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Information technology — Mixed Raster Content (MRC)

Technologies de l'information — Contenu des rasters-multiples (MRC)

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 16485 was prepared by the International Telecommunication Union (ITU) (as ITU-T Recommendation T.44) and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

Annex A forms a normative part of this International Standard.

Introduction and background

The Mixed Raster Content (MRC) Recommendation is a way of describing raster-oriented (scanned and/or rasterized synthetic images) documents with both bi-level (text and/or line-art) and multi-level (colour/continuous-tone) data within a page. The goal of this MRC Recommendation is to make exchange of raster-oriented mixed content colour documents among users with varied communication systems possible with higher speed, higher image quality and modest computing resources (memory, storage and processing power).

The dramatic increase in exchange of electronic documents has raised customer expectations and requirements for raster-oriented documents. Colour must be exchanged just as graceful and efficiently as black & white (bi-level) and quickly reproduce a copy of the original at the best possible image quality for that output device. The following technical relations can be associated with the customer requirements:

- efficient exchange of the raster data is directly related to the file size and compression ratios;
- image quality in a scan anywhere - print anywhere environment is directly related to the exchange of device independent data forms and the rendering compromises made by the output engine;
- fast printing with modest resources is related to low complexity of the format.

The best approach to achieve high compression ratios and retain quality is to compress the different segments of the raster data according to their individual attributes. Text and line-art data (bi-level data) would be compressed with an approach that puts high emphasis on maintaining the detail and structure of the input. Pictures and colour gradients (multi-level data) would be compressed using an approach that puts a high emphasis on maintaining the smoothness and accuracy of the colours. These different data types (bi-level and multi-level) are often conceptualized as being on separate layers/planes within the page.

This separation of the data by importance of content (spatial detail vs. colour) also directly implies that it is advantageous to use different resolutions for the different data, with a high spatial resolution used for text/line-art and high colour resolution for images/gradients.

This concept of data separation by importance of content has led to development of the base mode 3-layer model on which the MRC Recommendation is built. Provisions to extend the model beyond the base mode are defined in Annexes to this Recommendation. The base mode 3-layer model identifies three basic data types that may be contained within a page. These are multi-level data associated with contone colour (continuous-tone and/or palletized colour) image for which mid-to-low spatial and high colour resolution is typically appropriate for good reproduction; bi-level data associated with high detail of text/line-art for which high spatial and low colour resolution is typically appropriate for good reproduction; multi-level data associated with multi-level colours of the text/line-art data for which mid-to-high spatial and mid-colour resolution is typically appropriate for good reproduction. Each page within the MRC model is processed independently. The data types within each page are represented in distinct layers (also referred to as planes) to be image processed, compressed and transmitted independently. Multi-level contone data may be represented in the lower layer, bi-level in the middle layer and multi-level data of text/line-art colours in the upper layer. The lower and upper layers will from here on be referenced as the background and foreground layers respectively, see Figure 1. The process of image regeneration is controlled by the middle bi-level layer that acts as a mask or selector to select whether pixels from the background contone layer or foreground text/line-art colour layer will be reproduced. Due to its selection function this layer is referenced as the mask or selector layer, throughout this Recommendation the middle layer will be referenced as the mask layer. When the value of a mask layer pixel is one (1), the corresponding pixel from the foreground is selected and reproduced. When the value of the mask layer pixel is zero (0) the corresponding pixel from the background is selected and reproduced, see Figure 2.

Given limited device memory in many facsimile implementations and that mixed content pages often have a mixture of: text/line-art (monochrome or coloured) regions; contone image regions; text/line-art (monochrome or coloured) and contone image regions. There are provisions to subdivide the page into horizontal stripes that span the entire width of the page and isolate individual regions, see Figure 3. Stripes are composed of one or more layers as determined by the image type within the stripe. The mask layer must span the entire width and height of the stripe. The background and foreground layers need not span the width and height of the stripe. Reduction in the amount of white space coded in the background or foreground layers can be realized by taking advantage of the image width and height data included in the layer data stream and a horizontal and vertical offset provision. The default of the foreground base colour is black (layer base colour can be changed to any colour). The base colour is defined such that at mask pixel locations (value = 1) where a corresponding foreground pixel is not present, the foreground layer base colour is applied. The default of the background base colour is white (layer base colour can be changed to any colour). The base colour is defined such that at mask pixel locations (value = 0) where a corresponding contone image is not present, the background layer base colour is applied, see Figure 4.

The 3-layer model has 3 types of horizontal stripes that are implemented according to the type of data being addressed:

- 3-layer stripe (3LS), so referenced since it contains all three of the foreground, mask and background layers as in Figure 1. The 3LS is appropriate when addressing an image that contains both multi-coloured text/line-art and contone image or monochrome text/line-art on coloured background and contone image, as in stripes 3 and 5 of Figures 3 and 8;
- 2-layer stripe (2LS), so referenced since it contains coded data for two of the three layers (the third is set to a fixed value). The two layers may be mask and background, as in Figure 6a or mask and foreground layers, as in Figure 6b. All combination of multiple layers shall include the mask layer. The 2LS is appropriate when addressing an image that contains monochrome text/line-art and contone image or coloured text/line-art and no contone image, as in stripes 2 and 7 of Figures 3 and 8;
- 1-layer stripe (1LS), so referenced since it contains coded data for only one of the three layers (the other two are set to fixed values). The one layer may be mask, as in Figure 7a, background, as in Figure 7b or foreground, as in Figure 7c. The 1LS is appropriate when addressing an image that contains one of monochrome text/line-art, contone image or possibly richly coloured graphics, as in stripes 1, 4 and 6 of Figures 3 and 8.

Figure 8 provides an illustration of the various stripe types that may apply to the various image regions within a page.

The 3-layer model requires application of a multi-level coding scheme to the background and foreground layers. Any ITU multi-level coding (such as JPEG or JBIG, as defined in Recommendation T.81 and T.43, respectively) may be used for the background or foreground. A bi-level coding scheme is required for the mask layer, any ITU bi-level coding (such as JBIG or MMR, as defined in Recommendations T.85 and T.6, respectively) may be used, see Figure 5. The specific coders used throughout the page and over the various layers are identified at the start of each page. This information is provided by parameters in a Start of Page (SOP) Marker Segment. The spatial resolution of the mask layer, to be used throughout the page, is also identified by a SOP parameter. Layers with varied spatial resolutions may be combined within a stripe, the resolution of the foreground and background layers must be integral factors of the mask resolution layer, see Figure 5. The specific resolutions being used in the foreground and background layers are identified within a marker segment at the start of each layer within a stripe. A Start of Stripe marker segment contains parameters indicating type of stripe (1LS, 2LS or 3LS), the foreground and background layer base colour, offset of the foreground and/or background, the stripe height (number of lines) and the mask layer coded data length (number of octets).

An SOP marker segment denotes the beginning of an MRC page. This is followed by page data and terminated with a EOP (End of Page). The page data consists of stripes. During transmission, stripes are sent sequentially from the top of the page, stripe 1 through N, where N is an integer. Within a stripe, the mask layer is transmitted first, followed by the background and then the foreground as appropriate.

Information technology — Mixed Raster Content (MRC)

1 Scope

This Recommendation defines a means to efficiently represent raster-oriented pages that contain a mixture of multi-level and bi-level images. Any of the many ITU-T recommended encoding schemes, such as T.81 (JPEG) for the encoding of multi-level images and T.6 (MMR) for the encoding of bi-level images, may be combined within the context of this Recommendation. Similarly, ITU-T spatial and colour resolutions may be combined within a page. This Recommendation does not define new encodings or resolutions. The method of image segmentation is beyond the scope of this Recommendation, segmentation is left to manufacturers' implementation.

2 References

The following ITU-T Recommendations, and other references contain provisions, which through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendation and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendation and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation T.4 (1996) - *Standardization of Group 3 facsimile terminals for document transmission.*

– CCITT Recommendation T.6 (1988) - *Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus. (Commonly referred to as MMR standard.)*

– ITU-T Recommendation T. 42 (1996) - *Continuous-tone colour representation method for facsimile*.

– ITU-T Recommendation T.43 (1997) - *Colour and gray-scale image representation using lossless coding scheme for facsimile.*

– CCITT Recommendation T.81 (1992) | ISO/IEC 10918-1:1994 - *Information technology - Digital compression and coding of continuous-tone still image - Requirements and guidelines. (Commonly referred to as JPEG standard.)*

– ITU-T Recommendation T.82 (1993) | ISO/IEC 11544:1993 - *Information technology - Coded representation of picture and audio information - Progressive bi-level image compression. (Commonly referred to as JBIG standard.)*

– ITU-T Recommendation T.86 (1998) | ISO/IEC 10918-4:1999 - *Information technology - Digital compression and coding of continuous-tone still images: Registration of JPEG profiles, SPIFF profiles, SPIFF tags, SPIFF colour spaces, APPN markers, SPIFF compression types and Registration Authorities (REGAUT).*

– ITU-T Recommendation T.85 (1995) - *Application profile for Recommendation T.82 - Progressive bi-level image compression (JBIG coding scheme for facsimile apparatus).*

3 Definitions

The definitions contained in Recommendations T.4, T.6, T.42, T.43, T.81, T.82 and T.85 apply, unless explicitly amended.

APP13 Marker: Encoded as X'FFED', is the application marker, registered per Recommendation T.86, that uniquely identifies MRC.

End of page (EOP), encoded as two consecutive JPEG EOI (X'FFD9FFD9').

Joint Bi-level Image Experts Group (JBIG), and also shorthand for the encoding method, described in Recommendation T.82, which was defined by this group.

NOTE - It is expected that JBIG will be changed to JBIG1 when referencing Recommendation T.82. This nomenclature change is the result of a new standard that is being developed by the JBIG committee. This new standard will be referenced as JBIG2.

Joint Photographic Experts Group (JPEG), and also shorthand for the encoding method, described in Recommendation T.81, which was defined by this group.

layer: An image, either multi-level or bi-level, that is to be combined with other images using the method described here. Layers are encoded using ITU-T coding methods. One or more layers may be used.

background layer: The "bottom" layer (layer 1), multi-level data associated with a contone image segment, in a 3-layer segmentation of a page containing a combination of bi-level and multi-level images.

