find your way

Technical Reference Manual

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Revision History

Revision G (May, 2006)

0x30 – Software Options Output: Added W15 to x30 output message. Added change to W2 of x30 input message to show the increased size used by the system 2100.

0x30 – Software Options Entry: Fixed 0x30 software options entry message size

0x46 – Initial Time & Position: Corrected CSUM data type for 0x46

0x46 – Initial Time & Position: Corrected the notes for the 0x46 message.

0x47 – SV Tracking Control: Corrected the length of 0x47 message

0x86 – Channel Status: Changed W to Wn for repeating data in 0x86 message

0xAB – WAAS Data Stream: Fixed the length reported for the 0xAB message

0xAE – Added 2100 engine configurations to the 0xAE message

0xB1 - PVT Block: Fixed formatting error in the 0xB1 message

0xd1 - LBM Authorization Status Block: Fixed Wn2 of 0xD1 message to reflect proper logic in B7

0x42 – RTG QuickStart Control: Corrected the message ID in the 0x42 message

Revision F (July, 2005)

0xB0 – Raw Meas. Data Block Responses: Made Message Length of 0xB0 undetermined to eliminate confusion between 2000 and 2100 message lengths.

0xB1 - PVT Block: Changed W24 in the 0xB1 to a U16 from a U08 + U08 spare.

0xB1 - PVT Block: Updated the 0xB1 length to reflect actual byte count.

0xB1 - PVT Block: Changed RTG backing up RTK to RTK Extend in the 0xB1 message.

0x49 - Solution Control: Changed RTG backing up RTK to RTK Extend in the 0x49 message.

0xB1 - PVT Block: Corrected RTCM message types in the xB1 message.

0xB1 - PVT Block: Fixed wording in the xB1 message.

0x11 – Serial Port Configuration: Added missing W4. Changed W2 and W3 to Wn2 and Wn3 as they repeat. Added a message length of 0x00xx.

0x1A – Port Configuration Block: Corrected message length from 12 bytes to 14 bytes.

Revision E (Feb, 2005)

0x49 - Solution Control: Added W13 padding byte to 0x49 message. Corrected message length value, and number of bytes in message.

0x22 - CMR Control: Modified to include description on how to activate CMR+.

Revision D (Nov, 2004)

0x42 - RTG QuickStart Control: Changed command id from 0x48 to 0x42.

Revision C (Nov, 2004)

Layout Format

Added messages:

0xe1 – Unused Satellite Status: Failure code used to indicate why a sat is not being used in the position solution.

0x5d - Base Station. RTG/RTK Position Vector delta: Delta between ECEF RTG position and relative RTK fix.

Modified messages:

0x1a - Port Configuration Block: Modified W4 to be used for CAN data.

0x42 - RTG QuickStart Control: Corrected W6 byte count from 2 bytes to 1 byte.

0x30 - Software Options Output: Corrected message length to 19 bytes.

Added Max Power & Radio Hopping Parameters

0x49 - Solution Control: Modified W8 B15 to allow Ignore RTG/RTK Backup.

Modified W6 B6 to allow Solid Earth Tide corrections.

Extended message 1 byte (W12) to allow Reference Station ID format change in the field 14 of NMEA GGA.

0x50 - RTK Base Control: Corrected message length to 19 bytes.

0xae - Identification Block: Corrected message length to 55 or 75 bytes

(configuration dependant, see 0xae notes)

Updated message structure to conform to current code.

0xb1 - PVT block: Modified explanation of FOM (Figure Of Merit), see notes W13.

Changed Xb1 FOM scaling to centimeters for all navigation modes.

Modified to incorporate L1PNav

Corrected message length to 86 bytes.

Appended L1PNav results to end of existing message format.

Added SET delta NEU to end of message.

Added Nav failure mode to end of message.

Added additional NAV Modes to Xb1.

0xd0 - LBM Identification Block: Updated message structure to conform to current code.

0xd3 - LBM DSP Status Block: Corrected message length to U16 from U08.

0x21 - NMEA Data request: Added $GPGST and $PNCTSET to supported message list.

0x7e - MMC Data Logging Commands & Responses: Updated message structure to conform to current code.

Enabled W3 B7 to continuation logging to MMC after a power cycle (internal only).

0xb0 - Raw Meas. Data Block Responses: Changed W4 B7 from Navigation Valid to correct label of Channel Time Set.

0x55 - WAAS Satellite List: Added Auto selection field to message.

0x71 - NCT-2000D Special Communication: Removed from manual. Incorrectly added to list of user configurable messages.

Revision B (Jan, 2004)

Added messages:

0x71 -- NCT-2000D special communication block (Internal)

Sub messages to support Pass-Through Mode

Revision A (Nov, 2003)

Cover Only

Revision 2 (22 Aug, 2003)

Added messages:

0x42 – StarFire QuickStart Control

0x7b – IOP Ping

0x7c – User Text Message

0x7e – MMC Data Logging Cmds & Responses

Amended messages:

0x30 – Software Options

0x52 – RTCM Output Control

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Use of this Document

This User Guide is intended to be used by someone familiar with the concepts of *GPS* and satellite surveying equipment.

Note indicates additional information to make better use of the product

Indicates a caution, care, and/or safety situation.

Revisions to this User Guide can be obtained in a digital format from *http://www.navcomtech.com/support/docs.cfm*

NCT Binary Message Blocks

All messages listed in this document are contained within the NCT-2000D.

- Message blocks in blue have been created specifically for NCT-2000D products that are coupled with an I/O board and internal 2.4GHz radio.
- Message blocks in red have been created specifically for NCT-2000D products that are coupled with an I/O board and a LBM (L-band module).
- Message blocks in green have been created specifically for NCT RT-series or SF-series products. They remain constant regardless of product type, but not meant to be used for any NCT-2000D OEM application.

This document is broken into two sections, rather than three of its predecessor. The sections will be designated as **Control Commands** and **Data Responses**. Each of these message blocks may be queried by applying a special command by scheduling a special output through message block 0x20.

Message Organization

NCT2000D Receiver messages are composed of a variety of 1 to 8-bit byte segments. Definitions of terms used are as follows:

1) Parameter Length:

S08	Integer (1 Byte)
U08	Unsigned Integer (1 Byte)
S16	Integer (2 Bytes)
U16	Unsigned Integer (2 Bytes)
S24	Integer (3 Bytes)
↓	
U24	Unsigned Integer (3 Bytes)
S32	Integer (4 Bytes)
↓	
U32	Unsigned Integer (4 Bytes)
R32	Floating Point (4 Bytes)
↓	
R64	Floating Point (8 Bytes)

: U24 = U08 low, U08 middle, and U08 high.

2) Message Parameters are referred to as Parameter Words, (Wn). Parameter Words follow IEEE convention and Intel byte order (Little Endian). Bits within a Parameter Word are designated Bn, where B0 is the LSB. Exception for U24 and S24, which are low, middle and high.

3) Measurements:

L1	Carrier phase measurements at L1
C/A	C/A code phase measurements at L1
P1	P(Y) code phase measurements at L1
L2	Carrier phase measurements at L2
P2	P(Y) code phase measurements at L2

4) Input/Output Ports (Physical):
PORTA Serial Port #1
PORTB Serial Port #2
(Optionally, may also contain a radio and/ or CAN Bus)

5) Input/Output Ports (Logical):
Control
Diagnostic
Data
NMEA
RTCM
CMR_in
CMR_out

GPS Week Number

The GPS Week Number count began at midnight on the evening of 05 January 1980 / morning of 06 January 1980. Since that time, the count has been incremented by 1 each week, and broadcast as part of the GPS message. The GPS Week Number field in the data stream is modulo 1024. This meant that at the completion of week 1023, the GPS week number rolled over to 0 on midnight GPS Time of the evening of 21 August 1999 / morning of 22 August 1999.

The NCT-2000D™ uses an adjusted 16-bit integer (U16) in the data to avoid this confusion. It can handle up to week 65535.

Protocol

General message format:

STX		U08	0x02
Preamble (1)		U08	0x99
Preamble (2)		U08	0x66
Command ID	U08		
Msg. Len.	U16		
MESSAGE		variable	
CKSUM		U08	
ETX		U08	0x03

- 1: STX, Preamble and ETX are only used for serial communications.
- 2: Msg. Len. is inclusive byte count from Command ID to CKSUM.
- 3: CKSUM is one byte XOR inclusive from Command ID through MESSAGE.
- 4: Messages may have a variable number of Parameters (Wx) of variable length

0x11 - Serial Port Configuration - 6 + (2 x N) bytes

This system command configures the two serial ports. Physically, the two ports (A and B) are capable of different baud rates (user controlled). Furthermore, the logical/ physical mapping for the physical ports is controlled by message 0x1a.
Also, it is important to note that the radio and/ or CAN Bus options do NOT allow for configurable baud rates when packaged together in NavCom product lines.

Command ID U08 0x11
MSG LEN. U16 0x00xx
W1 U08 Command Action
B1=0: Do not store in NVRAM
B1=1: Store in NVRAM
B2=0: Do not use ACK/NAK
B2=1: Use ACK/NAK
B3=0: Use Commanded Values
B3=1: Use Default values
Wn2 U08 Port Selection
B0=0: Serial PORT1,
B0=1: Serial PORT2
Baud Rate Selection
B1=0, B2=0, B3=0: 1200
B1=1, B2=0, B3=0: 2400
B1=0, B2=1, B3=0: 4800
B1=1, B2=1, B3=0: 9600
B1=0, B2=0, B3=1: 19200 (Default)
B1=1, B2=0, B3=1: 38400
B1=0, B2=1, B3=1: 57600
B1=1, B2=1, B3=1: 115200
Parity Selection
B4=0, B5=0: NONE (Default)
B4=1, B5=0: ODD
B4=1, B5=1: EVEN
Reserved
B7-B6: Not Used
Wn3 U08 Reserved
Must be 0
…
W4 U08 Reserved
CKSUM U08

- 1: Configured for 8 bit word length and 1 stop bit.
- 2: For multiple command actions, the bits in W1 may be OR'ed.
- 3: W2 and W3 may be repeated to configure a second port.
- 4: During command echo, W2 and W3 will be repeated for the second port.

- 5: Due to hardware limitations, baud rates combinations of 1200/115200, 2400/57600, or 2400/115200 cannot be supported. Any attempt to select one of these combinations will be rejected. To prevent this problem, set both ports to a supported combination of baud rates in the same input sentence.
- 6: Engine is configured as DTE.
- 7: If ACK/NAK is selected, and the input sentence is accepted, the ACK will be put out at the new settings.

0x12 - Data-Sync Signal Configuration - 6 bytes

This message is used to select either the rising or falling edge of the sync trigger for data sync signal configuration.

Command ID		U08	0x12
	Msg. Len.	U16	0x0006
	W1	U08	Command Action
			B1=0: Do not store in NVRAM
			B1=1: Store in NVRAM
			B2=0: Do not use ACK/NAK
			B2=1: Use ACK/NAK
			B3=0: Use commanded value
			B3=1:Use default value
	W2	U08	B0=0: Use rising edge
			B0=1: Use falling edge
	CKSUM	U08	

1: For multiple command actions, the bits in W1 may be OR'ed.

0x14 - Channel, Mode and Raw Data assignment - 8 bytes

This command configures the Channel Mode and Raw Data assignment.

Command ID	U08	0x14
Msg. Len.	U16	0x0008
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use Commanded Values B3=1: Use Default values
W2	U08	Reserved
W3	U08	Raw Data Output Selection B0: C/A Code Measurements B1: P1 Code Measurements B2: P2 Code Measurements B3: L1 Carrier Measurements B4: L2 Carrier Measurements
W4	U08	Channel Moding B0: CA Mode (No P1/P2/L2 Tracking) B1: Extended CA Mode (Use P2CA Slot for additional CA Tracking channels) B2: CA/P1 Mode (P1 Tracking Required) B3: CA/P1/P2 Mode (P1/P2 Tracking Required) B4: WAAS Mode (WAAS Channels may Track WAAS Satellites).
CKSUM	U08	

1: For multiple command actions, the bits in W1 may be OR'ed.

2: W2 and W3 revert to factory settings as default values.

3: In Table 2, N is maximum channel limitation, which can be 6, 9 or 12.

4: On W4, B4 can be OR'ed with others

0x16 - 1PPS Configuration - 12 bytes

This is a 1 PPS (pulse per second) output pulse from the receiver that is in sync with the GPS time and is shaped according to satellite specifications.

Command ID	U08	0x16
Msg. Len.	U16	0x000C
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use Commanded Values B3=1: Use Default values
W2	U08	Active edge direction B0=0: Rising front edge true B0=1: Falling front edge true
W3	U08	Pulse Width (LSB = 10mS) from active edge 0x01 - 0x32: (1 to 50), 0.010 to 0.500 seconds
W4	S16	mSecond Delay (LSB = 1mS) (0 to 999), 0.000 to 0.999 second
W5	S16	CA Epoch Delay (LSB = 1mS/1023) (0 to 1023), 0.000 to 1 mSecond
W6	U08	Reserved
CKSUM	U08	

- 1: For multiple command actions, the bits in W1 may be OR'ed.
- 2: Default value W3 = 0x0A (0.100 seconds pulse width).
- 3: Default value W4 = 0x0000 (0.000 seconds delay from GPS zero second mark).
- 4: Default value W5 = 0x0000 (0 second delay)

0x19 - Reset Block - 6 or 8 bytes

Message 0x19 is the Reset Block. This message is being expanded to support the integrated systems.

Command ID	U08	0x19
Msg. Len.	U16	0x0006 or 0x0008
W1	U08	Command Action B2: Use Ack/Nak
W2	U08	Reset Conditions B0=1: Clear NVRAM (B6 indicates User/Factory) B1=1: Perform Hardware Reset (Engine only) B2: Reserved (was Almanac) B3=0: Assume Time Unknown B3=1: Use Last Know Time B4=0: Assume Position is Unknown B4=1: Use Current Position B5: Reserved (was Restore Factory Defaults) B6=1: if (B0=1) Clear Factor and User NVRAM B6=0: if (B0=1) Clear User NVRAM Only B7=1: Use W3
W3	U16	0xffff – Turn Off Engine or Integrated System 0x0000 – Cycle power on Integrated System (Equivalent to W2.B1 for Engine only) 0x0nnn – Integrated System shuts Off for NNN minutes (Engine only – Not Supported)
Checksum	U08	

0x1a - Port Configuration Block - 14 bytes

This message configures the Port Assignment for Port A, Port B, radio, and CAN bus as specified in Word 2, 3 and 4.

Command ID	U08	0x1a
Msg. Len.	U16	0x00xx
W1	U08	Command Action B1=1: Store in NVRAM B6=0: User NVRAM B6=1: Factory NVRAM B3=1: Use Default Values
W2	U16	Logical Assignment for Port A
W3	U16	Logical Assignment for Port B
W4	U16	Logical Assignment for CAN Port
W5	U16	Logical Assignment for Radio Port
W6	U08	Reserved
Checksum	U08	

☐ 1: Logical Assignment Definitions
- B0: Diagnostic Port (Output Only)
- B1: Control Port (Output Only)
- B2: Data Port (Output Only)
- B3: NMEA Port (Output only)
- B4: RTCM Port (Input/Output)
- B5: CMR input Port (Input Only)
- B6: CMR output Port (Output Only)
- B7-B11: Reserved for internal use. (Not available for users)
- B12-B15: Spare

☐ 2: Logical Ports May only be assigned to 1 physical port.

☐ 3: Control and RTCM may not be assigned to the same physical port.

☐ 4: Diagnostic, Control and Data port cannot all be assigned to the same physical port. The logical ports are all formatted in NCT proprietary Format. The three also have identical capabilities.

☐ 5: Port A, Port B and Radio Port is nominally configured for input to use NCT Proprietary input. This is true except when CMR input is assigned to a Physical port. In that case, CMR format and possibly RTCM are the only formats recognized. (RTCM can share with either NCT or CMR.

0x1c - Test Support Block - 8 bytes

Command	U08	0x1c
Msg. Len.	U16	0x0008
W1	U08	Command Action
		B2=1: Use ACK/NAK
W2	U08	Test Support ID
		0x01: Turn on All Pole Mount LEDS for *n* seconds
		0x02: Cycles sequentially through the 15 LED's
		0xXX TBD
W3	U08	Equal to *n* in W2
W4	U08	Reserved
Checksum	U08	

0x1d - LBM Download Block - Variable Length

This command is used for both commands to the LBM and responses from LBM. Assume format of this block is same as message 0x1e (listed below).

0x1e - IOP Download Block - Variable Length

This command is used for both commands to the IOP and responses from IOP

Command ID	U08	0x1e
Msg. Len.	U16	0x00xx
W1	U08	Sub ID/Function

0- PING. Verifies receiver unit is present and in download mode. (Also cause entry to download mode.)

1- ERASE. Address field contains first address to erase. Data field contains 4 bytes of last address to erase, least significant byte first. Erase begins with the first segment containing the specified address, and continues to the end of the segment containing the last address.

2- PROGRAM. Data supplied is written at address supplied.

3- SETBAUD. Receiver unit switches to baud rate specified in address field. If command is successful, reply is returned at new baud rate. Presently implemented baud rates are 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200 baud. These values are placed in the address field as U32.

