

NORTHSTAR NAVIGATOR SERIAL DATA FORMAT SPECIFICATION

**M2 LORAN
M2 LORAN/GPS
GPS-60
GPS-600
M3 GPS
M3 GPS/APPROACH**

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**Northstar Avionics
30 Sudbury Road
Acton, Massachusetts 01720**

Sales: (800) 628-4487 Service: (978) 897-6600 Fax: (978) 897-1595

Northstar Serial Data Format

Introduction

This specification defines the electrical and data format characteristics of the Northstar M2, M3, GPS-60, and GPS-600 Navigators serial data output for all firmware versions from 01.05 on. The purpose of this serial data output is allow the Northstar Navigator to send information to external devices such as fuel-flow systems and electronic map displays. This specification defines data formats for both loran and GPS. However, the system will only transmit those formats for which it has operating sensors.

Electrical Characteristics

The Navigators use a balanced differential output driver conforming to EIA RS-485 and RS-422 specifications. Recommended interconnection is by shielded twisted pair such as Belden 9501. Note that it is preferable to ground the shield at a listener rather than at the navigator because of ground noise considerations. This configuration was chosen because of its noise immunity, compatibility with optoisolation, and ability to handle multiple listeners in parallel and to accommodate multiple talkers in the future.

Because of the low data rates and short cable lengths involved, this bus is intended to be used unterminated. The output driver can drive a minimum of 32 RS-485 or ten RS-422 loads. Although bus loading is not likely to be a problem for some time, listeners are encouraged to limit their inputs to one RS-485 load (1 ma. maximum) where possible. This can easily be accomplished using any RS-485 transceiver chip or a low-current optocoupler such as the HP 6N139.

Transmission Parameters

Standard asynchronous serial data format is used with eight data bits, one stop bit, and no parity at 1200 baud. In addition there is an extended mode at 9600 baud, selectable and deselectable through SETUP service functions. Extended mode is also chosen, automatically, when the navigator is running in flight simulator mode (versions 02.16ff).

Data is transmitted largely in binary to minimize ASCII to binary conversion time. This also reduces the number of bytes transmitted and eliminates the need for formatting characters such as spaces, commas, carriage returns, etc.

When a numerical value extends over more than one byte, the high order byte is sent first.

Data Frame Format

Each data frame consists of four fields:

- 1. Synchronization** - Three bytes of FF₁₆. Any time the listener sees three sequential bytes of FF₁₆, then the next non-FF₁₆ will be the Data Type Identifier.
 - 2. Data Type Identifier** - One byte specifying the type of data frame as follows:
 - 0 - Reserved**
 - 1 - Platform Data**
(Information about the location of the receiver from either loran or GPS, whichever is currently selected.)
 - 2 - Destination Data**
(Information about the destination or path specified by the user.)
 - 3 - Route Data**
(Information about a sequence of waypoints in the current route.)
 - 4 - Loran Data**
(Information about the loran signals being used, only in M2 and M2V units.)
 - 5 - Supplemental Destination Data**
(Additional information about the destination. Replaces some data in data frame 2. Also includes current pressure altitude from the encoder, CDI sensitivity setting, and remote indicator statuses.)
 - 16 - Loran Platform Data**
(Same as 1 above but always from loran - only in extended mode, in M2 and M2V units with GPS as well as loran.)
 - 17 - GPS Platform Data**
(Same as 1 above but always from GPS - only in extended mode, in M2 and M2V units with both GPS and loran.)
 - 18 - GPS Data**
(GPS DOPs, satellite, and status information - extended mode only, in units with GPS.)
- Note:** FF₁₆ will never be assigned as a data type since it would conflict with the sync FF₁₆s.

