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**MIL-STD-188-198A  
NOTICE 1  
12 October 1994**

**MILITARY STANDARD  
JOINT PHOTOGRAPHIC EXPERTS GROUP (JPEG) IMAGE COMPRESSION  
FOR THE NATIONAL IMAGERY TRANSMISSION FORMAT STANDARD**

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# MILITARY STANDARD

JOINT PHOTOGRAPHIC EXPERTS GROUP (JPEG)  
IMAGE COMPRESSION

FOR THE  
NATIONAL IMAGERY TRANSMISSION FORMAT STANDARD



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MIL-STD-188-198A

NOTICE 1

FORWARD

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. The National Imagery Transmission Format Standard Technical Board (NTB) developed this standard based upon currently available technical information.
3. The DOD and other IC members are committed to interoperability of systems used for formatting, transmitting, receiving, and processing imagery and imagery-related information. This standard describes the Joint Photographic Experts Group (JPEG) compression algorithm and establishes its application within the NITFS.
4. Beneficial comments (recommendations, additions, deletions) and other 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), Attention: TBCE, 10701 Parkridge Boulevard, 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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MIL-STD-188-198A

NOTICE 1

CONTENTS

PARAGRAPH		PAGE
5.2.2.4	Quantization tables . . . . .	39
5.2.2.4.1	Default quantization tables . . . . .	39
5.2.2.4.2	Custom quantization tables . . . . .	39
5.2.2.5	Entropy encoder/decoder . . . . .	39
5.2.2.5.1	Huffman coding . . . . .	39
5.2.2.5.1.1	Coding models for Huffman coding . . . . .	39
5.2.2.5.1.2	Forming the DC symbol . . . . .	40
5.2.2.5.1.3	Encoding the DIFF value . . . . .	42
5.2.2.5.1.4	Forming the AC symbol . . . . .	43
5.2.2.5.1.5	Encoding the AC coefficient values . . . . .	43
5.2.2.5.1.6	Huffman codes . . . . .	43
5.2.2.5.1.7	Huffman table generation . . . . .	44
5.2.2.5.1.8	Default BITS and HUFFVAL tables . . . . .	44
5.2.2.5.1.9	Custom BITS and HUFFVAL tables . . . . .	44
5.2.2.5.1.10	Building the Huffman coding tables . . . . .	44
5.2.2.5.1.11	Huffman encoding . . . . .	44
5.2.2.5.1.12	Huffman decoding . . . . .	46
5.2.2.5.2	Arithmetic coding . . . . .	46
5.2.3	Compressed data interchange format . . . . .	46
5.2.3.1	Marker codes . . . . .	47
5.2.3.2	Byte stuffing . . . . .	48
5.2.3.3	Format of a JPEG compressed image within an NITF file . . . . .	48
5.2.3.3.1	Single block JPEG compressed format . . . . .	48
5.2.3.3.1.1	Single block image data format . . . . .	48
5.2.3.3.1.2	Frame format . . . . .	48
5.2.3.3.1.3	Scan format . . . . .	49
5.2.3.3.1.4	Restart intervals . . . . .	49
5.2.3.3.1.5	Byte alignment . . . . .	49
5.2.3.3.2	Multiple block JPEG compressed format . . . . .	51
5.2.3.3.2.1	Multiple block image data format (IMODE=B or P) . . . . .	51
5.2.3.3.2.2	Multiple block image data format (IMODE=S) . . . . .	51
5.2.3.3.3	Frame header . . . . .	53
5.2.3.3.4	Scan header . . . . .	55
5.2.3.3.5	Table-specification and miscellaneous marker segments . . . . .	55
5.2.3.3.5.1	Quantization table-specification . . . . .	57
5.2.3.3.5.2	Huffman table-specification . . . . .	58
5.2.3.3.5.3	Restart interval definition . . . . .	58
5.2.3.3.5.4	Comment segment . . . . .	59
5.2.3.3.5.5	Application data segment . . . . .	59
5.2.3.3.5.5.1	NITF APP <sub>6</sub> application data segment . . . . .	59

