Contents

1 Troubleshooting

This section of the manual presents troubleshooting information for the DC60 Automatic Guided Vehicle (AGV). We recommend that anyone responsible for the maintenance and repair of the DC60 and its associated facility installed equipment be thoroughly familiar with this entire section.

1.1 Training

All maintenance personnel understand that even relatively simple repairs become difficult without adequate, current training. If you have had no recent training or you encounter a problem for the first time, get assistance before attempting to repair an AGV. If your training is not current, arrange "refresher training" as soon as possible.

1.2 Test Areas

All vehicle testing, troubleshooting, and electronic adjustments, should be accomplished in an area of the guidepath which has been designated for testing by the system administrator. A designated test area ensures the following:

- All vehicles are adjusted under the same guidepath conditions.

- Vehicle maintenance information may be recorded and compared between maintenance actions under similar guidepath conditions.

- Test areas are usually selected because they provide safe working conditions for the vehicles, maintenance personnel, and other personnel within the automatic guided vehicle system area.

- Personnel are aware of the test area and become more alert when in the area.

1.3 Maintenance Procedures and Records

When testing or troubleshooting the vehicle or system, the following conditions apply:

- The vehicle's battery must be fully charged.

- A preliminary mechanical inspection must be conducted to ensure that no physical condition exists which will interfere with reliable performance. Check for loose or damaged sensors, cables, battery connectors, fuses,

wires, or other materials which may interfere with the proper operation of electronic devices.

- Make one adjustment at a time and note its effect before making another.

- Maintenance, whether preventive or corrective, should be recorded for historical purposes. Documented information should contain the vehicle serial or identification number, and hour meter reading, as well as information concerning the maintenance performed on the vehicle.

1.4 General Troubleshooting Procedure

To troubleshoot the DC60, determine the full extent of the problem(s) before attempting to fix the problem(s). Observe vehicle operation in both manual and automatic modes of operation.

1.4.1 Visual Inspection

To effectively troubleshoot a vehicle, begin with a visual inspection. Visually check the vehicle and ensure that:

- Bent or otherwise damaged parts are repaired or replaced.

- Mechanical parts operate freely at pivot or friction points.

- Mounting hardware, such as lock washers, spacers, nuts, and bolts, are present and properly secured.

1.4.2 Perform an Operational Test

After visual inspection perform an operational test. (See the "Preventive Maintenance" chapter, Figures 1 and 2, for Operational Test flowchart.) The test is designed to check the operation of the vehicle. Although you may have been informed of a problem with the vehicle, you may not know all of the symptoms of the problem. By performing the test, you will learn the full extent of the situation.

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1.4.3   Locate the Problem

⚠ WARNING	**Make certain that all power has been removed from the vehicle before attempting to service or remove any components.**

Determine where the problem is located. Is the problem with the vehicle, the system, or the guidepath?

NOTE Use two vehicles to determine whether the problem is with the system or vehicle. Seldom will two vehicles have the same problem unless the system is the cause.

Use the troubleshooting flowcharts in conjunction with the Control System Troubleshooting in this section to troubleshoot the problem. Fill out the DC60 Error Log. (See next page) To effectively troubleshoot the vehicle or system the technician must:

1. Understand the operational characteristics of the vehicle.

2. Know the capacity of the vehicle and the limits the vehicle is designed to operate within.

3. Understand the guidepath on which the vehicle is operating. The vehicle may be operating exactly as designed and the guidepath or system may be at fault.

DC60 ERROR LOG

Please fill in the following information when an error occurs. The more information noted, the easier it will be for maintenance or technical personnel to diagnose the problem.

VEHICLE ID:_____   DATE:__/__/__   TIME:_____   YOUR INITIALS:_____

HOUR METER READING:_____

VEHICLE APPROXIMATE LOCATION: _____

BUMPER COLLAPSED? YES____   NO____   LOADED? YES____   NO____
DIR OF TRAVEL? FWD____ REV____

ADDITIONAL COMMENTS:
_____
_____

DISPLAY THE MAIN STATUS SCREEN.

```
ON_PATH  COM_OK  IDLE    DEST=000  MODE
[DESTINATION]  PATH=1      DIR = FWD  BATT=9
```

WHICH MODES ARE SHOWN ON THE SCREEN

CIRCLE ONE   REMOTE   ONBOARD   RECIRC

CIRCLE ONE: ON PATH   NO PATH

CIRCLE ONE: COM OK   NO COM   COM??

     DEST=_____

     PATH=_____

PRESS THE BLANK KEY UNDER THE "9" FOUR TIMES TO SELECT DIAG MODE ON THE VEHICLE DISPLAY. PRESS "8" TO ACCESS STATUS SCREENS.

PRESS RIGHT ARROW   (→) ENTER AND NOTE ANY ERROR CODES:

     _____ _____ _____ _____ _____ _____ _____ _____

PRESS ESC, RIGHT ARROW (→) AND NOTE VIRTUAL CODES:

     _____ _____ _____ _____ _____ _____ _____ _____

PRESS RIGHT ARROW (→) AND NOTE MAGNETS READ AND POSITION READ.

     _____ , _____ / _____ , _____ / _____ , _____ / _____ , _____ / _____ , _____ / _____ , _____

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1.4.4   Make Repairs

Repair the problem(s). Use Savant Automation spare parts as listed in the Vehicle Spare Parts Drawing in the "Parts" section.

When parts are replaced, the technician may be required to make electrical and mechanical adjustments. See the "Repairs" chapter for further information.

1.4.5   Repeat Operational Test

Follow all repairs with an operational test. Observe vehicle operation in both automatic and manual modes before returning the vehicle to normal use.

1.4.6   For Help

Call Savant Automation Service Department for help. The telephone numbers are as follows:

Business Phone Number		1-800-951-2487
Fax Numbers	Parts:	1-616-791-8598
	Service:	1-616-791-8598
	Component Repairs:	1-616-791-8598

*   The Parts and Service Department provides toll free support for emergencies 24 hours per day, seven days per week. A call down list will be provided and a return call from a Service Engineer will occur to provide consultation. Should such a consultation fail to resolve the problem, the customer may authorize an emergency service call.

1.5   Using the Troubleshooting Guide

Once a problem area is identified, the following flowcharts provide instructions for isolating the problem and repairing the AGV. The flowcharts have been developed to sequentially separate problems caused by an individual AGV malfunction from problems caused by the installation or associated controls. Once a problem has been traced to a specific vehicle, the flowcharts allow for checking basic functions in manual operating mode followed by verification of more complex functions present only during automatic operation. The flowcharts provide logical troubleshooting sequences for most (not all!) DC60 vehicle and system malfunctions. Occasionally, problems will occur which are outside the scope of the flowcharts. In these cases, call Savant Automation Service for assistance.

Following the flowcharts, is a "Controls Troubleshooting Guide" which can be used in conjunction with the flow charts to isolate a problem. Each control subsystem is explained, with typical problem symptoms outlined. Detailed instructions on how to use the vehicle internal diagnostics to solve the problem are also included.

The "Troubleshooting Flowcharts" and the "Controls Troubleshooting Guide" should not be used alone. It is critical that anyone attempting to repair the AGV has read and understands the Operator Guide chapter which is included in this manual. Often it will be necessary to isolate circuits, connections, and components using the schematic provided in this manual. Finally, before attempting any repair, be sure to check for an applicable repair procedure in the "Repairs" section of this manual.

In general, the troubleshooting described in the flowcharts, focuses on electrical malfunctions and components. It is assumed that these areas will provide the greatest repair difficulty. Mechanical troubleshooting and repair, however, is assumed to be within the capabilities of most experienced maintenance personnel and therefore the repair procedures are not as detailed.

1.6 Warnings and Advisories

Anyone attempting to repair an AGV should be familiar with the following cautions before beginning testing or repair.

⚠ **DANGER**

Any modifications to the guidance system used by either the vehicle or the system must be approved, in advance, by Savant Automation. Injury to personnel, damage to the vehicle and system, and invalidation of any implied Savant Automation warranties may result when unauthorized modifications or changes are made.
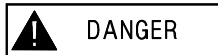
⚠ **DANGER**

"DIAGNOSTIC" or "MAINTENANCE" mode should be used only by qualified maintenance personnel. Improper use of the maintenance codes could result in danger to personnel or damage to the vehicle

⚠ **CAUTION**
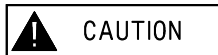
All physical connections of plugs and receptacles must be made with the battery disconnected, or damage to electronic components may be incurred.

1.7   Using Diagnostics
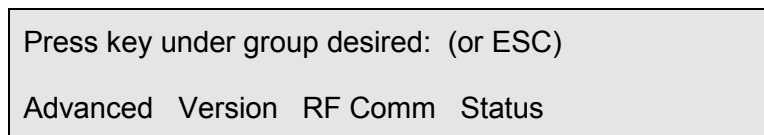
The DC60 AGV has a variety of Control Display Unit (CDU) functions designed to help trained maintenance personnel to determine the cause of various malfunctions. These functions are accessed by pressing the blank key under the "9" key four times. Diagnostic mode is not a dispatching mode but a maintenance function. Only properly trained maintenance personnel should attempt to use this function. The AGV will operate automatically with diagnostic mode selected.

The diagnostic mode menu tree is shown in Figure 2. The available diagnostic functions have been designed in two levels: basic functions and Advanced. The Version, RFComm, and Status modes are basic functions and are accessed by pressing the number under that group. Individual functions under each group are accessed using the arrow keys. Some of the Version and Status screen descriptions follow. Many of the Advanced and RFComm screen descriptions are covered later in the chapter. Some screens descriptions are not covered because they are useful only for software debugging for Savant Automation Engineering.

The Navigation Diagnostics menu tree is shown in Figure 3 and Figure 4. Many of the Navigation screen descriptions will be covered later in this chapter.

1.7.1   Control Display Unit (CDU) - Main Diagnostic Screen

Figure 1   Main Diagnostic screen

Press key under group desired: (or ESC)

