faxbw" application parameter is suitable for use by applications that can process one or more TIFF for facsimile profiles or subsets used for the encoding of black and white facsimile data.

The "faxcolor" application parameter is suitable for use by applications that can process one or more TIFF for facsimile profiles or subsets that can be used for the encoding of black and white, AND color facsimile data.

Since this document defines several profiles of TIFF for facsimile, the following rules should be followed when setting the application parameter value. For TIFF image data which is encoded for the profiles of TIFF for Facsimile that support black-and-white image data (Profiles S, F or J), applications which use one of these profiles or a subset should set the value of the application parameter to "faxbw". For TIFF image data which is encoded for the defined profiles of TIFF for Facsimile that support color image data (Profiles C, L or M), as well as black-and-white image data, applications which use one of these profiles or a subset should set the value of the application parameter to "faxcolor".

An example of the use of the image/tiff MIME Content-type with the application parameter set with the value 'faxbw' follows:

    Content-type: image/tiff; application=faxbw

In this example, use of this parameter value will enable applications to identify the content as being within a profile or subset of TIFF for Facsimile that is suitable for encoding black and white image data, Before attempting to process the image data.

In a similar respect, an example of the image/tiff MIME Content-type with the application parameter setting suitable for handling a color subset or profile of TIFF for facsimile is shown below:

    Content-type: image/tiff; application=faxcolor

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 that 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

[REQ] Bradner, S, "Key words for use in RFCs to Indicate Requirement
Levels", 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.82] ITU-T Recommendation T.82, Information technology - Coded
representation of picture and audio information - Progressive bi-
level image compression, March 1995

[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

[TIFF] Tag Image File Format, Revision 6.0, Adobe Developers
Association, June 3, 1992,
ftp://ftp.adobe.com/pub/adobe/devrelations/
devtechnotes/pdffiles/tiff6.pdf

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

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

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

[TIFF-REG] Parsons, G., Rafferty J. and S. Zilles, "Tag Image File
Format (TIFF) - image/tiff MIME Sub-type Registration", RFC 2302,
March 1998.

[TTN1] Adobe PageMaker 6.0 TIFF Technical Notes, Sept. 14, 1995,
http://www.adobe.com/supportservice/devrelations/PDFS/TN/TIFFPM6.pdf

[TTN2] Draft TIFF Technical Note 2, Replacement TIFF/JPEG
specification, March 17, 1995,
ftp://ftp.sgi.com/graphics/tiff/TTN2.draft.txt

[VPIM2] Vaudreuil G. and G. Parsons, "Voice Profile for Internet
Mail - version 2", work in progress, <draft-ema-vpim-06.txt>

The ITU-T Recommendations are available at http://www.itu.ch.

12. Authors' Addresses

Lloyd McIntyre                   Stephen Zilles
Xerox Corporation                Adobe Systems Inc.
Mailstop PAHV-121                Mailstop W14
3400 Hillview Ave.               345 Park Avenue
Palo Alto, CA 94304 USA          San Jose, CA 95110-2704, USA
Voice: +1-650-813-6762           Voice: +1-408-536-4766
Fax: +1-650-845-2340             Fax: +1-408-536-4042
Email: lmcintyre@pahv.xerox.com  Email: szilles@adobe.com


Robert Buckley                   Dennis Venable
Xerox Corporation                Xerox Corporation
Mailstop 0128-30E                Mailstop 0128-27E
800 Phillips Road                800 Phillips Road
Webster, NY 14580, USA           Webster, NY 14580, USA
Voice: +1-716-422-1282           Voice: +1-716-422-8009
Fax: +1-716-265-8871             Fax: +1-716-422-6117
Email: rbuckley@crt.xerox.com    Email: dvenable@crt.xerox.com

Glenn S. Parsons                James Rafferty
Northern Telecom                Human Communications
P.O. Box 3511, Station C        12 Kevin Drive
Ottawa, ON  K1Y 4H7, Canada     Danbury, CT 06811-2901, USA
Phone: +1-613-763-7582          Phone: +1-203-746-4367
Fax: +1-613-763-2697            Fax: +1-203-746-4367
Email: Glenn.Parsons@Nortel.ca  Email: Jrafferty@worldnet.att.net

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

| TIFF Field | Fax Profile | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Minimal B&W | Extended B&W | JBIG B&W | Lossy Color | Lossless Color | Mixed Raster Content |
| | S | F | J | C | L | M |
| BitsPerSample | 1 | 1 | 1 | 8, 12 | 1, 2-8 9-16 | 1, 2-8 9-16 |
| 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 |

| TIFF Field | Minimal B&W S | Extended B&W F | JBIG B&W J | Lossy Color C | Lossless Color L | Mixed Raster Content M |
| --- | --- | --- | --- | --- | --- | --- |
| ImageDescription | | {ASCII} | {ASCII} | {ASCII} | {ASCII} | {ASCII} |
| ImageLength | n | n | n | n | n | n |
| ImageWidth | 1728 | 1728, 2048, 2432 2592, 3072, 3456 3648, 4096, 4864 | 864, 1024, 1216, 1728, 2048, 2432, 2592, 3072, 3456, 3648, 4096, 4864 | | | |
| NewSubFileType | 2 | 2 | 2 | 2 | 2 | 16, 18 |
| Orientation | 1 | 1-8 | 1-8 | 1-8 | 1-8 | 1-8 |
| PhotometricInterpretation | 0 | 0, 1 | 0, 1 | 10 | 2, 5, 10 | 0, 1, 2, 5, 10 |

