TELEGRAM LISTING

Telegrams for Configuring and Operating the NAV200 Laser Positioning System

Firmware Version from V4.4.X

SICK
Sensor Intelligence.

Software Versions

Device	Function	Version
NAV200	Firmware	As of V 4.4.X

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Auto Ident, Reute Plant
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Trademark

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Telegram listing version

For the latest version of this telegram listing (PDF), see **www.sick.com.**

Contents

Used abbreviations

AGV **A**utomated **G**uided **V**ehicle

LSB **L**east **S**ignificant **B**yte

MSB **M**ost **S**ignificant **B**yte

UPF **U**ser **P**rotocol **F**rame

Tables

Figures

1 Notes on this document

1.1 Function

This document serves as a guideline for the configuration (parameterisation) of the laser positioning system NAV200 and for retrieving calculated position data with a compact command language, the telegrams.

This document contains the following information:

- Commands/responses in the telegrams
- Error messages of the NAV200
- Response times of the NAV200 to commands
- Timing for requesting position
- Diagnosis functions

Important The NAV200 laser positioning system is termed "NAV200" hereinafter.

1.2 Target group

This document addresses technicians and engineers who install and operate the software of the NAV200 into a vehicle control system.

1.3 Depth of information

As a reference manual, this supplementary document contains all the information required to communicate with the NAV200 help of telegrams.

A step-by-step approach is taken for the essential tasks.

The basic functions of the NAV200 and the **assembly, electrical installation and commissioning** are specified in the *manual NAV200* (No. 8011501,German-language version).

Further information on laser measurement technology is available from the Auto Ident Division of SICK AG. On the Internet at **www.sick.com**.

1.4 Used symbols

To gain easier access, some information in this documentation is emphasised as follows:

Reference Italic script denotes a reference to further information.

Important This important note informs you about specific features.

Recommendation A recommendation helps you to carry out tasks correctly.

This symbol indicates supplementary technical documentation.

HINWEIS

Notice!

A notice points out any potential risk of damage or impairment to the functioning of the NAV200.

WARNUNG

Warning notice!

A warning notice indicates real or potential danger. It has been installed to protect you against accidents.

The safety symbol next to the warning notice indicates why there is a risk of accident. e.g. due to electricity. The warning levels (CAUTION, WARNING, DANGER) indicate the seriousness of the risk.

➢ Carefully read and follow the warning notices.

2 Safety information

2.1 Authorised users

It is essential that the NAV200 be installed, configured and operated by adequately qualified specialised staff in order to ensure that it functions properly and reliably in combination with a vehicle control system.

The following qualifications are essential for integrating the software in the application:

- Knowledge of the hardware and software environment in each operational area
- Basic knowledge of data transfer
- Basic knowledge of programmig

2.2 Intended use

In the navigation system of an automated guided vehicle (AGV), the NAV200 continuously supplies absolute position data for the purpose of adjusting relative position data made available by the odometric system of the vehicle (shaft encoder).
A relative calculation of position will contain errors due to inaccuracies and would increasingly deviate from the real situation the further the vehicle drives. On the basis of absolute NAV200 position data, the vehicle processor of an AGV can minimise an error resulting from the odometric system and keep the AGV on the programmed route (course).
Installed on an AGV, the NAV200 scans its environment without any contact while driving in an industrial area and continuously measures the positions of recorded, fixed reflectors. In a comparison of the positions of these reflectors previously stored during commissioning and configuration, the NAV200 identifies valid reflectors on the course. The NAV200 uses these to determine its own current position and direction on the course, which is at the same time equivalent to those of the AGV. The NAV200 releases the current position data on request in each case to the vehicle processor of the AGV in the form of co-ordinates. The vehicle processor can hence use these to adjust the course of the AGV.

Important Any warranty claims against SICK AG shall be deemed invalid in the case of modifications to the NAV200, such as opening the housing, including modifications made during installation and electrical installation or changes to the SICK software.

Only operate the NAV200 indoors in the authorised ambient temperature range.

HINWEIS

The Laser Positioning System NAV200 is not a personal protection device in terms of respectively valid safety standards for machines!

➢ Only use the NAV200 for determining the position of an automated guided vehicle.

2.3 General safety precautions and protection measures

1. The NAV200 operates with Class 1 laser (eye-safe).
   Observe the most recently revised laser protection standard version according to EN/IEC 60825-1.
2. Observe current safety regulations when working with electrical equipment.
   (The NAV200 operates with extra-low voltage of DC 24 V).

3 Introduction

3.1 Position of determining position

The NAV200 positioning system is a laser measurement system. The system scans its environment two-dimensionally with a continuous 360° rotational movement and detects specifically defined reflector marks.

In the positioning mode (determining position) the NAV200 continuously calculates its own position and direction from the known position of the reflectors in an absolute co-ordinate system (termed "world co-ordinate system" in a previous version of this document). This position data is made available for transmission. On doing so, the NAV200 takes account of its own onward movement by means of consistently using the velocity vector, i.e. the system delivers its position and direction extrapolated at the point in time of data transmission. The NAV200 only transmits its data on request.

The reflector sets of data of a plant measured in absolute co-ordinates are transferred to the NAV200 from the outside to be permanently stored in its reflector memory (see the "download" mode). The "mapping" mode enables reflector positions to be measured with the NAV200 itself and to be stored as temporary sets of data for subsequent transfer to the NAV200 e.g. to be processed on a PC.

An arrangement of several reflectors is termed a layer (level) for the purpose of organisation. These layers each represent a defined leg of the course and may comprise up to 32 reflectors each; they must, however, comprise at least three reflectors. The NAV200 can be programmed with a total of 320 different layers for the route, distributed amongst two banks (Bank0 and Bank1). Current determination of position is always carried out within a defined, current layer. The NAV200 can change layers during operation. Layers and/or the bank are changed by a vehicle processor command.

The NAV200 has a data interface (RS-232/422) with a compact command format for connection to the vehicle processor of an automated guided vehicle (AGV) or a PC for the purpose of configuration and testing. The protocol is the master slave, i.e. the NAV200 delivers exactly one response for each command.

A standard proof total (XOR) is used throughout the telegram for the purpose of fault detection in telegram traffic.

The "NAV200 setup" configuration software is available for commissioning and for testing (can be loaded onto a PC/laptop).

3.2 Command formats

Telegram traffic and the exchange of data are carried out in blocks on application of the following format:

BYTES	BYTES	BYTES	BYTES	BYTES	BYTES
STX	No. of bytes	**Mode**	**Function**	Data block	BCC (block check)

BYTES	Description
STX	Start value (02 h)
No. of bytes	No. of BYTES in a whole telegram including STX and BCC
Mode*)	Letter (ASCII) as identification for the individual modes
Function*)	Letter (ASCII) as identification for the individual functions in a mode
Data block	Byte string of the length (number of bytes less 5) contains the data to be Data
BCC (block check)	Result of byte-oriented XOR operation throughout the telegram, including STX
*) In the telegram listing **semi-bold** is highlighted	

Tab. 3-1: Telegram component denotation

The content of the telegram is transferred binarily.

3.3 Data interface

The NAV200 makes a serial data interface (RS-232/422) available. None of the communication paraments can be adjusted, with the exception of the data transfer rate:

Parameter	Value
Data transfer rate	19,200 Bd (default setting)
Start bits	1
Data bits	8
Stop bits	1
Parity	Straight

Tab. 3-2: Communication parameters of the data interface (RS-232/422)

The RTS and CTS handshake signals are not used.

To change the data transfer rate see *chapter 4.2.2 Command SB: Select the transfer rate of the data interface closest", page 19*.

3.4 Co-ordinates

The co-ordinates are signed values denoted in mm and refer to a rectangular and plane cartesian system of co-ordinates.

The NAV200 uses four bytes (INT32) to transmit the data of a co-ordinate:

	BYTE0	BYTE1	BYTE2	BYTE3
	LSB			MSB
	Example:			
Hex	CFh	34h	F9h	FFh
Value	–445233			
LSB = least significant byte MSB = most significant byte				

In this case the NAV200 transmits the LSB first.

This results in a theoretical range of:
8000 0000h (–2,147,483,648 dec.) to 7FFF FFFFh (+2,147,483,647 dec.).

The permissible range for absolute co-ordinates is:
–8,380,000 mm ≤ X ≤ 8,380,000 mm
–8,380,000 mm ≤ X ≤ 8,380,000 mm

3.5 Angle

Angle data also refers to a rectangular cartesian system of co-ordinates (*Fig. 3-1*). The x-axis direction is 0°and the y-axis direction 90° (mathematical system).

A 2-byte format (INT16) (bdeg) is used as a unit of measurement containing the highest possible splitting of the full circle in 16 bits:

1 bdeg = (90/16384)°

90°= 16,384 bdeg dec. (4,000h)

	BYTE0	BYTE1
	LSB	MSB
	Example:	
Hex	00h	60h
Value	6,000h = 135°	

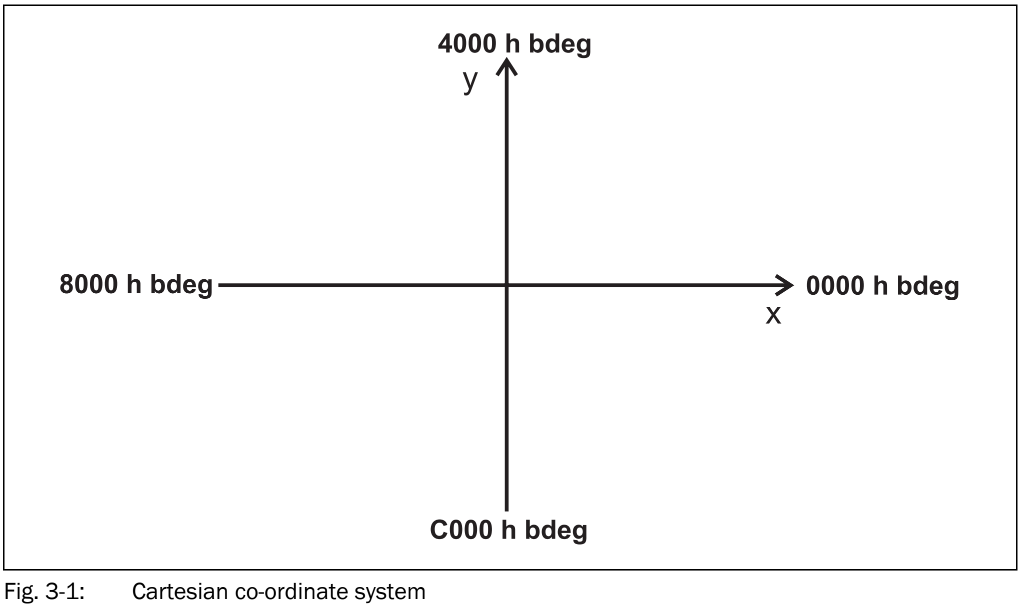


Fig. 3-1: Cartesian co-ordinate system

3.6 Co-ordinate systems

The NAV200 local co-ordinate system is within the range of the absolute co-ordinate system of the vehicle (the plant) defined by the user:

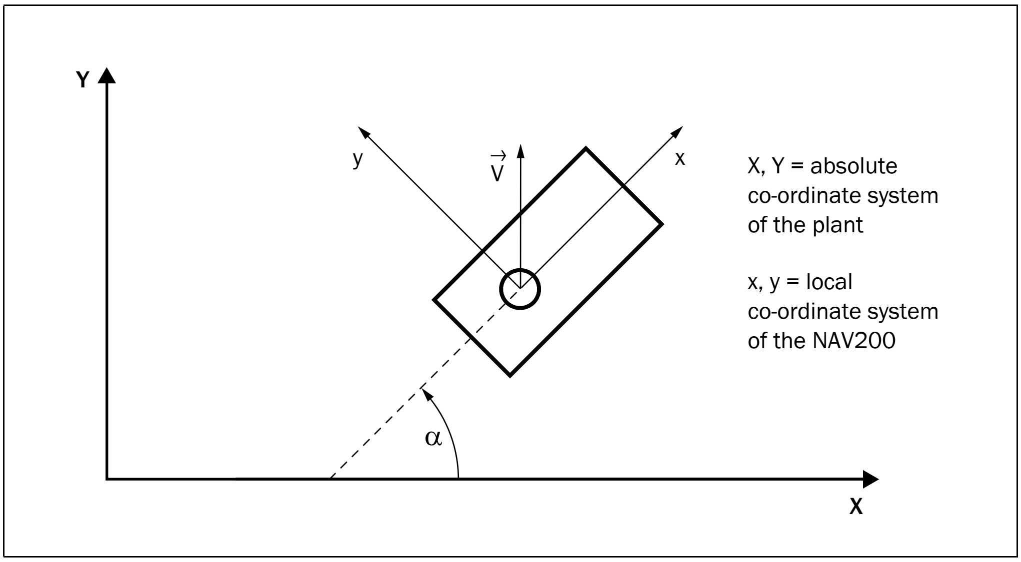


Fig. 3-2: Co-ordinate system of the NAV200

X, Y = absolute co-ordinate system of the plant

x,y = local co-ordinate system of the NAV200

α = Direction of the NAV200 in the absolute co-ordinate system

v = Velocity vector

Example:

Transformation of the velocity vector from the local co-ordinate system to the absolute co-ordinate system:

$VX = (Vx * \cos \alpha) - (Vy * \sin \alpha)$

$VY = (Vx * \sin \alpha) + (Vy * \cos \alpha)$

3.7 X/Y co-ordinates in the "reflector co-ordinate" mode

The x/y co-ordinates in the "reflector co-ordinate" mode are signed values denoted in mm and refer to the local cartesian co-ordinate system of the NAV200.

The NAV200 uses two bytes (INT16) to transmit the data of a co-ordinate:

	BYTE0	BYTE1
	LSB	MSB
	Examples:	
Hex	47h	18h
Value (mm)	18200	
Hex	F0h	D8h
Value (mm)	–10000	

In this case the NAV200 transmits the LSB first.

This results in a theoretical range of:
8,000h (–32,768 dec.) to 7FFFh (+32,768 dec.).

The range for NAV200 measurements in local co-ordinates is:
–30,000 mm ≤ x ≤ 30,000 mm
–30,000 mm ≤ y ≤ 30,000 mm

3.8 Polar co-ordinates in the "reflector co-ordinate" mode

The distances in the "reflector co-ordinate" mode are unsigned values denoted in mm and refer to the centre of the scanner head.

The NAV200 uses two bytes (INT16) to transmit the data of a distance:

	BYTE0	BYTE1
	LSB	MSB
	Example:	
Hex	56h	02h
Value (mm)	598	

In this case the NAV200 transmits the LSB first.

This results in a theoretical range of:
0 to +65,536 dec. (0000h ... FFFFh)

The range for distances D of the NAV200 is:
100 mm ≤ D ≤ 30,000 mm

Angle data refers to the NAV200local co-ordinate system.
The x-axis points from the scanner head to the connectors. Anti-clockwise values are positive (mathematical system).

The unit of measurement used is the 2-byte format (INT16) (bdeg) described in *chapter 3.5 Angle, page 12*.