Advanced   Version   RF Comm   Status

Softkeys: 1 or 2   4   6   8 or 9

Figure 2   Typical Menu Tree Diagnostics Mode

* See the Navigation Diagnostic Menu Tree (Figure 3 and Figure 4)
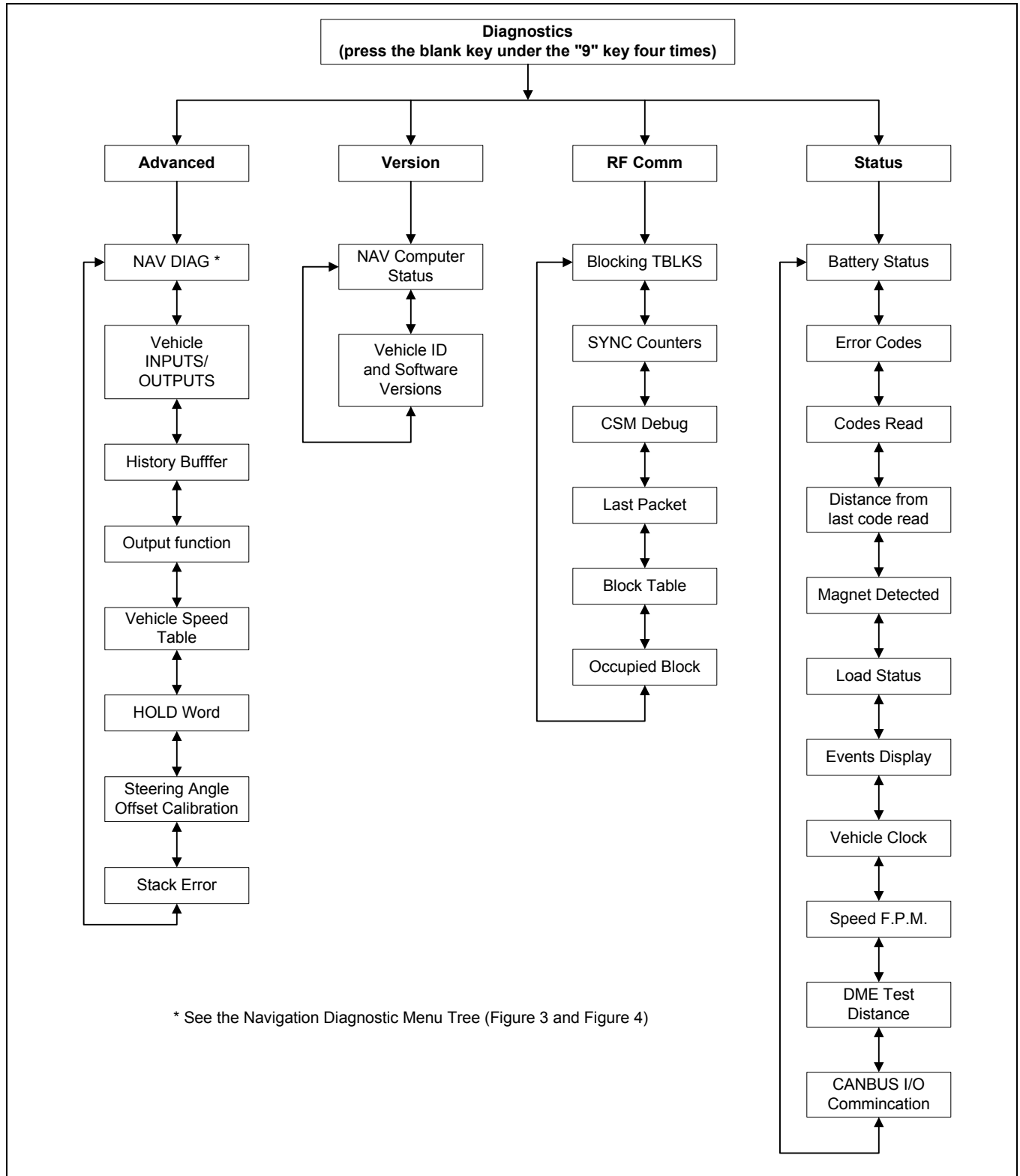
Figure 3   Navigation Diagnostics
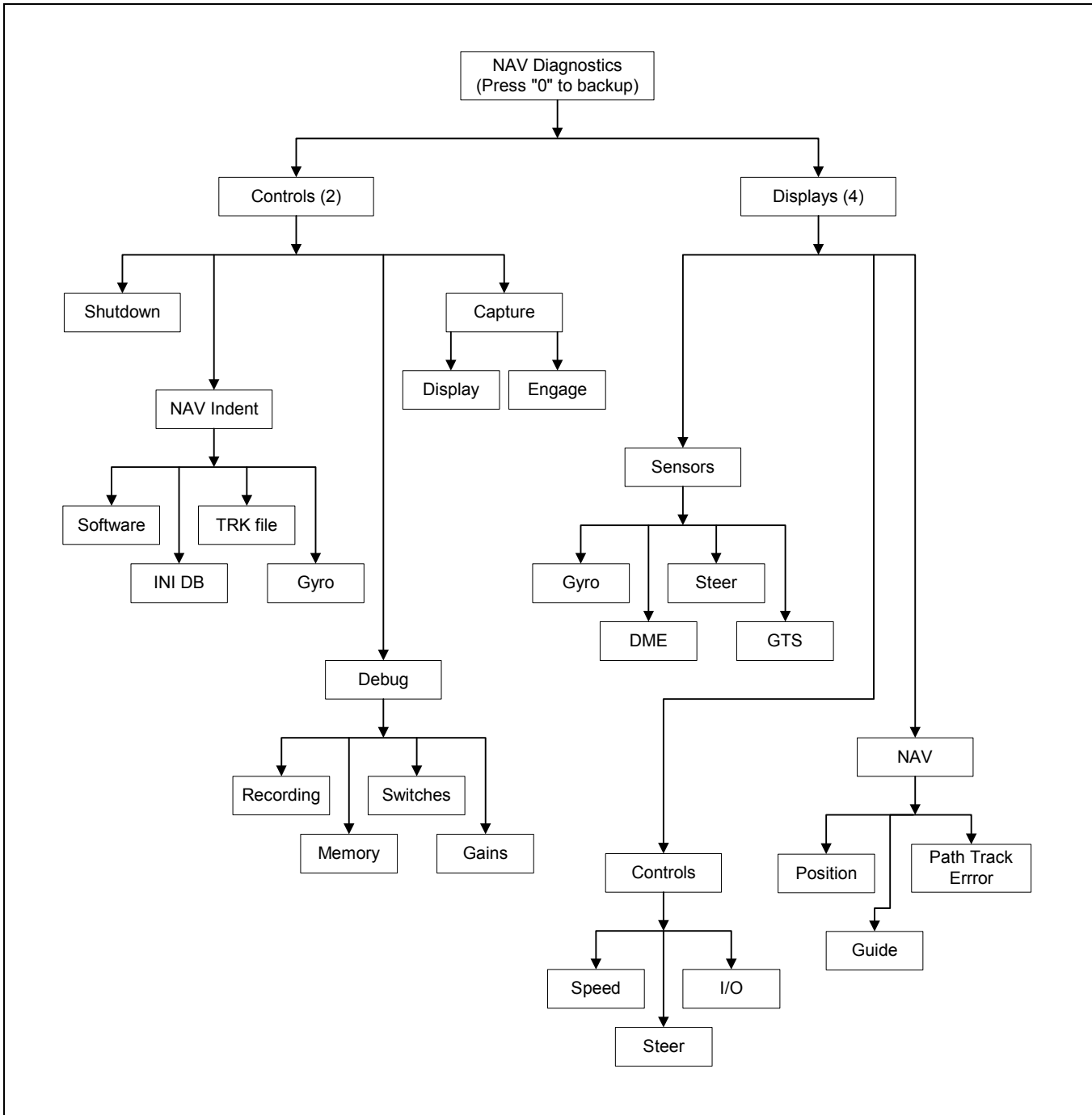
Figure 4   Navigation Diagnostics (continued)
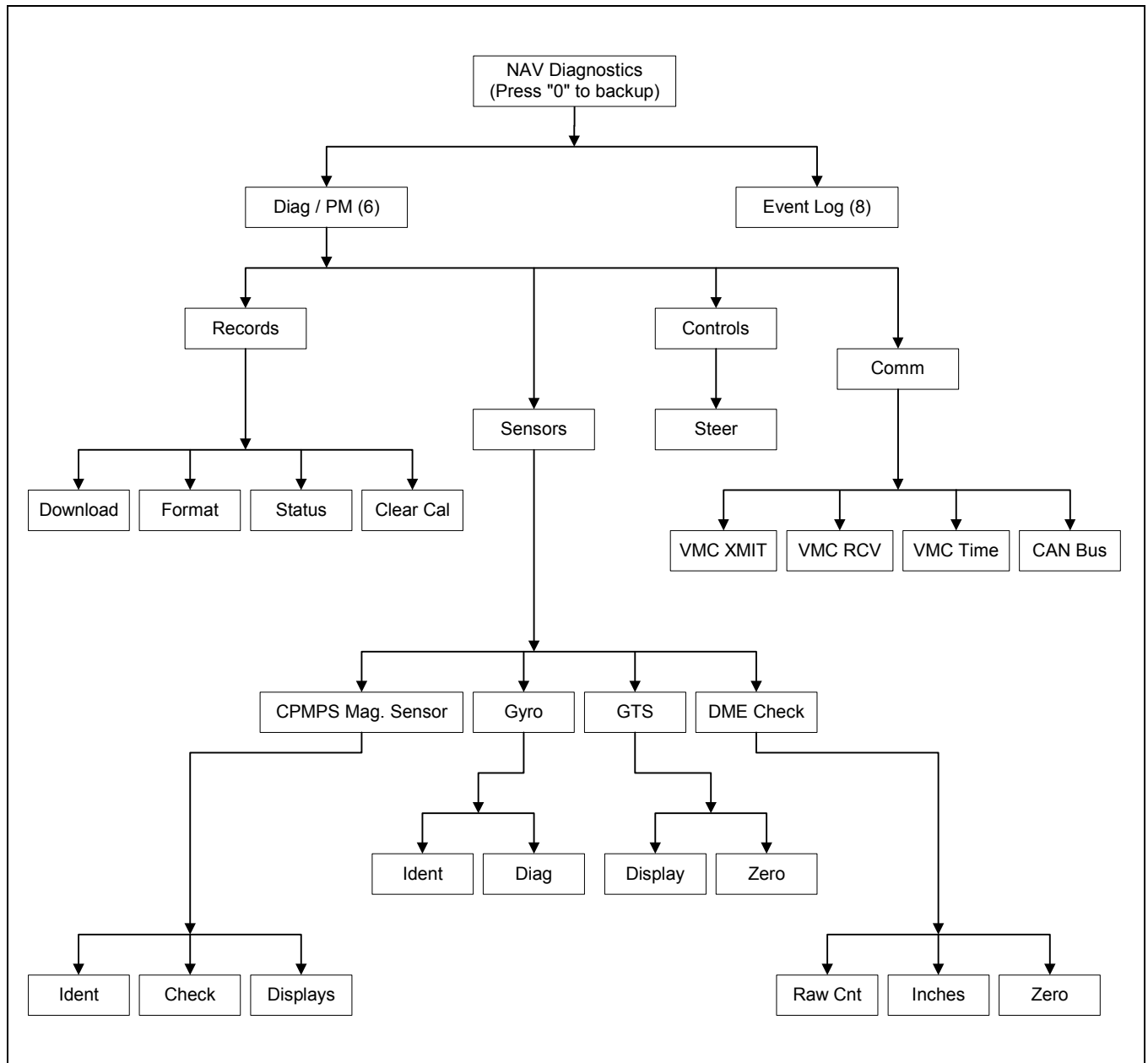
1.7.2 Version (Depress Softkey 4)

1.7.2.1 Diagnostic Mode NAV Computer Status Screen

This screen is used to display the status of the Navigation Computer. In addition, this screen identifies the current Navigation Computer Software (AGVMON=Vxx) version number and the guidepath layout (TRACK=Vxx) version number. See Figure 5.

Figure 5   Diagnostic Mode NAV Computer Status screen

```
NAV COMPUTER STATUS            DIAG

NAV STATE = X    AGVMON = Vxx  Track=Vxx
```
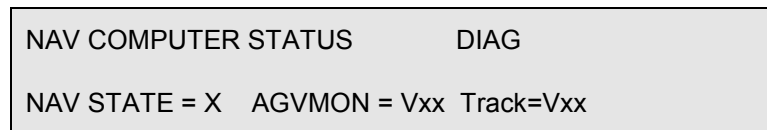
The displayed Navigation Computer states are as follows:

"0" indicates power up condition.

"1" indicates that the navigation system requires initialization.

"2" indicates an invalid path was selected.

"3" indicates that the Navigation System is operating properly.

Pressing ESC from this screen returns you to the DIAG mode screen.

1.7.2.2 Diagnostic Mode Vehicle ID and Version Screen

NOTE   Use arrow keys to scroll to this screen.

This screen indicates the vehicle identification number, Generic Vehicle Code (GVC) revision, Customer Vehicle Code (CVC) revision, and vehicle tables (TABLE) revision number. See Figure 6. This information is provided to ensure that each vehicle is operating with identical software and that the actual vehicle identification matches its programmed identification. In nearly all applications, the vehicle GVC, CVC, and TABLE revision value **must** be identical through the customer's AGV system. Pressing **ESC** from this screen returns you to the DIAG mode screen.

Figure 6   Diagnostic Mode Vehicle ID and Version screen

```
VEHICLE ID & SOFTWARE VERSIONS  DIAG

ID=XX  GVC=XXX  CVC=XXX  TABLES=XXX
```

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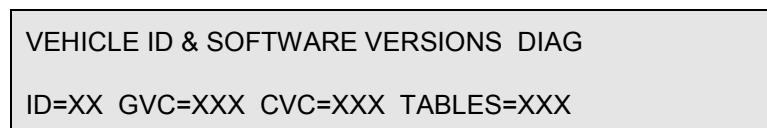
1.7.3 Status (Depress Softkey 8 or 9)

1.7.3.1 Diagnostic Mode Battery Status Screen

This screen provides an indication of the rate at which the electrical charge is being used from the battery, or the rate at which the battery is being recharged. The format for this screen is shown in Figure 7.

Figure 7

Battery Status	Level = X	MODE
Consuming At |_ _ _ _|		
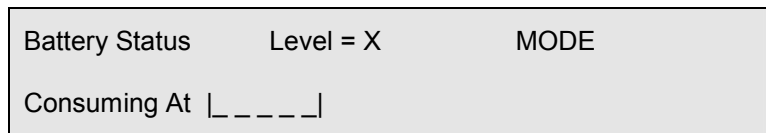
Pressing ESC from this screen returns you to the DIAGNOSTIC Mode Screen.

1.7.3.2 CAN Communicating Screen

Figure 8

CAN BUS I/O Boards Communicating

1 2 3 4
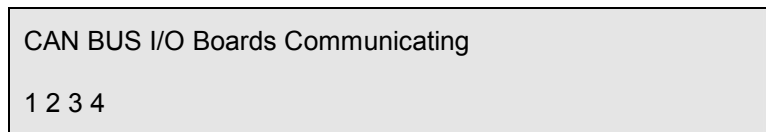
This screen provides an indication of the communication status of the each CAN I/O PCB to the vehicle computer.

1.7.3.3 Diagnostic Mode Error Code Screen

This screen displays the 8 most recent error codes along with an associated explanation. See Figure 9. After pressing the ENTER key to access the information, the arrow keys can be used to select a particular error code for explanation. A brief description of the selected error code appears on the top line of the display. Error codes appear on the bottom line with the most recent error to the far left. Errors occurring while this screen is active are displayed. Pressing ESC from this screen returns to the DIAG mode screen.