Note: Factory default is data types 1, 2, 3, 4, and 5 at 1200 baud. However, in Simulator/trainer Mode, the baud rate is 9600. (Simulator/trainer Mode is available in releases after 2.17.) Extended Mode, available as a SETUP function, also runs at 9600 baud, and adds data types 16, 17, and 18. Extended mode should be used only where required, since it will not be compatible with any existing installation, e.g. Shadin MiniFlow, Argus 5000, etc. If extended mode is required, switch to SETUP, rotate small right knob clockwise until END OF FUNCTIONS appears, press both cursor buttons simultaneously, use the right CRSR button and knobs to enter SER96, press CRSR again, and ACK. To restore normal operation use the same procedure and enter SER12. These changes do not take effect until the unit is powered off and back on.

3. Data - A number of bytes which depends on the Data Type, and which contains the actual information being sent.

4. Checksum - One byte which when added to the preceding bytes of the frame will yield an 8-bit sum of 0. Note that the three synchronization bytes are not included in this sum.

Note: A value of $7F_{16}$ in byte 17 indicates that the clock has not been initialized and time is relative to when the unit was turned on.

Estimated Error

This provides an estimate of error based on signal strength and transmitter geometry.

Byte 18

Bit 76543210

nnnnnnnn

nnnnnnnn = Estimated error in sixteenths of a nautical mile, plus 128 (80_{16}). A value of 128 (80_{16}) indicates zero and is sent when the unit is in DEMO mode. Values greater than 9.9 nm are shown as 20_{16} . A value of $7F_{16}$ in byte 18 indicates that the estimated error is unknown.

Data Type 2: Destination Data

This data is transmitted about once per second and provides information about the aircraft's current waypoint. "Current waypoint" here means the destination, or, if there is no destination, it means the origin of a course being flown.

Latitude/Longitude/Magnetic Variation

Bytes 1 to 9. "Current waypoint" as defined above. See Appendix for format.

Distance and Bearing to Current Waypoint

Byte 10 11
Bit 76543210 76543210
 nnnnnnnn nnnnnnnn
 nnnnnnnnnnnnnnnnn = Distance to waypoint above. 16-bit unsigned
 integer value in sixteenths of nautical miles.

Note: Bearing to waypoint in bytes 10 and 11 has been superseded by improved information in data frame 5. This data is retained only for compatibility with existing equipment.

Note: A value of 7F₁₆ in byte 10 indicates that distance is not presently available or is 2032 miles or more and byte 11 should be ignored.

Byte 12 13
Bit 76543210 76543210
 xxxnnnnn nnnnnnnn
 nnnnnnnnnnnnnnn = Bearing to waypoint above. 16-bit unsigned
 integer value in sixteenths of degrees TRUE.

Note: A value of 7F₁₆ in byte 12 indicates that bearing is not presently available and byte 13 should be ignored.

ETE

Estimated Time En Route To/From the waypoint above. Packed unsigned binary integers.

Byte 14 15 16
Bit 76543210 76543210 76543210
 xxxhhhhh xxmmmmmm xxssssss
 x = Undefined
 hhhhh = Time - hours
 mmmmm = Time - minutes
 sssss = Time - seconds

Note: A value of $7F_{16}$ in byte 14 indicates that ETE is not presently available (or is greater than 24 hours) and bytes 15 and 16 should be ignored.

Crosstrack Error

Byte 17

Bit 76543210

nnnnnnnn

nnnnnnnn = Crosstrack error. Two's complement binary in sixteenths of nautical miles. A positive value indicates that the aircraft is to the left of the desired direction of travel. Note -- the value in Data Type 5 only, *not* here, may have reverse sign.

Note: Crosstrack error in byte 17 has been superseded by improved information in data frame 5. This data is retained only for compatibility with existing equipment.

Note: A value of $7F_{16}$ in byte 17 indicates that crosstrack error is not presently available or is 8 miles or more.

Track Type

Byte 18

Bit 76543210

01111111 = $7F_{16}$ None.

000nnnnn = 0 - $1F_{16}$ Flying along route to waypoint number nnnnn of route, with no off-route queued point. See Data Type 3 below.

$1F_{16}$ (31) in nnnnn means the waypoint data has not been sent yet in Data Type 3.

001nnnnn = 20_{16} - $3F_{16}$ Flying direct to waypoint number nnnnn of route, with no off-route queued point. See Data Type 3 below.