1 bdeg = (90/16384)°

90°= 16,384 bdeg dec. (4,000h)

4 Modes

4.1 Command overview

Mode	Function	Command	Denotation	Page
Standby	Mode **S** (no measurement)	SA	Activate "standby" mode	*Chapter 4.2.1, page 18*
		SB	Select the transmission rate of the data interface (RS-232/422)	*Chapter 4.2.2, page 19*
		SV	Display Firmware version no.	*Chapter 4.2.3, page 21*
		ST	Display Firmware version string	*Chapter 4.2.4, page 22*
		St	Display identification string	*Chapter 4.2.5, page 23*
		SS	Display serial no.	*Chapter 4.2.6, page 24*
		SU	Enter scanner head direction of rotation	*Chapter 4.2.7, page 25*
		SR	Display a reflector position	*Chapter 4.2.8, page 26*
		SC	Change a reflector position	*Chapter 4.2.9, page 27*
		SI	Enter a new reflector position	*Chapter 4.2.10, page 28*
		SD	Delete a reflector position	*Chapter 4.2.11, page 30*
		SP	Configure reflector detection threshold	*Chapter 4.2.12, page 32*
		RG	Display reflector radius of a layer	*Chapter 4.2.13, page 33*
		RS	Enter reflector radius of a layer	*Chapter 4.2.14, page 34*
		BS	Select layer bank	*Chapter 4.2.15, page 35*
		BR	Read current layer bank	*Chapter 4.2.16, page 35*
	Change mode	PA	Activate position determination	*Chapter 4.4.6, page 49*
		PN	Activate position determination and enter the max. profile peak height	*Chapter 4.4.7, page 50*
		UA	Activate "upload" mode	*Chapter 4.5.1, page 69*
		DA	Activate "download" mode	*Chapter 4.5.3, page 71*
		RA	Activate "reflector co-ordinate" mode	*Chapter 4.6.3, page 74*
Mapping	Mode **M** (Measure reflector positions)	MA	Activate "mapping" mode	*Chapter 4.3.1, page 37*
		MS	Start mapping (scan)	*Chapter 4.3.2, page 38*
		MM	Start mapping with averaging	*Chapter 4.3.3, page 39*
		MN	Start "negative mapping" with averaging	*Chapter 4.3.4, page 41*
		MR	Display a mapping reflector position	*Chapter 4.3.5, page 43*
		SA	Activate "standby" mode	*Chapter 4.2.1, page 18*
		BS	Select layer bank	*Chapter 4.2.15, page 35*
		BR	Read current layer bank	*Chapter 4.2.16, page 35*

Tab. 4-1: Overview: Modes and possible commands for the NAV200

Mode	Function	Command	Denotation	Page
Positioning mode (determining position)	Mode **P** (Determine NAV200 position on the basis of detected reflectors)	PA	Reactivate reflector identification in the "determining position" mode (full map)	*Chapter 4.4.6, page 49*
		PN	Activate position determination and enter the max. profile peak height	*Chapter 4.4.7, page 50*
		PP	Display position on internal determination of velocity by the NAV200	*Chapter 4.4.8, page 51*
		Pv	Display position and enter the velocity externally in the local NAV200co-ordinate system	*Chapter 4.4.9, page 52*
		Pw	Display the position on the external input of the velocity and angular velocity in the local NAV200co-ordinate system	*Chapter 4.4.10, page 54*
		PV	Display position on the external input of velocity and angular velocity in the absolute co-ordinate system of the vehicle	*Chapter 4.4.11, page 56*
		BS	Select layer bank	*Chapter 4.2.15, page 35*
		BR	Read current layer bank	*Chapter 4.2.16, page 35*
		PL	Select current layer	*Chapter 4.4.12, page 58*
		PM	Select current layer and enter the NAV200position externally	*Chapter 4.4.13, page 59*
		PO	Select operating ranges	*Chapter 4.4.14, page 60*
		PC	Select number N of closest reflectors	*Chapter 4.4.15, page 61*
		PS	Suppress sectors in the visual range	*Chapter 4.4.16, page 62*
		PF	Define Quickmap identification window	*Chapter 4.4.17, page 64*
		SA	Activate "standby" mode	*Chapter 4.2.1, page 18*
Upload	Mode **U** (Display NAV200 in the stored reflector positions)	BS	Select layer bank	*Chapter 4.2.15, page 35*
		BR	Read current layer bank	*Chapter 4.2.16, page 35*
		UR	Display the next reflector position	*Chapter 4.5.2, page 70*
		RG	Display reflector radius of a layer	*Chapter 4.2.13, page 33*
		SA	Activate "standby" mode	*Chapter 4.2.1, page 18*
Download	Download **D** (Transfer new reflector position data to the NAV200 for the purpose of storing)	BS	Select layer bank	*Chapter 4.2.15, page 35*
		BR	Read current layer bank	*Chapter 4.2.16, page 35*
		DR	Transfer the next reflector position to the NAV200	*Chapter 4.5.4, page 72*
		RS	Enter reflector radius of a layer	*Chapter 4.2.14, page 34*
		SA	Activate "standby" mode	*Chapter 4.2.1, page 18*
Reflector co-ordinates	Mode **R** (Activate and deactivate the reflector position measurement. Extract the reflector co-ordinates (X/Y co-ordinates and polar co-ordinates))	BS	Select layer bank	*Chapter 4.2.15, page 35*
		BR	Read current layer bank	*Chapter 4.2.16, page 35*
		RD	Display reflector positions in polar output	*Chapter 4.6.4, page 75*
		RK	Display reflector positions in X/Y output	*Chapter 4.6.5, page 77*
		SA	Activate "standby" mode	*Chapter 4.2.1, page 18*
Record diagnosis data in the memory	Stores the selected type of reflector co-ordinates in the post-trigger memory of the NAV200	BS	Select layer bank	*Chapter 4.2.15, page 35*
		BR	Read current layer bank	*Chapter 4.2.16, page 35*
		PdM	Initialise and start up recording of the diagnosis data	*Chapter 5.4.1, page 85*
		Ps	Stop diagnosis data recording	*Chapter 5.4.2, page 85*
		P?	Display recording of diagnosis data	*Chapter 5.4.3, page 86*

Tab. 4-1: Overview: Modes and possible commands for the NAV200 (Cont.)

Important Modes are always changed in the standby mode with the activation command **MA, PA, PN, UA, DA** or **RA**. The respective current mode is exited by means of returning to the standby mode with the SA command.

4.2 "Standby" mode

In the "standby" mode the NAV200 will not determine position.
The "standby" mode is exited by switching to another mode. The modes are always changed on the basis of the "standby" mode.

The auxiliary functions "extracting the hardware and software versions" and "displaying and modifying individual reflector positions" can only be executed in the "standby" mode. The NAV200 automatically goes into the "standby" mode after being switched on.

4.2.1 Command SA: Activate "standby" mode

Mode	**S**	Standby
Function	**A**	Activate mode

Command SA to NAV200:

STX	5	**S**	**A**	BCC

NAV200 response (acknowledgement):

STX	5	**S**	**A**	BCC

The "standby" mode is active.

Each mode is switched to the "standby" mode with this command.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Block check
Structure	STX	5	**S**	**A**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	53h	41h	15h

4.2.2 Command SB: Select the transfer rate of the data interface closest"

Data interface default setting

Parameter	Value
Data transfer rate	19,200 Bd
Start bits	1
Data bits	8
Stop bits	1
Parity	Straight

Tab. 4-2: Default setting

The data transfer rate can be increased to 115,200 BD in several steps

In the received command, the NAV200 checks that the new data transfer rate is within the valid range and still acknowledges this command with the current data transfer rate.
If the rate is valid, the NAV200 re-initialises the interface. Data traffic is carried out at the newly initialised data transfer rate as of this point in time. The newly set data transfer rate is permanently stored. Any other interface traffic will use this data transfer rate, even after the NAV200 is switched off and then on again (cold start).
If the value is invalid, the NAV200 will display an error message.

Tip If the current data transfer rate is not known, it is recommended that an inquiry be made, e.g. with repeated identification inquiries by the **SA** command with the permissible data transfer rates and verification of the responses.

Mode	**S**	Standby
Function	**B**	Select data transfer rate

Command SB to NAV200:

STX	9	**S**	**B**	B0	B1	B2	B3	BCC

Block	Format	Denotation	Range (dec.)
B0, B1, B2, B3	INT32	Baud rate (LSB to MSB)	19200 Bd (default setting) 38400 Bd 57600 Bd 115200 Bd

Tab. 4-3: Command SB: Denotation of blocks B0 to B3

NAV200 response (acknowledgement):

STX	9	**S**	**B**	B0	B1	B2	B3	BCC

Important None of the other data interface communication parameters can be changed.

Example of a command input:

Set the data transfer rate at 57,600 Bd

Name	Start charac.	Length	Command		Data				Block check
Structure	STX	9	**S**	**B**	B0	B1	B2	B3	BCC
Byte position	1	2	3	4	5	6	7	8	9
Hex	02h	09h	53h	42h	00h	E1h	00h	00h	FBh
Value			SB		57600				

Example of NAV200response:

Name	Start charac.	Length	Command		Data				Block check
Structure	STX	9	**S**	**B**	B0	B1	B2	B3	BCC
Byte position	1	2	3	4	5	6	7	8	9
Hex	02h	09h	53h	42h	00h	E1h	00h	00h	FBh
Value			SB		57600				

4.2.3 Command SV: Display the NAV200 Firmware version number

Mode	**S** Standby
Function	**V** Display version number

Command SV to NAV200:

STX	5	**S**	**V**	BCC

NAV200 response (acknowledgement):

STX	8	**S**	**V**	V0	V1	V2	BCC

Block	**Denotation**	**Function**	**Range (dec.)**
V0	Version byte 0	Fundamental function modifications/extensions	0 ... 9
V1	Version byte 1	Minor function modifications/extensions	0 ... 9
V2	Version byte 2	Error corrections	0 ... 9

Tab. 4-4: Command SV: NAV200 response and Firmware version number output

The NAV200 displays the version number of its Firmware.

Example of a command input:

Name	Start character	Length	Command		Block check
Structure	STX	5	**S**	**V**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	53h	56h	02h

Example of NAV200response:

Name	Start character	Length	Command		Data			Block check
Structure	STX	8	**S**	**V**	V0	V1	V2	BCC
Byte position	1	2	3	4	5	6	7	8
Hex	02h	08h	53h	56h	04h	01h	00h	0Ah
Value					4	1	0	BCC

4.2.4 Command ST: Display the version string of the NAV200 firmware

Mode	**S** Standby
Function	**T** Display text of the version string

Command ST to NAV200:

STX	5	**S**	**T**	BCC

NAV200 response (acknowledgement):

STX	Size	**S**	**T**	Version string	BCC

Block	**Denotation**
Size	Length of the response, calculated on the basis of the number of version string characters **plus 5**
Version string	ASCII text string with information on the version and the version date

Tab. 4-5: Command ST: Structure of the NAV200response

The NAV200 displays the version string of its Firmware.

Example of a command input:

Name	Start character	Length	Command		Block check
Structure	STX	5	**S**	**T**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	53h	54h	00h

Example of NAV200 response:

Name	Start character	Size	Command		Data	Block check
Structure	STX	x + 5	**S**	**T**	Version string with x ASCII characters	BCC
Byte position	1	2	3	4	5 ... 32 (28 bytes)	33
Hex	02h	21h	53h	54h	4Eh 41h 56h 5Fh 44h 53h 50h 20h 34h 2Eh 31h 2Eh 30h 20h 20h 20h 20h 20h 31h 31h 2Eh 30h 34h 2Eh 32h 30h 30h 35h	53h
Value		33	ST		"NAV_DSP 4.1.0 11.04.2005"	

Figures 4, 1 and 0 in the Firmware version string are equivalent to the version number figures as displayed with command SV (see *chapter 4.2.3 Command SV: Display the NAV200 Firmware version number, page 21*).

4.2.5 Command St: Display NAV200 identification string

Mode	**S** Standby
Function	**t** Display text of the version string

Command St to NAV200:

STX	5	**S**	**t**	BCC

NAV200 response (acknowledgement):

STX	Size	**S**	**t**	Identification string	BCC

Block	**Denotation**
Size	Length of the command, calculated on the basis of the number of identification string characters **plus 5**
Identification string	ASCII text string containing device type, serial number and Firmware version.

Tab. 4-6: Command St: Structure of the NAV200 response

The NAV200 displays the identification string.

Example of a command input:

Name	Start character	Length	Command		Block check
Structure	STX	5	**S**	**t**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	53h	74h	20h

Example of NAV200 response:

Name	Start character	Size	Command		Data	Block check
Structure	STX	x + 5	**S**	**t**	Identification string with x ASCII characters	BCC
Byte position	1	2	3	4	5 ... 56 (52 bytes)	57
Hex	02h	39h	53h	74h	53h 74h 4Eh 41h 56h 32h 30h 30h 2Dh 31h 31h 33h 32h 20h 3Ah 20h 30h 35h 32h 31h 20h 39h 30h 31h 35h 20h 2Fh 20h 4Ch 41h 44h 41h 52h 20h 32h 44h 20h 4Eh 41h 56h 36h 2Eh 33h 2Eh 30h 2Ch 20h 30h 36h 2Eh 30h 32h	75h
Value		57	St		"NAV200-1132 0521 9015 / LADAR 2D NAV V6.3.0 06.02"	

The identification string contains the following information:

- NAV200-1132 = device type
- 0521 9015 = serial number (Unit No.), incl.
  0521 = calendar week 21/2005 in which the device was produced
  9015 = Serial number (binary), as displayed by command SS (see *chapter 4.2.6 Command SS: Display NAV200 serial number, page 24*)
- LADAR 2D NAV V6.3.0 06.02 = version string of the NAV200 measuring firmware

4.2.6 Command SS: Display NAV200 serial number

Mode	**S** Standby
Function	**S** Display serial number

Command SS to NAV200:

STX	5	**S**	**S**	BCC

NAV200 response (acknowledgement):

STX	7	**S**	**S**	S0	S1	BCC

Placeholder	**Denotation**
S0	LSB serial number
S1	MSB serial number

Tab. 4-7: Command SS: Structure of the NAV200 response

The NAV200 displays the last 4 figures of its serial number.

Example of a command input:

Name	Start character	Length	Command		Block check
Structure	STX	5	**S**	**S**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	53h	53h	07h

Example of NAV200 response:

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**S**	**S**	S0	S1	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	53h	53h	37h	23h	11h
Value			SS		9015		

4.2.7 Command SU: Enter the NAV200 scanner head direction of rotation

When installed normally with the scanner head on top, the head of the NAV200 will turn clockwise in the absolute and local co-ordinate system.
In contast, when the NAV200 is installed in an overhead position (scanner head to the bottom; scanner axis turned by 180°), the scanner head in the absolute co-ordinate system will turn anti-clockwise, so that the local co-ordinate system is reflected. The SU command will notify the NAV200 of this reflection. As a standard, when this command has not been entered, the normal installation position with a clockwise direction of rotation is presumed.

Mode	**S** Standby
Function	**U** Enter direction of rotation

SU command to NAV200:

STX	6	**S**	**U**	U	BCC

Block	Denotation	Range (dec.)	Default setting
U	Direction of rotation	1: Clockwise rotation 0: Anti-clockwise rotation	1

Tab. 4-8: Command SU: Denotation of block U

NAV200 response (acknowledgement):

STX	6	**S**	**U**	U	BCC

The NAV200 acknowledges the direction of rotation that has now been set.

Example of command input/NAV200 response:

Anti-clockwise direction of rotation (overhead installation)

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**S**	**U**	U	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	53h	55h	00h	02h
Value			SU		0	

4.2.8 Command SR: Display a reflector position stored in the NAV200

Mode	**S** Standby
Function	**R** Display a reflector position

Command SR to NAV200:

STX	7	**S**	**R**	E	No.	BCC

Block	**Denotation**	**Range (dec.)**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31

Tab. 4-9: Command SR: Denotation of blocks E and No.

Request for position data output for reflector *no.* in layer *E*.

NAV200 response (acknowledgement):

STX	15	**S**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**	**Range (dec.)**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31
X0 to X3	X position of the reflector (4 bytes, LSB to MSB)	–8,388,608 ... 8,388,607 mm
Y0 to Y3	Y position of the reflector (4 bytes, LSB to MSB)	–8,388,608 ... 8,388,607 mm

Tab. 4-10: Command SR: Structure of the NAV200 response

The NAV200 displays the position data of the selected reflector.

