NOT MEASUREMENT SENSITIVE

NOTE: The cover page of this standard has been changed for administrative reasons. There are no other changes to this document.

MIL-STD-188-199
27 June 1994

DEPARTMENT OF DEFENSE
INTERFACE STANDARD

VECTOR QUANTIZATION DECOMPRESSION
FOR THE
NATIONAL IMAGERY TRANSMISSION FORMAT STANDARD

AMSC N/A

AREA TCSS

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FOREWORD

1. The National Imagery Transmission Format Standard (NITFS) is the standard for formatting digital imagery and imagery-related products and exchanging them among members of the Intelligence Community (IC) as defined by Executive Order 12333, the Department of Defense (DOD), and other departments and agencies of the United States Government, as governed by Memoranda of Agreement (MOA) with those departments and agencies.

2. This standard was developed using currently available technical information.

3. The DOD and members of the IC are committed to interoperability of systems used for formatting, transmitting, receiving, and processing imagery and imagery-related information. This standard describes the Vector Quantization (VQ) decompression algorithm for the National Imagery Transmission Format (NITF) file format and establishes its application within the NITFS.

4. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Defense Information Systems Agency (DISA), Joint Interoperability and Engineering Organization (JIEO), Center for Standards (CFS), Attn: TBCE, Parkridge III, 10701 Parkridge Blvd., Reston, VA 22091-4398, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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PARAGRAPH PAGE

1. SCOPE

1.1 Scope. This standard establishes the requirements to be met by NITFS compliant systems when image data are decompressed using the VQ compression algorithm. This allows NITFS-compliant systems to accept and decompress data that are compressed using a VQ compression scheme. This standard describes the VQ compression in the general requirements section, but does not fully describe the steps for compression. The steps involved in decompressing images compressed with VQ are fully described by this standard.

1.2 Content. This standard provides technical detail of the NITFS VQ decompression algorithm, designated by the code C4 or M4 in the image compression field of the image subheader in a NITF file.

1.3 Applicability. This standard is applicable to the IC and the DOD. It is mandatory for all Secondary Imagery Dissemination Systems (SIDS) in accordance with the memorandum by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence ASD(C^3I) Subject: National Imagery Transmission Format Standard (NITFS), 12 August 1991. This directive shall be implemented in accordance with the MIL-STD-2500, JIEO Circular 9008 and MIL-HDBK-1300. New digital imagery equipment and systems, those undergoing major modification, or those capable of rehabilitation shall conform to this standard.

1.4 Tailoring task, method, or requirement specifications. The compliance requirements for implementation of this decompression algorithm are defined in JIEO Circular 9008.

1.5 Types of operation. This standard establishes the requirements for the communication or interchange of image data in VQ compressed form. Each type of operation defined by this standard consists of two parts:

a. The compressed data interchange format (which defines the image data field of the NITF file format).

b. The decoder.

Two types of operations are specified by the acquisition authority:

a. Type 1 - Eight-bit monochrome sample compression

b. Type 2 - 24-bit color sample compression

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issue of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

STANDARDS

MILITARY

MIL-STD-2500	-	National Imagery Transmission Format (Version 2.0) for the National Imagery Transmission Format Standard.

HANDBOOK

MILITARY

MIL-HDBK-1300	-	National Imagery Transmission Format Standard (NITFS).

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, 700 Robbins Avenue, Building #4, Section D, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified. Unless otherwise specified, the issues are those cited in the solicitation.

DISA/JIEO Circular 9008	-	NITFS Certification Test and Evaluation Program Plan.
ESC-TR-93-314	-	Analysis of Compression Techniques for Common Mapping Standard Data, Markuson, N.J., July 1994.

(Copies of DISA/JIEO Circular 9008 may be obtained from DISA/JIEO/JITC/TCDB, Fort Huachuca, AZ 85613-7020. Copies of the ESC Technical Report (TR) can be obtained from USAF/AFMC/ESC/YVD, 5 Eglin Street, Hanscom AFB, MA 01731-2124.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

Abut, Huseyin (Ed.), Vector Quantization, IEEE Press, NY, NY, 1990

(Non-Government standards and publications are usually available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other information services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Acronyms used in this standard. The following definitions are applicable for the purpose of this standard. In addition, terms used in this standard and defined in the FED-STD-1037B shall use the FED-STD-1037B definition unless noted.

a.	ADRG	ARC Digitized Raster Graphics
b.	AFMC	Air Force Materiel Command
c.	ARC	Equal Arc Second Raster Chart/Map
d.	ASCII	American Standard Code for Information Interchange
e.	ASD(C^3I)	Assistant Secretary of Defense for Command, Control, Communication, and Intelligence
f.	BWC	BandWidth Compression
g.	CFS	Center for Standards
h.	COMRAT	Compression Ratio
i.	CLEVEL	Compliance Level
j.	DISA	Defense Information Systems Agency
k.	DOD	Department of Defense
l.	DODISS	Department of Defense Index of Specifications and Standards
m.	ESC	Electronic Systems Center
n.	IC	(1) Intelligence Community (2) Image Compression
o.	JIEO	Joint Interoperability and Engineering Organization
p.	JITC	Joint Interoperability Test Center
q.	LUT	Lookup Table
r.	M	Monochromatic
s.	MOA	Memoranda of Agreement

t.	NBPC	Number of Blocks Per Column
u.	NBPR	Number of Blocks Per Row
v.	NITF	National Imagery Transmission Format
w.	NITFS	National Imagery Transmission Format Standard
x.	NPPBH	Number of Pixels Per Block Horizontal
y.	NPPBV	Number of Pixels Per Block Vertical
z.	NTB	National Imagery Transmission Format Standard Technical Board
aa.	PVTYPE	Pixel Value Type
ab.	RGB	Red, Green, Blue
ac.	SIDS	Secondary Imagery Dissemination System
ad.	TR	Technical Report
ae.	VQ	Vector Quantization

3.2 Definition of terms. The definitions used in this document are defined as follows:

a. Band - For the purpose of MIL-STD-188-199, a two-dimensional array of pixels that comprise a monochromatic image or one of multiple arrays that comprise a multidimensional image, such as multispectral image.

b. Big Endian - For the purpose of MIL-STD-188-199, an ordering of bytes within a file such that the most significant byte is recorded and read first, and successive bytes are recorded and read in order of decreasing significance.

c. Byte - For purpose of MIL-STD-188-199, a byte is a sequence of eight binary digits, usually treated as a unit.

d. C4 - The NITF American Standard Code for Information Interchange (ASCII) code used to indicate the VQ compression algorithm.

e. code_size - The size of each image code in bytes.

