5. DETAILED REQUIREMENTS

5.1 Waveform requirements. Time is divided into fixed timing intervals known as *frames*, as shown previously in Figure 1. Each frame is 8.96 seconds long and is further divided into 1024 increments known as *building blocks*. A single building block is 8.75 ms long. The building blocks in the frame are grouped in *segments, time-slots and fields* which are described in the following sub-paragraphs.

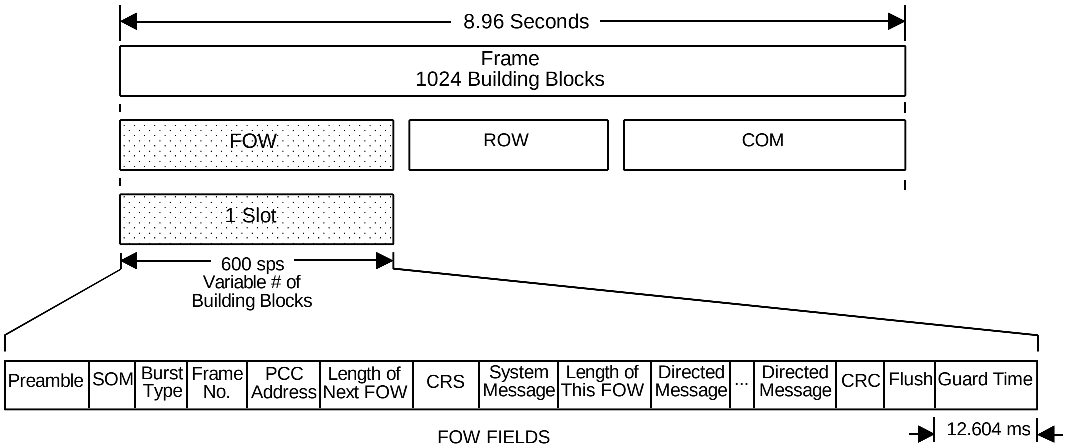
a. A frame consists of three segments: The FOW segment, the ROW segment, and the COM segment, as shown previously in Figure 1. The FOW segment consists of 1 time-slot and is always located at the start of each frame. The PCC maintains a fixed, 8.96-second time between transmitted FOWs, within the accuracy permitted by the PCC reference oscillator. The ROW segment follows the FOW segment and consists of a variable number of ROW message slots, and a variable number of ROW ranging slots. The Communications segment follows the ROW segment and consists of a variable number of communications message service type time-slots and communications circuit service type time-slots.

b. A time-slot is a time period allocated for the transmission of an orderwire or communications burst. Time-slots consist of a variable number of 8.75-ms building blocks. Each FOW indicates time-slot start times and time-slot durations for the next frame. There are three types of time-slots: (1) the FOW type that is described in 5.1.1; (2) the ROW type that has two versions, the range version ROW described in 5.1.2.1 and the message version ROW described in 5.1.2.2; (3) the communications type time-slot that also has two versions, the circuit service version described in 5.1.3.1 and the message service version described in 5.1.3.2.

c. Each type of time-slot has various fields used for synchronization and the conveyance of information to or from terminals. The fields for each type of time-slot are defined in 5.1.1, 5.1.2, and 5.1.3. A time-slot is used for a single burst that has one or more fields and includes guard time required to avoid adjacent time-slot transmission interference. Transmissions shall only occur during authorized time-slots.

5.1.1 Forward orderwire segment and time-slot fields. The FOW segment starts at absolute building block number 1 in the frame. It consists of one FOW slot that has 12 fields. The fields and the number of bits for each field shall be as illustrated in Figure 2 and described below. The 12 fields are as follows:

a. Preamble field (278 bits). A preamble shall be transmitted as the initial part of each orderwire and communications burst. The preamble provides information necessary for signal acquisition and



FIELD	BITS	ENCRYPTED	CONV. CODED	INTERLEAVED	CRC	DEFINITION
Preamble	278	N	N	N	N	Redundant Slot Preamble
SOM	42	N	N	N	N	Start of Message Sequence
Burst Type	12	N	N	N	N	Burst Type Indicator (Start of Frame)
Frame Number	20	N	Y	N	N	Frame Number
PCC Address	16	Y	Y	N	Y	Address of Transmitting PCC
Length of Next FOW	9	Y	Y	N	Y	Length of Next FOW (in building blocks)
CRS	3	Y	Y	N	Y	Number of contention ranging slots in next frame
System Message	6	Y	Y	N	Y	Message Conveying System Status, Notifications and Control parameters
Length of this FOW	12	Y	Y	N	Y	Length of this FOW (in Bits)
Directed Messages	Variable	Y	Y	N	Y	Messages Directed to Network Members Conveying Resource Assignments, Status Requests, Login Responses, etc.
CRC	16	Y	Y	N	N	Cyclic Redundancy Check For Error Detection
Flush	6	N	Y	N	N	Error Correction Flush Bits

FIGURE 2. FOW slot field definitions.

synchronization. The preamble format shall be a continuous wave (CW) carrier followed by a dot pattern. Using shaped offset quadrature phase-shift keying (SOQPSK) modulation, the preamble during the CW portion shall be generated with constant data on both the I and Q channels (I = 1, Q = 1). During the dot pattern portion, the preamble shall consist of alternating data on the I channel (I = 0 1 0 1 . . .) and a constant phase (Q = 1 1 1 1 . . .) on the Q channel. The length of the preamble and the length of the CW carrier portion of each preamble shall be as defined in Table VI.

TABLE VI. Burst preamble characteristics.

MODULATION RATE (sps)	**CW PORTION LENGTH (bits)***	**TOTAL PREAMBLE LENGTH (bits)***
600	60	278
800	60	264
1200	60	298
2400	120	358
3000	144	408

NOTE:

* Two bits per symbol.

b. Start-of-Message field (42 bits). The preamble shall be immediately followed by the 42-bit SOM sequence defined in Table VII. The I channel contains the first SOM field bit transmitted.

TABLE VII. Start-of-message sequence.

CHANNEL	**BIT SEQUENCE***
I	000000101110100111001
Q	001101100001000010101

NOTES:
21 bits in each sequence.
* Left-most bit transmitted first.

c. Burst Type field (12 bits). The burst type field shall be as defined in Table VIII, and immediately follows the SOM sequence in each orderwire and communications burst. This field distinguishes FOW bursts from other bursts and is also used to indicate to the PCC that a communications service (message or circuit) is to be torn down. Since this field is not coded, the terminal shall be able to identify the transmit burst type when the burst type is received with up to 3 bit errors in the 12 bits. The start-of-frame burst type is used on the FOW burst only, and it shall not be transmitted by a terminal. The end-of-service burst type shall be used on any communications burst assignment for which the terminal is attempting to tear down the service, as described in 5.4.2.5.6. The start-of-slot burst type shall be used on all other bursts.

TABLE VIII. Burst type field.

BURST TYPE	BIT SEQUENCE*
Start-of-Frame	000000000000
Start-of-Slot	110101110101
End-of-Service	011011011011

NOTES:
12 bits in each sequence.
* Left-most bit transmitted first.

d. Frame Number field (20 bits). This field identifies the frame number of each frame. The Frame Number is reset in the frame following a frame that has a System Message value of 15.

e. PCC Address field (16 bits). The PCC address field identifies the transmitting PCC.

f. Length of Next FOW field (9 bits). The Length of Next FOW field defines the number of building blocks allocated for the FOW segment in the next frame. With this information in the FOW bursts, and information in the directed message, the terminal shall determine the position of the time-slots in the next frame. (See examples 6.2 through 6.4.)

g. Contention Ranging Slots (CRS) field (3 bits). This field indicates the number of contention ranging slots available in the next frame. (See Table IX.) The terminals that use active ranging shall use these slots in accordance with 5.2.2.1.1.

TABLE IX. Contention ranging slot field.

Field value	0	1	2	3	4	5	6	7
Number of contention ranging slots	1	2	4	6	8	10	12	16

h. System Message field (6 bits). System messages are transmitted in the System Message field. System messages convey system status and control parameters to all terminals. The terminal shall interpret all system messages, comply with all applicable system messages, and ignore all system messages which were undefined at the time of terminal construction. System messages provide status notifications and system parameters to the network. Each system message is 6 bits long. Appendix A defines the FOW's system messages field. One system message is transmitted in each frame. The FOW:System Access Restriction, FOW:ROW Backoff Number, FOW:System Service Restriction On or Off (as applicable), and FOW:Channel Controller Connected or Isolated (as applicable) messages are transmitted nominally in a 4-frame cycle. Other system messages are transmitted as required, preempting nominal system message transmissions. When these preemptions occur, the preempting message is repeated in four successive frames to provide a high probability of reception.

i. Length of This FOW field (12 bits). The Length of This FOW field defines the length, in bits, of all FOW data in the current frame from (and including) the Frame Number field to (but not including) the CRC field. The Length of This FOW field can be used to locate the CRC field.

j. Directed Message field (variable # of bits). The PCC uses directed messages to direct information to subnets or specific terminals. These messages perform such functions as assigning ROW and communications time-slots, and responding to login or logout requests. All FOW requests, notifications, and assignments shall take effect during the frame following the one in which they are received. Directed messages are transmitted to a specific node or subnet. FOW directed messages assign network resources, request status, and update address guard lists, among other functions. Table I identifies the directed messages and identifies those messages that terminals must use. Table X identifies required responses to directed messages. Directed messages that assign ROW and communications slots are not transmitted in any predefined order. They can be intermingled, but the order of each directed message that assigns ROW slots is important in relation to other directed messages that assign ROW slots. The same is true for the relationship of directed messages that assign communications slots. Detailed descriptions of FOW directed message types are given in Appendix B. Future FOW directed message types (see Table 20-XXXII) will have a Length field, 7 bits wide, following the Message Type field. This allows terminals that use differing versions of this specification to parse all FOWs sent by the PCC. For future FOW directed messages, following the 7-bit Length field will be (i) a 1-bit ROW Assignment field that specifies whether or not a ROW message slot is assigned by this FOW directed message (if the field has a value 1, then a ROW slot is assigned), (ii) a 1-bit communications Assignment field that specifies whether or not a communications slot is assigned by this FOW directed message (if the field has a value 1, then a communications slot is assigned), and (iii) if the Communications Assignment field has a value 1, then a 10-bit Communication Slot Size field follows the Communication Assignment field and specifies the size of the communications slot in the building blocks. Terminals shall not fault on reception of any directed FOW message type that was not completely defined at the terminals' time of construction.

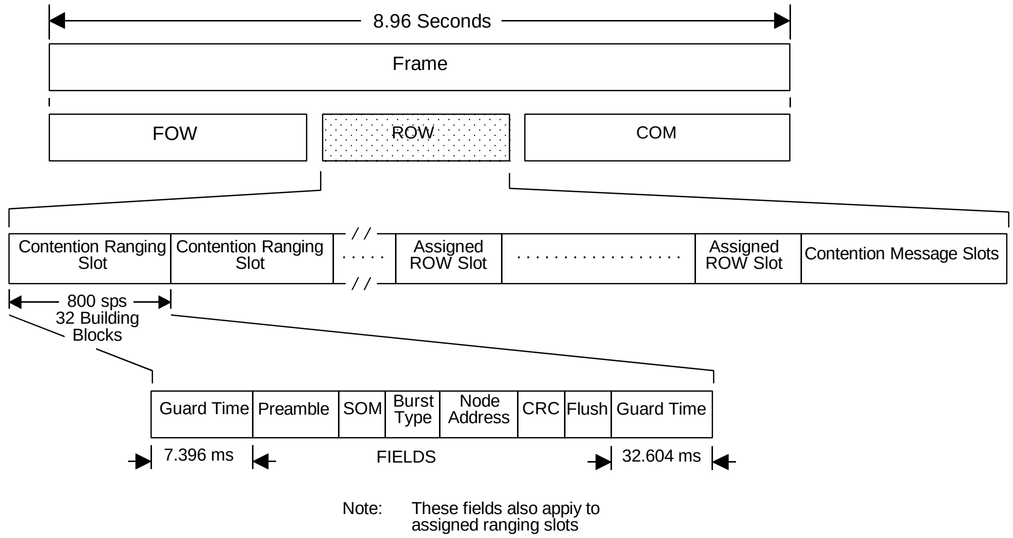
k. CRC field (16 bits). The CRC field contains CRC bits for error detection (see 5.4.3.1).

l. Flush field (6 bits). The Flush field contains data bits of value zero for flushing the forward error correction (FEC) encoder.

5.1.2 <u>Return orderwire segment</u>. The ROW segment begins immediately following the last building block in the FOW time-slot. The ROW is made up of a variable number of (a) ranging ROW time-slots, each 32 building blocks long, as shown in Figure 3, and (b) message ROW time-slots, each 17 building blocks long as shown in Figure 4. The first time-slots are contention ranging time-slots. They are used by terminals to perform initial ranging, as defined in 5.2.2.1.1. The contention ranging time-slots are followed by assigned ROW message and ranging slots which may be intermingled. Assigned ROW message and ranging time-slots, are followed by contention message time-slots. These slots are used by terminals to send ROW messages for which the PCC does not assign ROW time-slots.

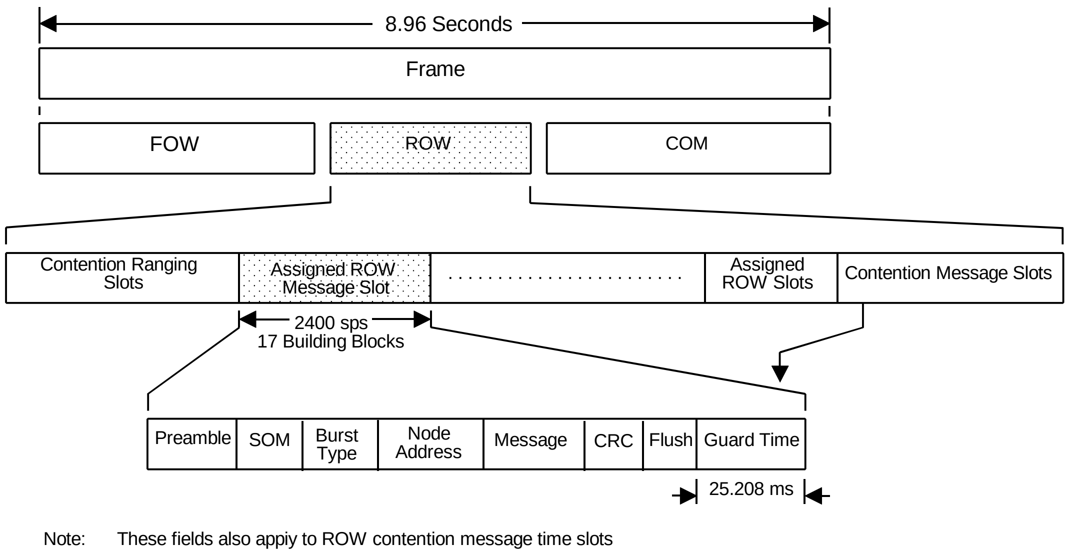
TABLE X. FOW directed messages and required responses.

TYPE OF FOW MESSAGE	MESSAGE	ROW CAPACITY ALLOCATED	REQUIRED RESPONSE
0	FOW:Acknowledge Message	Yes	ROW:Message Acknowledgment
1	FOW:Acknowledge Blocks	Yes	ROW:Blocks Acknowledgment
2	FOW:Alternate Channel Controller Designate Response Message	No	
3	FOW:Circuit Assignment	No	
4	FOW:Circuit Setup Response	No	
5	FOW:Circuit Teardown	No	
6	FOW:Login Response	No	
7	FOW:Logout Response	No	
8	FOW:Message Acknowledgment	No	
9	FOW:Message Assignment	No	
10	FOW:Message Setup Response	No	
11	FOW:Message Teardown	No	
12	FOW:Multiple-Hop Begin Assignments Response	No	
13	FOW:Multiple-Hop Circuit Assignment	No	
14	FOW:Multiple-Hop Circuit Preemption Response	No	
15	FOW:Multiple-Hop Circuit Teardown	Yes	ROW:Multiple-Hop Circuit Teardown Response
16	FOW:Network Status	Yes	ROW:Network Status Response
17	FOW:Network Status Response	No	
18	FOW:Null Assignment	No	
19	FOW:Participant Status Data Base	No	
20	FOW:Primary Channel Controller Designate	Yes	ROW:Primary Channel Controller Designate Response
21	FOW:Ranging Assignment	Yes	None
22	FOW:Relay Ringup	Yes	ROW:Relay Ringup Response
23	FOW:Relay Ringup Response	No	
24	FOW:Relay Select	Yes	ROW:Relay Select Response
25	FOW:Relay Select Response	No	
26	FOW:Report Status	Yes	ROW:Status Report or ROW:Channel Controller Status Report
27	FOW:Report Terminal Addresses	Yes	ROW:Terminal Addresses Report
28	FOW:Terminal Address Add or Delete	Yes	ROW:Terminal Address Add or Delete Response
29	FOW:Terminal Channel Assignment	Yes	ROW:Channel Assignment Response
30	FOW:Terminal Channel Return Response	No	



FIELD	BITS	ENCRYPTED	CONV. CODED	INTERLEAVED	CRC	DEFINITION
Preamble	264	N	N	N	N	Redundant Slot Preamble
SOM	42	N	N	N	N	Start of Message Sequence
Burst Type	12	N	N	N	N	Burst Type Indicator (Start of Slot)
Node Address	16	Y	Y	N	Y	Terminal or CC Node Address
CRC	8	Y	Y	N	N	Cyclic Redundancy Check For Error Detection
Flush	6	N	Y	N	N	Error Correction Flush Bits

FIGURE 3. ROW ranging field definition.



FIELD	BITS	ENCRYPTED	CONV. CODED	INTERLEAVED	CRC	DEFINITION
Preamble	358	N	N	N	N	Redundant Slot Preamble
SOM	42	N	N	N	N	Start of Message Sequence
Burst Type	12	N	N	N	N	Burst Type Indicator (Start of Slot)
Node Address	16	Y	Y	N	Y	Terminal or CC Node Address
Message	60	Y	Y	N	Y	ROW Message
CRC	8	Y	Y	N	N	Cyclic Redundancy Check For Error Detection
Flush	6	N	Y	N	N	Error Correction Flush Bits

FIGURE 4. ROW message field definitions.