Example of a command input:

Display position of reflector no. 2 in layer 10

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**S**	**R**	E	No.	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	53h	52h	0Ah	02h	0Ch
Value			SR		10	2	

Example of NAV200 response:

Name	Start character	Length	Command		Data										Block check
Structure	STX	15	**S**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	0Fh	53h	52h	0Ah	02h	1Fh	23h	00h	00h	07h	B3h	FFh	FFh	8Ch
Value			SR		10	2	8,991 mm				-19,705 mm				

4.2.9 Command SC: Change a reflector position stored in the NAV200

Mode	**S**	Standby
Function	**C**	Change a reflector position

Command SC to NAV200:

STX	15	**S**	**C**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**	**Range (dec.)**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31
X0 to X3	X position of the reflector (4 bytes, LSB to MSB)	–8,388,608 ... 8,388,607 mm
Y0 to Y3	Y position of the reflector (4 bytes, LSB to MSB)	–8,388,608 ... 8,388,607 mm

Tab. 4-11: Command SC: Denotation of the blocks

Change to the position data of reflector *no.* in layer *E*.

NAV200 response (acknowledgement):

STX	15	**S**	**C**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**
E	Number of the layer
No.	Number of the reflector in the layer
X0 to X3	X position of the reflector in mm (4 bytes, LSB to MSB)
Y0 to Y3	Y position of the reflector in mm (4 bytes, LSB to MSB)

Tab. 4-12: Command SC: Structure of the NAV200 response

The NAV200 acknowledges with the new position data of the selected reflector.

Example of command input/NAV200response:

Change position of reflector no. 3 in layer 10

Name	Start character	Length	Command		Data										Block check
Structure	STX	15	**S**	**C**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	0Fh	53h	43h	0Ah	03h	C9h	22h	00h	00h	79h	B6h	FFh	FFh	30h
Value			SC		10	3	X = 8,905 mm				Y = -18,823 mm				

4.2.10 Command SI: Enter a new reflector position in the NAV200

Mode	**S**	Standby
Function	**I**	Enter new reflector position

Command SI to NAV200:

STX	15	**S**	**I**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**	**Range (dec.)**
E	Number of the layer	0 … 159
No.	Number of the reflector added to the layer	0 … 31
X0 to X3	X position of the reflector (4 bytes, LSB to MSB)	–8,388,608 … 8,388,607 mm
Y0 to Y3	Y position of the reflector (4 bytes, LSB to MSB)	–8,388,608 … 8,388,607 mm

Tab. 4-13: Command SI: Denotation of the blocks

Enter the position data for a new reflector *no.* in layer *E*.

NAV200 response (acknowledgement):

STX	15	**S**	**I**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**
E	Number of the layer
No.	Number of the reflector added to the layer
X0 to X3	X position of the reflector in mm (4 bytes, LSB to MSB)
Y0 to Y3	Y position of the reflector in mm (4 bytes, LSB to MSB)

Tab. 4-14: Command SI: Structure of the NAV200 response

If the number selected is within the range, the NAV200 will acknowledge this with the position data of the newly included reflector.

The NAV200 will treat the reflector position to be newly added to the layer as follows in terms of the selected number:

1. The number has already been allocated a reflector position:
   The entry under this number and all those that follow will move up one number. The number of valid reflector positions is raised by one.
   Example: Entry number 2

   Old: Pos:0 1 2 3 4

   New: Pos:0 1 **2** 3 4 5

2. The number is the same as the last valid number of reflector positions for this layer:
   The new position is added. The number of reflector is raised by one.
   Example: Entry number 5

   Old: Pos:0 1 2 3 4

   New: Pos:0 1 2 3 4 **5**

3. The number is higher than the current number of reflector positions for this layer: the required entry is rejected as being invalid by means of an error message (see *chapter 6.1 Error bytes, page 88*).
   Example: Entry number 6

Old:	Pos:0	1	2	3	4	
		|	|	|	|	|
New:	Pos:0	1	2	3	4	

4. The new number of reflector positions would exceed the maximum possible number for the layer: the required entry is rejected as being invalid by means of an error message (see *chapter 6.1 Error bytes, page 88*).
   Example: Entry number 32

Old:	Pos:0	1	2	...	31	
		|	|	|		|
New:	Pos:0	1	2	...	31	

Example of command input/NAV200 response:

Add reflector no. 3 to layer 10

Name	Start character	Length	Command		Data										Block check
Structure	STX	15	**S**	**I**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	0Fh	53h	49h	0Ah	03h	B8h	0Bh	00h	00h	48h	F4h	FFh	FFh	11h
Value			SI		10	3	X = 8,000 mm				Y = -8,000 mm				

4.2.11 Command SD: Delete a reflector position in the NAV200

Mode	**S** Standby
Function	**D** Delete reflector position

Command SD to NAV200:

STX	7	**S**	**D**	E	No.	BCC

Block	**Denotation**	**Range (dec.)**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31

Tab. 4-15: Command SD: Denotation of blocks E and No.

Deleting the position data of the selected reflector *no.* in layer *E*.

NAV200 response (acknowledgement):

STX	15	**S**	**D**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

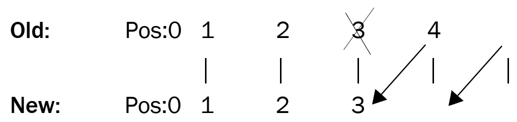
Block	**Denotation**	**Range (dec.)**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31
X0 to X3	X position of the reflector (4 bytes, LSB to MSB)	–8,388,608 ... 8,388,607 mm
Y0 to Y3	Y position of the reflector (4 bytes, LSB to MSB)	–8,388,608 ... 8,388,607 mm

Tab. 4-16: Command SD: Structure of the NAV200 response

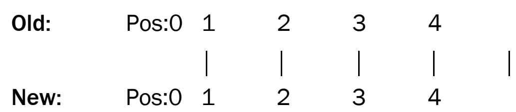
If the number selected is within the range, the NAV200 will acknowledge this with the position data of the reflector positioned under this particular number.

The NAV200 will treat the reflector to be deleted from the layer as follows in terms of the numbr selected:

1. The number has been allocated a reflector position.
   The entry under this number is deleted and all those that follow will move down one number. The number of valid reflector positions is reduced by one.
   Example: Entry number 2



2. The number is higher than or the same as the current number of reflector positions for this layer. The required deletion is rejected as being invalid (see *chapter 6.1 Error bytes, page 88*).
   Example: Entry number 5



Example of a command input:

Delete reflector no. 2 from layer 19

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**S**	**D**	E	No.	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	53h	44h	13h	02h	03h
Value			SD		19	2	

Example of NAV200 response:

Name	Start character	Length	Command		Data										Block check
Structure	STX	15	**S**	**D**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	0Fh	53h	44h	13h	02h	03h	22h	00h	00h	4Dh	DAh	FFh	FFh	BDh
Value			SD		19	2	X = 8,707 mm				Y = -9,651 mm				

4.2.12 Command SP: Configure reflector detection threshold in the NAV200

The SP command can be used in the "standby" mode and in the positioning mode.

Mode	**S** Standby
Function	**P** Configure reflector detection threshold

Command SP to NAV200:

STX	6	**S**	**P**	P	BCC

Block	Format	Denotation	Range (dec.)	Default setting
P	UINT8	Factor for changing the detection threshold as a percentage	0 % ... 100 %	50 % (average of the calibrated curve for white paper and the curve for 10-cm wide "3M Diamond Grade" reflector sheeting)

Tab. 4-17: Command SP: Denotation of block P

NAV200 response (acknowledgement):

STX	6	**S**	**P**	P	BCC

For detecting reflectors in comparison with less reflective material, the NAV200 uses an internal, distance-related reflection threshold curve. The threshold curve is located in the middle, between the device-specific calibrated curve on white paper and the curve on 10-cm wide "3M Diamond Grade" reflector sheeting, with the laser beam impacting vertically.

In order to make narrower or less reflective materials visible, this command enables the threshold curve to be adjusted on a percentage basis.
The following are equivalent in this case:

- the 0 % threshold curve and the calibrated curve on white paper
- the 100 % threshold curve and the calibrated curve on 10-cm wide "3M Diamond Grade" reflector sheeting

Important A lowering of the threshold curve will also reduce the signal-to-noise ratio between reflector sheeting and natural materials.

Raisng the threshold curve will reduce availability for reflector measurements.

The adjusted threshold curve is now used for all of the following reflector measurings, i.e. also in the "positioning" and in the "mapping" modes.

Example of command input/NAV200 response:

Set the reflector detection threshold at 45 %

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**S**	**P**	P	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	53h	50h	2Dh	2Ah
Value			SP		45 %	

4.2.13 Command RG: Display the reflector radius of a layer stored in the NAV200

The reflector radius is retrieved or set separately for each layer as a joint feature of the reflectors (see *chapter 4.2.14 Command RS: Enter the reflector radius of a layer in the NAV200, page 34*). Whereby the NAV200 operates on the currently active bank of layers (see *Chapter 4.2.15, page 35* / *Chapter 4.2.16, page 35*) The max. radius is 127 mm, the min. radius is 0 mm and indicates a flat reflector. Radii R Š 1 £ of 10 mm are possible; they are, however, not effective from a physical point of view.

The RG command may be used in the "standby" or "upload" modes.

Mode	**R**	Radius
Function	**G**	Display reflector radius (get)

Command RG to NAV200:

STX	6	**R**	**G**	E	BCC

Block	Denotation	Range (dec.)
E	Number of the layer	0 ... 159

Tab. 4-18: Command RG: Denotation of block E

NAV200 response (acknowledgement):

STX	7	**R**	**G**	E	R	BCC

Block	Denotation	Range (dec.)
E	Number of the layer	0 ... 159
R	Joint radius of the reflectors in a layer	0 ... 127 mm

Tab. 4-19: Command RG: Structure of the NAV200response

The NAV200 displays the reflector radius of the selected layer.

Example of a command input:

Display layer 10 reflector radius

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**R**	**G**	E	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	52h	47h	0Ah	1Bh
Value			RG		10	

Example of NAV200 response:

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**R**	**G**	E	R	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	52h	47h	0Ah	1Eh	09h
Value			RG		10	30 mm	

4.2.14 Command RS: Enter the reflector radius of a layer in the NAV200

The reflector radius is retrieved separately for each layer as a joint feature of the reflectors (see *chapter 4.2.13 Command RG: Display the reflector radius of a layer stored in the NAV200, page 33*). Whereby the NAV200 operates on the currently active bank of layers (see *Chapter 4.2.15, page 35 / Chapter 4.2.16, page 35*). The maximum radius is 127 mm, the minimum radius is 0 mm and indicates a flat reflector. Radii R ≥ 1 ≤ of 10 mm are possible; they are, however, not effective from a physical point of view. If no reflector radius is set in a layer, R = 0 (flat reflectors) is presumed; this is equivalent to the default setting

The RS command may be used in the "standby" or "download" modes.

Mode	**R**	Radius
Function	**S**	Set reflector radius

Command RS to NAV200:

STX	7	**R**	**S**	E	R	BCC

Block	**Denotation**	**Range (dec.)**
E	Number of the layer	0 ... 159
R	Joint radius of the reflectors in a layer	0 ... 127 mm

Tab. 4-20: Command RS: Denotation of blocks E and R

NAV200 response (acknowledgement):

STX	7	**R**	**G**	E	R	BCC

Block	**Denotation**
E	Number of the layer
R	Joint radius of the reflectors in a layer

Tab. 4-21: Command RS: Structure of the NAV200 response

The NAV200 acknowledges with the newly entered reflector radius of the selected layer. The formal response is identical to the response to command RG.

Example of a command input:

Set the reflector radius in layer 10 at 35 mm

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**R**	**G**	E	R	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	52h	47h	0Ah	23h	39h
Value			RS		10	35 mm	

Example of NAV200 response:

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**R**	**G**	E	R	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	52h	47h	0Ah	23h	39h
Value			RS		10	35 mm	

4.2.15 The BS command: Selecting a layer bank

The reflector storage plan is divided into two layer banks, Bank0 and Bank1. Each layer bank contains 160 layers (Layer 0 to Layer 159 each). Only one layer bank can be active at any time.

The BS command can be used in the Standby, Mapping, Positioning, Upload, Download and Reflector Co-ordinates operating modes.

Mode	**B** Layer Bank
Function	**S** Select Layer Bank

The BS command to the NAV200:

STX	6	B	S	newBankNr	BCC

Block	**Meaning**	**Value range (dec.)**
newBankNr	Number of the newly selected bank	0,1

Tab. 4-22: The BS command: meaning of the newBankNr block

NAV200 response (acknowledgement):

STX	6	B	S	actBankNr	BCC

Block	**Meaning**	**Value range (dec.)**
actBankNr	Number of the current layer	0,1

Tab. 4-23: The BS command: Structure of the NAV200 response

The maximum response time of the NAV200 is 895 ms.

4.2.16 The BR command: read the active layer bank

The reflector storage plan is divided into two layer banks, Bank0 and Bank1.

Each layer bank contains 160 layers (Layer 0 to Layer 159 each). Only one layer bank can be active at any time. The BR command can be used in the Standby, Mapping, Positioning, Upload, Download and Reflector Co-ordinates operating modes.

Mode	**B** Layer Bank
Function	**R** Read the active Layer Bank

The BR command to the NAV200:

STX	5	B	R	BCC

Block	Meaning	Value range (dec.)
actBankNr	Read current Layer Bank	0,1

Tab. 4-24: The BR command: meaning of the actBankNr block

NAV200 response (acknowledgement):

STX	6	B	R	actBankNr	BCC

Block	Meaning	Value range (dec.)
actBankNr	Number of the current layer Bank	0,1

Tab. 4-25: The BR command: Structure of the NAV200 response

The maximum response time ot the NAV200 is 10 ms.

4.3 "Mapping" mode

In the "Mapping" mode the NAV200 measures the reflector positions visible within its range in absolute co-ordinates. The measurings refer to one layer. To do so the NAV200 must be informed of the layer, its own position and direction in the absolute co-ordinate system and the radius of the reflectors. For reasons of compatability the radius is added at the end of the data string.

Important Mapping with the MS, MM or MN commands (see the following pages) makes recorded reflector positions temporarily available in the NAV200 main memory for the purpose of transfer with the MR command (see *chapter 4.3.5 Command MR: Reflector position from conducted NAV200 mapping output, page 43*). The data is however not permanently present in the NAV200 reflector memory.

The MA command can only be executed in the "standby" mode.

4.3.1 Command MA: Activate mapping in the NAV200

Mode	**M** Mapping
Function	**A** Activate mode

Command MA to NAV200:

STX	5	**M**	**A**	BCC

NAV200 response (acknowledgement):

STX	5	**M**	**A**	BCC

The "mapping" mode is active. Now the recording of the reflector positions at individual points of the course can be effectively started.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Block check
Structure	STX	5	**M**	**A**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	4Dh	41h	0Bh

4.3.2 Command MS: Start mapping in the NAV200

Mode	**M** Mapping
Function	**S** Start scanning

Command MS to NAV200:

STX	17	**M**	**S**	E	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	R	BCC

Block	Denotation	Range
E	Number of the layer	0 ... 159
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,350,000 ... 8,350,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,350,000 ... 8,350,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h .... FFFFh bdeg
R	Joint radius of the reflectors in a layer	0 ... 127 mm

Tab. 4-26: Command MS: Denotation of the blocks

Important The NAV200 must conduct the measuring of the reflector positions from a defined position in the selected layer.

NAV200 response (acknowledgement):

STX	7	**M**	**S**	E	No.	BCC

Block	Denotation	Range
E	Number of the layer	0 ... 159
N	Number of detected reflectors	0 ... 31

Tab. 4-27: Command MS: Structure of the NAV200 response

After measurement the NAV200 displays the number of reflectors detected in the layer.

Example of a command input:

Mapping in layer 2 from position x = 1000 mm, Y = 2000 mm, A = 0 °, R = 35 mm

Name	Start charac.	Length	Command		Data											Block check
Structure	STX	17	**M**	**S**	E	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	R	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hex	02h	11h	4Dh	53h	02h	F8h	03h	00h	00h	D0h	07h	00h	00h	00h	00h	23h	10h
Value			MS		2	1,000 mm				2,000 mm				0		35	

Example of NAV200 response:

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**M**	**S**	E	N	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	4Dh	53h	02h	07h	3Bh
Value			MS		2	7	

4.3.3 Command MM: Start "Mapping with scan averaging" in the NAV200

Mode	**M** Mapping
Function	**M** Start scan with averaging

Command MM to NAV200:

STX	18	**M**	**M**	E	S	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	R	BCC

Block	**Denotation**	**Range**
E	Number of the layer	0 ... 159
S	Number of rotations (scans) for averaging	1 ... 127
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,350,000 ... 8,350,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,350,000 ... 8,350,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h .... FFFFh bdeg
R	Joint radius of the reflectors in a layer	0 ... 127 mm

Tab. 4-28: Command MM: Denotation of the blocks

The NAV200 conducts the measuring of the reflector positions from a defined position in the selected layer. The command is equivalent to command MS with the additional possibility of entering the number of scans for the purpose of averaging.

