NOTICE OF CHANGE

NOT MEASUREMENT SENSITIVE

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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NEW PAGE	DATE	SUPERSEDED PAGE	DATE
cover	15 December 1993	cover	reprinted without change
ii	12 October 1994	ii	15 December 1993
v	12 October 1994	v	15 December 1993
vi	12 October 1994	vi	15 December 1993
vii/viii	12 October 1994	vii	15 December 1993
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49	12 October 1994	49	15 December 1993
50	12 October 1994	50	15 December 1993
51	12 October 1994	51	15 December 1993
52	15 December 1993	52	reprinted without change
59	12 October 1994	59	15 December 1993
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(Project TCSS-1980)

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MIL-STD-188-198A
15 December 1993
MIL-STD-188-198
18 June 1993

MILITARY STANDARD

JOINT PHOTOGRAPHIC EXPERTS GROUP (JPEG) IMAGE COMPRESSION

FOR THE NATIONAL IMAGERY TRANSMISSION FORMAT STANDARD

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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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FIGURE

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

0xFFC0	SOF_0 - Baseline DCT
0xFFC1	SOF_1 - Extended sequential DCT
0xFFC4	DHT - Define Huffman Table(s)
0xFFD0	RST_0 - Restart with modulo 8 count 0
0xFFD1	RST_1 - Restart with modulo 8 count 1
0xFFD2	RST_2 - Restart with modulo 8 count 2
0xFFD3	RST_3 - Restart with modulo 8 count 3
0xFFD4	RST_4 - Restart with modulo 8 count 4
0xFFD5	RST_5 - Restart with modulo 8 count 5
0xFFD6	RST_6 - Restart with modulo 8 count 6
0xFFD7	RST_7 - 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_6 - NITF application segment
0xFFE7	APP_7-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 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.

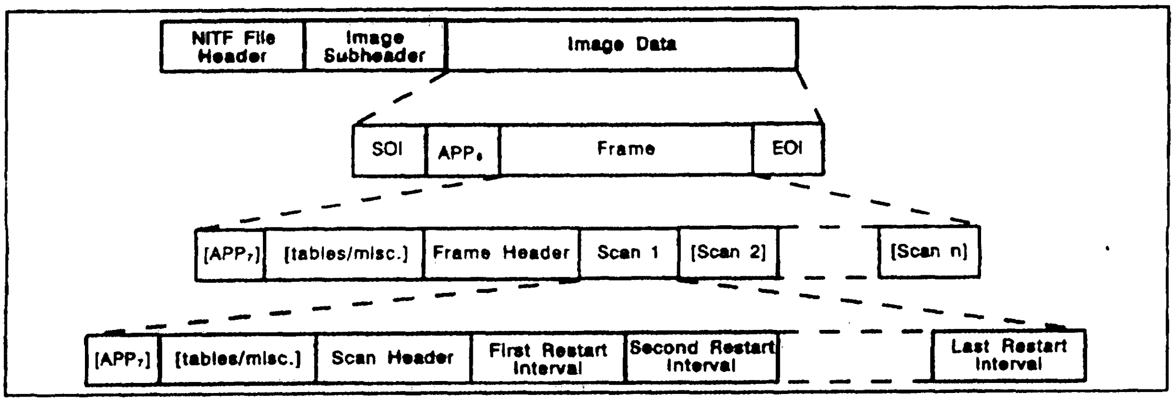

FIGURE 19. NITF single bock file structure (IMODE=B or P).

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_6 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_7 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_7 restart interval directory segment precedes all other table-specifications or miscellaneous marker segments.

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, $m=0,\ldots,7$) 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.