Figure 9

ERROR CODES (<-NEW OLD->	DIAG
Press ENTER to display error memory	

XXX (error message goes here)	DIAG
XXX --- --- --- --- --- --- ---	
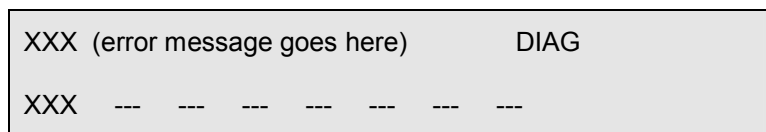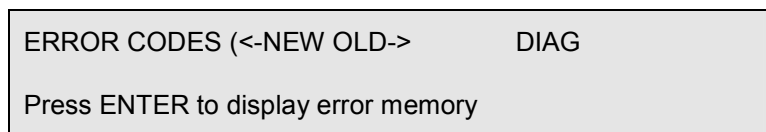
1.7.3.4   Diagnostic Mode Codes Read Screen

This screen displays the 8 most recent code reads. See Figure 10. The most recent code read is on the left end of the bottom line. Codes that are read while this screen is active are displayed. Pressing ESC from this screen returns you to the DIAG mode screen.

Figure 10

```
CODES READ (<-NEW OLD->)           DIAG

xxxx  xxxx  xxxx  xxxx  xxxx  xxxx  xxxx  xxxx
```
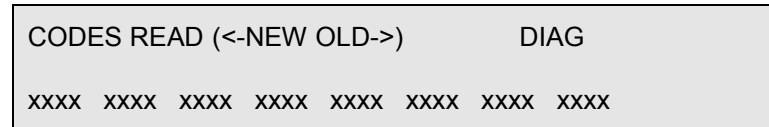
1.7.3.5   Code Read Distance Screen

Figure 11

```
Last Code Read =  XXXX

Distance from last code
```
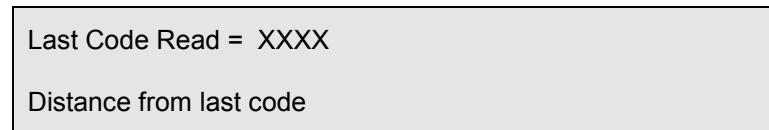
This screen is used in system and blocking checkouts. It measures the distance from the last virtual code read.

1.7.3.6   Vehicle Clock

Figure 12

```
Vehicle Clock

Tue Jan 01, 1980  23:56:40
```

1.7.3.7   Speed

Figure 13

```
Speed in Feet-Per-Minute

XXX
```
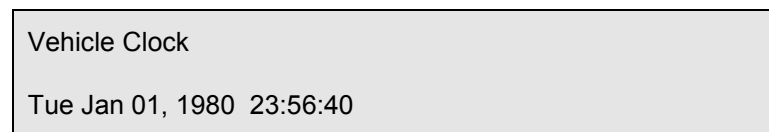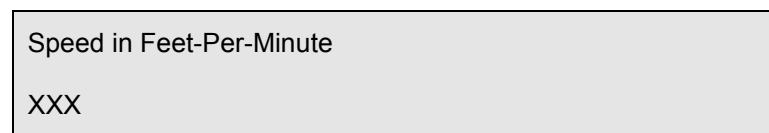
This screen is used to indicate the average vehicle speed in feet per minute.

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1.7.3.8   **Diagnostic Mode Magnets Detected Screen**

This screen displays the last four floor magnets detected in a scrolling display format. A maximum of the 145 most recent magnets detected are displayable. The screen format is shown in Figure 14.

Figure 14

```
MAGNETS DETECTED press: 1=<2=>    DIAG

XXX   XXXX,XX   XXXX,XX   XXXX,XX   XXXX,XX
```

In this display, the "000" position shows the order magnet code 1111, 22 was detected. "000" is the most recent detection, and "145" is the oldest detection.

The first four digits reflect the unique magnet identification number and the next two digits show the detected offset for the magnet. Magnets 000 through 145 are displayable using the "1" key to scroll "more recent" and the "2" key to scroll "older".

Pressing the ESC key from this screen returns you to the DIAG Mode Screen.

1.7.3.9 Events Display Screen

Figure 15

```
Events display     (<- OLD  NEW - >) RECIRC

.   .   .   .   .   .   .   .   .   .   .   .   .
```
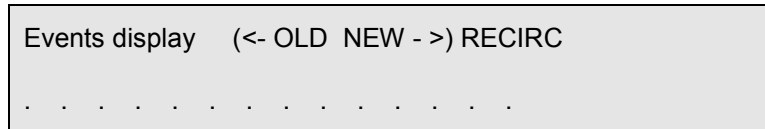
Displays any input function to computer from sensors.

Table 1   Diagnostic Event Code Descriptions

Display	Description
CODE	New virtual code read
ATMA	Automatic to Manual
MAAT	Manual to Automatic
STAR	Start switch pressed
MONF	Vehicle is no longer on path
BUMP	Bumper collapsed
ACOP	Access optic came on
TIME	Time out
PATH	Change in guidance path
OPTI	Change in object optics
BUOK	Bumper released
LINE	Line interlock dropped out
DIST	The vehicle has traveled the distance sent to a distance task
ESTO	Emergency stop switch pressed
NSTO	Normal stop switch pressed
LINN	Line interlock on
CYCM	Event cycle complete
NEWD	New destination entered
ZERO	Zero speed sensed
ACST	Accurate stop complete
TEMP	Motor over temperature
MODE	Mode change
DIRC	Direction change complete
LOAD	And load detect input changed state
PEND	Change in pendant switch input

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Figure 16   General System Check Flowchart

Figure 17   General System Check Flowchart (Cont.)

```
                    ┌─────────────────┐
                    │   Continued     │
                    │from previous page│
                    └────────┬────────┘
                             │
                             ▼
┌──────────────────────────────────────┐              ┌────────────────────────────────────────┐
│ After the AGV is initialized, the     │─────No──────▶│ • Repeat the initialization procedure in │
│ vehicle shows "ON_PATH" on CDU.        │              │   the Operator Guide.                     │
└──────────────────────────────────────┘              │ • Check all sensors (see the "Control     │
                             │                          │   System Troubleshooting Guide" in this   │
                            Yes                         │   chapter).                               │
                             ▼                          └────────────────────────────────────────┘
┌──────────────────────────────────────┐              ┌────────────────────────────────────────┐
│ Vehicle shows "COM-OK" on the CDU.     │─────No──────▶│ See Vehicle Communications Flowchart.    │
└──────────────────────────────────────┘              └────────────────────────────────────────┘
                             │
                            Yes
                             ▼
┌──────────────────────────────────────┐              ┌────────────────────────────────────────┐
│ Vehicle initiates automatic travel.    │─────No──────▶│ • Check Start Switch Status Screen on     │
└──────────────────────────────────────┘              │   display.                                │
                             │                          │ • Verify operating procedure was followed │
                            Yes                         │   correctly.                              │
                             │                          │ • See DRIVE Flowchart.                     │
                             ▼                          └────────────────────────────────────────┘
┌──────────────────────────────────────┐              ┌────────────────────────────────────────┐
│ Vehicle sustains automatic travel for  │─────No──────▶│ Refer to the DRIVE Flowchart or the       │
│ at least 15 seconds.                    │              │ "Controls Troubleshooting Guide" section  │
└──────────────────────────────────────┘              │ (in this chapter) to isolate controls     │
                             │                          │ symptoms to Drive Control, Ground Track   │
                            Yes                         │ Sensor, or Heading Reference Sensor.      │
                             ▼                          └────────────────────────────────────────┘
┌──────────────────────────────────────┐       ┌──────────────┐         ┌──────────────┐
│ Vehicle sustains automatic travel for  │──No──▶│ Unjustified  │──Yes──▶│ See BRAKE     │
│ an extended period of time without      │       │ emergency    │        │ Flowchart.    │
│ unjustified emergency stops or erratic  │       │ stops.       │        └──────────────┘
│ steering.                               │       └──────┬───────┘
└──────────────────────────────────────┘              │
                             │                          No
                             │                          ▼
                             │                   ┌──────────────┐         ┌──────────────┐
                             │                   │ Erratic      │──Yes──▶│ See STEER     │
                             │                   │ Steering.    │        │ Flowchart.    │
                             │                   └──────┬───────┘        └──────────────┘
                             │                          No
                             │                          ▼
                             │                   ┌────────────────────────────────────────┐
                             OK                   │ • See MAGNET SENSOR Diagnostics.          │
                             │                    │ • Check all guidance sensors (see the     │
                             │                    │   "Control System Troubleshooting" in     │
                             │                    │   this chapter)                           │
                             │                    └────────────────────────────────────────┘
                             ▼
┌──────────────────────────────────────┐              ┌────────────────────────────────────────┐
│ Battery maintains normal discharge     │─────No──────▶│ • Verify battery charger is operational.  │
│ time.                                   │              │ • Call Savant Automation Service.         │
└──────────────────────────────────────┘              └────────────────────────────────────────┘
                             │
                            Yes
                             ▼
┌──────────────────────────────────────┐
│ Automatic Operation OK.                 │
└──────────────────────────────────────┘
```

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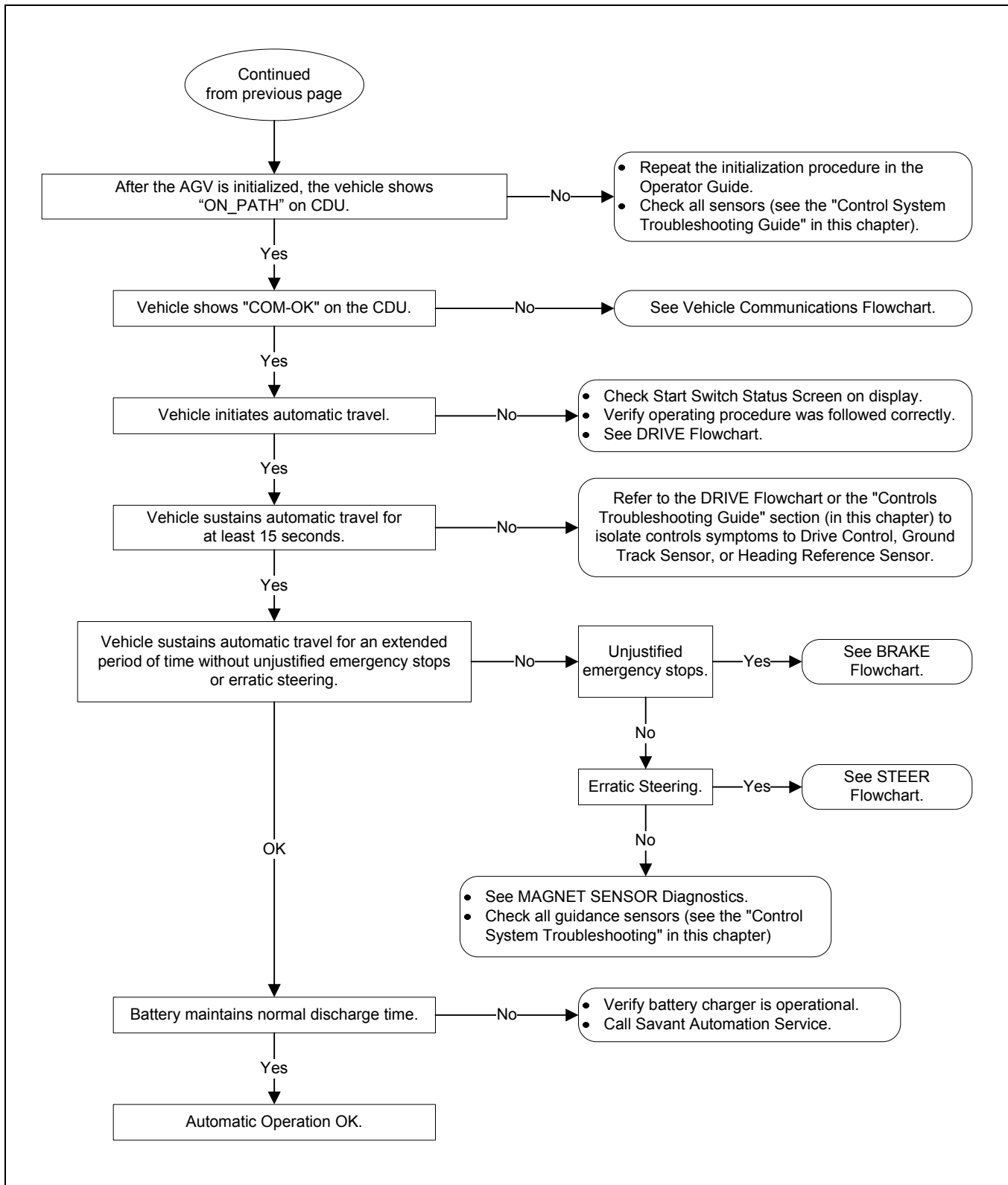automation