MIL-STD-188-198A

NOTICE 1

CONTENTS

PARAGRAPH	PAGE
5.2.3.3.5.5.2 NITF APP, directory segments . . . . .	61
5.2.4 Encoding procedure with marker codes . . . . .	62
5.2.5 Decoding procedure with marker codes . . . . .	62
5.2.5.1 Quantization tables . . . . .	62
5.2.5.2 Huffman tables . . . . .	62
5.3 Progressive DCT-based JPEG mode . . . . .	62
5.4 Hierarchical JPEG mode . . . . .	62
5.5 Lossless JPEG mode . . . . .	62
5.6 Region of interest encoding and decoding processes . . . . .	62
6. NOTES . . . . .	63
6.1 Critical data . . . . .	63
6.2 Input sample precision not 8 or 12 . . . . .	63
6.3 Use of restart intervals . . . . .	63
6.4 Definition of effectivity . . . . .	64
6.4.1 Effectivity 1 - Tables . . . . .	64
6.4.2 Effectivity 2 - Lossless coding . . . . .	64
6.4.3 Effectivity 3 - Region of interest coding . . . . .	64
6.4.4 Effectivity 4 - Multiple band images . . . . .	64
6.4.5 Effectivity 5 - Progressive coding . . . . .	64
6.4.6 Effectivity 6 - Hierarchical coding . . . . .	65/66
6.4.7 Effectivity 7 - Arithmetic coding . . . . .	65/66
6.4.8 Effectivity 8 - Defense Information Systems Network (DISN) . . . . .	65/66
6.5 Subject term (key word) listing . . . . .	65/66

FIGURE

1. Encoder . . . . .	17
2. NITF file structure . . . . .	18
3. Decoder . . . . .	18
4. DCT-based encoder simplified diagram . . . . .	19
5. Preparation of quantized coefficients for entropy encoding . . . . .	20
6. DCT-based decoder simplified diagram . . . . .	21
7. Lossless encoder simplified diagram . . . . .	22
8. 3-sample prediction neighborhood . . . . .	22
9. Component-interleave and table-switching control . . . . .	24
10. Interleaved vs. non-interleaved encoding order . . . . .	25
11. Interleaved order for components with different dimensions . . . . .	26
12. Partitioning an example source image with 52 lines and 68 samples into 8x8 blocks . . . . .	30
13. Low pass filter for downsampling . . . . .	32

MIL-STD-188-198A  
 NOTICE 1

CONTENTS

PAGE

FIGURE

14.	Sample positions for upsampling rules . . . . .	33
15.	Simplified encode flow chart . . . . .	36
16.	Simplified decode flow chart . . . . .	37
17.	Decoder table generation . . . . .	45
18.	Huffman decode procedure . . . . .	46
19.	NITF single block file structure (IMODE=B or P) . . . . .	48
20.	NITF multiple block file structure (IMODE=B or P) . . . . .	50
21.	NITF multiple block file structure (IMODE=S) . . . . .	50

TABLE

I.	Categories . . . . .	40
II.	AC symbols . . . . .	42
III.	Marker codes for sequential DCT-based mode . . . . .	47
IV.	Frame header . . . . .	52
V.	Variable frame header fields . . . . .	53
VI.	Scan header . . . . .	54
VII.	Variable scan header fields . . . . .	55
VIII.	Quantization table specification . . . . .	56
IX.	Variable DQT segment fields . . . . .	56
X.	Huffman table specification . . . . .	57
XI.	Variable DHT fields . . . . .	58
XII.	Restart interval definition . . . . .	58
XIII.	Comment segment . . . . .	59
XIV.	Application data segment . . . . .	59
XV.	NITF APP <sub>6</sub> application data segment . . . . .	60
XVI.	NITF APP <sub>7</sub> directory segments. . . . .	62

APPENDIX

A	. . . . .	67
B	. . . . .	73
C	. . . . .	77
D	. . . . .	83

TABLE III. Marker codes for sequential DCT-based mode.