At background pixel locations where the contone background image is not present, a background layer base colour (default of white) is applied. A means to define other values of background layer base colour is provided within the syntax described in clause 9.

contone layer: Continuous-tone and/or palletized colour. This definition is intended to account for both scanner and synthetic source image data. When a scanner is the source of an image, both continuous-tone and solid coloured images would be available as continuous-tone data. When the source of an image is synthetic, continuous-tone and solid coloured images may be available as continuous-tone or palletized colour data.

foreground layer: The "top" layer (layer 3), multi-level data associated with colours of text, graphics or line-art, in a 3-layer segmentation of a page containing a combination of bi-level and multi-level images.

At foreground pixel locations where the multi-level data associated with colours of text, graphics or line-art is not present, a foreground layer base colour (default of black) is applied. A means to define other values of foreground layer base colour is provided within the syntax described in clause 9.

image layer: Odd-numbered layer (e.g. layers 1, 3, 5, …), multi-level data associated with contone images, colours of texts, graphics or line-art, in a multi-layer segmentation of a page containing a combination of bi-level and multi-level images.

At image layer pixel locations, above layer 1, where the image is not present, a layer base colour, default of black, is applied. At layer 1 pixel locations where the image is not present, a layer base colour, default of white, is applied. A means to define other layer base colour values is provided within the syntax described in clause 9.

mask layer: Even-numbered layers (i.e. layers 2, 4, 6, …), bi-level data, in a multi-layer segmentation of a page containing a combination of bi-level and multi-level images. The bi-level mask layer selects the image layer directly above it or the image(s) below it to be visible. A corresponding image layer pixel above the mask layer is selected for reproduction when a mask layer pixel value is "1". A corresponding pixel from the image or collection of images below the mask is selected when a mask pixel value is "0".

The first mask layer (layer 2) may be distinguished as the main mask. The main mask selects the foreground or background to be visible. In a 3-layer segmentation it is simply referenced as the mask layer. When there is more than one mask layer, the other mask layers (layers 4, 6, 8, …) may be referenced as the overlay masks.

Virtual mask layer: Even-numbered layer (i.e. layers 2, 4, 6, …) that contains no coded data. A virtual mask layers is used to establish dimensions of a page or stripe when there is no coded mask layer that spans the full dimensions of the page or stripe.

Modified Huffman (MH), is shorthand for the lossless bi-level one-dimensional encoding method described in Recommendation T.4.

Modified Modified READ (MMR), (READ is an acronym for Relative Element Address Designate) is shorthand for the lossless bi-level encoding method described in Recommendation T.6.

Modified READ (MR), (READ is an acronym for Relative Element Address Designate) is shorthand for the lossless bi-level two-dimensional encoding method described in Recommendation T.4.

MRC Magic Number: MRC Magic number, encoded as the JPEG SOI (Start of Image - X'FFD8') to alert decoders that JPEG application markers registered per Recommendation T.86 follow.

Start of page marker segment (SOP), encoded as APP13 (X'FFED'), length of segment, SOP ident (MRC0), parameters.

Start of stripe marker segment (SOSt), encoded as APP13 (X'FFED'), length of segment, SOSt ident (MRC1), parameters.

Stripe: An image swath, spanning the width of the page, that may consist of one or more layers.

Termination Number (TN), encoded as the JPEG EOI (End of Image - X'FFD9') to alert decoders to the end of the initial JPEG application marker registered per Recommendation T.86. The TN is located directly after the SOP parameters.

4 Conventions

The conventions in Recommendation T.81 apply to this Recommendation.

5 Image representation

This Recommendation includes description of syntax for encapsulating one or more ITU-T encodings on a single page.

A page is composed from a set of page-wide stripes of image data, which are coded independently. The stripes are transmitted sequentially from the top to the bottom of the page.

In the base mode, stripes are composed of one to three (3) layers. Each layer is coded using a recommended ITU-T coding method. The base mode is mandatory and must be supported by all future modes. All future modes should support all previously defined modes unless specified otherwise.

Information required to decode the page, such as coding types used within the layers, is specified within the page header (start of page marker segment). Stripe height is specified within the stripe header (start of stripe marker segment).

Information required to decode a layer is included in the stripe header and the layer data.

In the base mode, the mask layer is transmitted first, followed by the background layer and then the foreground layer.

Details of the syntax are described below.

6 Stripe structure

In the base mode, stripes are composed of one to three layers; background layer, mask layer and foreground layer. Annex A to this Recommendation makes provision for stripes to be composed of more than three layers. One or more layers may be assigned a fixed value (e.g. fixed colour value). Virtual mask layers and fixed value layers are not counted in classifying the stripe types as follows:

- Three-layer stripe: (3LS).
- Two-layer stripe: (2LS).
- One-layer stripe: (1LS).

6.1 Three-layer stripe (3LS)

3LS is the basic structure of this Recommendation. The 3LS contains foreground, mask and background layers, see Figure 1 and stripes 3 and 5 of Figure 8. It provides a means to transfer two images and a bi-level mask layer describing their recombination on the same page. This capability enables representation of richly coloured text, graphics, and line-art together with contone imagery in the same region using only multi-level and bi-level coding methods. It also enables representation of monochrome or coloured text, graphics, and line-art that resides on a coloured background together with contone image in the same region. The text/line-art colour is placed in the foreground layer and the contone image in the background layer. The bi-level mask plane is used to select which of the images is expressed at every pixel location within the stripe. It may contain the high detail text shape or rectangular outlines of text and contone image areas.

6.2 Two-layer stripe (2LS)

2LS is one of the special cases of the 3LS, in which one of foreground or background layer is assigned a fixed colour value. The mask layer is mandatory in the 2LS stripe. The 2LS contains mask and background or mask and foreground layers. For the case of mask and background, the foreground is set to a layer base colour value (e.g. black), see Figures 6a and stripe 2 of Figure 8. It provides a means to transfer a continuous-tone image, a layer base colour value and a bi-level mask layer describing their recombination on the same page. This capability enables representation of monochrome text, graphics, and line-art together with contone imagery in the same region using only multi-level and bi-level coding methods. The monochrome text/line-art may overlay the coloured image. The text/line-art colour is represented by the fixed foreground value while the contone image is in the background layer. The bi-level mask plane is used to select which of the foreground layer base colour or the background images is expressed at every pixel location within the stripe. The mask contains the high detail shape of text, graphics or line-art. For the case of mask and foreground, the background is set to a layer base colour value (e.g. white), see Figures 6b and stripe 7 of Figure 8. It provides a means to transfer a colour foreground image, a background layer base colour value and a bi-level mask layer describing their recombination on the same page. This capability enables representation of coloured text, graphics, and line-art without contone imagery in the same region using multi-level and bi-level coding methods. The bi-level mask plane is used to select which of the foreground or the background images is expressed at every pixel location within the stripe.

6.3 One-layer stripe (1LS)

1LS is one of the special cases of the 3LS, in which two of the three layers are assigned a fixed value (e.g. fixed colour value in the case of fixed foreground or background layer). The 1LS contains a single coded layer. If the layer is coded using a bi-level coding method, the fixed foreground and background base layer colour values, defined within the stripe, are applied; a bi-level image is treated as a mask layer, see Figures 7a and stripe 1 of Figure 8. A page containing a single bi-level 1LS, where the foreground and background colours are the values of black and white respectively, is similar to a conventional bi-level facsimile page, see Figure 7a. There are two cases if the coding method is multi-level. Case 1: the mask is fixed to "0" (foreground colour is not applied) and the background layer base colour (e.g. white) is applied outside the area coded, see Figures 7b and stripes 4 and 6 of Figure 8. Case 2: the mask is fixed to "1" (background colour is not applied) and the foreground layer base colour (e.g. white in this case) is applied outside the area coded, see Figure 7c. To represent dimensions of pages that contain only case 1 or 2 stripe(s), where there is no coded mask data, a virtual mask layer should be assumed. The resolution of the virtual mask is fixed to that of the foreground or background layer while the dimensions of the virtual mask is fixed to the page dimensions, such as page width and height (number of scan lines). The width of the stripe is fixed to the page width. It is possible in cases 1 and 2 that the foreground or background layers may contain a fixed colour value (e.g. a layer base colour value), in effect there is no encoded colour data.

The 1LS is applied to areas containing only monochrome text, graphics (e.g. business graphics)/line-art, or continuous-tone image data.

7 Image coding

7.1 Spatial resolution

The resolution of the main mask layer is fixed for the entire page and defines the maximum resolution for the page. In general it is possible to define foreground and background layers of lower spatial resolution. Spatial resolution of all layers must be integral factors of the main mask layer resolution. All resolutions used must be square (i.e. same horizontal and vertical values) and conform to ITU-T recommended values. The main mask resolution is specified in the page header. The foreground and background resolutions are indicated in the layer data.

7.2 Stripe width and layer width

Stripes always span the entire width of a page. The main mask layer must always span the entire width.

This method takes advantage of the image width and height data included in the layer data stream, such as JPEG. A foreground and/or background layer (e.g. JPEG data) is not required to span the entire width. All layers must be fully contained within the boundaries of the stripe. In addition, a horizontal offset may be used to select a starting point to the right of the left stripe boundary. This offset is expressed in the main mask layer pixel units. A simple stripe containing only background (e.g. JPEG data) or foreground (e.g. T.43 JBIG data) image data may use this feature also.

7.3 Stripe height and layer height

To limit the data that must be buffered by an application, some applications may choose to limit the maximum height of two or more layer stripes (2LS & 3LS) to a specified number of lines (in mask layer resolution).

One layer stripes (1LS) are not required to conform to a maximum stripe height, and are only limited by page size. Layers without coded data (i.e. virtual mask layers and image layers with only base layer colour) are not to be counted when considering whether a stripe is a 1LS, 2LS or 3LS stripe.

Stripe and main mask layer height is always equal. Foreground and background layer heights are less than or equal to stripe heights. All layers must be fully contained within the boundaries of the stripe. In addition, a vertical offset may be used to select a starting point below the first scan line of the stripe. This offset is expressed relative to the first scan line at the top of the stripe and in the main mask pixel units. A simple stripe containing only background (e.g. JPEG) or foreground (e.g. JBIG) data may use this feature also.