NAV200 response (acknowledgement):

STX	7	**M**	**S**	E	N	BCC

Block	**Denotation**	**Range**
E	Number of the layer	0 ... 159
N	Number of detected reflectors in the layer	0 ... 31

Tab. 4-29: Command MM: Structure of the NAV200response

After measurement the NAV200 displays the number of reflectors detected in the layer.

Example of a command input:

Mapping with a standard scan in Layer 0 from Position X= 10,000 mm, Y= 5,000 mm, α = 90°

Name	Start ch.	Length	Command		Data													Block ch.
Structure	STX	18	**M**	**M**	E	S	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	R	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hex	02h	12h	4Dh	4Dh	00h	64h	10h	27h	00h	00h	88h	13h	00h	00h	00h	40h	00h	FDh
Value			MM		0	100	10,000 mm				5,000 mm				4000h=90°		0	

Example of NAV200 response:

4 reflectors detected

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**M**	**S**	E	N	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	4Dh	53h	00h	04h	1Fh
Value			MS		0	4	

4.3.4 Command MN: Start "Negative mapping with scan averaging" in the NAV200

Mode	**M**	Mapping
Function	**N**	Start "negative mapping" with averaging

Command MN to NAV200:

STX	18	**M**	**N**	E	S	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	R	BCC

Block	**Denotation**	**Range**
E	Number of the layer	0 ... 159
S	Number of rotations (scans) for averaging	1 ... 127
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,350,000 ... 8,350,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,350,000 ... 8,350,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h .... FFFFh bdeg
R	Joint radius of the reflectors in a layer	0 ... 127 mm

Tab. 4-30: Command MN: Denotation of the blocks

The NAV200 conducts the measuring of the reflector positions from a defined position and orientation in the selected layer. It compares the relfector positions measured with the reflector positions in this layer already present in the reflector memory. The radius for negative mapping must be identical with the radius for the selected layer in this case.

After measure the NAV200 displays the number of **new** reflectors detected in the layer. They are transferred to the NAV200 to be made available with command MR (see *chapter 4.3.5 Command MR: Reflector position from conducted NAV200 mapping output, page 43*). The formal response is identical to the response to command MS.

NAV200 response (acknowledgement):

STX	7	**M**	**N**	E	N	BCC

Block	**Denotation**
E	Number of the layer
N	Number of newly detected reflectors in the layer

Tab. 4-31: Command MN: Structure of the NAV200response

Example of a command input:

Negative mapping in layer 19 (radius 30 mm), 50 revolutions

Name	Start ch.	Length	Command		Data													Block ch.
Structure	STX	18	**M**	**N**	E	S	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	R	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hex	02h	12h	4Dh	4Eh	13h	32h	00h	00h	00h	00h	F0h	D8h	FFh	FFh	00h	40h	1Eh	44h
Value			MN		19	50	X = 0 mm				Y = -8,000 mm				4,000h= 90°		30 mm	

Example of NAV200 response:

3 new reflectors detected in layer 19

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**M**	**S**	E	N	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	4Dh	4Eh	13h	03h	16h
Value			MS		19	3	

4.3.5 Command MR: Reflector position from conducted NAV200 mapping output

The MR command is used to read the reflector positions previously measured with commands MS, MM or MN out of NAV200 main memory.

Mode	**M** Mapping
Function	**R** Display a reflector position (after mapping)

Command MR to NAV200:

STX	7	**M**	**R**	E	No.	BCC

Block	**Denotation**	**Range**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31

Tab. 4-32: Command MR: Denotation of blocks E and No.

Request for position data output for reflector *no.* in layer *E*.

NAV200 response (acknowledgement):

STX	15	**M**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**	**Range**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31
X0 to X3	X position of the reflector (LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the reflector (LSB to MSB)	–8,380,000 ... 8,380,000 mm

Tab. 4-33: Command MR: Structure of the NAV200 response

Position of reflector *no.* in layer *E*. In the case of –1 as a reflector number, the NAV200 will have transferred all the reflectors of a layer. This will, for example, occur when 3 reflectors (numbers 0, 1 and 2) were mapped and the position of No. 3 is requested.

Example of a command input:

Request for reflector 2 in layer 19

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**M**	**R**	E	N	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	4Dh	52h	13h	02h	0Bh
Value			MR		19	2	

Example of NAV200 response:

Name	Start character	Lengt h	Command		Data										Block check
Structure	STX	15	**M**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	0Fh	4Dh	52h	13h	02h	5Eh	FBh	FFh	FFh	54h	DAh	FFh	FFh	28h
Value			MR		19	2	X = -1,186 mm				Y = -9,644 mm				

4.4 "Positioning" mode (determining position")

The "positioning" mode is the standard mode of the NAV200.

In this mode the NAV200 analyses the reflector position measurements and uses a comparison with the reflector positions in its reflector memory to determine its own position and direction in the layer.
The NAV200 only transmits its position data upon request.

The active layer can be selected during the positioning process.

The first determination of a position after activating the positioning process by the PN or PA commands is carried out in the **full map**, which means that the NAV200 looks for its own position without any previous knowledge of its approximate position.
The allocation of measured reflector positions to the reflector positions stored in the reflector memory which is essential for calculating a position is carried out by means of a CPU-intensive process of matching the pattern of reflector allocation. Starting in the full map mode may take several seconds, depending on the number of reflectors in a layer.

After starting the NAV200 operates in **Quickmap** with the help of previous measurements. Reflectors are allocated in this case by means of tracing the reflectors in a geometric capture range. In the case of accelerated movement one or more reflectors may be seen beyond the scope of this capture range and hence no longer contribute to determining position. Detecting fewer than 3 reflectors may result in a **loss of contact** to the layer (also termed **loss of position).**

4.4.1 Details on speed when requesting positions

The NAV200 extrapolates the data on position and direction at the point in time of the data output to the vehicle processor. In this case the NAV200 needs the velocity and the angular velocity to be entered externally by the vehicle processor.

For a position request **PP** these speeds are determined by the NAV200 itself.

The velocity vector and the angular velocity are passed on by the vehicle processor direct on receipt of the commands requesting position **Pv** and **Pw** (see also *chapter 3.6 Co-ordinate systems, page 13*).

Command	**Velocity input**	
	Path velocity	Angular velocity
PP	–	–
Pv (Vx, Vy)	Velocity vector in the **local co-ordinate system of the NAV200**	–
Pw (Vx, Vy, ω)	Velocity vector in the **local co-ordinate system of the NAV200**	Angular velocity
PV (VX, VY, ω)	Velocity vector in the **absolute co-ordinate system**	Angular velocity

Tab. 4-34: Overview: Commands with velocity vectors

4.4.2 Timing when requesting a position

Reflector position measurement

The NAV200 calculates its position from a measurement on reflectors. The measurement data of each full rotation of the head (scan) are used for calculating a position. A scan takes 125 ms. When the AGV moves, measurement on the reflectors will be distorted due to this movement during a scanning process. A reflector position at the beginning of a scan is relative at a different position to that at the end of a scan.

After a full rotaton the measurement data are transferred into the position calculation process (POS). Due to distortion during a scan, the calculation process will need information on velocity in order to adjust the reflector measurement.

The scanning time and the time required for calculating a position will last approx. 135 ms.

When movement is accelerated, the point in time of passing on the speed will affect the precision of the calculation of a position and reflector identification.

Position determining speed and time

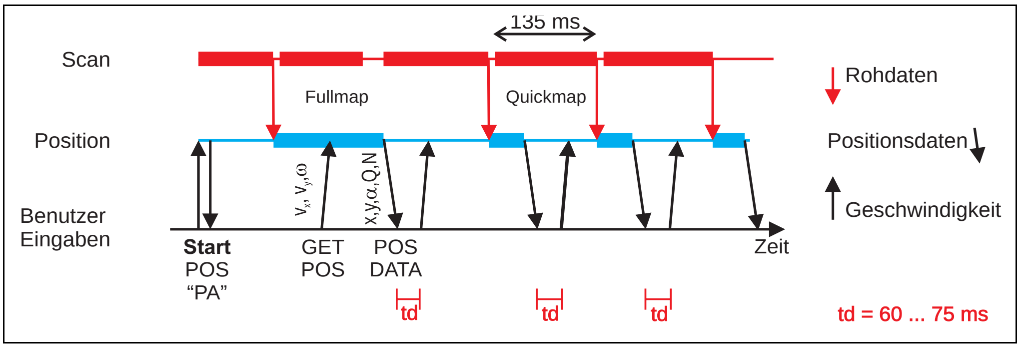


Fig. 4-1: Determining position timing

Principles for measuring position with movement

- Positions are determined with a full 360° scan.
- Scanning and evaluation of the previous scan are parallel processes.
- The movement of the NAV200 and the rotation of the scanner head are balanced by changing the shift and the speed of rotation.
- The position data at the data interface are extrapolated to the point in time of transmission.
- Speeds are either calculated by the NAV200 or they are delivered by the vehicle processor (taken from odometric system data).

The 360° scan, the calculation of the position from the previous scan and application input are parallel processes.

The velocity vectors made available by the Pw, Pv or PV commands or calculated by automatic detection in the PP command are used for:

a) Adjusting the reflector positions

With the help of the velocity vectors, the reflector positions measured are counted back to the temporal middle of a scan. Equivalent to a snapshot in the middle of a scan.

b) Identifiying the reflectors

In a current determination of position the NAV200 will be in the **Quickmap** mode. In Quickmap the NAV200 is in expectation of the approximate reflector positions. The information on velocity is used in the NAV200 for projecting the approximate position of the reflectors. Measurements on reflectors are then allocated to the respective corresponding reflectors (see also Section 3.6 and the following in the manual NAV200).

c) Extrapolating the position data to the point in time of transmission

The NAV200 extrapolates the calculated position data and the information on velocity to the point in time of transmission of the first byte.

Regulation on position for accelerated movement

The NAV200 calculates the position from a 360° scan and uses the current velocity vectors for this scan.

If the velocity vectors and the actual speed of the AGV at the point in time of scanning are identical, distortion caused by the movement of the AGV will be at the lowest level.

The best results can be achieved if a position enquiry with the latest information on speed is forwarded approximately 60 ... 75 ms after receipt of the first byte of the previous position data. The cycle time of the AGV vehicle processor must also be included in the calculation. The time delay for calculating the velocity information of the odemetric system signals must be included in the calculation.

4.4.3 Commands for selecting a layer in the positioning mode

The organisation of the course in layers (levels) means that the current layer must be indicated before the first position enquiry is delivered and for alternation between the layers. Command **PL**, with which only the layer number is indicated by means of parameter E and command **PM**, which also comprises a position and orientation default setting, are available here.

In addition, it is necessary to ensure that the NAV200 is operating on the correct layer bank. The appropriate bank can be activated by layer selection with the BS command.

A layer must always be selected prior to the first position enquiry after activating the positioning mode. The command **PM** can be used when the layer and the position are known and the NAV200 is newly switched to the positioning mode (e.g. at a battery charging station). The NAV200 will then operate in Quickmap.

4.4.4 Commands to select reflector measurements for determining position

The precision of determining position depends on the average distance of all the reflectors used for determining a position.
In order to optimise the positioning results, for example at docking stations, commands **PO** and **PC** are available and can be used to exclude reflectors that are located further away. The parameters that can be set with the commands already have effective default settings ("include all reflector measurements").

Please note Parameterisations undertaken by the PO and PC commands will be lost when the positioning mode is exited.

4.4.5 Recognising the reasons for losses of position

The reasons for losses of position can be seen in parameters **G** and **N** in the response of the NAV200 to a position request.

1. G = 0:
   No contact to the layer. The NAV200 attempts to restore contact in **Quickmap** until the user releases command PA or PN (force full map). The position data during the Quickmap process are calculated with virtual driving on at the current speeds (blind route).
2. G = –1 (FFh):
   No contact to the layer. The vritual determination of position has been outside of 3 m in X or Y since last determining position.
3. G = –2 (FEh):
   The NAV200 has determinined the position, but the number of valid reflectors determined by operational radii is less than 3. For this reason all the valid reflectors viewed, even those outside the operational range, are used.

The additional parameter **N** in the response to the position request **PP** contains the number of reflectors used for determining position.

4.4.6 Command PA: Activate the NAV200 position determination

Command PA is used to activate determining position from the "standby" mode.
On the other hand, when the positioning mode is activated, the PA command will initiate a restart in the full map mode (see *chapter 4.4 "Positioning" mode (determining position"), page 45*).

Mode	**P** Determining position
Function	**A** Activate mode

Command PA to NAV200:

STX	5	**P**	**A**	BCC

NAV200 response (acknowledgement):

STX	5	**P**	**A**	BCC

The "positioning" mode (determining position) is active.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Block check
Structure	STX	5	**P**	**A**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	50h	41h	16h

4.4.7 Command PN: Activate position determination of the NAV200 on entering the max. profile peak

Command PN is used to activate determining position from the "standby" mode.
On the other hand, when the positioning mode is activated, the PN command will initiate a restart in the full map mode (see *chapter 4.4 "Positioning" mode (determining position"), page 45*).

Mode	**P**	Determining position
Function	**N**	Activate a mode on entering the max. profile peak

Command PN to NAV200:

STX	6	**P**	**N**	S	BCC

Block	**Denotation**	**Range**	**Default setting**
S	Number of measurements for a gliding medium	1 ... 63	4

Tab. 4-35: Command PN: Denotation of block S

NAV200 response (acknowledgement):

STX	5	**P**	**A**	BCC

The "positioning" mode (determining position) is active. The formal response is identical to the response to command PA.

Example of a command input:

Activate the positioning mode with max. profile peak 1

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**P**	**N**	S	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	50h	4Eh	01h	1Bh
Value			PN		1	

Example of NAV200 response:

Name	Start character	Length	Command		Block check
Structure	STX	5	**P**	**A**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	50h	41h	16h

4.4.8 Command PP: Position of the NAV200 displayed on the automatic internal determination of velocity by the NAV200

Mode	**P**	Determining position
Function	**P**	Display current position without external speed entry into the NAV200

Command PP to NAV200:

STX	5	**P**	**P**	BCC

Request for output of the current position data of the NAV200.

NAV200 response (acknowledgement):

STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC

Block	**Denotation**	**Range**
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h ... FFFFh bdeg
G	Quality of position determination	0 ... 100, –1, –2
N	Number of reflectors used for determining position	0 ... 31

Tab. 4-36: Command PP: Structure of the NAV200 response

Example of a command input:

Name	Start character	Length	Command		Block check
Structure	STX	5	**P**	**P**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	50h	50h	07h

Example of NAV200 response:

Name	Start ch.	Length	Command		Data												Block check
Structure	STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hex	02h	11h	50h	50h	0Ch	27h	00h	00h	EDh	D8h	FFh	FFh	D7h	3Fh	56h	03h	B0h
Value			PP		X = 9,996 mm				Y = -10,003 mm				3FD7h bdeg		86	3	

4.4.9 Command Pv: Display position of the NAV200 on external velocity entry in the local co-ordinate system of the NAV200

Mode	**P**	Determining position
Function	**v**	Display current position on external velocity input in the local co-ordinate system of the NAV200

Command Pv to NAV200:

STX	9	**P**	**v**	Vx0	Vx1	Vy0	Vy1	BCC

Block	**Denotation**	**Range**
Vx0, Vx1	X component of velocity in the local co-ordinate system of the NAV200 (LSB to MSB)	–4,000 ... 4,000 mm/s
Vy0, Vy1	Y component of velocity in the local co-ordinate system of the NAV200 (LSB to MSB)	–4,000 ... 4,000 mm/s

Tab. 4-37: Command Pv: Denotation of the individual blocks

Request to display the current position data of the NAV200 on the external input of the velocity of the NAV200 **in the local co-ordinate system of the NAV200** by the vehicle processor.