| | Minimal B&W | Extended B&W | JBIG B&W | Lossy Color | Lossless Color | Mixed Raster Content |
|---|---|---|---|---|---|---|
| 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- Position- ing | | | | 1 | | 1 |
| Chroma- SubSampl- ing | | | | <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<br>S | Extended B&W<br>F | JBIG B&W<br>J | Lossy Color<br>C | Lossless Color<br>L | Mixed Raster Content<br>M |
| BadFax-Lines | | n | | | | |
| CleanFax-Data | | 0, 1, 2 | | | | |
| Coding-Method | | | n | n | n | n |
| Consecu-tiveBad-FaxLines | | n | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Decode | | | | <r> | <r> | <r> |
| Default-ImageColor | | | | | | <n> |
| Fax-Profile | | | n | n | n | n |
| Global-ParametersIFD | | IFD | IFD | IFD | IFD | IFD |
| Image-Layer | | | | | | n, m |
| Mode-Number | | | | | | n |
| Profile-Type | | | n | n | n | n |

| | | | | | | |
|---|---|---|---|---|---|---|
| Strip-RowCounts | | | | | | <n> |
| Version-Year | | | | <b> | <b> | |

Annex B.  IANA Registration for image/tiff Application Parameter Values used for facsimile

   To: IANA@isi.edu

   Subject: Registration of new Application parameter values for image/tiff

   MIME media type name: image/tiff

   Optional parameters: Application

   New Value(s): faxbw, faxcolor

   Description of Use:

   faxbw - The "faxbw" application parameter is suitable for use by applications that can process one or more TIFF for facsimile profiles or subsets used for the encoding of black-and-white facsimile data. The definition of the use of this value is contained in Section 9 of this document.

   Faxcolor - The "faxcolor" application parameter is suitable for use by applications that can process one or more TIFF for facsimile profiles or subsets that can be used for the encoding of black and

white, AND color facsimile data. The definition of the use of this
value is contained in Section 9 of this document.

Security Considerations:

   Security considerations related to use of the TIFF subsets described
   by the "faxbw" and "faxcolor" values of the Application parameter are
   identified in Section 10 of this document.

Persons & email addresses to contact for further information:

   Glenn W. Parsons (Glenn.Parsons@Nortel.ca)
   James Rafferty (Jrafferty@worldnet.att.net)
   Stephen Zilles (szilles@adobe.com)

   Change Controller:  Stephen Zilles

INFORMATION TO THE SUBMITTER:

   The accepted registrations will be listed in the "Assigned Numbers"
   series of RFCs.  The information in the registration form is freely
   distributable.