5.1.2.1 <u>ROW Ranging time-slot fields</u>. The ROW ranging time-slot is comprised of six fields as shown in Figure 3. A ROW ranging time-slot is 32 building blocks long. The ROW burst time-slot size allows a guard time of 7.396 ms prior to the nominal transmit time, and 32.604 ms of guard time after the nominal transmit time (see Figure 3). Considering that the last 12.604 ms of the assigned time-slot is allocated to the following slot, the total guard time before and after the nominal transmit time is 20.0 ms. The six ranging time-slot fields are described below:

a. Preamble field (264 bits). See 5.1.1a.

b. Start-of-Message field (42 bits). See 5.1.1b.

c. Burst Type field (12 bits). See 5.1.1.c. The Burst Type field for a ranging time-slot shall be Start-of-Slot.

d. Node Address field (16 bits). This field identifies the transmitting terminal's login address.

e. CRC field (8 bits). The CRC field contains CRC bits for error detection (see 5.4.3.1).

f. Flush field (6 bits). See 5.1.1l.

5.1.2.2 <u>ROW message time-slot fields</u>. Figure 4 illustrates the ROW message time-slot field format. ROW message formats are individually detailed in Appendix C. Table XI describes the expected response from each ROW message. The seven fields are described below:

a. Preamble field (358 bits). See 5.1.1a.

b. Start-of-Message field (42 bits). See 5.1.1b.

c. Burst Type field (12 bits). See 5.1.1c. The Burst Type field shall always be Start-of-Slot for ROW message time-slots.

d. Node Address field (16 bits). This field identifies the transmitting terminal's login address.

e. Message field (60 bits). The Message field contains the ROW message being transmitted to the PCC. The ROW messages are detailed in Appendix C.

f. CRC field (8 bits). The CRC field contains CRC bits for error detection (see 5.4.3.1).

g. Flush field (6 bits). See 5.1.1l.

TABLE XI. ROW messages and FOW responses.

ROW MESSAGE TYPE	ROW MESSAGE	ASSIGNED/ CONTENTION ROW	FOW ACKNOWLEDGEMENT MESSAGE
0	ROW:Alternate Channel Controller Designate	Contention	FOW:Alternate Channel Controller Designate Response
1	ROW:Assign Ranging	Contention	FOW:Ranging Assignment
2	ROW:Channel Controller Login	Contention	FOW:Login Response
3	ROW:Channel Controller Status Report	Assigned	
4	ROW:Circuit Setup	Contention	FOW:Circuit Setup Response, FOW:Circuit Assignment, FOW:Multiple-Hop Circuit Assignment Response, or FOW:Terminal Channel Assignment
5	ROW:Circuit Teardown	Contention	FOW:Circuit Teardown
6	ROW:Login	Contention	FOW:Login Response
7	ROW:Logout	Contention	FOW:Logout Response
8	ROW:Message Acknowledgment	Assigned	
9	ROW:Message Setup	Contention	FOW:Message Setup Response or FOW:Message Assignment
10	ROW:Message Teardown	Contention	FOW:Message Teardown
11	ROW:Multiple-Hop Begin Assignments	Contention	FOW:Multiple-Hop Begin Assignments Response
12	ROW:Multiple-Hop Circuit Preemption	Contention	FOW:Multiple-Hop Circuit Preemption Response
13	ROW:Multiple-Hop Circuit Resumption	Contention	FOW:Multiple-Hop Circuit Assignment
14	ROW:Multiple-Hop Circuit Teardown	Contention	FOW:Multiple-Hop Circuit Teardown
15	ROW:Multiple-Hop Circuit Teardown Response	Assigned	
16	ROW:Network Status	Contention	FOW:Network Status Response
17	ROW:Network Status Response	Assigned	

ROW MESSAGE TYPE	ROW MESSAGE	ASSIGNED/ CONTENTION ROW	FOW ACKNOWLEDGEMENT MESSAGE
18	ROW:Blocks Acknowledgment	Assigned	

TABLE XI. ROW messages and FOW responses. (Continued)

ROW MESSAGE TYPE	ROW MESSAGE	ASSIGNED/ CONTENTION ROW	FOW ACKNOWLEDGEMENT MESSAGE
19	ROW:Primary Channel Controller Designate Response	Assigned	
20	ROW:Relay Ringup	Contention	FOW:Relay Ringup Response
21	ROW:Relay Ringup Response	Assigned	
22	ROW:Relay Select	Contention	FOW:Relay Select Response
23	ROW:Relay Select Response	Assigned	
24	ROW:Status Report	Assigned	
25	ROW:Terminal Address Add or Delete Response	Assigned	
26	ROW:Terminal Addresses Report	Assigned	
27	ROW:Terminal Channel Assignment Response	Assigned	
28	ROW:Terminal Channel Return	Contention	FOW:Terminal Channel Return Response

5.1.3 Communications segment. Network communications shall be conducted in an assigned time-slot within the frame's communications segment. The communications segment follows the ROW segment and consists of time-slots that vary in number and length. Two types of communications time-slots exist: a circuit service and a message service.

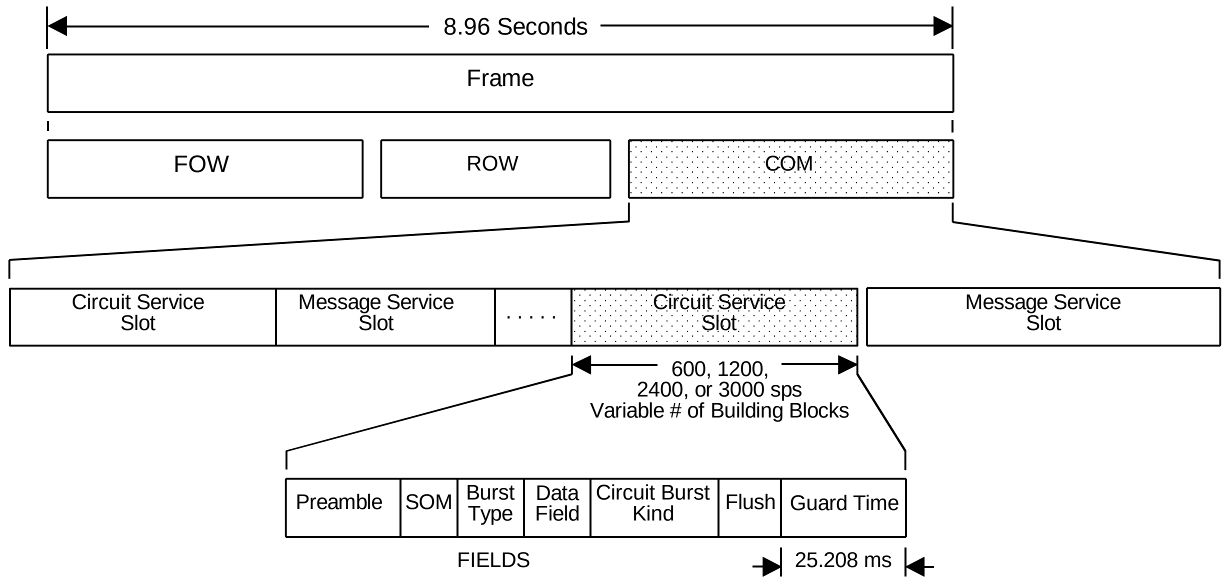
5.1.3.1 Communications circuit-service time-slot fields. The communications circuit-service time-slot consists of six fields. Figure 5 illustrates the time-slot format. The fields are described below:

a. Preamble field. (Variable number of bits based on the modulation rate) (See 5.1.1a.)

b. Start-of-Message field (42 bits). See 5.1.1b.

c. Burst Type field (12 bits). See 5.1.1c.

d. Data field (variable). The Data field contains data for transmission. Data field size depends on the I/O rate of the baseband equipment. (See 5.4.2.2.)



FIELD	BITS	ENCRYPTED	CONVOLUTIONALLY CODED**	INTERLEAVED**	DEFINITION	
Preamble	Variable	N	N	N	Burst Rate	Preamble Length (Bits)
					600	278
					1200	298
					2400	358
					3000	408
SOM	42	N	N	N	Start of Message Sequence	
Burst Type	12	N	N	N	Burst Type Indicator	
Data Field	Variable	N*	Y	Y	See 5.4.2.2.3	
Circuit Burst Kind	8	N	Y	N	See 5.4.2.2.4	
Flush**	6	N	Y	N	Error Correction Flush Bits	

* NOTE: Data may be encrypted by the user baseband device.

** NOTE: Applicable only if the communication is assigned to be coded.

FIGURE 5. Communications circuit-service field definitions.

e. Circuit Burst Kind field (8 bits). The Circuit Burst Kind field indicates whether the burst is (a) the first burst of a transmission that consists of at least one additional burst, (b) a nominal burst, not the first or last burst of a transmission, (c) the second from last burst of a transmission (not used in every transmission), or (d) the last burst of a transmission (see 5.4.2.2.4).

f. Flush field (6 bits). See 5.1.1l.

5.1.3.2 <u>Communications message-service time-slot fields</u>. The communications message-service time-slot consists of seven fields. Figure 6 illustrates the time-slot format. The fields are described below:

a. Preamble field (Variable number of bits based on modulation rate). See 5.1.1a.

b. Start-of-Message field (42 bits). See 5.1.1b.

c. Burst Type field (12 bits). See 5.1.1c.

d. Packet field (variable # of bits). The Packet field is an integer number of data blocks. Each data block is 224 bits. The integer number ranges between 1 and 10 for coded bursts, and is an even number between 2 and 20 for uncoded bursts. Message services are fully described in 5.4.2.3.2.

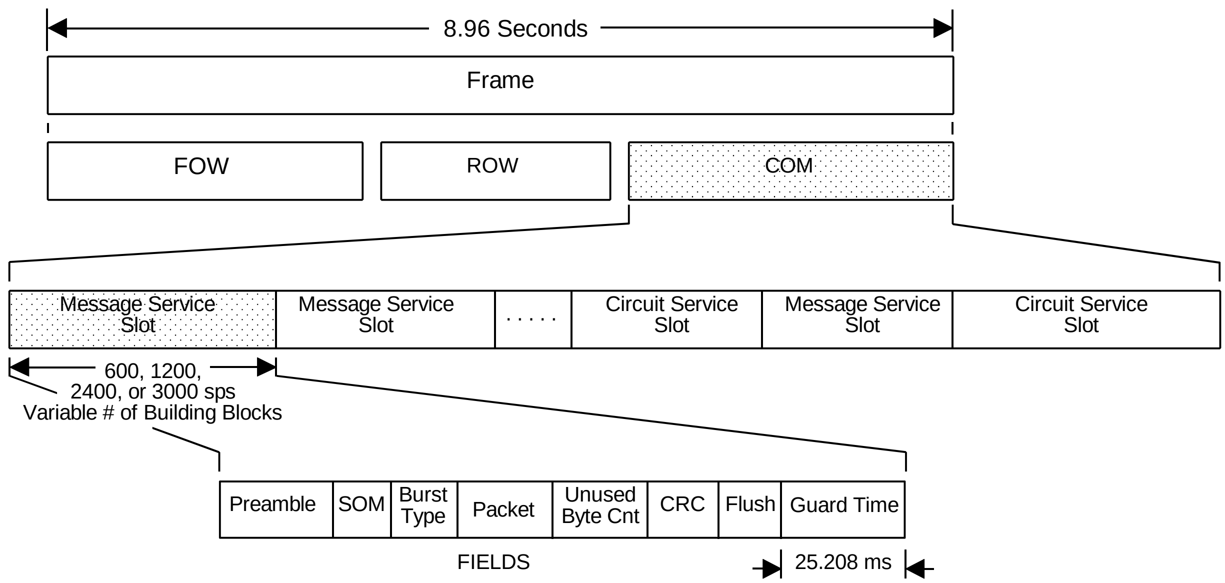
e. Unused Byte Counter field (8 bits). The Unused Byte Counter field indicates the number of unused (fill) bytes in the last burst message data block (see 5.4.2.3.2.5).

f. CRC field (16 bits). The CRC field contains CRC bits for error detection (see 5.4.3.1).

g. Flush field (6 bits). See 5.1.1l

5.1.4 <u>Data field transmission</u>. Data fields shall be transmitted in the sequence defined by Figures 3, 4, 5, 6, and 7. For each field, the MSB (the left-most bit) shall be transmitted first. For example, if the address of a terminal is 0000000011110101 (245), the first bits transmitted are the leading zeros.

5.1.5 <u>System guard time</u>. Each terminal shall ensure that its transmissions always fall within its allocated time-slots, as depicted in Figure 7. The nominal start of a nonranging transmission always coincides with the beginning of an assigned time-slot. The allocated time-slot, in each case, includes the nominal transmit time within the assigned time-slot, plus 12.604 ms of guard time preceding the assigned time-slot, and all but

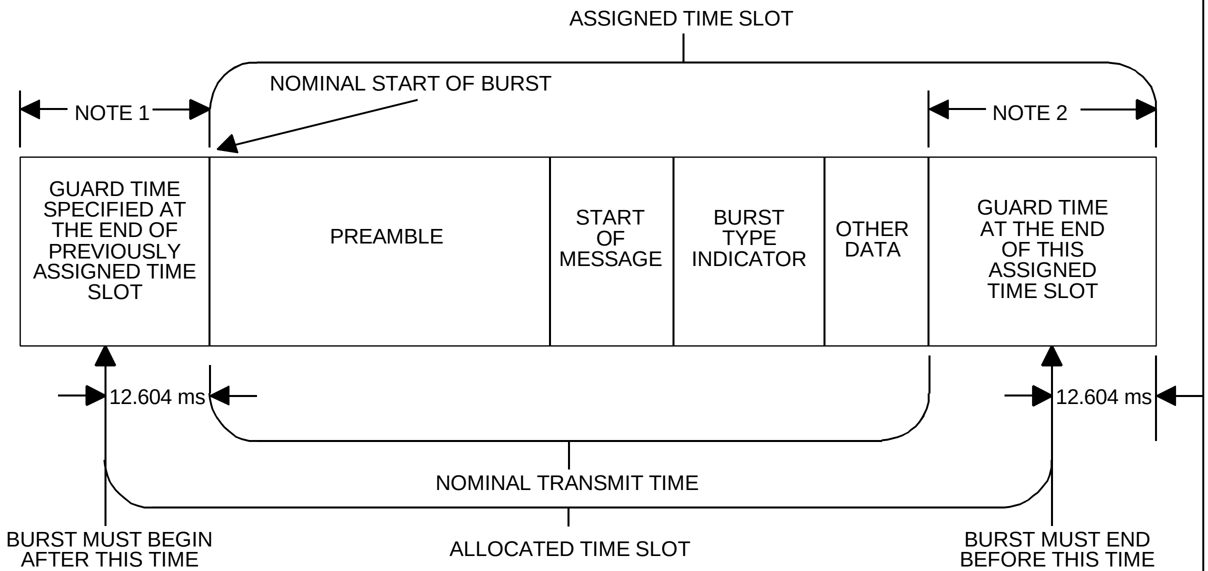


FIELD	BITS	ENCRYPTED	CONV. CODED**	INTERLEAVED**	CRC	DEFINITION	
Preamble	Variable	N	N	N	N	Burst Rate	Preamble Length (Bits)
						600	278
						1200	298
						2400	358
						3000	408
SOM	42	N	N	N	N	Start of Message Sequence	
Burst Type	12	N	N	N	N	Burst Type Indicator	
Packet	Variable	N*	Y	Y	Y	See 5.4.2.3	
Unused Byte Counter	8	N	Y	N	Y	See 5.4.2.3	
CRC	16	N	Y	N	N	Cyclic Redundancy Check For Error Detection	
Flush**	6	N	Y	N	N	Error Correction Flush Bits	

* NOTE: Data may be encrypted by the user baseband device.

** NOTE: Applicable only if the communication is assigned to be coded.

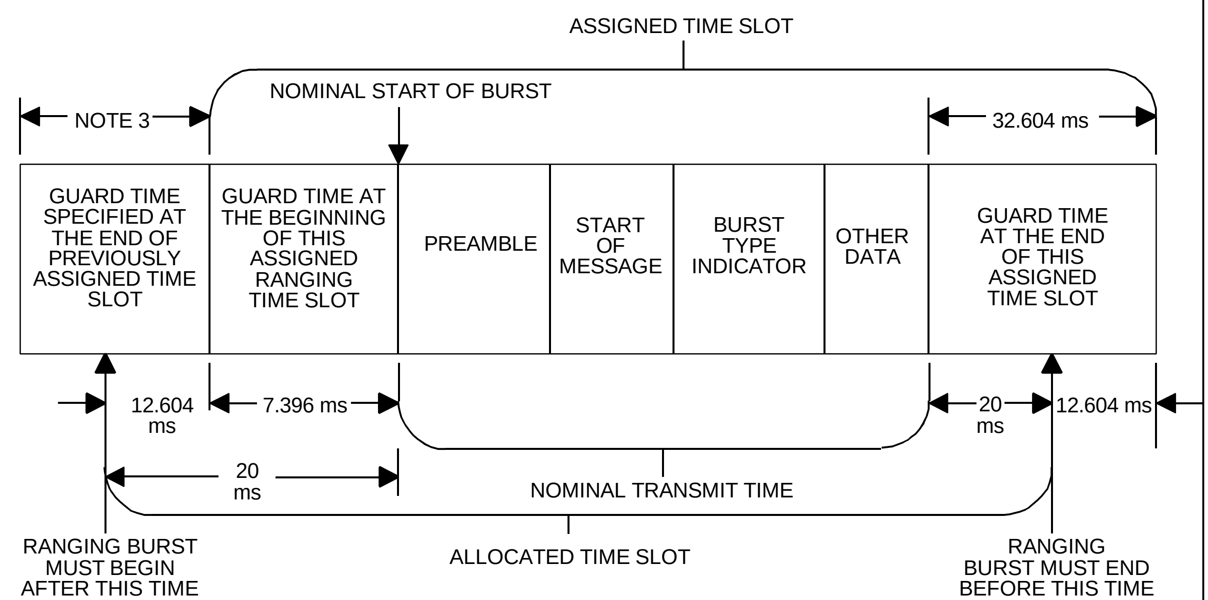
FIGURE 6. Communications message-service field definitions.



NOTE 1: At least 25.208 ms if previous slot is ROW message or communications slot.
At least 32.604 ms if previous slot is ROW ranging.

NOTE 2: At least 25.208 ms if assigned slot is ROW message or communications slot.
At least 12.604 ms if assigned slot is FOW slot, i.e., there is no guard time at the end of the allocated FOW slot.

FIGURE 7a. Allocated guard times for bursts except ranging



NOTE 3: At least 25.208 ms if previous slot is ROW message slot.
At least 32.604 ms if previous slot is ROW ranging slot.
At least 12.604 ms if previous slot is FOW slot, i.e., all of the guard time at the end of the previous slot (if a FOW slot) is allocated to the ranging slot.