NAV200 response (acknowledgement):

STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC

Block	**Denotation**	**Range**
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h ... FFFFh bdeg
G	Quality of position determination	0 ... 100, –1, –2
N	Number of reflectors used for determining position	0 ... 31

Tab. 4-38: Command Pv: Structure of the NAV200 response

The formal response is identical to the response to command PP.

Example of a command input:

Name	Start ch.	Length	Command		Data				Block check
Structure	STX	9	**P**	**v**	Vx0	Vx1	Vy0	Vy1	BCC
Byte position	1	2	3	4	5	6	7	8	9
Hex	02h	09h	50h	76h	EAh	03h	01h	00h	C5h
Value			Pv		Vx = 1,002 mm/s		Vx = 1 mm/s		

Example of NAV200 response:

Name	Start ch.	Length	Command		Data												Block check
Structure	STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hex	02h	11h	50h	50h	0Ch	27h	00h	00h	EDh	D8h	FFh	FFh	D7h	3Fh	56h	03h	B0h
Value			PP		X = 9,996 mm				Y = -10,003 mm				3FD7h bdeg		86	3	

4.4.10 Command Pw: Display position of the NAV200 on the external input of velocity and angular velocity in the local co-ordinate system of the NAV200

Mode	**P**	Determining position
Function	**w**	Display current position on the extermal input of velocity and Angular velocity in the local co-ordinate system of the NAV200

Command Pw to NAV200:

STX	11	**P**	**w**	Vx0	Vx1	Vy0	Vy1	VA0	VA1	BCC

Block	Denotation	Range
Vx0, Vx1	X component of velocity in the local co-ordinate system of the NAV200 (LSB to MSB)	–4,000 ... 4,000 mm/s
Vy0, Vy1	X component of velocity in the local co-ordinate system of the NAV200 (LSB to MSB)	–4,000 ... 4,000 mm/s
VA0, VA1	Angular velocity of the NAV200 (LSB to MSB)	0000h ... 4000h bdeg/s

Tab. 4-39: Command Pw: Denotation of the individual blocks

Request to display the current position data of the NAV200 on the external default setting of the velocity and the angular velocity of the NAV200 in the **local co-ordinate system of the NAV200** by the vehicle processor.

NAV200 response (acknowledgement):

STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC

Block	Denotation	Range
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h ... FFFFh bdeg
G	Quality of position determination	0 ... 100, –1, –2
N	Number of reflectors used for determining position	0 ... 31

Tab. 4-40: Command Pw: Structure of the NAV200response

The formal response is identical to the response to command PP.

Example of a command input:

Name	Start character	Length	Command		Data						Block check
Structure	STX	11	**P**	**w**	Vx0	Vx1	Vy0	Vy1	VA0	VA1	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11
Hex	02h	0Bh	50h	77h	EAh	03h	02h	00h	00h	00h	C5h
Value			Pw		Vx = 1,002 mm/s		Vx = 2 mm/s		VA = 0h bdeg/s		

Example of NAV200 response:

Name	Start ch.	Length	Command		Data												Block check
Structure	STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hex	02h	11h	50h	50h	0Ch	27h	00h	00h	EDh	D8h	FFh	FFh	D7h	3Fh	56h	03h	B0h
Value			PP		X = 9,996 mm				Y = -10,003 mm				3FD7h bdeg		86	3	

4.4.11 Command PV: Display the NAV200 position on the external input of velocity and angular velocity in the absolute co-ordinate system of the vehicle

Mode	**P**	Determining position
Function	**V**	Display current position on the extermal input of velocity and angular velocity in the absolute co-ordinate system of the vehicle

Command PV to NAV200:

STX	11	**P**	**V**	VX0	VX1	VY0	VY1	VA0	VA1	BCC

Block	**Denotation**	**Range**
VX0, VX1	X component of velocity in the absolute co-ordinate system of the vehicle (LSB to MSB)	–4,000 ... 4,000 mm/s
VY0, VY1	X component of velocity in the absolute co-ordinate system of the vehicle (LSB to MSB)	–4,000 ... 4,000 mm/s
VA0, VA1	Angular velocity of the NAV200 (LSB to MSB)	0000h ... 4000h bdeg/s

Tab. 4-41: Command PV: Denotation of the individual blocks

Request to display the current position data of the NAV200 on the external input of the velocity and the angular velocity of the NAV200 by the vehicle processor in the **absolute co-ordinate system of the vehicle**.

NAV200 response (acknowledgement):

STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC

Block	**Denotation**	**Range**
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–4,000 ... 4,000 mm/s
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–4,000 ... 4,000 mm/s
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h ... 4000h bdeg/s
G	Quality of position determination	0 ... 100, –1, –2
N	Number of reflectors used for determining position	0 ... 31

Tab. 4-42: Command PV: Structure of the NAV200response

The formal response is identical to the response to command PP.

Example of a command input:

Name	Start character	Length	Command		Data						Block check
Structure	STX	11	**P**	**V**	VX0	VX1	VY0	VY1	VA0	VA1	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11
Hex	02h	0Bh	50h	56h	EAh	03h	01h	00h	00h	00h	E7h
Value			PV		VX = 1,002 mm/s		VY = 1 mm/s		VA = 0h bdeg/s		

Example of NAV200 response:

Name	Start ch.	Length	Command		Data												Block check
Structure	STX	17	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hex	02h	11h	50h	50h	0Ch	27h	00h	00h	EDh	D8h	FFh	FFh	D7h	3Fh	56h	03h	B0h
Value			PP		X = 9,996 mm				Y = -10,003 mm				3FD7h bdeg		86	3	

4.4.12 Command PL: Select current layer in the NAV200

Mode	**P** Determining position
Function	**L** Select current layer

Command PL to NAV200:

STX	6	**P**	**L**	E	BCC

Block	**Denotation**	**Range**
E	Number of the next layer	0 … 159

Tab. 4-43: Command PL: Denotation of block E

Request to call up the next, current layer in the NAV200.

NAV200 response (acknowledgement):

STX	6	**P**	**L**	E	BCC

The NAV200 acknowledges by displaying the number of what is now the current layer.

Example of command input/NAV200response:

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**P**	**L**	E	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	50h	4Ch	13h	0Bh
Value			PL		19	

4.4.13 Command PM: Select the current layer in the NAV200 by means of the external input of the position of the NAV200

Mode	**P** Determining position
Function	**M** Select current layer with an external position entry

Command PM to NAV200:

STX	16	**P**	**M**	E	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	BCC

Block	**Denotation**	**Range**
E	Number of the next layer	0 ... 159
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h ... FFFFh bdeg

Tab. 4-44: Command PM: Denotation of the individual blocks

Selecting the layer with a position setting by the vehicle processor enables the Quickmap to be immediately activated for the purpose of determining position.

NAV200 response (acknowledgement):

STX	16	**P**	**M**	E	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	BCC

The NAV200 acknowledges with the input data.

Example of command input/NAV200response:

Name	Start ch.	Length	Command		Data											Block check
Structure	STX	16	**P**	**M**	E	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	10	12	13	15	15	16
Hex	02h	10h	50h	4Dh	07h	FAh	50h	00h	00h	67h	FCh	FFh	FFh	00h	80h	B9h
Value			PM		7	X = 20,730 mm				Y = -921 mm				8,000h bdeg		

4.4.14 Command PO: Select the operating radii of the NAV200

Mode	**P** Determining position
Function	**O** Operating radii default setting

Command PO to NAV200:

STX	13	**P**	**O**	Rfr0	Rfr1	Rfr2	Rfr3	Rto0	Rto1	Rto2	Rto3	BCC

Block	**Denotation**	**Range**	**Default setting**
Rfr0 to Rfr3	Operation radius of xxx mm (4 bytes, LSB to MSB)	50 ... 29,500 mm	500 mm
Rto0 to Rto3	Operation radius of up to xxx mm (4 bytes, LSB to MSB)	500 ... 30,000 mm	30,000 mm

Tab. 4-45: Command PO: Denotation of the individual blocks (rto > rfr)

The operation radii define an area in the locality of the NAV200 within which only the reflector positions measured here are to contribute towards determining position. The parameters"Rfr" and "Rto" define this area as being an annulus. The area is to be selected so that the NAV200 always sees sufficient reflectors which belong to the current layer. If there are fewer than three, the NAV200 will use all the reflector detected in its measuring range. **For the purpose of identification, the G is set at –2 (FEh)** (see also *chapter 4.4.5 Recognising the reasons for losses of position, page 48*).

The command can be used to change the operating range during the positioning mode. Default setting: Rfr = 500 mm, Rto = 30,000 mm.

Settings made for Rfr and Rto are only temporary and are reset at the default setting when the positioning mode is exited. Values which deviate from the default setting most hence be newly specified after each shift into the positioning mode.

NAV200 response (acknowledgement):

STX	13	**P**	**O**	Rfr0	Rfr1	Rfr2	Rfr3	Rto0	Rto1	Rto2	Rto3	BCC

The NAV200 acknowledges by displaying what is now the current operation radii.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Data								Block check
Structure	STX	13	**P**	**O**	Rfr0	Rfr1	Rfr2	Rfr3	Rto0	Rto1	Rto2	Rto3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	14
Hex	02h	0Dh	50h	4Fh	F4h	01h	00h	00h	34h	21h	00h	00h	F0h
Value			PO		Rfr = 500 mm				Rto = 8,500 mm				

4.4.15 Command PC: Select "the number N of closest reflectors"

Mode	**P** Determining position
Function	**C** Setting of the number N of closest reflectors

Command PC to NAV200:

STX	6	**P**	**C**	N	BCC

Block	**Denotation**	**Range**	**Default setting**
N	Number N of closest reflectors	0 (all), 3 ... 32	0

Tab. 4-46: Command PC: Denotation of the individual blocks

The parameter **N closest reflectors** enables the vehicle processor to select a certain number of valid reflectors when in the positioning mode for the purpose of determining position; they are to be closest to the NAV200.

N = 0 select all the valid reflectors. Otherwise N ≥ 3.

The number N of closest reflectors may be changed during the active process of determining position. Default setting: N = 0.
The setting for N is temporary and is reset to the default setting when the positioning mode is exited. Values which deviate from the default setting most hence be newly specified after each shift into the positioning mode.

NAV200 response (acknowledgement):

STX	6	**P**	**C**	N	BCC

The NAV200 acknowledges the command by displaying what is now the valid number N of closest reflectors.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**P**	**C**	N	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	50h	43h	05h	14h
Value			PC		5	

4.4.16 Command PS: Sector muting

In some of the applications individual segment angles (sectors) are to faded out in the 360° scanning range of the NAV200.
For example, when a raised load partially conceals individual reflectors from the NAV200 so that it is not possible to exactly determine the centre of the reflectors. This may then impair the accuracy of positions determined.

The NAV200 does not use any measurements on reflectors which are fully or partially located in the "muted sectors" for determining position.

Muted sectors are set in the "positioning" mode (determining position). The sectors are then activated for the following position request.

Important The reflector layout is to be designed so that at least three reflectors are always visible in the active sectors for the NAV200.
If this is not the case, the NAV200 will determine the position with all the visible reflectors (similar to command **PO** operation radii of the NAV200) and will display G = –2 in the following response to a request for a position.

The borders of the muted sectors are shown mathematically positive as angles in bdeg. Up to 4 sectors are possible. The sectors may not overlap and the start angle must be defined in a rising sequence beginning with a value which is ≥0. A sector which contains 0° must be defined as the final sector (*Fig. 4-2*).

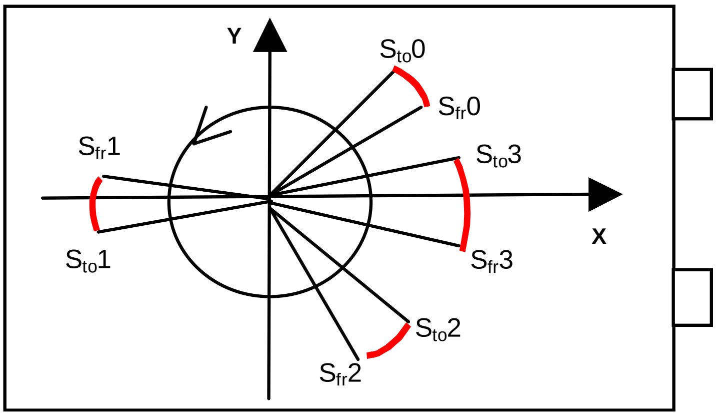


Fig. 4-2: Example of the definition of muted sectors

The NAV200 checks the defined sectors to ensure that their values are plausible and rejects these in the event of faulty input by means of an error message.

Mode	**P**	Determining position
Function	**S**	Define muted sectors

Command PS to NAV200:

STX	6 + (N * 4)	**P**	**S**	N	{$S0fr_i$, $S1fr_i$; $S0to_i$, $S1to_i$}	BCC

Block	**Format**	**Denotation**	**Range**
N	BYTE Sanz	Number of sectors	0 (default setting), max. 4
{$S0fr_i$, $S1fr_i$; $S0to_i$, $S1to_i$}	N * (UINT16 Sfr, UINT16 Sto)	Sector angle from ... to bdeg	No overlapping! $Sfr_i < Sfr_{i+1}$ ($i \le N$ for $0 < N \le 4$)

Tab. 4-47: Command PS: Denotation of the individual blocks

NAV200 response (acknowledgement):

STX	6 + (N * 4)	**P**	**S**	N	{$S0fr_i$, $S1fr_i$; $S0to_i$, $S1to_i$}	BCC

The NAV200 acknowledges the command by displaying what is now the valid number N of muted sensors and their ranges (start and end angles).

Example of command input/NAV200 response:

Name	Start ch.	Length	Command		Data					Block check
Structure	STX	10	**P**	**S**	N	S0fr	S1fr	S0to	S1to	BCC
Byte position	1	2	3	4	5	6	7	8	9	10
Hex	02h	0Ah	50h	53h	01h	71h	3Ch	8Eh	43h	8Ah
Value		10	PS			3C71h bdeg		438Eh bdeg		

4.4.17 Command PF: Define Quickmap identification window

The identification window is used for identifying the reflectors in Quickmap.
In Quickmap the NAV200 is in expectation of the approximate reflector positions.
The NAV200 sets an identification window with a radius of 300 mm around each of the reflector co-ordinates in the current layer. If the NAV200 recognises a reflector in this identification window, it will allocate the expected position to this reflector and will use it the next time a position is determined (see also Section 3.6.3 of the manual NAV200).

The radius of the identification window can be changed with command **PF**. This enables the NAV200 to be optimised for extremely dynamic changes in velocity of the AGV and for extreme conditions resulting from faulty reflections.

The radius can be adjusted depending on the distance between the NAV200 and the reflector.

The start and end points of an even function are transferred to the NAV200 to this purpose. The NAV200 uses these to calculate the respective radius of the identification window. The start and end point of the straight lines are defined at 0.5 m by the Rlow radius and at 28.5 m by the Rhigh radius.

The radius at these two points can be sent in the range of 100 ... 500 mm.