$1F_{16}$ (31) in nnnnn means the waypoint data has not been sent yet in Data Type 3.

01000000 = 40_{16} Flying a FROM/TO leg other than one of the above, or, in firmware version 02.06ff, possibly flying a HOLD or PT, or a radial inbound.

10000000 = 80_{16} Flying a radial outbound, not a HOLD nor PT.

Waypoint Identifier -or- True Course

If track type above is *not* 80_{16} , bytes 19 through 23 are defined as follows:

Byte 19

20

21

22

23

Bit 76543210

76543210

76543210

76543210

76543210

aaaaaaaa

aaaaaaaa

aaaaaaaa

aaaaaaaa

aaaaaaaa

aaaaaaaa = ASCII characters of five-character waypoint identifier.

Note: A value of $7F_{16}$ in byte 19 indicates that the waypoint identifier is unknown and bytes 20 through 23 should be ignored.

If track type above is 80_{16} , bytes 19 through 23 are defined as follows:

Byte	19	20	21	22	23
Bit	76543210	76543210	76543210	76543210	76543210
	01111111	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx

xxxxxxxx = Course to fly from origin. 16-bit unsigned integer value in sixteenths of degrees TRUE.

Note that regardless of track type, $7F_{16}$ in Byte 19 indicates that no waypoint identifier is being sent.

Waypoint Type

Byte	24
Bit	76543210
	nnnnnnnn

nnnnnnnn = 0 Intersection.
nnnnnnnn = 1 NDB.
nnnnnnnn = 2 VOR.
nnnnnnnn = 3 Airport.
nnnnnnnn = 4 User waypoint.
nnnnnnnn = 5 Local Approach waypoint (firmware vsn. 2.06ff).

Note: A value of $7F_{16}$ in byte 24 indicates that the waypoint type is unknown, or that the ID above was not sent.

Parallel Offset

Byte	25
Bit	76543210
	nnnnnnnn

nnnnnnnn = Parallel offset from original track. Two's complement binary in nautical miles. Positive values indicate a desired track to the right of the original track.

Data Type 3: Route Data

This section provides latitude/longitude, waypoint type, identifier, and sequence number of each waypoint defined in a route. This information is transmitted when a route is activated and whenever a change is made to the route. One waypoint frame is transmitted each second.

Route Sequence Number

Byte 1
Bit 76543210
xxwnnnnn
x = undefined.
nnnnn = Sequential waypoint number. 0 to 30, never 31.
w = 1 if last waypoint of route.
w = 0 otherwise

Route Waypoint Identifier

Byte 2 3 4 5 6
Bit 76543210 76543210 76543210 76543210 76543210
aaaaaaaa aaaaaaaaa aaaaaaaaa aaaaaaaaa aaaaaaaaa
aaaaaaaa = ASCII characters of five-character waypoint identifier.

Note: A value of 7F₁₆ in byte 2 indicates that the waypoint identifier is unknown and bytes 3 through 6 should be ignored.

Route Waypoint Type

Byte 7
Bit 76543210
nnnnnnnn
nnnnnnnn = 0 Intersection.
nnnnnnnn = 1 NDB.
nnnnnnnn = 2 VOR.
nnnnnnnn = 3 Airport.
nnnnnnnn = 4 User waypoint.

Route Waypoint Latitude/Longitude/Magnetic Variation

Bytes 8 to 16. See Appendix for format.

Data Type 4: Loran Data

This data is transmitted once per second and provides GRI, loran-C time differences, signal to noise ratio, and signal status. This data type is not transmitted at all for GPS-only Navigators such as the GPS-60, GPS-600, and M3.

GRI

Byte	1	2
Bit	76543210	76543210
	nnnnnnnn	nnnnnnnn

nnnnnnnnnnnnnnnn = GRI. 16-bit unsigned binary value in tens of microseconds.

Master Time-of-Arrival

This value represents the change in time-of-arrival of the master pulse relative to its TOA when first acquired. Sign and 23-bit binary magnitude in 16ths of tenths of microseconds.