f. Codebook - An array of values used to represent rectangular blocks or kernels of the image data.

g. Columns - Pixels per line in an image band.

h. Compression - For the purpose of MIL-STD-188-199, a reduction in the number of bits used to represent source image data.

i. Decompression - The process of transforming an image from a compressed form into a displayable and exploitable form.

j. Gray scale - An optical pattern consisting of discrete steps or shades of gray between black and white.

k. idepth - The size of each input pixel in bytes.

l. isize - The size of the input image in pixels.

m. Image codes - Image codes are compressed values, in the image data section, that are used to retrieve the v x h kernels from the image codebook.

n. Image data - Either source data or decompressed data.

o. Kernel - A rectangular group of pixels used in the compression of VQ image data.

p. Lookup Table (LUT) - For the purpose of MIL-STD-188-199, an array of values that represent color indices for the image data.

q. M4 - The NITF ASCII code used to indicate masked VQ algorithm.

r. Lossy - For the purpose of MIL-STD-188-199, a term used for compression processes that output values, after decompression, that are not necessarily the same as the original source image input.

s. odepth - The size of each output pixel in bytes.

t. Pixel - For the purpose of MIL-STD-188-199, one element in a two-dimensional array that comprises a band of an image.

u. Row Major - An organization whereby operation of reading, writing or decompressing pixels starts in a particular column (typically the leftmost column) of a file and proceeds across the columns of the same row until the last column has been reached. At that point, the next row of data is operated on, starting from the same side as the first set of operations.

v. v x h kernel - A rectangular group of pixels (kernel) with v rows and h columns.

w. vsize - The size of the compression kernel in pixels.

4. GENERAL REQUIREMENTS

4.1 Interoperability. The requirements in this document specify the format of imagery which has been compressed using Vector Quantization (VQ) compression algorithms. The information provided in the document will allow systems to decompress imagery data using the fields provided in the NITF subheader and NITF image sections of the NITF compliant file. This information will provide for data interoperability among NITFS compliant systems.

4.2 Vector quantization. Vector quantization is a lossy compression approach, chosen for use with certain types of image data (see MIL-HDBK-1300) because it can be implemented with acceptable performance and quality, because it provides a predictable compression ratio, and because decompression is very fast. Section 6 provides explanatory information about the vector quantization process. The fundamental concept of VQ is to represent monochrome or color image blocks with representative kernels from a codebook. The indices of the representative kernels replace the image data in the compressed image. The codebook and the color Lookup Table (LUT) are included in the file as overhead information.

4.3 Compression. The VQ compression algorithm examines each v x h pixel kernel in the input image and uses a clustering technique to develop a limited codebook that contains the most representative kernels. The codebook entries are v x h pixel kernels. These kernels are interpreted different ways, depending on the type of image that they represent. In the case of Red, Green, Blue (RGB)/LUT compressed images, these pixels are acutally indices into a color LUT. In other cases, they may represent indices to the grayscale pixel vlaues or spectral band pixel values depending on formats of the grayscale (n-bit), color (RGB/LUT), color bands, R, G, B or multispectral bands. Figure 1 shows a process flow for compression of the data. The procedure produces the codebook and color LUT, if applicable, as part of the VQ header at the beginning of the image data field of the NITF file. The NITF file structure is shown in figure 2. The decompression process flow is shown in figure 3. The image codes in figure 3 are codebook indices that the decoder used to reconstruct the pixel kernel. In the practical case, where the codebook does not contain all possible pixel kernels, the reconstructed image is an approximation of the original. More information about VQ compression can be found in Vector Quantization, edited by Huseyin Abut. The full reference is given in section 6.

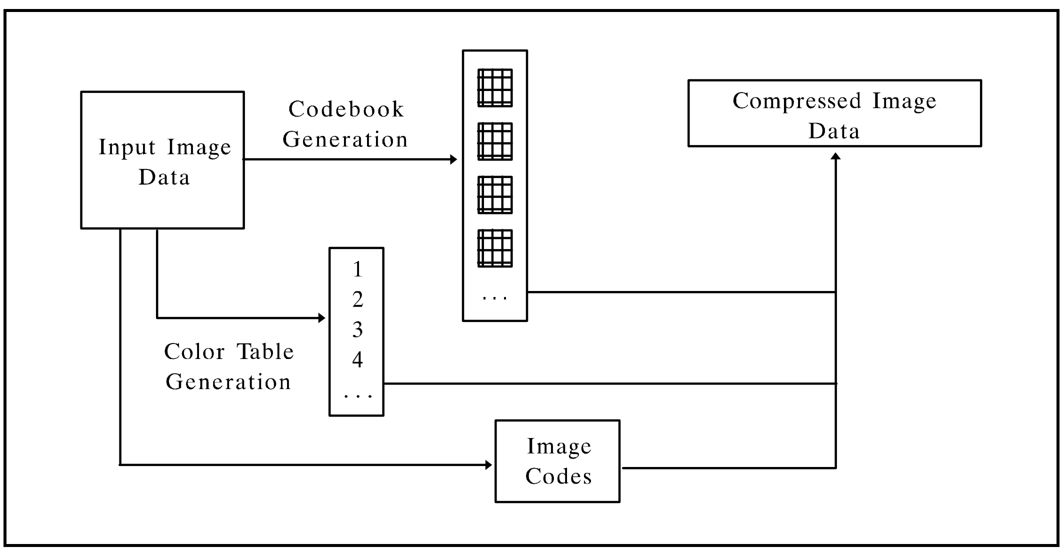

FIGURE 1. Compression process flow.