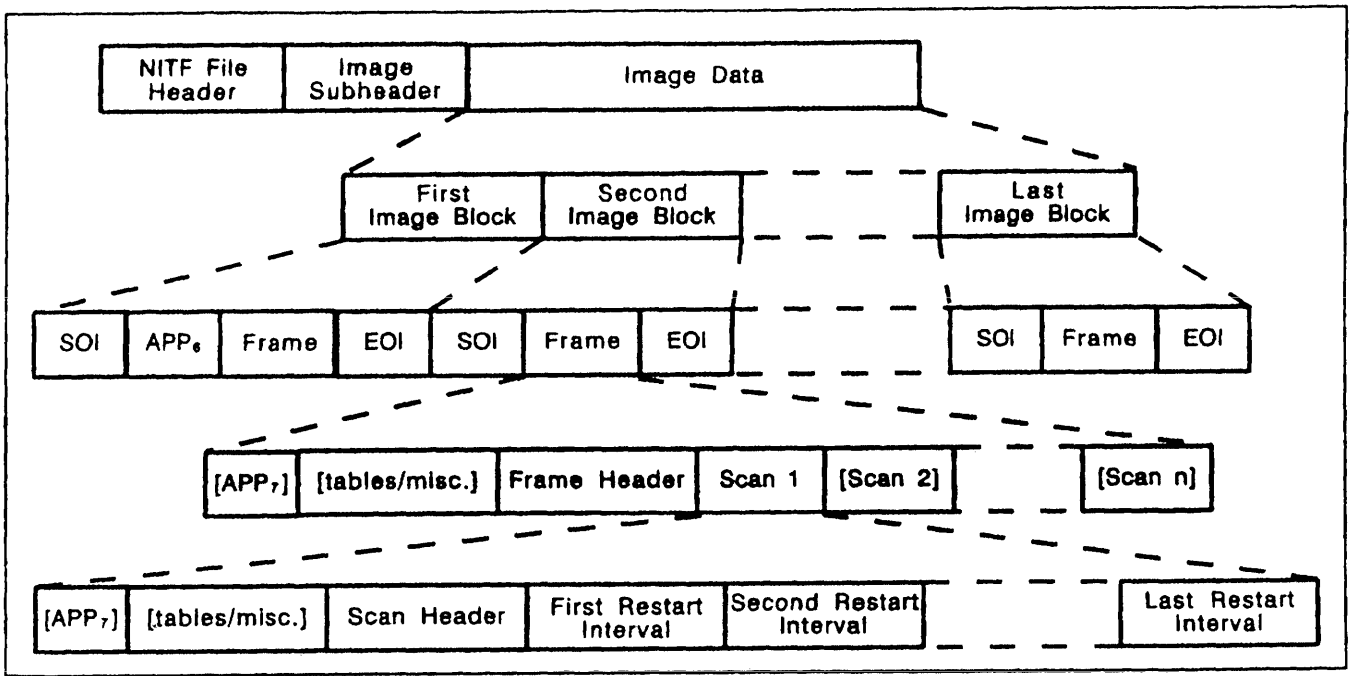

FIGURE 20. NITF multiple block file structure (IMODE=B or P).