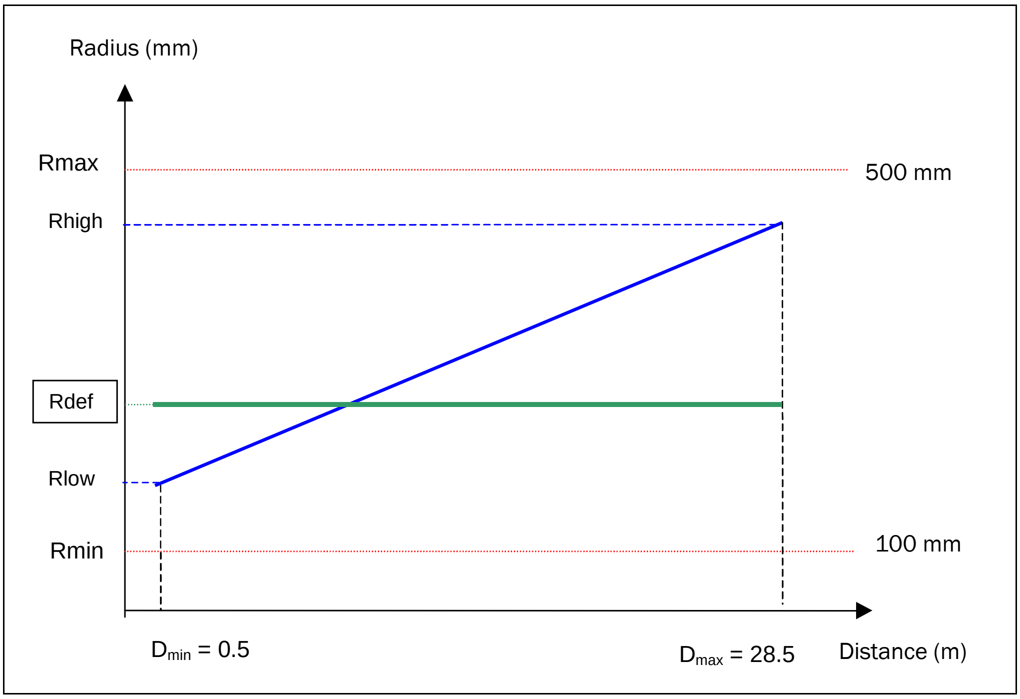


Fig. 4-3: Diagram: Radius of the identification window in Quickmap

Mode	**P** Determining position
Function	**F** Define radius of the identification window

Command PF to NAV200:

STX	9	**P**	**F**	Rlow0	Rlow1	Rhigh0	Rhigh1	BCC

Block	Format	Denotation	Range
Rlow0, Rlow1	UNIT16 Rlow (LSB, MSB)	Radius in mm at a distance of 0.5 m	100 mm ≤ R ≤ 500 mm (Default setting: 300 mm)
Rhigh0, Rhigh1	UNIT16 Rhigh (LSB, MSB)	Radius in mm at a distance of 28.5 m	100 mm ≤ R ≤ 500 mm (Default setting: 300 mm)

Tab. 4-48: Command PF: Denotation of the individual blocks

NAV200 response (acknowledgement):

STX	9	**P**	**F**	Rlow0	Rlow1	Rhigh0	Rhigh1	BCC

The NAV200 acknowledges the command by displaying what are now valid radii.

4.4.18 Sequence of commands for the positioning mode (determining position)

Principle

Commands for the positioning mode and the principle of detemining position are described in detail in the relevant sections of this document.

When determining position the quality **G** of the values should be verified:

- G = 0:
  Contact lost, the NAV200 attempts to resotre contact in **Quickmap.**
- G = –1:
  Contact lost, virtual determination of position outside 3 m in **X** or **Y**

If contact is lost temporarily, the NAV200 will recover contact with command **PM**, even if it moves. If the movement is accelerated, the vehicle should be brought to a halt prior to transmitting the PM command.

If contact cannot be restored, the vehicle must be brought to a halt and a **full map** must be enforced with command **PA** or **PN.**

Commands PM, PA and PN may be used without exiting the positioning mode.

Sequence of commands for the positioning mode (determining position)

a) Initialising the determinination of position in FULLMAP

For the initial determination of position in a layer E, the NAV200 is switched from the "stand-by" mode to the positioning mode with a **PA** or **PN** command. The initial determination of position is carried out by the NAV200 in the **full map mode** and **all** the visible reflectors are measured, if necessary subject to restrictions according to specifications.

Operation		Command to NAV200	NAV200 response	Comment
1. Switch to the positioning mode	*Alternative*	**PA**	**PA**	Gliding medium = 4 if selected
		PA N	**PA** N	Gliding medium = N if selected
2. Select a layer		**PL** E	**PL** E	
Optional	3a. Select radius operation	**PO** Rfr0 Rfr1 Rfr2 Rfr3 Rto0 Rto1 Rto2 Rto3	**PO** Rfr0 Rfr1 Rfr2 Rfr3 Rto0 Rto1 Rto2 Rto3	If no layer is selected before one of the commands was activated, the NAV200 will attempt to find its position in Layer 0. If this layer is not the current layer in which the NAV200 is located, a long response time may result.
	3b. Select number "N closest"	**PC** N	**PC** N	
4. Repeated position enquiry				
Alternative	5a. Determine position by means of automatic velocity determination	**PP**	**PP** X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1 G N	On initial position request the NAV200 in the positioning mode will conduct a **full map.** The vehicle with the NAV200 should not move during this **initial** operation. The following reflector position detections will be conducted by the NAV200 in **Quickmap** with the reflector identification gained in previous measurements.
	5b. Determine position by means of local velocity data input	**Pv** VX0 VX1 VY0 VY1		
	5c. Determine position with local velocity and angular velocity input	**Pw** VXL0 VXL1 VYL0 VYL1 VA0 VA1		
	5d. Determine position by entering velocity in world co-ordinates	**PV** VX0 VX1 VY0 VY1 VA0 VA1		

Tab. 4-49: Sequence of commands for initialising the FULL MAP

b) Initialising the positioning mode with pre-set position

The NAV200 is switched from the "standby" mode to the positioning mode with current position data.

Operation		**Command to NAV200**	**NAV200 response**	**Comment**
1. Switch to the positioning mode	*Alternative*	**PA**	**PA**	Gliding medium = 4 if selected
		PA N	**PA** N	Gliding medium = N if selected
2. Optional	2. Select layer bank	**BS** N	**BS** N	
2. Select a layer with a specified position#		**PM** E X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1	**PM** E X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1	The NAV200 uses the position data in order to recognise the reflectors by comparing the measurements with the expected reflector positions (**Quickmap**). This procedure is faster than a full map.
Optional	3a. Select radius operation	**PO** Rfr0 Rfr1 Rfr2 Rfr3 Rto0 Rto1 Rto2 Rto3	**PO** Rfr0 Rfr1 Rfr2 Rfr3 Rto0 Rto1 Rto2 Rto3	See ***chapter 4.4.14 Command PO: Select the operating radii of the NAV200, page 60*** and ***chapter 4.4.15 Command PC: Select "the number N of closest reflectors", page 61***.
	3b. Select number "N closest"	**PC** N	**PC** N	
4. Repeated position enquiry				
Alternative	5a. Determine position by means of automatic velocity determination	**PP**	**PP** X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1 G N	Once the layer selection process has been started with command PM, the NAV200 will carry out the first and the following position requests in **Quickmap** (with reflector identification, on the basis of the PM position data or the previous measurement).
	5b. Determine position by means of local velocity data input	**Pv** VX0 VX1 VY0 VY1		
	5c. Determine position with local velocity and angular velocity input	**Pw** VXL0 VXL1 VYL0 VYL1 VA0 VA1		
	5d. Determine position by entering velocity in world co-ordinates	**PV** VX0 VX1 VY0 VY1 VA0 VA1		

Tab. 4-50: Sequence for initialising the positioning mode with a specified position

c) Reactivating positioning mode when contact is lost

The NAV200 is prepared for operating in the positioning mode.

Operation			**Command to NAV200**	**NAV200 response**	**Comment**
Alternative	1a. Restore contact: Conduct FULL MAP	*Alternative*	**PA**	**PA**	The NAV200 is prepared for operation in the positioning mode but contact to the reflectors has been lost (shown as G = 0 or G = –1). The vehicle with the NAV200 should not move before the next response to a position request (with G > 0).
			PA N	**PA** N	
	1b. Restore contact: Select layout layer with position data input. Continue with QUICKMAP		**PM** E X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1	**PM** E X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1	The position data helps to regain contact to the reflectors by comparing the measurements with the expected reflector positions (**Quickmap**). This procedure is faster than a full map.
2. Repeated position enquiry					
Alternative	3a. Determine position by means of automatic velocity determination		**PP**	**PP** X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1 G N	If the positioning mode has been started with a PA or PN command, the NAV200 will conduct the first position request in the **full map** mode. The vehicle with the NAV200 should not move during this **initial** operation. Once the PM command has been entered, the NAV200 will carry out the first and the following position requests in **Quickmap** (with reflector identification on the basis of the PM position data or the previous measurement).
	3b. Determine position by means of entering local velocity data		**Pv** VX0 VX1 VY0 VY1		
	3c. Determine position with local velocity and angular velocity input		**Pw** VXL0 VXL1 VYL0 VYL1 VA0 VA1		
	3d. Determine position by entering velocity in world co-ordinates		**PV** VX0 VX1 VY0 VY1 VA0 VA1		

Tab. 4-51: Sequence of commands for reactivating the positioning mode for a lost contact

4.5 "Upload" and "Download" modes

Upload and download modes are available for transferring the reflector co-ordinates stored in the NAV200 between several positioning systems NAV200 with the help of a PC/vehicle processor.

Upload (from NAV200) and Download (to NAV200) are explicitly activated. In the upload/download modes each reflector position is requested individually from the NAV200/transferred individually to the NAV200 in order to ensure that data is properly processed and transferred.

Whereby the NAV200 operates on the currently active bank of layers (see *Chapter 4.2.15, page 35* / *Chapter 4.2.16, page 35*)

The reflector radii belonging to the respective layers are read out of the reflector memory in the upload mode with command **RG** (see *chapter 4.2.13 Command RG: Display the reflector radius of a layer stored in the NAV200, page 33*) and are placed in download with command **RS** (see *chapter 4.2.14 Command RS: Enter the reflector radius of a layer in the NAV200, page 34*)

4.5.1 Command UA: Activate upload in the NAV200

Mode	**U** Upload
Function	**A** Activate mode

Command UA to NAV200:

STX	5	**U**	**A**	BCC

NAV200 response (acknowledgement):

STX	5	**U**	**A**	BCC

The "upload" mode is active.
The reflector positions can now be requested step-by-step from the NAV200.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Block check
Structure	STX	5	**U**	**A**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	55h	41h	13h
Value			UA		

4.5.2 Command UR: Request the next reflector position from the NAV200

Mode	**U** Upload
Function	**R** Display the next reflector position

Command UR to NAV200:

STX	6	**U**	**R**	E	BCC

Block	**Denotation**	**Range**
E	Number of the layer	0 ... 159

Tab. 4-52: Command UR: Denotation of block E

Request to the NAV200 to display the position of the **next** reflector in Layer *E*.

NAV200 response (acknowledgement):

STX	15	**U**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**
E	Number of the layer
No.	Number of the reflector in the layer
X0 ... X3	X position of the reflector in mm (4 bytes, LSB to MSB)
Y0 ... Y3	Y position of the reflector in mm (4 bytes, LSB to MSB)

Tab. 4-53: Command UR: Structure of the NAV200 response

Position of the next reflector in the list.
When reflector number –1 is displayed, the NAV200 has transferred all the reflectors in a layer.

Example of a command input:

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**U**	**R**	E	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	55h	52h	02h	01h
Value			UR		2	

Example of NAV200 response:

Name	Start character	Length	Command		Data										Block check
Structure	STX	15	**U**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	0Fh	55h	52h	13h	02h	87h	22h	00h	00h	4Dh	DAh	FFh	FFh	29h
Value			UR		19	2	X = 8,839 mm				Y = -9,651 mm				

4.5.3 Command DA: Activate download to the NAV200

Mode	**D**	Download
Function	**A**	Activate mode

Command DA to NAV200:

STX	5	**D**	**A**	BCC

NAV200 response (acknowledgement):

STX	5	**D**	**A**	BCC

The "download" mode is active. The individual reflector positions may now be delivered step-by-step to the NAV200.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Block check
Structure	STX	5	**D**	**A**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	44h	41h	02h
Value			DA		

4.5.4 Command DR: Download the next reflector position in the NAV200

Mode	**D**	Download
Function	**R**	Deliver the next reflector position

Command DR to NAV200:

STX	15	**D**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC

Block	**Denotation**	**Range**
E	Number of the layer	0 ... 159
No.	Number of the reflector in the layer	0 ... 31, –1 as end identification
X0 to X3	X position of the reflector (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the reflector (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm

Tab. 4-54: Command DR: Denotation of the individual blocks

Position of the **next** reflector in the list. When reflector number –1 is entered, all the reflectors in a layer will have been transferred to the NAV200. The NAV200 then transfers the reflector positions from the main memory to the reflector memory.

Important Any reflector transfer sequence which has not be conducted sequentially and concluded in this manner will be rejected with an error message; the reflector data will be invalid.

NAV200 response (acknowledgement):

STX	7	**D**	**R**	E	No.	BCC

Block	**Denotation**
E	Number of the layer
No.	Number of the reflector in the layer

Tab. 4-55: Command DR: Structure of the NAV200response

The NAV200 acknowledges inclusion in the layer with the respective reflector number.

Example of a command input:

Name	Start character	Length	Command		Data										Block check
Structure	STX	15	**D**	**R**	E	No.	X0	X1	X2	X3	Y0	Y1	Y2	Y3	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	0Fh	44h	52h	13h	02h	87h	22h	00h	00h	4Dh	DAh	FFh	FFh	38h
Value			DR		19	2	X = 8,839 mm				Y = -9,651 mm				

Example of NAV200 response:

Name	Start character	Length	Command		Data		Block check
Structure	STX	7	**D**	**R**	E	No.	BCC
Byte position	1	2	3	4	5	6	7
Hex	02h	07h	44h	52h	13h	02h	02h
Value			DR		19	2	

4.6 "Reflector co-ordinate" mode

Important The information contained in this section refers only to a NAV200 as of Firmware 4.4.x.

When measuring reflector positions, the NAV200 combines the successive individual measurements for one and the same reflector to a single reflector co-ordinate. These reflector co-ordinates result from the point of intersection of the scanning surface and the centre line of a reflector. For flat reflectors this is the vertical middle line and for cylindrical reflectors it is the central axis. The NAV200 therefore needs to know the radius if it is to measure cylindrical reflectors.

Important Radius = 0 indicates flat reflectors; their width is not required for measurement.

In order to distinguish the reflector sheeting from the other surroundings, the NAV200 uses a previously stored, distance-related detection threshold. This detection threshold is measured in the factory for each NAV200 on a 100-mm wide flat reflector from "3M Diamond Grade" reflector sheeting.

The **SP** command is available for modifying the detection threshold, *chapter 4.2.12 Command SP: Configure reflector detection threshold in the NAV200, page 32* describes the detection threshold.

The reflector co-ordinates are each determined by means of a 360° rotation of the scanner head and are stamped with a time stamp. The time stamp facilitates synchronisation with the time axis of the application software.

Image rectification on taking account of sensor movement such as is used for positioning the NAV200 is not possible here, since velocities are not known. It needs to be carried out by the vehicle control system.

As additional information in this mode, the NAV200 displays the strength of signals received (average echoamplitude) and the number of individual measurements on the respective reflectors.

Basic information on data formats is available in *chapter 3 Introduction, page 10*.

4.6.1 Local co-ordinates

The origin of the NAV200 co-ordinates is in the central axis of the scanner head, which is perpendicular to the scanning surface (see *chapter 3.6 Co-ordinate systems, page 13*). The x-axis points towards the connectors parallel to the lateral edge of the bottom plate.

The angle data is mathematically positive in an anti-clockwise direction.
The scanner head turns in a clockwise direction on the scanning surface, i.e. mathematically negatively.

The local co-ordinate system can be reflected with command **SU** so that the scanner head turns anti-clockwise relative to the co-ordinate system. Command SU does not automatically change the direction of rotation here.

Users require this option for measuring on reflectors in an absolute co-ordinate system when the NAV200 is mounted upside down (scan axis turned by 180° and scanner head pointing downwards). The NAV200 needs the information when measuring in local co-ordinates for calculating the angle and co-ordinates and for the chronological order of the measurements. See also *chapter 4.2.7 Command SU: Enter the NAV200 scanner head direction of rotation, page 25*.