4- START. Exit download mode.

5- FAIL. IOP Response. Command could not be completed. Response varies by Command.

PING – Address field contains error status. Values are TBS.

ERASE – Address field contains address that failed. Data field contains error status, TBS.

PROGRAM – Address field contains requested program address. Data field contains error status, TBS.

SETBAUD – Address field contains value 9, indicating requested baud rate not supported.

6- PASS. IOP Response. Command completed successfully. Response varies by Command.

PING – Address field contains flags in two most significant bytes. The 3rd and 4th byte contain the software version, major and minor respectively. The data

field contains ASCII timestamp in YYMMDD.HHMM format.

ERASE – Address field contains specified start address. Data field contains status, TBS.

PROGRAM – Address field contains start address.

SETBAUD – Address field contains new baud rate.

START – Address field contains start address.

7- Reserved
8- Reserved

9- UNRECOGNIZED Command. IOP response. W5 contains unrecognized command. Data field may contain additional information. (IOP ignores this block if seen on input.)

W2	U08	Count of bytes included in data block (W6).
W3	U08	Reserved
W4	U08	Reserved
W5	U32	Address-- Value depends on function.
W6	U08[]	Data
Checksum	U08	

0x1f - NCT-2000D Download Block - Variable Length

Message Block 0x1f is used to load new firmware into the NCT-2000D GPS receiver.

0x20 - Data request - 4 + 2+(4 x N) bytes

Command ID	U08	0x20
Msg. Len.	U16	0x00xx
W1	U08	Command Action B1=1: Store in NVRAM B6=0: User NVRAM B6=1: Factory NVRAM B3=1: Use Default Values B4=1: Clear Present Output Messages
W2	U08	Count of Data Request Blocks (prior to version 1.93, this byte was zero).
…		
Wn1	U08	Data Block ID 0x00 All Currently Active Output Messages 0x01-0xff: Individual Block ID'
Wn2	U08	Logical Data Port Definition B0=1: Diagnostic Port B1=1: Control Port B2=1: Data Port B3=1: Network Port B4=1: Reserved B5=1: Log Port B6-B7: Reserved
Wn3	U16	Data Rate 0x0000: Output Data Block once or Stop Output 0x0001: 2 Hz 0x0002: 5 Hz 0x0003: 10 Hz 0x0004: 25 Hz 0x0005: 50 Hz 0x0006-0x0009: Reserved 0x000a-0x1ffe: n*10 where n is inverse of data rate (2 is ½ Hz) 0x2000: Output Data on External Trigger/ Event 0x4000: Output Data on Change. 0x80nn: Output data for SV NN (NN=0: all SVs)
… (Use the following only in conjunction with the network port)		
Wf1	U08	0x71
Wf2	U08	0x00
Address	U16	3rd Party Address 0x0000: Ignore This Address (Ignore Value) 0xc350: Broadcast ID (50000 decimal) Other: Radio ID of Unit to send Net Port Messages To.
Checksum	U08	

1: Wn1-Wn3 repeated for each Data Request.

2: Wf1-Address follows WnX (only required if network port is used).

0x21 - NMEA Data request - 4 + 2+(4 x N) bytes

This message initiates a NMEA data request as decoded by words 1 through 5.

COMMAND ID	U08	0x21
Msg. Len.	U16	00??
W1	U08	Command Action
		B1=0: Do not store in NVRAM
		B1=1: Store in NVRAM
		B6=0: Stow in user NVRAM
		B6=1: Store in factory NVRAM
		B3=0: Use Commanded Values
		B3=1: Use Default values
		B4=1: Clear Present NMEA Output Requests
W2	U08	B7:B3 Local Hours Adjustment +/-13 (Signed value)
		B2:B1 Local Minutes Adjustment (lsb is 15 minutes)
		0,15,30,45
		B0=1 Use data in B7:B1, else ignore. (Not set on output)
W3	U08	NMEA Message ID
		0x00: All currently active output messages
		if Data Rate 0 then clear all commands
		0x01 - 0xFF: Individual COMMAND IDs
W4	U08	Reserved
W5	U16	Data rate (x 1 second)
		0x0001 to 0x1770: begin data output at this rate
		Data rate – special (ALM not supported)
		0x0000: output data at once, or else stop
		ALM not supported
		0x2000: output data on external trigger
		Supports (GGA, GLL, RMC, VTG)
		0x4000: output data at Navigation Rate
		0x80nn: Output per SV (ALM only)
		0 -- all SV's
		nn – Only Satellite nn
...		
CKSUM	U08	

NMEA Message ID's

ALM	0x01
GGA	0x02
GLL	0x03
GSA	0x04
GSV	0x05
RMC	0x06
VTG	0x07
ZDA	0x08
GST	0x09
SET	0x0A

1: Complete message ID is **$GPxxx** where **xxx=above ID except in case of SET, see note 3.**

- 2: GGA may be output at up to a 10 Hertz rate by selecting 0x4000 in versions greater than 2.04.
- 3: SET is a NavCom proprietary NMEA message of the form: $PNCTSET. See Special ASCII Output Message Definitions

0x22 - CMR Control - Variable Length

Request output of CMR message 0, 1 and 2. The CMR request is made by using the following message, 0x22.
For CMR: (Wn1,Wn2,Wn3) should be (0x00, 0x00, 0x0nnn), (0x01, 0x00, 0x00nn)
For CMR+: (Wn1, Wn2, Wn3) should be (0x05, 0x00, 0x0001)

Command ID	U08	0x22
Msg. Len.	U16	00xx
W1	U08	Command Action B1=1: Store in NVRAM B3=1: Use default values B4=1: Clear all present CMR messages
W2		
…	U08	Reserved
Wn1	U08	CMR message ID
Wn2	U08	Reserved
Wn3	U16	Data rate (seconds) 0x0000 Turns off the message 0x0001 to 0x1fff Data Rate (every n seconds) 0x2xxx is not used 0x4000 on Change (1 Hz) 0x8xxx is not used
…		
Checksum	U08	

:

a. Wn1 through Wn2 is repeated for each block , as applicable. CMR0 is the Observables. CMR1 is the reference station's position. CMR2 is the description of the reference site.
b. No blocks come out if the reference position has not been installed with message 0x51 (Self Survey Block).
c. These blocks require a RTK Base license for sending and a RTK Rover license for receiving
d. The 0x5f message can be used to configure a wrapper port using the 'C' preamble.

0x2c - Ghost ID Block - 10 bytes

Command ID	U08	0x2c	
Msg. Len.	U16	0x000a	(10 Bytes)
W1	U08	Action Code	
		B1=1:	Store message in NVRAM
		B2=1:	Use ACK/NAK
		B3=1:	Use Default Values
W2	U08	Reserved	
W3	U16	Ghost ID (Default is the 16 bit portion of digital board serial number.	
W4	U16	network ID	
Checksum	U08		

0x30 - Software Options Entry - 17 bytes

COMMAND ID	U08	0x30
MSG. LEN.	U16	0x0011 for system 2000
MSG. LEN.	U16	0x0035 for system 2100
W1	U08	Command Action B1: Don't Care -- Block stored in NVRAM. B2=0: Do not use ACK/NAK. B2=1: Use ACK/NAK. B3=0: Use Commanded Values. B3=1: Use Default value.
Data stream used by system 2000		
W2	U08[12]	Data stream.
Data stream used by system 2100		
W2	U08[48]	Data stream.
Checksum	U08	

Output of software options configuration, in message 0x30, is defined on next page:

0x30 - Software Options Output - 19 bytes

Command ID	U08	0x30
Msg. Len.	U16	0x0013
W1	U08	Block Format
W2	U16	Serial Number Main
W3	U08	Serial Number Modifier
W4	U08	NavRate 5, 10, 25 Hz
W5	U08	DataRate 2:5Hz 3:10Hz 4:25Hz 5:50Hz
W6	U08	L1 Only 1:L1 only (No Dual Frequency
W7	U08	WAAS 0:No WAAS Satellite Tracking
W8	U08	RTCM Base 0:None 1:Static Base 2:Static/Dynamic Base
W9	U08	RTCM Rover 0:No RTCM Use 1:Use RTCM
W10	U08	RTK Base 0:No RTK Base 1:RTK Base Allowed
W11	U08	RTK Rover 0:No RTK Rover 1:RTK Rover Allowed
W12	U08	Starfire License 0: Active NCT-2000D License 1:Active Starfire License
W13	U08	Maximum Radio power 0 – 10 mW 1 – 50 mW 2 – 100 mW 3 – 250 mW 4 – 500 mW 5 – 750 mW 6 – 1000 mW 0xff – Radio Power Off
W14	U08	Radio hopping pattern (0-48)
Checksum	U08	

W12 indicates that software options are controlled by external licenses (i.e. StarFire).

It should be noted that NCT-2000D software options have no expiration time. They are good until changed. The options are defined as follows:

- L1 Only
- Allow WAAS corrections. Will not track WAAS satellites unless this option is enabled.
- Allow Navigation rates above 5 Hz. The license may be limited to either 10 or 25 Hz.
- Allow Measurement rates above 5 Hz. License may be limited to 10/25/50Hz.
- RTCM base support option. The software license allows the user to generate RTCM 104 differential corrections. The blocks presently supported are 1, 3, 9, 16 and 22. Types 18/21 are also available if RTK options are enabled. The options can be configured to support static base dGPS corrections or a future capability, which allows dynamic base corrections. Dynamic dGPS base allows the base to move.
- RTCM Rover license. Required for the user to use RTCM corrections in navigation.
- RTK base option. Required for the NCT-2000D to output RTK corrections.
- RTK Rover license. Required to accept and use RTK correction block.
- Maximum radio power. Sets the maximum power level the radio is allowed to transmit.
- Radio hopping pattern. Sets the hopping pattern that the radio can operate.

Entry of software options is completed using message 0x30.

0x3f - LED configuration block (Integrated Systems) - Variable Length

Command ID	U08	0x3f
Msg. Len.	U16	0x00xx
W1	U08	Command Action
		B1=1: Store in NVRAM
		B6=1: Use Factory NVRAM
		B6=0: Use User NVRAM
		B2=1: Use ACK/NAK
		B3=1: Use Default Values.
W2	U08	Generation (Presently equals 0)
W3	U08	Link Selection
		0x00: Micro Hard Radio Discrete
		0x01: Radio Port I/O
		0x02: Port A I/O
		0x03: Port B I/O
		0x04: LBM Port I/O
		0x05: LBM Signal Level
		0x06: CAN BUS Activity
		0x07: Log Port I/O
		0x08: RTK Proprietary Output
		0x09: RTK CMR Output
		0x0a: RTK RTCM Output
		0x0b: RTCM Output
W4	U08	Battery Test Duration (RT series only)
		0: Ignore this value
		1: Use Default (20 Seconds)
		2-9: Undefined
		10-254: Use this duration
		255: Battery LEDs always blinking.
Checksum	U08	

0x42 – RTG QuickStart Control

This message allows the StarFire RTG navigation solution to be initialized to a known position and therefore eliminate lengthy pull-in times. This message is used for both commands to the Starlight and responses from the Starlight.

Command ID	U08	0x42	
Msg. Len.	U16	0x0019	
W1	U08	Command Action	
			B1=0: Do not store in NVRAM
			B1=1: Store in NVRAM
			B2=0: Do not use ACK/NAK
			B2=1: Use ACK/NAK
			B3=0: Use Commanded Values
			B3=1: Use Default values
W2	U08	Mode	
			0x00: IDLE
			0x01: RESET
			0x02: INITIATE/INITIATED
			0x03: IN PROGRESS
			0x04: COMPLETE
			0x05: FAILED PROXIMITY
W3	S32	Latitude (LSB = 2.0e-11 arcseconds)	
W4	S32	Longitude (LSB = 2.0e-11 arcseconds)	
W5	S32	Height (LSB = 2.0e-10 meters)	
W6	U04	Extended Latitude (LSB = 2.0e-15 arcseconds) (B7…B4)	
	U04	Extended Longitude (LSB = 2.0e-15 arcseconds) (B3…B0)	
W7	U16	Latitude Uncertainty (LSB = 2.0e-11 sq. meters)	
W8	U16	Longitude Uncertainty (LSB = 2.0e-11 sq. meters)	
W9	U16	Height Uncertainty (LSB = 2.0e-11 sq. meters)	
CKSUM	U08		

On **input** to Starlight, the **Mode** field contains one of the following values:

- 0x00 - IDLE
  Cancels an initiated or in progress QuickStart without resetting RTG navigation. Also can be used to return the reported QuickStart mode to 'Idle' from either 'Completed' or 'Proximity Failure' as described in 1b) above.

- 0x01 - RESET
  Cancels an initiated or in progress QuickStart and causes a full reset of RTG navigation.

- 0x02 - INITIATE
  Initiates a QuickStart based on the latitude, longitude and height input from the corresponding fields in the x42 message.

On **output** from StarLight, the **Mode** field contains one of the following values::

- 0x00 - IDLE
  Following power-on and prior to any QuickStart having been requested, the QuickStart mode is reported as 'Idle'. Once a QuickStart has been initiated, the 'Idle' mode will not be reported again until one of the following occurs:
    - Power is cycled on the unit.
    - A QuickStart 'Idle' has been requested. If a QuickStart has been initiated and is still in progress, this will cancel it but not reset RTG navigation. This may result in only partial completion of the operation. If the reported QuickStart mode indicates successful completion or proximity failure, this request will return the reported QuickStart mode to 'Idle'.
    - A QuickStart 'reset' request has been requested. This causes a restart of the entire RTG navigation mode with no a-priori position information i.e. full pull-in duration.

- 0x02 - INITIATED
  This mode is reported after a QuickStart initiation request has been received but before the QuickStart operation has actually started. The QuickStart operation will not begin until RTG navigation commences. This requires at least five satellites each with full dual frequency tracking and at least 10 seconds of code-carrier smoothing. If, for example, a QuickStart initiation request is given shortly after power-on, it may be a few minutes before these conditions are met. During this period, the reported QuickStart mode would be 'Initiated'.

- 0x03 - IN PROGRESS
  This mode is reported after a QuickStart has actually commenced up until the time that either the operation completes or fails or until an 'Idle' or 'Reset' request are received.

- 0x04 - COMPLETE
  This mode is reported when a QuickStart operation has completed successfully. It takes 50 seconds from the time the QuickStart first begins (In Progress reported) until successful completion is reported.

- 0x05 - FAILED PROXIMITY
  While a QuickStart operation is in progress, a check is performed at each 1Hz navigation epoch which compares the 3D radial distance between the RTG code solution and the 'known' position input with the QuickStart initiation request. If this distance excedes 25 meters on the first QuickStart epoch or 15 meters on any of the subsequent epochs in the 50 second period, the QuickStart is terminated, RTG navigation is reset (full pull-in required) and the QuickStart mode is reported as 'Failed Proximity Limit'. The RTG code solution is the weighted least squares navigation solution performed with smoothed code (could be single or dual frequency depending on prefilter status) and RTG clock and orbit corrections. It is independent from the full RTG solution which uses the phase biases estimated by the RTG extended Kalman filter. It is the latter which is initialized by a QuickStart operation.

0x44 - Packed Almanac loading - 44 bytes

From a cleared memory without an almanac present, it takes about 13 minutes after satellite lock to obtain and display complete almanac information. With an almanac present, it takes only a matter of seconds.

This message contains navigation data corresponding to data-words 3 through 10 (without parity) of the specified page and subframe. The entire message is repeated 35 times, once for each of the pages/subframes containing pertinent almanac entries. The Almanac data subframes for SV PRNs 1 - 32 is sent first, in that order. The final 3 messages consist of those pages/subframes containing ionosphere and UTC parameters, AS flags, SV configuration and SV health. ACK/NAK (W1, B2) messaging is used to maintain integrity of the full almanac set.

Command ID	U08	0x44
Msg. Len.	U16	0x002C
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRam B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B6=1: Factory NVRam B6=0: User NVRam
W2	U16	GPS week of collection
W3	U32	Time of the week of collection
W4	U16	Almanac reference week
W5	U32	Almanac reference time
W6	U08	Almanac health
W7	U08	Almanac source SV
W8	U08	Data ID 0x01 - 0x19: Page number (1 to 25) B7=0: Subframe 4 B7=1: Subframe 5
W9	U08	Data byte 01
...		
W32	U08	Data byte 24
CKSUM	U08	

1: For multiple command actions, the bits in W1 may be OR'ed.

2: Words W9 through W32 contain the 24 bytes of packed GPS navigation message data corresponding to data-words 3 through 10 (without parity) of the specified page and subframe.

3: Entire message will be repeated 35 times, once for each of the pages/subframes containing pertinent almanac entries. Almanac data subframes for SV PRNs 1 - 32 will be sent first, in that order. The final 3 messages will consist of those pages/subframes containing ionosphere and UTC parameters, AS flags, SV configuration and SV health; the order will be Page18/Subframe4, Page25/Subframe4 and Page25/Subframe5.

4: Use ACK/NAK (W1, B2) messaging to maintain integrity of the full almanac set.

5: Block cannot be set to output based on trigger or by data rate. Only 'on change', 'by SV', and 'NOW' can be requested.