7.4 Layer combination

Image layers are rendered sequentially in ascending order of layer number (i.e. layer 1 then 3). The background layer (i.e. layer 1), if present, shall be rendered first. Bi-level mask layers (even-numbered layers, such as layer 2) select pixels from their corresponding image layer (odd-numbered layer directly above the mask layer, such as layer 3) for rendering. A corresponding image layer pixel (directly above the mask layer pixel) or its layer base colour value, is selected when a mask pixel value is "1". The selected image layer pixel is rendered on top of any layer that may have been previously rendered. A corresponding image layer pixel shall not be rendered when the mask pixel value is "0". The pixel from the layer below the mask, or its layer base colour value, shall remain visible when the mask pixel value is "0". In event of an image layer (i.e. layer 3), or portion thereof, without a corresponding mask layer, the image layer shall be rendered on top of any previously rendered layer.

8 Layer transmission order

In 3LS, the bi-level mask data is transmitted first, followed by the background layer and then the foreground layer. In 2LS, the bi-level mask image data is transmitted first, followed by the background or foreground layer.

9 Data format

9.1 Overview

The MRC image data consist of a series of: markers; parameter data that specify the image coder, image size, bit-resolution and spatial resolution; image data. The conventions of Annex B/T.81 are used broadly here. The JPEG registration body, per Recommendation T.86, has been used to register the marker code, APP13, classified as an application marker.

The MRC page structure for this application has the following elements: parameters, markers, and entropy-coded data segments. Parameters and markers are often organized into marker segments. Parameters are integers of length ½, 1, 2 or more octets. Markers are assigned two or more octet codes, an X'FF' octet followed by an octet not equal to X'00' or X'FF' and optionally preceded by extra X'FF' octet codes. This base mode application defines marker segments to denote the Start of Page (SOP), optional marker segments and the Start of Stripe (SOSt). The MRC Magic Number (JPEG SOI) is used immediately preceding the application marker as part of the SOP marker segment. The JPEG EOI is used as a termination number located directly after the last SOP parameter. The end of a page (EOP) is defined as X'FFD9FFD9'. These markers are inserted by the encoder, and understood by the decoder in addition to all markers used for the coding methods, such as SOS (start of scan) of Recommendation T.81.

9.2 Page data structure

The beginning of a MRC page is denoted by the Start of Page Marker Segment, followed by termination number, optional marker segments, page data, and EOP. The optional marker segments are optional, unless otherwise stated. Their purpose is to provide insight into reproduction of the image and as such are typically not mandatory for image reproduction. Skipping of any unrecognized optional marker segment is appropriate. Page data consists of stripes 1 to N, as described in 9.2.1.

9.2.1 Start of page marker segment

Start of Page Marker Segment has the following structure:

MRC Magic Number, APP13, Length of segment, SOP ident, version, mask coder, image layer coders, mask resolution, width.

The Start of Page Marker Segment is defined as follows:

MRC Magic number:	2 octets	X'FFD8'
APP13 Marker:	2 octets	X'FFED'
Length of Segment:	2 octets	Length of segment in octets, MSB to LSB, as an integer value including the octet count itself but not including Magic Numbers or APP13.
SOP Ident:	4 octets	'MRC0', represented as a 3-octet ASCII string plus an hexadecimal count (i.e. X'4D',X'52',X'43',X'00'). This X'00'-terminated string "MRC" uniquely identifies this marker segment as the start of page.
Version:	1 octet	Revision number, X'00' indicating revision "0".
Mode:	1 octet	X'01', indicating mode 1.0. Each mode identifies a different level of performance. Mode 1.0 identifies the base level of ISO/IEC 16485 / Recommendation T.44 as defined by the contents of this Recommendation. Each incremental mode shall be defined in an Annex to this Recommendation and support the capabilities defined in this mode.

Mask layer coders:	1 or more octet(s)	with value indicating coder as shown in Table 1. The identified coders may be used in any mask layer. The main mask layer is the only mask (even-numbered) layer permitted in this mode (Mode 1.0) and only one coder may be selected. Only one coder shall be used for the main mask (layer 2). The value shall be fixed to zero "0" in the event that there is no mask layer coder (i.e. no coded mask layer data present).
Image layer coders:	1 or more octet(s)	with value indicating coders as shown in Table 2. The identified coders may be used in any image layer. Background and foreground are the only image (odd-numbered) layers permitted in Mode 1.0. Any one of the selected coder(s) may be used in an image layer. The value shall be fixed to zero "0" in the event that there is no image layer coder.
Main Mask resolution:	2 octets	expressing vertical and horizontal resolution as a single integer value in units of pels/25.4 mm. Basic value is 200 pels/25.4 mm. The value shall be fixed to that of the image layer in the event that there is no coded mask data (layer) in the page.
Page width:	4 octets	expressing page width as a single integer value. For pages with two or more layers, the main mask layer image width defines the page width using units of the main mask resolution. For pages with only a single layer foreground or background image, no coded mask data, a virtual mask (i.e. a mask layer without coded data) shall be used to define the page width.

TABLE 1/T.44

Mask (even-numbered layer) coder octet(s)

Octet bit number	Coder used
LSB 0	One dimensional T.4 (MH) coding
1	Two dimensional T.4 (MR) coding
2	T.6 (MMR) coding
3	T.82 (JBIG) coding applying Recommendation T.85
4	Reserved
5	Reserved
6	Reserved
MSB 7	Extend, add another octet that follows immediately

NOTE - New bi-level coders (i.e. a 5th, 6th and 7th coder) would be assigned bit numbers 4, 5 and 6 respectively. Bit 7, the extend bit, would be set when adding another octet to accommodate additional coders, such as an 8th which would be assigned to bit number 8.

TABLE 2/T.44

Image (odd numbered layer) coder octet(s)

Octet bit number	Coder used
LSB 0	T.81 (JPEG) coding
1	T.82 (JBIG) coding applying Recommendation T.43
2	Reserved
3	Reserved
4	Reserved
5	Reserved
6	Reserved
MSB 7	Extend, add another octet that follows immediately
NOTE - New multi-level coders (i.e. 3rd through 7th coder) would be assigned bit numbers 2 through 6 respectively. Bit 7, the extend bit, would be set when adding another octet to accommodate additional coders, such as an 8th which would be assigned to bit number 8.	

9.2.2 Optional marker segments

The optional marker segments are optional, unless otherwise stated. Their purpose is to provide insight into reproduction of the image and as such are typically not mandatory for image reproduction. Skipping of any unrecognized optional marker segment is appropriate.

Optional marker segments (OMSx) consist of marker and associated parameters. The APP13 marker initiates identification of the entry. Each optional marker segment is identified by the 3-octet ASCII string plus a hexadecimal count for 'MRCn'. The 'MRCn' identifier is a 4-octet value X'4D',X'52',X'43',X'n', where n equals X'0A' (10) to a maximum of X'FE' (254). The optional marker segments are located after the Termination Number (TN).

Each optional marker segment (OMSx) has the following structure:

App13 Marker (X'FFED'), Length of entry, OMSx ident (MRCn), entry data.

OMSx represents specific optional marker segments, where "x" is the value of a character used to distinguish each optional marker segment.

9.2.2.1 Layer base colour gamut range marker segment (OMSg), MRC10 entry

This entry specifies the gamut range information for indicating image layer (i.e. odd numbered layers such as background and/or foreground layers) base colour. Structure of the OMSg marker segment entry is as follows:

APP13, length, OMSg identifier, gamut range data.

The OMSg marker segment is defined as follows:

APP13 marker:	2 octets	X'FFED'
Length:	(2 octets)	Total entry field octet count, MSG to LSB, including the octet count itself, but excluding the APP13 marker.
OMSg identifier:	(4 octets)	'MRC10', represented as a 3-octet ASCII string plus an hexadecimal count (i.e. X'4D',X'52',X'43',X'0A'). This X'0A'-terminated string "MRC" uniquely identifies this entry marker as containing MRC information about optional gamut range data

		used to represent the layer base colour of the image layer in all stripes of the page.
Gamut range data:	(12 octets)	The data field contains six two-octet signed integers. For example the two octets signed integer X'0064' represents 100. The example gamut range L* = [0, 100], a* = [-85, 85], and b* = [-75, 125] would be represented by the code: X'0000', X'0064', X'0080', X'00AA', X'0060', X'00C8'.

The calculation from a real value L* to an eight bit value, L, is made as follows:

$$L = (255/Q) \times L^* + P,$$

where the first integer of the first pair, P, contains the offset of the zero point in L* in the eight most significant bits. The second integer of the first pair, Q, contains the span of the gamut range in L*. Rounding to the nearest integer is performed. The second pair contains offset and range values for a*. The third pair contains offset and range values for b*. If the image is gray-scale (L* only), the field still contains six integers, but the last four integers are ignored.

NOTE - This description of gamut range is similar to APP1 (G3FAX1) defined in ITU-T T.4 Annex E, except that 12 bit numbers are not defined.

9.2.2.2 Layer base colour illuminant marker segment (OMSi), MRC11 entry

This entry specifies the illuminant information for indicating image layer (i.e. odd numbered layers such as background and/or foreground layers) base colour. Structure of OMSi entry is as follows:

APP13, length, OMSi ident, illuminant data

This option is for further study with the exception of the default case; the specification of the default illuminant, CIE Illuminant D50, may be added for information.