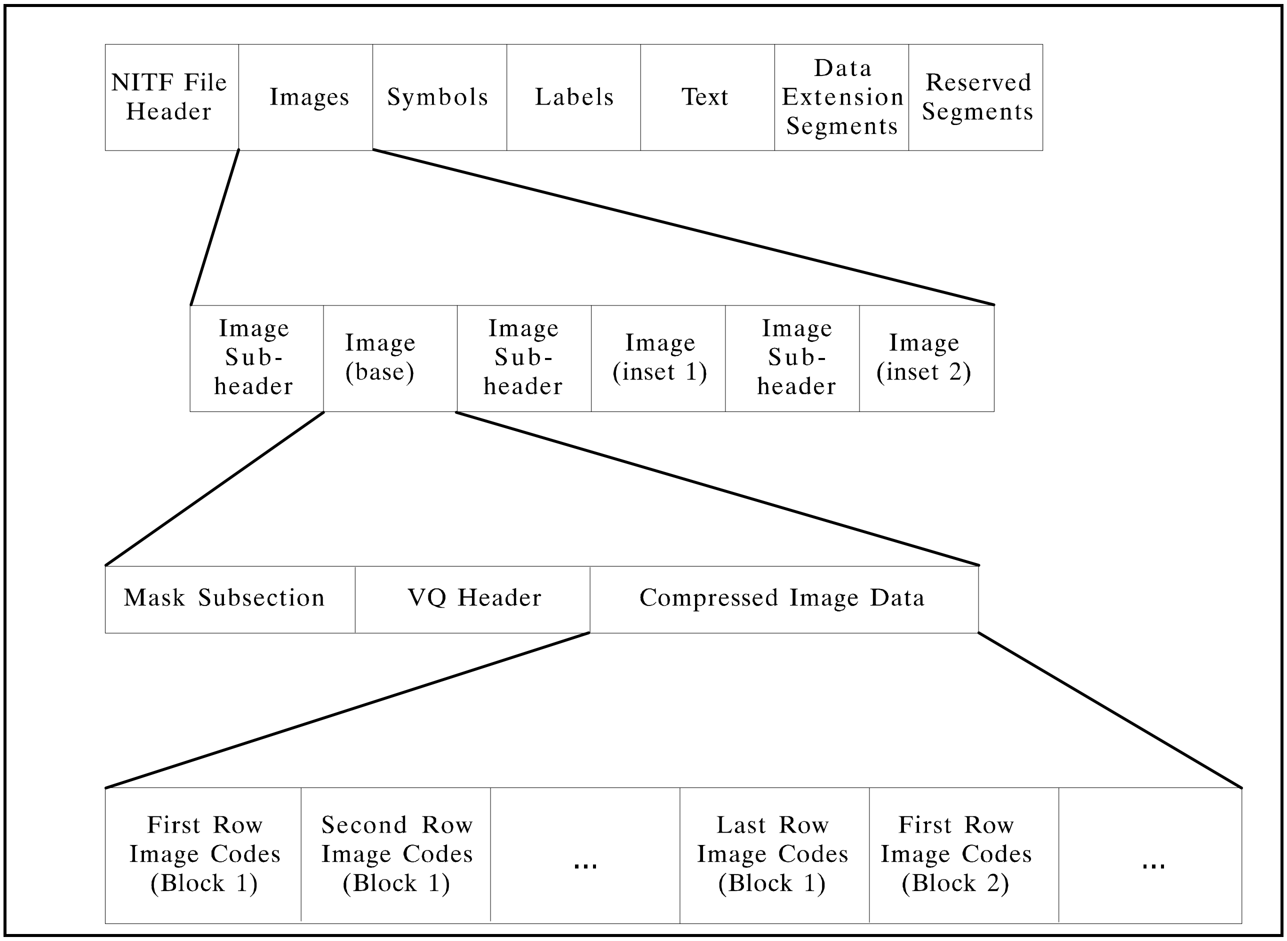

FIGURE 2. NITF file structure.

4.4 Decompression. The VQ data requires only a series of table lookups to decompress the image for display. As shown on figure 3, the decompression process takes as input the compressed image data, which includes the image codes, codebook(s) and color table (if applicable) and, by means of a specified set of procedures, generates as its output, digital reconstructed image data.

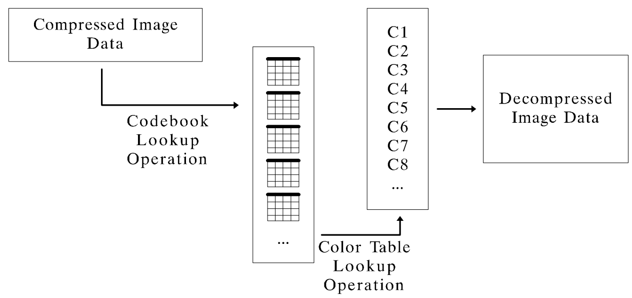

FIGURE 3. Decompression process flow.

This specification does not limit the implementation of VQ within NITF in terms of the types and sizes of color lookup tables allowed. However, current implementation of VQ within NITF uses a single RGB/LUT and many of the examples and figures in this document are specific to this implementation. Other organizations of VQ within NITF may be implemented in the future. VQ decompression detailed requirements are found in paragraph 5.2.

4.5 Compression ratio. The amount of compression provided by the VQ compression process is dependent on the size of the v x h kernel used for compression, and the number of entries in the color table and codebook. These values are given, for each image, in the VQ header section for the NITF image. A formula to determine the theoretical compression ratio provided by the VQ process (which is independent of the size of the input image and includes color compression) is as follows:

$$\text{Theoretical Compression Ratio} = \frac{\text{vsize x idepth}}{\text{code\_size x odepth}} \tag{1}$$

In the above equation, *vsize* is the size of the compression kernel in pixels (v x h), idepth is the size in bytes of each individual pixel for the input image For example, if the original image is an RGB Equal Arc Second Raster Chart/Map (ARC) Digitized Raster Graphics (ADRG) image, the value for idepth is 3. The parameter code_size is the size of each image code in bytes; odepth is the size of the color for the output pixels in bytes. For example, if the output of the decompression process is an image with a 256-entry (one-byte) LUT, odepth would be 1. Normally there is a significant difference between the theoretical compression ratio and the actual compression ratio. This difference is due to the fact that the compression codebook and color table add to the size of the compressed image. Overhead information, including the codebook and color table must be included to determine the actual compression ratio provided by the compression technique. The actual compression ratio for NITF VQ images can be calculated as follows, with isize equal to the size of the input image in pixels:

$$\text{Actual Compression Ratio} = \frac{\text{isize x idepth}}{\text{size / vsize x code\_size + Overhead}} \tag{2}$$

The following example shows the theoretical and actual compression ratios for a digitized 24-bit (3byte) RGB map image with size 1536 x 1536 pixels, kernel size of 4 x 4, codebook length of 4096 bytes with a 12 bit (1.5 byte) code_size, with 3K bytes for miscellaneous overhead, which includes an 8-bit (1-byte) color table that is 1K in size.

$$\text{Theoretical Compression Ratio} \quad \frac{16 \times 3}{1.5 \times 1} = 32 \tag{3}$$

$$\text{Actual Compression Ratio} = \frac{2{,}359{,}296 \times 3}{(2{,}359{,}296/16) \times 1.5 + 68608} = 24.49:1 \tag{4}$$

The overhead in this example is equal to the size of the codebook (4096 entries x 16 pixels per entry), plus the size of the color lookup table and other NITF overhead which total approximately three kilobytes, for a total overhead of 68,608 bytes. Additional information regarding the compression of data is provided in section 5 of this document.

