NATO STANDARD

AOP-60

DESIGN REQUIREMENTS FOR INDUCTIVE SETTING OF LARGE CALIBRE GUIDED MUNITION FUZING SYSTEMS, INCLUDING COURSE CORRECTING FUZING SYSTEMS

Edition A Version 1
AUGUST 2020

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED ORDNANCE PUBLICATION

Published by the
NATO STANDARDIZATION OFFICE (NSO)

INTENTIONALLY BLANK

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

28 August 2020

1. The enclosed Allied Ordnance Publication AOP-60, Edition A, Version 1, DESIGN REQUIREMENTS FOR INDUCTIVE SETTING OF LARGE CALIBRE GUIDED MUNITION FUZING SYSTEMS, INCLUDING COURSE CORRECTING FUZING SYSTEMS, which has been approved by the nations in the CNAD AMMUNITION SAFETY GROUP (AC/326), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4593.

2. AOP-60, Edition A, Version 1, is effective upon receipt.

3. This NATO standardization document is issued by NATO. In case of reproduction, NATO is to be acknowledged. NATO does not charge any fee for its standardization documents at any stage, which are not intended to be sold. They can be retrieved from the NATO Standardization Document Database ((https://nso.nato.int/nso/) or through your national standardization authorities.

4. This publication shall be handled in accordance with C-M(2002)60.

for

Dieter Schmaglowski
Deputy Director NSO
Branch Head P&C

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

INTENTIONALLY BLANK

RESERVED FOR NATIONAL LETTER OF PROMULGATION

INTENTIONALLY BLANK

RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

INTENTIONALLY BLANK

RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

INTENTIONALLY BLANK

TABLE OF CONTENTS

INTENTIONALLY BLANK

CHAPTER 1 INTRODUCTION

1.1. AIM

The aim of this AOP is to provide information in support of STANAG 4593 in order to assist NATO nations in achieving interoperability on inductive setting of fuzes used on guided or course correcting munitions. This AOP provides the setting requirements for fuzing systems used on these types of munitions.
Standard inductively set artillery fuzing systems are excluded from this AOP and are addressed in STANAG 4369, AOP-4369 and AOP-22.

1.2. AGREEMENT

No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

1.3. JOINT BALLISTIC MEMORANDUM OF UNDERSTANDING

The Joint Ballistic Memorandum of Understanding (JBMOU) and the Joint Ballistic Working Group (JBWG) can provide the additional information to set subject fuzes in response to official National requests. The form and instructions to submit such requests is provided in Annex C.

1.4. DEFINITIONS AND ABBREVIATIONS

The definitions and abbreviations of terms used in this AOP can be found in Annex A.

INTENTIONALLY BLANK

CHAPTER 2 GENERAL

2.1. ASSUMPTIONS

2.1.1 There may be any degree of automation at the interface between the setter and the operator at the launch platform. It is assumed that there exists at the launch platform a data base containing all of the fuze-specific parameters and bit pattern requirements for setting any fuze presented to the setter for any valid fire mission. It is also assumed that, where required, access is available to a GPS receiver, launch platform data and target location information. Fuze message data requirements with some munition specific examples (XM982, i.e. Excalibur) are identified in this AOP.

2.1.2 This AOP will not provide complete details to define fuze and setter message patterns and signal levels. The Joint Ballistic Working Group (JBWG) can, at their discretion, provide additional details if a request is made using the form provided in Annex C of this standard.

2.1.3 The units used in all Figures and Annexes conform to the International System (SI) of metric units, except those specifically designated otherwise.

2.2. INTERFACE DETAILS

2.2.1. The fuze setter and the fuze shall be designed to enable close coupling between the inductive fuze and setter coil(s) for reliable data transfer.

2.2.2. Two coil locations are defined herein. The standard inductive coil uses the location and configuration as specified in Figure 1 and labeled as Fuze Setter Coil (FSC). The high data rate coil, labeled Guided Initialization Coil (GIC), also shown in Figure 1, provides an alternative inductive interface to allow for the increased data rate and power transfer required by Guided Munitions Fuzing Systems (GM) or Course Correcting Fuzing Systems (CCF). Annex B describes which coils or combination of coils are used and how.

2.2.3 The setter will be designed to inform the operator when an error is detected, or when a fuze rejects a message. Verification of the integrity of the data transmissions ensures the reliability and safety requirements are met and achieved through both:

(a) 100% read back of safety critical/related information.

(b) The use of cyclic redundancy check (CRC) to verify data is unchanged during transmission.

2.2.4 The fuze and setter will communicate with each other in accordance with the fuze-specific parameters appropriate for the fuze being set. A setter used with more than one fuze type must be able to work with each set of parameters at the appropriate time. The message sent to the fuze includes the fuze ID code, byte count (as required), and data bits to program the particular fire mission. The results of communication and verification of successful setting between the fuze and setter are available to be read by the users for visual confirmation.

2.2.5 Communication protocols are selected by the fuze developer within the constraints of Chapter 3. The fuze is required to reject a message from the setter if the message contains the wrong ID code, incorrect message length, or fails the CRC. Additional rejection criteria should be identified in the fuze specification.

2.2.6 Fuze identification may be required by weapon systems using automatic loaders. Fuze ID codes will be assigned by the Custodian in consultation with the Joint Ballistic Working Group.

2.2.7 Testing of fuze and setter will require that production equivalent inert fuzes be tested with actual production or equivalent fuze setters. Standardized fuzes and setters are not feasible at this time. It is recommended for interoperability and interchangeability that Nations on a periodic basis jointly test possible combinations of their fuzes and setters to ensure their functionality.

CHAPTER 3 REQUIREMENTS

3.1. GENERAL

3.1.1 This AOP covers those munition fuzing systems that require large amounts of data, some of which could have additional requirements such as precise time synchronisation, to be transferred. The use of existing standards, including STANAG 4369, are either not practical in operational environments (too slow) or will not satisfy the need for synchronisation.

3.1.2. The large calibre guided munitions fuzing systems and course correcting fuzing systems will be identified within the fire control system prior to setting of the fuzing system. The specific munition fuzing system requirements is referenced in Annex B.

3.1.3 This AOP only addresses the inductive setting requirements for these fuzing systems. Other design requirements are addressed in the relevant STANAGs and AOPs. These include safety related issues, such as Safe Separation, which is covered in STANAG 4187 and its associated AOP(s).

3.1.4 Details of ratification and implementation of this agreement are in STANAG 4593. For more detailed information about ratifications and reservations, please refer to NATO Standardization Document Database (NSDD).

3.2. DETAIL REQUIREMENTS

3.2.1 Two coil locations are identified in Figure 1. The first is the Fuze Setter Coil (FSC) location and configuration as specified in STANAG 4369 and may be used to transfer data for guided munition fuzing systems, in addition to satisfying the requirements for standard (non-guided) inductively set fuzes. It is not optimized for speed and efficiency in transferring power or data.
The second coil, the Guided Initialisation (or setting) Coil (GIC) provides a means for setting only guided munition fuzing systems. Most guided munition fuzing systems utilize a single coil (the GIC coil, see Figure 1) to transfer power, TMP and data between them and the setter. The setter and the GIC coils form an air core transformer, which allows for power and data transfer faster than the FSC. The configuration has toroidal type setter and fuze coils. The configuration permits data communication in both directions.

3.2.2 As an example, a configuration of setter and fuzing system coils is shown in Figure 1 below.

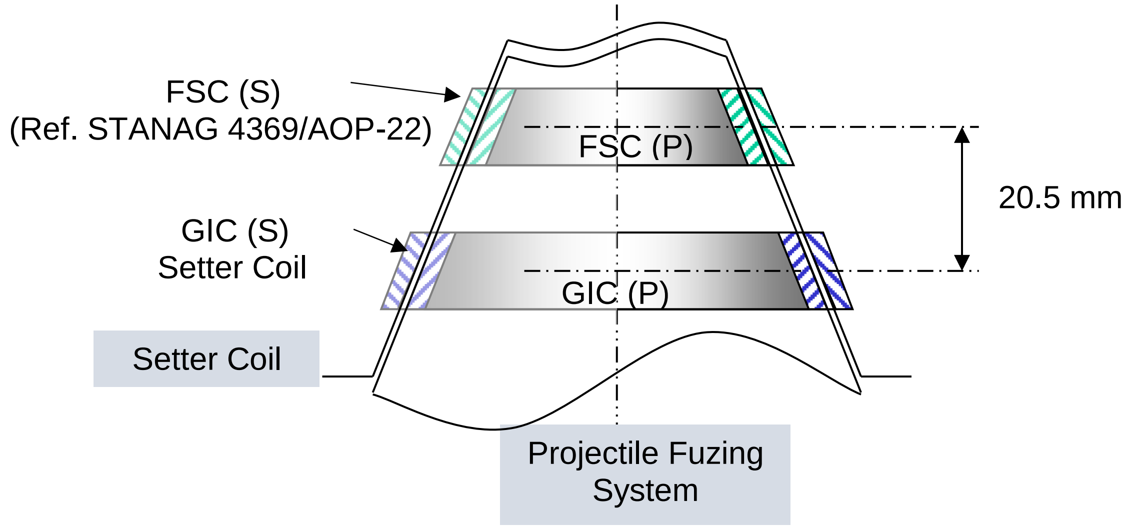

Figure 1 – Fuzing System Inductive Setting Coils

3.2.3 Annex B further defines coil locations and how the coils are used, with respect to each compliant large calibre guided munition fuzing system and course correcting fuzing system.

3.3 INDUCTIVE SETTING INTERFACE

3.3.1. The inductively coupled interface allows for the transfer of bi-directional serial data. This interface is also referred to as a data bus. The protocol is based on a Command/Response system, which removes the possibility of bus contention. The function of the Fuze Setter is to provide data flow control for all transmissions on the data bus.

3.3.2 The setting interface is also capable of transferring the following to the fuzing system:

(a) Power.
(b) Precise time by the use of a 'Time Mark' pulse.

3.4 MESSAGE OVERVIEW

3.4.1 The smallest data element transferred across the interface is a 'message'. A message contains a varying number of 16-bit words. Individual words of messages cannot be sent.

3.4.2 A 'block' is the largest data element, which contains a string of multiple messages. A block transfer may contain messages of different types. For example, a block may consist of a Target message, Gun Data message and a Meteorological Data message.

3.4.3 Every message has a message structure including a Message Header and Words associated with it as depicted in Figure 2. The Message Header consists of 2 words, placed at the beginning of every message:

(a) Message ID. Contains the unique message number (i.e. 1, 2, 3 ... 255).
(b) Message Length. Contains the number of words in that message, including the 2 words in the Message Header. The message length can be up to 65,535 (2^{16}-1) words.

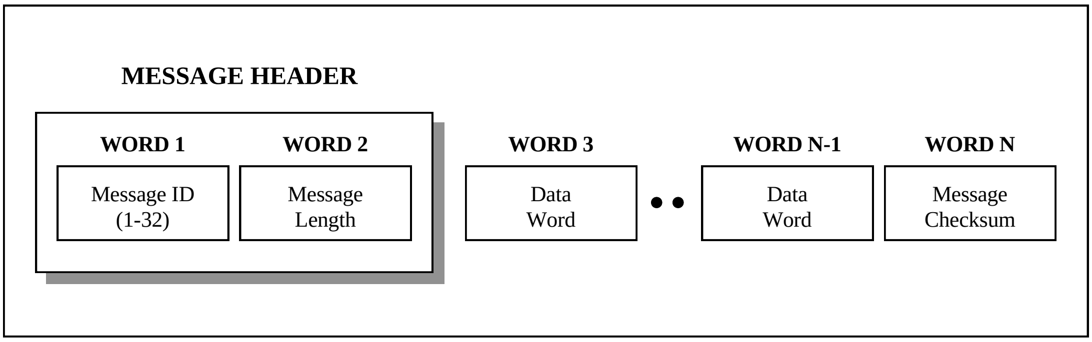

Figure 2: Message Structure

3.4.4 Guidance on message content and format for munition fuzing systems is provided in Annex B.

3.5 DATA TRANSFER VALIDATION

3.5.1 A critical function of the interface is to verify the integrity of the data transmissions in order to satisfy the reliability and safety requirements associated with data transfer. This is achieved through both:

(a) 100% read back of safety critical information.

(b) The use of checksums to verify data is unchanged during transmission.