FIGURE 7b. Allocated guard times for ranging bursts

FIGURE 7. Allocated guard times for bursts.

the last 12.604 ms of the guard time specified within the assigned time-slot. This results in a guard time of at least 12.604 ms provided before and after the nominal burst time, except for FOW and ranging time-slots.

a. The FOW defines system timing, therefore, no guard time is needed for the FOW. For the FOW time-slot, all of the 12.604-ms guard time specified at the end of the assigned time-slot is allocated to the first Contention Ranging time-slot. For ranging time-slots, the 12.604-ms guard time at the end of the previous time-slot and initial guard time ahead of the burst in the assigned time-slot combine to provide 20 ms of guard time before the nominal burst time. Subtracting 12.604 ms from the guard time specified at the end of the assigned time-slot results in 20 ms of guard time allocated after the nominal burst time.

b. Terminals can maintain timing by performing periodic range measurements (that is, active ranging) in ROW ranging time-slots assigned for that purpose. However, active ranging is not required if timing accuracy can be otherwise determined and maintained. Terminal design shall prohibit the use of the Contention Ranging time-slots except when (1) performing initial ranging (prior to login), or (2) its uplink timing error becomes excessive. If active ranging is used, the terminal design shall allow the terminal to maintain sufficient uplink timing (that is, within 12.604 ms) for a period of at least 4.6 hours following a successful range.

5.2 Synchronization. Terminal timing shall be aligned with the PCC timing. Prior to logging into the network, each terminal shall perform downlink and uplink acquisition to align its frame timing with that of the PCC. Thereafter, each terminal shall track the downlink and perform ranging (active or passive) to maintain uplink timing. The terminal can also maintain timing by making adjustments based on measured changes in frame timing. For this purpose the terminal can assume that the PCC time accuracy is 2.5×10^{-7} or better.

5.2.1 Downlink synchronization. Prior to initiation of any network transmission, the terminal shall perform downlink acquisition. When the terminal successfully completes initial frame acquisition and is able to interpret the FOW, downlink acquisition is achieved.

a. Initial frame acquisition shall involve (1) acquisition of downlink symbol timing by acquiring the FOW slot preamble, (2) acquisition of downlink slot timing by detecting the FOW slot SOM sequence, and (3) acquisition of frame timing by detecting the unique start-of-frame burst type indicator.

b. If the terminal achieves initial frame acquisition, the terminal shall attempt to interpret the FOW by proceeding with error correction decoding (see 5.4.3.2), decryption (see 5.5.1), and CRC validation (see 5.4.3.1). When the FOW is correctly decoded, decrypted, and CRC-checked, downlink acquisition is considered successful.

c. The terminal shall terminate uplink transmission upon loss of the downlink synchronization (loss of the FOW). If no FOW burst is received for 200 consecutive frames, the terminal shall assume that login and service request information at the PCC is lost. If downlink acquisition is recovered within 200 frames, the terminal shall not log in or retransmit service requests which have been previously acknowledged by the PCC.

5.2.2 Uplink synchronization. Prior to network log in, a terminal shall perform uplink acquisition. Terminals that use active ranging shall range in the Contention Ranging time-slots of the ROW. If a ranging attempt is successful, or if the terminal determines uplink timing in some other manner, uplink acquisition is successful. If the terminal's initial active ranging attempt is not successful, it will proceed in accordance with 5.2.2.1.2.

5.2.2.1 Terminal active ranging. The terminal that performs active ranging shall set the Ranging Type field of the ROW:Login message to zero (0). To perform active ranging, a terminal shall transmit a short burst in accordance with 5.1.2.1 and Figure 3 and shall measure the round-trip propagation time to the satellite. The propagation time value is then used to ensure that terminal timing is aligned with the timing of the PCC. Terminals may compute changes in satellite ranges based on when FOWs are received. Terminals that use this method should monitor for a change in the PCC address in the FOW as this may be accompanied by a jump in FOW timing.

5.2.2.1.1 Terminal contention ranging. Prior to login, the terminal may perform initial ranging in the ROW segment's Contention Ranging time-slots. If initial ranging is unsuccessful, subsequent ranging attempts shall occur in the Contention Ranging time-slots during frames determined by the algorithm defined in 5.2.2.1.2. A terminal that performs active ranging is permitted to perform an initial attempt (in a Contention Ranging time-slot) in any frame prior to login, and in any frame after its uplink timing error becomes excessive.

5.2.2.1.2 Contention-ranging backoff algorithm. Following an unsuccessful attempt to range in a contention-ranging time-slot, the terminal shall select a frame and slot for further contention-ranging attempts. The contention ranging ROW slot in which to retransmit the ROW ranging message shall be selected using an algorithm that uses two levels of randomization. The first level of randomization determines the frame in which retransmission of the ROW ranging message is to occur. The second level of randomization determines the contention ranging ROW slot for retransmission of the ranging message. The contention ranging ROW time-slot selection process shall be as follows:

a. To determine the frame in which to retransmit the contention ranging ROW message, the terminal shall use the acquisition backoff number. For initial retransmission, the value of the acquisition backoff number is 2. For subsequent retransmissions, the value of the acquisition backoff number is 5, 10, 50, 100, and 250. The terminal shall derive a uniformly distributed random number (U1) between 1 and the acquisition backoff number, inclusive. Starting at the next frame, the terminal shall determine the accumulated number of contention ranging slots (see 6.4). The frame in which the accumulated number equals or exceeds U1 shall be the frame for retransmission of the contention ROW ranging message.

b. To determine the contention ranging slot in which to retransmit the contention ROW ranging message, the terminal shall derive a uniformly distributed random number (U2) between 1 and the number of contention ranging slots inclusive, in the frame determined in a, above. The terminal shall use the contention ranging ROW slot U2 for retransmission of the contention ROW ranging message.

5.2.2.1.3 Terminal assigned ranging. The PCC allocates assigned-ranging time-slots to all logged-in participants in the satellite coverage area if they logged-in as active ranging terminals. The interval between assigned-ranging time-slots does not exceed 4.5 hours for each participant. If active ranging is used, the terminal shall range using the time-slot defined by the FOW:Ranging Assignment message.

a. If a terminal performs active ranging and does not receive a FOW:Ranging Assignment message within 4.5 hours since the time it most recently ranged successfully, or if the ranging in an assigned ROW time-slot is unsuccessful, the terminal shall request an assignment to range. The request shall be sent in the contention portion of the ROW, using an ROW:Assign Ranging message.

b. If a terminal performs active ranging and does not successfully range prior to its uplink timing error being greater than ±12.604 ms, the terminal shall inhibit transmissions (other than ranging) until ranging is successfully performed. If a terminal performs active ranging and its uplink timing error becomes excessive (that is, no longer within ±12.604 ms), the terminal shall range in the contention-ranging time-slot as defined in 5.2.2.1.2.

5.2.2.2 Terminal passive ranging. Terminals that passively range shall report this to the PCC in the ROW:Login Message by setting the Ranging Type field to 1. The PCC will not allocate assigned ranging slots to the logged-in terminals that use passive ranging. Any terminal that has identified itself as performing passive ranging may request an active ranging slot by a ROW:Assign Ranging message. The terminal shall then transmit a ROW ranging burst in accordance with 5.1.2.1 in the assigned ROW time-slot.

5.3 Link quality measurement. The terminal shall report the carrier-power--to--noise-spectral-density ratio (C/N_o) of the received FOW to within 1 dB. The terminal shall report link quality to the PCC at login using a ROW:Login message or when requested using a ROW:Status Report message.

5.4 Communications characteristics

5.4.1 Communications services

5.4.1.1 TDMA communications services. The protocol supports a mixture of circuit services and message services. Circuit services may be either preassigned or demand-assigned. Preassigned circuit services are set up by the PCC and assigned to the terminal in the FOW:Circuit Assignment message. The Virtual Port field of the FOW identifies the service as preassigned. Preassigned circuit services are not subject to preemption, as are demand-assigned services. Table XII lists the types of services available for local (operating within a single satellite footprint) and global (involving multiple-hop routing) coverage. Multiple-hop routing is accomplished by a relay capability, within the NCS, that can transfer information between channels in a global network. Point-to-point operation involves two terminals. Subnet operation can involve communications among any number of terminals, but is set up only when two or more participating terminals are logged in.

TABLE XII. Communications services.

COMMUNICATIONS SERVICE	OPERATION	TYPE OF SERVICE	END-TO-END ACKNOWLEDGMENT	COVERAGE AREA
Circuit (Data)	Point-to-point	Full-duplex	No	Local/Global
Circuit (Data/Voice)	Point-to-Point	Half-duplex	No	Local/Global
Circuit (Data/Voice)	Subnet	Half-duplex	No	Local
Message (Data)	Point-to-Point	Simplex	Yes	Local
Message (Data)	Subnet	Simplex	No	Local

5.4.1.1.1 Circuit service. Circuit service provides a communications path between terminals over which one-way or two-way communications can take place. Half-duplex service provides two-way communications, but with the communications in only one direction (from one source terminal) in any one frame. For a half-duplex circuit service, a single time-slot is assigned in each frame, and the addressed terminals must coordinate the use of the time-slot to prevent interference. A full-duplex circuit service is assigned two time-slots in each frame, permitting communications in two directions during the frame. The terminal shall provide circuit service at data I/O rates of 75, 300, 600, 1200, and 2400 bps and at the digital voice rate of 2400 bps, as indicated in Table XIII.

TABLE XIII. Network circuit communications I/O data rates.

COMMUNICATIONS CIRCUIT	FULL- OR HALF-DUPLEX SERVICE	I/O DATA RATE (bps)				
		75	300	600	1200	2400
Data Circuit	Half-Duplex	X	X	X	X	X
Data Circuit	Full-Duplex	X	X	X	X	
Voice Circuit	Half-Duplex					X

5.4.1.1.2 Message service. A message service provides communications resources for the transmission of data, using a block protocol. All message services are simplex services. A simplex service is one in which a single terminal is the source for all transmissions. Messages shall be less than or equal to 114,688 bits which is equivalent to 512 blocks of 224 bits each. Cryptographic equipment preambles and pad bits, and any I/O equipment overhead bits such as start, stop, and parity, shall be included in the 114,688-bit maximum.

5.4.1.2 Dedicated communications services. A dedicated channel service provides a 5- or 25-kHz UHF SATCOM channel over which two terminals (point-to-point) or multiple terminals (subnet) can communicate. Voice and data communications on dedicated channels shall be in accordance with MIL-STD-188-181.

5.4.1.3 25-kHz TDMA communication services. Terminals may be directed to switch to 25-kHz TDMA waveform operation using a FOW:Terminal Channel Assignment message. Communication on the assigned 25-kHz TDMA channel shall be in accordance with MIL-STD-188-183.

5.4.2 Communications Protocols

5.4.2.1 TDMA access control

5.4.2.1.1 Preassignment of circuit services. Any point-to-point circuit service can be preassigned. Additionally, among terminals on a single satellite channel, subnet circuits can be preassigned. Setup, control, and teardown of the preassigned services are performed at the NCS. When the preassigned service is set up, the PCC designates the source and destination terminals. The source terminal must be within the satellite coverage area controlled by the PCC. The source terminal need not be logged into the network at the time a preassigned circuit is set up. The destination terminal(s) also need not be logged into the local network at the time a preassigned circuit is set up if the service is local (single footprint). However, if a destination terminal is located in a different satellite coverage area (that is, the service is multiple-hop), the destination terminal must be logged into its local PCC at the time the service is set up.

a. If the NCS operator requests the set up of a preassigned circuit service and at least two participating terminals are logged in, the service is considered active and the PCC makes assignments using FOW:Circuit Assignment messages. When other participating terminals log in, they are notified of an active preassigned service via the FOW:Circuit Assignment message.

b. If the NCS operator requests the set up of a preassigned circuit service and less than two participating terminals are logged in, the PCC retains it in a dormant state in which assignments are not made. The service remains dormant until at least two participants log in, at which time the state of the service transitions to active and the PCC issues FOW:Circuit Assignment messages to the logged in participants.

c. As terminals log out or when a guard list changes such that less than two service participants are logged in, the preassigned circuit enters the dormant state and the PCC sends the FOW:Circuit Teardown message to the participating terminals. When the NCS operator explicitly tears down the preassigned circuit, the PCC uses a FOW:Circuit Teardown message to notify terminals. Multiple-hop preassigned circuits may be automatically torn down if there is an interruption in the relay communications connectivity established when the set up of the preassigned service was requested.

d. A terminal shall respond to normal FOW requests and commands while participating on a preassigned circuit. ROW service requests from a terminal involved in a preassigned point-to-point circuit, and point-to-point services addressed to a terminal involved in a preassigned point-to-point circuit are not set up until the preassigned service is torn down. If service requests are made by a terminal prior to the setup of a preassigned point-to-point service involving that terminal, the requested service is either blocked or torn down, depending on its state just before the preassigned point-to-point service is set up. A queued service request will be blocked, and an active service will be torn down. Terminals receive resource assignments for preassigned circuit services in the FOW:Circuit Assignment message. Terminals shall not request a teardown for preassigned circuits.

5.4.2.1.2 Precedence and preemption. The waveform supports preemption of lower-precedence, demand-assigned communications by higher-precedence communications. Terminals shall originate each service request at one of five levels of precedence. In decreasing order of precedence, these levels are Flash Override, Flash, Immediate, Priority, and Routine. After a service is assigned communications resources, the lack of a service assignment in an FOW burst indicates the service is preempted.

5.4.2.1.3 Access restrictions. The PCC can restrict access to network resources through terminal access restriction, system access restriction, and system service restriction.

5.4.2.1.3.1 Terminal access restriction. Terminal access restriction is a terminal attribute set at the NCS. It defines the maximum precedence for communications traffic originated by the terminal. Terminal access restriction does not apply to services assigned to a destination terminal. Terminal access restriction is provided to a terminal in the FOW:Login Response message. No service request whose precedence exceeds the terminal access restriction shall be transmitted by the terminal, unless the destination address is zero (numeric value). See 5.4.2.5.1.2.

5.4.2.1.3.2 System access restriction (Appendix A, Table 10-I, FOW System Message value 0-6). System access restriction, a system attribute set at the NCS, limits contention ROW transmissions during heavy traffic periods. System access restriction is the minimum precedence for service requests originating at any terminal in the network. A terminal shall not transmit a service request if the precedence is less than the system access restriction.

5.4.2.1.3.3 System service restriction (Appendix A, Table 10-I, FOW System Message value 7-8). The system service restriction is specified in a FOW system message. When the FOW system service restriction is specified as being on, a terminal shall not originate requests for 2400-bps multiple access channel circuit services. Terminals may request 2400-bps voice and data services on dedicated channels when the system service restriction is on.

5.4.2.1.4 Authorization. A terminal shall not transmit except as permitted in this MIL-STD and authorized by the PCC. The NCS operator can update the authorization status of any node address. Logged in network participants whose address authorization changes from authorized to unauthorized are automatically logged out of the network.

5.4.2.1.5 Network login

5.4.2.1.5.1 Terminal login. A terminal shall prohibit any type of transmission other than ranging and login until it receives a positive login acknowledgment. A terminal may login following acquisition of the downlink and the uplink. A terminal shall select a random time to transmit a ROW:Login message in the contention portion of the ROW. The random time shall be selected in accordance with 5.4.2.1.7.4.1. If the login message is received correctly, the PCC sends a FOW:Login Response message to the requesting terminal. Once the terminal receives a positive login acknowledgment, the terminal may participate in the network. If the terminal does not receive a login response in the FOW, within the time specified in 5.4.2.1.5.2.2, it shall retransmit the message using the ROW acknowledgment/retry protocol defined in 5.4.2.1.7.4.2. For terminal login only, the terminal may retransmit the message using the acknowledgment/ retry protocol until login is accomplished. Silent terminals may be logged in by the NCS operator.

5.4.2.1.5.2 Orderwire message acknowledgment

5.4.2.1.5.2.1 FOW message acknowledgment. Certain FOW messages require a terminal acknowledgement, using a ROW message (see Table X). Terminals logged in as Silent Terminals are not obligated to respond to these FOW messages. ROW messages responding to these FOW messages shall be transmitted within assigned ROW time-slots.

5.4.2.1.5.2.2 ROW message acknowledgment. A terminal sending a ROW message in a contention ROW slot should expect a FOW acknowledgment message. If no acknowledgment is received within four frames, the terminal shall use the acknowledgment/retry protocol specified in 5.4.2.1.7.4.2 for retransmission of the ROW message. If no acknowledgment is received within four frames after retransmission, the terminal shall terminate the orderwire message retransmission attempt. Further orderwire message retransmission attempts must be initiated by the terminal operator, except for terminal login messages as described in 5.4.2.1.5.1.

5.4.2.1.6 Network management

5.4.2.1.6.1 Terminal logout. Whenever possible, a terminal shall logout by transmitting a ROW:Logout message in a contention ROW time-slot. The terminal shall follow the protocol specified in 5.4.2.1.7.4. If a logout response is not received, the terminal shall terminate the logout protocol and consider itself logged out of the network.

5.4.2.1.6.2 Automatic logout. A terminal is logged out, and therefore cannot participate in the network, whenever a FOW:Logout Response message is received. An automatic logout occurs under any of the following circumstances:

a. The PCC changes the terminal address from authorized to unauthorized.

b. The PCC does not permit a node address to be duplicated in terminal guard lists. If this occurs, the PCC logs out the most recently logged-in terminal that has a duplicate node address.

c. The terminal does not respond to any of four consecutive FOW:Report Status messages and has not logged in as a Silent Terminal.

5.4.2.1.6.3 Queued service requests. Service requests that are queued are either blocked or pending. A service is considered blocked when its assignment requires the completion of another service or operation; that is, the source or destination is busy. A service becomes unblocked, either pending or active, when the blocking condition clears. A service is considered pending when it is not blocked, but it has not been assigned communications resources. This condition can occur when other services, such as equal or higher-precedence services or preassigned circuits, have been assigned all available communications resources. The PCC does not report blocked or pending status to the terminal. The PCC does, however, report queued status to the terminal in the FOW:Circuit Setup Response or FOW:Message Setup Response.