Figure 18   Drive Troubleshooting Flowchart
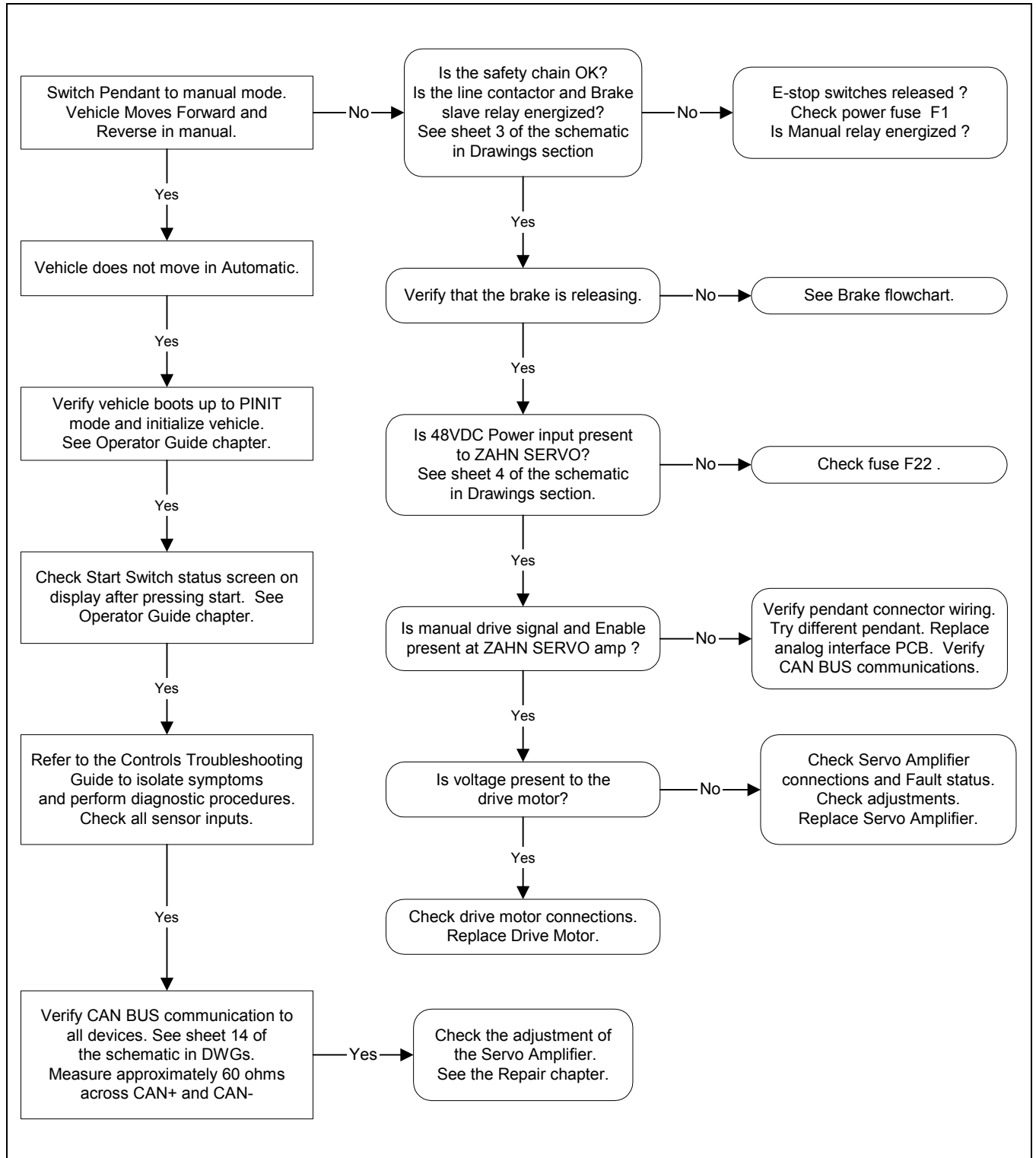
Figure 19   Brake Troubleshooting Flowchart
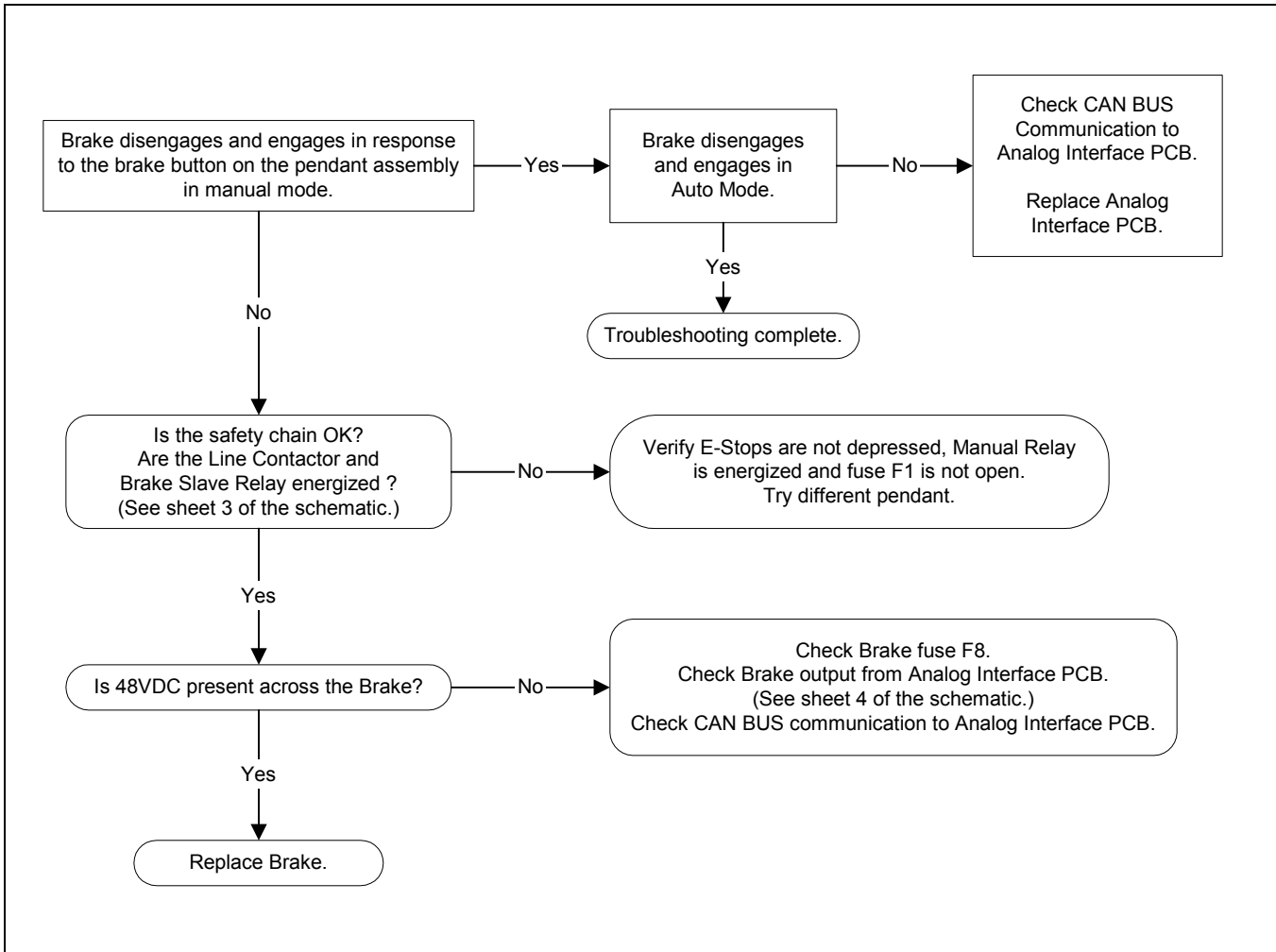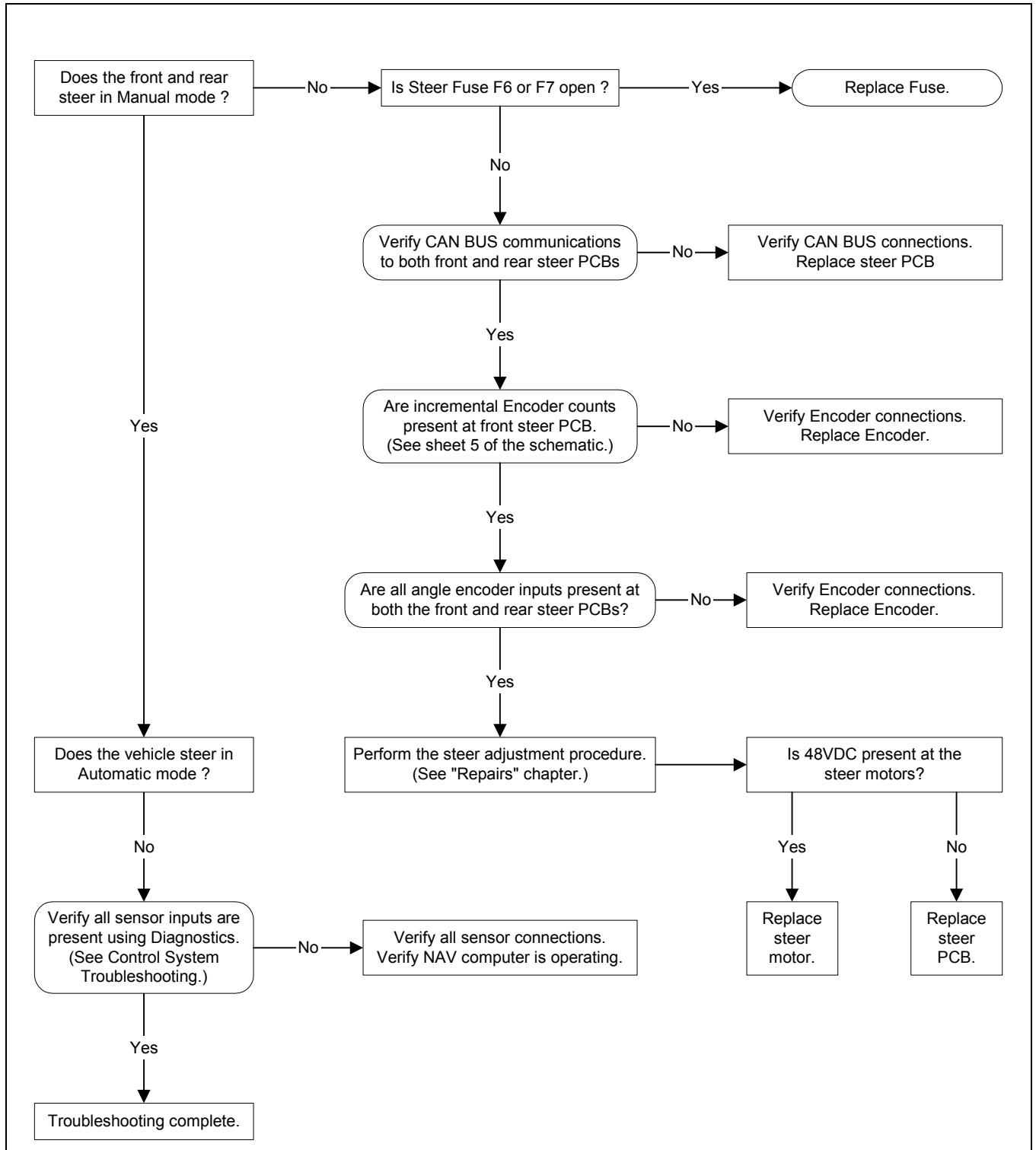
Figure 20   Steer Troubleshooting Flowchart
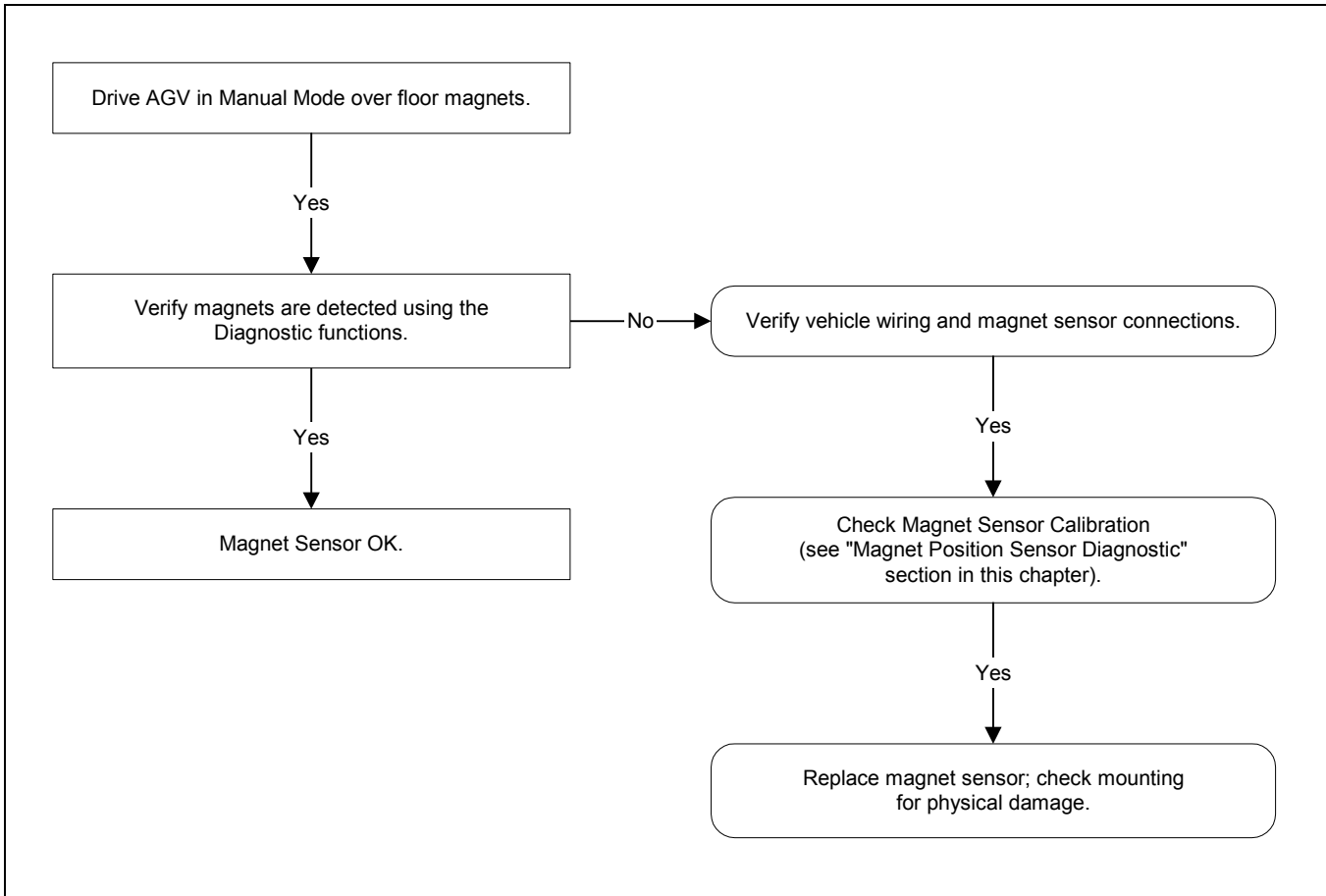
Figure 21   Magnet Sensor Troubleshooting Flowchart

```
┌──────────────────────────────────────────────────────────────────────────────────┐
│                                                                                    │
│   ┌──────────────────────────────┐                                                 │
│   │ Drive AGV in Manual Mode      │                                                │
│   │ over floor magnets.           │                                                │
│   └──────────────────────────────┘                                                 │
│                  │                                                                 │
│                 Yes                                                                │
│                  ▼                                                                 │
│   ┌──────────────────────────────┐        ┌──────────────────────────────────┐    │
│   │ Verify magnets are detected   │──No──▶ │ Verify vehicle wiring and magnet  │   │
│   │ using the Diagnostic          │        │ sensor connections.               │   │
│   │ functions.                    │        └──────────────────────────────────┘    │
│   └──────────────────────────────┘                        │                        │
│                  │                                        Yes                       │
│                 Yes                                        ▼                        │
│                  ▼                         ┌──────────────────────────────────┐    │
│   ┌──────────────────────────────┐        │ Check Magnet Sensor Calibration   │   │
│   │ Magnet Sensor OK.             │        │ (see "Magnet Position Sensor      │   │
│   └──────────────────────────────┘        │ Diagnostic" section in this       │   │
│                                            │ chapter).                         │   │
│                                            └──────────────────────────────────┘    │
│                                                            │                        │
│                                                           Yes                       │
│                                                            ▼                        │
│                                            ┌──────────────────────────────────┐    │
│                                            │ Replace magnet sensor; check      │   │
│                                            │ mounting for physical damage.     │   │
│                                            └──────────────────────────────────┘    │
│                                                                                    │
└──────────────────────────────────────────────────────────────────────────────────┘
```