The OMSi segment is defined as follows:

APP13 marker:	(2 octets)	X'FFED'.
Length:	(2 octets)	Total entry field octet, MSB to LSB, count including the octet count itself, but excluding the entry marker.
OMSi identifier:	(4 octets)	'MRC11', represented as a 3-octet ASCII string plus an hexadecimal count (i.e. X'4D',X'52',X'43',X'0B'). This X'0B'-terminated string "MRC" uniquely identifies this entry marker as containing MRC information about optional illuminant data for representing the layer base colour.
Illuminant data:	(4 octets)	The data consist of a four-octet code identifying the illuminant. In the case of a CIE standard illuminant, the four-octet code is one of the following:

- CIE Illuminant D50: X'00', X'44', X'35', X'30'
- CIE Illuminant D65: X'00', X'44', X'36', X'35'
- CIE Illuminant D75: X'00', X'44', X'37', X'35'
- CIE Illuminant SA: X'00', X'00', X'53', X'41'

– CIE Illuminant SC: X'00', X'00', X'53', X'43'
– CIE Illuminant F2: X'00', X'00', X'46', X'32'
– CIE Illuminant F7: X'00', X'00', X'46', X'37'
– CIE Illuminant F11: X'00', X'46', X'31', X'31'

NOTE - This description of illuminant is similar to APP1 (G3FAX2) defined in ITU-T T.4 Annex E, except the colour temperature alone is not allowed.

9.2.2.3 MRC3 to MRC9 and MRC12 to MRC254 entry for future extensions

The entries from MRC3 to MRC9 are to be reserved for future structural marker segments while MRC12 to MRC254 are to be reserved for other future use, such as optional marker segments, encoder marker segments (see Annex A/T.44) and reproduction information.

9.2.3 TN (Termination Number)

This is the JPEG EOI (End of Image) to alert decoders to the end of the initial JPEG application markers, registered per Recommendation T.86. The TN is located after the last SOP parameter (i.e. page width).

TN:	2 octets	X'FFD9'

9.3 Stripe data structure

The beginning of a stripe is denoted by the Start of Stripe Marker Segment, followed by stripe data.

The first layer represented is the mask layer, followed by the background layer, and next the foreground layer (as appropriate). When there are two or more layers, the mask layer shall always be one of them. In the case of background only pixel data, no mask or foreground pixel data, the mask shall be fixed to "0". In the case of foreground only pixel data, no mask or background pixel data, the mask shall be fixed to "1".

Start of Stripe Segment has the following structure:

APP13, Length of segment, SOSt ident, type of stripe, background layer base colour, foreground layer base colour, offset of background layer relative to upper left-hand pixel in the stripe, offset of foreground layer relative to upper left-hand pixel in the stripe, stripe height (number of lines), length of coded mask layer in number of octets.

In Mode 1 (base mode) all SOSt parameters must be present (i.e. layer base colour and offset values must be provided for both the foreground and background layers).

The Start of Stripe Marker Segment is defined as follows:

APP13 marker:		X'FFED'.
Length of Segment:	2 octets	Length of segment in octets, MSB to LSB, as a integer value not including APP13.
SOSt Ident:	4 octets	'MRC1', represented as a 3-octet ASCII string plus an hexadecimal count (i.e. X'4D',X'52',X'43',X'01'). This X'01'-terminated string "MRC" uniquely identifies this marker segment as the start of stripe.
Type of stripe:	1 or more octet(s)	with value indicating stripe type as shown in Table 3. The corresponding bit shall be set to "1" for each layer present. When there are ≥ 2 layers, the main mask layer must be one of the layers (bit 1 set to 1). A maximum of three layers may be present in this mode (Mode 1.0).

Background layer base colour:	3 octets	colour encoded using Annex E/T.4 and the layer base colour gamut range. The value is white X'FF', X'80', X'60' unless otherwise specified. If available, custom gamut range may be applied from the optional marker segments.
Foreground layer base colour:	3 octets	colour encoded using Annex E/T.4 and the layer base colour gamut range. The value is black X'00', X'80', X'60' unless specified otherwise. If available, custom gamut range may be applied from the optional marker segments.
Offset of background layer:	8 octets	horizontal offset, vertical offset as 2 integer values in mask layer units, as appropriate. Offsets are relative to stripe first scan line and left boundary.
Offset of foreground layer:	8 octets	horizontal offset, vertical offset as 2 integer values in mask layer units, as appropriate. Offsets are relative to stripe first scan line and left boundary.
Stripe height (lines):	4 octets	height of stripe as an integer value. For images with two or more layers, the main mask layer height defines the stripe height. For single layer images, a virtual mask layer height defines the stripe height.
Mask layer length (octets):	4 octets	coded length of the main mask layer as an integer value, when present. This value must be set to zero (0) when there is no coded mask data.

TABLE 3/T.44

Type of stripe

Octet bit number	Layer used
LSB 0	Background layer (layer 1)
1	Main mask layer (layer 2)
2	Foreground layer (layer 3)
3	Layer 4
4	Layer 5
5	Layer 6
6	Layer 7
MSB 7	Extend, add another octet that follows immediately

NOTE: Refer to Annex A of this Recommendation for stripes with 4 or more layers.

Layers above seven (7) would require an additional octet for representation. Bit 7, the extend bit, would be set when adding another octet to accommodate additional layer such as Layer 8 which would be represented by bit 8.

9.4 EOP (End of Page)

This End of Page code indicates the end of MRC page.

EOP: 4 octets X'FFD9',X'FFD9"

9.5 Layer data structure

Layers are coded using ITU-T coding methods indicated in the Start of Page Marker Segment. The coding method and resolution of the background and foreground layers are defined in the layer data. The resolutions of the background and foreground layers are restricted to ITU-T recommended values that must be integral factors of the main mask resolution. For example, if the mask resolution is 400 pels/25.4 mm, the background and foreground layer may each be either 100, 200 or 400 pels/25.4 mm.

9.6 Data format summary

9.6.1 High-level data format summary

SOP		**TN**	**OMSg**	**OMSi**	**Page data**								**EOP**
SOP marker	Para-meters	X"FFD9	OMSg marker	OMSi marker	Stripe 1					... ...	Stripe N		X'FFD9 FFD9'
X'FFD8', X'FFED', Length, MRC0	Version, Mode, ...		X'FFED, Length, MRC10	X'FFED, Length, MRC11	**SOSt**		Stripe data				**SOSt**	Stripe data	
			parameters	parameters	SOSt marker	Para-meters	Mask layer	B.G. layer	F.G. layer				
					X'FFED', Length, MRC1	Type, B. G. layer base colour, ...	(layer data)	(layer data)	(layer data)				

9.6.2 Detail data format summary

MRC Magic Number

SOP marker segment

APP13 marker

Length of Segment

MRC0 SOP identifier

- Version
- Mode
- Mask coder
- Image layer coder
- Mask resolution
- Page width

TN

Layer base colour gamut marker segments
App13
Length of Segment
MRC10 OMSg identifier
gamut range data
Layer base colour illuminant marker segments
App13
Length of Segment
MRC11 OMSi identifier
Illuminant data
OMSx (Optional marker segments)
App13
Length of Segment
MRCn (n = 12 - 254) OMSx identifier
optional maker segment data

Stripe 1
SOSt marker segment
APP13 marker
Length of Segment
MRC1 SOSt identifier
Type of stripe
Background layer base colour
Foreground layer base colour
Offset of background layer
Offset of foreground layer
Stripe height (lines)
Mask layer length (octets), when appropriate
Stripe data
Mask layer
Layer coded data ----------

Background layer
Layer coded data ----------

Foreground layer
Layer coded data ----------

Stripe 2
SOSt marker segment
APP13 marker

Stripe data
Mask layer
Layer coded data ----------

Background layer
Layer coded data ----------

Foreground layer
Layer coded data ----------

Stripe 3

Stripe N

EOP (X'FFD9', X'FFD9')