Byte	3	4	5
Bit	76543210	76543210	76543210
	snnnnnnn	nnnnnnnn	nnnnnnnn

s = Sign bit
nnnnnnnnnnnnnnnnnnnnnnnn = Magnitude of TOA

Note: A value of FE_{16} in byte 3 indicates that the TOA is not known.

Master Status

This byte provides status information on the master.

Byte	6
Bit	76543210
	0ap0bscu

a = 1 Signal not acquired
p = 1 Precipitation static warning
b = 1 Loran blink warning
s = 1 Low SNR warning
c = 1 Cycle selection warning
u = 1 Cycle selection not locked

Master SNR

Byte	7
Bit	76543210
	nnnnnnnn

nnnnnnnn = Master SNR. 8-bit unsigned binary value. 0 represents very weak signals and FF_{16} represents very strong signals.

Secondary Time Differences

Byte	8	9	10	Secondary 1
	13	14	15	Secondary 2
	18	19	20	Secondary 3
	23	24	25	Secondary 4
	28	29	30	Secondary 5
Bit	76543210	76543210	76543210	
	nnnnnnnn	nnnnnnnn	nnnnnnnn	
	nnnnnnnnnnnnnnnnnnnnnnnnnnnnnn = 24-bit unsigned binary value in 16ths of tenths of microseconds.			

Note: A value of FE₁₆ in bytes 8, 13, 18, 23, or 28 indicates that that time difference is not known.

Secondary Statuses

This byte provides status information for each secondary.

Byte	11	Secondary 1
	16	Secondary 2
	21	Secondary 3
	26	Secondary 4
	31	Secondary 5
Bit	76543210	
	0ap0bscu	
	a = 1	Signal not acquired
	p = 1	Precipitation static warning
	b = 1	Loran blink warning
	s = 1	Low SNR warning
	c = 1	Cycle selection warning
	u = 1	Cycle selection not locked

Secondary SNRs

Byte	12	Secondary 1
	17	Secondary 2
	22	Secondary 3
	27	Secondary 4
	32	Secondary 5
Bit	76543210	
	nnnnnnnn	
	nnnnnnnn = Secondary SNR. 8-bit unsigned binary value. 0 represents very weak signals and FF ₁₆ represents very strong signals.	

opposite sign from that shown on the M2 and sent to the CDI. This change, which affects this data stream only, was necessary to obtain the proper display on the Argus. See also the “Reverse” bit below.

Note: A value of $7F_{16}$ in byte 6 indicates that desired track is not presently available and byte 7 should be ignored. $7F_{16}$ is also sent during arc guidance, to avoid incorrect Argus displays.

Pressure Altitude

Byte	8	9
Bit	76543210	76543210
	nnnnnnnn	nnnnnnnn

nnnnnnnnnnnnnnnnnn = Uncorrected pressure altitude currently being reported by the encoding altimeter input. Value is in hundreds of feet in 2's complement form, between -24 and 999 inclusive. Available in firmware version 01.19ff.

Note: A value of $7F_{16}$ in byte 8 indicates that an encoding altimeter input is not available, and byte 9 should be ignored.

CDI Sensitivity

Byte	10	11
Bit	76543210	76543210
	nnnnnnnn	nnnnnnnn

n = Number of nautical miles represented by the distance between the leftmost (5 dots left) and rightmost (5 dots right) positions of the CDI needle. Value is between .06 and 10 nm, represented in 4096ths of a nautical mile. Available in firmware version 02.06ff. In earlier versions, 2 bytes of $7F_{16}$ were sent.

Crosstrack Delta, and Annunciators and Flags

Byte	12	13
Bit	76543210	76543210
	DDDDRNFT	AAWWPPMM

Available in firmware versions 02.14ff. In earlier released versions, 2 bytes of $7F_{16}$ were sent.

DDDD = 2's complement signed delta to add to the XTE obtained from Bytes 1, 2 to obtain a higher resolution value. In 1/128ths of nautical miles. The addition should be done after correcting the sign of XTE according to the R flag below. Due to the rounding of the original low resolution XTE, the sign of delta may or may not agree with that of XTE. In firmware versions 02.14ff.