0x46 - Initial Time and Position - 32 bytes

GPS Navigation is accelerated if the receiver has time, date, position, and almanac. This message presents the time of day and the initial position to the receiver by entering the GPS Week, Time of Week, Latitude and Longitude.

COMMAND ID	U08	0x46
MSG. LEN.	U16	0x0020
W1	U08	Command Action B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK
W2	U08	Usage flags B0=0: Do not set time B0=1: Set time B1=0: Do not set initial position B1=1: Set initial position
W3	U16	GPS week (0 -65535)
W4	U32	GPS time of week (seconds)
W5	R64	WGS84 Latitude (radians, +North)
W6	R64	WGS84 Longitude (radians, +East)
W7	R32	WGS84 Ellipsoidal height (meters)
CKSUM	U08	

1: For multiple command actions, the bits in W1 may be OR'ed.

0x47 - SV Tracking Control - 36 bytes

SV Tracking information is entered using the SV Tracking Control message assigning elevations masks, SV channels, and reservation using words 2 through 5.

COMMAND ID	U08	0x47
MSG. LEN.	U16	0x00XX
W1	U08	Command Action
		B1=0: Do not store in NVRAM
		B1=1: Store in NVRAM
		B2=0: Do not use ACK/NAK
		B2=1: Use ACK/NAK
		B3=0: Use Commanded Values
		B3=1: Use Default values
W2	U08	Elevation mask (0x00, 0 degrees default)
		Range: 0x00 - 0x5A (0 -90) [degree]
W3	U08	Reserved
W4	U08	SV/Channel assignment mode
		B0=0: Automatic assignment mode
		B0=1: Manual assignment mode
		Automatic SV assignment controls:
		B1= Reserved
		B2=0: Do not use SV reservation flags
		B2=1: Use SV reservation flags
		0x00: No minimum
W5	U32	SV reservation flags (B0 - B31 = PRN01 - PRN32)
		Bn=0: Only track if a channel is available
		Bn=1: Always track as long as possible
		Manual SV-to-channel assignment
W6	U08	Assign PRN to chan 1 (00=not assigned)
...		
Wx	U08	Assign PRN to chan n (00=not assigned)
CKSUM	U08	

1: For multiple command actions, the bits in W1 may be OR'ed.

2: The number of bytes is dependent on the number of channels.

3: To avoid control conflicts, parameters have following priority:

Highest	1)	Manual/Auto	W4-B0
	2)	Exclude by [< Elevation mask] & [unhealthy]	W2&0x48
	3)	Always track SV...	W5-Bn=1
	4)	Highest SVs	W4-B1

0x48 - SV Health Override Control - 6 + (2 x N) bytes

This message controls satellite health override as controlled by word 3, which in turn affects channel assignments.

Command ID	U08	0x48
Msg. Len.	U16	
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use Commanded Values B3=1: Use Default values
W2	U08	Reserved
W3	U16	SV to override 0x01 - 0x20: (1 to 32) SV PRN B6=0: Use broadcast health B6=1, B7=0: Force PRN healthy B6=1, B7=1: Force PRN unhealthy
...		
Checksum	U08	

- 1: For multiple command actions, the bits in W1 may be OR'ed.
- 2: W3 is repeated N times for multiple SVs.
- 3: All SVs revert to broadcast ephemeris health upon **default** (W1, B3=1).
- 4: Health override affects channel assignment.

0x49 - Solution Control - 26 bytes

This message describes the observable satellites to be used, the minimum number of SVs for solution, the maximum PDOP for solution, the elevation mask, constraint flags, height to be constrained, differential mode control, differential data to old time, DGPS station ID and Navigation Update rate, and also allow the user to implement a vertical or slope antenna bias, as defined by message 0x4b.

Command ID	U08	0x49
Msg. Len.	U16	0x001A
W1	U08	Command Action B1=1: Store message in NVRAM B2=1: Use ACK/NAK B3=1: Use Default Values
W2	U08	Observables to be used 0x00 Best available (Default)
W3	U08	Minimum number of SVs for solution (Default: 3) Range (3-10)
W4	U08	Maximum PDOP for a solution (Default: 0x64, 10) LSB=0.1 – Range is 0 to 25.5
W5	U08	Elevation Mask -- in Code Based Navigation Range is 0 to 90 (Default: 7 degrees)
W6	U08	Constraint flags B0:1 = Constrain Height; 0 = solve height (Default) B1:1 is iono correction enabled (Default) B2:1 Tropo-Correction enabled (Default) B3:1 is Tropo-Correction of dGPS messages (Valid only for RTCM type 1 and 9 msgs) Default is off. B4:0 is auto transition from 3D and 2D (Default) B5:0 is to use last known 3D height if available. (Default) 1 is to use entered height B6: Used to Enable SET B6: 1 is Apply SET correctors to navigation fix B6: 0 is do not use SET correctors B7:1 is to adjust vertical (height) by indicated bias (From 0x4b) (Affects output of message 0xb1.) Default is off (0).
W7	R32	Entered Constrained Height (meters above ellipsoid)
W8	U16	Differential Mode Control B0:(1 Default) Use Differential Corrections B1:(1) No solution without Corrections; (0-Default) Use when available B2:(1) DO NOT use Tgd (Group Delay) Applicable to RTCM messages 1 and 9 (0-Default) Use Tgd B3:(1) Invert sign of RTK Observables for Phase B4:(1) No RTK Navigation B5:(1) No RCP Navigation (Applicable to RTG and WCT only)

B6:Reserved
B7:(1-Default) Use Dual Frequency Measurements in Navigation.Transitions to navigation mode where only satellites producing Dual Frequency measurements are used.
B8:(1) Ignore RTCM Type 1 and 9 messages
B9:(1) Ignore RTCM RTK Messages (18-21)
B10:(1) Ignore WCT
B11:(1) Ignore RTG
B12:(1) Ignore WAAS
B13:(1) Ignore CMR
B14:(1) Ignore NCT RTK Blocks 0x5b, 0x5c, and 0x5e
B15:(1) Ignore RTG Extend

W9	U08	dGPS data too old time (Lsb 5 seconds) Default: 300 seconds, 5*60. (Non-RTK)
W10	U16	DGPS Station ID (RTCM) 0x0000: Use any station 0x0001-0x03ff: Use station (1-1023 Only)
W11	U08	Navigation Update Rate (n Hz) 0 – Ignore, use present rate 1,2,5 Selects applicable rates 10 and 25 if available
W12	U08	NMEA Options B0 = 1: NCT GGA Reference Station ID format B0 = 0: Use NMEA definition B1-7: Reserved
W13	U08	Reserved
Checksum	U08	

:

a) Priority of RTK input are as follows:
- NCT messages 0x5e and 0x5b
- RTCM Messages (Type 20 and 21)
- CMR and RTCM Messages (Type 18 and 19)

Blocks listed at the same level indicate that the system will keep with the active one until it is lost. A higher class will replace the active stream immediately.

b) Priority of Code Based Navigation dGPS Correction Inputs are as follows:
- RTK inputs (See above)
- RTG (Starfire Network)
- WCT (Starfire Network)
- RTCM Messages (Type 1 and 9)
- WAAS Corrections

0x4a - Vehicle Dynamics - 6 bytes

A new vehicle dynamics block, 0x4a, has been created to allow a user to indicate the maximum acceleration the NCT-2000D may see. The default value is 1g.

Command ID	U08	0x4a
Msg. Len.	U16	0x0006
W1	U08	Command Action
		B1=1: Store in NVRAM
		B2=2: Use ACK/NAK
		B3=1: Use default values.
W2	U08	Nominal maximum g seen by receiver
		0: Static or survey user.
		1: Land/Sea 1g.
…		
		6: Maximum value
Checksum	U08	

0x4b - Vertical Height Adjustment - 10 bytes

Message 0x4b is an implementation of a special surveyor block that allows the user to translate the output position vertically in one dimension from the tripod to a spot on the ground. The block, message 0x4b, is defined as follows:

Command ID	U08	0x4b	
Msg. Len.	U16	0x000a	Length is 10 bytes
W1	U08	Command Action	
		B1=1: Store in NVRAM	
		B2=1: Use ACK/NAK	
		B3=1: Use default values. (All zeroes)	
W2	S08	Phase Center Adjustment (H1) Units are millimeters	
W3	S16	Slant range of Antenna body.	
W4	S16	Radius of antenna body (R). Units are millimeters	
Checksum	U08		

0x50 - RTK Base Control - 10 bytes

Command ID	U08	0x50
Msg. Len.	U16	0x000A
W1	U08	Command Action
		B1=0: Do not store in NVRAM
		B1=1: Store in NVRAM
		B2=0: Do not use ACK/NAK
		B2=1: Use ACK/NAK
		B3=0: Use Commanded Values
		B3=1: Use Default values
W2	U08	Elev Mask (degrees)
W3	U08	Min P1P2 use count
W4	U16	Site ID
W5	U08	Reserved
Checksum	U08	

0x51 - Self Survey Control - 4 + n bytes

This message controls Self Survey by determining the number of seconds the survey is averaged, the initial Latitude and Longitude entered, the ellipsoidal height and the Latitude and Longitude LSBs as determined through words 2 through7.

Command ID	U08	0x51
Msg. Len.	U16	0x00xx
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM Only available for modes 4, 5 B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK
W2	U08	Mode 0 Off (Turn off Self Survey) 1 On (Start Self survey) 2 On 12 (Start Self survey, auto-lock after 12 hours) 3 On 24 (Start Self survey, auto-lock after 24 hours) 4 Locked (Lock present Survey Point) 5 Entered (Survey point follows) 6 Empty (Output only – No Data Available)
W3	U32	# of seconds averaged (0 indicates Entered Value)
W4	S32	Latitude (Lsb 2^-11 arc Seconds) (1.5 cm)
W5	S32	Longitude (Lsb 2^-11 arc Seconds) (1.5 cm)
W6	S32	Ellipsoidal Height (Lsb 2^-10 meters)
W7	U08	B7-B4: Latitude Lsb's (Lsb 2^-15, 1 mm) Always + B3:B0: Longitude Lsb's (Lsb 2^-15, 1 mm) Always +
W8	U08	Reserved
Checksum	U08	

0x52 - RTCM Output Control - 16 bytes

Supported message blocks were types 1, 3, 9, 16, 18, 19, 20, 21, and 22. It should be noted that Type 22 is sent as applicable as an “extension” to Type 3 (Immediately following). Message type 18 and 19, 20 and 21, are controlled by bits in W2 at the rate defined in W8.

Command ID	U08	0x52
Msg. Len .	U16	0x10
W1	U08	Command Action
		B1=1: Store in NVRAM.
		B2=1: Request ACK
		B3=1: Use Default Values
W1 (Output)	U08	B7=1: RTCM Correction Active
		B6=1: RTCM Correction Requested
		B5=1 Reference Position Available
		B4=1: Dynamic RTCM mode
		B3=1: RTK output Active
W2	U08	Control
		B0: 0-Type 1; 1-Type9
		B1: 1-Do Not Correct for Tgd
		B2: 1-Invert Sign of Phase in RTK Observables
		B3: 1-Dynamic RTCM; 0-Static from Survey Point
		B4: 1-Send extended reference position (Type 3 & 22)
		B5: 1-Output RTK corrections/Observables
		B6: 0-RTK Observables Type 18/19 1-RTK Corrections Type 20/21
		B7 1-Output Code Corrections (Type 1 or 9)
W3	U16	B9-B0: Station id
		B15-B10: Reserved
W4	U16	Max Bit Rate (Bits per second)
		0 is ignore; else, override correction rates
W5	U16	Code Correction Rate (zero is 1 Hz; else, every N seconds)
W6	U08	Type 3/22 Message Rate (One output ever N corrections)
		0 defines no output.
W7	U08	Type 16 Msg Rate. (One output ever N corrections)
		0 defines no output.
W8	U08	RTK Correction/Obs Rate (One output ever N seconds)
		0 is 1 Hz output
W9	U08	Reserved
Checksum	U08	

0x53 - RTK Navigation Control - 11 bytes

Message 0x53 provides RTK Nav Control.

Command ID	U08	0x53
Msg. Len.	U16	0x000B
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use Commanded Values B3=1: Use Default values
W2	U08	Min Prn Elevation mask used in RTK search (degrees).(**10**)
W3	U08	Min Prn Elevation mask used in RTK navigation (degrees).(**10**)
W4	U08	Min Prn Elevation mask used in RTK code fix (degrees).(**7**)
W5	U08	Min Prn Elevation mask to begin P1P2 smoothing (degrees).(**7**)
W6	U08	Min P1P2 smooth count to use in navigation. (**100**)
W7	U08	Max RTK Correction Age (Seconds). (**3 Sec**)
Checksum	U08	

0x55 - WAAS Satellite List - 8 bytes

This block yields control of what WAAS satellites are to be used. This will allow users to force the use of satellite 120 over the Atlantic (Egnos). The default list is Satellites 134 and 122.

Command ID	U08	0x55
Msg. Len.	U16	0x0008
W1	U08	Command Action
		B1=0: Do not store in NVRAM
		B1=1: Store in NVRAM
		B2=0: Do not use ACK/NAK
		B2=1: Use ACK/NAK
		B3=0: Use Commanded Values
		B3=1: Use Default values
W2	U08	WAAS PRN Selection 1
W3	U08	WAAS PRN Selection 2
W4	U08	Reserved
Checksum	U08	

1: For multiple command actions, the bits in W1 may be Or'ed.

2: W1 on retrieve contains number of WAAS capable channels.

0x56 - CMR Message Type 2 Input - Variable length

Define CMR message 2 data for output.

Command ID	U08	0x56
Msg. Len.	U16	0x00xx
W1	U08	Command Action
		B1=1: Store in NVRAM
		B3=1: Use default values
W2	U08	Length of Long Station Descriptor
W3	U08[8]	Short Station Id (ASCII)
W4	U08[16]	COGO Code
W5	U08[50]	Long Station Descriptor (ASCII - Variable length)
Checksum	U08	

0x5a - RTK Site ID Request - 8 bytes

RTK Site ID Request block, message 0x5a., has been installed. This block will allow a user to force the NCT-2000D to only use RTK messages 0x5b, 0x5c and 0x5e with the requested Site ID. A zero value indicates that any site may be used.

Command ID	U08	0x5a
Msg. Len.	U16	0x0008
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use commanded values B3=1: Use default values
W2	U08	Reserved
W3	U16	Site ID (0 indicates none selected, which is the default)
Checksum	U08	

0x5b - RTK Correction Message - 4+12+(n*18) bytes

This block has been added to extend the range of the corrections from +/-256 to +/-4096. The block length is the same as RTK correction block 1 (0x5e), however the p1 correction has been removed from the block. (Input block will echo if 0xfb output scheduled.)

Command ID	U08	0x5b
Msg. Len.	U16	0x00xx
W1	U08	Command Action
		B2=0: Do not use ACK/NAK
		B2=1: Use ACK/NAK
W2	U08	Count of corrections in message.
W3	U16	GPS Week Number.
W4	U32	GPS seconds in week.
W5	U16	Site ID
…		
Ws1	U08	Status
		B0-B4 Prn.
		B5 P2L2 valid.
		B6 P12 valid.
		B7 CAL1 valid.
Ws2	U08	IODE
Ws3	S16	CA Code Correction (1/8 m)
		Contain the most significant 16 bits of code correction.
Ws4	S16	P2 Code Correction (1/8 m)
		Contain the most significant 16 bits of code correction.
Ws5	U08	Code Corrections lsb's
	*U04	B0-B3 CA Code Correction (1/128 m)
		Least Significant bits of Ws3
	*U04	B4-B7 P2 Code Correction (1/128 m)
		Least Significant bits of Ws4
Ws6	S24	L1 Carrier Correction (1/2048 m)
Ws7	S24	L2 Carrier Correction (1/2048 m)
Ws8	U16	Smooth Count and P1.2 code correction lsb's
	*U04	B0-B3 P1.2 Code Correction (1/128 m)
		Least Significant bits of Ws9
	*U12	B15-B4 contains smooth count
Ws9	S16	P1.2 Code Correction(1/8 m)
		Contain the most significant 16 bits of code correction.
Ws10	U08	Slip counts
	U04	B0-B3 L1 Slip counter
	U04	B4:B7 L2 Slip counter
…		
CRC	U16	CRC Term
Checksum	U08	

1: Range of Corrections limited to less than +/- 4096 meters.

2: CRC covers data from W1 to CRC entry.

3: If Survey position greater than 1 km from navigation solution, the RTK correction blocks (0x5b/0x5e) will not be output. Furthermore, the message 0x5c, the RTK reference position block, will be output with an unhealthy indication and a site id of 0xffff.

0x5c - RTK Base Position - 22 bytes

Message 0x5c, the NCT Proprietary RTK base position block has been extended to provide additional precision and new information to support certain survey applications. W7 has been added to this block. The length of the block should be the indicator of the availability of W7.

The NCT-2000D must be able to receive the older message where W7 does not exist.