Annex C. List of edits to RFC2301

```
+----+---------+-------------------------------------------------+
| No.| Section |                      Edit                       |
+----+---------+-------------------------------------------------+
| 1. | 3-8     | Added "Profile" to section titles               |
+----+---------+-------------------------------------------------+
| 2. | All     | Changed "mode" to "profile" as appropriate      |
+----+---------+-------------------------------------------------+
| 3. | All     | Changed "encoding" to "compression" or          |
|    |         | "representation" as appropriate                 |
+----+---------+-------------------------------------------------+
| 4. | 2.2.4   | Added text drawing attention to the fact that   |
|    |         | multiple bits can be set in the CodingMethods   |
|    |         | field                                           |
+----+---------+-------------------------------------------------+
| 5. | 3.2.2   | Revised description of T4Options field wrt EOL   |
+----+---------+-------------------------------------------------+
| 6. | 3.4     | Replaced first paragraph with new paragraph     |
|    |         | clarifying use of EOL and RTC in Baseline TIFF  |
|    |         | and TIFF-FX                                      |
+----+---------+-------------------------------------------------+
| 7. | 5.2.1   | Added FillOrder=1 and clarified Profile J       |
|    |         | reader requirement to support both LSB and MSB  |
|    |         |                                                 |
|    |         | Rational: FillOrder=2 constraint was a result   |
|    |         | of fax JBIG (T.85 ) constraint. However, base-  |
|    |         | line TIFF 6.0 defines FillOrder=1 as default,   |
```

```
|    |          | additionally the other optional RFC2301 profiles|
|    |          | support both 1 and 2. Addition of FillOrder=1   |
|    |          | was made because it is reasonable that an image |
|    |          | with source other than a fax device may use 1.  |
|    |          | Functionality of FillOrder=1 was verified       |
|    |          | during interoperability testing.                |
+----+----------+-------------------------------------------------+
| 8. | 6.2.1    | Constrained ResolutionUnit to 2 (i.e. inch) for |
|    | 7.2.1    | all color profiles, per ITU-T Recommendations   |
|    | 8.2.1    |                                                 |
+----+----------+-------------------------------------------------+
| 9. | 7.1.1    | Added text explaining use of color palette in   |
|    | 7.2.1    | T.43 image data stream                          |
|    | 7.2.2    |                                                 |
+----+----------+-------------------------------------------------+
| 10.| 7.1.1    | Changed BitsPerSample values in Table to agree  |
|    |          | with Sections 7.2 and 7.4 and Annex A           |
+----+----------+-------------------------------------------------+
```

```
+----+----------+-------------------------------------------------+
| 11.| 7.2.1    | Deleted ColorMap field (see No. 9); it was      |
|    | 7.4      | superfluous and re-encoded the color palette    |
|    | Annex A  | already in the T.43 data stream                 |
|    |          |                                                 |
|    |          | Rational: ColoMap was included because TIFF 6.0 |
|    |          | uses it in the interpretation of palette values.|
|    |          | The T.43 standard referenced for Profile L      |
|    |          | palette representation, however, requires the   |
|    |          | palette interpretation information to be         |
|    |          | included within the data stream. This results   |
|    |          | in the same information being provided in two    |
|    |          | locations. The ColorMap field was deleted to    |
|    |          | remove duplication and a potential error source.|
|    |          | Interoperability between implementations using  |
|    |          | and those not using ColorMap field was verified.|
+----+----------+-------------------------------------------------+
| 12.| 7.2.2    | Changed TAG value of Indexed field from 364 to  |
|    |          | 346 to agree with Section 8.2.2 and Reference   |
|    |          | [TTN1]                                           |
+----+----------+-------------------------------------------------+
| 13.| 8.1.1    | Clarified text describing example and use of    |
|    |          | overlapping IFDs                                 |
+----+----------+-------------------------------------------------+
| 14.| 8.1.2    | Clarified text describing TIFF representation    |
|    |          | of RFC model; updated example of TIFF file      |
|    |          | structure and recommended one.                  |
|    |          |                                                 |
```

```
| |    |         | Rational: There are three possible ways to    |
| |    |         | reference the image layers that are part of the|
| |    |         | Profile M file structure. Based on            |
| |    |         | interoperability test results the decision was|
| |    |         | made to designate generation of just one,     |
| |    |         | maximizing interoperability. Readers are still|
| |    |         | recommend to process all.                     |
| +----+---------+-----------------------------------------------+
| | 15.| 8.2.1   | Added text clarifying the use of ImageWidth    |
| |    |         | when Background or Foreground layer is Primary |
| |    |         | IFD                                           |
| +----+---------+-----------------------------------------------+
```

```
     +----+---------+-----------------------------------------------+
     | 16.| 8.2.1   | Added Compression=1 for LayerBaseColor IFDs    |
     |    |         |                                               |
     |    |         | Rational: Uncompressed data, Compression=1, is |
     |    |         | not permitted in facsimile representation due to|
     |    |         | bandwidth implications. Profile M uses a base  |
     |    |         | colour value to represent regions of constant  |
     |    |         | colour. Compression of base colour regions is  |
     |    |         | not necessary because a single colour value    |
     |    |         | rather than a bitmap is used to represent them. |
     |    |         | The addition of Compression=1 is therefore     |
     |    |         | appropriate for LayerBaseColor IFDs.           |
     +----+---------+-----------------------------------------------+
     | 17.| 8.2.1   | Added StripByteCounts (from Sec. 2.2.1) and    |
     |    |         | added text drawing attention to  the cases in  |
     |    |         | which it can have 0 value                     |
     +----+---------+-----------------------------------------------+
     | 18.| 8.2.2   | Changed text to note XPosition and YPosition do|
     |    |         | not have default values                       |
     +----+---------+-----------------------------------------------+
     | 19.| 8.2.3   | Changed field name from DefaultImageColor to   |
     |    |         | LayerBaseColor, tracking change in ITU-T Rec.  |
     |    |         | T.44; TAG value and field use unchanged; added |
     |    |         | text and example clarifying use of            |
     |    |         | LayerBaseColor                                |
     |    |         |                                               |
     |    |         | Rational: Rec. T.44 changed the name, used to  |
     |    |         | reference the colours of constant colour       |
     |    |         | regions, from DefaultImageColor to            |
```

|     |         | LayerBaseColor. The change avoids confusion  |
|     |         | with the default value, which would be assigned |
|     |         | in the event that a colour value was not      |
|     |         | specified. The change clarifies reference to  |
|     |         | the default colour of the LayerBaseColor.     |
+----+---------+----------------------------------------------+
| 20.| 8.2.3   | Added text clarifying use of ImageLayer[1]   |
|    |         | value, per 8.1.1                             |
+----+---------+----------------------------------------------+
| 21.| 8.4     | Added text clarifying Rule 7 describing       |
|    |         | correspondence between T.44 stripes and Profile |
|    |         | M strips and IFDs, per 8.1.1                 |
+----+---------+----------------------------------------------+
| 22.| 12      | Updated authors addresses and phone numbers  |
+----+---------+----------------------------------------------+
| 23.| Annex B | Deleted reference to TIFFPLUS                 |
+----+---------+----------------------------------------------+