NOTICE OF CHANGE

METRIC

MIL-STD-188-161A
NOTICE 1
17 March 1989

MILITARY STANDARD
INTEROPERABILITY AND PERFORMANCE STANDARDS FOR DIGITIAL FACSIMILE EQUIPMENT

TO ALL HOLDERS OF MIL-STD-188-161A:

1. THE FOLLOWING PAGES OF MIL-STD-188-161A HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
Cover	4 July 1988	Cover	REPRINTED WITHOUT CHANGE
ii	17 March 1989	ii	4 July 1988
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8	17 March 1989	8	4 July 1988
9	4 July 1988	9	REPRINTED WITHOUT CHANGE
10	17 March 1989	10	4 July 1988
13	17 March 1989	13	4 July 1988
14	4 July 1988	14	REPRINTED WITHOUT CHANGE
17	17 March 1989	17	4 July 1988
18	4 July 1988	18	REPRINTED WITHOUT CHANGE
23	17 March 1989	23	4 July 1988
24	4 July 1988	24	REPRINTED WITHOUT CHANGE
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29	17 March 1989	29	4 July 1988
30	4 July 1988	30	REPRINTED WITHOUT CHANGE
31	17 March 1989	31	4 July 1988
32	4 July 1989	32	REPRINTED WITHOUT CHANGE
35	17 March 1989	35	4 July 1988
36	4 July 1988	36	REPRINTED WITHOUT CHANGE
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2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-188-161A will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate

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JTC3A - JT

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(Project SLHC-1612)

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MIL-STD-188-161A
4 JULY 1988
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MILITARY STANDARD

INTEROPERABILITY AND PERFORMANCE STANDARDS FOR DIGITAL FACSIMILE EQUIPMENT

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DEPARTMENT OF DEFENSE
WASHINGTON, DC 20301

Interoperability and Performance Standards for
Digital Facsimile Equipment
MIL-STD-188-161A

1. This military standard (MIL-STD) is approved and mandatory for use by all Departments and Agencies of the Department of Defense in accordance with DOD Directive (DODD) 4640.11, dated 21 December 1987.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Joint Tactical Command, Control, and Communications Agency, Washington Office, ATTN: Technical Standards Office, C3A-ADW-S, 11440 Isaac Newton Square, North, Reston, VA. 22090-5006, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

Supersedes Page ii of Revision A

1. SCOPE

1.1 Purpose. The purpose of this document is to promulgate technical interoperability and performance parameters in the form of mandatory system standards and optional design objectives that are considered necessary to ensure compatibility and commonality among digital facsimile equipment. It is also the purpose of this document to establish a level of performance for digital facsimile equipment considered necessary to satisfy the requirements of a majority of users. The technical parameters promulgated by this document represent, in general, minimum interoperability and performance characteristics which may be exceeded in order to satisfy specific requirements.

It is not the purpose of this document to serve as a stand-alone, comprehensive reference containing all technical parameters and other details required for the design of new equipment or the preparation of specifications. Therefore, parameters for such items as size and weight limitations, connectors, cable assemblies, or power supplies are not contained in this document. These parameters and other design details have to be established, based on specific requirements, and have to be carefully tailored in accordance with the policies of Department of Defense Directive (DODD) 5000.43 and MIL-STD-188-100.

This document is not intended to be an engineering textbook for a reference for digital facsimile equipment. It is assumed that users of this document have a basic technical background in the design and engineering of digital facsimile systems.

It is not the purpose of this document to inhibit advances in communications technology. Such advances are facilitated by not specifying the technology that should be used in the design and development of digital facsimile systems to meet the required standards.

1.2 Content. This standard provides technical interoperability and performance parameters for two types of digital facsimile equipment. These types are designated Type I and Type II, which are compatible with Type I and Type II NATO tactical digital fascimile equipment, respectively. This standard also includes requirements for CCITT Group 3 facsimile equipment in accordance with FED-STD-1062 and FED-STD-1063.

1.3 Applicability. This standard is mandatory within the Department of Defense (DOD) in the design and development of new facsimile equipment. It is not intended that existing equipment and systems be immediately converted to comply with the provisions of this standard. New equipment and systems and those undergoing major modification or rehabilitation shall conform to this standard. If deviation from this standard is required, see waiver procedures contained in DODD 4640.11.

1.3.1 Application guidance. Based on identified user requirements, facsimile equipment designated for both secure and nonsecure transmissions shall, at a minimum, be compatible with both Type I and/or Type II (see sections 4 and 5) and CCITT Group 3 (FED-STD-1062 and 1063) requirements. Facsimile equipment designated for only secure transmissions shall, at a minimum, be compatible with Type I and/or Type II requirements. Facsimile equipment designated for only nonsecure transmissions shall, at a minimum, be compatible with CCITT Group 3 (FED-STD-1062 and 1063) requirements. For additional information on application, refer to section 4 on application guidance.

1.4 Objective. The main objectives of this document are to ensure interoperability of digital facsimile equipment consistent with DOD requirements, to provide a degree of performance acceptable to a majority of users of digital facsimile equipment, and to achieve the necessary degree of interoperability, performance and compatibility in the most economical way.

1.5 System standards and design objective. The parameters and other requirements specified in this document are mandatory system standards if the word "shall" is used in connection with the parameter value or requirement under consideration. Nonmandatory design objectives are indicated in parenthesis after a standardized parameter value or by the word "should" in connection with the parameter value or requirement under consideration. For a definition of the terms "system standard" and "design objective" see FED-STD-1037.

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 issues 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.

Federal standards

FED-STD-1037	Glossary of Telecommunication Terms
FED-STD-1062	Group III Facsimile Apparatus for Document Transmission (Note: DOD Adopted)
FED-STD-1063	Procedures for Document Facsimile Transmission (Note: DOD Adopted)

Military standards

MIL-STD-188-100	Common Long Haul and Tactical Communications Systems Technical Standards
MIL-STD-188-114	Electrical Characteristics of Digital Interface Circuits
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

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

NTISSI 7000	TEMPEST Countermeasures for Facilities
DODD 5000.43	Acquisition Streamlining
DODD 4640.11	Mandatory Use of Military Telecommunications Standards in the MIL-STD-188 Series

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

(Copies of DOD Directives are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120.)

2.2 Non-Government publications. The following documents form a part of this standard 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.

STANAG 5000	Interoperability of Tactical Digital Facsimile Equipment
CCITT RED BOOK VOL. VII	
Recommendation T.4	Standardization of Group 3 Facsimile Apparatus for Document Transmission
Recommendation T.30	Procedures for Document Facsimile Transmission in the General Switched Telephone Network

(Applications for copies should be addressed to the U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.)

(Nongovernment standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

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

3. DEFINITIONS

3.1 Facsimile equipment type definitions.

3.1.1 Type I facsimile equipment. Facsimile equipment which provides for the transmission and reception of an image with black and white information only is called Type I facsimile equipment. This equipment is compatible with Type I NATO facsimile equipment as defined in STANAG 5000.

3.1.2 Type II facsimile equipment. Facsimile equipment which provides for the transmission and reception of an image in shades of gray, as well as black and white, is called Type II facsimile equipment. This equipment is compatible with Type II NATO facsimile equipment as defined in STANAG 5000.