Command ID	U08	0x5c	
Msg. Len.	U16	0x0016	
W1	U08	Command Action	
		B2=0: Do not use ACK/NAK.	
		B2=1: Use ACK/NAK	
		B4=1: Contains CRC term.	
W2	U08	Site Health	
W3	U16	Site ID	
W4	S32	ECEF(x) – LSB 1 centimeter	
W5	S32	ECEF(y) – LSB 1 centimeter	
W6	S32	ECEF(z) – LSB 1 centimeter	
CRC	U16	CRC Term	
W7	U16	ECEF LSB's (Units: 1mm) and Base Status	
		B15-B12:	U04 ECEF (x) W4
		B11-B8:	U04 ECEF (y) W5
		B7-B4:	U04 ECEF (z) W6
		B3:	Bool Battery Low
		B2-B0:	Spare
Checksum	U08		

0x5c Coding Example

```
void decode_x5c(U08* data, int len)

{

double BaseSite_X, BaseSite_Y, BaseSite_Z;

typedef_msg_x5c x5C;

memset(&x5C, 0, sizeof(typedef_msg_x5c)); // zero out memory incase message is too short

memcpy(&x5C, data, min(sizeof(typedef_msg_x5c), len)); // copy into structure

BaseSite_X = (x5C.x / 100.) + (x5C.xExtended / 1000.); // access data

BaseSite_Y = (x5C.y / 100.) + (x5C.yExtended / 1000.);

BaseSite_Z = (x5C.z / 100.) + (x5C.zExtended / 1000.);

return;

}
```

0x5d – Base Station RTG/RTK Position Vector delta (42 bytes)

Command ID	U08	0x5d
Msg. Len.	U16	0x00xx
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use Commanded Values B3=1: Use Default values
W2	U08	dGPS source
W3	R64	deltaX (RTK – CodeNav) in meters
W4	R64	deltaY (RTK – CodeNav) in meters
W5	R64	deltaZ (RTK – CodeNav) in meters
W6	U32	Accrued runtime in navMode [secs]
W7	U32	GPS tow time stamp for sending msg [secs]
W8	U16	CRC term
W9	U08	Whether this delta vector is valid
W10	U08	Reserved
Checksum	U08	

0x5e - RTK Correction - 4+12+(n*18) bytes

RTK base corrections block, 0x5e. (Input block will echo if 0xfe output scheduled.)

Command ID	U08	0x5e
Msg. Len.	U16	0x00xx
W1	U08	Command Action
		B2=0: Do not use ACK/NAK.
		B2=1: Use ACK/NAK
		B4=1: Contains CRC term.
W2	U08	Count of corrections in message.
W3	U16	GPS Week Number
W4	U32	GPS seconds in week
W5	U16	Site ID
…		
Ws1	U08	Status
		B0-B4 Prn
		B5 P2L2 valid
		B6 P12 valid
		B7 CAL1 valid
Ws2	U08	IODE
Ws3	S16	CA code Correction (1/128 m)
Ws4	S16	P1 code Correction (1/128 m)
Ws5	S16	P2 code Correction (1/128 m)
Ws6	S24	L1 Carrier Correction (1/2048 m)
		B4-B23 Correction.
		B0-B23 Cycle slip counter
Ws7	S24	L2 Carrier Correction (1/2048 m)
		B4-B23 Correction.
		B0-B23 Cycle slip counter
Ws8	U16	P1P2 smooth count.
Ws9	S16	P1P2 code correction
…		
CRC	U16	CRC Term
Checksum	U08	

If Survey position greater than 1 km from navigation solution, the RTK correction blocks (0x5b/0x5e) will not be output. Furthermore, the message 0x5c, the RTK reference position block, will be output with an unhealthy indication and a site id of 0xffff.

0x5f - Special Support Block - Variable Length

This message contains correction information, and is used for a variety of special control features.

Command ID U08 0x5f
Msg. Len. U16 0x00xx (variable length)
W1 U08 Command Action
B2=1: Use ACK/NAK
W2 U08 Sub ID (see below)
…
Checksum U08

- Sub ID W2= 'S'
  W2 U08 'S'
  W3 U08 Correction Identification
  B2-B0: Reserved
  B7-B3: Message ID
  W4 U08 Msg. Len.
  W5 U08[variable/ max 255] Data
  W6 U16 CRC
  W7 U08 Space
- Sub ID W2= 's' Reserved
- Sub ID W2= 'r'StarFire option override
- Sub ID W2= 'W' Set RTCM wrapper (put RTCM in a 0x6f block)
  W2 U08 'W'
  W3 U08 NCT Logical Port
  B0= Data
  B1= Diagnostic
  B2= Control
- Sub ID W2= 'C' Set CMR wrapper (put CMR in a 0x6d block)
  W2 U08 'C'
  W3 U08 NCT Logical Port
  B0= Data
  B1= Diagnostic
  B2= Control
- Sub ID W2= 'N' Set NMEA wrapper (put NMEA in a 0x6e block)
  W2 U08 'N'
  W3 U08 NCT Logical Port
  B0= Data
  B1= Diagnostic
  B2= Control

0x60 - LBM PVT Request block - 18 bytes

This block requests a message 0xcc and also acts as the heart beat for the LBM to NCT 2000D interface. The Physical port that receives a message 0x60 will be set up as the LBM logical port in NCT-2000D. If both an internal and external LBM exists (Not Recommended) the first message 0x60 will define the unit used.

Command ID	U08	0x60
Msg. Len.	U16	0x0012
W1	U08	Action Control
		B2=1: Use Ack/Nak
W2	U32	Reserved (Message 0xd0.W5)
W3	U16	Communication ID (Message 0xd0.W6)
Checksum	U08	

- 1: This block is output to request a PVT block, message 0xcc. PVT response is required.
- 2: 0x60 may be used to turn off internal LBM in NavCom newer SF series receivers.

0x73 - Radio configuration Control Block - Variable Length

This Block is actually multiple blocks sharing the same ID and multiple sub ID's.

- Present data is requested using a special 0x73 message rather than the more conventional message 0x20. The request command appears as follows:

Command ID	U08	0x73	
Msg. Len.	U16	0x0008	
W1	U08	0x00	
W2	U08	0x00	Sub ID
W3	U08	Block Request	
		0x01: Operation Mode (Master/Slave)	
		0x02: Radio Power Setting	
		0x04: FEC	
		0x08: HOP Pattern	
		0x10: HOP Interval	
		0x20: Packet Control	
		0x40: Roam Control	
		0x80: Remote Control	
W4	U08	Port	
		B0=1: Diagnostic Port	
		B1=1: Control Port	
		B2=1: Data Port	
		B3=1: Network Port	
		B4-B7: Reserved	
Checksum	U08		

- Multiple Blocks/Sub ID's can be returned to Default Values using the following special version of Block 0x73. Note this block requires both B3 and B4 to be set in W1.

Command ID	U08	0x73
Msg. Len.	U16	0x0006
W1	U08	Action Control
		B1=1: Store in NVRAM
		B2=1: Use ACK/NAK
		B3=1, B4=1: Use Default values
W2	U08	Sub ID (OR'd Combination of the following)
		0x01: Operation Mode (Master/Slave)
		0x02: Radio Power Setting
		0x04: FEC
		0x08: HOP Pattern
		0x10: HOP Interval
		0x20: Packet Control
		0x40: Roam Control
		0x80: Remote Control
Checksum	U08	

- Using the following block definitions sets radio control parameters. It should be noted that some parameters are limited by factory due to export/import limitations in various

parts of the world. This will be covered later. For now, assume these definitions for USA use.

- Operation Mode (Master/Slave Section) (0x01)

Command ID	U08	0x73	
Msg. Len.	U16	0x0008	
W1	U08	Action Control	
			B1=1: Store in NVRAM
			B2=1: Use ACK/NAK
			B3=1: Use Default values
W2	U08	0x01	Sub ID
W3	U08	Operation Mode	
			0x01: Master (Point to Multi Point)
			0x03: Slave
W4	U08	Spare (0x00)	
Checksum	U08		

- Radio Power Level (0x02)

Command ID	U08	0x73	
Msg. Len.	U16	0x0008	
W1	U08	Action Control	
			B1=1: Store in NVRAM
			B2=1: Use ACK/NAK
			B3=1: Use Default values
W2	U08	0x02	Sub ID
W3	U08	Radio Power Level	
			0 – 10 mW

1 – 50 mW
2 – 100 mW
3 – 250 mW
4 – 500 mW
5 – 750 mW
6 – 1000 mW
0xff: Power Radio Off

W4	U08	Spare (0x00)	
Checksum	U08		

- FEC. (0x04)

Command ID	U08	0x73	
Msg. Len.	U16	0x0008	
W1	U08	Action Control	
			B1=1: Store in NVRAM
			B2=1: Use ACK/NAK
			B3=1: Use Default values
W2	U08	0x04	Sub ID
W3	U08	FEC	
			0x02: No FEC
			0x04: FEC Enabled
W4	U08	Spare (0x00)	
Checksum	U08		

- HOP Pattern (0x08)

Command ID		U08	0x73
	Msg. Len.	U16	0x0008
	W1	U08	Action Control
			B1=1: Store in NVRAM
			B2=1: Use ACK/NAK
			B3=1: Use Default values
	W2	U08	0x08 Sub ID
	W3	U08	Primary Hopping Pattern (0)
	W4	U08	Secondary Hopping Pattern (0)
	Checksum	U08	

- HOP Interval (0x10)

Command ID		U08	0x73
	Msg. Len.	U16	0x0008
	W1	U08	Action Control
			B1=1: Store in NVRAM
			B2=1: Use ACK/NAK
			B3=1: Use Default values
	W2	U08	0x10 Sub ID
	W3	U08	Hopping interval
			1—8 ms
			2 – 12 ms
			3 – 16 ms
			4 – 20 ms
			5 – 30 ms
			6 – 45 ms
			7 – 80 ms
			8 – 120 ms
			9 – 100 ms
	W4	U08	Spare (0x00)
	Checksum	U08	

- Packet Control (0x20)

Command ID		U08	0x73
	Msg. Len.	U16	0x000e
	W1	U08	Action Control
			B1=1: Store in NVRAM
			B2=1: Use ACK/NAK
			B3=1: Use Default values
	W2	U08	0x20 Sub ID
	W3	U08	Minimum Pack Size (1)
	W4	U08	Maximum Packet Size (43)
	W5	U08	Retransmit count (1)
	W6	U08	Slaves and Repeaters use master's limit (0)
	W7	U08	Packet Repeat Interval (Don't Care) (1)
	W8	U08	Packet Character Timeout (8 ms)
	W9	U08	Packet Retry Limit (Don't care) (2)

W10	U08	Spare (0x00)
Checksum	U08	

- Roam Control (0x40)

Command ID	U08	0x73
Msg. Len.	U16	0x0008
W1	U08	Action Control B1=1: Store in NVRAM B2=1: Use ACK/NAK B3=1: Use Default values
W2	U08	0x40
W3	U08	0x00 Disable
W4	U08	Spare (0x00)
Checksum	U08	

- Remote Control (0x80)

Command ID	U08	0x73
Msg. Len.	U16	0x0008
W1	U08	Action Control B1=1: Store in NVRAM B2=1: Use ACK/NAK B3=1: Use Default values
W2	U08	0x80
W3	U08	0x00 Disable
W4	U08	Spare (0x00)
Checksum	U08	

0x75 - Transmit Envelope - Variable Length

This message is used to address a message to a specific NCT integrated receiver on an available network (i.e. turn off RTK base function on a distant unit).

Command ID	U08	0x75
Msg. Len.	U16	0x0xxx
W1	U08	Reserved
W2	U08	HOP count - Number of HOPS
W3	U16	To Address: Ghost ID of Unit (Radio ID) Unit uses internal block if Address matches (W3) Otherwise, Slave Rebroadcasts message and Increments HOP count, if HOP equals 0 (Master will rebroadcast with HOP count at 0 or 1, all messages not addressed to it). All Units will match to broadcast ID (0xc350, decimal 50000)
W4	U16	From Address: Ghost ID of the Unit to respond to.
W5		Internal Block
		B1 Command ID U08 …
		B2 Msg. Len. U16
		B3 W1 …
		…
		Bn Wm end of internal message
		Checksum U08
Checksum	U08	

0x76 - Return Address Envelope - Variable Length

This is a response to message 0x75.

Command ID	U08	0x76
Msg. Len.	U16	0x0xxx
W1	U08	Reserved
W2	U08	HOP - Number of HOPS
W3	U16	To Address: (From of message 0x75) If W3 matches Ghost ID of Unit If HOP count is 1 then block is rebroadcast to Control Port Else NCT-2000D uses block. Otherwise, unit Rebroadcasts message and Decrements HOP count, if HOP not 0.
W4	U16	From Address: Ghost ID of the Unit to respond to.
W5		Internal Block
		B1 Command ID U08
		B2 Msg. Len. U16
		B3 W1 …
		…
		Bn end of internal message
		Checksum U08
Checksum	U08	

0x77 - LBM Power Block - 6 bytes

This block is presently used to force the NCT-2000D/IOP to turn OFF the LBM in a GIS configuration.

Command ID	U08	0x77	
Msg. Len.	U16	0x06	
W1	U08	Action Control	
			B1=1: Store in NVRAM
			B2=1: Use ACK/NAK
			B3=1: Use Default values
W2	U08		0xff: Turn/Leave OFF LBM
			0x00: Turn/Leave ON LBM
			else Undefined (Assumed On)
Checksum	U08		

0x78 - Network Information (request) - 6 bytes

Message 0x78 is a block used to request Network information to be compiled by NCT-2000D and provided to the user. It uses a sub-ID located in W2 to determine what information is requested. (The standard block request process using Message 0x20 does not support this Command.) The length of the message determines if the block is a request or a response. A request message is always 6 bytes. It should be noted that the response from these requests might take a few seconds while the information is gathered.

- Network List (0x01)

REQUEST FOR NETWORK LIST.

Command ID	U08	0x78
Msg. Len.	U16	0x0006
W1	U08	Command Action
		B2: ACK/NAK
W2	U08	0x01: Sub-ID
Checksum	U08	

- RTK Base Location Query (0x02). This query, when entered into a RTK rover, will return the location of the base presently being used for RTK navigation.

REQUEST FOR RTK BASE LOCATION.

Command ID	U08	0x78
Msg. Len.	U16	0x0006
W1	U08	Command Action
		B2: ACK/NAK
W2	U08	0x02: Sub-ID
Checksum	U08	

0x7b - IOP Ping

Request:

Message ID	U08	0x7b
Msg. Len.	U16	0x0006
W1	U08	Command Action B2=1: ACK/NAK desired
W2	U08	Mode = 0x00 (ping request)
Checksum	U08	

Response:

Message ID	U08	0x7b
Msg. Len.	U16	0x0008
W1	U08	Reserved
W2	U08	Mode = 0xff (ping response)
W3	U08	Error code (0=no error)
Checksum	U08	

This block is used to determine connectivity to the IOP. There are certain commands (such as MMC format and MMC status) that can take 10 seconds or longer for a response. The user can send this message for an immediate response during these waits. The user should set the ACK/NAK bit in W1 to get a reply. The reply will be a Message 0x7b with W2 = 0xff. If a mode other than 0x00 or 0xff is specified, and the ACK/NAK bit is set, then the IOP will return a Msg 0x7b with error code 0x30 (NAK_X7B_BadParameter).

0x7c - User Text Message

Command:

Command ID	U08	0x7c
Msg. Len.	U16	0xXXXX (variable)
W1	U08	Action Control B2: ACK/NAK
W2	U08	Mode = 0x00 (command)
W3	U16	File Handle
W4	U08[]	null-terminated text message, max 512 chars
Checksum	U08	

Response:

Command ID	U08	0x7c
Msg. Len.	U16	0x08
W1	U08	Reserved
W2	U08	Mode = 0xff (response)
W3	U16	Error Code (0=no error)
Checksum	U08	

The entire message (including protocol overhead, i.e., 0x02 0x99 0x66 … 0x03) will be copied to the open file. If there is no open file, , the message will be discarded, and if the ACK/NAK bit of W1 was set, the IOP will respond with a message 0x7C error code equal to 0x32 (NAK_BadFileHandle). If the file system cannot be mounted, and if the ACK/NAK bit of W1 was set, the IOP will respond with message 0x7C error code equal to 0x33 (NAK_MMCMountFailure).

The message contains a text string and can be used for incorporating arbitrary user text/comments within a log file.

0x7e – MMC Data Logging Commands and Responses

This message can be sent to the IOP via COM1 (IOP external port) while the IOP is in MMC command mode (see message 0x7b).

This message uses a subID to provide a number of different commands and responses related to the data logging capability of the IOP. When the IOP is in MMC command mode, it directly handles 0x7e messages received on its external port (COM1 of pole mount or black-box units) rather than forwarding them to StarLight for processing. This has the advantage of allowing faster data transfer – in particular the retrieval of log files.

Every 0x7e command and response is of the following form:

Command ID	U08	0x7e
Msg. Len.	U16	0xxxxx
W1	U08	SubID
W2	U08	0x00 = command
0xff = response		
W3	U08[]	SubID dependent data
Checksum	U08	

Some commands use null-terminated file names. In order to preserve word alignment, the length of each file name, including null terminators, should be even. If necessary, an extra null terminator ('\0' character) should be appended to support this requirement. For example, a file name TEST.TXT consists of eight characters plus a null terminator, for a total of nine. An extra null terminator should be added in this case to bring the total number of bytes to ten.