5. DETAILED REQUIREMENTS

5.1 General. This section includes detailed information necessary to decompress VQ files using information contained in NITF fields.

5.2 Vector quantization decompression. VQ is a compression algorithm currently defined for multiband, color, and grayscale raster scanned maps and imagery. The basic algorithm for the various types of imagery decompression is the same, and all information required for decompression of an NITF VQ file is contained within the NITF file itself. Essentially, VQ decompression involves replacing image codes in the compressed image with pixel values for use in display or exploitation of the data. If the image has an associated LUT, the decompression shall be done in a two step process as shown on figure 4. If the image does not need color decompression, then the color decompression process (see 5.2.2) is not necessary. Color decompression would not be necessary in cases where the intended output pixel values are placed into the compression codebook. This may occur in the compression of grayscale imagery or in the compression of multispectral imagery where each band is compressed seperately. The two processes for decompression are described in the sections 5.2.1 and 5.2.2.

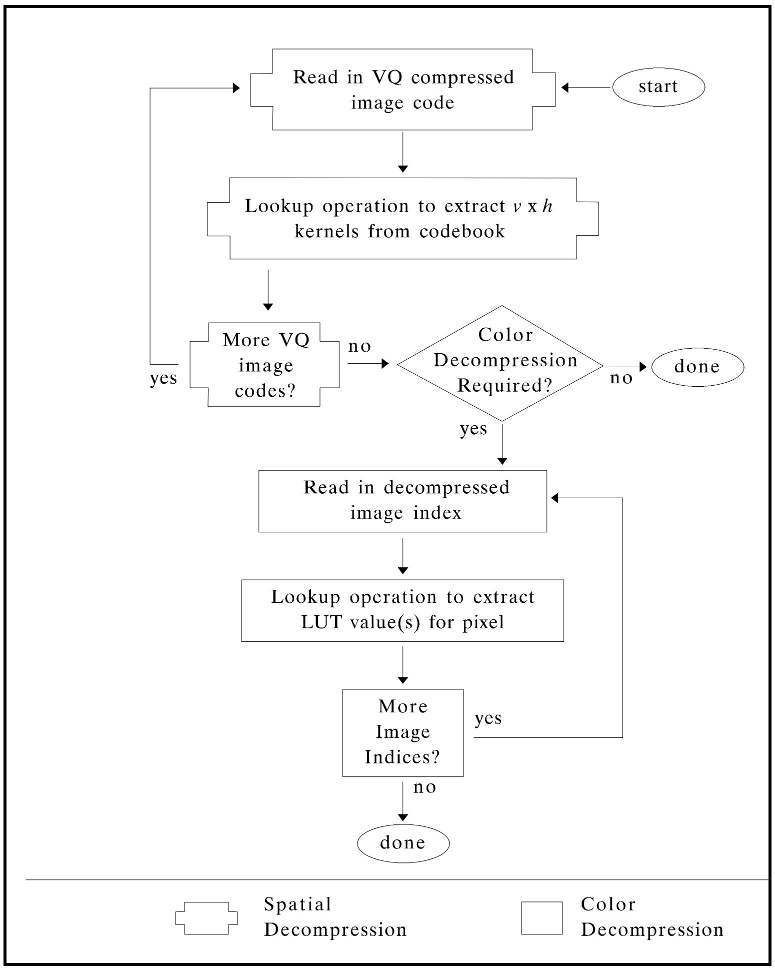

FIGURE 4. VQ decompression procedure.

5.2.1 Spatial decompression. When the image compression field is set to M4, the image data field of the VQ compressed NITF file shall contain a VQ header followed by the compressed image data (see figure 2). The VQ header shall contain information about the compressed data including mask information, and information defining the structure of the compressed image and codebook. The compression codebook that is used to decompress the image is also contained in the VQ header.

a. The compression codebook consists of an array of compression codes. Each image code is an index to the codebook that has been constructed for the image. Each codebook entry logically represents a group of v x h pixel indices. The NITF structure allows for the organization of the VQ codebook to be optimized for the specific use of the VQ compressed data. While some NITF VQ compressed products may require the VQ codebook to be arranged into v x h index kernels, other products may require that the individual rows for all v x h kernels be stored together such that the image can be decompressed line-by-line, instead of kernel-by-kernel. As an example, aircraft cockpit displays (or moving map applications) require a very fast decompression and display time (on the order of 30 times per second) and the map is constantly being shifted in position for redisplay as the aircraft is moving. For their application, decompressing the image line by line is optimal. For other applications such as ground-based mission planning, decompressing a kernel at a time is appropriate. The NITF VQ structure supports both organizations.

b. Each of the image codes, during VQ decompression, is converted to a kernel (or series of rows) of decompressed pixel indices. The first image code appearing in the VQ image data field shall be used to spatially decompress the v x h indices in the upper left corner of the image. The decompression shall continue from left to right across the columns of the first row of image codes, then down each of the rows of image codes sequentially. Decompression shall continue in this row major fashion until the image block has been spatially decompressed. The output from the spatial decompression process described above is a spatially decompressed image block. If the image has been color compressed, each value in the spatially decompressed image represents an index into the color table. The second lookup table procedure, described in 5.2.2 involves using the indices in this spatially decompressed image to construct the final color decompressed image. Figure 5 shows a schematic of the spatial decompression process. The spatially decompressed image on figure 5 shows various shades of gray to indicate higher or lower values in the codebook. If the image is not color compressed, then these values would be used to create a grayscale image where higher values in the codebook typically correspond to brighter displayed pixels. If the image is color compressed, then the values in the spatially decompressed image correspond to indices in the LUT.