3.1.3 CCITT Group 3 facsimile equipment. Facsimile equipment which provides for the transmission and reception of an image with black and white information as defined in CCITT Recommendations T.4 and T.30 (FED-STD-1062 and FED-STD-1063), which incorporate means for reducing the redundant information in the document signal using the coding scheme defined in CCITT Recommendation T.4 prior to the modulation process.

3.2 Facsimile mode definitions.

3.2.1 Basic mode. In the basic mode the transmitter for Type I and Type II facsimile does not pause after calling the receiving unit to wait for an acknowledgment before transmitting an image in the simplex and broadcast mode of operation.

3.2.2 Handshake mode. In the handshake mode the transmitter for Type I, Type II, and CCITT Group 3 facsimile pauses after calling the receiving unit to wait for an acknowledgment before transmitting an image in the duplex mode of operation.

NOTE: This is a normal method of operation for CCITT Group 3 facsimile equipment.

3.3 Synchronization code words and signaling sequences. The code words and signaling sequences used in Type I and Type II facsimile are defined in table I.

3.4 Other definitions. Other telecommunication terms used in this document are defined in FED-STD-1037.

TABLE I. Code words and signaling sequences for Type I and Type II.

Name	Make Up
Beginning of Intermediate Line Pair (BILP)	0000000000000011
Beginning of Line Pair (BOLP)	0000000000000010
End of Line (EOL)	000000000001
End of Message (EOM)	16 consecutive S_1 code words
Not End of Message ($\overline{\text{EOM}}$)	16 consecutive inverted S_1 code words
Return to Control (RTC)	EOL EOL EOL EOL EOL EOL
Start of Message (SOM)	S_1 S_0 X clock periods S_0 S_1 (Where X is the number of clock periods between the pairs of code words)
S_0	111100010011010
S_1	111101011001000
Fill	Variable length string of 0s
Stuffing	Variable length string of 1s
Preamble	Variable length string of all 1s or all 0s

4. GENERAL REQUIREMENTS

4.1 Interoperability. The overriding requirement is for interoperability within DOD, among all Services and Agencies and with our NATO allies.

a. Secure transmissions. Facsimile equipment designated for secure transmissions shall, at a minimum, be compatible with the requirements for Type I and/or Type II, as stated herein. (These requirements are compatible with STANAG 5000 parameters.)

b. Nonsecure transmissions. Facsimile equipment designated for nonsecure transmissions shall, at a minimum, be compatible with CCITT Group 3 requirements as documented in FED-STD-1062 and FED-STD-1063.

c. Dual mode transmissions. Facsimile equipment designated for both nonsecure and secure transmissions shall, at a minimum, be compatible with both CCITT Group 3 and Type I and/or Type II requirements as stated in subparagraphs a. and b., above.

4.1.1. Dual mode protocols. Type I and/or Type II protocols shall always be used between terminals implementing both CCITT Group 3 and Type I and/or Type II protocols. Receiving dual mode terminals shall be capable of recognizing and differentiating between CCITT Group 3 and Type I and/or Type II transmissions.(Note: There is no requirement for the CCITT Group 3 protocols and Type I and/or Type II protocols to interoperate.)

4.1.2. Dual mode security. When processing classified information in dual mode terminals, it shall be ensured that the classified traffic is not allowed access to the outside world through the CCITT Group 3 path.

4.2 TEMPEST. The facsimile equipment, when provided for secure operations, shall meet the applicable requirements of National Telecommunications and Information Systems Security Instruction (NTISSI) 7000.

5. DETAILED REQUIREMENTS FOR TYPE I AND TYPE II

5.1 Interface.

5.1.1 Transmission rates. The facsimile equipment, excluding the modem, shall be able to operate bit-by-bit asynchronously at data rates of 2400 bits per second, 4800 bits per second, 9600 bits per second, 16 kilobits per second (kb/s) and 32 kb/s with timing provided by an external clock.

5.1.2 Digital interfaces. The electrical characteristics of all digital interfaces for data, control, and timing signals shall comply with the applicable requirements as stated in MIL-STD-188-114.

5.1.3 Interchange circuits. The interchange circuits shown in table II are mandatory. Other circuits may be provided for specific applications.

TABLE II. Functional interchange circuits.

CIRCUIT	DIRECTION
REQUEST TO SEND	FROM DTE TO DCE
CLEAR TO SEND	FROM DCE TO DTE
RECEIVE INPUT CONTROL	FROM DTE TO DCE
SEND DATA	FROM DTE TO DCE
RECEIVE DATA	FROM DCE TO DTE
SEND TIMING	FROM DCE TO DTE
RECEIVE TIMING	FROM DCE TO DTE
SEND COMMON	RETURN
RECEIVE COMMON	RETURN
SIGNAL GROUND	GROUND

5.2 Type I facsimile equipment.

5.2.1 Image parameters.

5.2.1.1 Tolerance. The tolerance for the image parameters listed in subparagraphs 5.2.1.2 and 5.2.1.3, shall be ±1 percent.

5.2.1.2 Scan line length. The scan line length shall be 215 millimeters (mm), left justified.

5.2.1.3 Resolution. The facsimile equipment shall have three switch selectable standards for vertical and horizontal resolution. They are:

a. 3.85 lines per mm (vertical) by 1728 black and white picture elements (pels) along the horizontal scan line. (Note: This is a nominal medium resolution of 100 by 200 lines per inch.)

b. 3.85 lines per mm (vertical) by 864 black and white pels along the horizontal scan line. (Note: This is a nominal low resolution of 100 by 100 lines per inch.)

c. 7.7 lines per mm by 1728 pels along the horizontal scan line. (Note: This is a nominal high resolution of 200 by 200 lines per inch.)

5.2.1.4 Scanning direction. Scanning direction shall be from left to right and from top to bottom.

5.2.1.5 Scanned line transmission time. The minimum scanned line transmission time shall be 20 milliseconds (msec).

5.2.1.6 Contrast levels. The contrast levels shall be black and white.

5.2.2 Document dimensions. Input of documents up to a maximum of 215 mm wide by 1000 mm long shall be accepted. Documents up to 230 mm wide may be accepted into the scanner but only 215 mm of the document shall be scanned.

5.2.3 Image coding modes. The facsimile equipment shall be capable of operating in three modes: uncompressed, compressed, and compressed with forward error correction. (Note: Simplified block diagrams of the facsimile transmitter and receiver are shown in Appendix C.) Subparagraphs 5.2.3.1 through 5.2.3.3 apply to resolutions of x 200 (1728 pels). The same principles apply to the resolutions of x 100 (864 pels).

5.2.3.1 Uncompressed mode. In the uncompressed mode, facsimile data shall be transmitted pel by pel, with logic 1 representing black. Each line of the output data shall consist of a synchronization code followed by a number of pels as specified in subparagraph 5.2.1.3. The synchronization code shall be a sequence of two S_0 code words.