0xFFC0	SOF <sub>0</sub> - Baseline DCT
0xFFC1	SOF <sub>1</sub> - Extended sequential DCT
0xFFC4	DHT - Define Huffman Table(s)
0xFFD0	RST <sub>0</sub> - Restart with modulo 8 count 0
0xFFD1	RST <sub>1</sub> - Restart with modulo 8 count 1
0xFFD2	RST <sub>2</sub> - Restart with modulo 8 count 2
0xFFD3	RST <sub>3</sub> - Restart with modulo 8 count 3
0xFFD4	RST <sub>4</sub> - Restart with modulo 8 count 4
0xFFD5	RST <sub>5</sub> - Restart with modulo 8 count 5
0xFFD6	RST <sub>6</sub> - Restart with modulo 8 count 6
0xFFD7	RST <sub>7</sub> - Restart with modulo 8 count 7
0xFFD8	SOI - Start of Image
0xFFD9	EOI - End of Image
0xFFDA	SOS - Start of Scan
0xFFDB	DQT - Define Quantization Table(s)
0xFFDD	DRI - Define Restart Interval
0xFFE6	APP <sub>6</sub> - NITF application segment
0xFFE7	APP <sub>7</sub> -NITF directory segment
0xFFFE	COM - Comment

5.2.3.2 Byte stuffing. In the compressed data, any non-zero value following one or more 0xFF bytes is defined as a marker code, where 0x indicates a hexadecimal number. Therefore, whenever, in the



MIL-STD-188-198A  
 NOTICE 1

course of normal encoding, the byte value 0xFF is created in the code string, a 0x00 byte is stuffed into the code string, after the created 0xFF, to prevent the false detection of a marker code. If an 0x00 byte is detected after an 0xFF byte, the decoder must discard it. If the byte is not zero, a marker code has been detected and shall be interpreted to the degree needed to decode the data.

5.2.3.3 Format of a JPEG compressed image within an NITF file. The format for NITF image data compressed with the sequential DCT-based JPEG mode differs based on the number of blocks, bands, and IMODE value (B,P,S). These different cases are described below.

5.2.3.3.1 Single block JPEG compressed format. The format for NITF single block image data compressed with the sequential DCT-based JPEG mode is shown on figure 19.

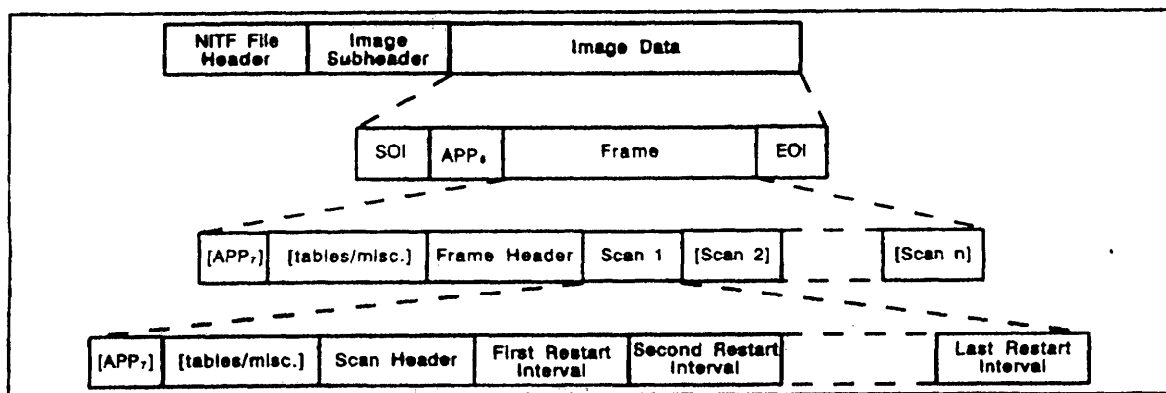


FIGURE 19. NITF single block file structure (IMODE=B or P).

5.2.3.3.1.1 Single block image data format. The top level of figure 19 specifies that the JPEG compressed data is contained in the Image Data Field of the NITF file. The second level of figure 19 specifies that the single block image format shall begin with an SOI marker, shall be immediately followed by the NITF APP<sub>6</sub> data segment, shall contain one frame, and shall end with an EOI marker.

5.2.3.3.1.2 Frame format. The third level of figure 19 specifies that a frame shall begin with a frame header and shall contain one or more scans. A frame header may be preceded by one or more table-specification or miscellaneous marker segments. When present, the optional NITF APP<sub>7</sub> scan directory segment precedes all other table-specification or miscellaneous marker segments. When the NITF image sub-header IMODE field is set to B, there shall be n scans within the frame, one for each of the components (n=1 or 3). The scan directory segment is not very useful when there is only one scan, and should not be used. When the IMODE field is set to P, there shall be a single scan within the frame consisting of three interleaved components. NITF does not allow the use of the JPEG DNL segment which, when present, would follow the first scan in the frame.