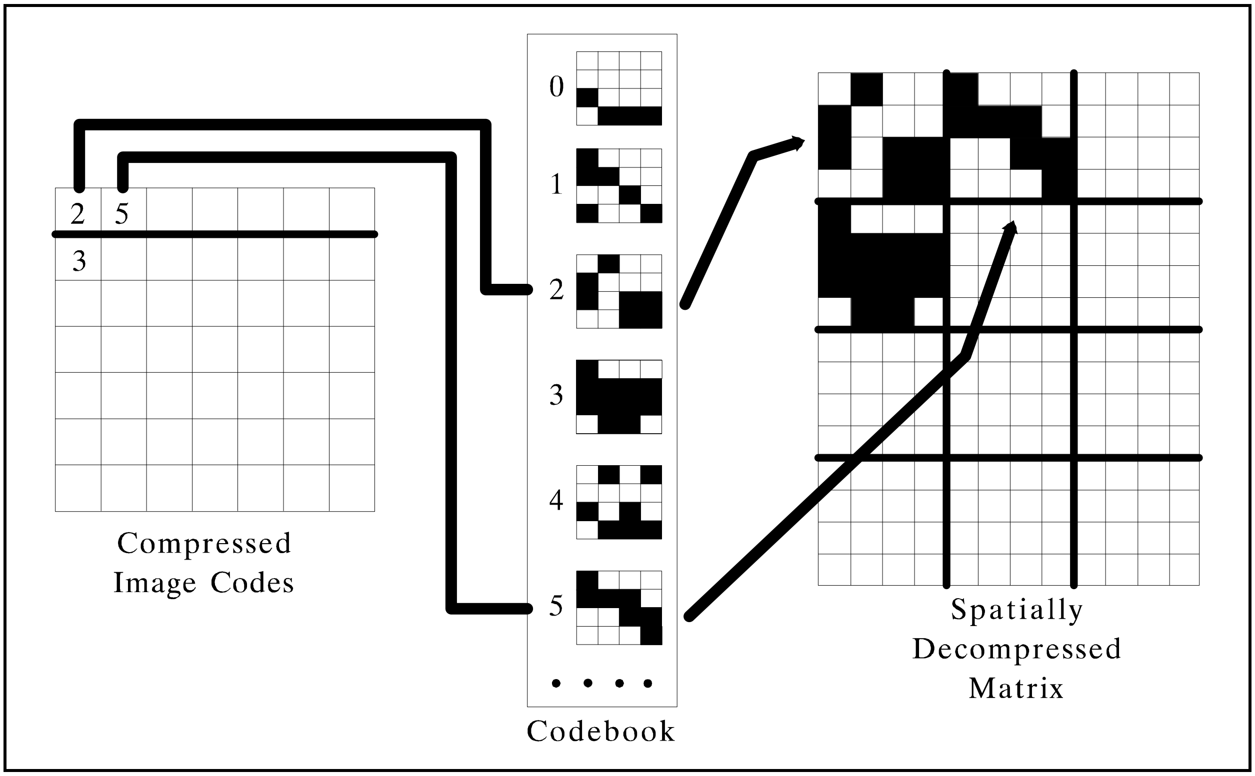

FIGURE 5. Spatial decompression.

5.2.2 Color decompression. As described in section 4.4, this specification does not limit the implementation of VQ within NITF in terms of the types and sizes of color lookup tables allowed. However, current implementation of VQ within NITF has a limited scope and uses a single RGB/LUT. Many of the examples and figures in this document are specific to this implementation. Other organizations of VQ within NITF may be implemented in the future.

a. The output from the spatial decompression process described in paragraph 5.2.1 is an array consisting of values that represent either (1) monochromatic (grayscale) values for an image that is not color compressed or (2) indices to the LUT in the NITF image subheader (see figure 2) if the image requires the use of a LUT. The final decompression step for color compressed images shall transform the indices into their corresponding pixel values by using the LUT values. Figure 6 shows an example LUT operation involving the use of a mapped color, or RGB LUT.

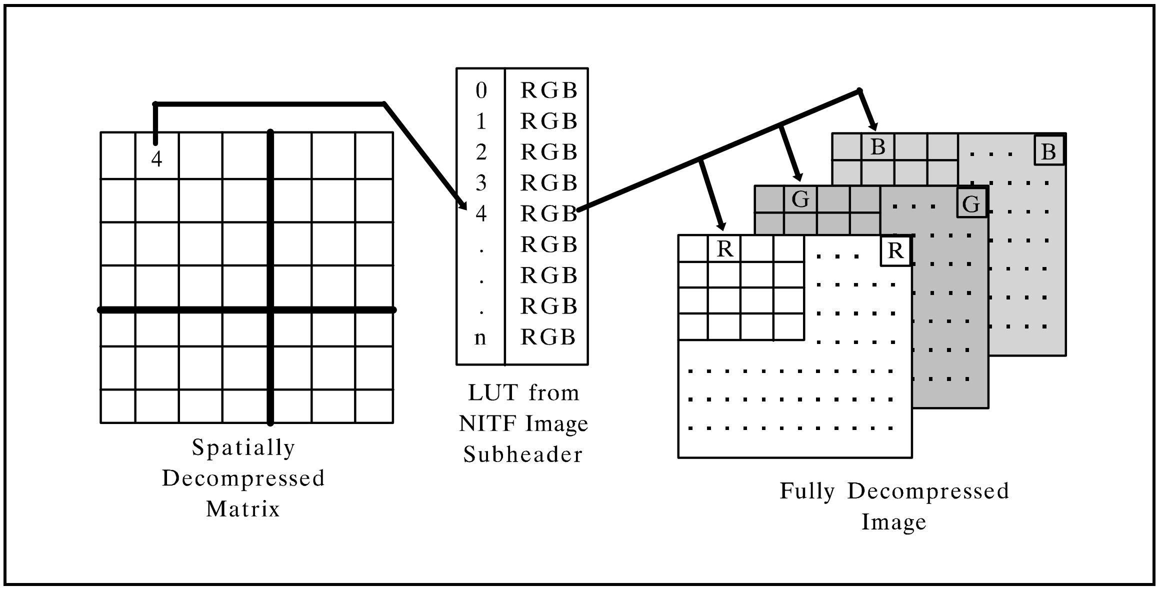

FIGURE 6. Color decompression.

5.2.3 Data elements. The NITF VQ format allows for many possible compression ratios, and several organizations of the compression codebooks and color tables. The NITF VQ file contains the information that the user needs in order to understand the organization of the data and to decompress the data for display. The following sections describe the fields in the NITF VQ file that shall be used to determine the VQ organization of a particular file. The various sections described in 5.2.3.1 through 5.2.3.4 identify various levels of organizations within the NITF VQ image data section and are shown on figure 7 beginning and ending with a square bracket, for example, [compression section]. The notation used for the VQ fields is given in Appendix A.

```
{1}
[nitf image data]
        {2}
        <blocked image data offset>,uint:4(0, 1)
        [mask subsection] (0, 1)
                {3}
                [mask subheader]
                [block mask table] (0,1)
                [transparency mask table] (0, 1)
        {2}
        [VQ Header]
                {3}
                 image display parameter sub-header]
                        {4}
                        <number of image rows>,uint:4
                        <number of image codes per row>,uint:4
                        <image code bit length>,unint:1
                {3}
                [compression section] (0,1)
                        {4}
                        [compression section subheader]
                                {5}
                                <compression algorithm id>,uint:2
                                <number of compression lookup offset records>,uint:2
                                <number of compression parameter offset records>,uint:2
                        {4}
                        [compression lookup subsection] (0,1)
                                {5}
                                <compression lookup offset table offset>,uint:4
                                <compression lookup table offset record length>,uint:2
                                [compression lookup offset table]
                                        {6}
                                        [compression lookup offset record] (1, ... many)
                                                {7}
                                                <compression lookup table id>,uint:2
                                                <number of compression lookup records>,uint:4
                                                <number of values per compression lookup record>,uint:2
                                                <compression lookup value bit length>,uint:2
                                                <compression lookup table offset>,uint:4
                                {5}
                                [compression lookup table] (1, ... many)
                                        {6}
                                        [compression lookup record] (1, ... many)
                                                {7}
                                                /compression lookup value/,bits:var (1, .. many)
        {2}
        [compressed image data]
                {3}
                [spectral group] (1, ... many)
                        {4}
                        [subframe table] (1, ... many)
                                {5}
                                [spectral band table] (1, ... many)
                                        (6)
                                        [image row] (1, ... many)
                                                  {7}
                                                  [spectral band line] (1, ... many)
                                                        {8}
```