The list of commands and responses is as follows:

0x00 – MMC Status Report

Request:

W1 SubID	U08	0x00
W2	U08	0x00 (request)

Response:

W1 Sub ID	U08	0x00
W2	U08	0xff (response)
W3	U16	Date
		B15-B9: Years since 1980
		B8-B5: Month (1-12)
		B4:B0: Day of Month (1-31)
W4	U16	Time
		B15-B11: Hours (0-23)
		B10:B5: Minutes (0-59)
		B4-B0: Seconds/2 (0-29)
W5	U08	Status Bits
		B7: Memory Mount Failure
		B6: Memory Mounted
		B5: File Open For Write

B4: File Open For Read
B3-B1: Reserved
B0: MMC Hardware Available

W6	U08	Reserved
W7	U32	Memory Size (bytes, including used and unused storage)
W8	U32	Memory Free Space (bytes)

When the IOP is initially powered up, the MMC file system will remain unmounted until the first 0x7c, 0x7d, or 0x7e message is received. At that time, the IOP will attempt to mount the file system. If this fails, the file system will be unusable and subsequent MMC commands will result in responses with the appropriate failure bits set. Once the file system is successfully mounted, it will remain mounted as long as the system remains powered, and the full suite of MMC commands will be available for use.

If the MMC is available and mounted at the time the MMC Status Report Request is received by the IOP, then the response message will include the actual memory size and free space. On the other hand, if the MMC is not available or was unable to be mounted, the memory size and free space will be set to zero.

0x01 –Directory (of files specified by name)

Request:

W1 Sub ID	U08	0x01
W2	U08	0x00 (request)
W3	U16	Page Number
W4	U08[]	File name or mask (Null Terminated String) Supports DOS 8.3 filenames. Supports wild card characters '*' and '?' '?' – Single character wild card '*' – String wild card

Response:

W1 Sub ID	U08	0x01
W2	U08	0xff (response)
W3	U16	Present Date B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W4	U16	Present Time B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)

File List:

W5	U08	Result B1 = 1 – Requested page out of range B2 = 1 – This is the final page B7 = 1 – Memory Mount Failure
W6	U08	Number of Directory Entries in This Page
W7	U16	Page Number
		Repeat for Each Directory Entry:

W(8+6n)	U16	File Creation Date B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W(9+6n)	U16	File Creation Time B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)
W(10+6n)	U16	Last Update Date B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W(11+6n)	U16	Last Update Time B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)
W(12+6n)	U08	File Attributes
W(13+6n)	U08	Reserved
W(14+6n)	U32	File Size (bytes)
W(15+6n)	U08[]	File Name (null-terminated string)

Obtaining a directory of files on the file system generally involves multiple requests. To initiate a directory request, the user should send a directory request specifying a file name mask and setting page number equal to zero. The IOP will respond with a message containing up to 18 directory entries matching the specified file name mask. If there are additional matching entries, bit 2 of W5 will be set to zero, indicating "this is not the final page." In this case, the user should send another request identical to the previous request except with the page number incremented by 1. The IOP will then respond with the next 18 matching entries. This process continues until an IOP response is received with B2=1 in W5. At that time, the user has received directory entries for all matching files.

In order to preserve word alignment, the length of each file name, including null terminators, should be even. If necessary, an extra null terminator ('\0' character) should be appended to support this requirement. For example, a file name TEST.TXT consists of eight characters plus a null terminator, for a total of nine. An extra null terminator should be added in this case to bring the total number of bytes to ten. The same convention will be used for the file names in the response message.

0x02 – Directory (of files specified by date/time)

Request:

W1 Sub ID	U08	0x02
W2	U08	0x00 (request)
W3	U16	Page Number
W4	U08	Control B0=1: Files Before Specified Date B0=0: Files Later Than Or Equal To Specified Date
W5	U08	Spare
W6	U16	Selected Date B15-B9: Years since 1980 B8-B5: Month (1-12)

		B4:B0: Day of Month (1-31)
W7	U16	Selected Time
		B15-B11: Hours (0-23)
		B10:B5: Minutes (0-59)
		B4-B0: Seconds/2 (0-29)

Response:

W1 Sub ID	U08	0x02
W2	U08	0xff (response)
W3	U16	Present Date
		B15-B9: Years since 1980
		B8-B5: Month (1-12)
		B4:B0: Day of Month (1-31)
W4	U16	Present Time
		B15-B11: Hours (0-23)
		B10:B5: Minutes (0-59)
		B4-B0: Seconds/2 (0-29)

File List:

W5	U08	Result
		B1 = 1 – Requested page out of range
		B2 = 1 – This is the final page
		B7 = 1 – Memory Mount Failure
W6	U08	Number of Directory Entries in This Page
W7	U16	Page Number
		Repeat for Each Directory Entry:
W(8+6n)	U16	File Creation Date
		B15-B9: Years since 1980
		B8-B5: Month (1-12)
		B4:B0: Day of Month (1-31)
W(9+6n)	U16	File Creation Time
		B15-B11: Hours (0-23)
		B10:B5: Minutes (0-59)
		B4-B0: Seconds/2 (0-29)
W(10+6n)	U16	Last Update Date
		B15-B9: Years since 1980
		B8-B5: Month (1-12)
		B4:B0: Day of Month (1-31)
W(11+6n)	U16	Last Update Time
		B15-B11: Hours (0-23)
		B10:B5: Minutes (0-59)
		B4-B0: Seconds/2 (0-29)
W(12+6n)	U08	File Attributes
W(13+6n)	U08	Reserved
W(14+6n)	U32	File Size (bytes)
W(15+6n)	U08[]	File Name (null-terminated string)

Obtaining a directory of files on the file system generally involves multiple requests. To initiate a directory request, the user should send a directory request specifying a date and time as well as setting bit 0 of W4 to 1 or 0 depending on whether files before or after the specified date are desired. In the initial request, the page number should be set equal to zero. The IOP will respond with a message containing up to 18 directory entries matching the specified time stamp criterion. If there are additional matching entries, bit 2 of W5 will

be set to zero, indicating "this is not the final page." In this case, the user should send another request identical to the previous request except with the page number incremented by 1. The IOP will then respond with the next 18 matching entries. This process continues until an IOP response is received with B2=1 in W5. At that time, the user has received directory entries for all matching files.

In order to preserve word alignment, the length of each file name, including null terminators, should be even. If necessary, an extra null terminator ('\0' character) should be appended to support this requirement. For example, a file name TEST.TXT consists of eight characters plus a null terminator, for a total of nine. An extra null terminator should be added in this case to bring the total number of bytes to ten. The same convention will be used for the file names in the response message.

0x03 –Delete Files (specified by name)

Request:

W1 Sub ID	U08	0x03
W2	U08	0x00 (request)
W3	U08	Special B7 = 1 B6 = 1 B5 = 0 B4 = 1 B3-B0: Spare (don't care)
W4	U08[]	Filename String (Null Terminated String) Supports DOS 8.3 filenames. Supports wild card characters '*' and '?' '?' – Single character wild card '*' – String wild card

Response:

W1 Sub ID	U08	0x03
W2	U08	0xff (response)
W3	U16	Present Date B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W4	U16	Present Time B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)
W5	U16	Number of Files Deleted
W6	U08	Result B1 = 1 – Incorrect "special" bits (W3) in request B1 = 0 – OK B4 = 1 – Badly Constructed Filename B7 = 1 – Memory Mount Failure
W7	U08	Reserved
W8	U08[]	Filename String (Null Terminated String) Supports DOS 8.3 filenames. (Copy of filename from request message.)

Supports wild card characters '*' and '?'
'?' – Single character wild card
'*' – String wild card

In order to delete files, the user should send a request message with the "special" bits of W3 specified as above. (This is a safety feature to guard against inadvertent erasure.) The user should also specify a file name mask. Any files matching this mask will be irretrievably deleted from the file system.

The response from the IOP includes a result bit (bit 1 of W6) which will be set to 1 if the "special" bits in the request were set incorrectly. Otherwise, bit 1 of W6 will be zero, and the response will indicate the number of files successfully deleted. In W8, the response will contain a copy of the file name mask from the request message.

In order to preserve word alignment, the length of each file name, including null terminators, should be even. If necessary, an extra null terminator ('\0' character) should be appended to support this requirement. For example, a file name TEST.TXT consists of eight characters plus a null terminator, for a total of nine. An extra null terminator should be added in this case to bring the total number of bytes to ten. The same convention will be used for the file names in the response message.

0x04 –Delete Files (specified by date/time)

Request:

W1 Sub ID	U08	0x04
W2	U08	0x00 (request)
W3	U08	Special
		B7 = 1
		B6 = 1
		B5 = 0
		B4 = 1
		B3-B1: Spare (don't care)
		B0=1: Files Before Selected Date
		B0=0: Files Since Selected Date
W4	U08	Spare
W5	U16	Selected Date
		B15-B9: Years since 1980
		B8-B5: Month (1-12)
		B4:B0: Day of Month (1-31)
W6	U16	Selected Time
		B15-B11: Hours (0-23)
		B10:B5: Minutes (0-59)
		B4-B0: Seconds/2 (0-29)

Response:

W1 Sub ID	U08	0x04
W2	U08	0xff (response)
W3	U16	Present Date
		B15-B9: Years since 1980
		B8-B5: Month (1-12)
		B4:B0: Day of Month (1-31)

W4	U16	Present Time B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)
W5	U16	Number of Files Deleted
W6	U08	Result B7 = 1 – Memory Mount Failure B1 = 1 – Incorrect “special” bits (W3) in request B1 = 0 – OK B0 = copy of B0 from W3 of request
W7	U08	Reserved
W8	U16	Selected Date (copy from request message) B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W9	U16	Selected Time (copy from request message) B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)

In order to delete files, the user should send a request message with the “special” bits of W3 specified as above. (This is a safety feature to guard against inadvertent erasure.) The user should also specify a date and time, and set bit 0 of W3 in accordance with whether files before or after that date/time are to be deleted. Any files with timestamps in the selected range will be irretrievably deleted from the file system.

The response from the IOP includes a result bit (bit 1 of W6) which will be set to 1 if the “special” bits in the request were set incorrectly. Otherwise, bit 1 of W6 will be zero, and the response will indicate the number of files successfully deleted. In W8, the response will contain a copy of the selected date and time from the request message.

0x05 – MMC Format

Request:

W1 Sub ID	U08	0x05
W2	U08	0x00 (request)
W2	U08	Control B7 = 1 B6 = 0 B5 = 1 B4 = 0 B3 = 1 B2 = 0 B1 = 1 B0 – Spare (don’t care)
W3	U08	Spare
W3	U16	Security Code – 0xabcd
W4	U08[]	Label – Null Terminated String

Response:

W1 Sub ID	U08	0x05
W2	U08	0xff (response)
W3	U16	Reserved
W4	U08	Result
		B1 = 1 – Incorrect control bits in W2 of request
		B2 = 1 – Incorrect security code in W3 of request
		B3 = 1 – Format error
		B4 = 1 – Bad Characters in Label
		B7 = 1 – Memory Mount Failure
W5	U08	Spare
W6	U08[]	Label -- Null terminated Text String

This command is used to format the file system. Any data already stored on the MMC will be lost. The user must correctly set the control bits (W2) and security code (W4) in the request message in order for the format to proceed. The user specifies a label (any label longer than ten characters will be truncated by the file system).

0x06 – Reserved

0x07 – Open File for Logging

Request:

W1 Sub ID	U08	0x07
W2	U08	0x00 (request)
W3	U08	Control
		B7=1: Resume logging after power failure
		B7=0: Don't' resume logging after power failure
		B6-B1: Spare
		B0=1: Append to File
		B0=0: Open New File
W4	U08	Spare
W5	U08[]	Filename – Null Terminated String

Response:

W1 Sub ID	U08	0x07
W2	U08	0xff (response)
W3	U08	Result
		B7 = 1 – Memory Mount Failure
		B6-B4: Spare
		B3=1: File already exists
		B2=1: File Open Failed
		B1=1: Illegal file name
		B0=1: Append Failed
		The rest of the bytes appear only if W3 = 0:
W4	U08	Reserved
W5	U16	Reserved

W6	U08[]	Filename – Null Terminated String

W3 B7 is only used by IOP to send resume logging command to Starlight. Normal user operation should set B7 to 0.

0x08 – Open File for Reading

Request:

W1 Sub ID	U08	0x08
W2	U08	0x00 (request)
W3	U16	Reserved
W4	U08	Filename – Null terminated String

Response:

W1 Sub ID	U08	0x08
W2	U08	0xff (response)
W3	U08	Result B0 = 1 – No such file B1 = 1 – Can't open file for reading B2 = 1 – A file is already open for reading The rest of the bytes appear only if W3 = 0:
W4	U08	Spare
W5	U16	Reserved
W6	U16	File Handle
W7	U32	File Size in Sectors (1 sector = 512 bytes)
W8	U32	File Size in Bytes
W9	U16	Creation Date B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W10	U16	Creation Time B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)
W11	U16	Modification Date B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W12	U16	Modification Time B15-B11: Hours (0-23) B10:B5: Minutes (0-59) B4-B0: Seconds/2 (0-29)
W13	U16	File Attributes
W14	U16	Access Date B15-B9: Years since 1980 B8-B5: Month (1-12) B4:B0: Day of Month (1-31)
W15	U08[]	File Name – Null Terminated String

To retrieve a file from the file system, the user first must open the desired file for reading. To do this, an Open File for Reading request should be sent specifying the desired file name.

No more than one file may be open for reading at a time. If a file is already open for reading, and another Open File for Reading request is received by the IOP, a response will be sent with bit 1 of W3 set to 1 ("can't open file for reading"). If no file with the requested name exists on the file system, bit 0 of W3 will be set to 1 ("no such file").

If the Open File for Reading request is successful, the response will include a 16-bit file handle, which should be used in subsequent manipulation of the file via messages 0x7e.0x09 and 0x7e.0x0a (File Record Request and Close File, respectively).

Once the command has been successfully issued (i.e., a response has been received with result code = 0), the user may request the contents of the file, one sector (512 bytes) at a time, using message 0x7e.0x09 (File Record Request). This is accomplished by consecutively requesting sectors 0 through (File Size in Sectors – 1) inclusive.

After the file has been completely retrieved, the user should send message 0x7e.0x0a (Close File).

0x09 –File Record Request

Request:

W1 Sub ID	U08	0x09
W2	U08	0x00 (request)
W3	U16	File Handle
W4	U32	Sector Number
W5	U08	Spare

Response:

W1 Sub ID	U08	0x09
W2	U08	0xff (response)
W3	U08	Result
		B0 = 1 – Invalid file handle
		B1 = 1 – Requested sector number out of range
		B2 = 1 – Unable to read file
		B7 = 1 – Memory Mount Failure
		The rest of the bytes appear only if W3 = 0:
W4	U08	Spare
W5	U16	File Handle
W6	U32	Sector Number
W7	U32	Number of Bytes in W8 (0 to 512)
W8	U08[512]	File data

After command 0x7e.0x08 (Open File for Reading) has been successfully issued, use this command as many times as necessary to retrieve the file contents, one sector (512 bytes) at a time. The number of sectors occupied by the file is returned in W7 (File Size in Sectors) of the response to the Open File for Reading request. The range of validity of the sector number field in the File Record Request is 0 to (File Size in Sectors – 1), inclusive. The file handle should match the one returned in the response to 0x7e.0x08.

The response contains a result code with possible failure conditions as specified above. If this result code is zero, then the request was successful, and the contents of the requested

sector appear in W8. There may be up to 512 bytes in this field; the number of data bytes is specified in W7. In general, only the final sector will contain fewer than 512 data bytes.

If no response to a File Record Request is received (perhaps due to an intermittent communication link), the missing sector may be re-requested by sending a duplicate request message.

After all sectors have been retrieved, the user should send command 0x7e.0x0a (Close File).

0x0a – Close File

Request:

W1 Sub ID	U08	0x0a
W2	U08	0x00 (request)
W3	U16	Reserved
W4	U08	Control B1 = 1: Close file open for reading B2 = 1: Close file open for writing

Response:

W1 Sub ID	U08	0x0a
W2	U08	0xff (response)
W3	U16	Reserved
W4	U08	Control (Copied from Request Message) B1 = 1: Close file open for reading B2 = 1: Close file open for writing
W5	U08	Result 0x00 – File successfully closed B0 = 1 – No file open for reading B1 = 1 – Error trying to close file open for reading B2 = 1 – No file open for writing B3 = 1 – Error trying to close file open for writing B7 = 1 – Memory Mount Failure

Use this command to close a file that was open for logging (0x7e.0x07) or a file that was open for reading (0x7e.0x08). In either case, after closing the file, the file handle is no longer valid and is rendered unusable.