5.2.3.3.1.3 Scan format. The fourth level of figure 19 specifies that a scan shall begin with a scan header and shall contain one or more restart intervals. A scan header may be preceded by one or more table-specification or miscellaneous marker segments. When present, the optional NITF APP<sub>7</sub> restart interval directory segment precedes all other table-specifications or miscellaneous marker segments.

MIL-STD-188-198A  
NOTICE 1

5.2.3.3.1.4 Restart intervals. Following the scan header, each scan shall be encoded as a series of one or more restart intervals. A restart interval is a self-contained entropy-coded data segment that can be decoded independently from the other intervals. Restart intervals are used for error recovery (6.3). If the image were encoded as a single interval, any transmission error would render all subsequent image data unusable. When several restart intervals are used, the effects of an error can be contained within a single interval. The restart interval is defined by the DRI marker in a miscellaneous marker segment, and each interval, except the last, shall be followed by a marker code ( $RST_m$ ,  $m=0, \dots, 7$ ) where  $m$  is the interval count modulo eight. In JPEG, restart intervals are optional but NITF requires the use of restart marker codes with a restart interval no larger than the number of MCUs per block-row.

5.2.3.3.1.5 Byte alignment. To achieve byte alignment at the end of a restart interval, any incomplete byte is padded with one-bits. If this padding creates a 0xFF value, a zero byte is stuffed (see 5.2.2.2) before adding the following 0xFF prefix and marker code to prevent a decoder from interpreting this incomplete byte as a marker code.

5.2.3.3.2 Multiple block JPEG compressed format. The format for NITF multiple block image data compressed with the sequential DCT-based JPEG mode is shown on figure 20 for IMODE=B or P. The corresponding format when IMODE=S is shown on figure 21. Default quantization tables and Huffman tables shall apply to all blocks unless the compressed stream for that block includes custom table definitions. There shall be no carryover of custom tables between blocks so that custom tables must be included in each block where the defaults are not used.