FIGURE 7. Structure of the NITF Image data section.

5.2.3.1 Compression ratio. The Compression Ratio (COMRAT) field shall be present in all NITF VQ files and shall contain a value given in the form n.nn representing the average number of bits-per-pixel for the image after compression (See MIL-STD-2500). In the example given in section 4.5, the value for COMRAT would be the idepth (bytes) x 8 (bits/byte) = 24 bits, divided by the theoretical compression ratio (32), yielding a bpp of 0.75. Although other NITF compression algorithms may need this value to properly decompress the NITF image, this entry in a VQ compressed file is purely informational and is not used in the decompression process.

5.2.3.2 Masked vs. unmasked images. In VQ images, the Image Compression (IC) field shall contain the value C4 if the image is not masked or M4 if the image is masked. MIL-STD-2500 contains an explanation of masking as it relates to VQ images.

5.2.3.3 Codebook organization. The compression section within the NITF VQ image data section (shown as image data on figure 2) defines the organization of the VQ codebook. The user of the VQ data will need to understand how many compression codes are present in the codebook, the size of each v x h kernel and how the data that make up the kernels are organized. The number of entries in the codebook is represented by the <number of compression lookup records>. For example, if the <number of compression lookup records> equals 4096, then there are a total of 4096 v x h kernels represented in the codebook.

a. To determine how many pixels make up each compression kernel, the <number of image rows> and <number of image codes per row> are used, along with the number of pixels per block vertical (NPPBV) and the number of pixels per block horizontal (NPPBH) in the NITF image subheader. For example, as 256 x 256 blocked image with 128 rows of compressed image data, and 128 compressed image codes per row would have a kernel size of v = (256/128) = 2 by h = (256/128) = 2. The following equation is used to determine the size of the compression kernel in pixels:

$$v = \frac{\text{NPPBV}}{<\text{number of image rows}>} \qquad h = \frac{\text{NPPBH}}{<\text{number of image codes per row}>} \qquad (5)$$

$$\text{kernel size} = v \text{ rows} \times h \text{ columns}$$

b. The <number of compression lookup offset records> within the structure (see figure 7) shall equal 1 if the data is organized such that all the /compression lookup value/s for each kernel are grouped together. In this case, if the kernel size is 4 x 4, then the 16 /compression lookup values/ that make up each kernel are grouped sequentially, starting with the first /compression lookup value/ in the first kernel and proceeding in a row major fashion, through the last /compression lookup value/ in the last kernel.

c. If the <number of compression lookup offset records> is greater than 1, then the data for each kernel is organized into tables. Typically, the tables represent the lookup values for each row of the kernel. The <number of compression lookup records> and the <number of values per compression lookup record> can be used to determine the structure of the codebook when the <number of compression lookup tables> is greater than 1. For example, in the case above where the kernels are 4 x 4 in size, if the <number of compression lookup tables> equals 4, then the 16 pixels that make up the kernel are divided into four tables, each of which represents the /compression lookup values/ for one row of the kernel. In this scenario, the <number of values per compression lookup record> would also be equal to 4. The 16 element kernel is effectively split into 4 tables, one representing each row of the 4 x 4 kernel. Each table, in turn, contains 4096 records, each of which contain 4 pixels.

5.2.3.4 Spatial data subsection. The spatial data subsection of the NITF image data section is organized such that several different file formats (IMODES), as defined in MIL-STD-2500, including band interleaved by pixel, band sequential and band interleaved by block can be accommodated. In addition, the spatial data subsection is partitioned into one or more image block tables (or subframe tables). In all, there are 5 levels of organization above the /image code/ values. The implementation of VQ within the NITF does not limit the type of IMODE that can be used. However, current implementation of VQ within the NITF uses a single band with an associated LUT. It is therefore considered to have an IMODE of B, or band interleaved by block. In the future, other organizations of the VQ data within the NITF may be implemented. The following paragraphs describe the levels of organization of the data within the [compressed image data] group.

a. The [spectral group] organization is present within the VQ NITF image data section in order to allow for the inclusion of multispectral images that are blocked, but are represented as a band sequential image. That is, an image that is represented as n blocks all of one band, followed by n blocks of a second band, etc. For current VQ NITF applications, the number of spectral groups shall be 1. In the future, other implementations may be used.

b. The image is organized into one or more image blocks, each of which is contained in an [subframe table]. The Number of Blocks Per Row (NBPR) and Number of Blocks Per Column (NBPC) fields within the NITF image subheader define the number of [image block tables] in the spatial data subsection.

c. The image contains one or more [spectral band tables], which define how the pixels are organized. If an image contains one [spectral band table] then the pixels within the image correspond to a single-valued quantity such as a grayscale value, or they refer to a single entry within a color table, which may contain values for each color plane. In a VQ compressed color map, for instance, the values within the codebook index one color table value and therefore, only one spectral table exists.

d. The [image row] level of organization corresponds to the < number of image rows > in the VQ header data. If an image contains 128 x 64 /image code/s, then there shall be 128 [image row]s.

e. The [spectral band line] level of organization corresponds to the < number of image code/s per row > in the [image display parameter subheader]. If an image contains 128 x 64 /image codes/, then there shall be 64 [spectral band line]s.

5.3 File organization. VQ compressed NITF files shall comply with MIL-STD-2500 and MIL-HDBK-1300. Fields containing identification and origination information, file security information and the number and size of the data items contained in the NITF file are located in the NITF file header, defined in MIL-STD-2500. Information required to decompress the file is located in the image subheader and the NITF VQ image data section. Within the image data section, multibyte fields are written in the "big endian" format for distribution and exchange. The big endian format refers to the ordering of bytes such that the most significant byte is recorded and read first, and successive bytes are recorded and read in order of decreasing significance.