5.4.2.1.6.4 Queued maintenance. The PCC manages and maintains all service requests. The PCC processes demand-assigned service requests on a first-in, first-out (FIFO) basis within a precedence category.

a. For each requested service, the PCC maintains a timer whose duration is 805 frames (approximately 2 hours) for local services, and 1342 frames (approximately 3.3 hours) for multiple-hop services. The terminal should maintain similar timers. The PCC deletes from its queue the requests held at the

PCC which have not been allocated resources prior to the PCC timer expiration. The PCC notifies the source terminal of the service termination and the reason for termination. If the requesting terminal does not receive an assignment or a teardown for a service prior to the expiration of the terminal's timer, the terminal should consider the service torn down.

b. The PCC also maintains a timer on a preempted service. The duration of this timer is 38 frames (approximately 6 minutes) for a local service, and 53 frames (approximately 8 minutes) for a multiple-hop service. If the PCC's timer for a preempted service expires prior to resumption of assignment of channel resources to that service, the PCC tears down the service. The PCC notifies the source terminal of the teardown and the reason for the teardown. On receipt of the teardown, the terminal shall inform the operator that the service has been torn down by the PCC. It is possible that the terminal could miss the notifications of torn down services. Therefore, it is recommended that the terminal maintain similar timers (as defined in the terminal specifications) for its preempted services.

5.4.2.1.7 Frame construction

5.4.2.1.7.1 Forward orderwire resource assignment. The quantity of channel resources allocated to the FOW for a given frame is determined one frame in advance and is transmitted to each network member in the Length of Next FOW field in each FOW. Adaptive techniques are used to determine the allocation of channel resources, based on whether the previous allocation was inadequate, adequate, or excessive for FOW messages to be transmitted.

5.4.2.1.7.2 Communications service assignment. The PCC removes communications service requests from the top of the queue (oldest in the queue) and assigns resources until the communications segment of the frame is full or until there are no more queued requests. The PCC sends communications assignments in the FOW. The process may result in service assignment to different positions within a frame from one frame to the next. The position of a time-slot shall be determined from the ordering of assignments in the FOW burst. Communication time-slots are assigned in reverse order, that is, from the latest (last) to the earliest (first). More specifically, the service receiving the first time-slot assignment in the FOW is assigned to the last time-slot in the communications segment of the next frame, the second in the second to last, and so on. At most, one 2400-bps, digital-voice, circuit-service time-slot is assigned in any frame. The 2400-bps time-slot for digital voice service is assigned only to the last time-slot in the frame's communications segment.

5.4.2.1.7.3 Return orderwire resource assignment. The ROW segment contains three sequential sections: contention ranging time-slots, assigned ROW time-slots, and contention ROW message time-slots (see Figure 4). The assigned ROW time-slots are used for both assigned ranging and ROW messages, and are assigned by the PCC in the FOW. The position of a ROW time-slot assignment is based on the ordering of assignments in the FOW burst. ROW time-slots are assigned from the earliest assigned time-slot to the latest. Thus, the terminal receiving the first ROW assignment in the FOW shall transmit during the first assigned ROW time-slot (following the contention ranging time-slots), the second in the next, and so on.

5.4.2.1.7.4 Protocol for contention return orderwire message transmission. A terminal shall identify the beginning of contention ROW time-slots by analyzing the Length of Next FOW field and FOW directed messages that assign ROW capacity. All channel time from immediately following the end of the assigned ROW time-slots (determined by parsing the FOW), and preceding the assigned communications time-slots (also determined by parsing FOW directed messages), is available for contention ROW time-slots. This remaining time (measured in building blocks) is divided by 17 to provide the number of contention ROW message time-slots available in the frame. These contention ROW message time-slots shall immediately follow the assigned ROW time-slots.

5.4.2.1.7.4.1 Initial transmission of contention return orderwire message. Any frame may be used for initial transmission of a contention ROW. The contention ROW time-slot within the frame shall be selected at random, based on a uniform distribution over the contention ROW time-slots within the frame.

5.4.2.1.7.4.2 Return orderwire acknowledgment/retry protocol. This protocol is used for the selection of a single automatic retry. Further retries shall not be automatic (will require operator intervention). Multiple automatic retries are allowed only for terminal login messages as described in 5.4.2.1.5.1. Terminals transmitting a contention ROW message shall expect to receive a FOW response. Terminals that do not receive a response shall assume that the contention ROW message was not received by the PCC. The contention ROW slot in which to retransmit the contention ROW message shall be selected using an algorithm that uses two levels of randomization. The first level of randomization determines the frame in which retransmission of the contention ROW message is to occur. The second level of randomization determines the contention ROW slot for retransmission of the contention ROW message. The contention ROW time-slot selection process shall be as follows:

a. To determine the frame in which to retransmit the contention ROW message, the terminal shall use the contention backoff number most recently transmitted by the PCC (in a FOW system message). The terminal shall derive a uniformly distributed random number (U1) between 1 and the contention backoff number, inclusive. Starting at the next frame, the terminal shall determine the accumulated number of contention ROW slots. The frame in which the accumulated number equals or exceeds U1 shall be the frame for retransmission of the contention ROW message.

b. To determine the contention ROW slot in which to retransmit the contention ROW message, the terminal shall derive a uniformly distributed random number (U2) between 1 and the number of contention ROW slots, inclusive, in the frame determined in a, above. The terminal shall use the contention ROW slot U2 for retransmission of the contention ROW message.

5.4.2.1.7.5 Contention reporting. The terminal has two methods of reporting its success in receiving acknowledgments to contention ROW messages. One method is in a contention ROW using the Retry Flag, and the other is in an assigned ROW using the Retransmission Flag, as indicated below:

a. Within a contention ROW message, the terminal shall use the Retry Flag to indicate if the transmission is a first attempt or a retry.

b. Within an assigned ROW message, the terminal shall use the Retransmission Flag to indicate if the last contention ROW transmission was successful.

The terminal shall remember if the contention ROW message most recently transmitted was acknowledged. The terminal shall set the Retransmission Flag if a response to a retransmitted contention ROW is not received within four frames. The terminal shall reset the Retransmission Flag if (1) it receives a response to a contention ROW, (2) it detects a change in the ROW backoff number received in the FOW, or (3) 30 minutes has elapsed since the Retransmission Flag was set. The PCC uses this Retransmission Flag and Retry Flag information in computing the ROW backoff number.

5.4.2.2 TDMA circuit service

5.4.2.2.1 Circuit service setup. To originate a circuit service, the terminal shall transmit a ROW:Circuit Setup message. In response to the request, the PCC sends either a FOW:Circuit Assignment message that establishes the service, or a FOW:Circuit Setup Response message that indicates the request is in the queue or explains the denial of service. If a response is received, the terminal shall abort the ROW acknowledgment/retry protocol.

5.4.2.2.2 Circuit service management. For each queued circuit service, the PCC determines the number of building blocks required, the modulation rate, and if coding is required. This determination is a function of (1) whether the communications service is voice or data, (2) whether the service is full- or half-duplex, (3) the I/O data rate, and (4) the end-to-end link quality, as identified in Table IV. For each assigned circuit service, the PCC transmits an FOW:Circuit Assignment message or FOW:Multiple-Hop Circuit Assignment message that specifies (1) whether the communications service is voice or data, (2) whether the service is full- or half-duplex, (3) the I/O data rate, (4) the modulation rate, and (5) if coding is required. The terminals can determine the time-slot size (number of building blocks required) for a circuit service from this information, using the information shown in Table IV. For a full-duplex service, the PCC assigns two communication slots in the same frame.

5.4.2.2.3 Buffer requirements imposed by clock differences. To account for clock differences at the transmitting terminal, channel controller, receiving terminal, and I/O devices, data buffers may be required in the terminal equipment. If the receiving terminal transfers data to and the transmitting terminal transfers data from the input/output device at a rate which tracks the rate at which data is transferred within the DAMA frames, no buffer requirement is imposed by the clock differences. If the receiving terminal transfers data to the input/output device at a fixed rate based on the terminal's or input/output device's internal clock, then a receive buffer shall be required. Likewise, if the transmitting terminal transfers data from the input/output device at a fixed rate based on the terminal's or input/output device's internal clock, then a transmit buffer shall be required. Sufficient buffering in the terminal shall be provided to accommodate at least 24 hours of continuous operation at a I/O device rate of 2400 bps. The channel controller clock accuracy will be 2.5×10^{-7} or better. The terminal clock accuracy shall be 1×10^{-6} or better.

5.4.2.2.4 Circuit burst format for synchronous communications. With the possible exception of the last two bursts of a transmission, the same number of data bits shall be transmitted within each burst. The size shall be

$$N = \text{(User I/O Rate) (8.96 seconds)}$$

where N is the nominal number of data bits sent in each burst. The size of the data field for circuit communications is shown in Table XIV.

TABLE XIV. Size of the data field for circuit communications.

DATA RATE (bps)	NOMINAL DATA *N* (bits)
75	672
300	2,688

DATA RATE (bps)	NOMINAL DATA *N* (bits)
600	5,376
1,200	10,752
2,400	21,504

The last two bursts of a data circuit service may contain fewer than N data bits. This is required to handle transmission lengths that are not an integral multiple of the data field size. Each burst includes an 8-bit Circuit Burst Kind (CBK) field to identify the format of the circuit service communication burst and to indicate the first and last bursts of a transmission (see Figure 8). The burst format associated with each CBK is also a function of the circuit type (voice or data). The receiving terminal shall correctly interpret the CBK if no more than 2 bit positions of the 8-bit CBK are received in error.

a. Unless an entire transmission has N or fewer data bits, the first burst for a voice circuit service shall use the first burst CBK format. The CBK field for the first burst shall be 11111000. All voice circuit service bursts, except the first and last of a transmission, shall use the nominal CBK format. The CBK field for the nominal burst shall be 00000000. All bursts for voice circuit service shall use the same burst format except that the CBK shall be set appropriately. Unused bits in the data subfield shall be filled with the repeating 4-bit sequence 1001. When the service is voice and the entire transmission has no more than N data bits, then the last burst CBK format shall be used in the first and only burst of the transmission. The CBK field for the last burst shall be 10101111.

b. For data circuit service, the format for the last burst contains an 80-bit Last Burst Count subfield. The maximum number of bits that may be transmitted in the last burst is N-80 bits. Unused bits in the data subfield shall be filled with the repeating 4-bit sequence 1001. The Last Burst Count subfield shall contain a count of the number of non-fill data bits in the burst. The count shall consist of a 16-bit binary number repeated 5 times to fill the 80-bit Last Burst Count subfield. Each time the 16-bit number is repeated, the most significant bit shall be transmitted first. The receiving terminal shall correctly interpret the Last Burst Count subfield if no more than 2 of the 16-bit binary numbers are received in error.

The second from last burst format is used only for data circuit service transmissions, and only if the remaining number of data bits is too small to fill a nominal burst (less than N) and too large to fit into the last burst (greater than N-80). For the second from last burst, the CBK field shall be 01010111. The 80-bit Last Burst Count subfield shall be filled with the repeating 4-bit sequence 1001, and the data subfield shall contain N-80 bits.

When the service is data and the entire transmission has no more than N-80 data bits, then the last burst CBK format shall be used in the first and only burst of the transmission. When the service is data and the entire transmission has N or fewer data

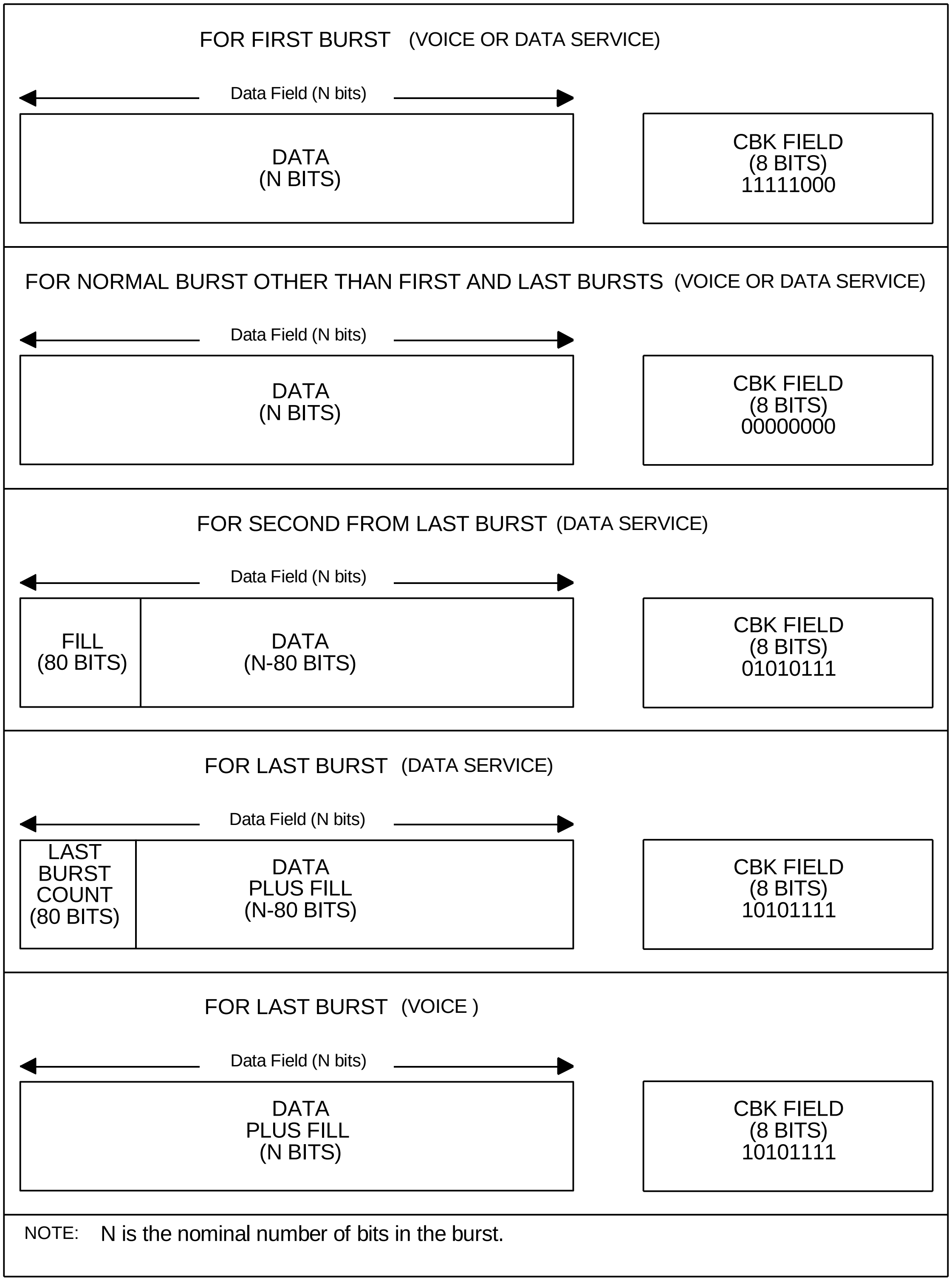


Figure 8. Circuit service communications field formats for synchronous communications.

bits but more than N-80 data bits, then the second from last burst CBK format shall be used for the first burst of the transmission and the last burst CBK format shall be used in the second and last burst of the transmission.

5.4.2.2.5 Circuit burst format for asynchronous communications. When communications terminals are used to communicate off-line encrypted data, the interfacing I/O equipment typically uses asynchronous data communications. For interfacing with asynchronous I/O equipment, the transmitting terminal shall strip start and stop bits, and the receiving terminal shall put these bits back onto the data stream. Therefore, the over-the-air data rate is always below the user I/O data rate.

Each burst includes an 8-bit CBK field (see Figure 9). The CBK field shall be 11111000 for the first burst of the transmission, shall be 00000000 for all but the first and last burst of the transmission, and shall be 10101111 for the last burst. The receiving terminal shall correctly interpret the CBK if no more than 2 bit positions of the 8-bit CBK are received in error. When the entire transmission has no more than N-80 data bits, the last burst CBK format shall be used in the first and only burst of the transmission. Unused bits in the data subfield shall be filled with the repeating 4-bit sequence 1001. The Burst Count subfield shall contain a count of the number of non-fill data bits in the burst. The count shall consist of a 16-bit binary number repeated 5 times to fill the 80-bit Burst Count subfield. Each time the 16-bit number is repeated, the most significant bit shall be transmitted first. The receiving terminal shall correctly interpret the Burst Count subfield if no more than 2 of the 16-bit binary numbers are received in error.

5.4.2.2.6 Circuit service teardown. The PCC tears down a local circuit service under the following circumstances:

a. a ROW:Circuit Teardown request is received,

b. an end-of-service burst type field is detected in the assigned communications time-slot,

c. an NCS operator teardown command is applied,

d. a service preemption timer expires, or

e. a service queuing delay timer expires.

On teardown, the PCC sends a FOW:Circuit Teardown message to notify the terminals in the service. The FOW:Circuit Teardown message includes the reason for service teardown. When the PCC teardown command is received, terminals shall cease transmission pertaining to that service.

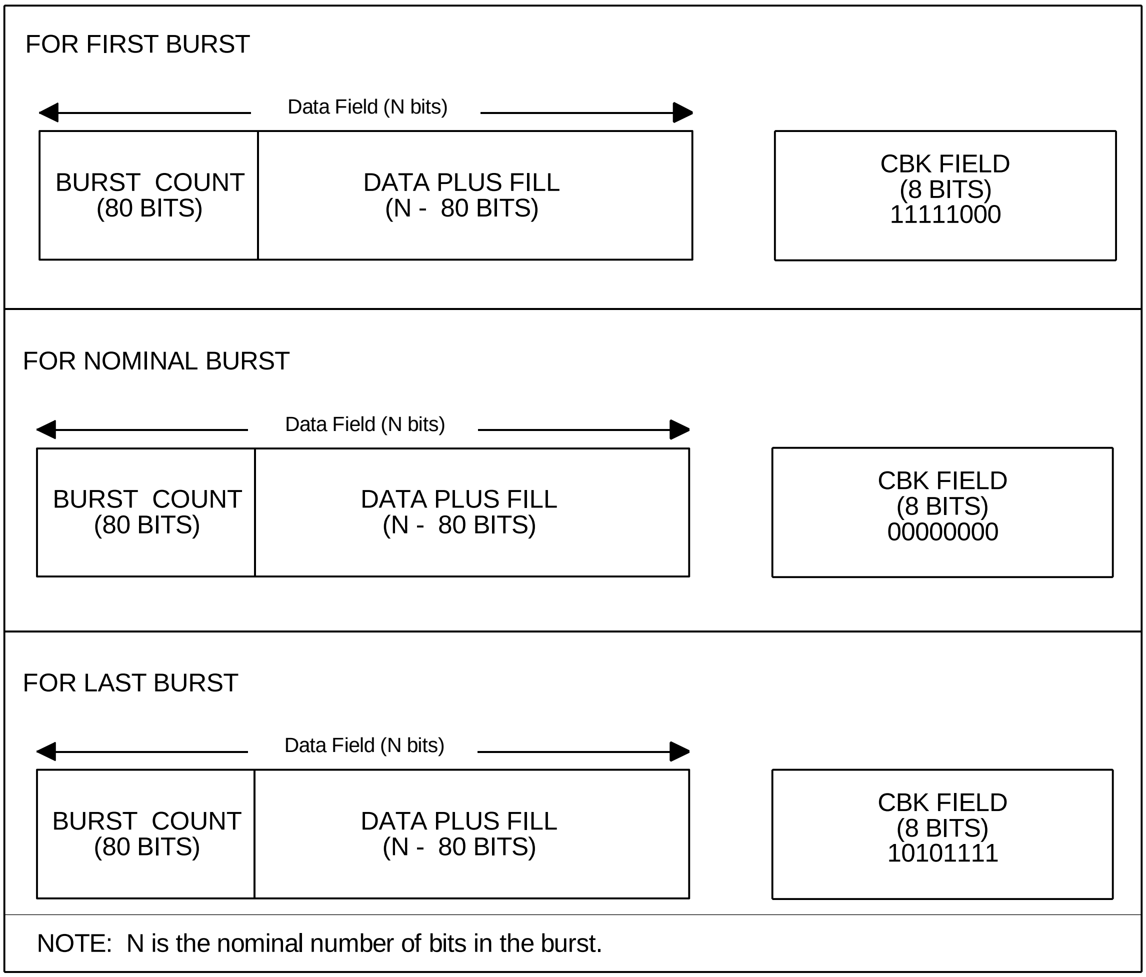


Figure 9. Circuit service field formats for asynchronous communications.