5.2.3.2 Compressed mode. In the compressed mode, facsimile data shall be transmitted after compression by the redundancy reduction algorithm. A line of data shall be composed of a series of variable length code words. Each code word represents a run-length of either all white or all black. White runs and black runs shall alternate. All data lines shall begin with a white run-length code word to ensure that the

receiver maintains color synchronization. A white run-length of zero shall be sent if the actual scan line begins with a black run. Black or white run-lengths, up to a maximum length of one scanning line (1728 pels), are defined by the code words in tables III and IV. The code words are of two types: terminating code words and make-up code words. Each run-length shall be represented by either one terminating code word, or one make-up code word followed by a terminating code word.

5.2.3.2.1 Short runs. Run-lengths in the range of 0 through 63 pels shall be encoded with the appropriate terminating code word. (Note: The black run-length code words and the white run-length code words are in separate lists.

5.2.3.2.2 Long runs. Run-lengths in the range of 64 through 1728 pels shall be encoded first by the make-up code word representing the run-length which is equal to or shorter than that required. The make-up code word shall be followed by the terminating code word representing the difference between the required run-length and the run-length represented by the make-up code word.

5.2.3.2.3 End of line (EOL). The EOL code word shall follow each line of facsimile data. (Note: This is a unique code word that can never be found within a valid line of data. Therefore, resynchronization after an error burst is possible.) In addition, the EOL code word shall also be sent prior to the first data line of a page.

5.2.3.2.4 Fill. Fill may be placed in the data flow to generate a pause. Fill may be inserted between a line of data and an EOL, but never within a line of data. Fill shall be added to ensure that the transmission time of each total coded scan line is not less than the minimum. To prevent premature disconnects, the maximum transmission time of any total coded scan line should be less than the interval specified in the loss of synchronization specifications. (Note: Fill format is a variable length string of 0s.)

5.2.3.2.5 Return to control (RTC). A minimum of two contiguous RTC signals shall be sent to indicate the end of document transmission. (Note: Each RTC consists of six consecutive EOLs.) Following the RTC signals, the transmitter shall send the post-message commands.

5.2.3.3 Compressed with forward error correction. In the compressed with forward error correction mode, facsimile data shall be further processed by a channel coder and bit interleaving buffer to provide forward error correction (FEC). The channel coder shall use a Bose Chandhuri Hocquenghem (BCH) forward error correction code with the

capability of correcting two errored bits per block. Table V lists the syndromes of the BCH code that shall be used.

5.2.3.3.1 Encoder. An encoder shall be provided in the facsimile transmitter to encode the facsimile data using the BCH code. For information on possible implementation of the encoder, see Appendix C.

5.2.3.3.2 Decoder. A decoder shall be provided in the facsimile receiver to decode the received facsimile data. For information on possible implementation of the decoder, see Appendix C.

5.2.3.3.3 Interleaving buffer. An interleaving buffer shall be used to improve the error correcting capability of the channel encoder, especially considering transmission bit errors clustered in bursts. The buffer shall be a matrix of 63 x 5 = 315 bits. Figure 1 shows the interleaving buffer configuration on the transmitting side. (Note: The figure labeling follows STANAG 5000 format, hence the long side of the matrix is designated N (N = 63) and the short side is designated W (W = 5).) Data input shall be line-by-line, data output shall be column-by-column. The data input sequence shall be

$$D_0, D_1, \ldots\ldots, D_{313}, D_{314}.$$

Accordingly, the data output sequence shall be:

$$D_0, D_{63}, D_{126}, D_{189}, D_{252}, D_1, D_{64}, \ldots., D_{188}, D_{251}, D_{314}.$$

At the receiving side, the data input and data output sequence shall be the reverse of the transmitting side (as shown in figure 2).

5.2.3.3.4 Synchronization. The transmitting BCH-encoder and interleaving buffer respectively shall be synchronized with the receiving BCH-decoder and interleaving buffer, before starting the transmission of encoded facsimile data. The FEC control block shall be the synchronization SOM sequence when the BCH-encoder and interleaving buffer are used. Figure 3 illustrates the format for the synchronization SOM sequence. The synchronization process shall be as follows:

a. The transmitter shall send the synchronization SOM sequence without using the BCH-encoder and interleaving buffer. Immediately after the synchronization SOM sequence, the transmitter uses the BCH-encoder and interleaving buffer to send encoded facsimile data.

b. At the receiver, the incoming signal shall be initially monitored bit-by-bit without using the BCH-decoder and interleaving buffer. When the first synchronization SOM sequence is detected,

TABLE V. Syndromes of the BCH decoder.

	r11	r10	r9	r8	r7	r6	r5	r4	r3	r2	r1	r0
R1	1	0	0	0	0	0	0	0	0	0	0	0
R2	1	1	0	0	0	0	0	0	0	0	0	0
R3	1	0	1	0	0	0	0	0	0	0	0	0
R4	1	0	0	1	0	0	0	0	0	0	0	0
R5	1	0	0	0	1	0	0	0	0	0	0	0
R6	1	0	0	0	0	1	0	0	0	0	0	0
R7	1	0	0	0	0	0	1	0	0	0	0	0
R8	1	0	0	0	0	0	0	1	0	0	0	0
R9	1	0	0	0	0	0	0	0	1	0	0	0
R10	1	0	0	0	0	0	0	0	0	1	0	0
R11	1	0	0	0	0	0	0	0	0	0	1	0
R12	1	0	0	0	0	0	0	0	0	0	0	1
R13	0	0	1	0	1	0	0	1	1	1	0	0
R14	1	1	0	1	0	1	0	0	1	1	1	0
R15	1	0	1	0	1	0	1	0	0	1	1	1
R16	0	0	1	1	1	1	0	0	1	1	1	1
R17	0	1	1	1	0	1	1	1	1	0	1	1
R18	0	1	0	1	0	0	1	0	0	0	0	1
R19	0	1	0	0	0	0	0	0	1	1	0	0
R20	1	1	1	0	0	0	0	0	0	1	1	0
R21	1	0	1	1	0	0	0	0	0	0	1	1
R22	0	0	1	1	0	0	0	1	1	1	0	1
R23	0	1	1	1	0	0	0	1	0	0	1	0
R24	1	1	1	1	1	0	0	0	1	0	0	1
R25	0	0	0	1	0	1	0	1	1	0	0	0
R26	1	1	0	0	1	0	1	0	1	1	0	0
R27	1	0	1	0	0	1	0	1	0	1	1	0
R28	1	0	0	1	0	0	1	0	1	0	1	1
R29	0	0	1	0	0	0	0	0	1	0	0	1
R30	0	1	1	1	1	0	0	1	1	0	0	0
R31	1	1	1	1	1	1	0	0	1	1	0	0
R32	1	0	1	1	1	1	1	0	0	1	1	0
R33	1	0	0	1	1	1	1	1	0	0	1	1
R34	0	0	1	0	0	1	1	0	0	1	0	1
R35	0	1	1	1	1	0	1	0	1	1	1	0
R36	1	1	1	1	1	1	0	1	0	1	1	1
R37	0	0	0	1	0	1	1	1	0	1	1	1
R38	0	1	1	0	0	0	1	0	0	1	1	1
R39	0	1	0	1	1	0	0	0	1	1	1	1
R40	0	1	0	0	0	1	0	1	1	0	1	1
R41	0	1	0	0	1	0	1	1	0	0	0	1
R42	0	1	0	0	1	1	0	0	0	1	0	0
R43	1	1	1	0	0	1	1	0	0	0	1	0
R44	1	0	1	1	0	0	1	1	0	0	0	1
R45	0	0	1	1	0	0	0	0	0	1	0	0
R46	1	1	0	1	1	0	0	0	0	0	1	0
R47	1	0	1	0	1	1	0	0	0	0	0	1
R48	0	0	1	0	1	1	1	1	1	1	0	0
R49	1	1	0	1	1	1	1	1	1	1	1	0
R50	1	0	1	0	1	1	1	1	1	1	1	1
R51	0	0	1	1	1	1	1	0	0	0	1	1
R52	0	1	1	1	0	1	1	0	1	1	0	1
R53	0	1	0	1	0	0	1	0	1	0	1	0
R54	1	1	1	0	1	0	0	1	0	1	0	1
R55	0	0	0	1	1	1	0	1	0	1	1	0
R56	1	1	0	0	1	1	1	0	1	0	1	1
R57	0	0	0	0	1	1	1	0	1	0	0	1
R58	0	1	1	0	1	1	1	0	1	0	0	0
R59	1	1	1	1	0	1	1	1	0	1	0	0
R60	1	0	1	1	1	0	1	1	1	0	1	0
R61	1	0	0	1	1	1	0	1	1	1	0	1
R62	0	0	1	0	0	1	1	1	0	0	1	0
R63	1	1	0	1	0	0	1	1	1	0	0	1