Figure 7 is a field-by-field description of the NITF image data section. The notation used in the figure is given in Appendix A. Note that the mask subsection (shown in schematic on figure 2) is shown at a high level only. The specific fields and definitions for the mask subsection are given in MIL-STD-2500. Section 5.4 defines the fields in the VQ header and compressed image data section of VQ NITF and list the valid range of values. NITF fields which have specific definitions for VQ compressed data are defined as such. Fields in the NITF header and image subheader that have specific values for NITF images are listed in Section 5.5.

5.4 Definitions - image data section. This section lists the elements of the VQ header and compressed image data sections (refer to Figure 2), listed in alphabetical order. The file notation used in this section is described in appendix A.

(1) <blocked image data offset> ::= a 4-byte unsigned integer defining the offset in bytes of the [compressed image data] from the beginning of the [nitf image data] section (labeled "image data" on Figure 2). This field is present only for masked images.

(2) <compression algorithm id> ::= a 2-byte unsigned integer defining the compression algorithm used to compress and decompress the image data in this [frame file]. ::= 1 to indicate that this image data is VQ compressed.

(3) <compression lookup offset table offset> ::= a 4-byte unsigned integer indicating the displacement, measured in bytes, between the beginning of the [compression lookup subsection] and the first byte of the [compression lookup offset table] (counting the first byte of the [compression lookup subsection] as 0).

(4) <compression lookup table id> ::= a 2-byte unsigned integer identifying the [lookup table] described in this [compression lookup offset record], encoded as follows:

::= 1 to indicate that this is row 0 of a 4 x 4 kernel,

::= 2 to indicate that this is row 1 of a 4 x 4 kernel,

::= 3 to indicate that this is row 2 of a 4 x 4 kernel,

::= 4 to indicate that this is row 3 of a 4 x 4 kernel,

::= 5 to indicate that this is a 16-element, 4 x 4 kernel,

::= 6 to indicate that this is a 4-element, 2 x 2 kernel.

The nth [compression lookup offset record] shall contain the <compression lookup table id> of the nth [compression lookup table] in this [compression lookup subsection].

(5) <compression lookup table offset> ::= a 4-byte unsigned integer defining the displacement, measured in bytes, between the beginning of the [compression lookup subsection] and the first byte of the [compression lookup table] identified in this [compression lookup offset record] (counting the first byte of the [compression lookup subsection] as 0).

(6) <compression lookup table offset record length> ::= a 2-byte unsigned integer indicating the length

of each [compression lookup offset record].

(7) /compression lookup value/ ::= a variable-length bit field specifying a value in the VQ compression codebook. For a particular VQ compression scheme, the /compression lookup value/ shall have a fixed length, which is defined in the <compression lookup value bit length>.

(8) <compression lookup value bit length> ::= a 2-byte unsigned integer ≥ 4, defining the length in bits of the /compression lookup value/ field in each [compression lookup record] of each [compression lookup table] in the [compression section]. All /compression lookup value/ fields in a given [compression lookup table] shall have the same <compression lookup value bit length>, which shall be a multiple of 4 bits.

(9) /image code/ ::= a variable-length bit string indicating an index to the associated VQ compression codebook in a VQ compressed map or image file. Successive /image code/ values in a given [image row] shall be stored contiguously. The total number of bits in the /image code/s constituting a given [image row] shall be a multiple of 8 bits, to ensure that each [image row] consists of an integer number of bytes.

(10) <image code bit length> ::= a 1-byte unsigned integer defining the length, in bits, of /image code/.

(11) <number of compression lookup records> ::= a 4-byte unsigned integer ≥ 1, indicating the number of [compression lookup record]s in each [compression lookup table].

(12) <number of compression lookup offset records> ::= a 2-byte unsigned integer ≥ 1, indicating the number of [compression lookup offset record]s in the [compression lookup offset table].

(13) <number of compression parameter offset records> ::= a 2-byte unsigned integer ≥ 0, indicating the number of [compression parameter offset record]s in the [compression parameter subsection]. For VQ images, no [compression parameter offset record] is present and therefore, this value shall ::=0.

(14) <number of image codes per row> ::= a 4-byte unsigned integer ≥ 1, defining the number of /image code/ fields in each [image row] of each [color band table]. All [image row]s in every [spectral band table] in every [subframe table] shall contain the same number of contiguous /image code/s. The <number of image codes per row> shall be chosen to ensure that the total number of bits in the /image code/s constituting a given [image row] shall be a multiple of 8 bits, to ensure that each [image row] consists of an integer number of bytes.

(15) <number of image rows> ::= a 4-byte unsigned integer ≥ 1, indicating the number of [image row]s in each [spectral band table]. All [spectral band table]s in every [subframe table] shall contain the same number of [image row]s.

(16) <number of values per compression lookup record> ::= a 2-byte unsigned integer ≥ 1, indicating the number of contiguous /compression lookup value/ fields in each [compression lookup record] of a given [compression lookup table]. All [compression lookup table]s in a given [compression section] shall have the same number of /compression lookup value/ fields in each [compression lookup record].

5.5 Definitions - NITF header and image subheader. The following fields within the NITF header and image subheader sections have the following specified values for VQ NITF images.

a. < image compression > (IC) ::= A 2-byte alphanumeric field identifying the image compression type. The field also indicates whether the image is masked. For VQ images ::= C4 if the image is not masked and ::=M4 if the image is masked.

b. < pixel value type > (PVTYPE) ::= an indicator of the type of computer representation used for the value of each /image code/ in the NITF image. For VQ this value ::= INT.

c. < compliance level > (CLEVEL) ::= A 2-byte alphanumeric value defining the NITF compliance level required to interpret fully all components of the file. For monochromatic VQ NITF files, less than or equal to 1024x1024 in size with no blocking, this value will be 1. However, for larger, blocked and/or colormapped or multispectral VQ images, the NITF compliance level required to interpret the file will be 2 or higher.

6. NOTES

(This section contains general or explanatory information that may be helpful but is not mandatory.)

6.1 Selection of VQ for NITFS. Several criteria were considered in selecting the VQ compression method over other methods. These criteria include display and print quality, as well as compression and decompression performance.

6.2 Compression performance. In determining when it is appropriate to use VQ for image compression, it is important to understand that VQ emphasizes decompression performance over other factors. VQ, which can provide excellent image quality, but has a relatively complex compression algorithm is most appropriate for centralized production.

6.3 Decompression performance. A major factor that drives the format of the data is the refresh rate and/or display speed required by using systems. The VQ decompression algorithm is much faster than other decompression methods, requiring only a series of table lookups --without special hardware -- to decompress each block of pixel data. This has big advantages to receiving systems.