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Figure 22   AGV Transceiver Troubleshooting Flowchart

Ensure the AGV is positioned on/very near to the guidepath. With power applied in manual or automatic mode, check the AGV's Control Display Unit (CDU). See Operator Guide chapter. Check the status line for:

"COM_OK"
Vehicle is properly communicating with the CSM.

"COM_??"
Vehicle is receiving invalid data from CSM.

"NO_COM"
The vehicle is not in "SYNC" with the CSM. Precautionary measures should be taken by personnel in the immediate area to prevent vehicle collisions.

Are other vehicles communicating with the CSM?

— No — See CSM Flowchart or refer to RF Modem Diagnostic Procedure.

Are other vehicles communicating with the CSM?

No → See CSM Flowchart.

Yes

Check for power to RF Modem (See schematic in the "Drawings" chapter).

Ok

Yes — Check circuit wiring and connections.

Ok

Check for physical damage to antenna. Replace if damaged.

Ok

Verify the LEDs on the modem are correct. — No → Replace Modem

Yes

NOTE: If problem cannot be resolved, call Savant Automation Service.

"COM_OK"
Vehicle is properly communicating with the CSM. — No → Call Savant Automation Service.

Figure 23   CSM Troubleshooting Flowchart

```
┌──────────────────────────────────────────────────────────────────────────────┐
│                                                                                │
│   ┌────────────────────────────────────────────────────────┐                  │
│   │  If all (or multiple) AGVs exhibit communication         │                  │
│   │  problems, the CSM (Constant System Monitor) computer    │                  │
│   │  or RF Base Station may be at fault.                     │                  │
│   └────────────────────────────────────────────────────────┘                  │
│                            │                                                   │
│   ┌────────────────────────────────────────────────────────┐                  │
│   │  Verify that the CSM computer and RF Base Station are    │                  │
│   │  ON and receiving facility power.                        │                  │
│   │  Check all circuit breakers  and power connections.      │                  │
│   └────────────────────────────────────────────────────────┘                  │
│                            │                                                   │
│   ┌────────────────────────────────────────────────────────┐                  │
│   │  See the "Field Wiring Layout" in the drawings section   │                  │
│   │  before proceeding.                                      │                  │
│   └────────────────────────────────────────────────────────┘                  │
│                            │                                                   │
│   ┌────────────────────────────────────────────────────────┐                  │
│   │  Switch to the back-up RF Base Station                   │                  │
│   └────────────────────────────────────────────────────────┘                  │
│                            │                                                   │
│   ( Are multiple AGVs indicating "NO COMM" ) ──No──▶ ( OK )                     │
│                            │ Yes                                               │
│   ┌────────────────────────────────────────────────────────┐                  │
│   │  Switch to the back-up CSM computer (A/B box to the      │                  │
│   │  "B" position).                                          │                  │
│   └────────────────────────────────────────────────────────┘                  │
│                            │                                                   │
│   ( Communications ok? ) ──Yes──▶ ( OK )                                        │
│                            │ No                                                │
│   ┌────────────────────────────────────────────────────────┐                  │
│   │  Verify software is installed in the CSM computer.       │                  │
│   └────────────────────────────────────────────────────────┘                  │
│                            │                                                   │
│   ( If problem persists, call Savant Automation service. )                      │
│                                                                                │
└──────────────────────────────────────────────────────────────────────────────┘
```

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1.8   Control System Troubleshooting Guide

1.8.1   Introduction

Certain aspects of DC60 operation are quite unique, relative to other industrial equipment. The following sections break down the vehicle control system into functional blocks and guide the repair technician in the use of the onboard diagnostics capabilities. The diagnostics provide performance measures and procedures to quickly and accurately diagnose a problem or verify normal running operation.

For a quick reference, scan the sections below for **Common Symptoms** to locate a procedure which will get you started in diagnosing a problem or follow the flowcharts provided earlier in this section.

In the paragraphs that follow, you will be asked to access the Diagnostics Screens, built in to the vehicle. A bold heading under each section will give the key sequences necessary to reach the appropriate diagnostic screen. To familiarize yourself with the diagnostic screen, enter the following key sequence:

Key Sequence to Access the Main Diagnostics Menu

Press the blank key under the "9" key four times.

1.8.2   Navigation and Guidance Subsystem

The following components are the major elements of the Navigation and Guidance Subsystem as used on the DC60. (See Figure 24)

1. System Virtual Guidepath and Floor Magnets
2. Magnet Position Sensor (MPS).
3. Navigation Computer.
4. Vehicle Steering Subsystem consisting of:
    - Front and Rear Steer Motors.
    - Front and Rear Steer Printed Circuit Boards.
    - Front and Rear Angle Encoders.
5. Vehicle Ground Track Sensor Subassembly:
    - Ground Track Swivel Caster.
    - Ground Track Incremental Encoder.
    - Ground Track Angle Encoder.
6. Vehicle Heading Reference Sensor (HRS or Gyro).

Figure 24   Guidance Diagram
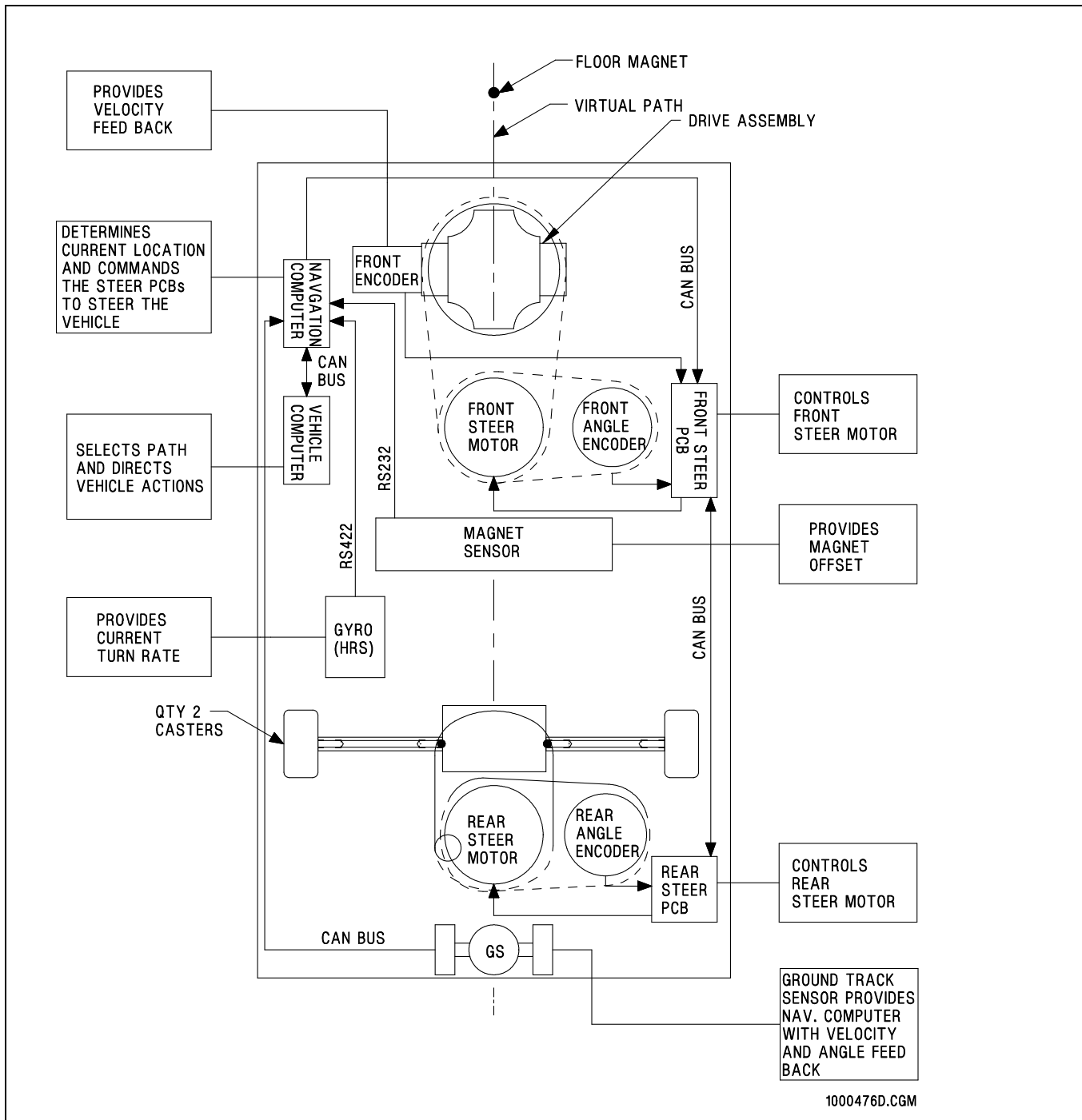
1.8.3   System Guidepath and Track Error

The AGV path of travel is referred to as a virtual guidepath. This path exists only as a floor layout drawing which is loaded into the Navigation Computer software. Each vehicle retains this system guidepath layout, in memory, and directs vehicle travel to programmed locations along the path. Magnets placed along the path, are used as reference points, which the vehicle uses to verify its calculated position on the path with respect to the plant floor.