MIL-STD-188-198A  
 NOTICE 1

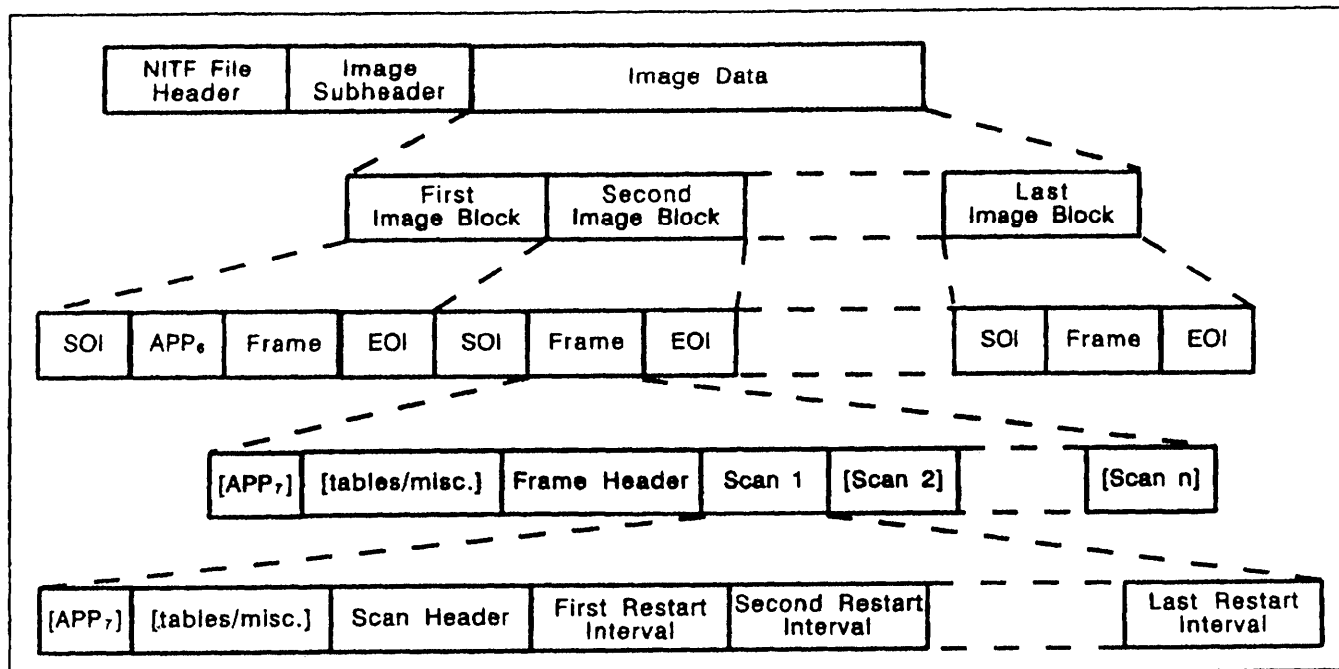


FIGURE 20. NITF multiple block file structure (IMODE=B or P).