4.6.2 Commands in the "reflector co-ordinate" mode

The "reflector co-ordinate" mode is activated with command RA and is switched off again with command SA.

Reflector measurement commences after initialisation by command RA.
Command **RD** for reflector positions in polar co-ordinates and command **RK** for X/Y co-ordinates (cartesian co-ordinates) are used to enable the NAV200 to retrieve reflector positions. The time stamp in ms included in the measurement data is the time span from taking a measurement for an individual reflector to the display of the first bytes of a response.

The NAV200 transfers a maximum of 30 reflector positions. If it identifies more reflectors it selects the data of the 30 closest reflectors.

The following describes commands relevant for reflector measurement and data transmission.

4.6.3 Command RA: Activate "reflector co-ordinate" mode

Mode	**R** Reflector co-ordinates
Function	**A** Activate mode

Command RA to NAV200:

STX	5	**R**	**A**	BCC

NAV200 response (acknowledgement):

STX	5	**R**	**A**	BCC

The "reflector co-ordinate" mode is active.

Example of command input/NAV200 response:

Name	Start character	Length	Command		Block check
Structure	STX	5	**R**	**A**	BCC
Byte position	1	2	3	4	5
Hex	02h	05h	52h	41h	14h
Value			RA		

4.6.4 Command RD: Display reflector positions measured in polar co-ordinates

Mode	**R** Reflector co-ordinates
Function	**D** Display distance in polar co-ordinates

Command RD to NAV200:

STX	6	**R**	**D**	R	BCC

Block	Format	Denotation	Range
R	UINT8	Reflector radius	For cylindrical (round) reflectors: 0 ≤ R ≤ 127 mm (Radii of < 10 mm not physically effective) For flat reflectors: R = 0 mm

Tab. 4-56: Command RD: Denotation of block R

NAV200 response (acknowledgement):

STX	LEN	**R**	**D**	R	Num									BCC
					Dataset no.	D0	D1	A0	A1	T0	T1	E	N	

Block	Format	Denotation	Range
LEN	UINT8	Number of response bytes	7 + (Num * 8)
R	UINT8	Reflector radius in mm Identical for all the reflectors of a scan	see *Tab. 4-56* above
Num	UINT8	Number of reflectors transferred	0 ... 30
Reflector dataset no.			
D0 to D1	UINT16 (LSB, MSB)	Distance in mm	0 ... 28,500 mm
A0 to A1	IN16 (LSB, MSB)	Angle in bdeg	90° = 16,384 bdeg
T0 to T1	UINT16 (LSB, MSB)	Time in ms from taking a measurement for the respective reflector to the display of the first bytes	10 ... 200 ms (typical)
E	UINT8	Medium echoamplitude	0 ... 255
N	UINT8	Number of individual measurements	1 ... 255 (theoretic)

Tab. 4-57: Command RD: Structure of the NAV200 response

Example of a command input:

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**R**	**D**	R	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	52h	44h	1Eh	0Ch
Value			RD		30	

Example of NAV200 response:

Name	Start ch.	Length	Command		Data		Dataset no.								Block check
Structure	STX	LEN	**R**	**D**	R	Num	D0	D1	A0	A1	T0	T1	E	N	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	27h	52h	44h	1Eh	04h	1Bh	0Ch	FBh	DFh	36h	00h	67h	04h	92h
Reflector 0 value		39	RD		30 mm	4	D = 3,099 mm		DFFBh bdeg		54 ms		103	4	
Hex							DFh	08h	80h	CEh	2Dh	00h	8Ch	05h	
Reflector 1 value							D = 2,271 mm		CE80h bdeg		45 ms		103	4	
Hex							72h	03h	F1h	CAh	2Bh	00h	D7h	05h	
Reflector 2 value							D = 882 mm		CAF1h bdeg		43 ms		125	5	
Hex							D7h	04h	EBh	34h	61h	00h	91h	05h	
Reflector 3 value							D = 1,239 mm		34EBh bdeg		97 ms		145	5	

4.6.5 Command RK: Display measured reflector positions in X/Y co-ordinates

Mode	**R** Reflector co-ordinates
Function	**K** Display cartesian coordinates

Command RK to NAV200:

STX	6	**R**	**K**	R	BCC

Block	Format	Denotation	Range
R	UINT8	Reflector radius	For cylindrical (round) reflectors: 0 ≤ R ≤ 127 mm For flat reflectors: R = 0 mm

Tab. 4-58: Command RK: Denotation of block R

NAV200 response (acknowledgement):

STX	LEN	**R**	**K**	R	Num									BCC
					Dataset no.	X0	X1	Y0	X1	T0	T1	E	N	

Block	Format	Denotation	Range
LEN	UINT8	Number of response bytes	7 + (Num * 8)
R	UINT8	Reflector radius in mm Identical for all the reflectors of a scan	see *Tab. 4-58* above
Num	UINT8 (LSB, MSB)	Number of reflectors transferred	0 ... 31
Reflector dataset no.			
X0 to X1	INT16 (LSB, MSB)	X co-ordinates in mm	–28,500 ... +28,500 mm
Y0 to Y1	IN16 (LSB, MSB)	Y co-ordinates in mm	–28,500 ... +28,500 mm
T0 to T1	UINT16 (LSB, MSB)	Time in ms from taking a measure-ment for the respective reflector to the display of the first bytes	10 ... 200 ms (typical)
E	UINT8	Medium echoamplitude	0 ... 255
N	UINT8	Number of individual measurements	1 ... 255 (theoretic)

Tab. 4-59: Command RK: Structure of the NAV200 response

Example of a command input:

Name	Start character	Length	Command		Data	Block check
Structure	STX	6	**R**	**K**	R	BCC
Byte position	1	2	3	4	5	6
Hex	02h	06h	52h	4Bh	32h	2Fh
Value			RK		50	

Example of NAV200 response:

Name	Start ch.	Length	Command		Data		Dataset no.								Block check
Structure	STX	LEN	**R**	**K**	R	Num	X0	X1	Y0	Y1	T0	T1	E	N	BCC
Byte position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	02h	37h	52h	4Bh	32h	04h	9Dh	08h	5Fh	F7h	44h	00h	67h	04h	00h
Reflector 0 value		55	RK		50 mm	4	X = 2,205 mm		Y = -2,209 mm		68 ms		103	4	
Hex							D0h	04h	34h	F7h	3Eh	00h	83h	04h	
Reflector 1 value							X = 1,232 mm		Y = -2,252 mm		62 ms		131	4	
Hex							6Fh	04h	2Bh	F7h	3Dh	00h	87h	04h	
Reflector 2 value							X = 1,135 mm		Y = -2,261 mm		61 ms		135	4	
Hex							1Eh	03h	99h	F7h	3Bh	00h	8Bh	05h	
Reflector 3 value							X = 798 mm		Y = -2,151 mm		59 ms		139	5	

5 Diagnosis functions

5.1 Introduction

For each position request, the "positioning" mode (determining position) delivers the position data of the NAV200 in an absolute co-ordinate system.

The system output of a moving AGV with a NAV200 is influenced by three main factors:

- Reflector influences:
  - Positioning of the reflectors and visibility conditions in the environment
  - Measurement precision and also subsequent shifting
  - Balanced distribution of reflectors along the guide path
- Performance and properties of the NAV200
  - Precisions and possible ageing
  - Possible defects
- System dynamics and features of the AGV
  - Speed, particularly for turning movements
  - Precision and time needed for information on movement (speed, angular velocity) made available to the NAV200 by the AGV

In order to facilitate commissioning a plant or any troubleshooting, e.g. on the route, the NAV200 can deliver diagnosis data in addition to the position data. This diagnosis data constitutes measuring data and interim calculations based on the determination of position.

There are two methods of accessing the NAV200 diagnosis data:

- Online in the positioning mode, in each case as a set of additional diagnosis data in an extended NAV200 response for each position request.
  The commands specified in ***chapter 4.4 "Positioning" mode (determining position"), page 45*** are extended in order to request diagnosis data.
- Offline in the positioning mode once a number of data sets have been recorded in the post-trigger memory. Once recording has commenced, the NAV200 does not release diagnosis data for each position request; it files them instead as a set of data in the memory.
  Retrieving the (selectable) sets of data with a command.

5.1.1 Purpose of an online diagnosis data output

The online output of diagnosis data is an extension of the position response of the NAV200 with additional information. This information enables the NAV200response to be precisely and consistently analysed. Various parameters are important in accordance with the main focus of an analysis.

The amount of additional data which may be added to the position response is limited. This means that it is essential to select required data by means of setting a parameter prior to initialising the positioning mode with an extended data output Failure to do so would result in excessively long NAV200 response times.

Important For the purpose of retrieving additional diagnosis data it must be ensured that the data transfer rate of the NAV200 is sufficient. If may be advisable to select a higher transfer rate (see here ***chapter 4.2.2 Command SB: Select the transfer rate of the data interface closest", page 19***).

5.1.2 Purpose of an offline diagnosis data output (post-trigger memory)

After a request in the positioning mode, the NAV200 records sets of diagnosis data and stores these in its internal post-trigger memory.

The max. recording time for a sequence of data sets is 10 s (approx. 80 sets of data). The data buffer used is in the form of a circular buffer. After startup, the NAV200 continuously stores one set of data after another for each position request. After 10 seconds it begins to overwrite the existing sets of data again, beginning with the oldest set of data.

This method has the advantage that after a request, the output of diagnosis data sets will be far greater than the online outpu in the positioning mode. The internal organisation of the NAV200 has no influence on the cycle time in the positioning mode during the recording process.

The vehicle processor can use commands to start and stop the recording of diagnosis data and also to read data for the purpose of further analysis via the data interface.

5.2 Overview: Data formats of the diagnosis data per set

Description		(Number of) BYTES	Format
Time stamp			
Online mode with a time stamp			
Time difference in ms in relation to the start of the positioning mode		(4) BYTES	UINT32 u32TimeDiff_ms
Time difference in ms in terms of the point in time of the receipt of a command to request a position		(2) BYTES	UINT16 u16TimeDiff_ms
Post-trigger recording			
Time difference in ms in relation to the start of data recording in the buffer		(2) BYTES	UINT16 u16TimeDiff_ms
Reflector measurement			
Identifica-tion	Number of co-ordinates	BYTES	Mnum (0 ... 27)
0	Valid, measured reflector positions in absolute co-ordinates (mm)	max. (225) BYTES	Mnum * (INT32 MaX_mm, INT32 MaY_mm)
1	Valid, used reflector positions in absolute co-ordinates (mm)	max. (225) BYTES	Mnum * (INT32 MuX_mm, INT32 MuY_mm)
2	Reflector positions expected in QUIVKMAP in absolute co-ordinates (mm)	max. (225) BYTES	Mnum * (INT32 MeX_mm, INT32 MeY_mm)
Parameters for determining position			
Current layer		BYTES	BYTE layer
Current "N closest" parameter		BYTES	BYTE nClosest
Current operation radius		(4) BYTES	INT16 OpRadFr_mm INT16 OpRadTo_mm
Current mode: QUICKMAP (0) / FULLMAP (1)		BYTES	BYTE IsQuickmap (0 or 1)
Position data			
Absolute X position in co-ordinates (mm)		INT32	INT32 X_mm
Absolute Y position in co-ordinates (mm)		INT32	INT32 Y_mm
Richtung in the absolute co-ordinate system in binary degrees (bdeg)		INT16	INT16 A_bdeg
Type (–2, –1, 0)		BYTES	BYTE Q
Number of used reflector measurements		BYTES	NUsed

Tab. 5-1: Data formats of diagnosis data for online output in the positioning mode and for requesting data from the post-trigger memory

5.3 Online output of diagnosis data

The output of additional diagnosis data per position request is initialised simultaneously with the start of the positioning mode.

For the purpose of requesting the additional data, commands **PA** and **PN** were extended by the M byte (add.mode) for which a value is to be selected in accordance with the required type of data.

5.3.1 Command PA M: Activate determining position mode of the NAV200 inlcuding diagnosis data output

Mode	**P** Determining position
Function	**A** Activate mode **M** Specify type of diagnosis data (reflector positions)

Command PA M to NAV200:

STX	6	**P**	**A**	**M**	BCC

Time stamp	**M**	**Denotation**
No time stamp	00h	Display all the valid, measured reflector positions in absolute co-ordinates (mm)
	01h	Display all the valid reflector positions used for determining position in absolute co-ordinates (mm)
	02h	Display all the expected reflector positions in aboslute co-ordinates (mm). These reflector positions are calculated from the previous position on application of the velocity information entered and transfered to the absolute co-ordinate system. The expected reflector positions facilitate a rapid detection of reflectors in **Quickmap.**
With a time stamp	80h	Display time information + all the valid, measured reflector positions in absolute co-ordinates (mm)
	81h	Display time information + all the valid reflector positions used for determining position in absolute co-ordinates (mm)
	82h	Display time information + all the expected reflector positions in absolute co-ordinates (mm)

Tab. 5-2: Extended PA M command: Denotation of parameter M in the add. mode

NAV200 response (acknowledgement):

STX	5	**P**	**A**	BCC

The positioning mode (determining position) is active.

5.3.2 Command PN M: Activate determining the NAV200 position with a diagnosis data output on specification of the max. profile peak

Mode	**P** Determining position
Function	**N** Activate a mode on entering the max. profile peak **M** Specify type of diagnosis data (reflector positions)

Command PN M to NAV200:

STX	7	**P**	**N**	**S**	**M**	BCC

Block	**Denotation**	**Range**	**Default setting**
S	Number of measurements for a gliding medium	1 … 63	4
M	See *Tab. 5-2, page 81*		–

Tab. 5-3: Extended command PN: Denotation of blocks S and M in the add. mode

NAV200 response (acknowledgement):

STX	5	**P**	**A**	BCC

The positioning mode (determining position) is active.

5.3.3 Structure of NAV200 responses in the positioning mode

The responses to a position request are extended in accordance with the diagnosis data selected for output as described below.

a) Diagnosis data, no time stamp

M	Denotation
00h	Display all the valid, measured reflector positions in absolute co-ordinates (mm)
01h	Display all the valid reflector positions used for determining position in absolute co-ordinates (mm)
02h	Display all the expected reflector positions in aboslute co-ordinates (mm). These reflector positions are calculated from the previous position on application of the velocity information entered and transfered to the absolute co-ordinate system. The expected reflector positions facilitate a rapid detection of reflectors in **Quickmap.**

Tab. 5-4: Denotation of diagnosis data without the use of a time stamp

NAV200 response (acknowledgement):

STX	Len	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	Nm	{RC}	BCC

Block	Denotation	Range
Len	Number of bytes in a datastring	17 + (Nm * 8)
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h ... FFFFh bdeg
G	Quality of position determination	0 ... 100, –1, –2
Nm	Number of reflector co-ordinates transferred (type of reflectors selectable, see identification in *Tab. 5-4*)	1 ... 30 (max. 256 bytes)
{RC}	Set of Nm reflector co-ordinates	N * {Rx0 Rx1 Rx2 Rx3, Ry0 Ry1 Ry2 Ry3 }

Tab. 5-5: Command PP: Structure of the NAV200 response without the use of a time stamp

Important For the output of position data in the positioning mode without additional diagnosis data, N will always be the number of reflectors used for determining position.
This information is replaced on the output of the additional diagnosis data by the reflector co-ordinates (RC) selected for output.

b) Diagnosis data with a time stamp

M	Denotation
80h	Display time information + all the valid, measured reflector positions in absolute co-ordinates (mm)
81h	Display time information + all the valid reflector positions used for determining position in absolute co-ordinates (mm)
82h	Display time information + all the expected reflector positions in aboslute co-ordinates (mm).