R = Reverse flag. 1 if Desired Track (if any) is 180 degrees off, and therefore Cross Track Error (if any) has reverse of normal sign. In firmware versions 02.14ff.

N = NAV flag: 1 if flag in view, 0 if not.

F = FROM flag: 1 if flag in view, 0 if not.

T = TO flag: 1 if flag in view, 0 if not.

AA: APCH (approach) annunciator (formerly VFR)
WW: WPT (waypoint) annunciator
PP: PTK (parallel track) annunciator
MM: MSG (message) annunciator (formerly WARN)

For each annunciator above:

00: off
01: flashing
11: on solid

Data Type 16: Platform Data - Loran only

This data is transmitted about once per second and provides information about the aircraft's present position, speed, and track. Data is from loran receiver on M2 and M2V units in extended mode only, when GPS also is installed. Format is identical to Data Type 1.

Data Type 17: Platform Data - GPS only

This data is transmitted about once per second and provides information about the aircraft's present position, speed, and track. Data is from GPS receiver on M2 and M2V units in extended mode only. Format is identical to Data Type 1.

Data Type 18: GPS Data and Status

This data is transmitted about once per second and provides information about the GPS sensor's status. Data is sent in extended mode only, for units with GPS.

GPS Altitude

GPS-determined altitude. Packed, signed binary value in meters.

Byte 1 2
Bit 76543210 76543210
 aaaaaaaaa aaaaaaaaa

a = Altitude in meters above sea level, in 2's complement form, between -32768 and 32767 inclusive.

Note: A value of 7F₁₆ in both bytes indicates that no up-to-date value is available. However, since this condition may also represent a possible (very high) altitude, the GPS Navigation Status Byte below can be used to detect the 7F condition.

GPS Navigation Status

GPS navigation operation mode.

Byte 3
Bit 76543210
 mmmmmmm

m = 0 - Not navigating.

m = 1 - Not used.

m = 2 - 2D

m = 3 - 3D

m = 4 - 2D differential

m = 5 - 3D differential

m = 127 (7F₁₆) - no recent information available

GPS HDOP

GPS HDOP. Packed, unsigned binary value.

Byte 4 5
Bit 76543210 76543210
 00000hh hhhhhhh

hhhhhhhhh = HDOP * 3.6 (hundredths of nm 2-sigma estimated error)

NOTE: both bytes will be 7F₁₆ if no up-to-date value is available.

GPS VDOP

GPS VDOP. Packed, unsigned binary value.

Byte 6 7
Bit 76543210 76543210

vvvvvvvvv vvvvvvvv
 vvvvvvvvvvvvvvvvv = VDOP * 3.75 (hundredths of nm 2-sigma
 estimated error)

NOTE: both bytes will be 7F₁₆ if no up-to-date value is available.

Satellite Information

Note: The following sets of data bytes may or may not contain valid data, depending on the number of satellites currently in view. For each satellite, a group of four bytes will be sent, containing PRN, azimuth, elevation, and SNR. This data occupies 12 groups of 4 bytes each, ending with byte 55.

Byte	8	9	10	11 ... etc.
Bit	76543210	76543210	76543210	76543210
	0PPPPPPA	AAAAAAA	EEEEEEES	SSSSSSSS

PPPPPP = PRN 1 to 32, or 0 if no satellite in this slot

AAAAAAA = Azimuth in degrees, from 0 to 360

EEEEEE = Elevation in degrees, plus 4 degrees, from 0 to 94.

SSSSSSSS = Signal-to-noise ratio, in tenths of dB's, minus 128 and clipped between 0 and 511. Raw SNR values are usually between 280 and 550. The values displayed on the Navigator are scaled between 0 and 99.

Note: These bytes are 7F₁₆ if and only if a current record from the sensor containing data from this group of four satellites is not available.

GPS HILG (Geometric Horizontal Integrity Limit)

GPS HILG. Packed, unsigned binary value.