5.4.2.3 TDMA message service

5.4.2.3.1 Message service setup. To originate a message service, the terminal shall transmit a ROW:Message Setup message. In response to the request, the PCC sends either a FOW:Message Assignment message that establishes the service or a FOW:Message Setup Response message that informs the terminal that the request is in queue or explains the denial of service. If the terminal receives a response, the terminal shall abort the ROW acknowledgment/retry protocol.

5.4.2.3.2 Message service management. Message information transmitted over the channel shall be arranged into packets. A data block containing 224 message bits shall be the minimum packet size. However, the last block in a message can have fill bytes. A separate communications burst is used to transmit each packet, and a FOW:Message Assignment message is used for each assigned communications burst.

a. The PCC commands the source terminal to transmit one or more packets in each frame. Multiple packets for the same service are not assigned to be transmitted during the same frame unless all other services on the queue have been considered for scheduling.

b. For a queued message service, the PCC determines the number of 224-bit data blocks to be transmitted in a burst, the number of building blocks required, the modulation rate, and if coding is required. This determination is a function of (1) the end-to-end link quality, (2) the number of blocks remaining to be transmitted, and (3) the available communications resources, see Table V. The number of blocks remaining to be transmitted is known by the PCC because the message length is indicated in the ROW:Message Setup message. For each assigned message service, the PCC specifies the modulation rate, coding, and number of data blocks in the FOW:Message Assignment message. The terminal shall determine the time-slot size (number of building blocks required) for a message service from this information, as shown in Table V.

5.4.2.3.2.1 Block status polling. For a point-to-point message service, the PCC polls the destination terminal after packet transmissions to determine which blocks have been correctly received. Polling occurs by transmission of a FOW:Acknowledge Blocks message. If the PCC does not poll the destination terminal after a given packet transmission, the PCC continues to command transmission of the packets until able to poll. When polled, the destination terminal shall respond in a ROW:Blocks Acknowledgment message.

5.4.2.3.2.2 Block acknowledgments. The ROW:Blocks Acknowledgment message is used with point-to-point message services and shall contain information to acknowledge the block up to which all blocks have been received correctly. The PCC commands transmission of data blocks beyond the acknowledged block. This procedure shall continue until all message data has been transmitted and acknowledged, or until the service is torn down. If the PCC does not receive a ROW:Blocks Acknowledgment message in response to its poll, the PCC continues to poll the destination terminal while commanding sequential transmission of the data blocks.

5.4.2.3.2.3 Point-to-point message processing. If the PCC determines from the ROW:Blocks Acknowledgment message that the destination terminal still did not receive a particular data block after retransmission, the PCC increases the robustness of the service's burst code (that is, moves up one line in Table V). For a message service, the burst code is a combination of modulation rate, coding, and maximum burst size, corresponding to a line in Table V. The PCC commands up to two retransmissions of the message data, beginning at the data block in error. If the destination terminal still does not acknowledge receipt of the message data, the PCC again increases the robustness of the burst code and commands, at most, two more retransmissions of the message data. This procedure repeats until either the destination terminal acknowledges correct receipt of all transmitted data blocks or the most robust burst code has been reached. Once the most robust burst code has been reached, the PCC no longer commands block acknowledgments or a final message acknowledgment. Also, no acknowledgment is requested for point-to-point message services whose initial link quality is less than 32 dB-Hz. The PCC will, however, continue to command sequential transmission of data blocks.

5.4.2.3.2.4 Subnet message processing. For subnet message services, the PCC commands the source terminal to transmit the blocks sequentially. The PCC does not poll the destination terminals for acknowledgements. The service is torn down when the source terminal has completed transmission of the last data block or when a teardown request is received.

5.4.2.3.2.5 Unused-byte counter. All packets, except the last, contain an integer number of data blocks of valid message data. The last packet also contains an integer number of data blocks, but the data blocks can contain both valid message data and fill bytes. The last packet shall use the unused-byte counter to identify the number of fill bytes that follow valid data bytes in the packet. Each fill byte has the pattern 10011001. These fill bytes are removed by the receiving terminal. The size of the last packet is the smallest packet that satisfies the link conditions and whose size exceeds the remaining number of data blocks. If completely filled with valid message data, the last packet will contain no fill bytes.

5.4.2.3.2.6 Message acknowledgment. The PCC assigns a ROW time-slot to the destination terminal for the transmission of a message acknowledgment, following the positive acknowledgment of the last data block. This assignment is made by transmission of a FOW:Acknowledge Message message. The earliest the ROW slot is assigned is in the *N*th frame from the frame in which the last block acknowledgement was received, where *N* will be calculated as follows:

$$N = \text{Integer}\ [(\text{Msg\_length} / \text{IO\_Device\_Rate}) / 8.96\ \text{sec}\ ] + 1$$

where Msg_length is in bits and IO_Device_Rate is in bits per second.

a. When multiple I/O Device Rates are stored at the PCC for the destination terminal, the PCC assumes that messages are always output at the highest rate.

b. The receiving terminal shall send a ROW:Message Acknowledgement only after the terminal has successfully delivered the message to the terminal I/O device. The terminal specification shall define if the message should be delivered to the I/O device after the message has been completely and correctly received, or incrementally as continuous blocks are correctly received. When the PCC receives a ROW:Message Acknowledgment message from the destination terminal, it transmits a FOW:Message Acknowledgment message, (Acknowledgment Type field set to 1) notifying the source terminal of the acknowledgment.

c. The PCC may send a FOW:Message Acknowledgment message with the Acknowledgment Type field set to 0, to a terminal that was the source of a message when the destination terminal acknowledges all blocks in a message. This makes the source terminal available for other services while the destination terminal is attempting to transfer the message to its I/O device.

5.4.2.3.3 Message service teardown. The PCC terminates channel resource allocations for message services when they are no longer required. For a point-to-point message service, if all message data is transmitted and acknowledged and a ROW:Message Acknowledgment message is received from the destination terminal, the FOW:Message Acknowledgment message sent by the PCC serves as a teardown notification. The PCC otherwise sends an explicit FOW:Message Teardown message, which indicates the reason for teardown. The PCC sends a FOW:Message Teardown message under the following circumstances:

a. message service is complete (that is, all data blocks have been assigned transmission time-slots) but not all blocks were acknowledged, such as for subnet services;

b. point-to-point message service is complete but message acknowledgment was not received from the destination terminal;

c. a ROW:Message Teardown message is received;

d. an end-of-service burst type field is detected in the assigned communications slot;

e. an NCS operator teardown command is applied;

f. a service preemption timer expires; or

g. a service queuing delay timer expires.

5.4.2.3.4 Terminal busy status. The PCC considers a subnet service not busy in the frame following the allocation of channel capacity for the last packet. The PCC considers terminals involved in a point-to-point message service not busy in the following frame when:

a. the PCC receives the message acknowledgment,

b. the PCC fails to receive an acknowledgment following the second request for message acknowledgment,

c. the last data block of a nonacknowledged delivery is transmitted, or

d. the PCC transmits a FOW:Message Acknowledgement message indicating all blocks acknowledged.

5.4.2.4 Dedicated channel service

5.4.2.4.1 Terminal requirements. Only terminals that are Automatic Frequency Change capable (ROW:Login message) shall respond to a FOW:Channel Assignment message by changing to the new channel. Only terminals that are Automatic Frequency Change capable shall request an assignment of a dedicated channel.

5.4.2.4.2 Protocol. Terminals may request an assignment of a dedicated channel using a ROW:Circuit Setup message. The dedicated channel request includes a Channel Duration time in minutes. The PCC responds with either a) a FOW:Circuit Setup Response message identifying that the service is queued or identifying the reason for rejecting the service request, or b) a FOW:Terminal Channel Assignment message assigning the requesting terminal to a dedicated channel. When a service is assigned to a dedicated channel, the PCC will individually assign members of subnet destinations using separate FOW:Terminal Channel

Assignment messages. The FOW:Terminal Channel Assignment message includes the allotted time on the dedicated channel assigned by the PCC in minutes. When a FOW:Terminal Channel Assignment message is sent, a slot for an assigned ROW message is reserved and the terminal guarding that node address shall respond with a ROW:Terminal Channel Assignment Response message before switching to the dedicated channel. The terminal shall reject any terminal channel assignment which it does not accept (as when it is participating in a higher precedence subnet service, for example), using the ROW:Terminal Channel Assignment Response message.

The terminal shall return to the initial TDMA channel prior to, or immediately after the allotted time assigned. The terminal shall achieve downlink and uplink synchronization upon return to the initial TDMA channel. The PCC will assume that a terminal has achieved downlink and uplink synchronization, and is available for TDMA service assignments, 10 frames after the allotted time assigned. The terminal shall send a ROW:Terminal Channel Return message in the contention ROW message time-slots for early re-entry into the TDMA network if the selected contention ROW message slot occurs before the end of the allotted dedicated channel time assigned. The PCC responds to a ROW:Terminal Channel Return message with a FOW:Terminal Channel Return Response.

5.4.2.5 <u>Network management</u>

5.4.2.5.1 <u>Addressing</u>. Sixteen-bit addresses shall be used for identifying network nodes and subnets. A node address identifies a particular point in the network, such as a terminal or a CC. A subnet address identifies a group of terminals, local to one satellite footprint, that have a need for common communications. Each terminal shall receive the FOW messages and process those messages directed to its terminal node address or to any other address on its guard list. Each terminal shall maintain an address guard list. This guard list shall contain the node and subnet addresses for which the terminal receives services. (See Table XV.)

5.4.2.5.1.1 <u>Node address</u>. A terminal shall always use its unique terminal node address to identify itself in orderwire messages, that is, when logging into the network, requesting services, and in other orderwire messages. Each channel controller within an NCS has one unique CC node address to identify the channel controller in orderwire messages including service requests. Each channel controller can guard additional addresses, both node and subnet.

5.4.2.5.1.2 <u>Reserved address</u>. Zero is a reserved address, guarded by the PCC, that controls the local network; that is, all traffic addressed to address zero is routed to the user at the PCC. Terminals shall not use address zero for a login address or maintain address zero on their guard lists.

TABLE XV. Address guard-list contents.

terminal node address
node/subnet address #1
node/subnet address #2
node/subnet address #3
node/subnet address #4
node/subnet address #5
node/subnet address #6
node/subnet address #7
node/subnet address #8
node/subnet address #9
node/subnet address #10
node/subnet address #11
node/subnet address #12
node/subnet address #13
node/subnet address #14
node/subnet address #15

5.4.2.5.1.3 Demarcation of subnet addresses. The address space is partitioned to indicate whether an address is a node or subnet address. The NCS operator sets the address demarcation point. All addresses with a numeric value greater than the demarcation point are subnet addresses. By default, the demarcation point is 16384: the node addresses occupy addresses 1 through 16384, and the subnet addresses occupy addresses 16385 through 65535. A subnet address shall not be used for a terminal node address. If a login is attempted with a subnet address, the login is rejected and the FOW:Login Response message indicates the problem. The FOW:Login Response message informs the terminal of the address demarcation.

5.4.2.5.2 Address guard lists. The address guard list contains addresses for up to fifteen nodes or subnets, in addition to the terminal node address. Table XV illustrates the address guard-list contents. A terminal shall report the number of addresses on its guard list and a guard list cyclic redundancy check (CRC) in the ROW:Login message. Only node and subnet addresses shall be counted for the number of addresses in the login message. The terminal node address is not counted.

a. When requested by the PCC in one or more FOW:Report Terminal Address messages, the terminal shall report its guard list of node and subnet addresses in ROW:Terminal Address Report messages. The terminal node address is not reported in this message.

b. When reporting guard list addresses in the ROW:Terminal Address Report message, the terminal shall fill with zeros any fields corresponding to empty locations on the terminal address guard list (the PCC updates it's copy of the guard list to match that which is reported by the terminal). If the terminal reports an unauthorized address or if the report is not received by the PCC, the PCC may log out the terminal.

c. The terminal shall update its address guard list, when requested by the PCC in a FOW:Terminal Address Add or Delete message. The terminal shall respond to the FOW request with a ROW: Terminal Address Add or Delete Response message. The terminal shall report a failure to delete an address only if the address is not on its guard list. The terminal shall report a failure to add an address only if the address is already on its guard list or the guard list already contains fifteen addresses in addition to the terminal node address. If the terminal is involved in a receive service directed to a deleted address, the terminal shall ignore any further communications associated with the service.

5.4.2.5.3 Service requests and time-slot assignments. The PCC queues up to five service requests from a terminal. Each service request shall be identified by a unique service identification number (0-4) known as the terminal virtual port number. The terminal shall not reuse a virtual port number until the initial request with the virtual port number is no longer valid (such as is the case with a rejected request, a received teardown, or a timeout). The terminal shall not use virtual port numbers greater than those permitted.

a. The terminal shall be capable of processing any assigned services in the sequence established by the PCC, independent of the services requested by the terminal. The terminal will be assigned no more than one point-to-point service, as either the source or destination, at a time. The terminal will not be assigned as the source of more than one subnet service at a time. The terminal will not be assigned as the source of a subnet service while it is participating in a point-to-point service, and vice versa. Before transmission of a service request, the terminal shall validate the service request against terminal access restrictions, system access restrictions, and system service restrictions.

b. The terminal shall be capable of processing at least two active subnet message services as the service destination during a single frame while participating in one other active service of any type (as either the source or the destination). The terminal shall process multiple assignments in the following manner: (1) If the terminal is assigned multiple services that it cannot process simultaneously (example being, both a point-to-point service and a subnet circuit service), it shall process the service with the highest precedence. (2) If the terminal is assigned multiple services at the same precedence level, it shall process the first service assigned and continue to process the service until the service is preempted, completed, or if the operator intervenes.

If at any time the services assigned are more than what the terminal can process, the terminal may identify to the operator all assigned services and may provide the means for the operator to select which should be processed. Terminal specifications should define the detail requirements of the operator-terminal interface.

c. The terminal shall automatically request tear down of any point-to-point service it will not process.

d. The terminal shall automatically request teardown of any subnet service (for which it is identified as the source) that it will not process.

e. The terminal shall not request tear down of a subnet service (for which it is identified as a destination) that it will not process.

f. The terminal shall automatically request teardown of any service that falsely identifies it as the originator.

5.4.2.5.4 Network transition

5.4.2.5.4.1 PCC transition. Network control transition occurs when responsibility for generating the FOW transitions from one PCC to another. Control transition is indicated in either a FOW:Manual Control Transition Countdown system message (see Table 10-I in Appendix A), or by detection of a change of PCC address in subsequent FOWs. Upon detecting a control transition, the terminal can expect to receive a FOW:Participant Status Data Base message that reports the terminal's status being held at the new PCC. If the message is not received, the terminal shall consider that it is logged out and the terminal specification should define what action the terminal and the operator should take. If a FOW:Participant Status Data Base message that reports the terminal's status is received, and the number of indicated services (either active or queued) does not agree with the number in the terminal's data base, the terminal shall send a service request message to the PCC for each service that should be active or queued.

5.4.2.5.4.2 Channel transition. When a FOW system message indicates a dedicated channel mode countdown is in progress, the terminal shall follow the FOW system message countdown and shall cease DAMA operations in the frame identified by the countdown message (see Table 10-I in Appendix A). The terminal specifications shall define the detail requirements of the operator notification.

5.4.2.5.5 Status report. Terminals shall respond to a FOW:Report Status message from the PCC by transmitting a ROW:Status Report message in the assigned ROW time-slot. If the PCC does not receive a response for four consecutive requests, the terminal is automatically logged out. The PCC does not request status reports from terminals that are logged in as silent terminals.

5.4.2.5.6 TDMA service teardown. Only the PCC issues service teardowns.

5.4.2.5.6.1 Service teardown request. Terminals may request a service teardown under the conditions specified in 5.4.2.5.6.1.1 through 5.4.2.5.6.1.2.2.

5.4.2.5.6.1.1 Circuit service

5.4.2.5.6.1.1.1 Active circuit service. Any terminal participating in an active circuit service may request service teardown while the service is active (after the PCC has made a communications time-slot assignment).

5.4.2.5.6.1.1.2 Queued circuit service. The terminal shall not request teardown of a queued circuit service that it did not originate.

5.4.2.5.6.1.2 Message service

5.4.2.5.6.1.2.1 Active message service. The terminal shall not request teardown of an active message service that it did not originate.

5.4.2.5.6.1.2.2 Queued message service. The terminal shall not request teardown of a queued message service that it did not originate.

5.4.2.5.6.2 Service teardown protocol

5.4.2.5.6.2.1 Circuit service

5.4.2.5.6.2.1.1 Active circuit service. The terminal (either source or destination) requesting the service teardown shall transmit a preamble, an SOM sequence, and an end-of-service burst type in each assigned communications time-slot. The PCC should respond with a FOW:Circuit Teardown message. The terminal shall transmit a ROW:Circuit Teardown message in the contention portion of the ROW if, after the fourth frame following the time the teardown request is originated, the response has not been received. The terminal shall continue to transmit the preamble, SOM sequence, and end-of-service burst type field in each assigned communications time-slot until a FOW:Circuit Teardown message is received.