0xc8 - LBM Data Request Block - Variable Length

Command ID		U08	0xc8	
Msg. Len.		U16	0x00xx	
W1		U08	Command Action	
				B1=0: Do Not Store in NVRAM
				B1=1: Store in NVRAM
				B6=0: Store in user NVRAM
				B6=1: Store in factory NVRAM
				B3=0: Use Commanded Values
				B3=1: Use Default values
				B4=1: Clear Present Output Messages
W2		U08	0xff	User should place 0xff here. Upon receipt, Value contains Physical Port used.
Wn1	U08	Data Command ID		
				0x00: All currently active output messages
				0x01 - 0xFF: Individual Command IDs
Wn2	U08	Reserved		
Wn3	U16	Data rate		
				0x0001 to 0x1770: begin data output at this rate
				0x0000: output data at once, and/or stop
				0x4000: output data on Change/Update
...Repeat Wn as necessary				
Checksum		U08		

0xc9 - the LBM Serial Port Control - 7 bytes

NavCom receivers that contain an internal L-band module do not support this message.

Command ID	U08	0xc9
Msg. Len.	U16	0x0007
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in_NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use Commanded Values B3=1: Use Default values
W2	U08	0xff User should place 0xff here. Upon receipt, Value contains Physical Port used.
W3	U08	Port Setup Reserved B0: Not Used Baud Rate B1=0, B2=0, B3=0: 1200 B1=1, B2=0, B3=0: 2400 B1=0, B2=1, B3=0: 4800 B1=1, B2=1, B3=0: 9600 B1=0, B2=0, B3=1: 19200 B1=1, B2=0, B3=1: 38400 B1=0, B2=1, B3=1: 57600 ~~B1=1, B2=1, B3=1: 115200~~ Parity Selection B4=0, B5=0: NONE B4=1, B5=0: ODD B4=1, B5=1: EVEN Reserved B7-B6: Not Used
Checksum	U08	

- **1:** Configured for 8-bit word length and 1 stop bit.
- **2**: For multiple command actions, the bits in W1 may be OR'ed.
- **3**: LBM is configured as DTE.
- **4:** If ACK/NAK is selected, and the input sentence is accepted, the ACK will be put out at the new settings.
- **5:** Present LBM oscillator (20 mHz) will not support 115200. This is not a serious requirement.
- **6:** In the internal LBM configuration this block will be NAK'ed by the NCT-2000D without being sent to the LBM.
- **7:** Before converting an external LBM to an internal configuration, this blocked should be saved into NVRAM using default values.

0xca - LBM Factory Reset Block - Variable Length

Command ID	U08	Command Action	
Msg. Len.	U16	0x00xx	
W1	U08	Command Action	
			B2=1: Use Ack/Nak
W2	U08	0xff	User should place 0xff here. Upon receipt, Value contains Physical Port used.
W3	U08	Sub ID	
W4	U08	Reserved (0x00)	
If Sub ID is 0 (Reset Block)			
W5	U08	Reset Commands	
			B0=1: Clear NVRAM
			B1=1: Undefined
			B2=1: Restore all defaults to Factory Settings
			B3-B5: Not Defined
			B6=1: Clear Factory NVRAM
			B7: Not Defined
W6	U08	Reserved	
If Sub ID is 5 (Run the LOADSTAR boot code) (TBD)			
If Sub ID is 7 (Assign Communication ID)			
W5	U16	Communication ID	
W6	U32	Confirmation Seed	
Checksum	U08		

0xcb - LBM Authorization Block Entry - 22 bytes

Command ID	U08	0xcb	
Msg. Len.	U16	0x0016	
W1	U08	Command Action	
			B2=1: Use Ack/Nak
W2	U08	0xff	User should place 0xff here. Upon receipt, Value contains Physical Port used.
W3	U08[18]	Authorization String (18 bytes)	
Checksum	U08		

0xcc - PVT Input Block - Variable Length

Command ID		U08	0xcc
	Msg. Len.	U16	0x00xx
	W1	U08	Action Control
	W2	U08	0xff User should place 0xff here. Upon receipt, Value contains Physical Port used.
	W3	U16	GPS Week Number
	W4	U32	GPS Seconds in Week
	W5	S32	Latitude in 2^-11 arc Seconds
	W6	S32	Longitude in 2^-11 arc Seconds
	W7	U16	Communication ID
	W8	U32	Confirmation data
	Checksum	U08	

: Block must be input at least every 15 Minutes or upon request (0x60). Confirmation data requires data from the output of LBM Identification Block (0xd0).

0xcd - LBM channel configuration - 11 bytes

Command ID	U08	0xcd
Msg. Len.	U16	0x000b
W1	U08	Command Action B1=0: Do not store in NVRAM B1=1: Store in NVRAM B2=0: Do not use ACK/NAK B2=1: Use ACK/NAK B3=0: Use Commanded Values B3=1: Use Default values
W2	U08	Reserved for responded port in ACK/NAK message
W3	U08	Use alternate channel
W4	S32	Alternate channel
W5	U08	Control -- used for input to LBM. LBM sets this field to 0 on output message. B0 = 1: Update Oscillator Frequency Error field = 0: Ignore Oscillator Frequency Error field B1-B3: Reserved B4 = 1: Update Factory Oscillator Freq. Error field = 0: Ignore Factory Oscillator Freq. Error field B5-B7: Reserved
W6	U16	Reserved
W7	R32	Oscillator Frequency Error (Hz) Input to LBM: current frequency error Output from LBM: frequency error from NVRAM
W8	R32	Factory Calibrated Frequency error (Hz)
Checksum	U08	

Data Responses

0x06 - Acknowledgment (without error) - 6 bytes

This message indicates that the initial inquiry was acknowledged without error.

Command ID	U08	0x06
Msg. Len.	U16	0x0006
W1	U08	Command ID Echo
W2	U08	Responding Physical Port (See Message 0x1a) 0 = Port A 1 = Port B
CKSUM	U08	

0x15 - Negative Acknowledge - 6 + (n x 2) bytes

This message indicates that the initial inquiry was not acknowledged because of error(s). NAK words W2 and W3 are repeated for multiple errors. The maximum number of errors reported by NAK is six. If the total number of errors is greater than six, then the first five will be reported and a "Too many errors" Error ID (0xFF) will be reported as the sixth error. ACK word W2 and NAK word Wx are used to identify which port is currently responding to a data request.

Command ID	U08	0x15
Msg. Len.	U16	6 + (n x 2) bytes
W1	U08	Command ID Echo
W2	U08	Error ID
W3	U08	Error Description
...		
Wx	U08	Responding Physical Port (See Message 0x1a) 0 = Port A 1 = Port B
CKSUM	U08	

0x6d - CMR Wrapper block - Variable Length

CMR wrapper block will be accepted as a NCT formatted message in lieu of an actual CMR input message stream.

Command ID	U08	0x6d
Msg. Len.	U16	0x?? (variable)
W1	U08[]	CMR message string
…		
Checksum	U08	

: 0x6d only functions when CMR(in) is set to the Null Port.
Block does not support ACK/NAK. However, if the block is rejected due to Note a, then a NAK is sent. No ACK is ever sent.

0x6e - NMEA Wrapper block - Variable Length

NMEA wrapper block will be accepted as a NCT formatted message in lieu of an actual NMEA input message stream.

Command ID	U08	0x6e
Msg. Len.	U16	0x??
W1	U08[]	NMEA message string
…		
Checksum	U08	

0x6f - RTCM Wrapper block - Variable Length

RTCM wrapper block will be accepted as a NCT formatted message in lieu of an actual RTCM input message stream.

Command ID	U08	0x6f
Msg. Len.	U16	0x??
W1	U08[]	RTCM message string
…		
Checksum	U08	

: Special care should be taken to avoid both the RTCM Wrapper block and the RTCM input stream being active at the same time. Unpredictable results could occur.

0x78 - Network Information (response) – Variable Length

Message 0x78 is a block used to request Network information to be compiled by NCT-2000D and provided to the user. It uses a sub-ID located in W2 to determine what information is requested. (The standard block request process using Message 0x20 does not support this Command.) The length of the message determines if the block is a request or a response. A request message is always 6 bytes. It should be noted that the response from these requests might take a few seconds while the information is gathered.

- Network List (0x01)

RESPONSE TO NETWORK LIST.

Command ID		U08	0x78
Msg. Len.		U16	0x00xx (14 + n*4 bytes)
W1		U08	0x00
W2		U08	0x01: Sub-ID
W3		U16	GPS Week
W4		U32	Seconds in week
W5		U08	Spare (0x00)
W6		U08	List count
W7—List			
	Wn1	U16	Units Ghost ID (See 0xad.W1)
	Wn2	U08	Unit Configuration (See 0xad.W2)
	Wn3	U08	Spare
…			
Checksum		U08	

- RTK Base Location Query (0x02). This query, when entered into a RTK rover, will return the location of the base presently being used for RTK navigation.

RESPONSE RTK BASE LOCATION QUERY.

Command ID		U08	0x78
Msg. Len.		U16	0x001c Length 28 bytes
W1		U08	0x00
W2		U08	0x02: Sub-ID
W3		U16	GPS Week
W4		U32	Seconds in Week
W5		U16	Station ID
			B15: Reserved
			B14=1: Position is accurate to only 1 cm
			B13=1: Battery Low
			B12-B10: Type of RTK Corrections
			1 Message 0x5e
			2 Message 0x5b
			3 RTCM type 18/19
			4 RTCM type 20/21
			5 CMR
			B9-B0: Site ID

: (U16) 0xffff – No Data Available

W6	S32	ECEF (x) Units 4mm
W7	S32	ECEF (y) Units 4mm
W8	S32	ECEF (z) Units 4mm
W9	U08	LSB's of ECEF values (Units 1 mm) B6-B7: U02 ECEF (x) W6 B4-B5: U02 ECEF (y) W7 B2-B3: U02 ECEF (z) W8 B0-B1: Spare
W10	U08	Spare
Checksum	U08	

0x80 - BITAFI Results - 14 bytes

Command ID	U08	0x80
Msg. Len.	U16	0x000E
W1	U32	Baseband ASIC initial self test - Part 1 B0 - B2: Channel 1 (CA, P1, P2CA) CA is lsb B3 - B5: Channel 2 (CA, P1, P2CA) CA is lsb B6 - B8: Channel 3 (CA, P1, P2CA) CA is lsb B9 - B11: Channel 4 (CA, P1, P2CA) CA is lsb B12 - B14: Channel 5 (CA, P1, P2CA) CA is lsb B15 - B17: Channel 6 (CA, P1, P2CA) CA is lsb B18 - B20: Channel 7 (CA, P1, P2CA) CA is lsb B21 - B23: Channel 8 (CA, P1, P2CA) CA is lsb B24 - B26: Channel 9 (CA, P1, P2CA) CA is lsb B27 - B29: Channel 10 (CA, P1, P2CA) CA is lsb B30 - B31: Reserved
W2	U32	Baseband ASIC initial self test - Part 2 B0 - B2: Channel 11 (CA, P1, P2CA) CA is lsb B3 - B5: Channel 12 (CA, P1, P2CA) CA is lsb B6 - B29: Reserved B30: WAAS Channel 1 B31: WAAS Channel 0
W3	U08	Other initial self tests B0=0: SRAM OK B0=1: SRAM failure B1=0: NVRAM OK B1=1: NVRAM failure B2=0: Real time clock OK B2=1: Real time clock failure B3=0: ROM OK B3=1: ROM failure B4-0: Authorized B4=1: Not Authorized
W4	U08	Run time self tests B0=0: Antenna minimum current OK B0=1: Antenna connection open circuited B1=0: Antenna maximum current OK B1=1: Antenna connection short circuited B2 : Reserved B3 : Reserved B4=0: RF PLL locked B4=1: RF PLL unlocked B5=0: IF PLL locked B5=1: IF PLL unlocked B6=0: External oscillator PLL locked B6=1: External oscillator PLL unlocked B7=1: Bad Oscillator Temperature Sensor
Checksum	U08	

1: For W1 and W2, Bn=0 indicates OK, Bn=1 indicates failure.

- 2: Subchannel order is C/A, P1, P2.
- 3: W4, B0-B1,B6 only supported by some products

0x81 - Packed Ephemeris Data - 86 bytes

Command ID	U08	0x81
Msg. Len.	U16	0x0056
W1	U08	SV ID (PRN) 1-32
W2	U16	GPS Week Number of Collection
W3	U32	GPS Time of Week of Collection (Seconds)
W4	U16	IODC
W5	U08[24]	Sub-frame 1 data. Satellite Data Stream with parity bits removed.
W6	U08[24]	Sub-frame 2 data. Satellite Data Stream with parity bits removed.
W7	U08[24]	Sub-frame 3 data. Satellite Data Stream with parity bits removed.
W8	U08	Reserved
Checksum	U08	

: Detail of W5 through W7 should refer to the GPS System Specification for words 3 through 10 with the parity bits removed. (Each word contains 30 bits but the last 6 bits, parity, have been removed to leave 24 bits.)

0x82 - Ephemeris Status - 4 + (4 x N) bytes

This data block sends Ephemeris Status of the various satellites. Word 1 identifies the satellite and Word 2 presents the status or IODC. This is repeated for the various satellites being tracked.

Command ID	U08	0x82
Msg. Len.	U16	
...		
W1	U16	SV ID (PRN)
W2	U16	IODC
...		
CKSUM	U08	

1: W1 and W2 will be repeated for each SV available or requested, up to N=32 (maximum).

0x83 - Ionosphere and UTC Data - 32 bytes

This message provides the ionosphere correction data and the Universal Coordinated Time (UTC) information. The two frequency users (L1 and L2) correct the time received from the SV by utilizing the time delay differential between L1 and L2. The one frequency user may use the ionosphere model.

Command ID	U08	0x83
Msg. Len.	U16	0x0020
W1	U16	GPS week of collection
W2	U32	GPS time of week of collection
W3	S08	alpha0
W4	S08	alpha1
W5	S08	alpha2
W6	S08	alpha3
W7	S08	beta0
W8	S08	beta1
W9	S08	beta2
W10	S08	beta3
W11	S32	A1
W12	S32	A0
W13	U08	UTC reference time (Tot)
W14	U08	UTC reference week (WNt)
W15	S08	Time difference (dTLS)
W16	U08	Week of leap seconds (WNLSF)
W17	U08	Day number of leap seconds (DN)
W18	S08	Time difference (dTLSF)
CKSUM	U08	

1: Data values are decoded from SV navigation message per GPS-ICD-200C, but not scaled.

2: Output cannot be ‘by rate’, ‘on trigger’, or ‘by SV’.

0x84 - Time Data - 16 bytes

This message reports time parameters such as the GPS Week Number, the time of week in seconds, the Time of Data Applicability and the Time Figure of Merit (FOM).

Command ID	U08	0x84
Msg. Len.	U16	0x0010
W1	U16	GPS week
W2	R64	GPS Time of week (seconds)
W3	U08	Time of data applicability
		B0=1: Time of next 1PPS
W4	U08	Time FOM
CKSUM	U08	

: May NOT be output ‘on trigger’ or ‘by SV’.

0x86 - Channel Status - 18 + (14 x N) bytes

This message provides receiver channel status information and contains the GPS week, GPS Time of Week, Engine status, solution status, number of satellites being tracked and the number and identity of satellites used in solution, PDOP and the satellite ID. The Channel Tracking Status, channel number, current IODC, elevation, azimuth C/A ration P2 C/A ratio, dGPS data stage and hardware channel number is repeated for each satellite.

COMMAND ID	U08	0x86
MSG. LEN.	U16	0x00XX
W1	U16	GPS week
W2	U32	GPS time of week
W3	U08	Engine status

B0 - B2
- 000 - Performing power up and initial BIT test
- 001 - (Reserved)
- 010 - Cold start
- 011 - Warm start
- 100 - Navigating normally
- 101 - Hardware failure

B3=0 - Almanac invalid, B3=1 - Almanac valid

B4 - B5
- 00 - Time is invalid
- 01 - Time is from RTC
- 10 - Time is from one SV solution
- 11 - Time is from normal navigation

B6 - B7
- 00 - Position is invalid
- 01 - Position is old
- 10 - Position is from normal navigation

W4	U16	Solution status

B0=0: Invalid solution, B0=1: Valid solution
When solution status word B0=0, indicating a position solution failure, the reason for failure is located in bits B8 through B11.
- 0000 - No error
- 0001 - Less satellites available than the specified minimum
- 0010 - PDOP is greater than the specified limit
- 0101 - Solution residuals too high
- 0110 - New navigation
- 0111 - Less satellites available than the specified minimum
- 1000 - PDOP is greater than the specified limit
- 1011 - Navigation jumped
- 1100 - COCOM limits reached
- 1101 - Required DGPS messages not received

B1=0: Clock is unstable, B1=1: Clock is stable
B2=0: Unaided position, B2=1: DGPS position
B3=0: Constrained height, B3=1: Solved height
B4: Reserved

B5:Reserved 0x0100 - 0x0F00: Invalid solution codes

W5	U08	Number of SVs visible
W6	U08	Number of SVs being tracked
W7	U08	Number of SVs used in solution
W8	U08	PDOP (LSB = 0.1)
W9	U08	Reserved
Wn10	U08	SV ID (PRN)
Wn11	U08	Channel tracking status B0 - B1: C/A tracking status B2 - B3: P1 tracking status B4 - B5: P2 tracking status 00 - Acquisition or reacquisition 01 - Code loop locked 10 - Costas loop locked 11 - Full tracking with aiding and active multipath reduction - all data is valid B6=1 - C/A Bit sync B7=1 - C/A Frame sync
Wn12	U08	Channel number B5 - B0: Logical Super Channel ID (1-31) SV flags B6=0: S/A is Off B6=1: S/A is On B7=0: A-S is Off B7=1: A-S is On
Wn13	U16	Current IODC
Wn14	U08	Elevation (Degrees)
Wn15	U16	Azimuth (Degrees)
Wn16	U08	C/A C/No ratio (LSB = 0.25 dBHz)
Wn17	U08	Reserved
Wn18	U08	P2 C/No ratio (LSB = 0.25 dBHz)
Wn19	U16	DGPS data age (LSB = 0.1 seconds)
Wn20	U08	Hardware Channel Number 0x00 - 0F: Primary channel 0x10 - 1F: Extended channel 0x20 - 2F: WAAS channel
...		
CKSUM	U08	

1: W10 through W20 will be repeated N times for all tracked SVs.