The floor area along the guidepath must be clear and well maintained, to reduce physical damage to the AGV and its components. The vehicle chassis and component mounting are designed to withstand the normal plant floor deficiencies. **Shock, due to "pot holes", will cause higher maintenance cost and downtime.**

Floor magnets should be inspected periodically for chips or cracks. Damaged magnets should be replaced with factory authorized components using the Savant Automation recommended replacement procedure.

If magnets are badly damaged, the vehicle may not be able to detect them. If all or many vehicles are stopping with "missed magnet" errors, this is a good indication that the magnet has been damaged. If one vehicle stops at the same magnet every trip, perform the Magnet Sensor Diagnostic procedure before suspecting a bad magnet.

1.8.3.1   Track Error Diagnostics

The track file (floor layout drawing in .DXF format) that is loaded into the Navigation Computer is used to guide the vehicle via the steer controllers. The Gyro, angle and GTS DME encoders provide feedback to the Navigation Computer. The path "tracking error" should be less than 1" on a straight path and less than 4" through a turn.

Operate the AGV in automatic mode and access the track error diagnostic screen. As the AGV navigates a straight section of path, verify that the track error is consistently close to 0. If the track error continually indicates a number over 1, check all navigation and guidance sensor inputs for alignment/calibration and verify the input angles of the three angle encoders and the gyro throughout their range. See the following sections for sensor information.

Key Sequence to Access Track Error

If you are not in Diagnostic Mode - Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 – Advanced	
Enter	NAV Diagnostic Mode
	NAV Computer (Press 0 to backup)
4 – Displays	Controls Displays Diag/PM EventLog
6 – NAV	Sensors Controls NAV
6 – Path	Position Guide Path

Trk Err	Deg	T	F	Limit
1.0 L	28	5	2	6.0

Check all guidance sensor inputs throughout their range to verify the correct data is being received.

1.8.4   Magnetic Position Sensor

The magnet position sensor detects the presence of floor magnets as the AGV passes over them. Since each floor magnet location is precisely known, each magnet detected by a moving AGV provides verification of the AGV location on the virtual guidepath. The AGV is required to verify it's X,Y position. The Navigation Computer compares the computed position with the stored position and lateral steering corrections are made to keep the vehicle on the path.

Common Symptoms *of a failing Magnet Sensor are:*

- NAV Magnet sensor not communicating error

- NAV Missing Magnet error (can also be a magnet problem)

- NAV Overtravel without update error

- NAV Magnet Position error

1.8.4.1   Magnet Position Sensor Diagnostics

If the Magnet Sensor has failed, you <u>may</u> be unable to initialize the vehicle on the path. The first procedure listed, below, is a quick test of the communications cabling from the Magnet Sensor to the NAV Computer. If you can initialize the vehicle, the communications and power connections are OK. If you have an intermittent problem, check the cable, connectors, and case of the Magnet sensor.

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Key Sequence to Access Magnet Reads

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
8 - Status	
→ Right Arrow	
→ Right Arrow	
→ Right Arrow	Magnets Detected press: 1 = < 2 = >
	000 1001, 80 1002, A3 1048, 6E 1234,76

1.8.4.1.1   Definition of Number Code

000   = Screen position counter

● Press 1 to move the position down one

● Press 2 to move the position up one

1001   = Magnet number passed (0000 if the vehicle is not initialized on the path)
  80   = Position on the sensor that the magnet passed

● 80 is exactly on the centerline of the vehicle

● First digit in inches

● Second digit in sixteenths of an inch (hexadecimal notation)

1.8.4.1.2   Examples

A position reading of AA is 2 + 10/16 or 2.625 inches to the right of center.

A position reading of 78 is 8/16 or 1/2 inch to the left of center.

1.8.4.1.3   Magnet Sensor Communications Test

The Magnet Sensor communications can be verified using the onboard diagnostics, as described below:

1. Drive the vehicle, in manual, over a floor magnet.

2. Press ENTER to update the Magnet Detected Screen.

A new magnet read should be posted. If the vehicle has not been initialized on the path, the new magnet reading will be:

0000,00   Magnet 0000 (unknown number), position sensed

● If the vehicle is initialized, the communications system is working, and the actual magnet number will be displayed.

● If the screen does not update with a magnet reading, repeat the test a few times, in case you missed the magnet on the first try.

If the screen still does not update, check the following:

● Ensure magnet sensor power fuse is not blown.

● Ensure magnet sensor cable and connector are in good condition at both the sensor and at the Navigation Computer.

● Ensure magnet sensor assembly is properly mounted and in good condition.

1.8.4.2   Magnet Position Sensor Calibration Check

If all these checks are OK and the MPS does not read magnets, as a last resort, before changing the MPS, is to check the calibration.

Key Sequence to Access Magnet Sensor Diagnostics

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr
6 - Diag/PM	Diagnostics & Preventative Maintenance
4 - Sensors	MPS Gyro GTS DMECHK
2 - MPS	MPS Maintenance
4 - Check	Check calibration

If the calibration check indicates "Poor" or "Bad", replace the sensor with a new unit.

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Key Sequence to Display Position Data (Magnet Read) from the MPS

If you are not in Diagnostic Mode - Press the blank key under the "9" key four times.

Press:	Advanced Version Rfcomm Status (Screen View)
2 - Advanced	NAV Diagnostic Mode (Press 0 to back up)
ENTER	To access the NAV Computer Diagnostics
	2-Controls 4-Displays 6-Diag/PM 8-Last Err
6 - Diag / PM	Diagnostics & Preventive Maintenance
	2-Records 4-Sensors 6-Control 8-Comm
4 - Sensors	Sensor Diagnostics
	2-MPS 4- Gyro 6- GTS 8- DMECHK
2-MPS	MPS Maintenance
	2-Cal 4-Check 8-Norm Disp
8-Norm Disp	

The diagnostic page displays the data put out by the MPS each time it read a magnet.

The normal mode screen looks similar to the following:

```
NORM                    Last← >First

     xx  xx  xx  xx  xx  B0  A9  45
```

Where,

> xx = no magnet read
>
> B0, A9, etc = the lateral position of the magnet relative to the MPS; 80 is the center, 10 is the left, E0 is the right

This diagnostic page is very similar to another screen, shown below, with the following exceptions:

- The magnet number is not shown.
- The screen can be left on in Automatic or Manual so the technician can watch each magnet read come in real time.
- The screen 'beeps' each time the MPS reads a magnet.
- The screen shows only the last eight magnet reads.

Alternative Key Sequence to Access Magnet Reads

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version Rfcomm Status (Screen View)
8 - Status	
← Left Arrow 5 times	Magnets Detected press: 1= < 2= >
	000 1001, 80 1002, A3 1048, 6E 1234,76

Definition of Number Codes

000   = Screen position counter

- Press 1 to move the position down one

- Press 2 to move the position up one

1001   = Magnet number passed (0000 if the vehicle is not initialized on the path)
    80   = Position on the sensor that the magnet passed

- 80 is exactly on the centerline of the vehicle, 10 is the left side, E0 is the right side

- FF indicates that the expected magnet was missed.

- First digit in inches

- Second digit in sixteenths of an inch (hexadecimal notation)

Examples

A position reading of AA is 2 + 10/16 or 2.625 inches to the right of center.

A position reading of 78 is 8/16 or 1/2 inch to the left of center.

1.8.5   Navigation Computer

The Navigation Computer continually determines the current AGV location based on inputs from the various guidance sensors. Using this established location, the computer steers the AGV along the programmed virtual guidepath. The navigation computer continually communicates to the Vehicle Micro Computer and if communications between the two computer is lost a "NAV MESSAGE TIMEOUT" error will be displayed.

1.8.6   Steer Control Subsystem

The DC60 steering subsystem uses a three-wheel steer configuration. The drive (front) and load (rear) wheels are independently steered and electronically linked through the front and rear Steer Motor Control PCBs using the CANBUS network.

In Automatic mode, the NAV computer sends commands to the front and rear Steer Motor Control PCBs through the CANBUS network. The Steer Motor Control PCBs drive the steer motors to keep the AGV on the Virtual Path. Front and rear Angle Encoders connected to the Steer Motor Control PCBs are used to indicate the steer angles.

In Manual mode, the Vehicle Pendant potentiometer values are monitored by the Pendant Control PCB and relayed to both Steer Motor Control PCBs through the CANBUS network.

If the vehicle is "dog tracking" on a straight guidepath, perform the Steer Calibration Procedure found in the Repairs section of this manual.

Common Symptoms *of Steer Control problems are:*

● Vehicle will not stay on path

● NAV Steer Offset Exceeded error

● No Front or Rear steer control

● Front or Rear Steer: Miss Target error

● Front or Rear Steer Not Communicating error.

1.8.6.1   Steer Control Subsystem Diagnostics

Use the Steer Control Diagnostics Page to monitor the Steer System status.

1.8.6.1.1   Initial Checkout

1. Check Steer Motor fuses F6 and F7.

2. Check 48VDC power to J2 connector of both Steer Motor Control PCBs.

3.   Check the display to verify no Steer Control errors are shown.

4.   Switch to Manual mode and verify both the front and rear are operating using the pendant.

5.   Access the Steer Control Diagnostics screen.

Key Sequence to Access Steer Control Diagnostics

If you are not in diagnostic mode –

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 – Advanced	NAV Computer (Press 0 to backup)
Enter	To Access NAV Computer
4 – Displays	Controls Displays Diag/PM EventLog
4 – Controls	Sensors Controls NAV
4 – Steer	Speed Steer I/O

Information Displayed on the "Steer Control Diagnostics Screen".

STCMD / OFFSET	MDF	CMD	ACT	CMD	ACT
0.0 / 0.0	BFO	0.0	- 1.8	0.0	1.4
		FRONT STEER		REAR STEER	

In Manual mode no commands from the NAV computer will be sent to the Steer Control PCBs. Angle Encoder feedback can be verified by monitoring the ACT (Actual) angle. If both Steer Control PCBs are communicating, a change in angle will be displayed.

1.8.6.1.2   Automatic Checkout

1.   Initialize the vehicle on the path and verify the AGV tracks on a straight path and turns. The CMD (Command Angle) and ACT (Actual Angle) should increment or decrement together.

2.   The offset number in most cases should be close to 0.0. if the number consistently approaches 1, perform the Ground Track Sensor and Steer Calibrations. When the offset number is at 2, a steer offset error will occur.

3.   If the vehicle is "dog tracking", perform the Steer Calibration procedure located in the "Repairs" section of this manual.

1.8.7 Vehicle Ground Track Sensor (GTS) Subassembly

The DC60 Vehicle Ground Track Sensor Subassembly consists of a non-load bearing swivel caster. As the AGV travels the virtual guidepath, the Navigation Computer receives a measurement of distance traveled from the Ground Track increment encoder (DME) and the angle of travel from the Ground Track angle encoder. This data is sent to the Navigation Computer via CANBUS.

Common Symptoms of a failing GTS are:

- NAV Missing Magnet error
- NAV Magnet Position error
- NAV Steer Offset Exceeded error
- Vehicle will not initialize on the path
- NAV DME Encoder error

1.8.7.1 Ground Track Sensor Diagnostics

Key Sequence to Access Ground Track Sensor (GTS) Diagnostics

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr
6 - Diag/PM	Diagnostics & Preventive Maintenance
4 - Sensors	MPS Gyro GTS DMECHK
6 - GTS	Ground Track Sensor Calibration
	Display Zero
2 - Display	

Information displayed on the GTS Display Screen:

RAW: 7f5 46; COOKED: 0.0. 0.000

Definitions of GTS Display Screen Codes:

- RAW is the raw value from the encoder.

  7f5 is the raw value returned from the absolute encoder.
  46 is the raw pulse count from the DME encoder.

- COOKED is the calculated value converted to degrees or inches.

  0.0 is the angle of the absolute angle encoder in degrees.
  0.000 is the distance recorded from the DME encoder in inches.

1.8.7.2   Ground Track Sensor Diagnostic Tests

1.8.7.2.1   Absolute Encoder Diagnostic

1. Move the vehicle forward 2-3 feet, in as straight a line as possible. The easiest way to do this is to drive the vehicle next to a floor joint or painted line. The cooked angle should change in response to the vehicle. If you are very accurate with the pendant, the angle should remain fairly constant. If the angle changes more than approximately 5 degrees, or does not follow the movement of the vehicle, check the cable and connector to the absolute encoder.

2. Next, check the belt tension, and ensure that the pulleys are tightened and properly aligned.

    NOTE   Before changing the encoder, perform step 3, while the vehicle is moving in reverse.

    ■   If the angle is steady but outside the specifications under "Forward" in Table 6, set the zero point of the encoder, as outlined in the next section.