5.4.2.5.6.2.1.2 Queued circuit service. The source terminal requesting teardown shall transmit a ROW:Circuit Teardown message. The PCC responds with a FOW:Circuit Teardown message. The terminal shall assume the service has been torn down if it receives no response to the request.

5.4.2.5.6.2.2 Message service

5.4.2.5.6.2.2.1 Active message service. The source terminal shall transmit a preamble, a SOM sequence, and an end-of-service burst type in each assigned communications time-slot. The PCC should respond with a FOW:Message Teardown message. The terminal shall transmit a ROW:Message Teardown message in the contention portion of the ROW if, after the fourth frame following the time the teardown request is originated, the response has not been received. The terminal shall continue to transmit the preamble, SOM sequence, and end-of-service burst type field in each assigned communications time-slot until a FOW:Message Teardown message is received.

5.4.2.5.6.2.2.2 Queued message service. The source terminal requesting teardown shall transmit a ROW:Message Teardown message. The PCC responds with a FOW:Message Teardown message. The terminal shall assume service has been torn down if it receives no response to the request.

5.4.3 Error control

5.4.3.1 Error detection. Two CRC code lengths shall be used for error detection. A long code (16 bits) shall be used on the FOW transmissions, on message service data blocks, and as a check of guard-list consistency. A short code (8 bits) shall be used on the ROW message and ROW ranging transmissions. Only bursts received correctly, as determined by the CRC, shall be used by the terminal for FOW transmissions and ROW ranging transmissions. For point-to-point message services for which the PCC no longer commands block acknowledgements, and for subnet message services, the message data will be output to the terminal's I/O device whether or not the CRC calculations are valid. The generator polynomials for the long and short codes, respectively, shall be as given below.

Generator polynomial 16-bit CRC:

$$G(x) = x^{16} + x^{12} + x^{5} + 1$$

Generator polynomial 8-bit CRC:

$$G(x) = x^{8} + x^{7} + x^{6} + x^{3} + 1$$

The transmitted CRC is the remainder after an integer divide of the generator polynomial *G(x)* into the data polynomial *D(x)* for which the error detection code is to be generated. The data polynomial is

$$D(x) = a_m x^m + a_{m-1} x^{m-1} + ... + a_1 x^1 + a_0$$

where

m+1	=	the number of bits over which the CRC is computed
$a_m, a_{m-1}, ..., a_1, a_0$	=	the bits for which the CRC is computed, a_m is the most significant bit
x	=	2

a. If the number of bits in the orderwire is not an integer number of bytes (8 bits) in length, the orderwire is extended with zero fill after the last bit to be transmitted to result in an integer number of bytes, but the zeros are not transmitted. The CRC is transmitted MSB first.

b. For the check of guard-list consistency, a_m is the MSB of the terminal node address, a_{m-15} is the least significant bit (LSB) of the terminal node address, a_{m-16} is the MSB for the first address in the guard list, and so on. All address fields of the 15-address guard list for which there is no guarded address shall be zero filled for the CRC calculation, and the CRC is computed over a 256-bit data field. All zero fill shall occur at the end of the valid guard list addresses.

5.4.3.2 Error correction encoding/decoding. Forward error correction (FEC) encoding shall be performed using a rate 1/2, constraint length seven convolutional code (see Figure 10). The code tap positions are given below, and are also shown in Figure 10. The encoder is initially loaded with all zeros. When the first data bit is shifted into the encoder, the encoder outputs *P1* and *P2* will provide the first and second bits to be transmitted, respectively. A new data bit is then shifted into the encoder (left-most position in Figure 10), and one bit (right-most position in Figure 10) is shifted out of the encoder. The encoder outputs *P1* and *P2* then provide the next two bits to be transmitted (in the order *P1* followed by *P2*). The

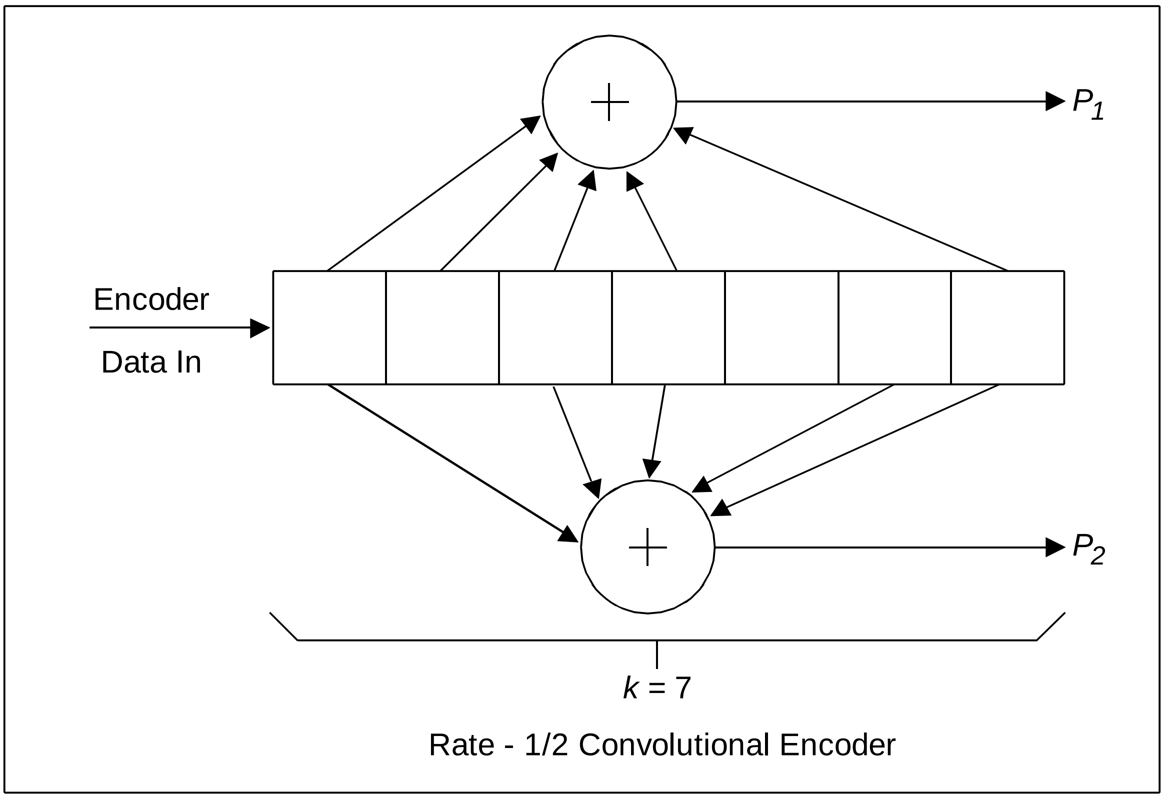


FIGURE 10. Rate - 1/2 convolutional encoder.

process of shifting data into the encoder and taking data from encoder outputs *P1* and *P2* then continues. Following the last data bit, six zeros (the Flush Bit field) are shifted into the encoder to produce the last twelve encoded bits.

P1 taps: 1111001
P2 taps: 1011011

5.4.3.3 Interleaving/deinterleaving. The block interleaving structure shall consist of two independently constructed blocks of 112 code bits used in sequence. Tables XVI and XVII define the order of the output (interleaved) bits. The interleaving process shall be equivalent to writing input bits into the 112-bit blocks sequentially and read out in the sequence dictated by the tables. Deinterleaving shall reverse this operation.

Interleaver boundaries shall start at the beginning of the data field within each burst for circuit services (see Figure 5); they shall start at the beginning of the data block within each packet for message service (see Figure 6); with the first interleaved bit of the burst in the first position defined by the block of Table XVI. Note: Each circuit service burst or message service packet contains an even integer number of interleaver blocks.

5.4.4 Modulation requirements

5.4.4.1 Modulation formats. The modulation for all transmissions shall be interoperable with shaped offset quadrature phase-shift keying (SOQPSK). The modulation used shall have spectral containment equal to or better than constant envelope SOQPSK. The ideal SOQPSK signal can be represented as

$$s(t) = A \sin[w_o t + \phi(t)]$$

$$= \frac{A}{\sqrt{2}}\, a_i(t) \cos\left(w_o t + \frac{\pi}{4}\right) + \frac{A}{\sqrt{2}}\, a_q\left(t - \frac{T}{2}\right) \sin\left(w_o t + \frac{\pi}{4}\right)$$

where

the steady-state values of $\Phi(t) = 0$, $\pi/2$, π, and $3\pi/2$,

and where

$a_i(t)$ = in-phase data modulation signal, with shaping, as shown by example in Figure 11

$a_q(t)$ = quadrature data modulation signal, with shaping, as shown by example in Figure 11

T = symbol period (reciprocal of the modulation rate)

TABLE XVI. Interleaver sequence--block 1.

ADDRESS	DATA	ADDRESS	DATA	ADDRESS	DATA	ADDRESS	DATA
0	19	28	22	56	4	84	69
1	61	29	85	57	60	85	84
2	86	30	32	58	108	86	13
3	49	31	106	59	68	87	43
4	94	32	73	60	44	88	93
5	25	33	23	61	52	89	103
6	87	34	3	62	2	90	77
7	34	35	88	63	110	91	64
8	9	36	96	64	72	92	15
9	50	37	28	65	10	93	24
10	107	38	79	66	35	94	89
11	99	39	41	67	53	95	75
12	8	40	59	68	97	96	33
13	40	41	11	69	62	97	47
14	111	42	70	70	0	98	5
15	74	43	42	71	81	99	95
16	65	44	21	72	12	100	57
17	45	45	29	73	109	101	46
18	14	46	1	74	91	102	7
19	83	47	101	75	20	103	82
20	30	48	90	76	51	104	56
21	48	49	16	77	6	105	38
22	58	50	80	78	37	106	102
23	100	51	54	79	63	107	76
24	26	52	67	80	78	108	66
25	39	53	27	81	55	109	17
26	71	54	105	82	18	110	36
27	104	55	92	83	31	111	98

TABLE XVII. Interleaver sequence--block 2.

ADDRESS	DATA	ADDRESS	DATA	ADDRESS	DATA	ADDRESS	DATA
112	116	140	203	168	131	196	195
113	140	141	137	169	166	197	215
114	193	142	129	170	177	198	125
115	156	143	180	171	123	199	164
116	214	144	219	172	223	200	112
117	171	145	209	173	208	201	172
118	205	146	190	174	144	202	220
119	113	147	160	175	114	203	206
120	181	148	198	176	122	204	158
121	128	149	118	177	134	205	192
122	221	150	212	178	162	206	174
123	211	151	141	179	154	207	145
124	120	152	173	180	202	208	153
125	196	153	161	181	191	209	216
126	147	154	204	182	218	210	207
127	182	155	126	183	124	211	127
128	139	156	143	184	136	212	184
129	115	157	217	185	178	213	175
130	152	158	167	186	151	214	142
131	165	159	157	187	119	215	121
132	187	160	133	188	138	216	200
133	176	161	148	189	130	217	168
134	201	162	213	190	170	218	183
135	210	163	197	191	155	219	149
136	150	164	169	192	194	220	199
137	132	165	222	193	135	221	163
138	189	166	188	194	185	222	186
139	179	167	146	195	159	223	117

Below, in a through d, is an explanation of how this SOQPSK signal expression relates to the I and Q channels, I/O data rates, spectral shaping, and Figure 11:

a. By definition, the QPSK modulated radio frequency (rf) signal contains two transmit data bits per symbol. Therefore, the modulation rate, in symbols per second (sps), is one-half the transmit data rate in bps. The transmit data rate does not necessarily equal the terminal's baseband [input/output (I/O)] data rate. Transmit data bits consist of all user data; extra bits introduced by forward error correction (FEC) coding; and all overhead introduced by the terminal, including preamble field bits, start-of-message (SOM) field bits, burst-type field bits, and other bits defined in this MIL-STD. The transmit data is divided into the two modulation bit sequences $a_i(t)$ and $a_q(t)$. If the sequence of bits to be transmitted consists of bits numbered 1, 2, 3, ... then $a_i(t)$ consists of all odd-numbered bits and $a_q(t)$ all even-numbered bits of the transmit data (the bit sequence for each of the modulation signals, $a_i(t)$ and $a_q(t)$, is every other transmit data bit) as shown in Figure 11. Data buffering is used to accommodate I/O data rate and modulation rate inequalities.

b. In the equation, this representation of the signals, +1 for $a_i(t)$ or $a_q(t)$ corresponds to a bit value of 1, and -1 corresponds to a bit value of 0. At the start of a transmission, while the first bit on the I channel is being transmitted, a bit value of 1 is transmitted on the Q channel during the first quarter of a symbol period. At the end of any transmission, while the last data bit is being transmitted on either the I or Q channel, during the last half-symbol period, the bit level most recently transmitted on the other channel continues to be transmitted with no change.

c. The spectral shaping used during modulation, including additive noise, shall introduce no greater than a 1.0 dB degradation in a receiver's performance, if the receiver uses matched-filter demodulation and expects the incoming signal to have 50 percent sinusoidally shaped modulation, as illustrated in Figure 11. Note that the shaping referred to as 50 percent sinusoidally shaped modulation spreads each phase transition over a total time interval of $T/2$, as shown in Figure 11.

d. For 3.0 ksps the sinusoidal transitions on $a_i(t)$ and $a_q(t)$ result in a linear rate of change for phase, and a constant-amplitude transmitted signal. Figure 11 shows the Q channel offset (staggered) relative to the I channel by one-half of a symbol. At a time 75 percent through a symbol period, on either the I or Q channel, prior to a change in the modulation data bit, the signal begins a sinusoidal transition toward the value corresponding to the next modulation data bit. The signal reaches the new value at a time 25 percent into the next symbol period. For lower symbol rates shaping may be reduced to minimize the degradation of the receiver performance.

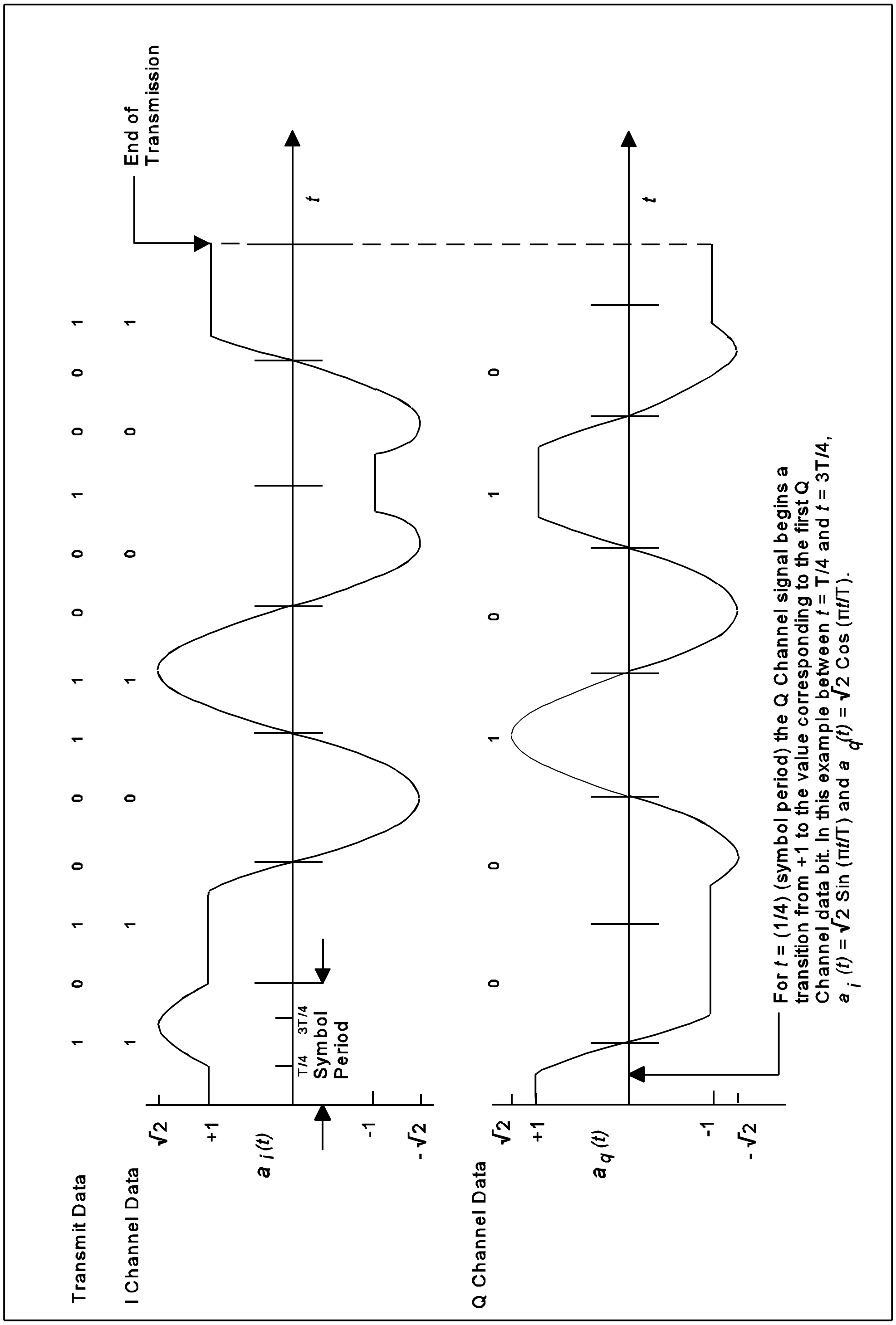


FIGURE 11. Example input to the modulator.

5.4.4.2 Modulation rates. The modulation rates shall be 600, 800, 1200, 2400, and 3000 sps, as specified in Table III.

5.4.4.3 Adjacent channel emissions. In a nominal 5-kHz bandwidth whose center frequency is displaced by Δf from a terminal transmitter's carrier frequency, the EIRP shall be as specified in Table XVIII.

TABLE XVIII. Allowable adjacent channel emissions, narrowband.

Δf (kHz)	Relative EIRP (dBW) (Carrier level < +18 dBW)	Maximum EIRP (dBW) (Carrier level $\geq$ +18 dBW)
	3.0 ksps SOQPSK	3.0 ksps SOQPSK
5	-16	+2
10	-34	-16
15	-38	-20
20	-47	-29
25	-47	-29
$\geq$30	-50	-32

5.5 Security characteristics

5.5.1 Orderwire encryption/decryption. The protection of orderwire messages during transmission is referred to herein as transmission security (TRANSEC). All orderwires shall be encrypted for normal transmission, however an orderwire encryption/decryption bypass shall be provided. Orderwire encryption/decryption shall be performed using the COMSEC/TRANSEC Integrated Circuit (CTIC) or an alternate NSA-approved device that is cryptographically and functionally compatible with the CTIC implementing KGV-11 as specified in NSA specifications 88-4A and 87-1. Hardware implementation of the terminal shall include provisions for future implementation of Over the Air Rekeying (OTAR) for the orderwire. Inputs to the TRANSEC encryption/decryption process shall be a cryptographic key and an initialization vector called the Time Slot Number (TSN).