0x8c - Decoded Reference Station Location - 34 bytes

The Decoded Reference Station Location message provides the location of the Reference Station and includes the decoded GPS time, Reference Station ID and Health and Latitude, Longitude and Ellipsoidal Height. Figure A5.9-6 depicts the message stream and subsequent paragraphs describe the message stream in detail.

Command ID	U08	0x8C
Msg. Len.	U16	0x0022
W1	U16	Decoded GPS week
W2	U32	Decoded GPS time of week (LSB = 0.1 sec)
W3	U16	Reference station ID
W4	U08	Reference station health
W5	R64	WGS84 Latitude (radians, +North)
W6	R64	WGS84 Longitude (radians, +East)
W7	R32	WGS84 Ellipsoidal height (meters)
W8	U08	Reserved
CKSUM	U08	

: After power up and until first decode of this message, W1 and W2 are filled by zero.

0x8d - Decoded RTCM Special Message (#16) - 14 + N bytes

This message contains the Decoded RTCM Special Message (#16) which comprise the decoded GPS Week, the Reference Station ID, the Reference Station Health and ASCII characters, usually identifying the Reference Station.

Command ID	U08	0x8D
Msg. Len.	U16	(Variable Length)
W1	U16	Decoded GPS week
W2	U32	Decoded GPS time of week (LSB = 0.1 sec)
W3	U16	Reference station ID
W4	U08	Reference station health
W5	U08	ASCII character per RTCM SC-104 v2.1
...		
W6	U08	Reserved
CKSUM	U08	

1: W5 will be repeated N times for the length of the message; 90 bytes maximum.

2: An RTCM message will always be reported with an even number of ASCII characters. Thus, if an odd character length RTCM message is decoded, then the first reported ASCII character in the message string will be an ASCII 'space' (0x20) filler character.

3: After power up and until first decode of this message, W1 and W2 is filled by zero.

0x8e - Decoded RTCM DGPS data - 14 + (18 x N) bytes

This message contains the decoded RTCM dGPS data stream that comprises the Decoded GPS Week, the Decoded GPS Time of Week, the Reference Station ID, the Reference Station Health and Correction Source. The second part contains the satellite, IODE and Pseudorange correction rate, Pseudorange correction UDRE, Pseudorange correction rate UDRE that is repeated for every satellite.

Command ID	U08	0x8e
Msg. Len.	U16	(Variable Length)
W1	U16	Decoded GPS week
W2	U32	Decoded GPS time of week (LSB = 0.1 sec)
W3	U16	Reference station ID
W4	U08	Reference station health
W5	U08	Correction source 0x01: RTCM message #1 0x02: RTCM message #9
...		
W6	U08	SV PRN
W7	U08	IODE
W8	R32	Pseudorange correction
W9	R32	Pseudorange correction UDRE
W10	R32	Pseudorange correction rate
W11	R32	Pseudorange correction rate UDRE
...		
CKSUM	U08	

1: W6 through W11 will be repeated N times for all correction sets decoded.

2: After power up and until first decode of this message, W1 and W2 is filled by zero.

0x96 – CMR Message Type 2 (received) – 80 bytes

Report CMR message 2 data received, message 0x96. Description is as follows:

Command ID	U08	0x96	
Msg. Len.	U16	0x0050	
W1	U08	Station ID	
W2	U08	Status	
		B1B0:	Motion State (0 = Unknown, 1 = Static, 2 = Kinematic)
		B2:	Low Battery indicator for Base
		B3:	Low Memory indicator for Base
W3	U08[8]	Short Station Id (ASCII)	
W4	U08[16]	COGO Code	
W5	U08[50]	Long Station Descriptor (ASCII - Fixed length)	
Checksum	U08		

0x9c - RTK Reference Position Block – 80 bytes

Command ID	U08	0x96
Msg. Len.	U16	0x0050
W1	U16	Station ID
		B9B0: Site ID
		B12B10:Reference Type of Corrections/Observables
		1 Message 0x5e
		2 Message 0x5b
		3 RTCM type 18/19
		4 RTCM type 20/21
		5 CMR
		B15-B13: Reserved
W2	S32	ECEF(x)
W3	S32	ECEF(y)
W4	S32	ECEF(z)
W5	U08	ECEF lsb's
		B1B0: ECEF(x) lsb's – 1 mm
		B3B2: ECEF(y) lsb's – 1 mm
		B5B4: ECEF(z) lsb's – 1 mm
		B7B6: Reserved
W6	U08	Reserved
Checksum	U08	

0xa0 - Alert Text Message - Variable Length (max 84 bytes)

Command ID	U08	0xa0
Msg. Len.	U16	0x00xx
W1	U08[max 80] Null terminated text string	
Checksum	U08	

0xab - WAAS Data Stream - 48 bytes

Command ID	U08	0xab
Msg. Len.	U16	0x002E
W1	U16	GPS Week Number
W2	U32	GPS Seconds in Week
W3	U08[32]	250 Bits of Data (see WAAS spec)
W4	U08	WAAS Satellite ID
W5	U08	WAAS message type
W6	U08	C/N0 (LSB=.25dBHz)
W7	U08	WAAS channel used
Checksum	U08	

0xad - Net presence block - 7 bytes

Command ID	U08	0xad
Msg. Len.	U16	0x0007
W1	U16	Ghost/Radio ID
W2	U08	Configuration
		B0: Master Radio Configuration
		B1: RTK Base
		B2: External Power
		B3: Battery 1 Low
		B4: Battery 2 Low
		B5: Radio Type (0 is micro Hard)
		B6: Memory Low
		B7: Spare
Checksum	U08	

0xae - Identification Block - 55 bytes or 75 bytes

Command ID	U08	0xae
Msg. Len.	U16	0x0037 (No IOP) or 0x004B (IOP)
W1	U08	Engine/Configuration
		0x00: Unknown/Undefined
		0x01: NCT 2000 S
		0x02: NCT 2000 D
		0x03: Starfire 2000 Single
		0x04: Starfire 2000 Dual
		0x05: Pole Mount RTK (Internal Radio Found)
		0x06: Pole Mount GIS (LBM Available)
		0x07: Black Box RTK (Internal Radio Found)
		0x08: Black Box GIS (LBM Available)
		0x09: NCT 2100 S
		0x0A: NCT 2100 D
		0x0B: Starfire 2100 Single
		0x0C: Starfire 2100 Dual
		0x80: R100
		0x81: R200
		0x82: R210
		0x83: R300
		0x84: R310
W2	U08	ASIC Type
		0x01: A-ASIC (C/A, L1)
		0x02: B-ASIC (C/A, P1. P2, L1, L2)
		0x03: C-ASIC (C/A, P1, P2, L1, L2, WAAS)
		0x04: M-ASIC (C/A. L1, WAAS)
		0xff: Unknown
W3	U16	NCT-2000D Software Version
	U08	Major
	U08	Minor
W4	U24	Digital Card Number
	U16	Serial Number
	U08	Class
W5	U24	RF Card Number
	U16	Serial Number
	U08	Class
W6	U08[16]	Software Time Mark
W7	U08[16]	Boot String
W8	U08[8]	Reserved
W9	U16	IOP Software Version
	U08	Major
	U08	Minor
W10	U08[16]	IOP Time mark
W11	U08	PIC version
W12	U08	Starlight Software build number
W13	U08	IOP Software build number
Checksum	U08	

1: If IOP is not Present, W9 to W13 are not present, and the block is shorter. W12 will then move up to the W9 position in the message.

0xb0 - Raw Meas. Data Block - 4+8+(16*N) bytes

This message contains the Raw Measurement Data Block that contains the GPS Week, GPS Time of Week, Time Slew Indicator and Status. Word Wn1 is the number of the first satellite reporting Raw Measurement Data. Information included is Channel Status, CA Pseudorange, L1 Phase, P1-CA Pseudorange, P2-CA Pseudorange, and L1 Phase. This data stream is repeated for any additional satellite.

Command ID	U08	0xb0
Msg. Len.	U16	0x00xx
W1	U16	GPS week
W2	U32	GPS time of week (LSB = 1mS)
W3	U08	Time slew accumulator Least significant byte (LSB=1/1023mSec)
W4	U08	Status B7: Channel time set (Last measurement) B6: Clock Stable (offset was < 2 ppm) B5-B4: Reserved B3-B0: Number of blocks to follow
…		
Wn1	U08	SV ID Status B7: CA,&L1 Valid B6: P1 Valid B5: P2&L2 Valid B4-B0: SV id (PRN)
Wn2	U08	Channel Status B3-B0: Logical Channel (1-15) B7-B4: CA C/No (dB Hz > 35)
Wn4	U32	CA pseudorange (1/16 L1 cycle)
Wn5	S24	L1 phase (1/256 L1 cycle) B23-B4: carrier phase B3-B0: cycle slip counter L1 Carrier phase = CA + L1 phase
Wn6	S16	P1-CA pseudorange (1/16 L1 cycle)
Wn7	S16	P2-CA pseudorange (1/16 L1 cycle)
Wn8	S24	L2 phase (1/256 L2 cycle) B23-B4: carrier phase B3-B0: cycle slip counter (Use with L1 slip counter) L2 Carrier phase = (CA + P2)*(120/154) + L2 phase
…		
CKSUM	U08	

- 1: Output ‘on change’ limited to 1Hz.
- 2: ‘on trigger’ and ‘by SV’ outputs not supported.
- 3: 50Hz output available as an option.

0xb1 - PVT block - 86 bytes

Command ID	U08	0xb1
Msg. Len.	U16	0056 Length is 86 bytes
W1	U16	GPS Week – Weeks from 6 Jan 1980
W2	U32	Milliseconds in Week
W3	U32	Satellites Used (B0 is SV 1…B31 is SV32)
W4	S32	Latitude (Lsb 2^-11 arc second. Approx.1.5cm)
W5	S32	Longitude (Lsb 2^-11 arc seconds. Approx. 1.5cm)
W6	U08	Lat/Lon LSB's. (2^-15 arc seconds. Approx. 1mm)
	U04…B7-B4: Latitude.	
	U04…B3-B0: Longitude.	
W7	U08	Navigation Mode
	If	B7=1. Navigation Valid
		B7=1: Navigation Valid
		B6=1: 3D Navigation
		B5=1: dGPS used Tropo
		B4=1: Clock Stable (offset < 2 microseconds)
		B3=1: 1PPS output Valid
		(Nominally < 15 nanoseconds)
		B2=1: Dual Frequency Navigation
		B1-B0: Mode
		00 Non-Differential
		01 Code Based dGPS
		10 RCP Navigation
		11 RTK Navigation
	else,	B7=0: Navigation Invalid
		B6-B0: Failure Code
		1 - Navigation Init – To few measurements
		2 - Navigation Init – PDOP to high.
		3 - Fast Navigation Failure – Jump to Far
		4 - Fast Navigation Failure – Numerical Error
		5 - Slow Navigation – Residuals too large
		6 - Navigation Init – New Initialization
		7 - Slow Navigation -- To few measurements
		8 - Slow Navigation – PDOP to high
		9 - Fast Navigation -- To few measurements
		10- Navigation First Pass – No velocity
		11- Slow Navigation – Jump to large
		12- Navigation COCOM limits reached
		13- dGPS Navigation required – Not available
		14- Navigation Init – Numerical Error
		15- Navigation Init – Navigation Fault
		16… Reserved
W8	S32	Ellipsoidal Height (Lsb 2^-10 meters)
W9	S32	Altitude (Lsb 2^-10 meters)
W10	S24	Velocity North (2^-10 m/s) +/-8192 m/s
W11	S24	Velocity East (2^-10 m/s) +/-8192 m/s
W12	S24	Velocity Up (2^-10 m/s) +/-8192 m/s
W13	U08	Position "FOM"

Figure of Merit (FOM) characterizes the magnitude of horizontal measurement error. It is defined as: FOM = DRMS = (σlat2 + σlon2) ½ , where σlat and σlon are the standard deviations of error in latitude and longitude, respectively. In all navigation modes, units are in centimeters (LSB = 1 cm).

W14	U08	GDOP (Lsb .1) 255 is undefined.
W15	U08	PDOP (Lsb .1) 255 is undefined
W16	U08	HDOP (Lsb .1) 255 is undefined
W17	U08	VDOP (Lsb .1) 255 is undefined
W18	U08	TDOP (Lsb .1) 255 is undefined
W19	U08	TFOM – Time Figure of Merit
W20	U16	Maximum dGPS correction age (Lsb .1 seconds)
W21	U08	dGPS Configuration B0 - Ignore RTCM Code Input B1 - Ignore RTCM RTK Input B2 - Ignore WCT Corrections B3 - Ignore RTG Corrections B4 - Ignore WAAS Corrections B5 – Ignore CMR Input B6 - Ignore RTK input B7 - Reserved
W22	U08	Extended Navigation Mode. 0. Non differential 1. Code (RTCM Type 1 and 9) 2. Code, Single Frequency (WAAS) 3. Code, Dual Frequency (WAAS) 4. Code, Single Frequency (WCT) 5. Code/RCP, Dual Frequency (WCT) 6. Code, Single Frequency (RTG) 7. Reserved 8. Reserved 9. Reserved 10. Code (RTCM Type 1 and 9) Dual Frequency SV's only 11. Code/RCP, Dual Frequency (RTG) 12. Code, Single Frequency (RTK NCT Corrections) 13. Code, Single Frequency (RTCM type 18 and 19) 14. Code, Single Frequency (RTCM type 21 and 22) 15. Code, Single Frequency (CMR) 16. Code, Dual Frequency (RTK NCT Corrections) 17. Code, Dual Frequency (RTCM type 18 and 19) 18. Code, Dual Frequency (RTCM type 20 and 21) 19. Code, Dual Frequency (CMR) 20. RTK (RTK NCT Corrections) 21. RTK (RTCM type 18 and 19) 22. RTK (RTCM type 20 and 21) 23. RTK (CMR) 24. Code, Single Frequency with SET (RTG) 25. Code/RCP, Dual Frequency with SET (RTG)

: 2 and 3 can also be seen as 130 and 131 respectively when using the WAAS Test Configuration now in use

W23	S16	Height adjustment for Antenna (Lsb 1mm) If 0x49.w6.b7=1 then W8 and W9 of this block adjusted by this amount
W24	U16	B0 is copy of 0x49.w6.b7. B1 – 1 if in RTG Dual and the solution is a continuation of a RTK solution, (effectively RTG is backing up RTK). B1 – 1 0 if RTG is Not Backing RTK (ie in RTK), or in any other mode. B15-B2: Reserved
W25	U32	L2_synthesized_flag (the flag Used L1 to synthesized L2, (Bit 0 = PRN 1, …bit 31 = PRN 32).
W26	U32	SlowNavSigma (lsb 2^-20 m)
W27	U32	L1PNavSigma (lsb 2^-20 m)
W28	U32	L1PNav Satellites Used (B0 is SV 1…B31 is SV 32)
W29	S32	SET delta North (lsb 1mm)
W30	S32	SET delta East (lsb 1mm)
W31	S32	SET delta Up (lsb 1mm)
W32	U08	NAV failure code 0. Too few measurements (INIT) 1. PDOP too high (INIT) 2. Fast navigation failed (NAV) 3. Fast navigation NAN (NAV) 4. Residuals too large 5. New initialization (NAV) 6. Too few measurements (NAV) 7. PDOP too high (NAV) 8. Fast navigation failure (NAV) 9. No velocity (NAV) 10. Jump too large (NAV) 11. COCOM limits met (NAV) 12. Required DGPS message failure (NAV) 13. Navigation initialization NAN (NAV) 14. Navigation initialization fault (NAV) 15. Time initialization fault (NAV)
W33	U08	Reserved
Checksum	U08	

: Precise Lat/Lon can be computed by S32 + U04. Where S32 lsb is 2^-11 and U04 is 2^-15.

0xb2 - Satellite Selection Block - 4+4+n*4 Bytes

This message provides information on visible satellites and contains the Number of satellites visible, the number of eligible satellites, the number of satellites selected and the satellite PRN number used for the almanac. For each satellite, the Elevation and Azimuth are then repeated. This message is helpful in locating and acquiring satellites.