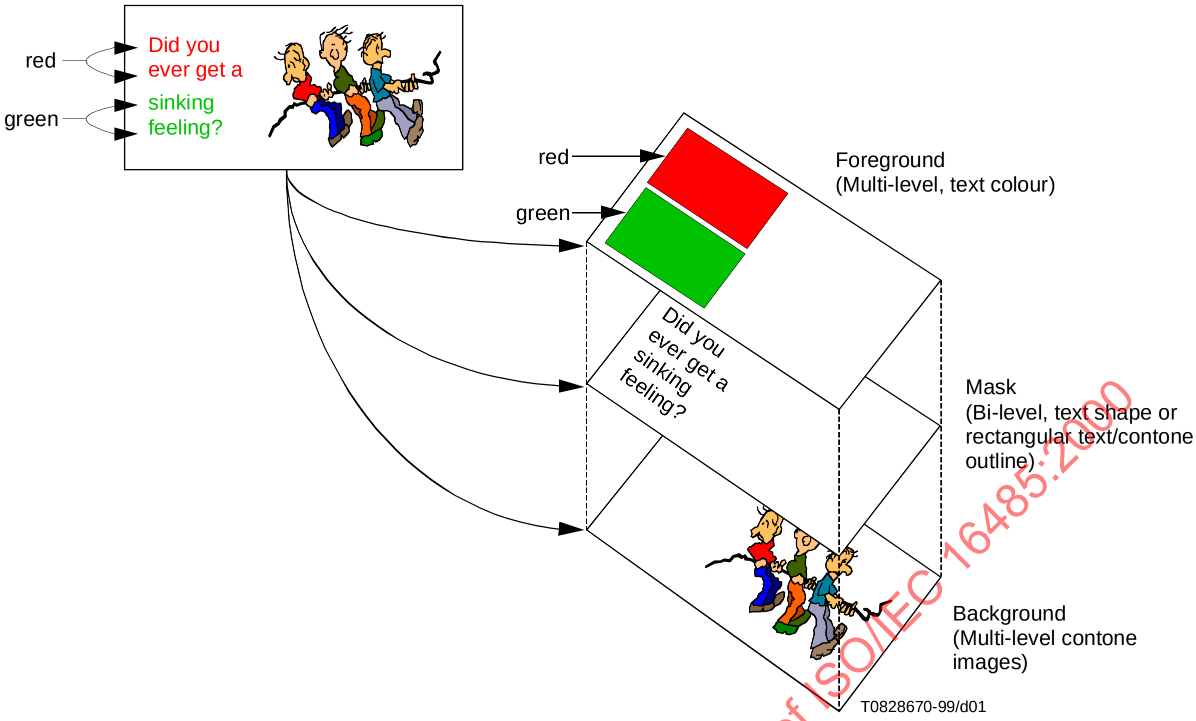

Figure 1/T.44

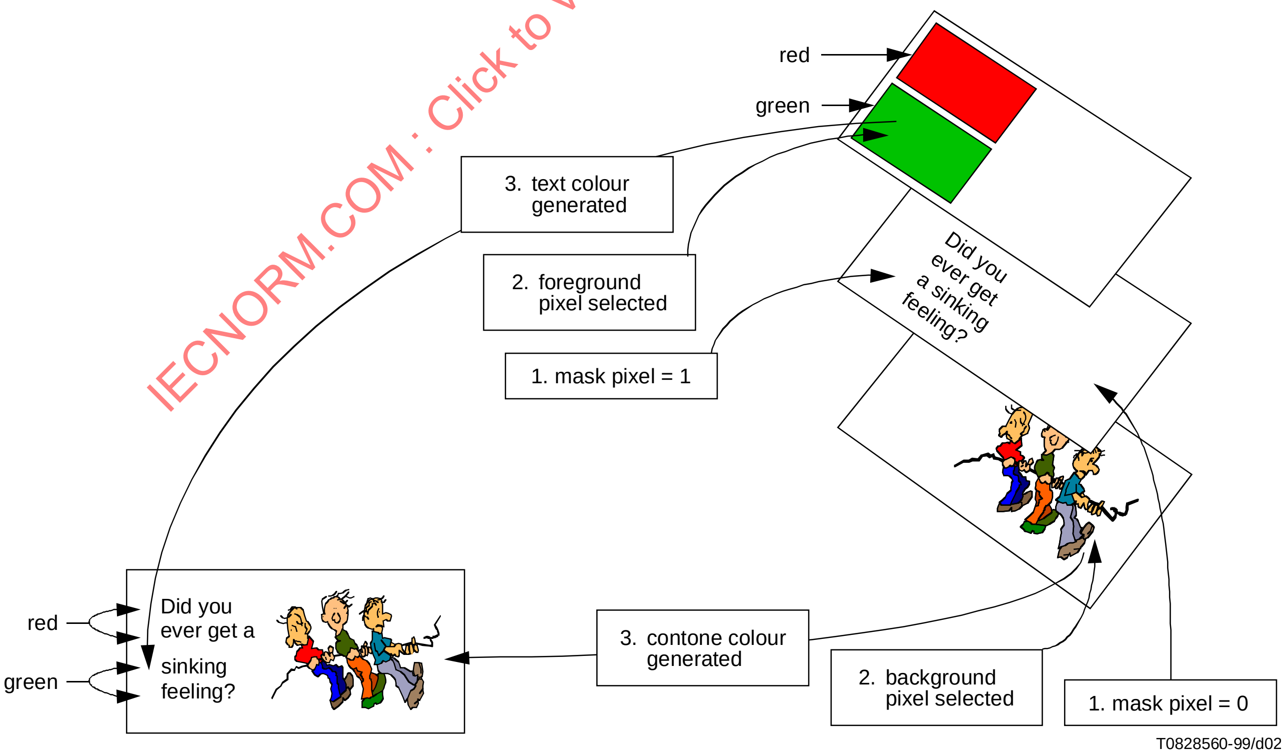

Figure 2/T.44

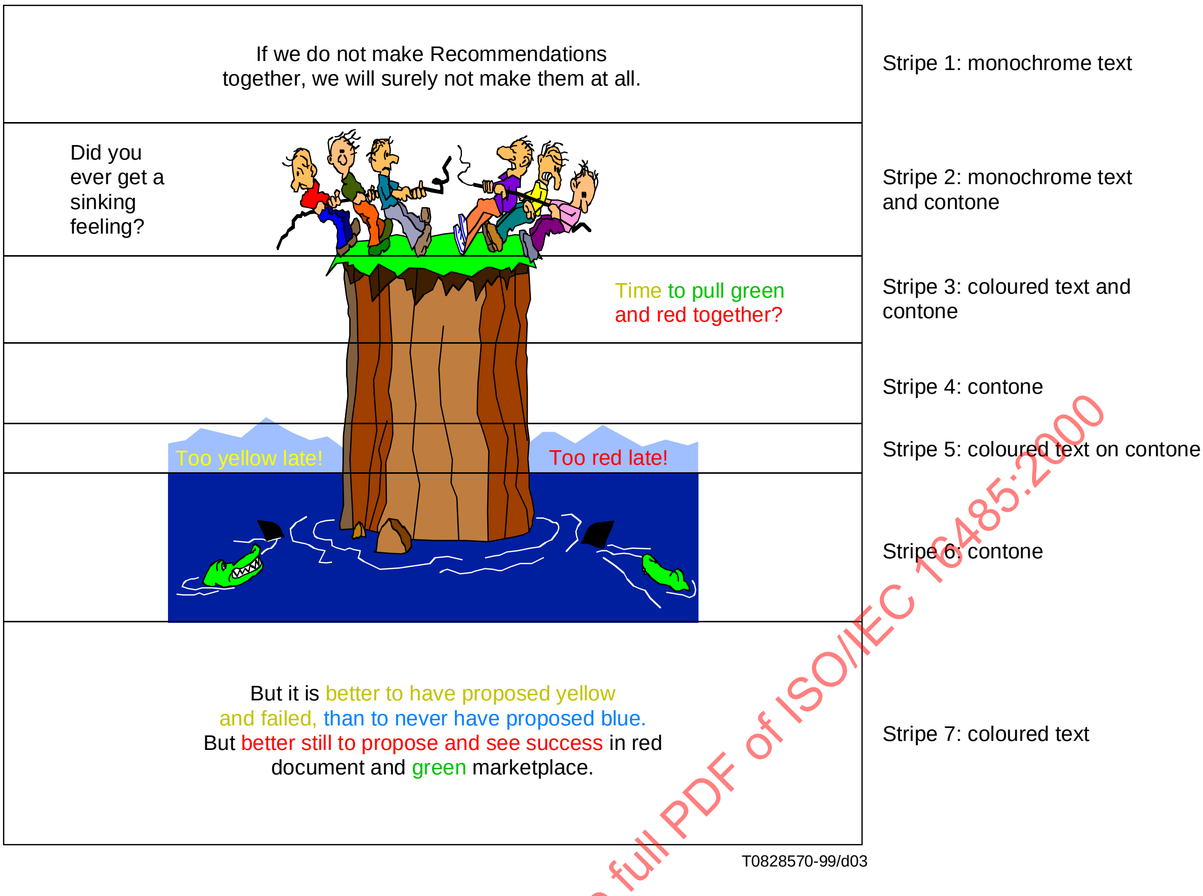

Figure 3/T.44

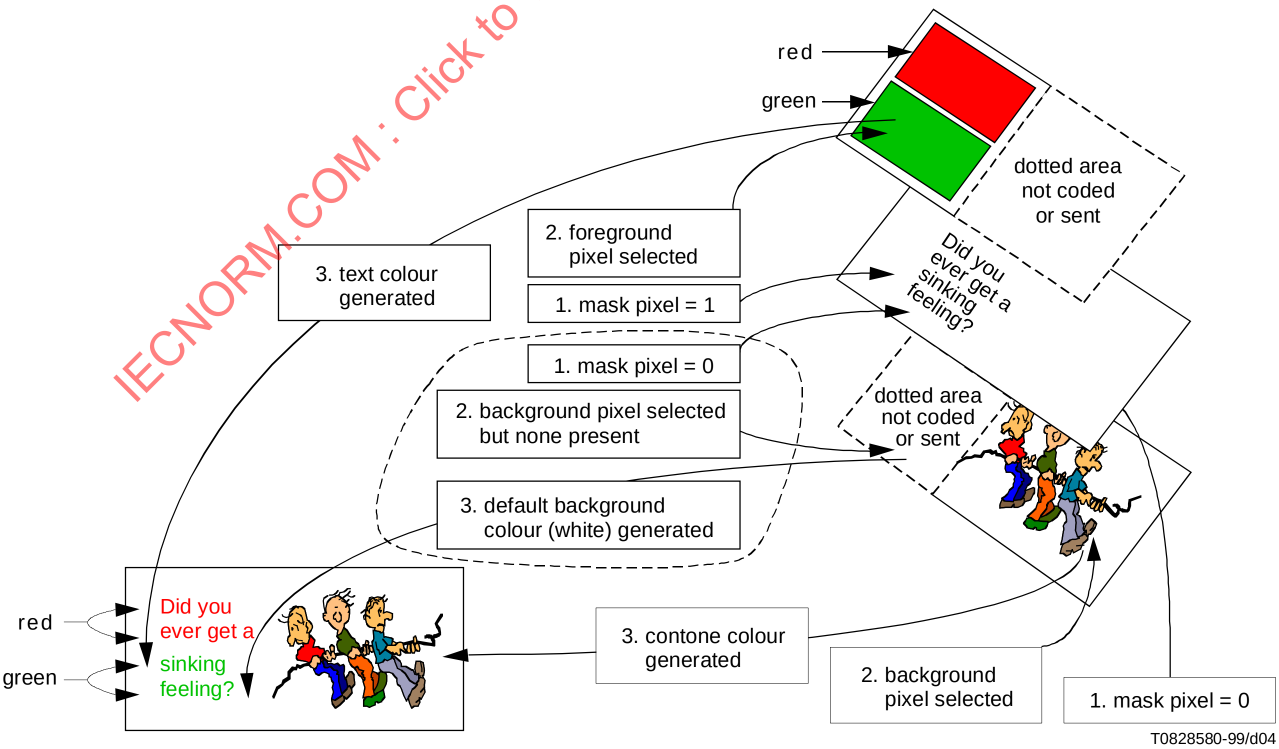

Figure 4/T.44

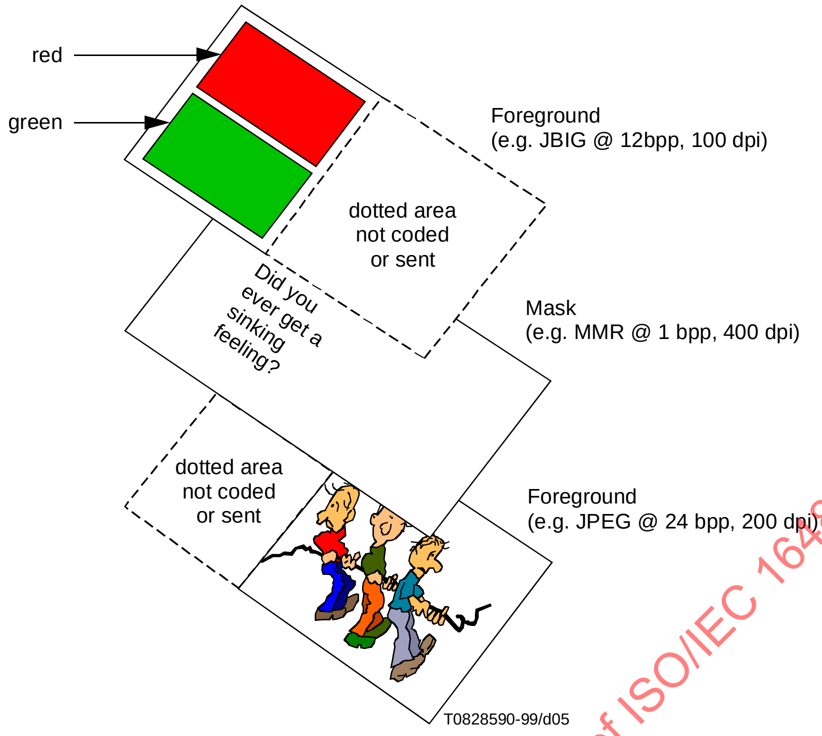

Figure 5/T.44

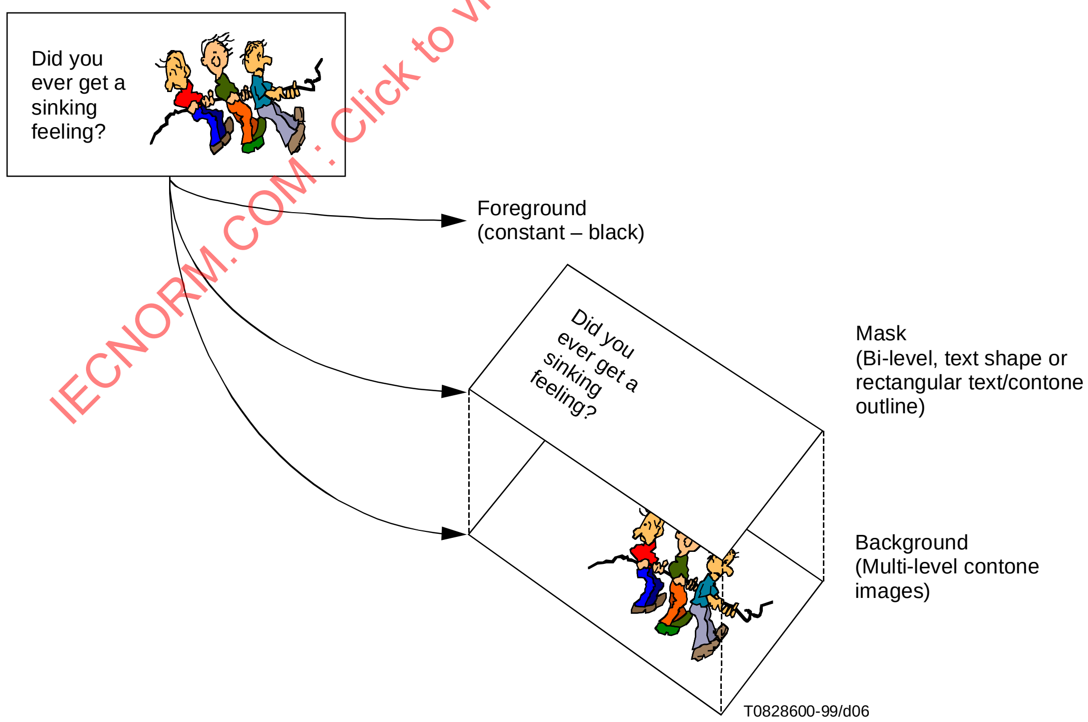

Figure 6a/T.44 – Mask and background

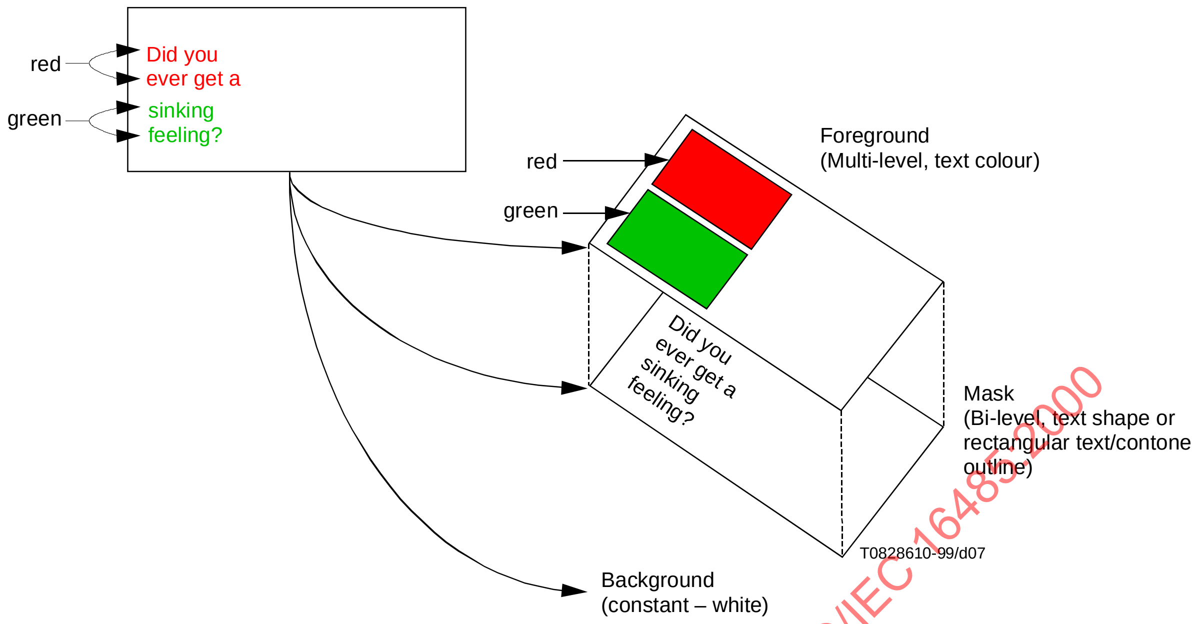

Figure 6b/T.44 – Mask and foreground

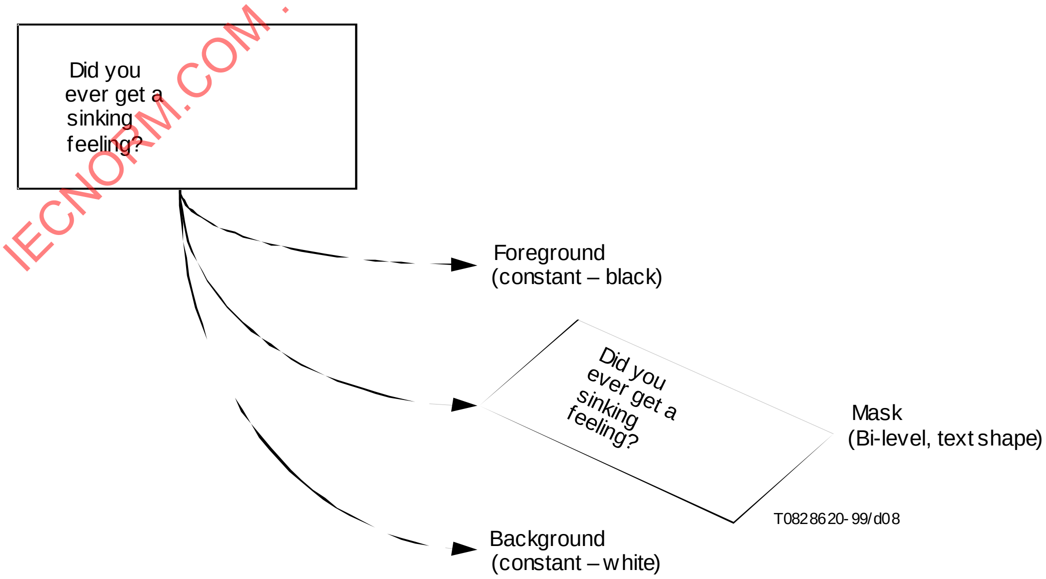

Figure 7a/T.44 – Mask

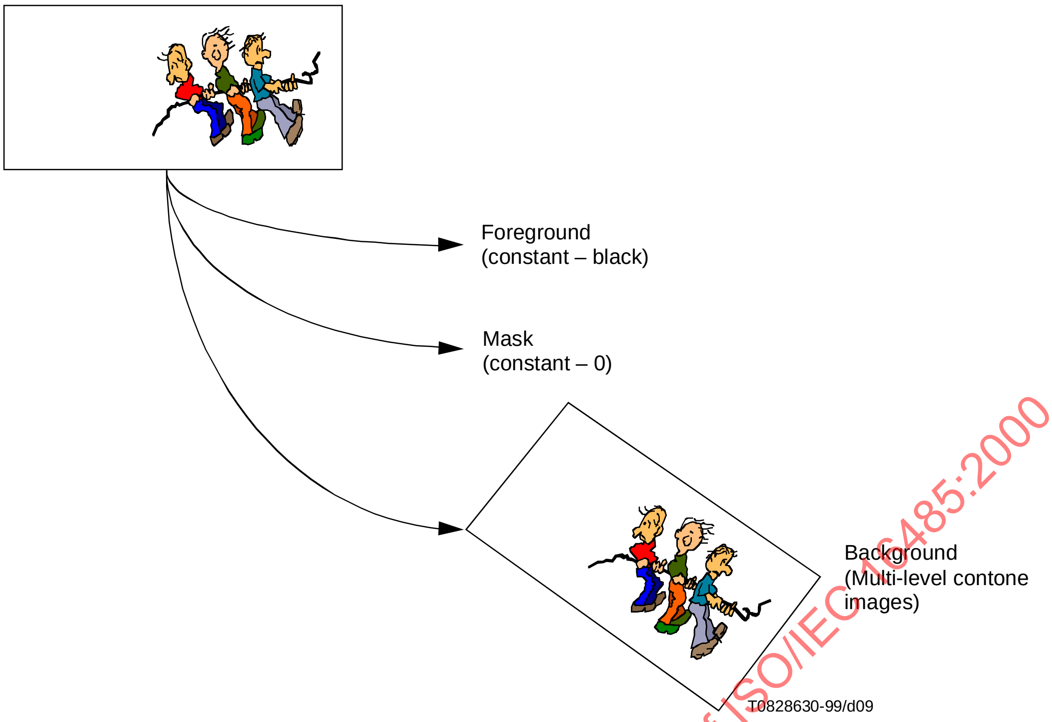

Figure 7b/T.44 – Background

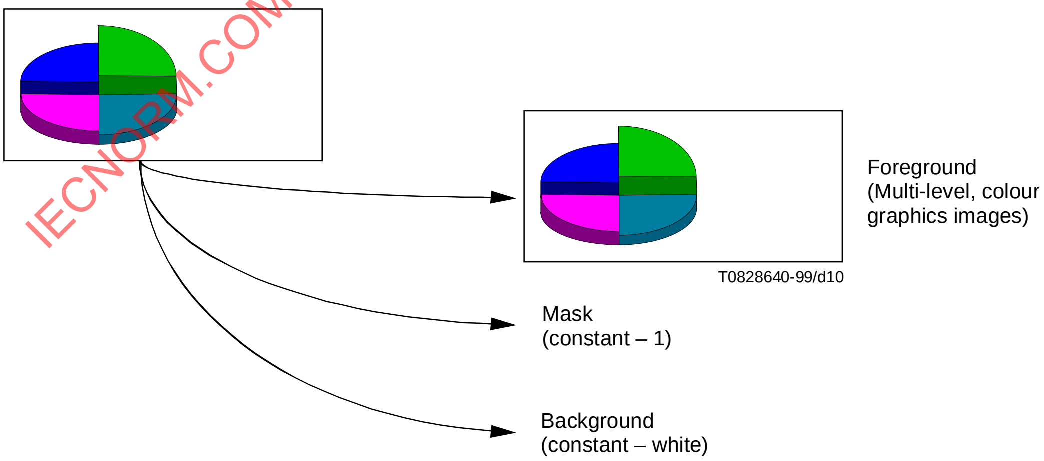

Figure 7c/T.44 – Foreground

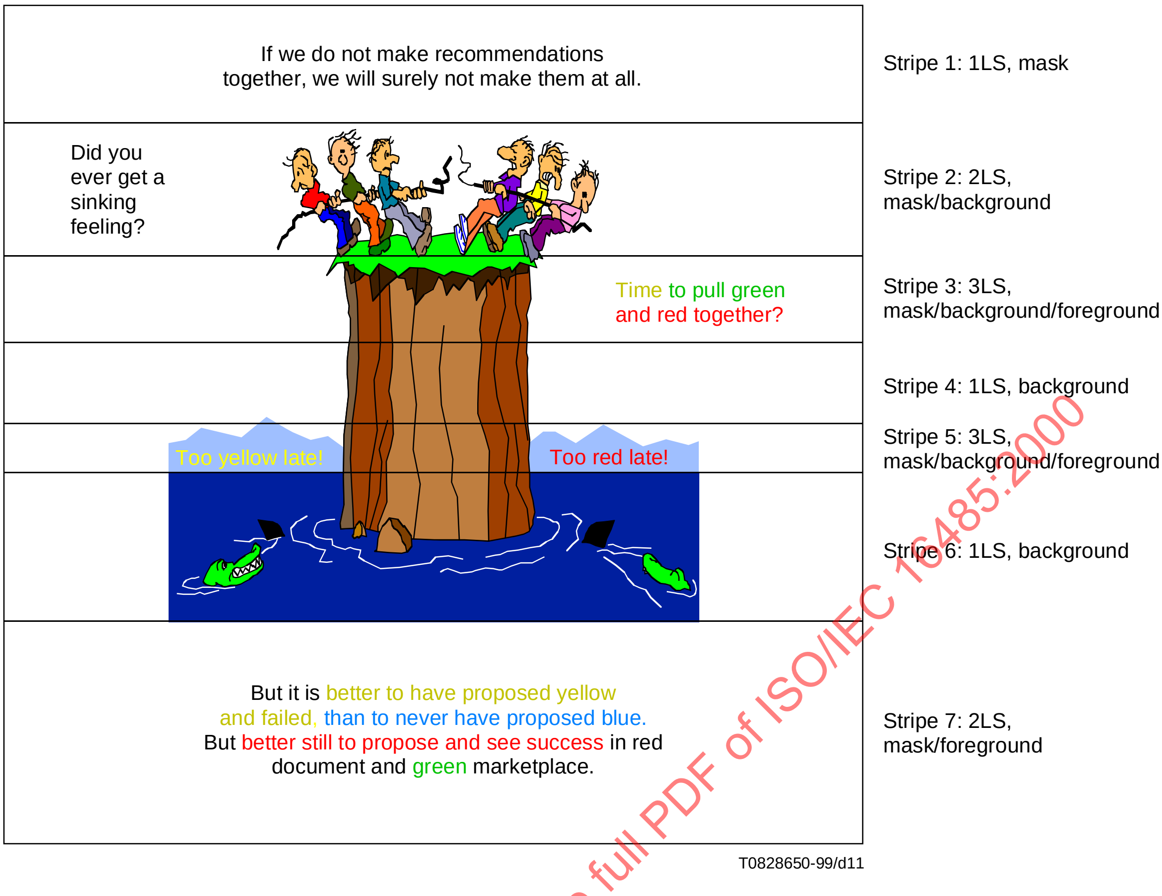
If we do not make recommendations together, we will surely not make them at all.
Stripe 1: 1LS, mask
Did you ever get a sinking feeling?
Stripe 2: 2LS, mask/background
Time to pull green and red together?
Stripe 3: 3LS, mask/background/foreground
Stripe 4: 1LS, background
Too yellow late!
Too red late!
Stripe 5: 3LS, mask/background/foreground
Stripe 6: 1LS, background
But it is better to have proposed yellow and failed, than to never have proposed blue.
But better still to propose and see success in red document and green marketplace.
Stripe 7: 2LS, mask/foreground
T0828650-99/d11

Figure 8/T.44

ANNEX A

(to ISO/IEC 16485 / Recommendation T.44)

Mixed Raster Content (MRC) Modes 2 and 3

A1 Scope

This Annex defines Modes 2 and 3 to ISO/IEC 16485 / Recommendation T.44. Mode 2 adds SLC (start of layer coded data segment) support to the 3-layer model defined in Mode 1. Mode 3 adds SLC support and extends the model beyond three (3) layers to realize greater capability. Applications implementing Mode 2 shall support Mode 1 while applications supporting Mode 3 shall support modes 1 and 2. As with ISO/IEC 16485 / Recommendation T.44 Mode 1, this Annex does not define new encodings or resolutions. The method of image segmentation is beyond the scope of this Annex, segmentation is left to manufacturer's implementations.