synchronization is achieved and, thereafter, the BCH-decoder and interleaving buffer shall be used. Block synchronization can be achieved at any of the three points illustrated in figure 3. After the detection of any block synchronization point, incoming data shall pass through the BCH-decoder/corrector and the interleaving buffer to the facsimile decoder.

5.2.4 Loss of synchronization. In the event of the loss of the synchronization signal, the receiver shall be capable of detecting loss of synchronization. At any time following detection of the first synchronization signal, the receiver shall declare a loss of synchronization if a line synchronization code or an EOM has not been detected within a time-out period. This period shall be sufficiently long to preclude false declaration of loss of synchronization. The signal indicating the loss shall be an "on" state, as defined by MIL-STD-188-114, applied to the loss of synchronization interchange circuit. In addition, criteria for declaring loss of synchronization, based on incorrectly decoded lines, may be applied. (Note: Implementation of this feature is a performance factor and does not bear directly on interoperability.)

5.2.5 Signaling protocols. Signaling protocol frames shall be used to coordinate message transmission. The parameters to be used for each transmission shall be signaled to the receiver using SOM frames and the termination of the facsimile transmission shall be signaled by an EOM sequence. (Note: The Type I and Type II protocol signals have been specifically designed to provide extremely high assurance of correct receiver operation (automatic start, mode setup, and automatic stop) in error environments as high as a 10^{-2} bit error rate (BER). This means that a return acknowledgment is not necessary for the basic mode.)

5.2.5.1 Protocol elements and frames.

5.2.5.1.1 Synchronization code words. Two special synchronization code words shall be used, in various combinations, to generate all protocol requirements. The code words are designated as S_0 and S_1. Each code word shall be made up of a 15-bit pseudorandom noise (PN) sequence as shown in table I. The composition of the protocol elements in terms of the synchronization code words shall be as shown in table VI. (Note: This lists the probability of detection, P_d, of each protocol element in a noise environment of 10^{-2} BER. All elements have detection probabilities in excess of 99.99 percent in this environment.)

(Note: If either of the PN sequences (code words) are compared, bit-by-bit, with any cyclical shift of the sequence, the number of agreements differs from the number of disagreements by one, except at the autocorrelation peak where there are 15 agreements. Consequently, the correlation improvement for exact synchronization is 15 to 1 for noise-free operation and is reduced by one for every bit perturbed by noise.

TABLE VI. Protocol elements.

Protocol Element	Composition	P_d at 10^{-2} BER	Transmissions Required	Detections Required
SOM	$S_1\ S_0\ X\ S_0\ S_1$	0.999945	3	1
EOM	S_1	0.99995	16 minimum	4 in sequence

(Note: This enables the receiver to correct a channel inversion.) Three command SOM frames with an appropriate X value shall be sent next, followed by three FEC control SOM frames with an X value of 254 signifying that FEC will not be used. Stuffing shall be inserted as needed, before and after the FEC control SOM frames. The facsimile data shall start with an EOL code word no less than two seconds and no more than three seconds after the end of the third control SOM frame. At the end of the document, the facsimile data stream shall end with at least two contiguous RTC signals. Following RTC, an EOM shall signify the end of the current transmission. Stuffing should be inserted as required between RTC and EOM.

5.2.5.2.2 Compressed, FEC used. Figure 6 illustrates the signaling sequence for the compressed mode with FEC. The data communications channel should be established as described in paragraph 5.2.5.2.1. Inverted S_1 code words shall be sent as defined in paragraph 5.2.5.2.1. Three command SOM frames with an X value of nine shall then be sent followed by three FEC control SOM frames with an X value of 255 to synchronize the FEC system. The insertion and timing of the start of facsimile data shall be as in paragraph 5.2.5.2.1. At the end of the document, the facsimile data shall end with at least two RTC signals. To allow freedom of implementation, EOM shall be sent both before the end and after the end of FEC coding. To ensure that the first EOM can be decoded correctly, the FEC block containing the final bit shall be transmitted in full. Stuffing bits should be inserted as required between RTC and EOM. The second EOM (outside of FEC) shall not commence earlier than 500 msec after the end of the FEC block containing the final bit of RTC. Further signaling may then commence immediately after the second EOM.

5.2.5.2.3 Uncompressed. Figures 7 and 9a illustrate the signaling for the uncompressed mode. The data communications channel shall be established as described in paragraph 5.2.5.2.1. Sixteen inverted S_1 code words shall be sent followed by three command SOM frames with an X value of 41. Facsimile data shall follow no less than two seconds and no more than three seconds after the end of the last command SOM. At the end of the document, the facsimile data stream shall end with two seconds of S_1 code words. Further signaling may commence immediately after the S_1 code words. Whenever the receiver does not detect EOM within fifteen seconds after the last line synchronization code, the receiver shall assume that the transmission has terminated and proceed as if it had received an EOM.