5.5.1.1 TRANSEC key selection. The terminal shall have storage for up to eight TRANSEC keys. Each TRANSEC key shall be loaded into a specific location in the terminal's key storage memory, numbered from 0 to 7. The network administrator will determine how many TRANSEC keys will be used in the local network and into which storage location each key will be loaded.

A TRANSEC key will be used for a cryptographic period limited by the 20-bit frame number and by the network administrator. Upon expiration of the cryptographic period, the PCC will command a rollover to another TRANSEC key, identified by storage location number. The rollover sequence will begin with the transmission of the system FOW:Next Key Indicator message in four successive frames. This will be followed by the system FOW:Time Slot Change Countdown message, announcing the rollover in the next four frames. The new TRANSEC key takes effect in the frame after the fourth FOW:Time Slot Change Countdown message.

When a terminal enters the network, it shall try all loaded TRANSEC keys until it correctly decrypts the FOW (determined by a correct CRC). If the terminal enters the network during the Time Slot Countdown, it will have missed the Next Key Indicator and shall determine the next key using the trial process for all stored TRANSEC keys (until obtaining the correct CRC).

5.5.1.2 Time Slot Number definition. A 39-bit TSN shall be used as the cryptographic initialization vector for the CTIC. This TSN shall have four fields, as shown in Figure 12 and as described below.

a. Net Number field. This is a 7-bit field and contains the number of the DAMA network which the terminal communicates within. The Net number shall be 127 (1111111).

b. Frame Number field. This field contains the 20-bit frame number transmitted in the FOW by the PCC.

c. Frame Offset field. This 10-bit field indicates the number of the first building block in the time slot in which the message is transmitted. It shall be coded from 0 through 1023 for the first through one thousand twenty fourth building block in the frame. The Frame Offset field shall be zero for the FOW.

d. Operation Allowance field. This is a 2-bit field. This field shall start at a value of zero for all encryptions and decryptions. This field allows for various hardware implementations of the security requirements and is required for the CTIC implementation.

The TSN for encryption of the orderwire shall be generated using the Frame Number and Frame Offset of the time slot within which the orderwire is transmitted. The TSN for decryption of the orderwires shall be generated using the Frame Number and Frame Offset of the time slot within which the orderwire was received.

5.5.1.3 Encryption of the FOW. The sequence of events used to encrypt FOW data is as follows:

a. The primary channel controller (PCC) builds the FOW using the PCC Address, Length of Next FOW, number of Contention Ranging Slots, System Message, Length of this FOW, and Directed Messages.

b. The generation of the CRC is now completed and the CRC shall be added to the end of the already built FOW.

c. The CTIC is initialized to operate in Mode B Encrypt Common Initialization, using the TSN as defined in 5.5.1.

d. The FOW is encrypted beginning with the MSB of the PCC address and ending with the LSB of the CRC.

e. The Frame Number field (20 bits) is added to the beginning of the existing FOW.

f. The resulting FOW is now error correction encoded.

g. The 600 sps preamble, Start-of-message indicator, and Burst Type fields are added to the beginning of the FOW. The FOW is now complete and agrees with Figure 2 and is ready for transmission.

5.5.1.4 Decryption of the FOW. The sequence of events used to decrypt FOW data is as follows:

a. The 600 sps preamble, Start-of-message indicator, and Burst Type fields are used for acquisition and are not used for further processing.

b. The remaining FOW data shall be error correction decoded.

c. The Frame Number field is used in building the TSN for CTIC initialization.

d. The CTIC shall be initialized to operate in Mode B Decrypt Common Synchronization, using the TSN as defined in 5.5.1.

e. The FOW shall be decrypted beginning with the MSB of the PCC address and ending with the LSB of the CRC.

f. A CRC shall be computed on the decryupted data and compared with the CRC field (see 5.4.3.1).

g. The FOW now consists of the PCC Address, Length of Next FOW, number of Contention Ranging Slots, System Message, Length of this FOW, and Directed Message fields.

5.5.1.5 Encryption of the ROW. The sequence of events used to encrypt ROW data is as follows:

a. The net member builds the ROW using the Node Address and ROW Message. For a ranging ROW there is not a ROW message.

b. The generation of the CRC shall now be completed and the CRC shall be added to the end of the already built ROW.

c. The CTIC shall be initialized to operate in Mode B Encrypt Common Initialization, using the TSN as defined in 5.5.1.

d. The ROW shall be encrypted beginning with the MSB of the Node Address and ending with the LSB of the CRC.

e. The resulting ROW shall now be error correction encoded (see 5.4.3.2).

f. The preamble, Start-of-message indicator, and Burst Type fields shall be added to the beginning of the ROW. The ROW is now complete and agrees with Figure 3 or 4 and is ready for transmission.

5.5.1.6 Decryption of the ROW. The sequence of events used to decrypt ROW data for use by a terminal is as follows:

a. The preamble, Start-of-message indicator, and Burst Type fields are used for acquisition and are not used for further processing.

b. The remaining ROW data is now error correction decoded.

c. The CTIC is initialized to operate in Mode B Decrypt Common Synchronization, using the TSN as defined in 5.5.1.

d. The ROW is decrypted beginning with the MSB of the Node Address and ending with the LSB of the CRC.

e. A CRC is computed on the decrypted data and compared with the CRC field (see 5.4.3.1).

f. The ROW now consists of Node Address and ROW Message fields. For a ranging ROW there is no ROW Message field.

5.5.2 User data encryption/decryption. The protection of user data during transmission is referred to herein as communications security (COMSEC). Classified information will be encrypted for transmission. Unclassified information may be transmitted as ciphertext or plaintext. The terminal originating a service request shall indicate whether or not the user data is to be encrypted. The NCS will include the requestor-specified encryption indication in service assignments. Terminals shall transmit user data in plaintext only if authorized by the terminal operator.

5.5.2.1 Voice security. For joint operations, secure voice at 2400 bps shall be interoperable with the digitization and encryption techniques used in the Advanced Narrowband Digital Voice Terminal (ANDVT), application 3 (see MIL-C-28883A).

5.5.2.2 Data security. For joint operations, data encryption shall be interoperable with KYV-5 and KG-84A encryption devices. Terminals that embed COMSEC devices shall support all data rates specified in this MIL-STD for communication over the DAMA channel.

5.6 Multiple channel network operations. Multiple channel (Multi-channel) network operations shall take place on the channels listed in Appendix D. Multi-channel operations will include a number of TDMA channels and a number of dedicated channels assigned and controlled by a single PCC. Terminals may request dedicated channel operations by the ROW:Circuit Service Request message. Requests are for a 5- or 25-kHz channel and a period of time up to 5115 minutes. Only terminals which are capable of changing from TDMA to dedicated channel operations within one frame (8.96 sec), from TDMA operations on one channel (5- or 25-kHz) to TDMA operations on another channel (5- or 25-kHz) within 90 seconds, and from dedicated to TDMA channel operations within 90 seconds will be allowed to participate in Multi-channel operations. Those terminals that are not "automatic frequency change" capable shall indicate this in the ROW:Login message when they log into a network, and will not be commanded to change channels via the FOW:Terminal Channel Assignment message.

5.6.1 Channel reassignment (TDMA). While operating on a TDMA channel, the terminal shall change to a new channel only when directed to by the PCC. The direction to change channels shall be by the FOW:Terminal Channel Assignment message. The terminal shall change to the channel identified in the message. If the

Channel Type field is a zero, the channel operates in the DAMA mode and the terminal can assume that the new channel operates via the same satellite. The terminal shall determine, based on the Channel field and Appendix D, whether the assigned channel is 5- or 25-kHz. If the channel is a 5-kHz, the DAMA Waveform shall be in accordance with this document (MIL-STD-188-182). If the assigned channel is 25-kHz, the DAMA Waveform shall be in accordance with MIL-STD-188-183. The terminal shall achieve downlink and uplink synchronization in the new channel. If the terminal cannot achieve downlink and uplink synchronization on the assigned channel within 90 seconds, the terminal shall return to the previous channel of operation. If the terminal is switching from a 5-kHz DAMA channel to another 5-kHz DAMA channel, then the terminal shall retain all pending service requests it held in queue and shall not send a ROW:Login message on the new channel. If the terminal is switching from a 5-kHz DAMA channel to a 25-kHz DAMA channel, then the terminal shall clear (i.e., delete) all pending service requests that it previously held in queue. After a terminal is reassigned to a new TDMA channel (5- or 25-kHz), it shall not return to the previous channel or change to any other channel unless directed to by the PCC.

5.6.2 Timed channel assignment (dedicated). While operating on a TDMA channel, the terminal shall change to a new channel only when directed to by the PCC. The direction to change channels shall be by the FOW:Terminal Channel Assignment message. The terminal shall change to the channel identified in the message. If the Channel Type field is a one, the channel operates in the dedicated mode. The terminal shall determine, based on the Channel field and Appendix D, whether the assigned channel is 5- or 25-kHz. The channel shall be in accordance with MIL-STD-188-181. The use of this channel shall be in accordance with 5.4.2.4.2.

6. NOTES

6.1 Communication Scenarios. The following communications scenarios can take place using the equipment in global locations as shown in Figure 13, with all terminals and CC's logged-in and connected:

1. Message service from T1 to T2

2. Message service from T1 to Subnet T2-T6

3. Half duplex circuit service from T1 to T2

4. Half duplex Multiple-hop circuit service from T1 to T3

The scenarios and equipment locations were chosen to demonstrate the interaction of the largest number of FOWs and ROWs possible. If PCC2 and ACC2 were to swap locations, the number of FOWs and ROWs would change. If multiple-hop communications would be required to pass through more than just two satellites, then the quantity of FOWs and ROWs would go up proportionally.

1. Message service from T1 to T2

    a. T1-PCC1 ROW:Message Setup (contention)

    b. PCC1-T1 FOW:Message Setup Response

    c. PCC1-T1&T2 FOW:Message Assignment (assigns communications time-slots)

    d. T1-T2 message packets transmitted

    c. & d. repeated as often as necessary

    e. PCC1-T2 FOW:Acknowledge Blocks (assigns ROW time-slot)

    f. T2-PCC1 ROW:Block Acknowledgement (not all packets acknowledged)

    g. PCC1-T1&T2 FOW:Message Assignment (assigns communication time-slots)

    h. T1-T2 data blocks not acknowledged are transmitted

    i. PCC1-T2 FOW:Acknowledge Blocks (assigns ROW time-slot)

j. T2-PCC1 ROW:Block Acknowledgment (all packets acknowledged)

Insert Figure 13

k.	PCC1-T2	FOW:Acknowledge Message (assigns ROW time-slot)
l.	T2-PCC1	ROW:Message Acknowledge
m.	PCC1-T1	FOW:Message Acknowledgement

2. Message service from T1 to Subnet T2-T6

a.	T1-PCC1	ROW:Message Setup (contention)
b.	PCC1-T1	FOW:Message Setup Response
c.	PCC1-T1&Subnet	FOW:Message Assignment (assigns communication time-slots)
d.	T1-Subnet	data blocks transmitted
	c. & d. repeated as often as necessary	
e.	PCC1-T1&Subnet	FOW:Message Teardown

3. Half duplex circuit service from T1 to T2

a.	T1-PCC1	ROW:Circuit Setup (contention)
b.	PCC1-T1	FOW:Circuit Setup Response
c.	PCC1-T1&T2	FOW:Circuit Assignment (assigns communication time-slots)
d.	T1-T2 or T2-T1	communication bursts transmitted
	c. & d. repeated as often as necessary	
e.	T1-PCC1 or T2-PCC1	Start to transmit End-of-service burst type
f.	PCC1-T1&T2	FOW:Circuit Teardown
	If the preceeding FOW is not heard then the following steps are taken	
g.	T1-PCC1 or T2-PCC1	ROW:Circuit Teardown (contention)
h.	PCC1-T1&T2	FOW:Circuit Teardown

For a full duplex communications service two communications time slots would be assigned using separate FOW directed messages in step c. Then in step d above, "T1-T2 or T2-T1" becomes "T1-T2 and T2-T1".

4. Half duplex Multiple-hop circuit service from T1 to T3

a. T1-PCC1 ROW:Circuit Setup (contention)

b. PCC1-T1 FOW:Circuit Setup Response

c. PCC1-ACC1 FOW:Relay Ringup (assigns ROW time-slot)

d. ACC1-PCC1 ROW:Relay Ringup Response

e. ACC2-PCC2 ROW:Relay Ringup (contention)

f. PCC2-ACC2 FOW:Relay Ringup Response

g. PCC2-ACC2 FOW:Relay Select

h. ACC1-PCC1 ROW:Relay Select Response (contention)

i. PCC1-ACC1 FOW:Relay Select Response

j. PCC2-ACC2&T3 FOW:Multiple-Hop Circuit Assignment

k. ACC2-T3 communication bursts transmitted

(typically no bursts are transmitted prior to event "o" below because the destination normally only responds to the source after the source transmits some data)

j. & k. repeated as often as necessary

l. ACC1-PCC1 ROW:Multiple-Hop Begin Assignments (contention)

m. PCC1-ACC1 FOW:Multiple-Hop Begin Assignments response

n. PCC1-T1 & ACC1 FOW:Mutilple-Hop Begin Assignments Response

o. T1-ACC1 communication bursts transmitted

n. & o. repeated as often as necessary

PCC2 preempts communications

p.	ACC1-PCC1	ROW:Multiple-Hop Circuit Preemption (contention)
q.	PCC1-ACC1	FOW:Multiple-Hop Circuit Preemption Response

PCC1 preempts communication

PCC2 resumes communication by

r.	PCC2-T3&ACC2	FOW:Multiple-Hop Circuit Assignments
s.	ACC2-T3	communication bursts transmitted

r. & s. repeated as often as necessary

t.	ACC1-PCC1	ROW:Multiple-Hop Circuit Resumption (contention)
u.	PCC1-T1&ACC1	FOW:Multiple-Hop Circuit Assignment
v.	T1-ACC1	communication bursts transmitted

u. & v. repeated as often necessary

w.	T1-ACC1	End-of-service burst type starts to be transmitted
x.	T1-PCC1	ROW:Circuit Teardown (contention)
y.	PCC1-T1&ACC1	FOW:Multiple-Hop Circuit Teardown
z.	ACC1-PCC1	ROW:Multiple-Hop Circuit Teardown response
aa.	ACC2-PCC2	ROW:Multiple-Hop Circuit Teardown (contention)
bb.	PCC2-T3&ACC2	FOW:Multiple-Hop Circuit Teardown

If full-duplex communications are supportable by each terminal, then two communication time-slots would be assigned (two different FOWS) in steps j., n., r., and u.

6.2 Communications time-slot assignment example. Terminals request assignments to the communications portion of the frame by sending ROW messages to the PCC. The PCC assigns communications slots to terminals using FOW messages. The following example demonstrates this assignment process and shows how FOW messages are used to assign communications slots.

EXAMPLE: Assume that four terminals (Terminal A, Terminal B, Terminal C, and Terminal D) have gained access to the network. the following services are required:

Terminal A:	A half-duplex, data circuit service with an I/O data rate of 300 bps
Terminal B:	A message service
Terminal C:	A message service
Terminal D:	A message service

Each terminal sends a ROW message to the PCC requesting these services. Terminal A sends a ROW:Circuit Setup message while Terminals B-D send ROW:Message Setup messages. We will assume that the PCC receives each request without difficulty and processes each request. It responds with the FOW communications assignment messages in Figure 14.

STEP 1: Determine the communications time-slot length that the PCC has assigned to each service.

The four FOW messages each assign a separate time-slot in the communications portion of the frame. Each FOW must be parsed by each of the terminals in order to determine the total number of building blocks allocated for the communications portion of the frame. The number of building blocks assigned to each communications time-slot can be determined using the information provided in the FOW message fields and Table IV and V. In FOW #1, the message fields indicate that Terminal B will transmit three coded data blocks of information at a modulation rate of 600 sps. Referring to Table V, the time-slot size required to handle this transmission is 169 building blocks. In FOW #2, the message fields indicate that the Terminal A's service is a half-duplex data circuit with an I/O rate of 300 bps, and that the transmission will be coded and modulated at a 1200 sps rate. Referring to Table IV, the time-slot length for this transmission will be 278 building blocks. In FOW #3, the message fields indicate that Terminal C will transmit nine coded data blocks of information at a modulation rate of 2400 bps. Referring to Table V, the time-slot size required to handle this transmission is 111 building blocks. In FOW #4, the message fields indicate that Terminal D will transmit two uncoded data blocks of information at a modulation rate of 3000 sps. Referring to Table V, the time-slot size required to handle this transmission is 21 building blocks.