A2 References

See the main body of this Recommendation.

A3 Definitions

The definitions of the main body of this Recommendation apply, plus the following definitions:

Encoder specific marker segment (EMSe), encoded as APP13 (X'FFED'), length of segment, EMSe ident (MRC12 to 254), parameters/data. This category of marker segments provides information that is specific to the encoding/decoding of the image. These marker segments are not always present since they are encoder dependent. When present, parsing of the EMSe is required for proper decoding of the layer data stream for which they are defined, unless otherwise stated.

End of header marker segment (EOH), encoded as APP13 (X'FFED'), length of segment, EOH ident (MRC255), parameters.

Start of layer coded marker segment (SLC), encoded as APP13 (X'FFED'), length of segment, SLC ident (MRC2), parameters.

A4 Conventions

See the main body of this Recommendation.

A5 Image Representation

This Annex includes description of syntax for encapsulating two or more ITU-T encodings on a single page. The base mode is mandatory and shall be supported by this mode.

A page is composed from a set of page-wide stripes of image data. The stripes are transmitted sequentially from the top to the bottom of the page.

The stripes are composed of one or more layers. Each layer is coded using a recommended ITU-T coding method.

Information required to decode the page, such as coding types used within the layers, is specified within the page header (start of page marker segment). Stripe height is specified within the stripe header (start of stripe marker segment).

Information required to decode a layer is included in the stripe header and the layer data.

The main mask layer is transmitted first, followed by the background layer, followed by the foreground layer, and then any subsequent layer in increasing numeric order.