5.2.5.3 Handshake mode protocols. This subparagraph provides the details of the handshaking protocols needed for interoperation in the

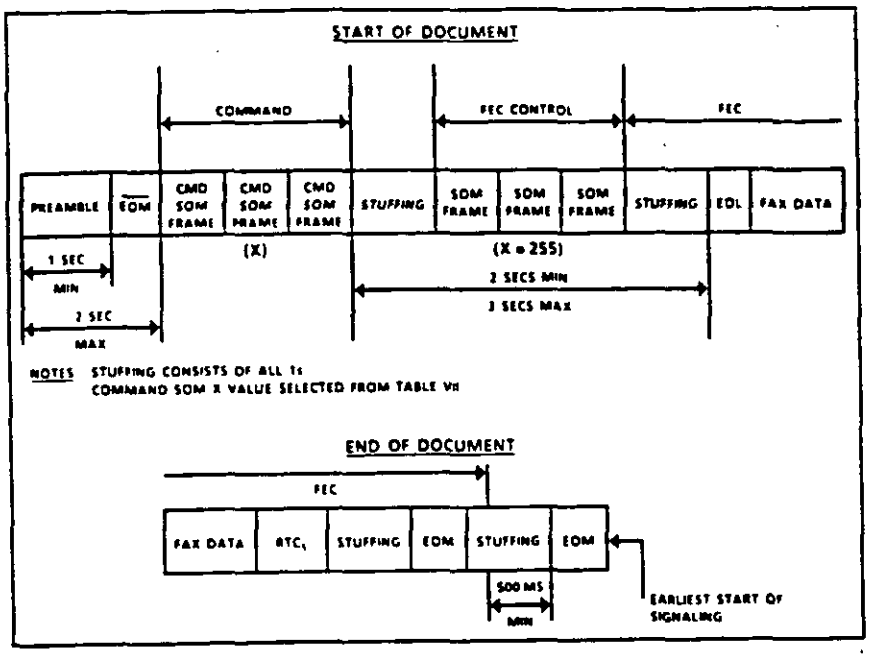

FIGURE 6. Signal timing, compressed mode, FEC used.

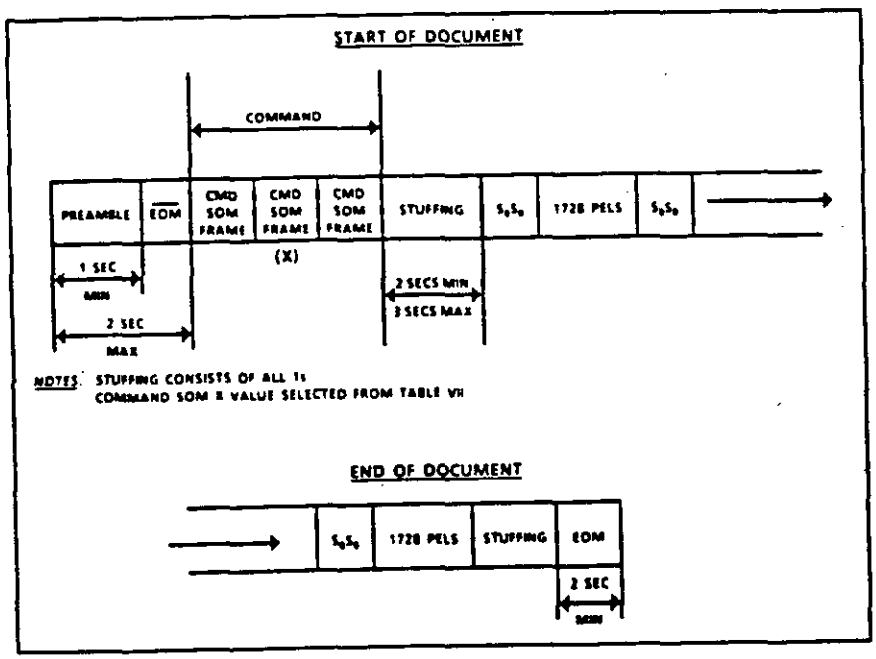

FIGURE 7. Signal timing, uncompressed mode.

handshake mode. Figure 4 shows the X value assignments for the handshake SOM (HSOM) frame.

5.2.5.3.1 Timing. Timing in the handshake mode is more complicated because the sending station shall interrupt transmission after sending the command SOM frames to listen for an acknowledgment. The FEC control SOM frames shall be sent after the receipt of acknowledgment. Figures 8 and 9 illustrate the timing required to transmit HSOM (with FEC enabled or disabled, respectively) when the receiving equipment's transmitter is in the standby mode. Figures 10 and 11 illustrate the timing required to insert the HSOM within a line of facsimile data when the receiving unit is also transmitting data.

5.2.5.3.2 Format. The signal format for the handshake mode shall be the same as described in subparagraph 5.2.5.2.1 up to the end of the third command SOM frame. At this point the transmitter shall prepare to receive an acknowledgment. The signal format of the receiver response acknowledging HSOM shall be the same as the command SOM except for the X values defined in table VII. The binary value allocations for the response SOM frame shall be as shown in figure 12.

5.2.5.3.3 Acknowledgment. When satisfactory acknowledgment is received in a period extending from two to fifteen seconds from the end of the first command SOM frame, then the transmission of facsimile data, including the FEC control SOM frames, shall commence no less than two seconds after the detection of a response SOM frame or no more than three seconds from the last response SOM frame.

5.2.5.3.4 Response. When a response SOM frame is not received within the defined period (see subparagraph 5.2.5.3.3), or if a response SOM is received which is not a positive acknowledgement SOM, the equipment shall return to a mode in which it is ready to respond to command SOM frames. Similarly, if a facsimile line synchronization code has not been received within 15 seconds after transmitting the final response SOM frame, the receiver shall return to the mode where it can respond to command SOM frames.

5.2.5.3.5 End of message. The end of document signal format is the same as in subparagraph 5.2.5.1.3 or 5.2.3.2.5.

5.2.5.3.6 Full duplex. When in full duplex and a transmission is being sent in the opposite direction, the response SOM shall be inserted in the data stream at the end of a line (or a line pair) of data, prior to fill and the line synchronization code word.

5.2.5.4 Extended protocols. Some equipment may require additional protocols for the exchange of status and capabilities in excess of