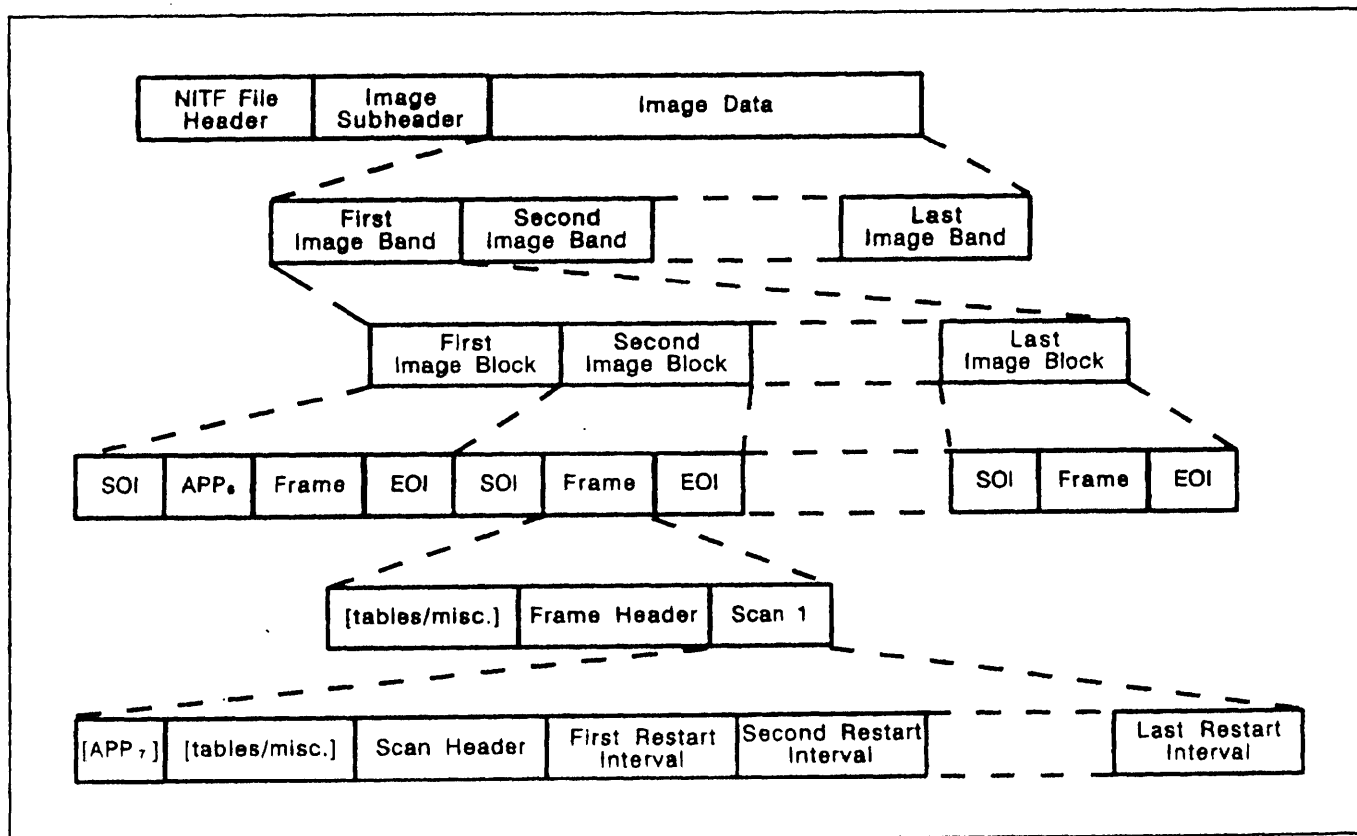


FIGURE 21. NITF multiple block file structure (IMODE=S).

Supersedes page 50 of MIL-STD-188-198A.

MIL-STD-188-198A

NOTICE 1

5.2.3.3.2.1 Multiple block image data format (IMODE=B or P). The top level of figure 20 specifies that the JPEG compressed data is contained in the Image Data Field of the NITF file. The second level of figure 20 specifies that this multiple block image format shall begin with the compressed data for the first image block and shall be followed by the compressed data for each image block, one after the other, left to right, top to bottom. The third level of figure 20 specifies that each compressed block shall begin with an SOI marker, shall contain one frame, and shall end with an EOI marker. The first block differs from the others. The SOI marker in the first block shall be immediately followed by the NITF APP<sub>6</sub> data segment. The format below this level is identical to the single block case previously described in 5.2.3.3.1.

5.2.3.3.2.2 Multiple block image data format (IMODE=S). The use of this IMODE requires that the image contain multiple blocks and multiple bands, otherwise IMODE shall be set to B or P. The top level of figure 21 specifies that the JPEG compressed data is contained in the Image Data Field of the NITF file. The second level of figure 21 specifies that this multiple block image format shall begin with the compressed data for the first image band and shall be followed by the compressed data for each image band, one after the other, first to last. The third level of figure 21 specifies that each compressed image band shall consist of the compressed data ( for that band) for each image block, one after the other, left to right, top to bottom. The fourth level of figure 21 specifies that each compressed block shall begin with an SOI marker, shall contain one frame, and shall end with an EOI marker. The first band differs from the others. The SOI marker in the first block of the first band shall be immediately followed by the NITF APP<sub>6</sub> data segment. The format below this level is identical to the single block case previously described in 5.2.3.3.1 with each frame containing only one scan that contains the compressed data from only one band. Since there is only one scan there will be no scan directory segment.

5.2.3.3.3 Frame header. The frame header specifies the source image characteristics, the components in the frame, the sampling factors for each component, and selects the quantization table to be used with each component. The format is shown in table IV with variable fields specified in table V for the different image types.

MIL-STD-188-198A

TABLE IV. Frame header.

Offset	Field Value	Field Name	length (bytes)	comments
0	see table V	SOF <sub>n</sub>	2	Start of frame. SOF <sub>0</sub> is used for "Baseline DCT sequential" mode when P=8. When P=12, SOF <sub>1</sub> must be used for "Extended DCT sequential, Huffman coding". Essentially, Baseline requires: sequential DCT, P=8; Huffman coding; 8-bit quantization tables; and no more than two sets of Huffman tables. Extended sequential allows: P=12, arithmetic coding; 16-bit quantization tables, and up to four sets of Huffman tables.
2	see table V	L <sub>r</sub>	2	Length of parameters = (8+3N <sub>r</sub> )
4	see table V	P	1	Sample precision, 8 or 12, (see SOF <sub>n</sub> note)
5	1-65535	Y	2	Number of lines (note 0 is not allowed)
7	1-65535	X	2	Number of samples per line
9	see table V	N <sub>r</sub>	1	Number of components per frame, 1 or 3
10	0	C <sub>1</sub>	1	Component number = 0 (R or Y)
11	see table V	H <sub>1</sub> V <sub>1</sub>	1	Horizontal & vertical sampling factors
12	see table V	TQ <sub>1</sub>	1	Quantization table selector
13	1	C <sub>2</sub>	1	Component number = 1 (G or Cb)
14	see table V	H <sub>2</sub> V <sub>2</sub>	1	Horizontal & vertical sampling factors
15	see table V	TQ <sub>2</sub>	1	Quantization table selector
16	2	C <sub>3</sub>	1	Component number = 2 (B or Cr)
17	see table V	H <sub>3</sub> V <sub>3</sub>	1	Horizontal & vertical sampling factors
18	see table V	TQ <sub>3</sub>	1	Quantization table selector

if N<sub>r</sub> = 3

if N<sub>r</sub> = 3

if N<sub>r</sub> = 3

if N<sub>r</sub> = 3

if N<sub>r</sub> = 3

if N<sub>r</sub> = 3

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MIL-STD-188-198A  
 NOTICE 1

TABLE XIII. Comment segment.