3.5.2 Additional information is contained within AOP-60.

INTENTIONALLY BLANK

ANNEX A DEFINITIONS AND ABBREVIATIONS

A.1. DEFINITIONS

For the purposes of this AOP, the definitions, terms and acronyms herein shall apply.

a. Course Correcting Fuzing Systems (CCF)/Guided Munition Fuzing Systems (GM). Fuzes or Munitions that modify their trajectory in accordance with preprogrammed instructions (or received instructions during flight) to increase the projectile accuracy and precision beyond those of conventional ballistic rounds.

b. Command Message. Method by which access is controlled to a data bus. It is used by the Bus Controller (BC) to control the messages between devices on the bus.

c. Competent Fuze. The electronic section of a GM/CCF which has the capability to accept the power, time mark pulse, and setting data necessary to enable it to guide to target and function in accordance with the data sent to it from a Fuze Setter.

d. Inductive interface. The characteristics that control the interaction of an inductive fuze setter with an inductively settable fuze, in accordance with this AOP. A modulated magnetic field between two coils which can be used to transfer data and power; and to provide time synchronisation.

e. Ionospheric Correction. An analytical method by which the GPS derived position error caused by atmospheric effects is minimized.

f. Time Mark Message. The time mark message enables the munition clock to be synchronised with a standard clock, such as that used with GPS.

g. Time Mark Pulse (TMP). TMPs are periodic pulses that are used to synchronise and calibrate a clock. It forms part of the Time Mark Message.

h. Initialisation. When setting the fuze, the process of transferring power, data, and time mark pulses, as necessary, to prepare a guided projectile or course correcting fuze for mission execution.

i. Inductive fuze setter - A device which communicates with a fuze/fuzing system utilizing an inductive interface. It will provide the means to validate responses and confirm the fuze or guided munition fuzing system is set correctly. It may be connected to a FCS to enable automatic transfer of data between the FCS and the fuze or GM fuzing system. This is typically the configuration for initializing course correcting fuzes or guided munitions due to the large volume of data required.

A.2. ABBREVIATIONS

The following abbreviations have been used:

AWG	American Wire Gauge
BC	(Data) Bus Controller
BC	Bus Controller
CRC	Cyclic Redundancy Check
DWord	Double Word (a 32-bit word, consisting of two 16-bit words)
EPIAFS	Enhanced Portable Inductive Artillery Fuze Setter (Fuze Setter)
FCS	Fire Control System
FS	Fuze Setter
FSC (S)	Fuze Setter Coil in the Setter
FSC (P)	Fuze Setter Coil in the Projectile Fuze
GIC(S)	Guided Initialisation Coils in Setter
GIC(P)	Guided Initialisation Coils in Projectile Fuze
GM/CCF	Guided Munition Fuzing Systems / Course Correcting Fuzing Systems
GPS	Global Positioning System
ICD	Interface Control Document
LSB	Least Significant Bit
LSW	Least Significant Word
ms	milli (10^{-3}) second
MSB	Most Significant Bit
MSW	Most Significant Word
NRZ	Non-Return to Zero
NSB	Non-Significant Bit
ns	nano (10^{-9}) second
PPS	Pulses Per Second
PRN	Pseudo-Random Noise (Unique code transmitted by each GPS satellite)
RT	Remote Terminal
Rx	Receiver (GPS)
STANAG	Standardisation Agreement
SV	Satellite Vehicle
TMP	Time Mark Pulse
Tx	Transmit
U/S	Unserviceable
UTC	Universal Time Coordinated
μs	micro (10^{-6}) second

ANNEX B MESSAGING REQUIREMENTS

ANNEX B IS COMPOSED OF THREE PARTS.

Annex B.1 describes the protocols, messages, etc. required to use STANAG 4593 GIC coils only, to initialise or set a GM/CCF.

Annex B.2 describes similar requirements when utilizing STANAG 4369 FSC coils only, to initialise or set a GM/CCF. Currently only a place holder.

Annex B.3 describes similar requirements when utilizing a combination of STANAG 4593 GIC and 4369 FSC coils to initialise or set a GM/CCF. Currently only a place holder.

ANNEX B.1 – PROTOCOLS FOR USE OF STANAG 4593 SINGLE COIL

1. PURPOSE

This Annex defines the message protocols, data transfer rates, and electrical parameters to be used when initialising or setting either a Guided Munition Fuzing Systems (GM) or Course Correcting Fuzing Systems (CCF).

1.1 Section 1 provides an overview of the setting requirements for a GM/CCF.

1.2 Section 2 describes the GM/CCF protocol.

1.3 Section 3 defines the MANDATORY ‘Command’ message (ID 1) and GM/CCF Status’ message (ID 4), which are used by ALL GM/CCFs. Additional RECOMMENDED data structures for GPS aided GM/CCFs are described (e.g. GPS ephemeris data, precise time, etc.). However, the flexible protocol enables unique data structures to be defined for each munition or fuze variant.

1.4 Section 4 describes data formats for mandatory and recommended messages.

1.5 Section 5 describes the GM/CCF electrical interface, including the provision of power transfer to the GM/CCF.

SECTION 1: OVERVIEW OF THE SETTING REQUIREMENTS

2. Overview

The Fuze Setter shall be able to set GM/CCFs, which require large volumes of data to be transferred. Figure B-1 details the determination of the fuze identity.

3. GM/CCF Protocol

The GM/CCF protocol is described in Section 2.

3.1 The GM/CCF-to-Fuze Setter interface is an inductively coupled interface that allows the high-speed transfer of bi-directional serial data. This interface is also referred to as a data bus.

3.2 The GM/CCF interface protocol is based on a Command/Response system, which removes the possibility of bus contention.

3.3 The function of the Fuze Setter is to provide data flow control for all transmissions on the bus; the Fuze Setter acts as a Bus Controller (BC).

3.4 The function of the GM/CCF communication interface electronics is to perform data transfer to and from the Fuze Setter, as controlled by the Fuze Setter. The GM/CCF will not ‘speak unless spoken to’; i.e. the Fuze Setter commands the GM/CCF to either receive data from the Fuze Setter or to transmit data to the Fuze Setter. The GM/CCF acts as a Remote Terminal (RT) on the data bus.

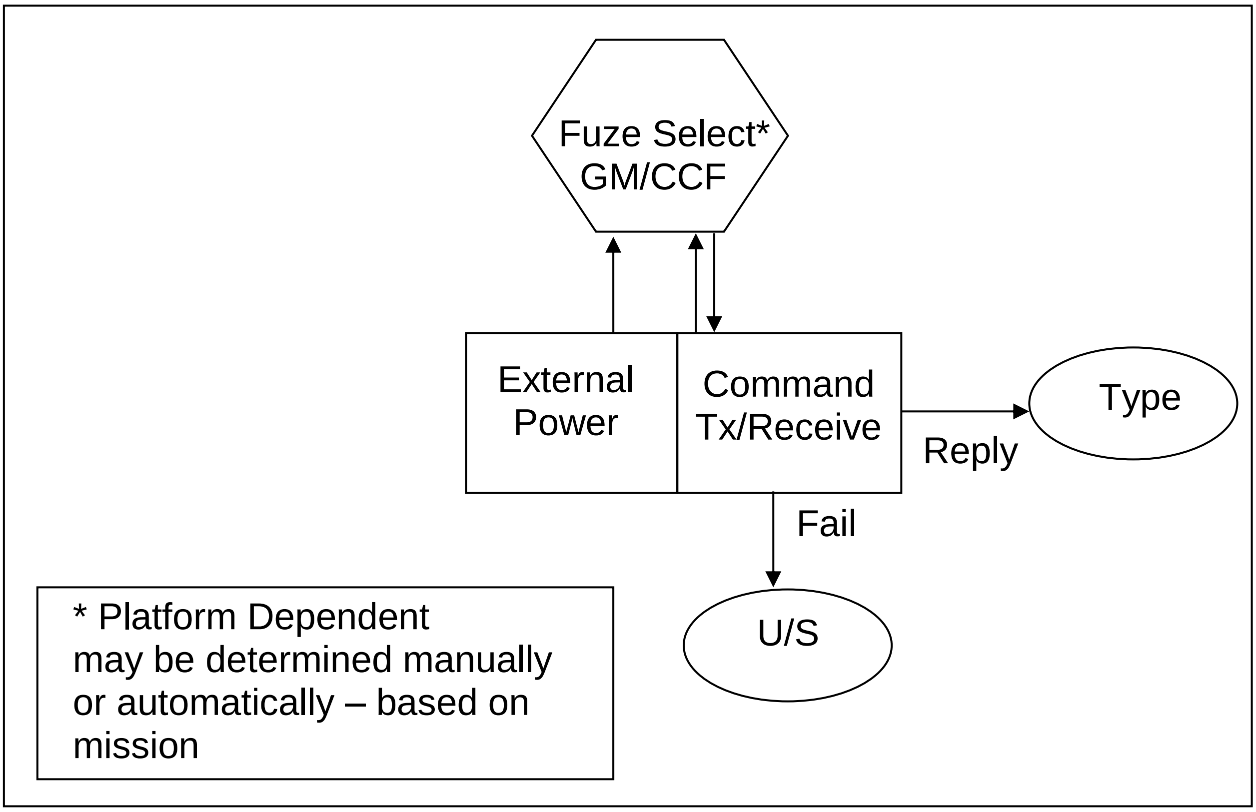

Fig. B-1 Determination of the Fuze Identity (type)

4. Determination of GM/CCF type

4.1 The Fuze Setter will apply External Power, followed by a command (Message 1, Command/Transmit) to transmit the 'GM/CCF Status' message (Message 4) using the GM/CCF protocol.

4.2 The GM/CCF will respond to the transmit 'GM/CCF Status' message command by sending Message 4. Word 4 of Message 4 defines the GM/CCF type and variant (if applicable).

4.3 The data structure of further transmissions to and from the Fuze Setter will be determined by the GM/CCF type returned by the GM/CCF.

5. Transmission of Precise Time

5.1 A GM/CCF containing an embedded GPS receiver requires the transmission of precise time across the interface using a 'Time Mark' message (Message 16). The transmission of precise time has an associated timing pulse, used for precise time message synchronization and GPS oscillator calibration.

5.2 The timing pulses which are modulated onto the data stream are described in Section 6.13.

Section 2: GM/CCF PROTOCOL

6. GM/CCF Messages

6.1 **Data Message** - The smallest data element transferred across the interface is a 'message.' A message contains a varying number of 16-bit words. Individual words of messages cannot be sent.

6.2 **Data Block** - A 'block' is the largest data element, which contains a string of multiple messages. A block transfer may contain messages of different types. For example, a block may consist of a Target message, Gun Data message, and a Meteorological Data message. The practical maximum size of the block is constrained by the requirement to transmit a TMP every 100 ms. (Ref. para. 6.13).

6.3 **Message Header** - Every message has a Message Header, depicted in Fig B-2

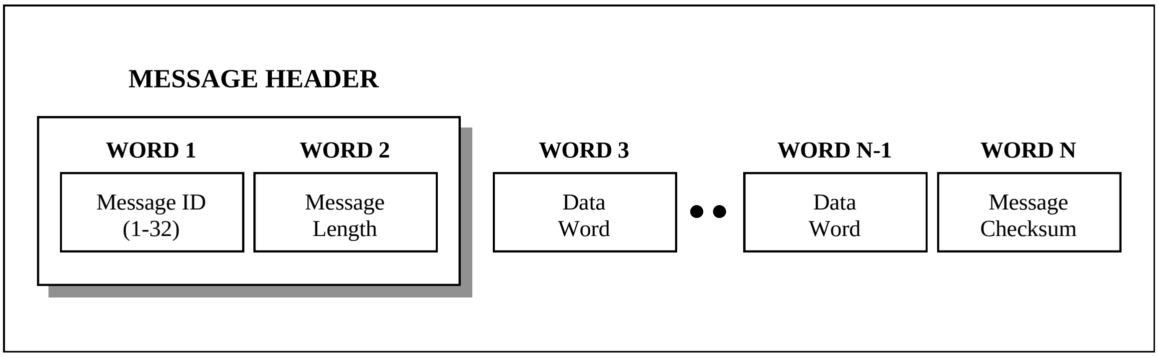

Fig.B-2 Message Header

the Message Header consists of 2 words, placed at the beginning of every message:

6.3.1 **Message ID**. Contains the unique message number (i.e. 1, 2, 3...255).

6.3.2 **Message Length**. Contains the number of words in that message, including the 2 words in the Message Header. The message length can be up to 65,535 (216-1) words. The last word in every message is the Message Checksum word. This word contains the checksum for the message, including the two words in the Message Header. Message checksums shall be calculated in accordance with Section 6.10.