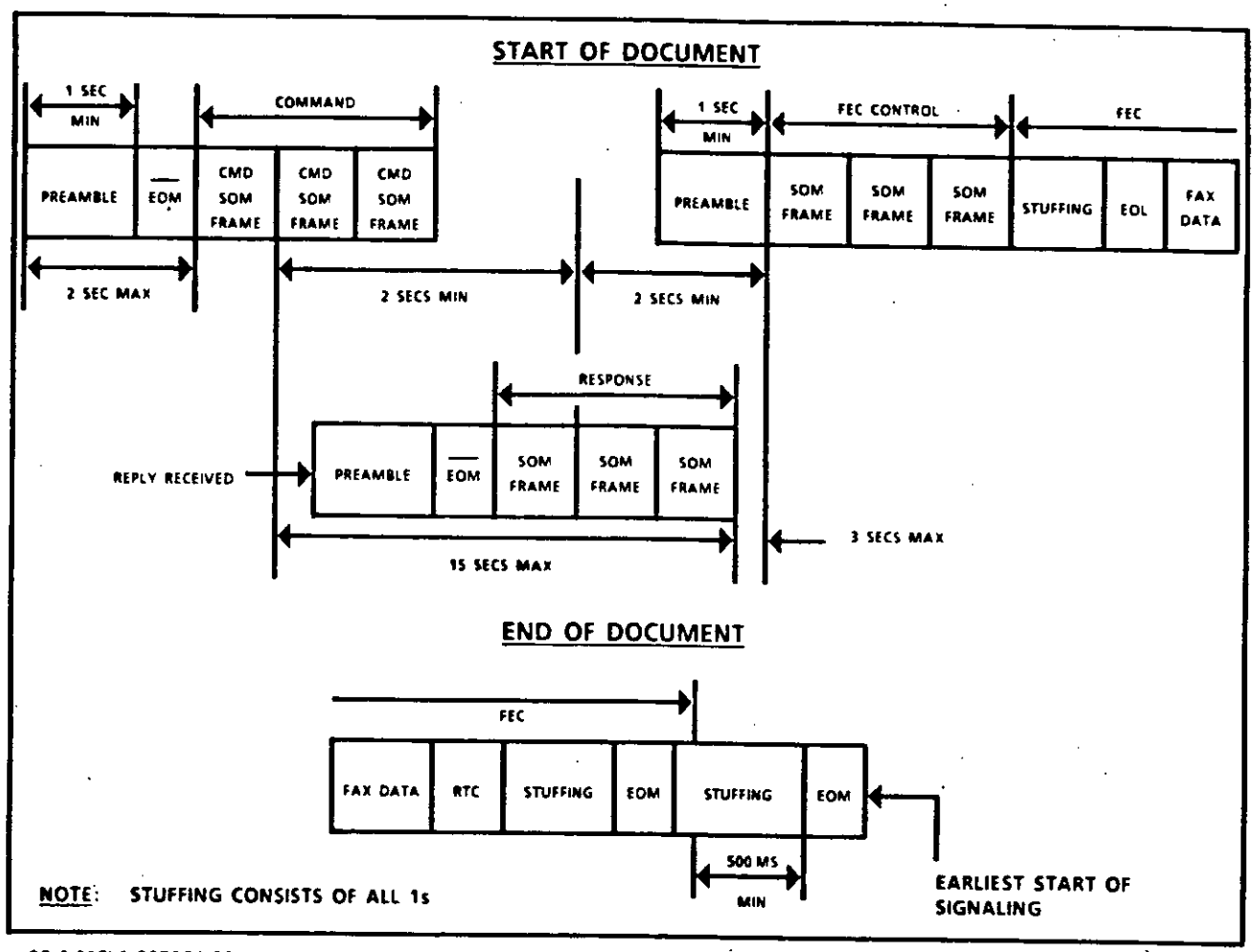

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Figure 8. Signal timing, handshake mode, FEC used.

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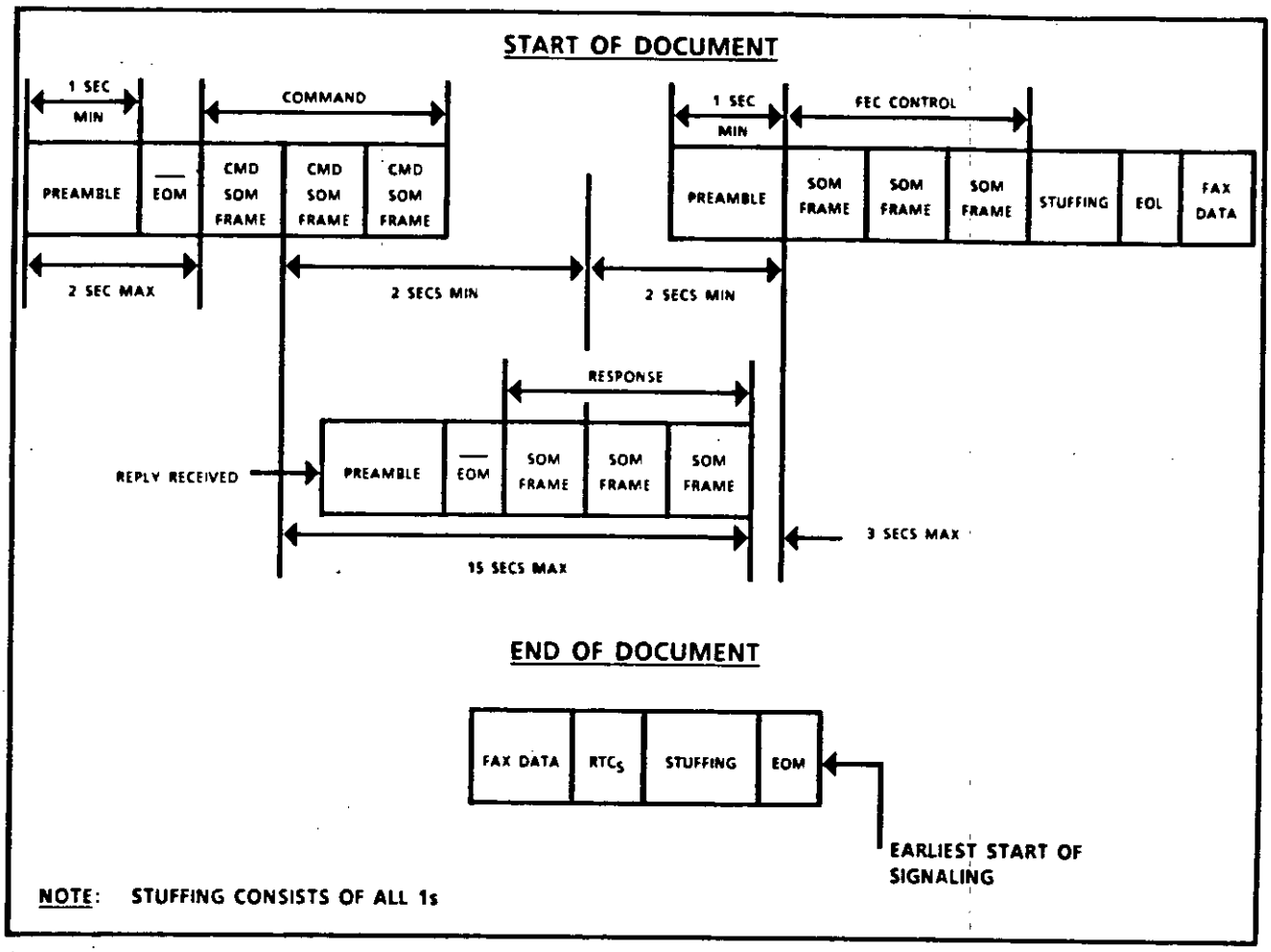

*8-1-MCL1-007064-10

Figure 9. Signal timing, handshake mode, FEC not used.