Offset	Field Value	Field Name	length (bytes)	comments
0	0xFFFE	COM	2	Comment marker.
2	2-65535	$L_c$	2	Segment length (2 + length of comment).
4	0-255	$Cm_1-Cm_{L_c-2}$	$L_c-2$	Comment bytes.

5.2.3.3.5.5 Application data segment. JPEG defines an application data segment with the general structure in table XIV. Sixteen different application marker codes are defined:  $APP_0 - APP_F$  with corresponding values 0xFFE0 - 0xFFEF.

TABLE XIV. Application data segment.

Offset	Field Value	Field Name	length (bytes)	comments
0	0xFFE0-0xFFEF	$APP_n$	2	Application data marker: $APP_0 - APP_F$ .
2	2-65535	$L_p$	2	Segment length (2 + length of application data).
4	0-255	$AP_1-AP_{L_p-2}$	$L_p-2$	Application data bytes.

5.2.3.3.5.5.1 NITF  $APP_6$  application data segment. NITF requires the use of an  $APP_6$  application data segment. Optional  $APP_7$  directory segments can also be used. No other application data segments shall be present in the compressed data. The NITF  $APP_6$  application data segment shall immediately follow the first SOI marker in the Image Data Field. The NITF  $APP_6$  application data segment contains information which is needed by an interpreter but not supported by the ISO/CCITT JPEG format. Most of this information is also present in some fields of the NITF image subheader (COMRAT, IREPBAND, NBPP, etc.). The format for  $APP_6$  is shown in table XV.



MIL-STD-188-198A  
 NOTICE 1

Offset	Field Value	Field Name	length (bytes)	comments
21	0-2	Stream Color	1	Compressed color representation. Three values are defined at this time. 0 - monochrome 1 - RGB 2 - YCbCr601
22	8 or 12	Stream Bits	1	Compressed image sample precision.
23	1	Horizontal Filtering	1	This field specifies the filtering used in the horizontal direction prior to subsampling the chrominance samples. One value is defined at this time. 1 - Centered samples, [1/2, 1/2] filter
24	1	Vertical Filtering	1	This field specifies the filtering used in the vertical direction prior to subsampling the chrominance samples. One value is defined at this time. 1 - Centered samples, [1/2, 1/2] filter
25	0	Flags	2	Reserved for future use.

5.2.3.3.5.5.2 NITF APP<sub>7</sub> directory segments. The NITF APP<sub>7</sub> directory segments are used to provide random access to the variable length compressed data segments. APP<sub>7</sub> segments contain a directory of offset information for a series of scans or restart intervals depending on the directory type. In all cases, offsets are measured from the beginning of the Image Data Field in the NITF file to the beginning of the element. The number of entries depends on the directory type and is the number of (restart intervals per scan) or (scans per block) for directory types: 'R' and 'S', respectively. The format for APP<sub>7</sub> is shown in table XVI where all integers are stored in big endian format. The number of directory entries can be very large for restart interval directories. In these cases it is possible for a directory to exceed the, approximately 64 kbyte, segment limitation fixed by the 2 byte L<sub>p</sub> field at offset 2 in any JPEG application data segment. Since each element requires 4 bytes in the directory, this translates to a maximum of 16,382 entries. When a logical directory contains more than 16,382 elements, they must be split between more than one physical directory. In this case, multiple APP<sub>7</sub> directory segments must follow each other with no other intervening data and they must be of the same directory type (restart interval). Each additional APP<sub>7</sub> directory contains those elements, in the same order, that would have been present in the directory had there been no size limitation.

MIL-STD-188-198A  
 NOTICE 1

TABLE XV. NITF APP<sub>7</sub> application data segment - Continued.