6.4 **Command Message** - To control data transmissions on the bus, the BC shall utilise the Command Message (Message ID 1), depicted in Fig B-3.
The Command Message contains 7 words and can take one of two forms, depending upon the direction of data across the bus: Command/Receive Message or Command/Transmit Message. Both forms have the same Message ID (1). The Control Word in the Command Message specifies whether the Command Message is a Command/Receive or Command/Transmit Message[1].

[1] The unique words in the two different command messages are words 3-6 (see fig. B-3). All other words have the same structure and function.

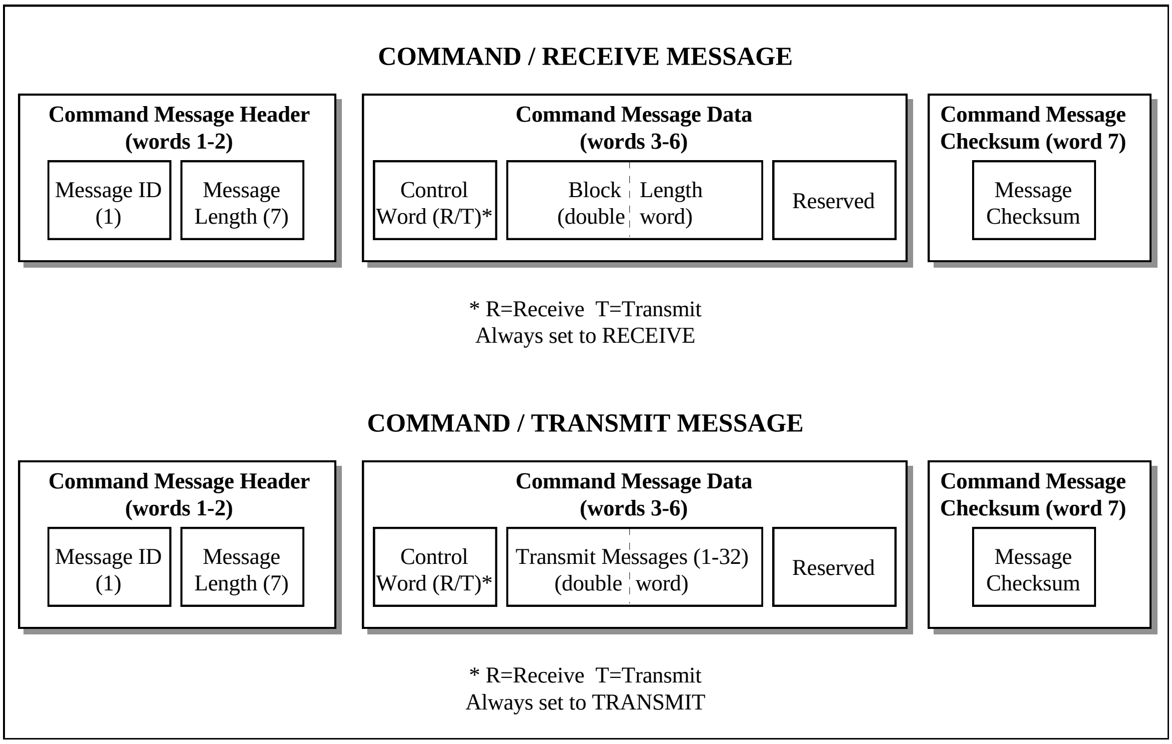

Fig. B-3 Command Message

6.5 **Command/Receive Message** - The Command/Receive Message is utilised by the BC to instruct the RT that it is to receive a data message(s), which follows the transmission of the Command/Receive Message. The Command/Receive Message consists of 7 words, of which the first 2 are the Message Header:

6.5.1 **Words 1-2: Message Header**. The Message Header is the same format as described above. The Message ID will always have a value of 1 and Message Length will always have a value of 7.

6.5.2 **Word 3: Control Word**. The Control Word specifies the direction of the data transfer. For a Command/Receive Message, i.e. an instruction to receive data transferred from the BC to the RT, the word will always be set to Receive (see Section 4, paragraph 10.1 Mandatory Messages, for message format of this word).

6.5.3 **Word 4-5: Block Length**. A double word that specifies the total number of words in the block transmission to follow (does not include the Command/Receive Message).

6.5.4 **Word 6: Reserved**.

6.5.5 **Word 7: Message Checksum**. Contains the checksum of the Command/Receive Message.

6.6 **Command/Transmit Message** - The Command/Transmit Message is utilised by the BC to instruct the RT that it is to send a data message(s). The Command/Transmit Message consists of 7 words, of which the first 2 are the Message Header:

6.6.1 **Words 1-2: Message Header**. The Message Header is the same format as described above. The Message ID will always have a value of 1 and Message Length will always have a value of 7.

6.6.2 **Word 3: Control Word**. The Control Word specifies the direction of the data transfer. For a Command/Transmit Message, i.e. an instruction for a data transfer from the RT to the BC, the word will always be set to Transmit (see Section 4, paragraph 10.1 Mandatory Messages for message format of this word).

6.6.3 **Word 4-5: Transmit Messages**. A double word that contains a bit map to specify the message(s) to be transferred from the RT to the BC[2].

6.6.4 **Word 6: Reserved**.

6.6.5 **Word 7: Message Checksum**. Contains the checksum of the Command/Transmit Message.

6.7 **Data Transfer Formats** - Both types of data transfer on the bus, BC-RT and RT-BC, require a Command Message from the BC. Figure B-4 illustrates the two transfer formats used by this protocol.

6.7.1 Command Messages cannot be bundled with any other messages. Data messages can be bundled to form a Data Block.

6.7.2 Following transmission of a Command/Receive Message, the Fuze Setter allows a minimum 2 millisecond delay before transmitting the subsequent data messages to allow for an inter-message gap and GM/CCF processing of the Command/Receive Message.

6.7.3 Following transmission of a Command/Transmit Message, the Fuze Setter and GM/CCF will configure the bus for a RT-BC transmission. The GM/CCF will not transmit the requested message(s) until a minimum of 2 milliseconds after the receipt of the Command/Transmit Message to allow for processing of the Command/Transmit message and bus synchronisation. The GM/CCF will initiate transmission of the requested message within 4 milliseconds after receipt of the Command/Transmit Message. Following the RT-BC transmission of the data message, the Fuze Setter and GM/CCF will configure the bus within 2 milliseconds for a BC-RT transmission, thus maintaining the Fuze Setter as the bus controller and avoiding bus contention.

[2] This constrains the message IDs that may be transmitted by the GM/CCF to lie between 1 and 32.

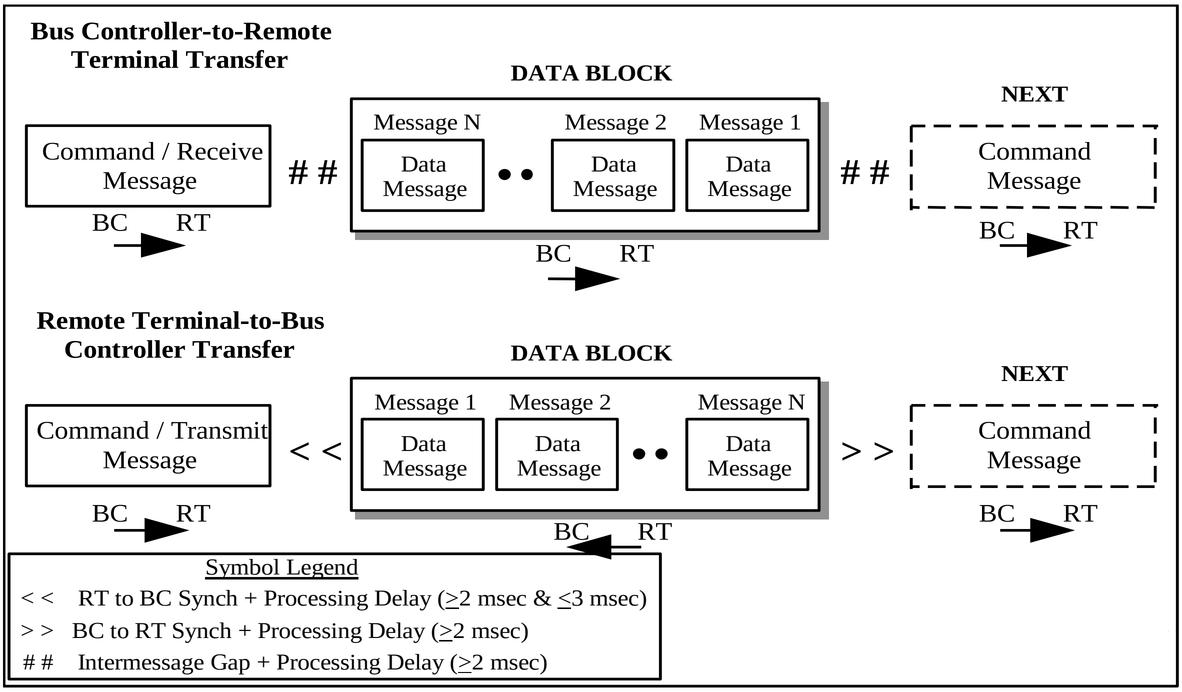

Fig. B-4 Data Transfer Formats

6.8 **Byte Transmission Order** - The byte transmission order and details of the serial channel byte/bit ordering are described below. All data passed over the interface will be passed LSBit/LSByte/LSWord first.

The transmission of the data is as follows:

6.8.1 **Word Order.** DWords, or 32-bit words, consist of two 16-bit words, a Most Significant Word (MSW) and Least Significant Word (LSW). The LSW is always transmitted before the MSW, regardless of the data direction.

6.8.2 **Byte Order.** Figure B-5 illustrates the byte order transmission of a DWord. Within each word, the least significant byte is always transmitted before the most significant byte.

6.8.3 **Bit Order**. Figure B-6 details the transmission of individual bits within each byte (shown in the example is a 16-bit word). The least significant bit is always transmitted first.

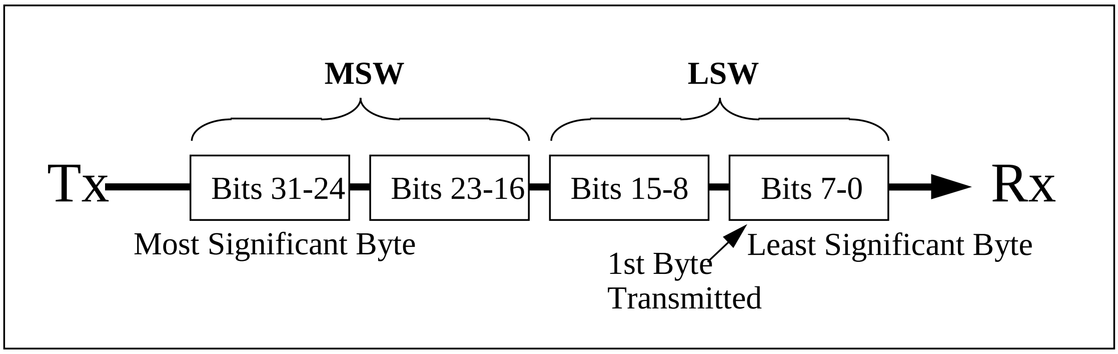

Fig. B-5 Word/Byte Order

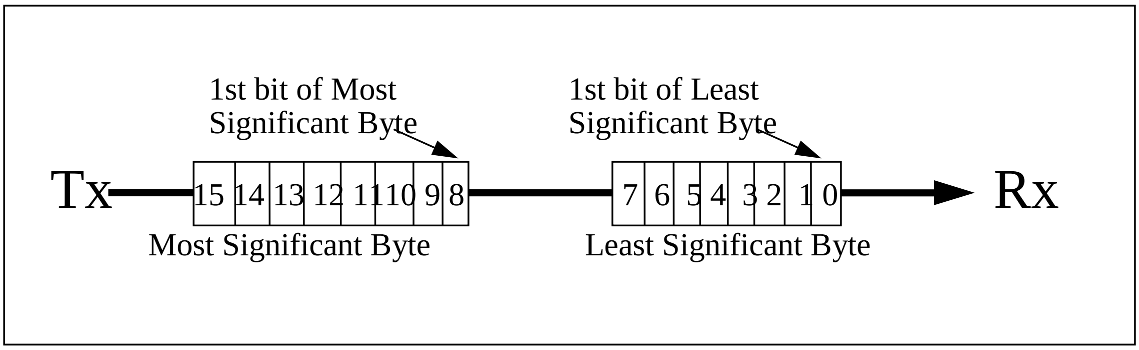

Fig. B-6 Bit Order

6.8.4 Data is transmitted across the interface in 8-bit bytes. A byte is transmitted as a 9 bit character consisting of a start bit, followed by one byte (8 bits) of data. This format is depicted below in Figure B-7.