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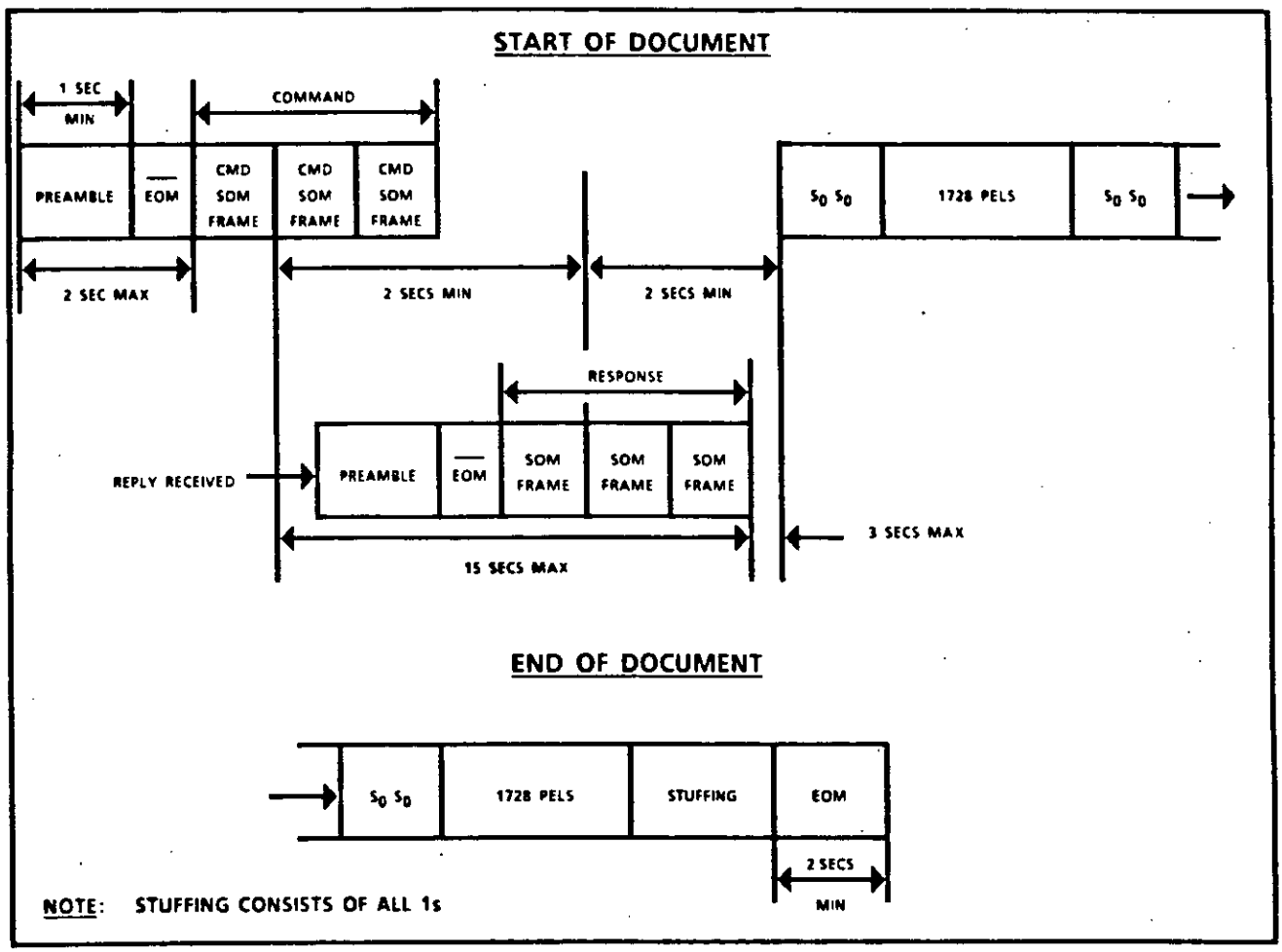

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Figure 9A. Signal timing, handshake mode, uncompressed mode.

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those covered by this standard. Bits 0, 1, and 2 of the Command SOM are reserved for Gray Scale Definition in those additional protocols. Bit 6 is "Ø" in all SOM frame designators defined herein. When set to "1" bit 6 will identify the use of an extended protocol involving the transmission of further SOM frames containing additional information. In all of these SOM frames, bit 6 will be set to "1." The precise code allocations for such a protocol are not at present a concern of this standard.

5.3 Type II facsimile equipment.

5.3.1 Image parameters. The image parameters listed in subparagraph 5.2.1 apply to the Type II facsimile equipment. The minimum transmission time of any scanned line pair shall be 40 msec for all compressed gray scale modes and 20 msec per line for all black and white, and uncompressed gray scale modes.

5.3.2 Black and white operation. All Type II facsimile equipment shall be capable of being operated as Type I black and white facsimile equipment. All of the requirements of paragraph 5.2 shall apply.

5.3.3 Gray scale operation. In addition to black and white operation, Type II facsimile equipments shall be capable of transmitting and receiving documents in 4, 8, and 16 shades of gray. The scanned dynamic range (D_{max}/Step 16 to Paper White/Step 1) shall be selected and the linear distribution of steps between these two shall be determined by the fractional values of table VIII. The recorded dynamic range (D_{max}/Step 16 to Paper White/Step 1) shall be determined by the reprographic process capability. The distribution of steps over the dynamic range is determined by the fractional values of table VIII. Recorded gray shade values shall be in accordance with table IX. (Note: The separation of this specification for the scanner and recorder allows a different dynamic range capability for each.)

5.3.3.1 Gray-coding the gray scale. Gray scale shall be processed by initial conversion of each picture element of the scanned signal to a four bit, Gray-code data unit (image data) representating one of the 16 shades of gray. A Gray-code in accordance with table IX shall be used so that a minimum number of transitions occur between adjacent gray levels. Gray-coding applies to all three image coding modes (uncompressed, compressed, and compressed with forward error correction).

5.3.3.2 Bit plane encoding the gray scale. After Gray-coding the data shall be processed as bit planes. The most significant bit (MSB) plane contains the MSB of each Gray-coded pel. Similarly, plane two shall contain the next most significant bit of each Gray-coded pel. (Note: Each plane, consisting of black and white pels, can be treated as a black and white image.) For 16 gray shades, the four bit planes shall be passed directly to the transmission process. For eight gray shades, bit plane four shall be discarded by discarding bit four and the remaining three bit codes representing eight gray shades shall be passed to the transmission process. Similarly, for four gray shades,

TABLE IX. Gray-codes for 4, 8, and 16 gray shades.

16 SHADES		8 SHADES		4 SHADES	
STEPS	GRAY CODE	STEPS	GRAY CODE	STEPS	GRAY CODE
1	0000	1	000	1	00
2	0001				
3	0011				
4	0010	4	001		
5	0110				
6	0111	6	011	6	01
7	0101				
8	0100	8	010		
9	1100				
10	1101	10	110		
11	1111				
12	1110	12	111	12	11
13	1010				
14	1011	14	101		
15	1001				
16	1000	16	100	16	10

plane three shall be discarded in addition to plane four. The remaining two bit codes represent four gray shades as shown in table IX.

5.3.3.3 Gray scale transmission. See Appendix C for general information (including block diagrams) relating to the modular make-up of the facsimile transmitter and receiver. Three output modes shall be available: (1) Uncompressed facsimile data with line synchronization codes added: (2) Compressed facsimile data using a two-dimensional algorithm; and (3) Compressed as in (2) with the addition of FEC using a BCH code and bit interleaving buffer. The scheme selected for a given transmission shall be signaled to the receiver. This signaling protocol shall be the same as covered in subparagraphs 5.2.5.2 and 5.2.5.3.

5.3.3.3.1 Uncompressed. Uncompressed facsimile data shall be transmitted pel-by-pel per bit plane, with logic 1 representing black. Each scan line of the output data shall consist of a synchronization code followed by 1728 pels of the MSB plane followed by the 1728 pels of the next MSB planes in order until all bit planes of the line have been transmitted. (Note: Each bit plane is made up of black and white pels. The first bit plane contains the most significant bits of each gray encoded pel, the second bit plane contains the second MSB of each gray encoded pel, and the following bit planes are made up in a corresponding manner.) The synchronization codes shall consists of a sequence of two code words designated S_0, and are identical to the codes utilized for Type I facsimile uncompressed transmission. See Appendix C for examples of the format used to transmit facsimile data with multiple gray shades.