Offset	Field Value	Field Name	length (bytes)	comments
21	0-2	Stream Color	1	Compressed color representation. Three values are defined at this time. 0 - monochrome 1 - RGB 2 - YCbCr601
22	8 or 12	Stream Bits	1	Compressed image sample precision.
23	1	Horizontal Filtering	1	This field specifies the filtering used in the horizontal direction prior to subsampling the chrominance samples. One value is defined at this time. 1 - Centered samples, [1/2, 1/2] filter
24	1	Vertical Filtering	1	This field specifies the filtering used in the vertical direction prior to subsampling the chrominance samples. One value is defined at this time. 1 - Centered samples, [1/2, 1/2] filter
25	0	Flags	2	Reserved for future use.

5.2.3.3.5.5.2 NITF APP<sub>7</sub> directory segments. The NITF APP<sub>7</sub> directory segments are used to provide random access to the variable length compressed data segments. APP<sub>7</sub> segments contain a directory of offset information for a series of scans or restart intervals depending on the directory type. In all cases, offsets are measured from the beginning of the Image Data Field in the NITF file to the beginning of the element. The number of entries depends on the directory type and is the number of (restart intervals per scan) or (scans per block) for directory types: 'R' and 'S', respectively. The format for APP<sub>7</sub> is shown in table XVI where all integers are stored in big endian format. The number of directory entries can be very large for restart interval directories. In these cases it is possible for a directory to exceed the, approximately 64 kbyte, segment limitation fixed by the 2 byte L<sub>p</sub> field at offset 2 in any JPEG application data segment. Since each element requires 4 bytes in the directory, this translates to a maximum of 16,382 entries. When a logical directory contains more that 16,382 elements, they must be split between more that one physical directory. In this case, multiple APP<sub>7</sub> directory segments must follow each other with no other intervening data and they must be of the same directory type (restart interval). Each additional APP<sub>7</sub> directory contains those elements, in the same order, that would have been present in the directory had there been no size limitation.



MIL-STD-188-198A

NOTICE 1

TABLE XVI. NITF APP<sub>7</sub> directory segments.

Offset	Field Value	Field Name	length (bytes)	comments
0	0xFFE7	APP <sub>7</sub>	2	NITF directory segment marker.
2	4N+5	L <sub>p</sub>	2	Segment length (2 + length of application data).
4	0x52, 0x53	Directory Type	1	Directory type. Two values are defined at this time. 'R' - Restart Interval Directory 'S' - Scan Directory
5		N	2	Number of directory entries. Note 0 is not allowed. Maximum value of N (16,382) maximizes L <sub>p</sub> at 65533.
7		1st Offset	4	Offset to first element in this directory. (restart interval, scan).
11		2nd Offset	4	Offset to second element in this directory.
4N+3		Last Offset	4	Offset to last element in this directory.

5.2.4 Encoding procedure with marker codes. Figure 15 illustrates the overall encoding procedure when the marker codes are added to the entropy-coded data segments.

5.2.5 Decoding procedure with marker codes. Figure 16 illustrates the overall decoding procedure when the marker codes are added to the entropy-coded data segments.

5.2.5.1 Quantization tables. If the DQT marker is not in the compressed data, then information from the COMRAT field in the NITF image subheader (defined in MIL-STD-2500A) shall be interpreted to determine the appropriate default table(s). If the DQT marker is in the compressed data, then this table specification shall take precedence over any defaults specified in the COMRAT field.

5.2.5.2 Huffman tables. If the DHT marker is not in the compressed data, then the default Huffman table, from Appendix B, for this image data type, image sample precision, and image color shall be used. If the DHT marker is in the compressed data, then this table specification shall take precedence over any defaults.

5.3 Progressive DCT-based JPEG mode. (Effectivity 5)

5.4 Hierarchical JPEG mode. (Effectivity 6)

5.5 Lossless JPEG mode. (Effectivity 2)

5.6 Region of interest encoding and decoding processes. (Effectivity 3)

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MIL-STD-188-198A

2 DOCUMENT DATE (YYMMDD)

931215

3. DOCUMENT TITLE **JPEG IMAGE COMPRESSION FOR THE NITFS**

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

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