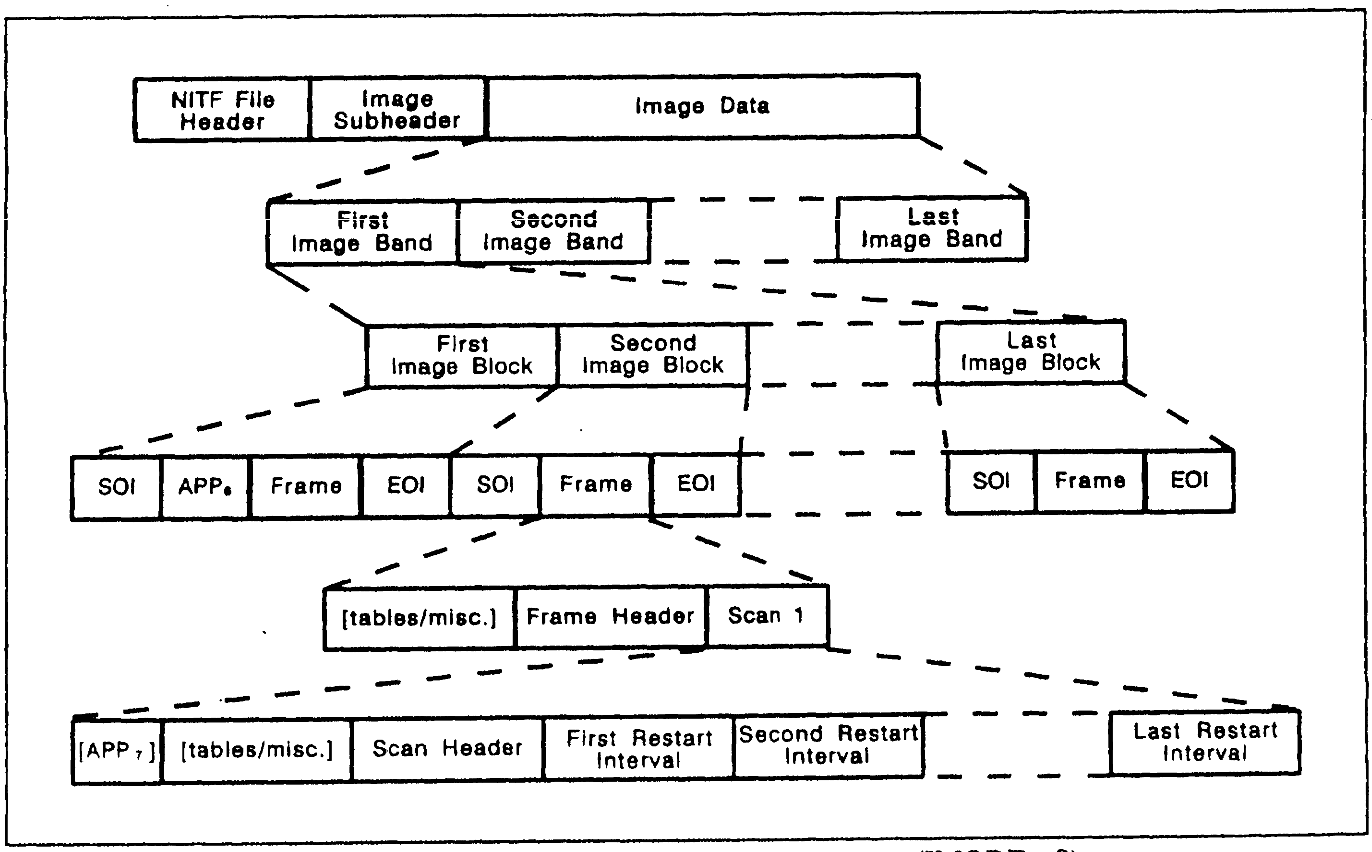

FIGURE 21. NITF multiple block file structure (IMODE=S).

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_6 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_6 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.

TABLE IV. Frame header.

Offset	Field Value	Field Name	length (bytes)	comments	
0	see table V	SOF_n	2	Start of frame. SOF_0 is used for "Baseline DCT sequential" mode when P=8. When P=12, SOF_1 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_f	2	Length of parameters = $(8+3N_f)$	
4	see table V	P	1	Sample precision, 8 or 12, (see SOF_n 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_f	1	Number of components per frame, 1 or 3	
10	0	C_1	1	Component number = 0 (R or Y)	
11	see table V	H_1V_1	1	Horizontal & vertical sampling factors	
12	see table V	TQ_1	1	Quantization table selector	
13	1	C_2	1	Component number = 1 (G or Cb)	if $N_f = 3$
14	see table V	H_2V_2	1	Horizontal & vertical sampling factors	if $N_f = 3$
15	see table V	TQ_2	1	Quantization table selector	if $N_f = 3$
16	2	C_3	1	Component number = 2 (B or Cr)	if $N_f = 3$
17	see table V	H_3V_3	1	Horizontal & vertical sampling factors	if $N_f = 3$
18	see table V	TQ_3	1	Quantization table selector	if $N_f = 3$

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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.

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 <u>NITF APP_7 directory segments.</u> The NITF APP_7 directory segments are used to provide random access to the variable length compressed data segments. APP_7 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_7 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_p 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_7 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_7 directory contains those elements, in the same order, that would have been present in the directory had there been no size limitation.

TABLE XV. NITF APP_6 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_7 directory segments. The NITF APP_7 directory segments are used to provide random access to the variable length compressed data segments. APP_7 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_7 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_p 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_7 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_7 directory contains those elements, in the same order, that would have been present in the directory had there been no size limitation.

TABLE XVI. NITF APP_7 directory segments.

Offset	Field Value	Field Name	length (bytes)	comments
0	0xFFE7	APP_7	2	NITF directory segment marker.
2	4N+5	L_p	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_p 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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