5.3.3.3.2 Compressed. Compressed facsimile data shall be transmitted after compression by using a two-dimensional procedure.

5.3.3.3.2.1 Compressed data format. A line pair of compressed data (shown in figure 13) shall be composed of a series of variable length code words forming the bit planes (designated P1 through P4) representing the first 864 picture elements of each of the two adjacent horizontal scan lines of the original document (1728 total), followed by the second 864 elements of the two adjacent horizontal scan lines of the original document. Each half line pair of the output data shall consist of the bit planes in order (MSB plane first), each bit plane separated by a synchronization code word, EOL (000000000001). (Note: It is a unique code word that can never be found within a valid line pair of data. Therefore, resynchronization after an error burst is possible.)

5.3.3.3.2.2 Scan line pair. Each half line pair of output data shall be preceded by a three bit auto resolution code word (see subparagraph 5.3.3.3.3). The relative placement of the BOLP and BILP code

words, auto resolution signaling bits, encoded data, EOL, RTC, and fill shall be as illustrated in figures 13 and 14. (Note: Transmission of 16 gray shades is shown. For the transmission of fewer gray shades, the appropriate bit planes and preceding EOL are not present.)

5.3.3.3.2.3 Wobbled scan lines. The two adjacent scan lines of data shall be "wobbled" on a bit plane by bit plane basis prior to variable-length encoding, by combining the spatially related data bits per bit plane in a wobble fashion as illustrated in figure 15. (Note: L_{11}, L_{12}, L_{13}, etc., represent the sequentially scanned bits derived from line N; and L_{21}, L_{22}, L_{23}, etc., represent the sequentially scanned bits derived from line N + 1. This produces a combined output of:

$$L_{11}, L_{21}, L_{22}, L_{12}, L_{13}, L_{23}, L_{24}, L_{14}, \text{etc.}$$

The purpose of this wobble pattern is to take advantage of both horizontal and vertical correlations of adjacent pels. This leads to a higher compression than can be achieved when one scan line (thus one dimensional coding) is processed at a time.)

5.3.3.3.2.4 Variable length code words. Each of the variable length code words shall represent a run-length of either all white or all black in a bit plane. White and black runs shall alternate. In order to ensure that the receiver maintains color (black and white) synchronization, each of the bit planes for each half of the data line pair shall begin with a white run-length code word. If an actual half data line of a bit plane begins with a black run, a white run-length of zero shall be sent first. Black or white run-lengths, up to a maximum length of one half scan line pair (1728 bits) shall be defined by the table III terminating codes and table IV make-up codes for each bit plane presentation of the image.

5.3.3.3.2.5 Run-length representation. Each run-length shall be represented by either one terminating code word, or one make-up code word followed by a terminating code word. (Note: Each bit plane represents a black and white image and four images comprise a total gray shade image.) Run-lengths in a range of 0 through 63 pels shall be encoded with their appropriate terminating code word. Run-lengths in the range of 64 through 1728 pels shall be encoded first by the make-up code word representing the run-length which is equal to or shorter than that required. This shall be followed by the terminating code word representing the difference between the required run-length and the run-length represented by the make-up code.

5.3.3.3.3 Auto resolution. Means shall be provided to implement a half (low) resolution function, on a selected bit plane basis to

increase the achievable compression. (Note: This takes advantage of the fact that not all regions of a gray scale image contain high resolution information. Lower order bit planes have little effect on the perceived resolution and, as a consequence, may be transmitted at a lower resolution in regions of slow intensity variations.) Bit-plane activity shall be determined and low resolution operation shall be automatically applied on a half scan line pair (bit plane) basis when the number of transitions of a given bit plane is less than 60. (Note: The number of transitions is not an issue of interoperability and a threshold of sixty is a suggested implementation number.) (Note: The total number of decoded pels for a line pair with auto resolution is 432 decoded pels before expanding for use by the recorder.)

5.3.3.3.3.1 Auto resolution algorithm. The auto resolution algorithm is illustrated in table X. When half resolution processing is applied, a majority logic decision shall take place for each bit-plane group of four bits (L_{11}, L_{12}, L_{13}, etc.) being read in prior to run-length encoding. The process shall create a single bit which represents the average of the four bits.

5.3.3.3.3.2 Transmitter. The transmitter performs a majority logic decision such that if three or four bits are black, a black bit shall be substituted for the group of four. If zero, one, or two bits are black, a white bit shall be substituted for the group of four.

5.3.3.3.3.3 Receiver. The receiver shall expand each black data bit, or white data bit, received into four identical bits prior to processing the data stream for use by the recorder.

5.3.3.3.3.4 Signaling the auto resolution mode. Auto resolution processing shall be signaled to the receiving unit on a half scan line pair basis by preceding each half scan line pair, as shown in figure 13, with one of the three bit codes of table XI. If the first bit (as a consequence of majority logic decision) of a half scan line pair bit plane is black, a white run-length of zero shall be sent prior to the coded half line pair of bit plane data.

5.3.3.3.3.5 Beginning of line pair (BOLP). The BOLP code word shall precede each line pair of coded data (see figure 11). (Note: This is a unique code word than can never be found within a valid half line pair of coded data. Therefore, resynchronization after an error burst is possible (BOLP = 0000000000000010).)

5.3.3.3.3.6 Beginning of intermediate line pair (BILP). The BILP code word shall precede each (right half page) half line pair of data (see figure 13). (Note: This is a unique code word that can never be found within a valid half line pair of coded data. Therefore, resynchronization after an error burst is possible (BILP = 0000000000000011).)

TABLE X. Bit plane vs auto resolution function.

	Auto Resolution Algorithm		
Bit Plane	16 Gray Shades	8 Gray Shades	4 Gray Shades
1 (MSBP)	Not invoked	Not invoked	Not invoked
2	Automatic decision	Automatic decision	Automatic decision
3	Automatic decision	Automatic decision	Discard
4 (LSBP)	Low resolution	Discard	Discard
	Always invoked		

TABLE XI. Auto resolution - signaling codes.

16 Gray Shades		8 Gray Shades		4 Gray Shades	
Code	Meaning	Code	Meaning	Code	Meaning
110	HHHL	110	HHH	---	---
100	HHLL	100	HHL	100	HH
000	HLLL	000	HLL	000	HL

6. NOTES

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

6.1 Subject term (key word) listing. The following key words and phrases apply to MIL-STD-188-161A:

basic mode
bit plane
code word
compressed mode
facsimile
facsimile synchronization
gray code
gray scale
group three facsimile
handshake mode
image coding
military standard
scan line
signaling protocols
STANAG 5000
type I facsimile
type II facsimile
uncompressed mode
wobbled scan

6.2 International standardization agreement. Certain provisions of this standard are the subject of international standardization agreement STANAG 5000. When change notice, revision, or cancellation of this standard is proposed that will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.3 Changes from previous issue. The margins of this standard are marked with asterisks (or vertical lines) to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

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Air Force - XOKC
NSA - NS
NCS - NCS

User Activities:
Navy - MCLB
Air Force - 11

Other Interest:
Applicable International Organizations
North Atlantic Treaty Organization
EIA

Preparing Activity
JTC3A - JT

(Project SLHC-1611)

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