Byte	56	57
Bit	76543210	76543210
	000000hh	hhhhhhhh

hhhhhhhhhh = Horizontal Integrity Limit, in hundredths of nm, 0-999

NOTE: both bytes will be 7F₁₆ if a recent value is not available.

GPS HILR (Residuals Horizontal Integrity Limit)

GPS HILR. Packed, unsigned binary value.

Byte	58	59
Bit	76543210	76543210
	000000hh	hhhhhhhh

hhhhhhhhhh = Residuals Integrity Limit, in hundredths of nm, 0-999

NOTE: both bytes will be 7F₁₆ if a recent value is not available.

GPS HFOM (Horizontal Figure of Merit)

GPS HFOM. Packed, unsigned binary value.

Byte	60	61
Bit	76543210	76543210
	000000hh	hhhhhhhh
	hhhhhhhhhh = Horizontal Figure of Merit, in hundredths of nm, 0-10000	

NOTE: both bytes will be $7F_{16}$ if a recent value is not available.

Revision History

- Revision 1.1 15 November 1987** Minor typographical corrections.
- Revision 1.2 24 February 1988** Minor typographical corrections. Add Data Type 4 (loran) data specifications.
- Revision 1.21 25 February 1988** Minor typographical corrections.
- Revision 1.3 12 April 1988** Add new Supplemental Destination Data frame to include Desired Track and add additional range for Cross-Track Error and Distance To Waypoint. Correct Bearing to Waypoint over long distances. Minor typographical corrections.
- Revision 2.0 May 1992** M2 adopted this specification for serial data output.
- Revision 2.1 14 August 1992** Added data types 16, 17, and 18 for loran-only platform data, GPS-only platform data, and GPS DOPs and status information.
- Revision 2.2 4 June 1996** Added V1.19 features. Includes 12-channel satellite status in type 18, and pressure altitude and CDI sensitivity in type 5. Also added textual references to non-M2 receivers.
- Revision 2.3 18 November 1996** Added software V2.07 features, including treatment of approaches, arcs, and more general radials. Changed format of CDI sensitivity and added status of remote flags and indicators in data type 5.
- Revision 2.4 28 January 1997** Added that high byte goes first, and under Platform Data clarified time zone offset. Added Reverse flag bit in data type 5. Updated phone numbers.
- Revision 2.5 6 March 1997** Moved Reverse flag bit 4 bits to the right and inserted XTE delta.
- Revision 2.6 28 May 1997** Cosmetic changes. Back into Microsoft Word.
- Revision 2.7 16 June 1997** Incorporated historical information and some rewording.
- Revision 2.8 17 March 1999** Added information about route sequence number 31 and other clarification under Data Types 2 (Track Type) and 3 (Route Sequence Number). Added format of Simulator/trainer mode output. Updated phone numbers.

Appendix - Latitude/Longitude/Magnetic Variation Format

Latitude/Longitude

Packed, unsigned binary values for degrees, minutes, and hundredths of minutes.

Byte	1	2	3
Bit	76543210	76543210	76543210
	sddddddd	xxmmmmm	xhhhhhh

s = 0 North latitude

s = 1 South latitude

x = Undefined

ddddddd = Latitude degrees

mmmmm = Latitude minutes

hhhhh = Latitude hundredths of minutes

Note: A value of 7F₁₆ in byte 1 indicates that latitude and longitude are not presently available and bytes 2 through 7 should be ignored.

Byte	4	5	6	7
Bit	76543210	76543210	76543210	76543210
	sxxxxxxxx	ddddddd	xxmmmmm	xhhhhhh

s = 0 East longitude

s = 1 West longitude

x = Undefined

ddddddd = Longitude degrees

mmmmm = Longitude minutes

hhhhh = Longitude hundredths of minutes

Magnetic Variation

Byte	8	9
Bit	76543210	76543210
	nnnnnnnn	nnnnnnnn

nnnnnnnnnnnnnnnnnn = Magnetic variation at position above. Two's complement binary in sixteenths of degrees. Easterly variation is positive.

Note: A value of 7F₁₆ in byte 8 indicates that magnetic variation is not presently available and byte 9 should be ignored.