Tab. 5-6: Denotation of diagnosis data on using a time stamp

NAV200 response (acknowledgement):

STX	Len	**P**	**P**	X0	X1	X2	X3	Y0	Y1	Y2	Y3	A0	A1	G	N	M	TS0	TS1	TS2	TS3	TD0	TD1	Nm	{RC}	BCC

Block	**Denotation**	**Range**
Len	Number of bytes in a datastring	25 + (Nm * 8)
X0 to X3	X position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
Y0 to Y3	Y position of the NAV200 (4 bytes, LSB to MSB)	–8,380,000 ... 8,380,000 mm
A0, A1	Orientation of the NAV200 (LSB, MSB)	0000h ... FFFFh bdeg
G	Quality of position determination	0 ... 100, –1, –2
N	Number of reflector co-ordinates used for determining position	0 ... 30 (max. 256 bytes)
M	Type of diagnosis data with a time stamp	80h, 81h or 82h
TS0 to TS3	Time difference in ms in relation to the start of the positioning mode by command PA or PN	0 ... 66,536 ms (then overrun, counting commences again at 0 ms)
TD0, TD1	Time difference in ms in terms of the point in time of the receipt of a command to request a position	0 ... 232 ms
Nm	Number of reflector co-ordinates transferred (type of reflectors selectable, see identification in *Tab. 5-1, page 80*)	1 ... 29 (max. 255 bytes)
{RC}	Set of Nm reflector co-ordinates	N * {Rx0 Rx1 Rx2 Rx3, Ry0 Ry1 Ry2 Ry3 }

Tab. 5-7: Command PP: Structure of the NAV200 response on using a time stamp

Important For the output of position data in the positioning mode without additional diagnosis data, N will always be the number of reflectors used for determining position.
This information is not overwritten on the output of additional diagnosis data with a time stamp.
Nm, the number of reflector co-ordinates (RC), may deviate accordingly from N, depending on the type of reflector co-ordinate selected.

5.4 Offline diagnosis data output (post-trigger store)

The circular buffer has a maximum length of 80 data sets. Command **P?** can be used to request the number Z of the most recent data sets from this circular buffer individually. The index I of the 80. data set is N – 1 = 79, I_{min} = 0.

If, for example, the NAV200 is to display the 5. data set, the reqest is to be made with command P? and index I = 4.

The command for reading the content of the memory also contains the number of data sets of an index for selecting the data. (*Tab. 5-8*).

5.4.1 Command Pd M: Initialise and start up recording of the diagnosis data

Command Pd M to NAV200:

STX	6	**P**	**d**	**M**	BCC

M	**Denotation**
0	Record time information + positioning parameters + positioning data + all the valid, measured reflector positions in absolute co-ordinates (mm)
1	Record time information + positioning parameters + positioning data + all the valid reflector positions used for measuring position in absolute co-ordinates (mm)
2	Record time information + positioning parameters + positioning data + all the expected reflector positions in absolute co-ordinates (mm)

Tab. 5-8: Command Pd M: Denotation of parameter M

NAV200 response (acknowledgement):

STX	6	**P**	**d**	**M**	BCC

5.4.2 Command Ps: Stop diagnosis data recording

STX	5	**P**	**s**	BCC

NAV200 response (acknowledgement):

STX	8	**P**	**s**	**M**	**N0**	**N1**	BCC

Block	**Denotation**
M	Type of diagnosis data with a time stamp, see *Tab. 5-8*
N0, N1	Number of data sets in the circular buffer (INT16)

Tab. 5-9: Command Ps: Structure of the NAV200response

Important The response contains the number N of available data sets. The oldest stored data set is indicated by the number (index) 0 and the last, most recent data set by the number (index) N-1. The number N of the latest data sets is available.

5.4.3 Command P?: Display recording of diagnosis data

STX	8	**P**	**?**	**M**	**N0**	**N1**	BCC

Block	**Denotation**
M	Type of diagnosis data with a time stamp, see *Tab. 5-8, page 85*
N0, N1	Index for data sets in the circular buffer (INT16)

Tab. 5-10: Command P?: Denotation of blocks M and N0, N1

NAV200 response (acknowledgement):

STX	Data + 7	**P**	**?**	**M**	**N0**	**N1**	Data	BCC

Composition of the recorded data sets

Type of data	Buffer no. since commencement of recording	Identification for the recorded reflector types	Time difference in ms	Positioning parameters					Positioning data					Reflector positions (absolute co-ordinates in mm) (i = (0 ... Nrefs) – 1))			
Bytes in the output area	7,8	9	10, 11	12	13	14, 15	16, 17	18	19 ... 22	23 ... 26	27, 28	29	30	31		(8 * i) +32 + (0...3)	(8 * i) +36 + (0...3)
Type	INT16	BYTES	INT16	BYTES	BYTES	INT16	INT16	BYTES	INT32	INT32	INT16	BYTES	BYTES	BYTES		INT32	INT32
Value	NPufferNo	DiagMode *)	TimeStamp_ms	Layer	NClosest	OpRadFr	OpRadTo	IsQuickmap	X_mm	Y_mm	A_bdeg	Q	NUsed	Nrefs	Nrefs	MaX_mm	MaY_mm

*) Identification see *Tab. 5-8, page 85*

Tab. 5-11: Overview: Structure of the recorded data sets

5.5 Parallel operation of online output and recording diagnosis data for offline output

It is possible to operate the online output and the recording of diagnosis data for offline output at the same time. For example, with each position request, the NAV200 can release all the valid measured reflector positions required for this determination of position online (with or without a time stamp) and at the same time it can also internally record the data sets of all the reflector positions used for determining position (with or without a time stamp).

6 Error messages

Each NAV200 response to a command entry may be an error message, either due to a syntax error in the command or to indicate an applicance error which has occurred.

Error messages begin with an "E" instead of the second byte (function byte) and each comprises 4 bytes. The content of error bytes is supplemented by the bytes relevant to the reflector interface.

6.1 Error bytes

The 4 error bytes F0 to F3 contain the following entries:

F0 (error byte 0)

Entry of the function byte of the last command.

F1 (error byte 1)

Entry of the error class.
The error class indicates the position in the NAV200 system at which an error has occurred.

Error class	Denotation	Error
1	Software	Content error in the software protocol (commands) of the customer's driver. *See error specification in error byte 3*
2	Transputer	not used
3	Sensor link (raw data interface)	Error on the internal measurement data interface of the NAV200
4	End-to-end measurement	Faulty measurement
5	Rotation and angle measurement	Angle measurement error
6	EEPROM link	Error on the reflector memory connector
7	User link	Error on the link between the vehicle processor/PC and NAV200 (RS232 data interface)

Tab. 6-1: Error byte 1: Error class denotation

F2 (error byte 2)

Error group entry.
The error group specifies in which mode an error has occurred.

Error group	Denotation
1	Input/output, telegram traffic
2	Standby
3	Reflector memory
4	Download
5	Upload
6	Mapping
7	Positioning mode (determining position")
8	Test
9	Navigation mode general
10	Reflector co-ordinators (measuring mode)

Tab. 6-2: Error byte 2: Error group denotation

F3 (error byte 3)

Error specification entry. An error specification describes an error in more detail and is to be viewed in conjunction with error bytes F1 and F2.

Error specification	**Denotation**
1	Unknown command
2	Command (function) not implemented in this mode
3	Incorrect command
4	No reflector
5	Incorrect reflector number
6	Incorrect data block
7	Adding not possible
8	Invalid layer
9	No reflectors in the layer
10:	Reflectors all transferred
11:	Communication error (BCC error)
12:	Impermissible number of reflectors in the current layer (< 3)
13	Incorrect radii for information on the range of operation
14	Flash EPROM defect
15	Incorrect reflector radius
16	Invalid parameter
17	Error in the check total on the raw data interface
18	Error message by the raw data interface
19	Incomplete scan
20	Timeout exceeded on the raw data interface
21	Scan faulty

Tab. 6-3: Error byte 3: Error specification denotation

6.2 Example of an error message

STX	9	**P**	**E**	v	7	9	11	BCC
				F0	F1	F2	F3	

Byte	**Denotation**
P	"Positioning" mode (determining position")
E	Identification "error"
v	Position function v, the most recent command was a Pv command
7	Error byte 1: User link error
9	Error byte 2: Navigation mode general
11	Error byte 3: Communication error (BCC error)

Tab. 6-4: Example of an error message

Result: Data interface (RS-232) communication error while determining
position with command Pv. This error is usually caused by electrical faults or a megative block check.

7 Appendix

7.1 Overview: NAV200 commands and response times

7.1.1 Principle

The NAV200 protocol is a request and response protocol (Master/Slave). Each request forwarded to the NAV200 generates a response after the request has been processed. If the NAV200 is not able to carry out the requested operation, it will respond with an error message.

A response may fail to appear if the power supply or the data link is cut off or if the system develops a fault.

This is to be backed up by a corresponding timeout mechanism of the vehicle processor.

No response is generated by the NAV200 after timeout.

7.1.2 Response times

Please note the following concerning the analysis times shown in the tables below:

- The NAV200 is activated with commands in various modes. In the case of some of the commands for NAV200 the response time will depend on the current mode and the preceding functions. The following tables have hence been structured according to the various modes.
- The response time is contingent on the reflector layout and the operating status in the positioning mode.
- The first command in the positioning mode and the PA and PN commands for determining the first position or a new position in the full map may differ considerably in terms of response time, while determining position in Quickmap will depend on the reflector layout and the connection between measured and stored reflectors.

  The response times depend on the number of stored reflectors in a layer, the number of detected reflectors and the number of detected Ireflectors that do not belong to a layer. Long response times result from measuring numerous reflectors that do not belong to the selected layer. The response time may exceed 120 seconds in a few situations.
- The response times listed are intended for the first byte transmitted by the NAV200. The coordinated byte timeout for data transmission by the NAV200 should be >3 ms.

Commands in the "standby" mode

Operation	Command to NAV200	NAV200 response	NAV200 response time		Comment
			Typical	Recomm. timeout	
"Standby" mode Activate	**SA**	SA	5 ms	100 ms	
Display the Firmware version number	**SV**	SV V0 V1 V2	5 ms		
Display the version string	**ST**	ST version string	5 ms		
Display the identification string	**St**	St version string	5 ms		
Serial no. output	**SS**	SS S0 S1	5 ms		
Direction of rotation input	**SU** C	SU C	5 ms		
Display the reflector position	**SR** E Nr	SR Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3	1. Request: 2 s All the following: 50 ms	5 s	The respective reflector level in the EEPROM of the NAV200 must be read for the first request for reflector data. This results in delays of 2 seconds at the most. For changing, deleting or adding a reflector position the entire reflector level to the EEPROM of the NAV200 is written and read again from there.
Change reflector position	**SC** E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3	SC E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3			
Add new reflector position	**SI** E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3	SI E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3			
Delete reflector position	**SD** E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3	SD E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3			
Enter reflector radius of a layer	**RS** E R	RS E R			
Reflector radius of a layer output	**RG** E	RG E			
Start mapping mode	**MA**	MA	New mode: 4 s or: 50 ms	10 s	The NAV200 reads all the reflector levels which have not been read yet for switching to the mapping or positioning mode (detecting position). This results in a delay of 4 seconds at the most.
Start determining position	**PA**	PA			
Start position determination and enter the max. profile peak height	**PN** S	PN S			
Activate upload mode	**UA**	UA	50 ms	100 ms	
Activate download mode	**DA**	DA			
Select the transmission rate of the data interface	**SB**	SB	5 ms	10 ms	

Tab. 7-1: Commands and response times in the "standby" mode

Commands in the "rmapping" mode

Operation	Command to NAV200	NAV200 response	NAV200 response time		Comment
			Typical	Recomm. timeout	
Start mapping	**MS** E X0 X1 X2 X3 Y0 Y1 Y2 Y3 R	MS E N	14 s	15 s	The NAV200 carries out 100 scans and stores the reflector positions. These are then available in the main memory to be retrieved with the MR command
Start "negative mapping with averaging"	**MN** E S X0 X1 X2 X3 Y0 Y1 Y2 Y3 R	MS E N			
Start "mapping with averaging"	**MM** E S X0 X1 X2 X3 Y0 Y1 Y2 Y3 R	MS E N	S * 14 s	S * 1.5 s	The NAV200 carries out the number S of scans and stores the reflector positions. These are then available in the main memory to be retrieved with the MR command
Display a mapping reflector position	**MR E Nr**	MR E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3	10 ms	100 ms	
Change to the "standby" mode	**SA**	SA	50 ms	200 ms	
Set layer bank	**BS**	BS actBankNr		895 ms	The appropriate bank is loaded in the operating memory of the NAV200 during selction of a layer bank. This process takes up to 895 ms.
Read the number of the active layer bank	**BR**	BR actBankNr		10 ms	

Tab. 7-2: Commands and response times in the "mapping" mode

Commands in the "positioning" mode

Operation	Command to NAV200	NAV200 response	NAV200 response time		Comment
			Typical	**Recomm. timeout**	
Select current layer	**PL** E	PL E	If 1. command in a layer > 0: 5 s or: 90 ms	120 s	
Select current layer on external input of the NAV200 position	**PM** E X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1	PM E X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1			
Select the operating radii of the NAV200	**PO** Rfr0 Rfr1 Rfr2 Rfr3 Rto0 Rto1 Rto2 Rto3	PO Rfr0 Rfr1 Rfr2 Rfr3 Rto0 Rto1 Rto2 Rto3			If no layer was selected by these commands, the NAV200 will attempt to find its position in layer 0. If this layer is not the right one, a response time of 60 s and longer will result. The first position request in the positioning mode is carried out by the NAV200 in **the full map** mode. When positioning in **Quickmap** the response time will be shorter or the same 300 ms
Select number N of closest reflectors	**PC** N	PC N	Full map: 5 s Quickmap: 60 ms	120 s	
Display position on internal determination of velocity	**PP**	PP X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1 N		1. Command: 120 s Other commands: 300 ms	
Display position on ext. input of velocity in the local co-ordinate system of the NAV200	**Pv** VX0 VX1 VY0 VY1	PP X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1 N			
Display position on ext. input of velocity and angular velocity in the local co-ordinate system of the NAV200	**Pw** VXL0 VXL1 VYL0 VYL1 VA0 VA1	PP X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1 N			
Display position on ext. input of velocity and angular velocity in the absolute co-ordinate system of the vehicle	**PV** VX0 VX1 VY0 VY1	PP X0 X1 X2 X3 Y0 Y1 Y2 Y3 A0 A1 N			
Reactivate reflector detection in the determining position mode (full map)	**PA**	PA	Full map: 5 s Quickmap: 60 ms	120 s	The largest time limit applies for operation in an incorrect layer.
Activate position determination and enter the max. profile peak height	**PN** S	PN S			
Change to the "standby" mode	**SA**	SA	50 ms	120 s	
Mute sectors	**PS**	PS	135 ms	300 ms	
Define Quickmap identification window	**PF**	PF	135 ms	300 ms	

Tab. 7-3: Commands and response times in the "positioning" mode

Commands in the "upload" mode

Operation	Command to NAV200	NAV200 response	NAV200 response time		Comment
			Typical	Recomm. timeout	
Display the next reflector position	**UR** E	UR E Nr X0 X1 X2 X3 Y0 Y1 Y2 Y3	2 s	5 s	On first request the NAV200 will read data from the EEPROM. This may take up to 5 seconds.
Display reflector radius of a layer	**RG** E	RG E R	50 ms	200 ms	
Change to the "standby" mode	**SA**	SA	50 ms	200 ms	

Tab. 7-4: Commands/response times in the "upload" mode

Commands in the "download" mode

Operation	Command to NAV200	NAV200 response	NAV200 response time		Comment
			Typical	Recomm. timeout	
Deliver the next reflector position	**DR** E NR X0 X1 X2 X3 Y0 Y1 Y2 Y3	DR E NR X0 X1 X2 X3 Y0 Y1 Y2 Y3	2 s	5 s	The response time depends on the active layer. On completing a download, the NAV200 wri-tes the data into the EEPROM. This may take up to 5 seconds.
Enter reflector radius of a layer	**RS** E R	RG E R	90 ms	200 ms	
Change to the "standby" mode	**SA**	SA	50 ms	200 ms	

Tab. 7-5: Commands/response times in the "download" mode

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