6.4 Quality. Studies have shown that the quality of the VQ compressed images is very high when the appropriate VQ factors are used (ESC-TR-93-314, ESC-TR TBD). VQ compressed maps can have legible fine lettering, sharp edges and retain the color fidelity of the original source map.

6.5 Suggested reading. The following book contains several articles defining VQ compression and contains background information that the reader may find useful: Vector Quantization, Edited by Huseyin Abut, IEEE Press, New York, New York, 1990.

6.6 Subject term (key word) listing.

BWC
Compression Algorithm
Compression, Imagery
File format
Grayscale Imagery
Image
Image Compression
Raster
Secondary Imagery Dissemination Systems
SIDS
Tags

APPENDIX A

FILE NOTATION

10. GENERAL

10.1 Scope. This appendix is a mandatory part of the standard. The information contained in it is intended for guidance only.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. DEFINITIONS

30.1 Definitions used in this appendix. For purposes of this appendix, the definitions are listed in Section 3.

40. GENERAL REQUIREMENTS

40.1 File structure notation. The file structures given in section 5 of this document employ the following notations for clarity and conciseness:

The notation " ::= " is used to note "is defined as." For example, the statement; <image table> ::= a four byte . . . can be read as <image table> is defined as a four byte . . . .

<x> denotes an elementary field composed of bytes. Every byte field in this standard will be defined in terms of its data type, length, and domain (range of values).

/x/ denotes an elementary field or subfield composed of bits. Every bit field or subfield in this standard will be defined in terms of its data type, length, and domain (range of values).

[x] denotes a directory, file, or record --for example, a group of logical elements -- that is composed of ordered collections of fields and other groups of logical elements.

{x} denotes the start of a level of one or more elements in an ordered sequence. Each sequence of elements composing a file shall have an assigned numeric level {x}, where x = 1, 2, 3, 4, ... When a given group in a sequence of elements at level {x} is composed of subordinate elements, the sequence of subordinate elements shall be assigned to level {x+1}. The structure of each file and record is shown as an ordered indented list of its component parts, beginning with a level number. The structure of each directory is shown as an unordered indented list of its component parts, beginning with a level number. Each level of indentation corresponds to a level of subordination. For example, for a directory,

[directory 1]
    {1} (unordered)
    [file 1]

[file 2]
[directory 2]

indicates that [directory 1] contains [file 1], [file 2], and [directory 2], in any order.

Each file is defined completely in terms of its records and fields, recorded in the exact order indicated. For example:

[file 1]
{1}
< field a >
< field b >

[record 1]
{2}
< field c >
< field d >
{1}
[record 2]
{2}
< field e >
< field f >
< field g >

indicates that [file 1] is composed of < field a > , followed by < field b > , followed by [record 1], followed by [record 2].

In turn, [record 1] consists of < field c > followed by < field d > ; [record 2] is likewise composed of < field e > , < field f > , and < field g > , in that order.

In the figures that define the file structures, the complete entry for a field will include its name, data type, and length in the format:

< field name > ,data type:length or
/field name/,data type:length

The data type shall be a four-character abbreviation, as specified in table A-1. The length of a fixed-length byte field shall be an integer (number of bytes); the length of a fixed-length bit string shall be an integer (number of bits); the length of a variable-length field shall be designated as var. For example,

{5}
[record 3]
{6}
< field h length > ,uint:4
< field h > ,asci:var

< field j > ,asci:7
/field k/,bits:12 (2)

indicates that [record 3] has the components < field h length > , < field h > , < field j > , and /field k/. Of these, < field h length > is a 4-byte unsigned integer (which also defines the length in bytes of < field h >); < field h > is a variable-length ASCII character string; < field j > is a 7-byte ASCII character string; and /field k/ is a bit string, 12 bits long, which occurs twice.

TABLE A-1. Data types and their abbreviations.

Data Type	Abbreviation (used in defining data structures)
ASCII string	asci
Bit string	bits
Byte string	byte
Boolean	bool
Integer (signed)	ints
Integer (unsigned)	uint
Real	real
Alaphabetic string (ASCII character subset)	alph
Alphanumeric string (ASCII character subset)	alnm
Unsigned number (ASCII character subset)	numr
Signed number (ASCII character subset)	snum

The following description defines directory and file structures.

A directory may be composed of (contain) files and other directories. A file may be composed of records and fields. A record may be composed of fields and other records. Every occurrence of an [x] constitutes one occurrence of each of its component parts.

Any logical group [x] or field < x > or field /x/ may be repeated. In general, the directories and files contain repeating groups of elements. Directories may contain repeating groups of files and other directories. Files may contain repeating groups of records and fields. When an element occurs exactly once, it is shown on a line by itself without further elaboration. However, when an element is to be repeated, the range of repetition is shown in parentheses following the neme of the element. For example,

[record 1] (1, … 5)
[record 2]

indicates that [record 1] may occur 1, 2, 3, 4, or 5 times, but [record 2] occurs exactly once. The repetition of a group implies a repetition of each of its component parts, in turn. Note that components of any group may have their own repetition ranges as well. For example,

```
{4}
[record 1] (1, … many)
        {5}
         < field a > ,uint:2
         < field b > ,asci:8 (1, … 3)
         < field c > ,byte:1 (32)
```

indicates that [record 1] occurs at least once, but can repeat an indeterminate number of times. Each occurrence of [record 1] will entail one occurrence of < field a > ; 1, 2, or 3 occurrences of < field b > (each 8 bytes long); and 32 occurrences of < field c > , which is a byte string one byte long.

If a logical element may be present in some instances and not in others, then the range of repetition begins at 0. For example,

```
< field a > ,real:4 (0, … many)
< field b > ,real:4 (0, 1)
```

indicates that < field a > , a 4-byte floating-point number may be omitted entirely, or it may occur 1 or more times. < field b > may be omitted as well, but it will not occur more than once. This notation is extended to logical groups as well as to fields.

CONCLUDING MATERIAL

Custodians:

Army - SC
Navy - OM
Air Force - 02
Misc - DC

Review activities:

OASD - SO, DO, HP, IR
Army - AM, AR, MI, TM, MD, CE, SC, IE, ET, AC, PT
DLA - DH
Misc - NS, MP, DI, NA

Civil agency coordinating activities:

USDA - AFS, APS
DOC - NIST
DOE
EPA
GPO
HHS - NIH
DOI - BLM, GES, MIN
DOT - CGCT

Preparing activity:

Misc - DC

Agent:

Not applicable

(Project TCSS-1990)

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