Command ID	U08	0xb2
Msg. Len.	U16	0x00xx
W1	U08	Number of satellites visible
W2	U08	Number of eligible satellites
W3	U08	Number of satellites selected
W4	U08	SV PRN number used for almanac collect [Number Visible]
Wn1	U08	SV PRN
Wn2	S08	SV elevation
Wn3	S16	SV azimuth
…		
CKSUM	U08	

0xb4 - Event Latch Data - 16 bytes

This message provides the time of the event latch and the event latch data stream.

Command ID	U08	0xB4
Msg. Len.	U16	0x0010
W1	U16	GPS week
W2	R64	GPS Time of week (seconds)
W3	U08	Event latch
		B0=0: Primary event latch
		B1=1: Secondary event latch (not nominally available)
W4	U08	Time FOM
CKSUM	U08	

0xb5 - Pseudorange Noise Statistics - 17 bytes

The block can be scheduled using message 0x21 **"On Change"** or at **"selected data rates"**.

Command ID		U08	0xb5
	Msg. Len.	U16	0x0011
	W1	U16	GPS Week
	W2	U32	Milliseconds in Week
	W3	R64	RMS of the standard deviation of the range of inputs to the Navigation Process.
	W4	R64	Standard Deviation of semi-major axis of the error ellipse.
	W5	R64	Standard Deviation of semi-minor axis of the error ellipse.
	W6	R64	Orientation of semi-major axis of the error ellipse (degrees from true north)
	W7	R64	Standard deviation of Latitude error (meters)
	W8	R64	Standard deviation of Longitude error (meters)
	W9	R64	Standard deviation of Altitude error (meters)
	Checksum	U08	

: The NCT-2000D does not contain RAIM support, so this block should be considered our best estimate with no liability implied.

0xb6 - Iono block - Variable Length

Command ID	U08	0xb6
Msg. Len.	U16	0x00xx (12 + count*15)
W1	U16	GPS Week
W2	U32	GPS milliseconds in week
W3	U08	Count (Corrections in Block)
W4	U08	format (Presently 1)
…		
Wn1	U08	SV number
Wn2	U16	Smooth count for measured iono
Wn3	S32	Measured iono value (lsb is .1 mm)
Wn4	S32	GPS broadcast iono (lsb is .1 mm) (Bit31 only is invalid or NA)
Wn4	S32	WAAS iono (lsb is .1 mm) (Bit31 only is invalid or NA)
…		
Checksum	U08	

0xd0 - LBM Identification Block - 44 bytes

Command ID	U08	0xd0
Msg. Len.	U16	0x002C
W1	U08	LBM Software Version (Major)
W2	U08	LBM Software Version (Minor)
W3	U32	Serial Number
W4	U16	Hardware Configuration
W5	U32	Reserved
W6	U16	Communication ID
W7	S08[22]	Build ID String
W8	U08[4]	Boot Version
Checksum	U08	

: W5 changes with every message output. Other data nominally remains unchanged. The message needs to be saved for creation of data required in message 0xcc, PVT input block. The process is required to help prevent spoofing of the LBM authorization. W5 and W6 are also output in 0x60.

0xd1 - LBM Authorization Status Block - Variable Length

Command ID	U08	0xd1
Msg. Len.	U16	(variable length)
W1	U08	Number of Licenses (0, 1, 2)
W2	U08	Spare (U08 alignment)
W3	U32	Serial number of LBM
(repeat for each license, in order of license-in-use (if any), then backup-license (if any)		
Wn1	U08	Number of center points
Wn2	U08	License type: B0: 1 = RTG precise, 0 = RTG degraded B5: 1 = Elapsed time license, 0 = Calendar License B7: 0 = Active license, 1 = License not active
Wn3	U32	License issue date: B31:B17 -- Days from Jan. 1, 1999 (Jan. 1, 1999=0 days) B16:B0 -- Seconds in Day
Wn4	U16	License start date (from Jan. 1, 1999)
Wn5	U16	License end date (from Jan. 1, 1999)
Wn6	U16	Generic Region Selection
Checksum	U08	

0xd2 - LBM Geo-Fencing Extension Data Block - Variable Length

Command ID	U08	0xd2
Msg. Len.	U16	0x00xx
W1	U08	Number of Entries
W2	U08	Reserved
Wn1	U48	Center Point Radius Definition
		B47:B28 – Longitude of Center Point. (lsb: 2 arc seconds)
		B27:B9 – Latitude of Center Point. (lsb: 2 arc seconds)
		B8:B0 – Radius in km. (1 to 512 km)
… Repeat as necessary		
Checksum	U08	

0xd3 - LBM DSP Status Block - 70 bytes

Command ID	U08	0xd3
Msg. Len.	U16	0x0046
W1	U16	DSP Status – used for DSP Software Debug.
W2	S32	SF channel number. Frequency is 1525 Mhz + channel * 500 Hz
W3	U16	SF signal FEC quality. 20 or less is considered good.
W4	S16	Expected baseband frequency in Hz
W5	R64	Tracked baseband frequency in Hz.
W6	R64	SF signal C/N0
W7	R64	Oscillator frequency error in Hz
W8	U16	SF downlink circular buffer input pointer.
W9	U16	SF downlink circular buffer output pointer
W10	U08	DSP Software major version.
W11	U08	DSP Software minor version.
W12	U08	True if SF parser is receiving valid packets from downlink.
W13	U08	True if DSP is locked on to downlink signal.
W14	U16	SF parser packet framing re-synchronization count.
W15	U08	Authorization Status (See 0xd1.w3)
W16	U08	True if SF is set to an alternate channel (manual override).
W17	U08	Percentage of idle packets in received SF data.
W18	U08	Percentage of bad packets in received SF data.
W19	U16	“Ignition” input voltage in units of 0.1v.
W20	U16	DSP tuning voltage 1 (VT1) in units of 0.1 v.
W21	U16	DSP tuning voltage 2 (VT2) in units of 0.1 v.
W22	U16	DSP lock detect voltage 1 (LD1) in units of 0.1 v.
W23	U16	DSP lock detect voltage 2 (LD2) in units of 0.1 v.
W24	U16	SF downlink circular buffer lost data count
W25	R32	SF downlink Doppler in Hz (Filtered tracked-expected)
W26	S16	Last Doppler Frequency in Hz
Checksum	U08	

0xd4 - LBM Status Block - Variable Length

Command ID	U08	0xd4
Msg. Len.	U16	0x00xx
W1	U32	Hobbs counter in seconds.
W2	U32	Total number bytes received in download.
W3	U32	Number of bytes received as part of an idle packet.
W4	U32	Number of bytes received as part of a bad packet
W5	U08	Reserved
W6	U08	Reserved
Checksum	U08	

0xd5 - LBM Cancel History - Variable Length

Command ID	U08	0xd5
Msg. Len.	U16	(variable length)
W1	U08	Spare
W2	U08	Number of cancel blocks
(repeat for each cancel block)		
Wn1	U32	Original license issue date B31:B17 -- Days from Jan. 1, 1999 (Jan. 1, 1999=0 days) B16:B0 -- Seconds in Day
Wn2	U16	Original license end date (from Jan. 1, 1999)
Wn3	U32	Cancel issue date: If (cancel reason = expired per 0xcc timestamp) Use date from 0xcc timestamp Else (must be from user input) Use cancel block's authorization issue date B31:B17 -- Days from Jan. 1, 1999 (Jan. 1, 1999=0 days) B16:B0 -- Seconds in Day
Wn4	U32	Unused seconds of license (good for ~ 136 years)
Wn5	U08	B7: 0 = Calendar, 1 = Elapsed time B6: Timestamp pending 1 = cancel issued, but time unknown until next 0xcc block arrives B5-B0: Cancel reason 1 = Expired license ("now"= "end date") 2 = User cancelled (user entered code to cancel license)
Wn6	U08	Spare (U08 alignment)

0xd6 - LBM Text Message - Variable Length

(Equivalent to NCT-2000D Text message 0xA0.)

Command ID	U08	0xd6
Msg. Len.	U16	0x00xx
W1	U08[]	Null terminated text string.
Checksum	U08	

: NCT-2000D should nominally send this block to the StarUtil Port when received.

0xd7 - ACK/NAK Message for the LBM only - Variable Length

Command ID	U08	0xd7
Msg. Len.	U16	0x0006 for ACK 0x0006+2N for NAK
W1	U08	Command ID of original message.
W2	U08	Responding Physical Port 0: Port A 1: Port B 2: Radio Port
… Block Continues for NAK Block		
Wn1	U08	Error ID
Wn2	U08	Error Description
… Repeat as necessary		
Checksum	U08	

0xe1 – Unused Satellite Status Block (12 Bytes + 8bytes * Number of Channels)

Command ID U08 0xe4
Msg. Len. U16 0x00xx (xx Bytes)
W1 U16 GPS Week;
W2 U16 Reserved
W3 U32 GPS time (milliseconds in week)
Wn(4+ chnl #) U08[8] Failure reason code which is one of the following:

```
0x0001  FAILED_NCO,
0x0002  FAILED_CSD,
0x0003  FAILED_CSDTIMEOUT,
0x0004  FAILED_MPPCODEDETECT,
0x0005  FAILED_MPPTIMEOUT,
0x0006  FAILED_CLDTIMEOUT,
0x0007  FAILED_CLDLOCK1,
0x0008  FAILED_CLDLOCK2,
0x0009  FAILED_CLDLOCK3,
0x000A  FAILED_LOCKHOW,
0x000B  FAILED_SLEWX1D,
0x000C  FAILED_SLEWX1D1,
0x000D  FAILED_LOCKX1D1,
0x000E  FAILED_LOCKX1D2,
0x000F  FAILED_LOCKPAC,
0x0010  FAILED_LOCKPACWAIT,
0x0011  FAILED_LOCKPAC2CARR,
0x0012  FAILED_PTRKL1,
0x0013  FAILED_PTRKP1,
0x0014  FAILED_MDDL1,
0x0015  FAILED_MDD_LOSTP,
0x0016  FAILED_PARITY,
0x0017  FAILED_PREAMBLE,
0x0018  FAILED_AMBIG,
0x0019  FAILED_SMOOTH,
0x001A  FAILED_LOSTL1CARRIER,
0x001B  FAILED_LOSTL2CARRIER,
0x001C  FAILED_CAS_SLIP,/* CAS detected slip  in MeasProc */
0x001D  FAILED_CAS_EDIT,/* CAS edited measurement in MeasProc */
0x001E  FAILED_RESIDFAST,   /* Failed residual edit in nav_fast */
0x001F  FAILED_RESID,   /* Failed residual edit in resid_edit (slow nav) */
0x0020  FAILED_NOSATP,  /* Satellite position not available in nav_slow */
0x0021  FAILED_BUSY,/* State machine is still processing a command */
0x0022  FAILED_MFBIG,   /* Message frame calculation out of range */
0x0023  FAILED_L1INVALID,   /* L1 Measurement invalid in MeasProc */
0x0024  FAILED_L2INVALID,   /* L2 Measurement invalid in MeasProc */
0x0025  FAILED_MEASTIME,/* Wrong measurement time in MeasProc */
0x0026  FAILED_DUPPRN,  /* Duplicate PRN in MeasProc */
0x0027  FAILED_LOWCN0,  /* C/N0 too low */
0x0028  FAILED_MFSET,   /* MF not set */
0x0029  FAILED_CALOCK,  /* C/A channel not locked */
0x002A  FAILED_L1ML2,   /* L1 minus L2 slip detected */
```

```
        0x002B   FAILED_L1ML2DOPPLER,/* L1 doppler minus L2 doppler slip detected
        */
        0x002C   FAILED_NOTIME,  /* Time not set in hwtime */
        0x002D   FAILED_NOL1,/* L1 not marked valid (or cycle slip) in hwmeas */
        0x002E   FAILED_USERMEAS,/* Meas not valid in MeasProc */
CheckSum            U08
```

0xec - RTK Communications Status Block - 24 bytes

Command ID	U08	0xEC
Msg. Len.	U16	0x18
W1	U16	Site ID
		B9B0: Site ID
		B12B10:Reference Type of Used Corrections/Obs.
		1 Message 0x5e
		2 Message 0x5b
		3 RTCM type 18/19
		4 RTCM type 20/21
		5 CMR
		B15-B13: Reserved
W2	S16	Time between 0x5e messages (-1 is none seen)
W3	S16	Time between 0x5c messages (-1 is none seen)
W4	U08	Number of L1 PRN's in active message stream
W5	U08	Number of L2 PRN's in active message stream
W6	S16	Time between 0x5b messages (-1 is none seen)
W7	S16	Time between RTCM Type 3/22 messages (-1 is none seen)
W8	S16	Time between RTCM Type 18/19 messages (-1 is none seen)
W9	S16	Time between RTCM Type 20/21 messages (-1 is none seen)
W10	S16	Time between CMR Type 0 messages (-1 is none seen)
W11	S16	Time between CMR Type 1 messages (-1 is none seen)
Checksum	U08	

0xef - Clock Drift and Offset - 32 bytes

Command ID	U08	0xef
Msg. Len.	U16	0x0020 (Length 32 bytes)
W1	U16	GPS Week
W2	U32	GPS milliseconds in week
W3	S08	Oscillator Temperature (degrees C)
W4	U08	Navigation Status
W5	R64	Navigation Clock Offset
W6	R32	Navigation Clock Drift
W7	R32	Oscillator Filter drift estimate
W8	S32	Accumulated time slew value
Checksum	U08	

Special ASCII Output Message Definitions

The definitions listed in this section characterize the NavCom Technology, Inc. proprietary ASCII data output strings, and only those fields of standard NMEA messages that have been altered to reflect NavCom Technology, Inc. special codes. All standard NMEA message are defined in the copywrited NMEA v3.01 Standard document, which can be obtained directly from the National Marine Electronics Association.

NMEA $GPGAA Field 14; Reference Station ID

Tables B1 & B2 detail the information contained in field 14 of the GGA message when NCT STATION ID is chosen in W12 B0 of message 0x49. Note that the Navigation Mode in field 14 is the same as that of the 0xB1 binary message.

The format of field 14 when NCT STATION ID is chosen is a 3 digit integer value as denoted below as XYY, where X is the StarFire™ satellite beam in use and YY is the GPS correction signal type being used.

ID (X)	DOWNLINK BEAM
0	None selected, or error
1	INMARSAT Americas
2	INMARSAT EAME
3	INMARSAT ASPAC
4	- reserved - (Inmarsat AOR-E)
5	- reserved - (Inmarsat POR)
6	- reserved -
7	- reserved -
8	- reserved -
9	Forced to unknown frequency (Manual selection)

Table B1: Beam Selection; ID X

ID (YY)	GPS CORRECTION SIGNAL
00	Non dGPS
01	dGPS, RTCM type 1 or 9, Single Freq
02	WAAS/EGNOS, Single Freq., (See GSA for SBAS Id in use)
03	WAAS/EGNOS Dual Freq., (See GSA for SBAS ID in use)
04	StarFire WCT, Single freq.
05	StarFire WCT, Dual freq.
06	StarFire RTG, single freq. (no 'Tide' Adjustment)
07	- reserved -
08	- reserved -
09	- reserved -
10	dGPS, RTCM type 1 or 9, Dual Freq.
11	StarFire RTG dual freq. (no 'Tide' Adjustment)
12	Code base Nav, Single Frequency, NCT Proprietary Format
13	Code base Nav, Single Frequency, RTCM 18/19
14	Code base Nav, Single Frequency, RTCM 20/21
15	Code base Nav, Single Frequency, CMR
16	Code base Nav, Dual Frequency, NCT Proprietary Format
17	Code base Nav, Dual Frequency, RTCM 18/19
18	Code base Nav, Dual Frequency, RTCM 20/21
19	Code base Nav, Dual Frequency, CMR
20	RTK Mode, NCT Proprietary Format (5e/5c or 5b/5c)
21	RTK Mode, RTCM 18/19
22	RTK Mode, RTCM 20/21
23	RTK Mode, CMR
24	StarFire RTG, single freq., Adjusted for "Tides"
25	StarFire RTG, dual freq., Adjusted for "Tides"
26	RTK Extend Active (StarFire RTG filling in for missing RTK epochs)

Table B2: Navigation Mode; ID YY

Proprietary NMEA $NCTSET; Solid Earth Tide

The SET message output via the NMEA port is a NavCom proprietary NMEA type message. This means that it conforms to the header, checksum, and electrical characteristics of a standard NMEA string, but is not recognized by the NMEA governing body as an officially sanctioned message.

Table A1 details the information contained in the following actual NCT SET output message.

$PNCTSET,214040.00,-0.060,-0.018,0.110,,,,,*47

$PNCTSET	hhmmss.ss	xxxx.xxx	xxxx.xxx	xxxx.xxx	xxxx.xxx	xxxx.xxx	xxxx.xxx	xxxx.xxx	xxxx.xxx	xxxx.xxx	*hh
Label	UTC	SET dN (meters)	SET dE (meters)	SET dU (meters)	PT dN (meters)	PT dE (meters)	PT dU (meters)	Ocean Loading dN (meters)	Ocean Loading dE (meters)	Ocean Loading dU (meters)	CK SUM

Table A1: NCT Solid Earth Tide (SET) NMEA message

This NMEA message will be output ONLY when W6 B6 of the 0x49 message is set to APPLY CORRECTION.