3. Move the vehicle in reverse and watch the angle reading. The angle should change by 180 degrees as the GTS flips around. Once the sensor has stabilized in the reverse direction, move the vehicle 2-3 feet and observe the angle reading. If the reading is steady and follows the movement of the vehicle in one direction, but is bad in the opposite direction, the encoder may be bad. If the angle reading is questionable in both directions and you have inspected connectors and the mechanical assembly, replace the absolute encoder.

Table 2   Absolute Encoder Coded Angle Values

	Left Pivot		Right Pivot		Forward		Reverse	
Vehicle	RAW	COOKED	RAW	COOKED	RAW	COOKED	RAW	COOKED
DC60	1b0 to 1dd	+38.0 to +42.0	983 to 9b0	-34.0 to -38.0	817 to 017	-2.0 to +2.0	fe9 to 7e9	-178.0 to +178.0

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1.8.7.2.2   Setting the Zero Point for the GTS Absolute Encoder

 CAUTION

Do not perform this procedure unless you have determined the zero point is out of specification or you are re-installing a GTS assembly. This procedure is NOT required as part of general preventive maintenance.

1. Move the vehicle straight forward 3-5 feet. This should cause the GTS wheel to align itself parallel with the vehicle. Note that the accuracy of the zero point depends on how straight the ground track sensor is with respect the vehicle.

2. Access the GTS Calibration Screen, and Press 8 - Zero.

3. When the process is complete, the Display Screen will return and the angle will be reset.

1.8.7.2.3   Distance Measuring Encoder (DME) Checks

Key Sequence to Access Encoder Check Diagnostics

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr
6 - Diag/PM	Diagnostics & Preventive Maintenance
4 - Sensors	MPS Gyro GTS DMECHK
8 - DMECHK	Distance Measuring Encoder Check
	RawCnt Inches Zero
8 - Zero	Zeroes **currently displayed** sensor counts
0 (backup)	GTS 00 FDME 0 RDME 0
4 - Inches	RawCnt inches Zero
	Displays each encoder in inches instead of counts, see display below.

The following Information should be displayed on the DME Check Screen:

Cooked DME Suite Values

GTS 0.00   FDME 0.00   RDME 0.00

1.8.7.2.4   Definitions of DME Check Screen Codes

- Cooked means the values displayed have been converted to inches from the raw count values.

- GTS = Ground Track Sensor DME encoder distance.

- FDME = Front DME encoder distance.

- RDME = Not used.

Drive the AGV forward and allow the Ground Track Sensor to rotate fully - close to 0 degrees and align a corner of AGV frame to an expansion joint line.

Using a tape measure, measure 10 feet (120 inches) and mark the location.

Slowly move the vehicle straight forward to the marked location so the corner of the AGV frame is aligned to the marked location.

The display should indicate 120 $\pm$ 2 inch travel on the encoders. If the display indicates travel outside the required range, check the suspect encoder; verify that its cable and connectors are free from damage. Replace defective component(s).

1.8.8   Vehicle Heading Reference Sensor (HRS or Gyro)

The HRS is an inertial sensor, which provides the Navigation Computer with a precise measure of the AGV's rate of turn or rotation. This information is used by the Navigation Computer to continually determine the current AGV location and orientation.

Common Symptoms *failing Gyro include:*

- NAV Heading Reference Sensor (Gyro) not communicating error

- NAV Steer offset exceed error

- NAV Bad heading error

- Vehicle will not initialize on the path

- On power-up, NAV status will not change from NPWR to P_INIT

- Please refer to "Heading Reference Sensor (GYRO) Diagnostics" and perform a complete performance check, before replacing the HRS.

1.8.8.1   **Heading Reference Sensor (Gyro) Diagnostics**

Key Sequence to Access Gyro Diagnostics

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr
6 - Diag/PM	Diagnostic & Preventive Maintenance
4 - Sensors	Records Sensors Control Comm
4 - Gyro	MPS Gyro GTS DMECHK
4 - Diag	Ident Diag

Information displayed on the Gyro Diagnostic Screen:

T	DB	DH	BIAS	L-SF	R-SF	RATE
8	5	0	-143	1876	1222	1016

Table 3   Gyro Diagnostic Codes

Item	Description
T	Timer - Increments every 0.1 second
DB	Delta Bias
DH	Delta Heading
BIAS	Gyro Bias
L-SF	Left Scale Factor
R-SF	Right Scale Factor
Rate	Period of communications messages

NOTE   Most of the information displayed on this screen requires a high level of understanding of Gyro characteristics and is normally only useful to Savant Automation engineering for initial factory testing.

1.8.8.2   Gyro Communications Test

The following procedure checks the communications channel between the Gyro and the NAV Computer.

If the NAV Computer is correctly receiving communications packets from the HRS, the RATE should be between 1014 and 1019. That is, 10.14 milliseconds and 10.19 milliseconds. If the RATE is **not** within this range, then:

1.   Check the cable and connectors between the HRS and NAV Computer, and

2.   Verify that 24 volt power is present at the HRS connector.

If power is present and cables have been checked out, but the RATE indicator is still out of range, follow the instructions for replacing the Gyro, found in "Repairs".

1.8.8.3   Static Gyro Test

The following procedure checks the Gyro internal sensors.

Locate a square reference such as the corner of a cement floor slab. The area you pick should be free of magnets. Drive the vehicle in MANUAL so that the frame is aligned with the floor joint. Power down the vehicle, then re-apply power. When the vehicle computer comes up, use the following procedure.

Key Sequence to Access NAV Position Diagnostics

Press ENTER to display the main status screen.

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr
4 - Displays	NAV Diagnostic Displays
6 - NAV	Navigation Displays
2 - Position	Navigation Diagnostics

The information displayed should be as follows.

29,	0,	0.0	00000:	0.0,	0.0
X position	Y position	Heading	LastMag	X update	Y update

Table 4   Description Of NAV Positon Diagnostic Codes

Item	Description
X position	The vehicle's current X axis position referenced to the AutoCad map of the path.
Y position	The vehicle's current Y axis position referenced to the AutoCad map of the path.
Heading	The angle the vehicle is headed, referenced to the +X axis.
LastMag	The last magnet ID seen by the NAV Computer.
Xupdate	The distance the vehicle had to correct at the last magnet in the X direction.
Yupdate	The distance the vehicle had to correct at the last magnet in the Y direction.

The initial heading on power up should be 0.0. Move the vehicle so the frame is aligned with the perpendicular ground floor joint. The new Heading should differ from the first measurement by about 90 degrees (depending on the squareness of the cement pad and your ability to align with the joint). Note that a clockwise 90 degree turn will show 270-90 degrees, a counterclockwise 90 degree turn will show +90 degrees.

If the heading does not change, follow the instructions for changing the Gyro found in "Repairs".

1.8.8.4   Gyro Zero Bias Test

The following procedure checks the Gyro for stable operation while stationary.

Using the same NAV Position Screen as the Static Gyro Test, above, observe and note the vehicle heading. Allow the vehicle to sit, stationary for 30 minutes. If the heading has changed by .5 degrees or more, replace the Heading Reference Sensor (Gyro).

1.8.8.5   Gyro Slow Drift

If the vehicle is slowly drifting off path as it travels down a long straightway, first verify that the vehicle is reading magnets properly and that the steering system is in good working order. If both the magnet sensing and steering check out OK, the Gyro may have failed. Contact Savant Automation for further assistance.

1.8.9   Input / Output (I/O) Boards

Various discrete signals are sensed and output by the Vehicle Micro Computer (VMC). Examples of sensed inputs are Start, Stop, and E-Stop switches. Examples of output signals are the warning lights, line contactor, and warning beeper.

Common Symptoms *of a failed I/O Board are:*

● Safety chain fault - each I/O Board can open the safety chain if its processor detects a problem.

● Sensor checks OK, but the vehicle does not respond. An example would be if a Start switch checks OK electrically, but does not start the vehicle.

● Output relay will not operate.

NOTE   The safety chain is a series of safety devices, which include safety relays and emergency stop switches, that are wired together in series to energize a safety line contactor. When one or more of the devices fail, the safety line contactor opens and the AGV will set its brake and emergency stop.

1.8.9.1   I/O Board Diagnostics

Every discrete Input and Output signal in the vehicle can be checked via this menu subsystem. Refer to the vehicle schematic in the "Drawings" chapter section or the hardware documentation "HARD" in "Software and Controls" for board and port positions of specific signals.

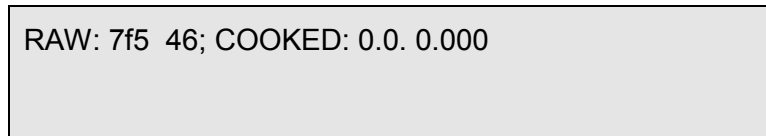**Key Sequence to Access Input/Output Board Diagnostics**

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
→ Right Arrow	
ENTER	To access the I/O Board Menu

Use Arrows to select Board/Port

B1P1=80Hex MSB=10000000=LSB Binary

Table 5   Description Of I/O Board Diagnostic Codes

Item	Description
B1	Board number 1
P1	Port number 1
MSB	Most Significant Bit, also referred to as bit 7
LSB	Least Significant Bit, also referred to as bit 0

Example

To view the current state of the Front Right – Normal Stop (yellow) switch, the hardware documentation located in "Software and Controls", shows that it resides on I/O board 1, port 4, bit 0. Press the Right Arrow key -> until the display shows:

B1P4=80Hex MSB=0010000<u>0</u>=LSB Binary

Activate and release the N-Stop and note that the underlined bit changes state. Any discrete input or output described on the schematic or in the hardware documentation can be testing using this sub-screen.

1.8.10   CANBUS Communications

The **C**ontroller **A**rea **N**etwork BUS is used for high-speed data communications between sub-system microprocessors. CAN was originally developed for automotive use, to allow the various microprocessors in the engine, transmission, and dashboard to be connected using a simple two wire, twisted pair cable.

The AGV uses the BUS to link the Vehicle Micro Computer, Navigation Computer, Ground Track Sensor, I/O Boards, Steer Controllers, Battery Monitor sensor, Pendant and Analog Interface Board (Drive). See sheet 14 of the schematic for all CANBUS components which are utilized on the DC60 vehicle.

Common Symptoms of CANBUS problems include:

● One of the above devices is off line

● Vehicle displays a 290 - 299 series error code.

Refer to the CANBUS Diagnostics Troubleshooting and Maintenance procedures to check out communications to each device.

1.8.10.1 CANBUS Subsystem Component Communications

1.8.10.1.1 Component Level Checks

The paragraphs that follow will guide you through the process of checking communications for each sub-system component. If a component will not communicate, check cables and connectors first. Next, try swapping out the component. Finally, go through the entire procedure, below, to see if more than one component shows that it failed. Again, check cables and connectors first, then try swapping out components. If you find the problem is isolated to one board, make sure to replace all other original boards, one at a time, and replace only the defective one.

1.8.10.2 CANBUS Diagnostics

The CANBUS has two 120 ohm termination resistors connected in parallel. To check the wiring, verify approximately 60 ohms of resistance across CAN+ and CAN -.

General integrity of the CANBUS can be determined by checking the LED's on the CAN boards mounted on the NAV and Vehicle computers. Remove the access panel from the front left side of the vehicle. The board closest to the front of the vehicle is the NAV Computer stack. The second board from the bottom is the CAN communications board. You will see four LEDs, D1 through D4. Under normal operation, you should observe the following:

Table 6   CANBUS Diagnostics Leds

Led	Color	Description
D1	Green	On, slightly flickering
D2	Green	On, flashing
D3	Yellow	On, flashing
D4	Red	Off

The vehicle computer is to the right of the NAV Computer. It uses the same CAN board. Verify that the same LED activity as the NAV Computer is present.

1.8.10.3 NAV Computer Communications

By accessing the NAV Computer Diagnostics, you can verify communications with the NAV Computer:

Key Sequence to Access NAV Diagnostics

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 – Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr

If this screen is displayed correctly, the NAV Computer is communicating.

If a blank screen appears, the NAV computer is not communicating with the
Vehicle Computer through the CANBUS.

1.8.10.4   Steer Control PCB Communications

If either the front or rear Steer Control PCB is not communicating, an error will be
displayed.

1.8.10.5   Analog Interface PCB Communications

If the communications to the Analog Interface PCB is not present, the AGV will
not drive in Manual or Automatic modes.

1.8.10.6 Vehicle Computer to I/O board Communication

If any one of the two CAN I/O boards is not communicating to the Vehicle Computer, an error will be displayed.

1.8.10.7 Ground Track Sensor Communications

By accessing the DME check diagnostic, you can verify communications with the ground track sensor distance encoder:

Key Sequence to Access Encoder Check Diagnostics

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr
6 - Diag/PM	Diagnostics & Preventative Maintenance
4 - Sensors	MPS Gyro GTS DMECHK
8 - DMECHK	Distance Measuring Encoder Check
	RawCnt Inches Zero
8 - Zero	Zeroes currently displayed sensor counts
0 (backup)	GTS 00 LDRV 0 RDRV 0
4 – Inches	RawCnt inches zero
	Displays each encoder in inches of counts, see display below.