Details of the syntax are described below.

A6 Stripe structure

Stripes are composed of one or more layers; background layer (layer 1), main mask layer (layer 2) foreground layer (layer 3), a series of overlay mask layers (even-numbered layers 4, 6, 8,…) and image layers (odd-numbered layers 5, 7, …). One or more image may be assigned a fixed colour value, while mask layers may be assigned a fixed bit value (i.e. 0, selecting the background or 1, selecting the foreground layer). Virtual mask layers and fixed value layers are not counted in classifying the stripe types as follows:

N layer stripe	(NLS)
:	
:	
Three layer stripe	(3LS)
Two layer stripe	(2LS)
One layer stripe	(1LS)

A6.1 Three layer stripe (3LS)

See the main body of this Recommendation.

A6.2 Two layer stripe (2LS)

See the main body of this Recommendation.

A6.3 One layer stripe (1LS)

See the main body of this Recommendation.

A6.4 N-layer stripe (NLS)

N-layer stripes (NLS), where N is an integer, are an extension to the basic structure of ISO/IEC 16485 / Recommendation T.44, as defined in this Annex. The NLS contains more than three (3) layers; see the figure below. It provides a means to transfer one or more multi-level image layers (background, foreground, layer 5, layer 7, …) and one or more bi-level mask layers (layers 2, 4, 6, …) that define layer recombination on the same page. Beyond layer 1 (background), the layers occur in pairs, 2 & 3, 4 & 5, etc. The main mask layer (layer 2) must span the full dimension of the stripe while other layers (i.e. layer 1, 3, 4, 5, …) may have an offset and dimensions that are less than those of the stripe. The offset and dimensions of the masks need not be the same as those of the corresponding image layers, see the figure below. This capability enables representation of richly coloured text, graphics, and line-art together with contone image using a combination of multi-level and bi-level coding methods.