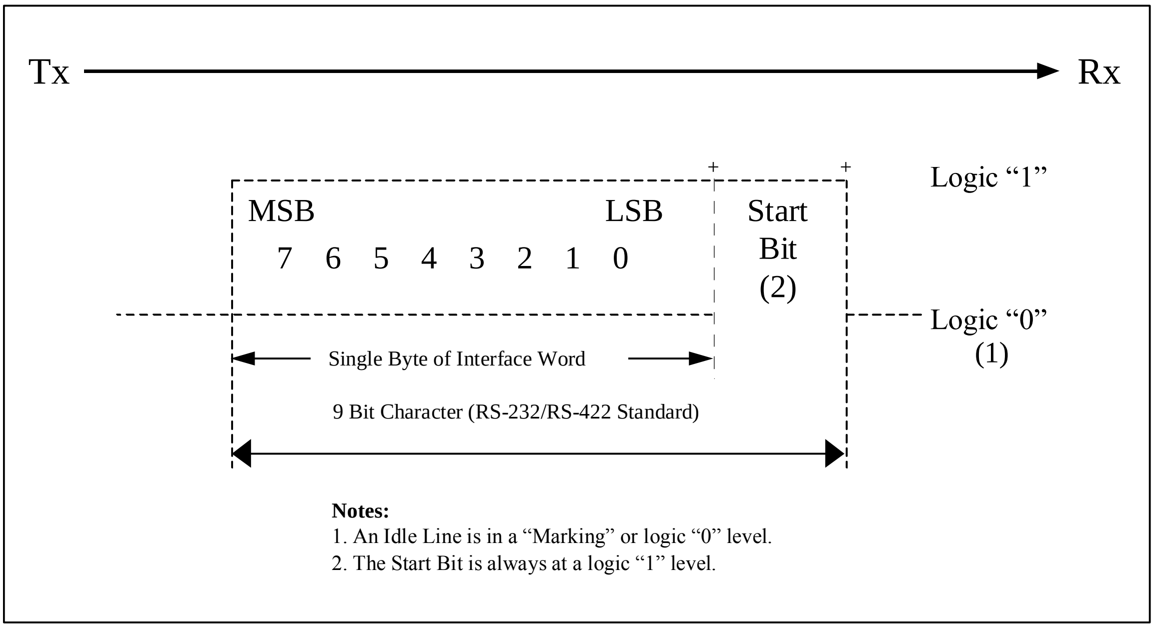

Fig. B-7 Data Byte with Start Bit

6.9 **Transmission Monitoring** - Checksum Passed Bits

6.9.1 A critical function of the interface is to verify the integrity of the data transmissions. The interface will use CRC checksums as the method to verify data is unchanged during transmission.

6.9.2 The Fuze Setter calculates a checksum word for all Fuze Setter to GM/CCF messages. The Fuze Setter uses the checksums provided by the GM/CCF to verify the integrity of the data.

6.9.3 The GM/CCF calculates a checksum word for all GM/CCF to Fuze Setter messages The GM/CCF verifies all checksums provided by the Fuze Setter. The GM/CCF shall not use any data from messages that fail the checksum test.

All message checksums will be computed in accordance with the algorithm described in Section on Message Checksum Algorithm (CRC) below.
All message checksums occupy the last word in the message.

6.10 Message Checksum Algorithm (CRC)

A 16-bit Cyclic Redundancy Check (CRC) will be used as the checksum method for the interface between the Fuze Setter and the GM/CCF.

6.10.1 The feedback equation of the CRC is:

$$X^{16} + X^{9} + X^{5} + X^{2} + 1$$

The LSB position is bit 0. The bit position of the feedback taps, as defined by the above equation is: 15, 8, 4, 1.

6.11 For a given data transmission, the following process will be used on each 16-bit word, until the last word has yielded the final signature register, or Message Checksum. This Message Checksum will be appended to the data stream as the last word in the transmission for the message. Since the value of the signature register at the initial start of the CRC calculation process cannot be a value of 0000 hexadecimal, an initial value of FFFF hexadecimal will be used. This value is loaded into the signature register before the steps begin for a given message.

6.12 The CRC process used to calculate the signature of the data transmission, or Message Checksum, is (reference Figure B-8):

1. Exclusive-or the signature with the next memory location.
2. Compute exclusive-or of tap bits of the signature.
3. Shift signature register left one bit (towards MSB), shifting a ‘0’ into the LSB.
4. Replace least significant bit with result of step 2.
5. Repeat steps 1-4 for all memory (all other 16-bit words).

On the receiving end, the check will be done by performing a Boolean AND on the calculated Checksum and the transmitted CRC word. If this results in a value in the shift register of 0000 hexadecimal, then it will be assumed the message was received without error.

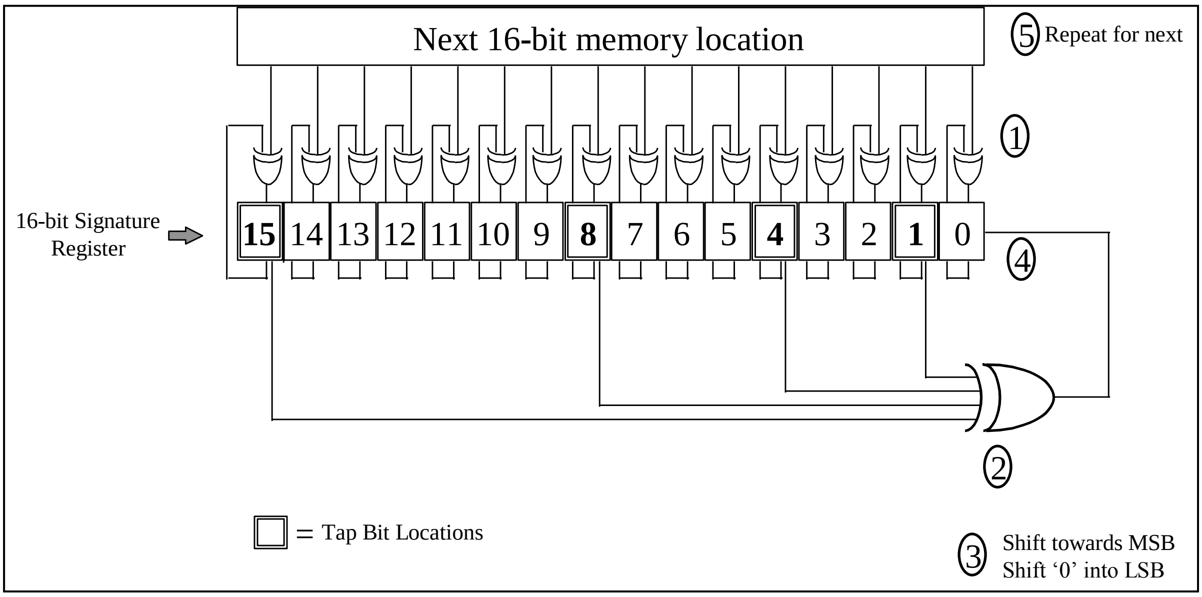

Fig. B-8 CRC Process

6.13 **Time Mark Pulse** - Scheduling

In addition to serial data being sent across the interface, GPS Time Mark Pulses (TMP) will also be sent from the BC to RT at a 10 Hz rate. This constrains the practical maximum size of block data which may be transferred, Figure B-9.

a) The BC must control serial data transmissions on the bus within 100 millisecond frames. In addition, the BC must also send a GPS Time Mark Message that correlates with the previous TMP before the next TMP is sent to the GM/CCF. Within each 100 millisecond frame, the BC may initiate data transfers between the transmission of the TMP and the associated GPS Time Mark Message.

b) Regardless of data transmissions occurring on the bus, the GM/CCF must configure for a BC-RT transmission at the scheduled time for the TMP. Data transmission errors and interpretation of data as TMPs will occur if there are any data transmissions occurring at this time of transition.

c) The GM/CCF will enter the TMP waiting state no sooner than 100 microseconds before the scheduled pulse at the 10 Hz period. The Fuze Setter is responsible for ensuring that a Command/Transmit Message and subsequent GM/CCF response is capable of completing at least 200 microseconds before the scheduled pulse at the 10 Hz period in order to avoid TMP conflict. The GM/CCF will be capable of receiving data transmissions no earlier than 2 milliseconds after the leading edge of the TMP.

If the GM/CCF does not receive a TMP after it has entered the TMP waiting state, the GM/CCF will 'time-out' the waiting state and return to the data receiving state within 2.1 milliseconds after opening the TMP 'wait window' (2 milliseconds after the expected TMP).

See Paragraph 8.1 below for TMP signal characteristics, transmission and processing.

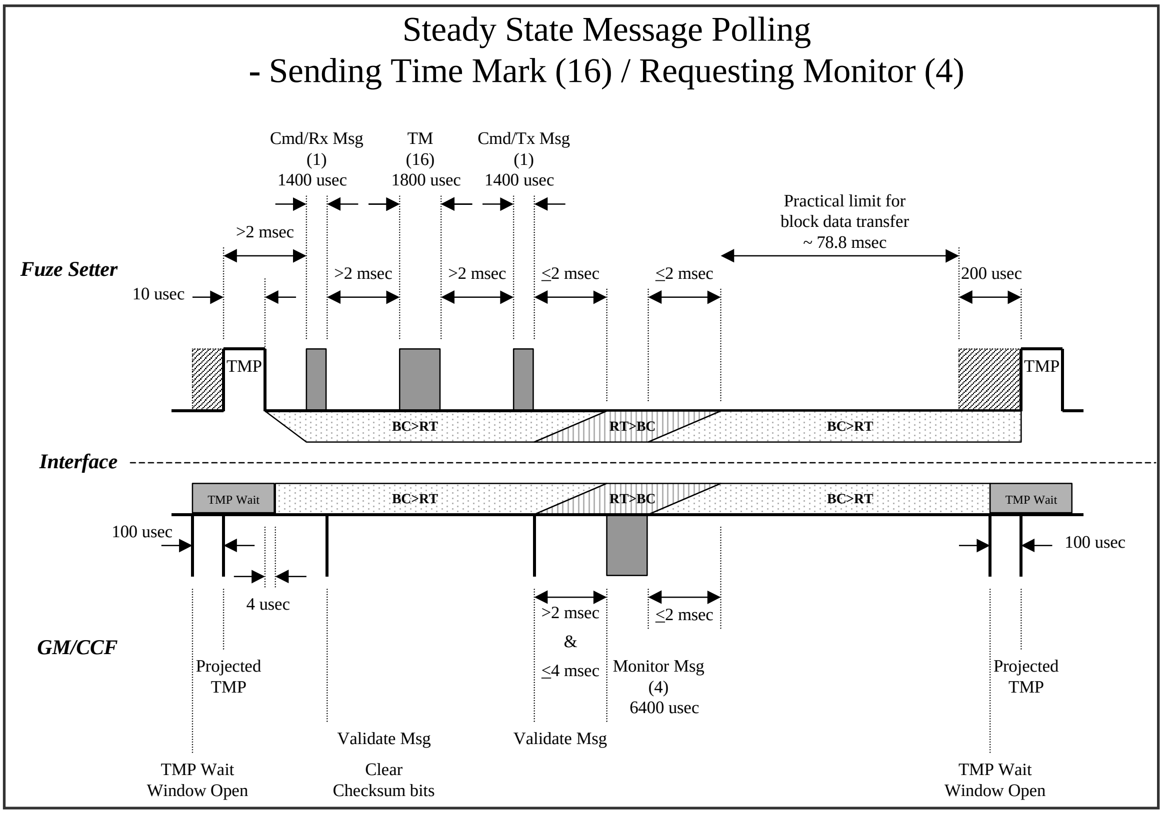

Fig. B-9 Data Transfer Timing - update

Section 3. DATA STRUCTURES

7. MANDATORY MESSAGES

7.1 Command Message (Message 1)- The format of this message is defined in Section 4.
This message is **MANDATORY**, i.e. each GM/CCF **SHALL** support this message.

7.1.1 The Command Message contains 7 words and can take one of two forms, depending upon the direction of data across the bus: Command/Receive Message or Command/Transmit Message. Both forms have the same Message ID (1). The Control Word in the Command Message specifies whether the Command Message is a Command/Receive or Command/Transmit Message

7.1.2 **Function description** - The Command Message is transmitted by the Fuze Setter acting as bus controller.
The Command/Receive Message (Message 1 [Receive]) is utilised by the BC to instruct the RT that it is to receive a data message(s), which follows the transmission of the Command/Receive Message. The Command/Receive Message consists of 7 words.
The Command/Transmit Message (Message 1 [Transmit]) is utilised by the BC to instruct the RT that it is to send a data message(s). The Command/Transmit Message consists of 7 words.