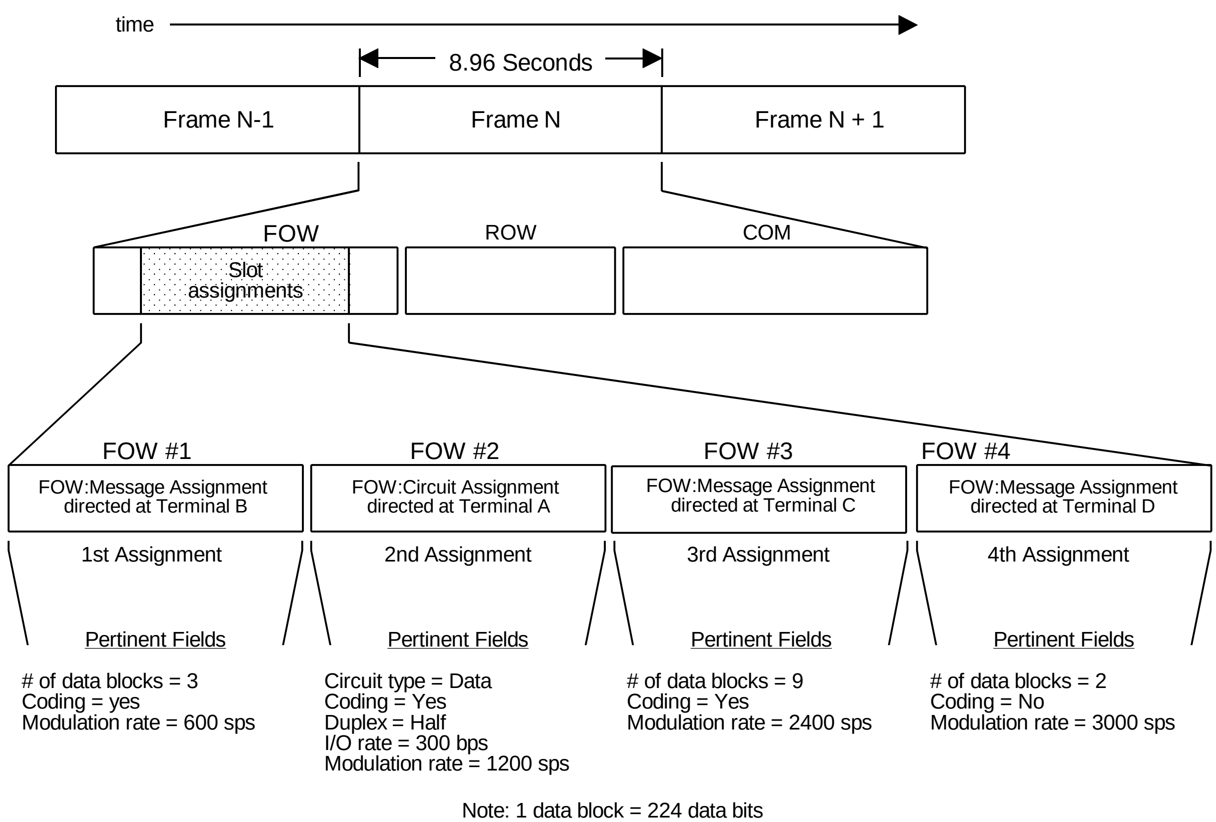


FIGURE 14. FOW communications assignment messages.

STEP 2: Determine the starting location for each communications time-slot.

The determination of the starting location for a communications time-slot is based upon the ordering of assignments in the FOW. Time-slots are assigned from the latest (last) slot to the earliest (first) slot. Thus, the service receiving the first assignment in the FOW will transmit during the last slot in the communications portion of the next frame, the second assignment in the FOW will transmit in the second-to-last slot in the next frame, and so forth.

Therefore, the starting location for each communications time-slot in our example is as shown in Figure 15.

6.3 ROW time-slot assignment example. ROW time-slots are assigned by the FOW directed messages as are the assignments of communications resources. The assigned ROW slots follow the last contention ranging slot in the ROW portion of the frame, and therefore begin with the next ROW slot in the frame (see Figure 4). The determination of the actual ROW slot assignment is based on the ordering of assignments in the FOW. ROW slots are assigned starting from the first slot following the variable number of contention ranging slots. The following example demonstrates this assignment process and shows how FOW messages are used to assign ROW slots.

EXAMPLE: Assume that the same four terminals as in section 6.2 (Terminal A, Terminal B, Terminal C, and Terminal D) are to be assigned individual ROW time-slots. The FOW messages are transmitted by the PCC as shown in Figure 16. The number of contention ranging slots are indicated in the FOW of the previous frame. In this example assume that the number of contention ranging slots is equal to one.

The "Length of the next FOW" field in our example is 134 building blocks. Assigned ROW slots follow the contention ranging slot of the ROW (which are 32 building blocks long). Therefore, the assigned ROW slots begin at building blocks 167 (135 + 32). Terminal D received the first ROW assignment. It will transmit a ROW:Message Acknowledgment message at building block 167 of the next frame in response to FOW #10. Terminal B received the second ROW assignment. It will transmit a ROW:Status Report message starting at building block 184 (167 + 17) of the next frame in response to FOW #11. Terminal C received the third ROW assignment. It will range starting at building block 201 (184 + 17)in response to FOW #12. Ranging time-slots are 32 building blocks in length. Terminal A received the fourth ROW assignment. It will transmit a ROW:Status Report message starting at building block 233 (201 + 32) in response to FOW:Report Status message.

This is summarized in Figure 17.

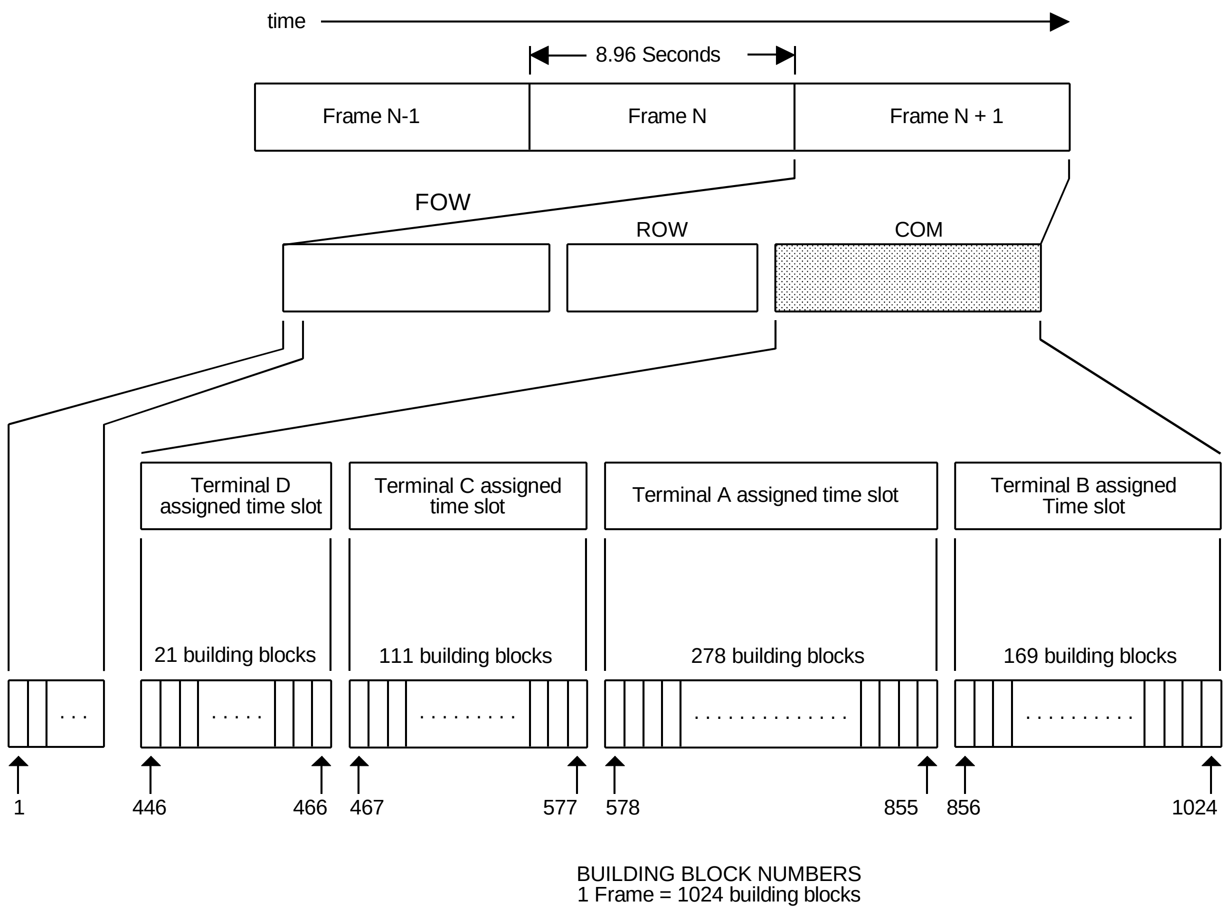


FIGURE 15. Starting location for communications time slots.

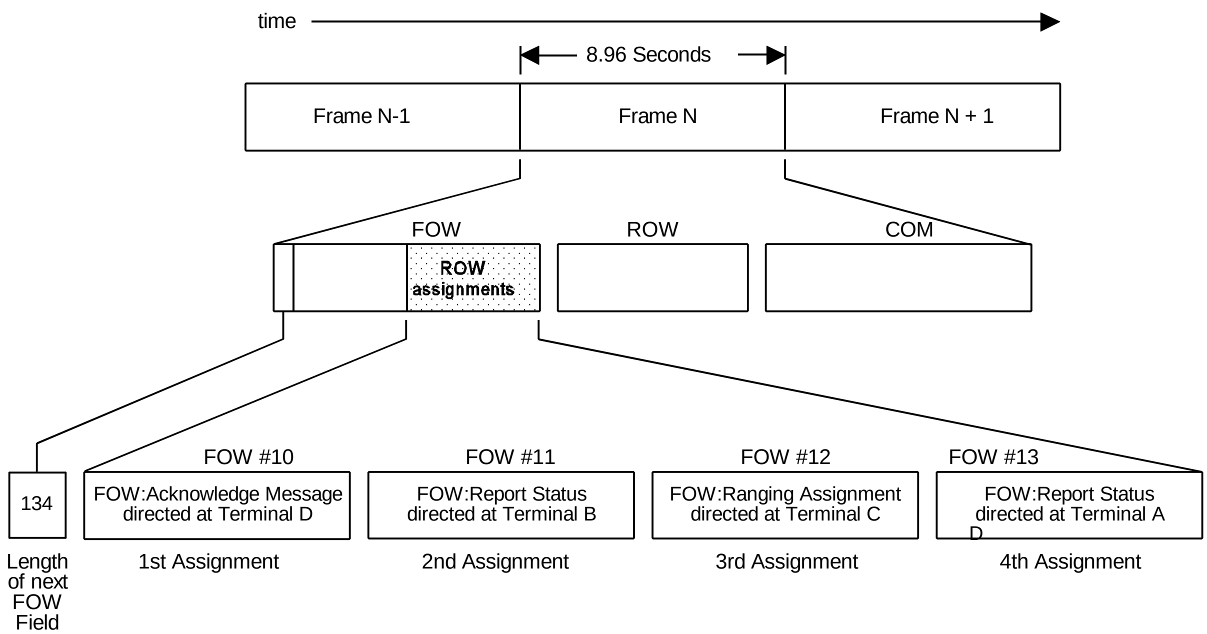


FIGURE 16. FOW messages transmitted by PCC.

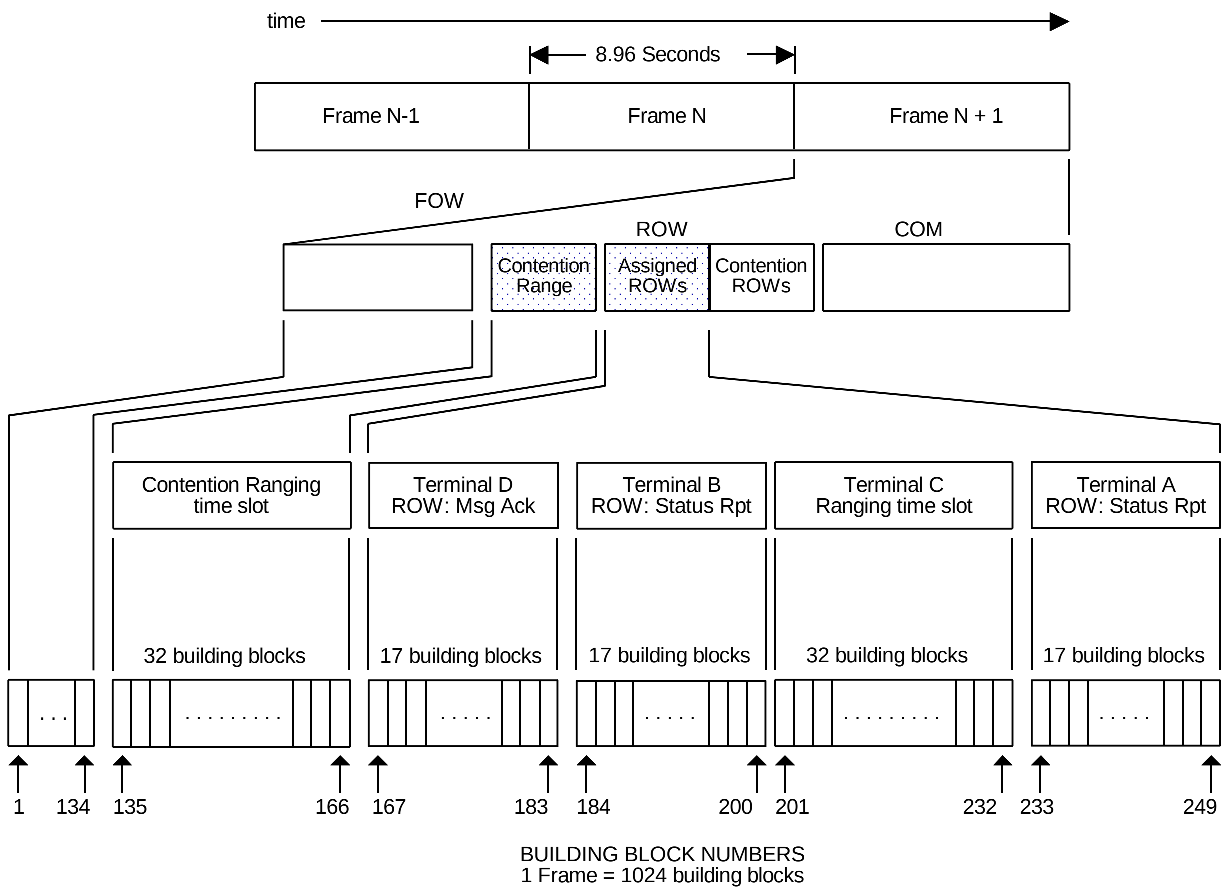


FIGURE 17. ROW slot assignments.

6.4 Contention ROW segment size determination example. Using the frame defined in 6.2 and 6.3, the number of contention ROW time-slots available can be determined by dividing the number of building blocks in the contention portion of the ROW by the number of building blocks in a contention ROW (which is 17). By knowing the number of building blocks in the FOW, contention ranging slot, assigned ROW slots, and communications slots, the number of contention ROW slots can be determined. Figure 18 illustrates the number of contention ROW time-slots that are available in our example.

As illustrated, the contention ROW slots begin at building block number 250. Eleven contention ROW slots are available each starting at 17 building block increments (for example: 250, 267, 284, 301...). Building Blocks 437 to 445 are not assigned any communication slot and are not available for contention messages in this example.

6.5 Tailoring guidance. To ensure proper application of this standard, invitations for bids, requests for proposals, and contractual statements of work should tailor the requirements in sections 4 or 5 of this standard to exclude any unnecessary requirements. For example, if the statement of work required a revision to a standard, then all the paragraphs related to handbooks, bulletins, and notices should be excluded.

6.6 Key word listing. The following key words, phrases, and acronyms apply to MIL-STD-188-182:

- demand assigned multiple access (DAMA)
- fleet satellite communications system (FSCS)
- satellite communications (SATCOM)
- time division multiple access (TDMA)
- ultra high frequency (UHF)
- 5-kHz UHF SATCOM Channels

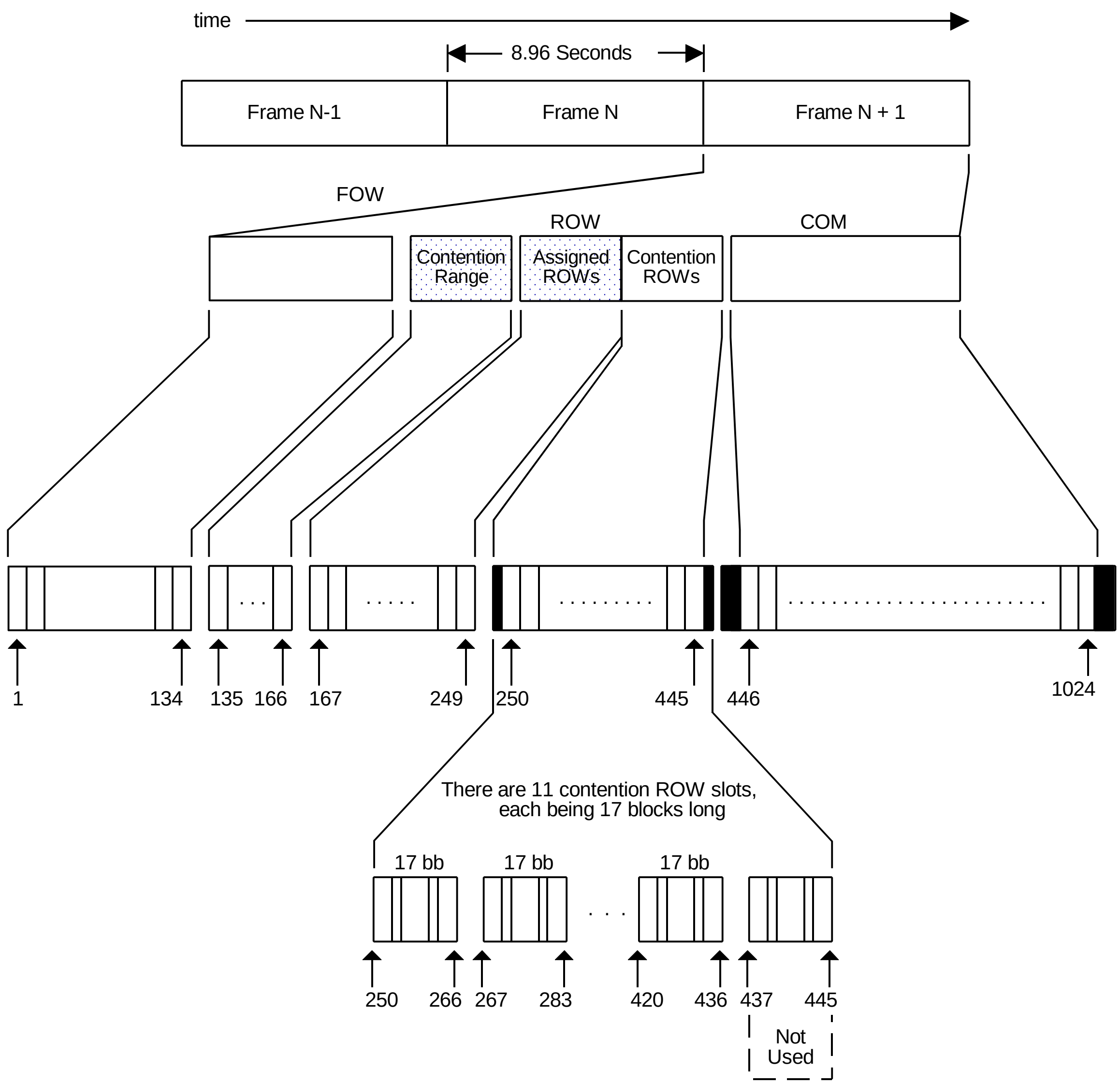


FIGURE 18. Contention ROW segment size determination.

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