Mask and image Layers in N-layer Stripe

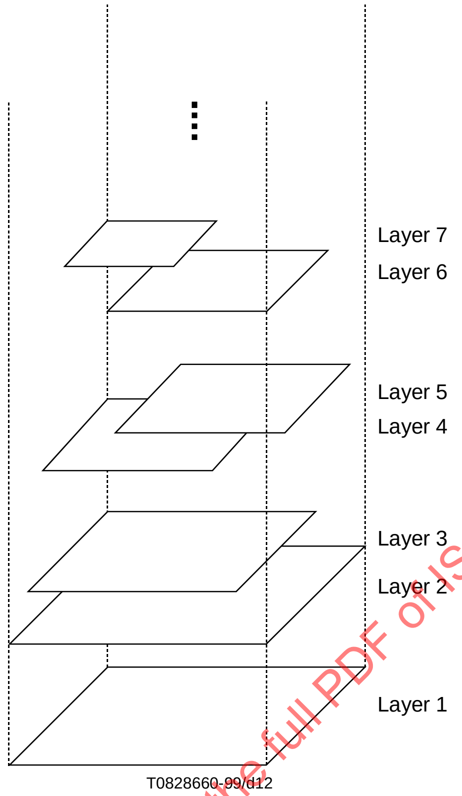

Figure A.1/T.44 – Mask and image layers in N-layer stripe

A7 Image Coding

A7.1 Spatial resolution

The resolution of the main mask layer is fixed for the entire page and defines the maximum resolution for the page. In general it is possible to define lower spatial resolution for other layers. Spatial resolution of all layers must be integral factors of the main mask resolution. All resolutions used must be square (i.e. same horizontal and vertical values) and conform to ITU-T recommended values. The main mask resolution is specified in the page header. The resolution of other layers is specified in the stripe data stream.

A7.2 Stripe width and layer width

Stripes always span the entire width of a page. The main mask layer must always span the entire width.

This method takes advantage of the image width and height data included in the layer data stream. Layers other than the main mask are not required to span the entire width. All layers must be fully contained within the boundaries of the stripe. The width value of the mask layers (even numbered layers) and the width value of the corresponding image layers (odd numbered layers) are independent. In addition, for layers other than the main mask layer, a horizontal offset may be used to select a starting point to the right of the left stripe boundary. The offset value of the mask layers (even numbered layers) and the offset value of the corresponding image layers (odd numbered layers) are independent. This offset is expressed in the main mask pixel units in the layer data. A simple stripe containing only background (e.g. JPEG data) or foreground (e.g. T.43 JBIG data) image data may use this feature also.

A7.3 Stripe height and layer height

To limit the data that must be buffered by an application some applications may chose to limit the maximum height of two or more layer stripes (2LS to NLS) to a specified number of lines (in main mask layer resolution).

One layer stripes (1LS) are not required to conform to a maximum stripe height, and are only limited by page size. Layers without coded data (i.e. virtual mask layers and image layers with only base layer colour) are not to be counted when considering whether a stripe is a 1LS, 2LS, 3LS or NLS stripe.

Stripe height and main mask layer height is always equal. Heights of layers, other than the main mask, are less than or equal to stripe heights. All layers must be fully contained within the boundaries of the stripe. The height value of the mask layers (even numbered layers) and the height value of the corresponding image layers (odd numbered layers) are independent. In addition, for layers other than the main mask layer, a vertical offset may be used to select a starting point below the first scan line of the stripe. The offset value of the mask layers (even numbered layers) and the offset value of the corresponding image layers (odd numbered layers) are independent. This offset is expressed relative to the first scan line at the top of the stripe and in the main mask pixel units. A simple stripe containing only background (e.g. JPEG) or foreground (e.g. T.43 JBIG) data may use this feature also.

A7.4 Layer combination

Image layers are rendered sequentially in ascending order of layer number (i.e. layer 1, then 3, then 5, … then N). The background layer (i.e. layer 1), if present, shall be rendered first. Bi-level mask layers (even-numbered layers, such as layer 2) select pixels from their corresponding image layer (odd-numbered layer directly above the mask layer, such as layer 3) for rendering. A corresponding image layer pixel (directly above the mask layer pixel) or its layer base colour value, is selected when a mask pixel value is "1". The selected image layer pixel is rendered on top of any layer or layers that may have been previously rendered. A corresponding image layer pixel shall not be rendered when the mask pixel value is "0". The pixel from the layer or layer combination below the mask, or its layer base colour value, shall remain visible when the mask pixel value is "0". In event of an image layer, or portion there of, without a corresponding mask layer, the image layer shall be rendered on top of any previously rendered layers.

A8 Layer Transmission Order

In NLS, the bi-level main mask data is transmitted first, followed by the background (layer 1), foreground (layer 3), layer 4, layer 5, …, layer N. In NLS without a background layer, the bi-level main mask image data is transmitted first, followed by the foreground layer, layer 4, layer 5, …, layer N.

A9 Data format

A9.1 Overview

The MRC image data consist of a series of markers; parameters; data that specify the image coder, image size, bit resolution and spatial resolution; coded image data. The conventions of Annex B of ITU-T Recommendation T.81 are used broadly here. The JPEG registration body, per Recommendation T.86, has been used to register the marker code, APP13, classified as an application marker.

The MRC page structure for this application has the following elements: Parameters, markers, and entropy-coded data segments. Parameters and markers are often organized into marker segments. Parameters are integers of length ½, 1, 2 or more octets. Markers are assigned two or more octet codes, an X'FF octet followed by an octet not equal to X'00' or X'FF' and optionally preceded by extra X'FF' octet codes. This application defines marker segments to denote the start of page (SOP), optional marker segments, the start of a stripe (SOSt), the start of layer coded data (SLC), encoder marker segments and end of header (EOH). The MRC Magic Number (JPEG SOI) is used immediately preceding the application marker as part of the SOP marker segment. The JPEG EOI is used as a termination number located directly after the last SOP parameter. The end of a page (EOP) is defined as X'FFD9FFD9'. These markers are inserted by the encoder, and understood by the decoder in addition to all markers used for the coding methods such as the SOI of ITU-T Recommendation T.81.

A9.2 Page data structure

The beginning of an MRC page is denoted by the Start of Page Marker Segment, followed by optional marker segment(s), Termination Number, page data, and EOP. The parameters of the optional marker segments are optional, unless otherwise stated. Their purpose is to provide insight into reproduction of the image and as such are typically not mandatory for image reproduction. Skipping of any unrecognized optional marker segment is appropriate. Page data consists of stripes 1 to n (where n is an integer), as described in the next section.

A9.2.1 Start of page marker segment

Start of Page Marker Segment has the following structure:

MRC Magic Number, APP13, Length of segment, SOP ident, version, mask coders, image layer coders, main mask resolution, width.

The Start of Page Marker Segment is defined as follows:

MRC Magic Number:	2 octets	X'FFD8'
APP13 marker:	2 octet	X'FFED'
Length of Segment:	2 octets	Length of segment in octets, MSB to LSB, as an integer value including the octet count itself but not including Magic Number or APP13.
SOP Ident:	4 octets	'MRC0', represented as a 3-octet ASCII string plus an hexadecimal count (i.e. X'4D',X'52',X'43',X'00'). This X'00'-terminated string "MRC" uniquely identifies this marker segment as the start of page.
Version:	1 octet	Revision number, X'00' indicating revision "0".
Mode:	1 octet	X'02', indicating Mode 2.0. Each mode identifies a different level of performance. Mode 2.0 identifies the SLC (start of layer coded marker segment) supported 3-layer mode of ISO/IEC 16485 / Recommendation T.44 as defined by the contents of this Annex. Applications supporting this mode shall support the capabilities defined in Mode 1.0.

		X'03', indicating Mode 3.0. Each mode identifies a different level of performance. Mode 3.0 identifies the SLC (start of layer coded marker segment) supported N-layer mode of ISO/IEC 16485 / Recommendation T.44 as defined by the contents of this Annex. Applications supporting this mode shall support the capabilities defined in Modes 1.0 and 2.0.
Mask layer coders:	1 or more octet(s)	with value indicating coder as shown in Table 1. The identified coders may be used in any mask layer. Only one coder shall be used in the main mask layer. Only one mask layer is present in Mode 2.0. More than one mask layers (i.e. main mask, layer 2, plus other even-numbered layers) may be present in Mode 3.0. The value shall be fixed to zero "0" in the event that there is no mask layer coder (i.e. no coded mask layer data present).
Image layer coders:	1 or more octet(s)	with value indicating coders as shown in Table 2. The identified coders may be used in any image layer. Only two image layers may be present in Mode 2.0. There is no restriction to the number of image layers that may be present in Mode 3.0 (i.e. image layers, layer 1, 3, plus other odd-numbered layers). The value shall be fixed to zero "0" in the event that there is no image layer coder.
Main Mask resolution:	2 octet	expressing vertical and horizontal resolution as a single integer value in units of pels/25.4 mm. Basic value is 200 pels/25.4 mm. The value shall be fixed to that of the image layer in the event that there is no coded mask data (layer) in the page.
Page width:	4 octet	expressing page width as a single integer value. For pages with two or more layers the main mask layer image width defines the page width using units of the main mask resolution. For pages with only a single layer foreground or background image, no coded mask data, a virtual mask (i.e. a mask layer without coded data) shall be used to define the page width.

A9.2.2 Optional marker segments

See the main body of this Recommendation.

A9.2.3 TN (Termination Number)

See the main body of this Recommendation.

A9.3 Stripe data structure

The beginning of a stripe is denoted by the Start of Stripe Marker Segment, followed by stripe data.

The first layer represented is the main mask (layer 2), followed by the background (layer 1), followed by the foreground (layer 3), followed by layer 4, followed by layer 5, …, followed by layer N (as appropriate). When there are two or more layers, the main mask layer shall always be one of them. The stripe height is determined by the height of the first layer within the stripe.