7.2 GM/CCF Status (Message 4)

7.2.1 The format of this message is defined in Section 4.
This message is **MANDATORY**, i.e. each GM/CCF SHALL support this message. Thereafter unique data structures may be used for each munition / fuze variant.

7.2.2 **Function description** - GM/CCF status data is transmitted by the GM/CCF in response to the Message 1, Command/Transmit command issued by the Fuze Setter acting as bus controller.
Embedded within Word 4 of this message are the identity and variant of the GM/CCF to be initialised (or set). The received GM/CCF type determines which further messages are to be transmitted by the Fuze Setter.

7.2.3 **Fuze Setter requirements** - The Fuze Setter SHALL AS A MINIMUM process Words 4, 9 & 10 (GM/CCF ID and software revision) of message 4, thus establishing the GM/CCF type to be initialised or set and determining what further messages are required to be transmitted on the bus.

7.2.4 **GM/CCF requirements** - The GM/CCF SHALL AS A MINIMUM transmit its ID, variant and software revision in Words 4, 9 & 10 of message 4. It is RECOMMENDED the GM/CCF serial number is encoded in words 5 to 8 of message 4.

Word 3 and Words 11 to 31 of message 4 are GM/CCF variant specific.
Word 32 is the Status message checksum.
The GM/CCF SHALL transmit all 32 words of message 4. Unused words SHALL be set to zero.

8. RECOMMENDED MESSAGES - GPS DATA

This section describes the GPS related data passed over the interface, the data format, and the data transfer between the Fuze Setter and the GM/CCF. Table B-1 depicts the recommended messages for GPS Data Transfer.

Message Name	Message	Description
GPS Time Mark Message	16	Provides time associated with the GPS Time Mark Pulse.
Ephemeris	17	Provides satellites ephemerides as defined in ICD-GPS-059. Also contains Ionospheric Correction.
GPS Crypto Key	Reserved	Reserved

Table B-1 GPS Data Transfer Messages

8.1 **Time Mark Message (Message 16)** - The GM/CCF will resolve GPS time to within ±1.0 μs by utilising a periodic series of pulses (TMP) received and a GPS Time Mark Message [16] associated with each pulse. The TMP leading edge defines the instant in time when the data in the preceding GPS Time Mark Message [16] is valid.

8.1.1 **Fuze setter requirements** - The fuze setter provides the TMP at a 10 Hz rate and maintains the pulses throughout the duration that the GM/CCF is inductively interfaced to the Fuze Setter. Each TMP pulse shall have a width of 10 μs and a jitter of less than or equal to 0.1 μs, measured at the input to the GM/CCF GPS receiver. The TMP is used by the GM/CCF GPS receiver to calibrate its oscillator. The Fuze Setter provides the GPS Time Mark Message [16] associated with at least one TMP. The Fuze Setter sends the GPS Time Mark Message [16] before the next TMP is sent to the GM/CCF. The GPS Time Mark Message [16] shall provide the time of pulse transmission with an uncertainty of ±1.0 μs.

8.1.2 **GM/CCF requirements** - The GM/CCF utilises the TMP to calibrate the GPS oscillator. The GM/CCF associates the rising edge of the pulse with the time in the first GPS Time Mark Message [16] that is received before the next TMP. The GM/CCF will use subsequent valid Time Mark Messages if the transmitted

Time Figure of Merit is an equal to or better value than the previous transmitted value. The GM/CCF will process only the first Time Mark Message received within a 100 ms Time Mark interval.

8.2 Ephemeris data (Message 17)

8.2.1 Function description - Ephemeris data is used by the GM/CCF to acquire a satellite constellation for navigating during GM/CCF free flight. Ephemeris data parameters describe satellite vehicle (SV) orbits for short sections of the satellite orbits and are used with an algorithm that computes the SV position for any time within the period of the orbit described by the ephemeris parameter set. Ionospheric data is included in the ephemeris message and is used by the GM/CCF to reduce potential target location bias by compensating the L1 pseudorange measurements.

Up to 32 ephemeris data sets may be available to the Fuze Setter from an associated GPS receiver. However, some of this data will be obsolete at the time of initialisation (i.e., SVs have set below the horizon). Therefore, ephemeris data processing will be performed to determine which SV data sets to pass to the GM/CCF for initialisation, based on the following criteria:

a) SV must report healthy, where any non-zero value is considered unhealthy.
b) Ephemeris data must contain ionospheric corrections which are less than 6 minutes old.

8.2.2 Fuze setter requirements - The fuze setter sends ALL ephemeris data [17] sets that meet the filtering criteria to the GM/CCF.

8.2.3 GM/CCF requirements – The GM/CCF has the capability to receive ephemeris data for satellite PRNs 1 through 32. Data associated with PRNs outside this range will be discarded

.

<u>8.3 GPS CRYPTOGRAPHIC KEYS</u>

8.3.1 Function description
Reserved

8.3.2 Fuze setter requirements
Reserved

8.3.3 GM/CCF requirements
Reserved

Section 4: DATA FORMATS

9. Introduction

Section 4 describes the logical interface messages used to communicate between the Fuze Setter and the GM/CCF. The messages are comprised of formatted and scaled 16-bit digital data words. The GM/CCF messages are defined by a message page that provides a description of the entire message and a word page that defines each word contained within the message.

9.1 Digital data message sheet descriptions

The message page is listed first in each message subsection and provides an overall description of the message.

9.2 Message page header

The message page header fields are defined in Table B-2.

Message Page Header Field	Message Page Header Field Description
MESSAGE NAME	Formal name selected to identify the message.
MESSAGE ID	Unique code identifying the message. Example: Message 16 (Time Mark)
SOURCE	Source of message transmission. Fuze Setter = Source of message transmission is the fuze setter. GM/CCF = Source of message transmission is the GM/CCF.
DESTINATION	Destination of message transmission. GM/CCF = Destination of message transmission is the GM/CCF Fuze Setter = Destination of message transmission is the fuze setter.
TRANSFER TYPE	Direction of data transmission. In the case of BC-RT, the message is transferred from the bus controller (or fuze setter) to the remote terminal (GM/CCF). In the case of RT-BC, the message data is transferred from the remote terminal (GM/CCF) to the bus controller (fuze setter) upon command from the bus controller.
WORD COUNT	Number of data words including checksum, contained in the message.

Table B-2 Message Page Header Field Description

9.3 Message descriptor

Table B-3 provides descriptions of the message descriptor fields.

Message Descriptor Field	Description
WORD NAME	Formal name selected for the data word.
WORD NO.	Word number within the message.
DESCRIPTION	Brief description of the data word, references to notes, etc.
PAGE NO.	Message subsection page number for bit-level description of the data word.

Table B-3 Message Descriptor Field Descriptions

9.4 Message page footer

The message page footer contains any applicable remarks or notes pertaining to the message. Notes referenced in the message descriptor ‘DESCRIPTION’ field may be found in the message page footer.

9.5 Word page description

The message page is listed first in each message subsection and provides an overall description of the message.
Each word in a message will have a corresponding word page describing the details of the data word.

9.6 Word page header

The word page header fields are defined in Table B-4

Word Page Header Field	**Word Page Header Field Description**
WORD NAME	Formal name selected to identify the data word.
WORD ID	Code identifying the message of which data word is a subset. WORD ID Codes: XX-YY XX = Message ID YY = Word number within message
SOURCE	Source of message transmission. Fuze Setter = Source of message transmission is the fuze setter. GM/CCF = Source of message transmission is the GM/CCF.
DESTINATION	Destination of message transmission. Fuze Setter = Destination of message transmission is the fuze setter. GM/CCF = Destination of message transmission is the GM/CCF.
SIGNAL TYPE	Valid Signal Types: 2’s Complement Unsigned Binary ASCII Discrete: Single binary bit whose state of 1 or 0 has a specified Meaning Coded (Binary): A grouping of bits in which the pattern of 1’s and 0’s has a specified meaning Floating Point: As defined in IEEE 754 - 1985 Floating Point Format
UNITS	Engineering units of the data word. Some data words may not have units or N/A. Note: Message Length units are Words.
MAX VALUE	Maximum value that the signal, as supplied by the subsystem, can attain. The MAX value must be less than or equal to the FULL SCALE value.
MIN VALUE	Minimum value that the signal, as supplied by the subsystem, can attain.
MSB	The value of the most significant bit.
LSB	The value of the least significant bit. (The minimum detectable change in value of the signal as supplied by the subsystem.)
FULL SCALE	Maximum value the data field can attain, as dictated by the LSB value and the number of bits in the data field. ‘Full Scale’ does not account for the Min and Max values.

Table B-4 Word Page Header Field Description

9.7 Word descriptor

Table B-5 provides descriptions of the Word Descriptor Fields

Word Descriptor Field	Description
FIELD NAME	Formal name selected for describing a bit, field, single or double precision data word. Double precision words are described with a Most Significant Word (MSW) and a Least Significant Word (LSW) data field. Field Name Field Coding: <u>Code</u> <u>Description</u> MSW Most significant word LSW Least significant word Reserved: Denotes a bit which is not used in the Fuze Setter-to-GM/CCF interface for any purpose except message checksum calculations and which may be required to be set to a logic one or zero by the message originator. If not specified, the bit may be either state. Reserved bits may have already been designated for use by other systems that interface with GM/CCF electronics and are not available for future use in the Fuze Setter-to-GM/CCF interface. Unused: Denotes a bit which is not used by the message receiver for any purpose except message checksum calculations and which may be required to be set to a logic one or zero by the message originator. If not specified, the bit may be either state. Unused bits are available for future use. Spare: Denotes a bit which is not used in the GM/CCF interface and which is available for future use without impacting other GM/CCF interfaces. The message originator must set all spare bits to logic zero.
BIT NO.	Bit number within the word(s). Bit No. Field Coding: <u>Code</u> <u>Description</u> N Numeric D Discrete C Coded A ASCII Alphanumeric code 0 Logic 0 1 Logic 1 B Binary E Exponent M Mantissa X Not Used (may be logic 0 or 1)
DESCRIPTION	Brief description of the bit, references to notes, etc. Description Field Coding: <u>Code</u> <u>Description</u> MSB Most significant bit LSB Least significant bit

Table B-5 Word Page Descriptor Field Descriptions

9.8 Signal Type

Table B-6 provides definitions for the Signal Type Field in the heading of the Word Descriptions.

Signal Type	Notation
2's Complement	MSB, LSB and N (data bits). The sign bit occupies the MSB location.
Binary	MSB,LSB, and B (data bits)
Unsigned	MSB, LSB, and N (data bits)
Discrete	D
Coded	MSB, LSB, and C (data bits)
ASCII	MSB, LSB and A (data bits)
Floating Point	MSB, LSB, S (Sign), E (Exponent), M (Mantissa)

Table B-6 Signal Type Notation

9.9 Word page footer

The word page footer contains applicable remarks or notes pertaining to the data word. Notes referenced in the word descriptor ‘DESCRIPTION’ field may be found in the message page footer.

10. Message Formats –

For more details on all messages contact the Joint Ballistics Working Group (JBWG) with the form provided in Appendix C.

10.1 Mandatory Messages

10.1.1 Message 1

MESSAGE NAME: **Command/Receive and Command/Transmit Message**

MESSAGE ID:	**1**	TRANSFER TYPE:	**BC-RT**
SOURCE:	**Fuze Setter**	WORD COUNT:	**7**
DESTINATION:	**GM/CCF**		

WORD NAME	WORD NO.	DESCRIPTION
Message ID	**- 01 -**	**Message Descriptor**
Message Length	**- 02 -**	**Message Length**
Control Word	**- 03 -**	**Control of Data Transfer**
Block Length	**- 04 -**	**Length of Data Transmission to Follow (LSW)**
	- 05 -	**Length of Data Transmission to Follow (MSW)**
Reserved	**- 06 -**	**Reserved**
Message Checksum	**- 07 -**	**Message Checksum**

REMARKS/NOTES:

1. This **MANDATORY** message is used to instruct the GM/CCF to receive or transmit data.

10.1.2 Message 4

MESSAGE NAME: **Status Message**

MESSAGE ID: **4** TRANSFER TYPE: RT-BC
SOURCE: GM/CCF WORD COUNT: 32
DESTINATION: Fuze Setter

WORD NAME	WORD NO.	DESCRIPTION
Message ID	**- 01 -**	**Message Descriptor**
Message Length	**- 02 -**	**Message Length**
GM/CCF Specific	- 03 -	GM/CCF Specific
GM/CCF ID Code	**- 04 -**	**Identifies GM/CCF Configuration**
S/N Char 1/2	- 05 -	GM/CCF Serial No - Chars 1 & 2 (RECOMMENDED)
S/N Char 3/4	- 06 -	GM/CCF Serial No - Chars 3 & 4 (RECOMMENDED)
S/N Char 5/6	- 07 -	GM/CCF Serial No - Chars 5 & 6 (RECOMMENDED)
S/N Char 7/8	- 08 -	GM/CCF Serial No - Chars 7 & 8 (RECOMMENDED)
SW Rev Char 1/2	**- 09 -**	**GM/CCF Software Revision Number - Chars 1 & 2**
SW Rev Char 3/4	**- 10 -**	**GM/CCF Software Revision Number - Chars 3 & 4**
GM/CCF Specific	- 11 -	GM/CCF Specific
GM/CCF Specific	- 12 -	GM/CCF Specific
GM/CCF Specific	- 13 -	GM/CCF Specific
GM/CCF Specific	- 14 -	GM/CCF Specific
GM/CCF Specific	- 15 -	GM/CCF Specific
GM/CCF Specific	- 16 -	GM/CCF Specific
GM/CCF Specific	- 17 -	GM/CCF Specific
GM/CCF Specific	- 18 -	GM/CCF Specific
GM/CCF Specific	- 19 -	GM/CCF Specific
GM/CCF Specific	- 20 -	GM/CCF Specific
GM/CCF Specific	- 21 -	GM/CCF Specific
GM/CCF Specific	- 22 -	GM/CCF Specific
GM/CCF Specific	- 23 -	GM/CCF Specific
GM/CCF Specific	- 24 -	GM/CCF Specific
GM/CCF Specific	- 25 -	GM/CCF Specific
GM/CCF Specific	- 26 -	GM/CCF Specific
GM/CCF Specific	- 27 -	GM/CCF Specific
GM/CCF Specific	- 28 -	GM/CCF Specific
GM/CCF Specific	- 29 -	GM/CCF Specific
GM/CCF Specific	- 30 -	GM/CCF Specific
GM/CCF Specific	- 31 -	GM/CCF Specific
Message Checksum	**- 32 -**	**Message Checksum**

REMARKS/NOTES:

1. This **MANDATORY** message is used by the gun system to monitor GM/CCF functions.
2. Only words in **BOLD** face are mandatory. All other words must be sent regardless of content.

10.2 Recommended Messages

10.2.1 Message 16

MESSAGE NAME: GPS Time Mark Message

MESSAGE ID:	16	TRANSFER TYPE:	BC-RT
SOURCE:	Fuze Setter	WORD COUNT:	9
DESTINATION:	GM/CCF		

WORD NAME	WORD NO.	DESCRIPTION
Message ID	- 01 -	Message Descriptor
Message Length	- 02 -	Message Length
GPS Time	- 03 -	GPS Time (LSW)
	- 04 -	GPS Time (MSW)
GPS Time (Fractional Part)	- 05 -	GPS Fractional Time (LSW)
	- 06 -	GPS Fractional Time (MSW)
GPS Week	- 07 -	GPS Week Number (current)
Time Figure of Merit	- 08 -	Characteristics of the Time Mark Message
Message Checksum	- 09 -	Message Checksum

REMARKS/NOTES:

10.2.2 Message 17

MESSAGE NAME: Ephemeris Message

MESSAGE ID:	17	TRANSFER TYPE:	BC-RT
SOURCE:	Fuze Setter	WORD COUNT:	58
DESTINATION:	GM/CCF		

WORD NAME	WORD NO.	DESCRIPTION
Message ID	- 01 -	Message Descriptor
Message Length	- 02 -	Message Length
G-10 Word 1	- 03 -	GPS Time (16 MSB)
G-10 Word 2	- 04 -	GPS Time (16 NSB)
G-10 Word 3	- 05 -	GPS Time (16 NSB)
G-10 Word 4	- 06 -	GPS Time (16 LSB)
G-10 Word 5	- 07 -	Satellite PRN Number
G-10 Word 6	- 08 -	Reserved
G-10 Word 7	- 09 -	Reserved
G-10 Word 8	- 10 -	TLM Preamble/TLM Message (8 MSB)
G-10 Word 9	- 11 -	TLM Message (6 LSB)/HOW (8 MSB)
G-10 Word 10	- 12 -	HOW (14 LSB)
G-10 Word 11	- 13 -	Week Number/Satellite Status Data
G-10 Word 12	- 14 -	SV Health/IODC (2 MSB)/L2 P-Code
G-10 Word 13	- 15 -	Reserved
G-10 Word 14	- 16 -	Reserved
G-10 Word 15	- 17 -	Reserved
G-10 Word 16	- 18 -	Reserved
G-10 Word 17	- 19 -	Reserved
G-10 Word 18	- 20 -	Group Delay Time/IODC (8 LSB)
G-10 Word 19	- 21 -	Clock Date Reference Time
G-10 Word 20	- 22 -	af2/af1 (8 MSB)
G-10 Word 21	- 23 -	af1(8 LSB)/af0 (8 MSB)
G-10 Word 22	- 24 -	af0 (14 LSB)
G-10 Word 23	- 25 -	TLM Preamble/TLM Message (8 MSB)
G-10 Word 24	- 26 -	TLM Message (6 LSB)/HOW (8 MSB)
G-10 Word 25	- 27 -	HOW (14 LSB)
G-10 Word 26	- 28 -	IODE/Crs (8 MSB)
G-10 Word 27	- 29 -	Crs (8 LSB)/Delta n (8 MSB)
G-10 Word 28	- 30 -	Delta n (8 LSB)/Mean Anomaly (8 MSB)
G-10 Word 29	- 31 -	Mean Anomaly (16 NSB)
G-10 Word 30	- 32 -	Mean Anomaly (8 LSB)/Cuc (8 MSB)
G-10 Word 31	- 33 -	Cuc (8 LSB)/Eccentricity (8 MSB)
G-10 Word 32	- 34 -	Eccentricity (16 NSB)
G-11 Word 1	- 35 -	Eccentricity (8 LSB)/Cus (8 MSB)
G-11 Word 2	- 36 -	Cus (8 LSB)/SQRT(A) (8 MSB)
G-11 Word 3	- 37 -	SQRT(A) (16 NSB)
G-11 Word 4	- 38 -	SQRT(A) (8 LSB)/Toe (8 MSB)
G-11 Word 5	- 39 -	Toe (8 LSB)/Fit Interval Flag
G-11 Word 6	- 40 -	TLM Preamble/TLM Message (8 MSB)
G-11 Word 7	- 41 -	TLM Message (6 LSB)/HOW (8 MSB)

CONTINUED ON NEXT PAGE

MESSAGE NAME: Ephemeris (continued)

MESSAGE ID:	17	TRANSFER TYPE:	BC-RT
SOURCE:	Fuze Setter	WORD COUNT:	58
DESTINATION:	GM/CCF		

WORD NAME	WORD NO.	DESCRIPTION
G-11 Word 8	- 42 -	HOW (14 LSB)
G-11 Word 9	- 43 -	Cosine Harmonic Correction Term
G-11 Word 10	- 44 -	Longitude Ascending Node-Orbit Plane
G-11 Word 11	- 45 -	Longitude Ascending Node-Orbit Plane
G-11 Word 12	- 46 -	Sine Harmonic Correction Term
G-11 Word 13	- 47 -	Inclination Angle (16 MSB)
G-11 Word 14	- 48 -	Inclination Angle (16 LSB)
G-11 Word 15	- 49 -	Cosine Harmonic Correction Term
G-11 Word 16	- 50 -	Argument of Perigee (16 MSB)
G-11 Word 17	- 51 -	Argument of Perigee (16 LSB)
G-11 Word 18	- 52 -	Rate of Right Ascension (16 MSB)
G-11 Word 19	- 53 -	Rate of Right Ascension (8 LSB)/IODE
G-11 Word 20	- 54 -	Rate of Inclination Angle
Iono Correction	- 55 -	Iono Correction
	- 56 -	Iono Correction (continued)
G-11 Word 23	- 57 -	Satellite PRN Number
Message Checksum	- 58 -	Message Checksum

REMARKS/NOTES:

1. The Ephemeris message provides the indicated Ephemeris parameters for the identified space vehicles.
2. Reference ICD-GPS-059, G-10 Ephemeris Output Message 1 and G-11 Ephemeris Output Message 2. Ephemeris parameters are further defined in ICD-GPS-200, Subframes 1 through 3.

Section 5: INDUCTIVE INTERFACE

11. Introduction

This section provides the electrical interface requirements for both the GM/CCF inductive setter and all compliant GM/CCF fuzes, where power transfer is required. It specifies the configuration and position of the required coils and the power transfer protocols.

11.1 Requirements Interface

The GM/CCF inductive setter will provide the following capabilities:

- Transfer of data to the fuze (data may include 10 PPS Time Mark Pulse, dependent upon projectile type).
- Acceptance of data from the fuze.
- Transfer power to the fuze.

The GM/CCF projectile will provide the following capabilities:

- Accept data from the fuze setter.
- Transfer data to fuze setter (when commanded by the fuze setter).

Utilise power provided by the fuze setter (if required).

11.2 Hardware Overview

This section refers to the inductive interfaces, which may be used for transferring data and power:

a) The inductive interface, defined below, consists of a pair of coils (one on setter and one in the fuze) and is referred to as the Guided Initialisation (setting) Coils (GIC), and transfers power and/or data.

b) The information in this section focuses on the use of the GIC to transfer data and power as it has been shown to be the most efficient in doing so. Both sets of coils, GIC and Fuze Setter Coil (FSC) are not needed to set this type of fuze. The FSC used for setting standard projectile fuzes (non-guided) can be used with less efficiency and speed but it is not described here.

11.3 Guided Initialization Coils - Geometry

The GIC (S - setter) and the GIC (P – projectile fuze system) form an air core transformer, which allows for power and data transfer. The configuration permits data communication in both directions. The GIC should be capable of transferring power and data as defined below. The configuration has torroidal type setter and fuze coils.
The centre of the GIC (P) will be 20.5 mm from the reference point on the FSC(P) (see figure B-10).
The centre of the GIC (S) will be 20.5 mm from the reference point on the FSC(S) (see figure B-10).

The following configuration of GIC(S) with 20 anti-clockwise turns, when viewed from the nose, x 20 AWG magnet wire in a single layer and GIC(P) with 20 anti-clockwise turns, when viewed from the nose, x 20 AWG magnet wire in a single layer has been shown to work.

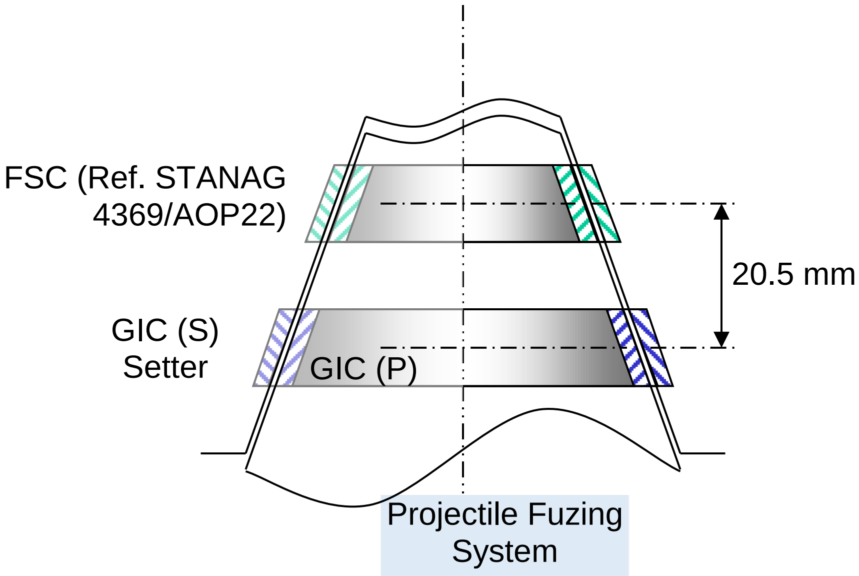

Figure B-10 – GIC Configuration

11.4 Alignment of Coils

Any misalignment of the GIC(P) & GIC(S) coils shall not reduce the transferred power below the required limit (munition specific - see Figure B-12) at the GIC (projectile fuze system).
The maximum permissible radial separation and axial misalignment of the coils is not specified but it is recommended that they be no more than 3.8 mm & 5.1 mm respectively.

11.5 Waveforms

The remaining paragraphs define:

1. The waveforms for Time Mark Pulse, Power Cycle and Data Cycle
2. The timing of the waveforms
3. Equivalent Circuits
4. The timing of the waveforms, Figures B-11, 12, 13, 14 and 15, shown below and the equivalent circuits are specific to XM982 (Excalibur) but are included as an example.

11.6 Types of Waveforms

Three waveforms are defined as follows.

11.6.1 Time Mark Pulse

The setter shall send a Time Mark Pulse (TMP) to the projectile fuze system when required with a pulse to pulse jitter of less than 100ns. The setter shall drive the GIC(S) to produce a TMP conforming to Figure B-11.

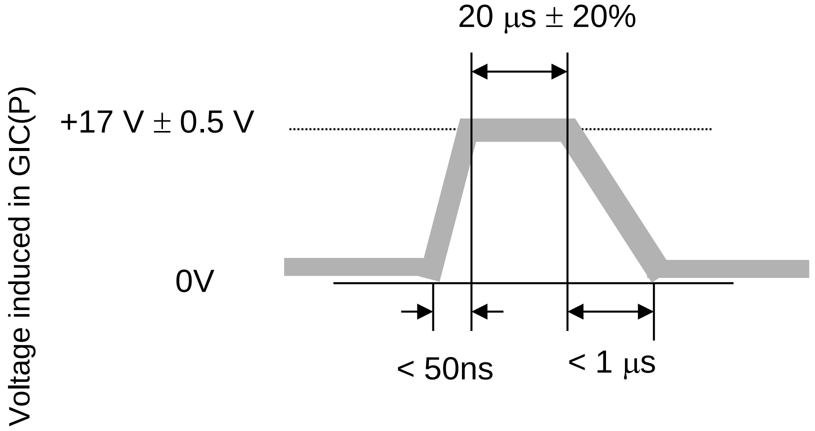

Figure B-11. Detail of Time Mark Pulse Waveform

11.6.2 Power Cycle Waveform

The setter shall drive the GIC (S) so that Vpro across the GIC (P) is within the limits of Figure B-12 when no data or time mark pulse is transferred.

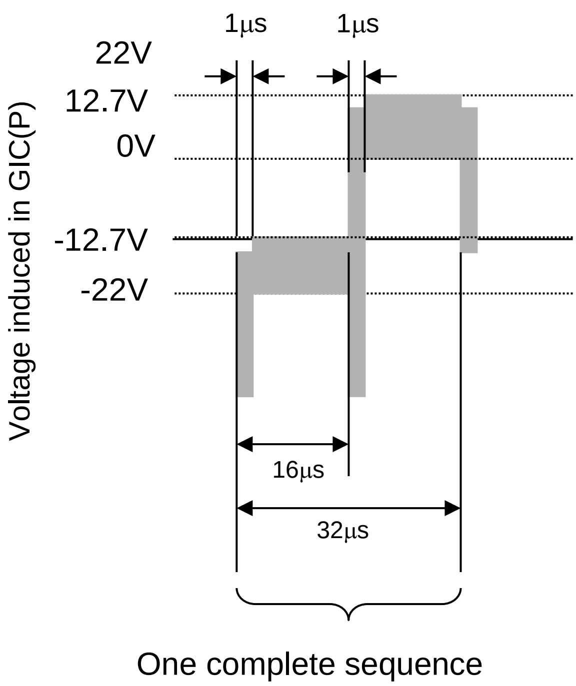

Figure B-12. Detail Of 50% Duty Cycle Power Waveform (Vpro)

Equivalent circuits have been produced to enable Vpro and Vcon to be measured. These are shown below.

1. Power to Projectile Fuze

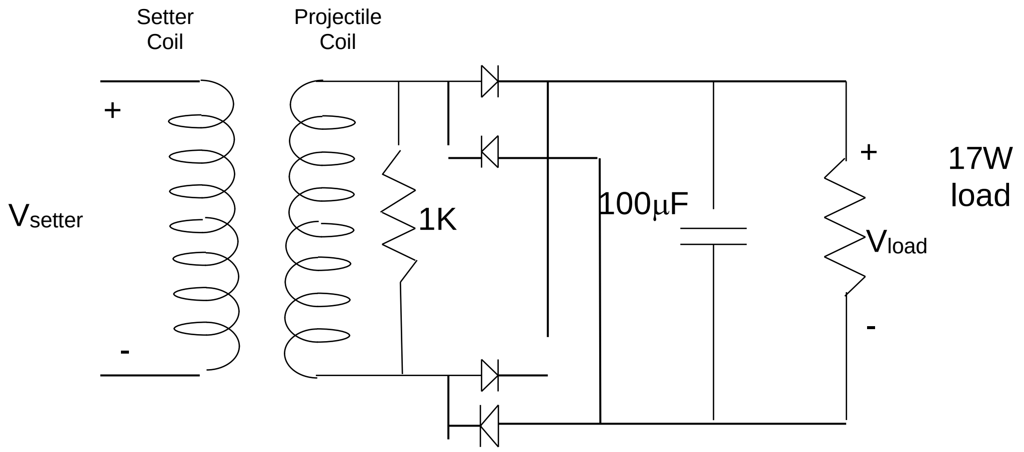

Figure B-13 Equivalent Circuit For Power To Projectile Fuze

An equivalent circuit for the GIC (P) is shown in Figure B-14. The setter shall drive the GIC (S) so that Vpro across the GIC (P) is within the limits of Figure B-12 when no data or time mark pulse is transferred.

2. Equivalent Circuit For Data To Projectile Fuze

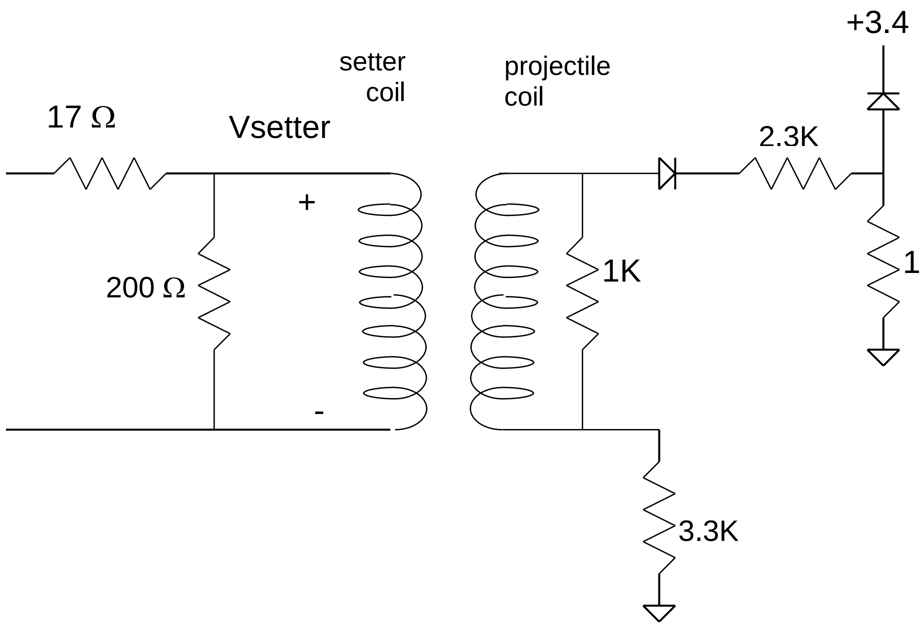

Figure B-14 Equivalent Circuit For Data To Projectile Fuze

The setter shall have at least 100Ω of source resistance as shown in figure B-14. The setter data drive shall not cause Vpro to exceed ± 12V.

3. Equivalent Circuit For Data To Setter

When the setter requires data from the projectile fuze, it will generate the power waveform in Figure B-12. With the equivalent circuit shown in Figure B-15 data from the projectile fuze will not generate a signal exceeding ±12V at Vset with the equivalent circuit shown in Figure B-15.

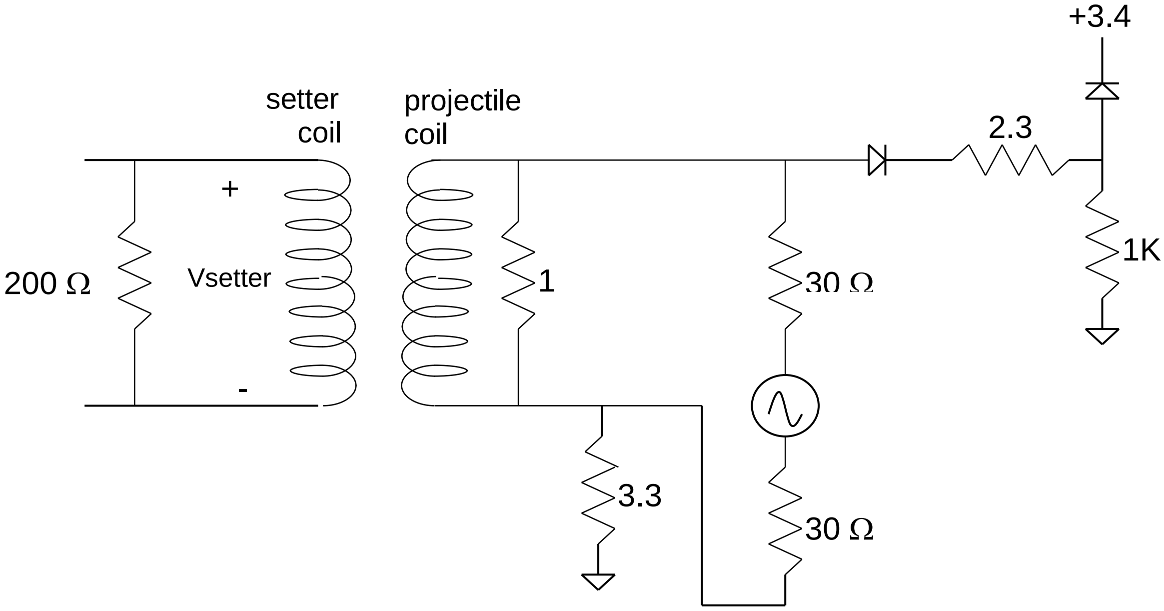

Figure B-15 Equivalent Circuit For Data To Setter

BIT NO.	Bit number within the word(s). Bit No. Field Coding: Code / Description N Numeric D Discrete C Coded A ASCII Alphanumeric code 0 Logic 0 1 Logic 1 B Binary E Exponent M Mantissa X Not Used (may be logic 0 or 1)
DESCRIPTION	Brief description of the bit, references to notes, etc. Description Field Coding: Code / Description MSB Most significant bit LSB Least significant bit

Table B-7 Word Page Descriptor Field Descriptions

Table B-8 provides definitions for the Signal Type Field in the heading of the Word Descriptions.

Signal Type	Notation
2's Complement	MSB, LSB and N (data bits). The sign bit occupies the MSB location.
Binary	MSB, LSB, and B (data bits)
Unsigned	MSB, LSB, and N (data bits)
Discrete	D
Coded	MSB, LSB, and C (data bits)
ASCII	MSB, LSB and A (data bits)
Floating Point	MSB, LSB, S (Sign), E (Exponent), M (Mantissa)

Table B-8 Signal Type Notation

4. **Word page footer**
   The word page footer contains any applicable remarks or notes pertaining to the data word. Notes referenced in the word descriptor 'DESCRIPTION' field may be found in the message page footer.
5. **Time Mark Pulse**
   See Para. 6.13

11.6.3 Data Waveform

The data shall consist of a start bit (always '1'), followed by 8 data bits, LSB first. This provides a nominal effective data rate of 70.7 kHz. The data waveform at Vcon (Voltage conditioned as shown in electrical circuit Figure B-13) should be within the limits shown in Figure B-13.

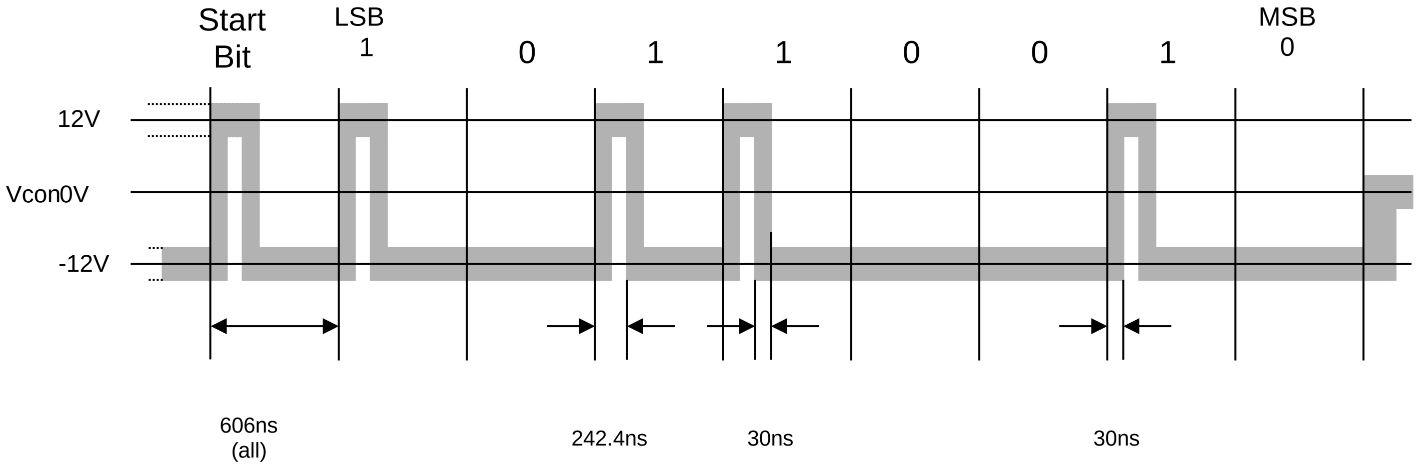

Figure B-16 Data Waveform

1. The overall timing will be specific to each munition. For Excalibur, the following waveforms are defined.

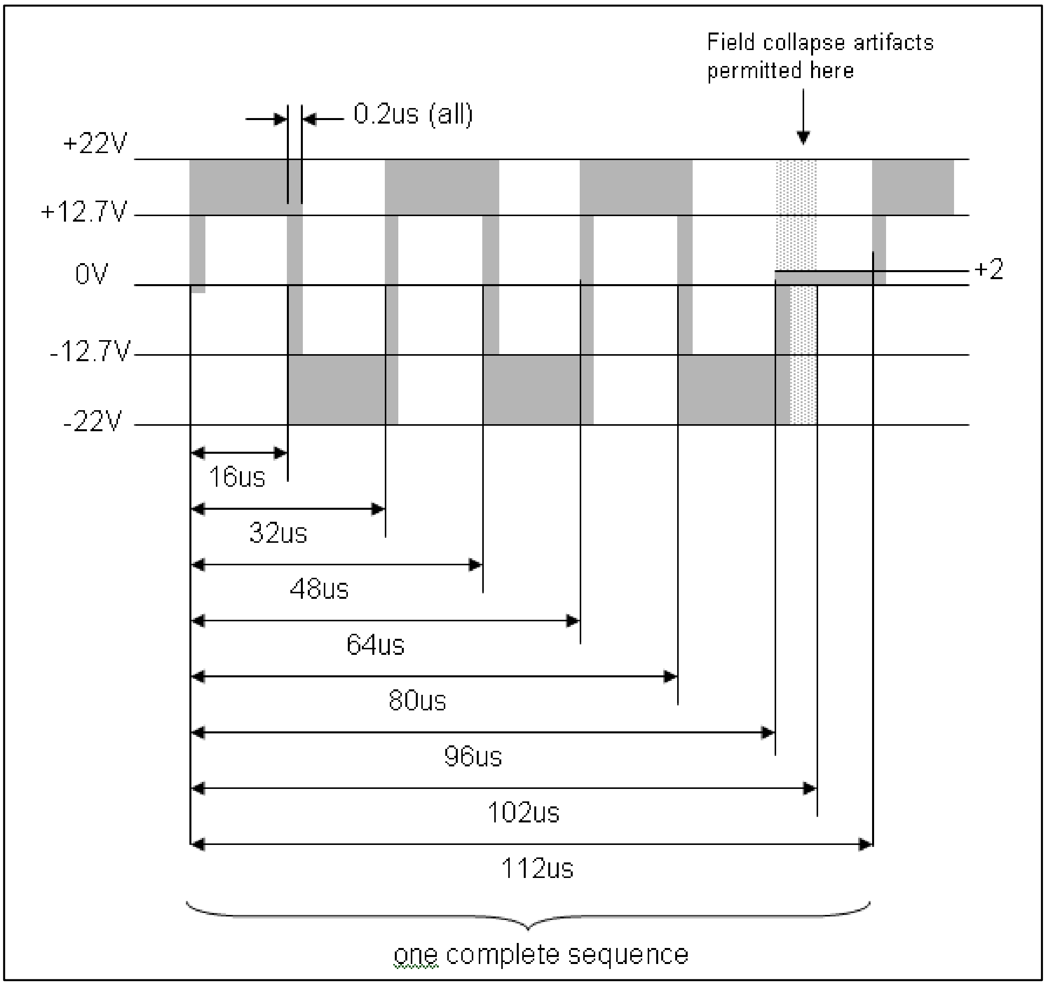

Figure B-17 Power Waveform With Data For Projectile; Timing And Voltage Envelope (Vpro)

2. Figure B-18 shows the power waveform, with data transfer (either to or from the projectile) as required. The setter shall insert the data, if required, in the quiet gap after every third power pulse, as shown in Figure B-17.

3. Figure B-18 shows the timing of the TMP. The setter shall send a Time Mark Pulse (TMP) to the projectile every 100ms. 1ms ± 112 µs, before the rising edge of the next TMP, data transfer in either direction shall cease and the power waveform shall change to a 50% duty cycle waveform. 50µs ± 32µs, before the rising edge of the next TMP, the setter shall cease driving the GIC(S). 4µs ± 1µs, later, the setter shall resume sending power and data (if any).

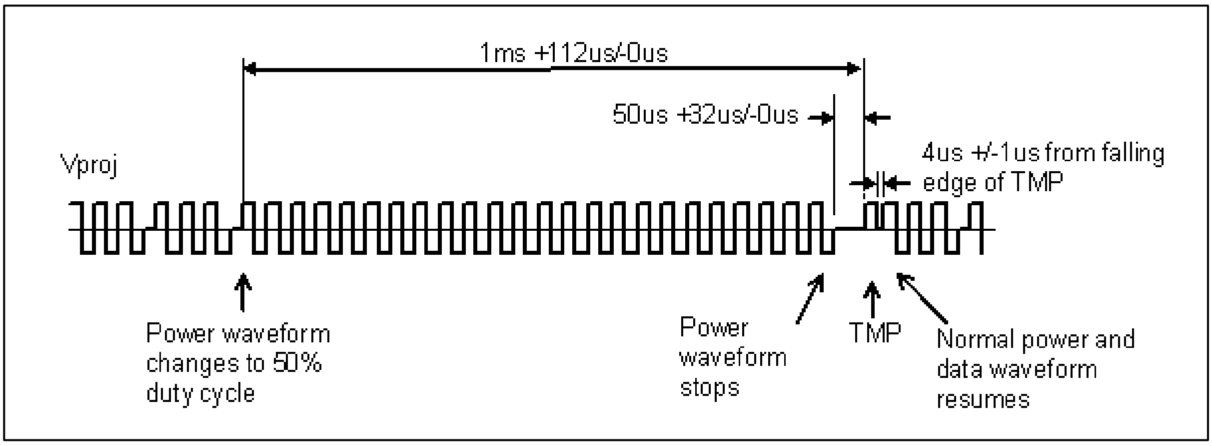

Figure B-18 Time Mark Pulse Overall Timing

BIT NO.	Bit number within the word(s). Bit No. Field Coding: Code Description N Numeric D Discrete C Coded A ASCII Alphanumeric code 0 Logic 0 1 Logic 1 B Binary E Exponent M Mantissa X Not Used (may be logic 0 or 1)
DESCRIPTION	Brief description of the bit, references to notes, etc. Description Field Coding: Code Description MSB Most significant bit LSB Least significant bit

Table B-9 Word Page Descriptor Field Descriptions

4. Table B-10 provides definitions for the Signal Type Field in the heading of the Word Descriptions.

Signal Type	Notation
2's Complement	MSB, LSB and N (data bits). The sign bit occupies the MSB location.
Binary	MSB, LSB, and B (data bits)
Unsigned	MSB, LSB, and N (data bits)
Discrete	D
Coded	MSB, LSB, and C (data bits)
ASCII	MSB, LSB and A (data bits)
Floating Point	MSB, LSB, S (Sign), E (Exponent), M (Mantissa)

Table B-10 Signal Type Notation

5. The word page footer contains any applicable remarks or notes pertaining to the data word. Notes referenced in the word descriptor ‘DESCRIPTION’ field may be found in the message page footer.

ANNEX B.2 - PROTOCOLS FOR USE OF STANAG 4369 SINGLE COIL

Using the STANAG 4369 coil to transfer data and power for a GM/CCF application.

This Annex is intended to provide requirements when the fuze design intends to use the STANAG 4369 Fuze Setter Coil (labeled FSC in Fig. B.11) to transfer data and power for a GM/CCF application. The ability of this coil to transfer data has been proven in standard fuzes however its speed is limited and its ability to transfer power is even more limited. This section has been left as a place holder until a nation can provide information based on its experience using this coil to transfer data and power to a GM/CCF.

ANNEX B.3 - PROTOCOLS FOR USE OF BOTH COILS

Using a combination of STANAG 4593 and STANAG 4369 coils to transfer data and power for a GM/CCF application.

This Annex is intended to provide requirements when the fuze design intends to use both the STANAG 4369 and STANAG 4593 (FSC and GIC) coils to transfer data and power for a GM/CCF application. The ability of the FSC coil (used in STANAG 4369) to transfer data has been proven in standard fuzes however its speed is limited and its ability to transfer power is even more limited. The design of the GIC coil (used in this AOP) has improved data transmission speed and a much higher level of power transfer capability. There is no current GM/CCF design that uses both coils for this purpose. It is assumed that if both coils are used the STANAG 4369 coil will be used to transfer data while the STANAG 4593 coil will be used to transfer power. Both coils however cannot be used simultaneously. This section has been left as a place holder until a nation can provide information based on its experience using both coils to set (initialise) GM/CCF.

INTENTIONALLY BLANK

ANNEX C JBMOU FORM TO REQUEST ADDITIONAL INFORMATION

Use this form to request additional information from the JBWG.

JCCC Form2 25 June 2015

Form Requesting Release of
Technical Annexes associated with the
Joint Ballistics Memorandum of Understanding
to a Non-Member Nation *

1. NON-MEMBER NATION REQUESTING JBMOU TECHNICAL ANNEXES:			**2. DATE OF NON-MEMBER'S REQUEST:**		
3. NATO MEMBER? ***(check one)***	**YES**	**NO**	**4. HAS REQUESTOR RECEIVED A COPY OF THE JBMOU OR IT'S TECHNICAL ANNEXES BEFORE?** ***(check one)***	**YES**	**NO**
5. NON-MEMBER NATION'S POINT OF CONTACT (POC) AND MAILING ADDRESS:					
6. POC's E-MAIL ADDRESS:			**7. POC's TELEPHONE:** *(with country code)*		

To request a copy of the **Technical Annexes** associated with the **"Joint Ballistics Memorandum of Understanding (JBMOU) Concerning the Standardization of Elements of 155MM Weapon and Ammunition Systems,"** please complete the form above as follows:

Box 1: Type name of the Nation requesting the JBMOU's Technical Annexes.

Box 2: Type date this form is being completed by the Requesting Nation.

Box 3: Check one of the two boxes with an "X" to indicate "yes" or "no".

Box 4: Check one of the two boxes with an "X". If not known, leave blank.

Box 5: Type POC's name and office address that the Technical Annexes should be mailed to.

Box 6: Type POC's office e-mail address.

Box 7: Type POC's office telephone number, including country code.

*** *Member nations include France, Germany, Italy, United Kingdom, & United States.*

Procedure to Submit JBMOU Form.
After completing the above form:

- Either mail, e-mail, fax, or hand carry a copy of this Form (JCCC Form2, 25June 2015) to the Requesting Nation's Embassy in the United States.

- From the Requesting Nation's Embassy in the United States, forward this Form to:
-

usarmy.pica.rdecom-ardec.mbx.jbwg@mail.mil

- A response to the Requesting Nation's POC will generally be returned within 4 to 6 weeks, depending on circumstances. *Thank you for your interest!*

JCCC Form2 25 June 2015

INTENTIONALLY BLANK

AOP-60(A)(1)