Information displayed on the DME Check Screen, should look like the following:

Cooked DME Suite Values

GTS 0.00   FDME 0.00   RDME 0.00

Move the vehicle in Manual and observe whether GTS reading changes. If the reading changes, the associated components are communicating.

Next, check the ground track sensor's absolute encoder:

Key Sequence to Access Ground Track Sensor (GTS) Diagnostics

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
2 - Advanced	NAV Computer (Press 0 to backup)
ENTER	To access the NAV Computer
	Controls Displays Diag/PM LastErr
6 - Diag/PM	Diagnostics & Preventative Maintenance
4 - Sensors	MPS Gyro GTS DMECHK
6 - GTS	Ground Track Sensor Calibration
	Display Zero
2 - Display	

Information displayed on the GTS Display Screen:

RAW: 7f5 46; COOKED: 0.0. 0.000

Move the vehicle in manual, causing it to change heading. The first RAW value, shown here as 7f5, should change. If this value changes as the heading of the vehicle is changed, the absolute encoder <u>is</u> communicating.

1.8.11   Drive Control Subsystem

A Zahn Servo Amplifier is utilized to drive the motor/drive assembly connected to the front drive wheel. In Auto mode, the Servo Amplifier is controlled by the Vehicle Computer via an analog Interface PCB through the CANBUS network. The amplifier uses Pulse-Width-Modulation (PWM) of the supply voltage to control the speed. Counter Electro Motive Force (CEMF) provides velocity feedback to the Servo Amplifiers.

Velocity feedback is also sent to the Vehicle Computer by an encoder mounted to the front drive assembly. The encoder is connected to the front steer PCB and data is relayed over the CANBUS network.

Manual operation is controlled by the vehicle pendant (joystick). Potentiometer values are monitored by the Pendant Control PCB and relayed to the Analog Interface PCB via the CANBUS network.

Common Symptoms of drive control problems include:

- Vehicle will not move

- Speed Control errors

- Front DME errors

- NAV DME Encoder error

- There are no specific Drive Control Diagnostics. The operation of the Front Incremental Encoder (DME) can be checked by accessing the Speed Display.

- If you are not in Diagnostic Mode –

- Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
8 – Status	
← Left Arrow	
← Left Arrow	
← Left Arrow	Speed in feet per minute

- If a speed is displayed, the Vehicle Computer is receiving front encoder information.

1.8.11.1   Drive Control Subsystem Diagnostics

1.8.11.1.1   Initial Checkout

1. Check fuses: Drive power fuse and brake fuse (F22, F28)

2. Switch to Manual mode. Press the pendant brake release switch and verify that the brake is releasing.

3. Check the LEDs at the ZAHN Servo Amplifier. Green LED indicates power and no fault to the unit. Red LED indicates fault.

4. Verify the Enable / Disable line is enabled at the Servo Amplifier.

5. Slowly move the joystick straight forward and back to verify incremental acceleration in both directions.

6. Initialize the vehicle on the path, enter a destination, switch to Automatic mode and start the vehicle.

7. Verify that the AGV accelerates to full speed and that the speed remains constant. (200 fpm $\pm$10 fpm.)

8. If these procedures have not isolated the problem, calibrate the Amplifier per the Calibration Procedure in the "Repairs" section of this manual.

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Figure 25   Typical Transceiver System Block Diagram

ANTENNA SYSTEM

RF COMMUNICATIONS

MDS 4790 BASE STATION

RS232 DATA

CSM

CSM PENTIUM
RACKMOUNT COMPUTER

RS232

VEHICLE MANAGER

VEHICLE MANAGER
RACKMOUNT COMPUTER

ETHERNET

PLC

1000543A.CGM
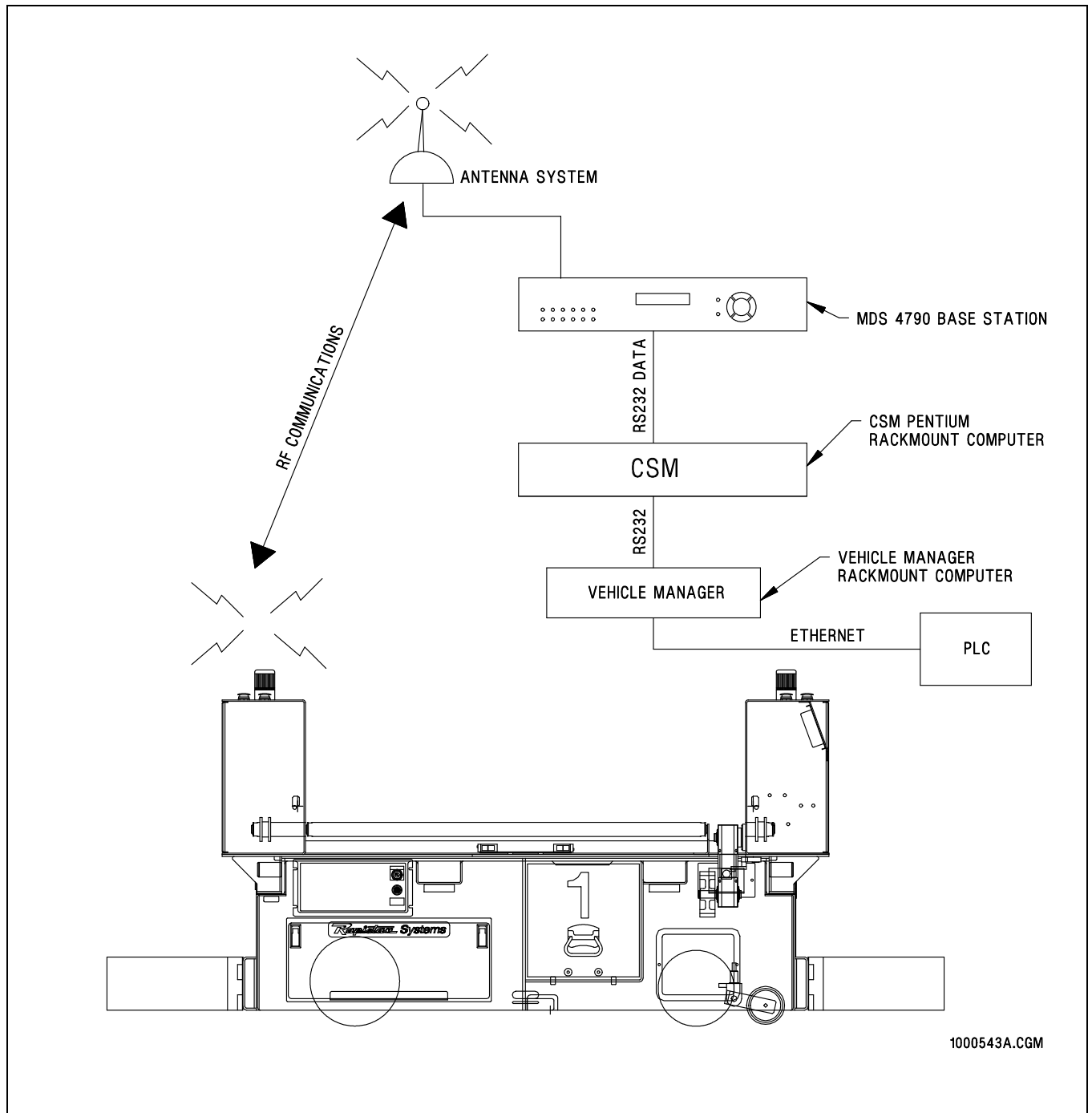
1.8.12 RF Communications

The vehicle communicates with other vehicles and ground based control and monitoring equipment via Radio Frequency modems. The ground based Constant System Monitor (CSM) sends a synchronization message to all vehicles, then each vehicle responds with its blocking (collision avoidance) information.

The CSM not only synchronizes the vehicle blocking messages, it also sends commands to specific vehicles, to go to a stop station, or just return its current status. The CSM also takes all the vehicle blocking information and broadcasts it to all vehicles in the system.

The Vehicle Microcomputer on the AGV handles all RF Communication activity via the RF Transceiver Modem. The Navigation Computer sends a "Virtual Code" number to the Vehicle Microcomputer requesting a location on the guidepath. The Vehicle Microcomputer uses the Virtual Code information for routing, traffic control, actions and executing station cycles.

Common Symptoms *of RF Communication problems include:*

- Vehicle stops and starts erratically

- Vehicles collide

- Vehicles remain "Stopped Blocked" for long periods with no other vehicles nearby.

- Vehicle status display shows "NO COM", COM_?B, or "COM ??"

1.8.12.1 Vehicle Communications - General

Each vehicle communicates to the CSM using an RF communications system which consists of a vehicle modem and antenna. The CSM is able to receive and transmit to the vehicles via the RF Base Station. This section deals specifically with the vehicle's onboard communications system. The general status of communications, received by the vehicle, can be checked on the RF Comm Diagnostic screen labeled "Blocking Debug #1".

Key Sequence to Access RF Communications

If you are not in Diagnostic Mode -

Press the blank key under the "9" key four times.

Press:	Advanced Version RFComm Status
6 - RFComm	Blocking Debug Screen #1 COM_OK, 2E TBLKS=

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Table 7   Communications Status:

Message Displayed	Description
COM_OK	Communications is OK
COM_??	The vehicle did not receive the last synchronizing message from the CSM.
COM_?B	The vehicle did not receive at least one copy of each blocking packet during this synchronizing cycle. (Two COM_?B in succession will hold the vehicle)
NO_COM	The vehicle is not receiving reliable communications from the CSM.
ENALOS	Vehicle has been put into a diagnostic/test mode which will override NO_COM and allow movement without communications.

If a vehicle occasionally displays NO_COM, COM_?B, or COM_??, this may be caused by local interference. If the vehicle stops and starts, the vehicle modem could be defective. Refer to the Vehicle Modem sections, which follow. If all vehicles exhibit communications faults, the Base Station or system antenna could be the problem. Refer to the RF Base Station sections, which follow.

1.8.12.2   Packet Count

The number displayed in the upper right corner of the Blocking Debug display is the number of good packets received in each communications frame (0.5 to 1.5 second frame length, depending on the system size). This number is displayed in hexadecimal (base 16). Most systems will have between 18 and 2E (24 and 46 in decimal) packets. During normal operation, it is typical for the number packets to vary slightly. If this packet count is consistently below 10 hexadecimal (first digit = 0), there is a problem with the vehicle's ability to receive signals from the Base Station. Check a good vehicle for normal packet count and write it down for later evaluation of questionable vehicles.

If the packet count is below 10 hex (00 to 0F), and other vehicles are communicating properly, check the modem status lights as described below. If all vehicles are receiving low packet counts, check the RF Base and system antenna.

1.8.12.3   Transmitted Blocks (TBLKS)

When the vehicle is traveling in Automatic mode, it transmits the block zone areas that it currently occupies. This information is helpful when checking out the initial installation or new guidepath additions. Sometimes, a communications problem is mistaken for a blocking problem. If vehicles stop at the same place on the path "STOP BLOCKED", there may be a "stand off" problem, unrelated to communications. Write down the last codes read, current destination and the T-

Blocks being transmitted. Report this information to Dematic Corp. service for resolution.

NOTE If the AGV is receiving its own block that it transmitted an asterisk (*) will appear next to "TBLKS."

1.8.12.4   Vehicle Modem

The Radio Frequency (RF) modem's general operating conditions can be determined by viewing the status indicator lights located between the RS232 and Power connectors on the face of the modem. More detailed failure analysis can be accomplished using the information contained herein and with the MDS configuration software that can be downloaded from the MDS software downloads website: https://www.microwavedata.com. The Vehicle Modem is located inside the Power Panel Assembly. See the Spare Parts Drawing in the "Parts" chapter for details.

1.8.12.5   Normal Status Light Operation

- PWR - Power is always ON while the vehicle is plugged in.

- CD - Carrier Detect should be ON if the vehicle is receiving a good signal level from the RF Base Station. If this light is not on steady, refer to "Vehicle Carrier Problems" which follows.

- RXD - Received Data should be ON if the vehicle is receiving information from the RF Base Station. Under normal operation, this light will be on all the time, except during RTS. If the CD light is on, but no data is being received, most likely, there is a problem with the CSM computer. If other vehicles are operating properly, replace the modem.

- RTS - Request To Send should flash on, briefly, during the time the vehicle is transmitting to the RF Base Station. When RTS is on, both CD and RXD will go off. This is normal. Also see "Vehicle RTS Problems" below.

- TX - Transmit should be ON whenever RTS is ON. There is actually a short delay after RTS comes on, which is not visible without an oscilloscope.

- TXD - Transmit data should also be ON whenever RTS is ON. This shows that data is being received from the vehicle computer. If RTS and TX are ON but TXD is not, check the connections on the CTS and TXD signal wires.

Proper cable connections from the modem are:

Modem ANTENNA connector goes to the vehicle antenna.

* Always check cables for damage, especially near the crimped connectors!

Figure 26   MDS Vehicle Modem
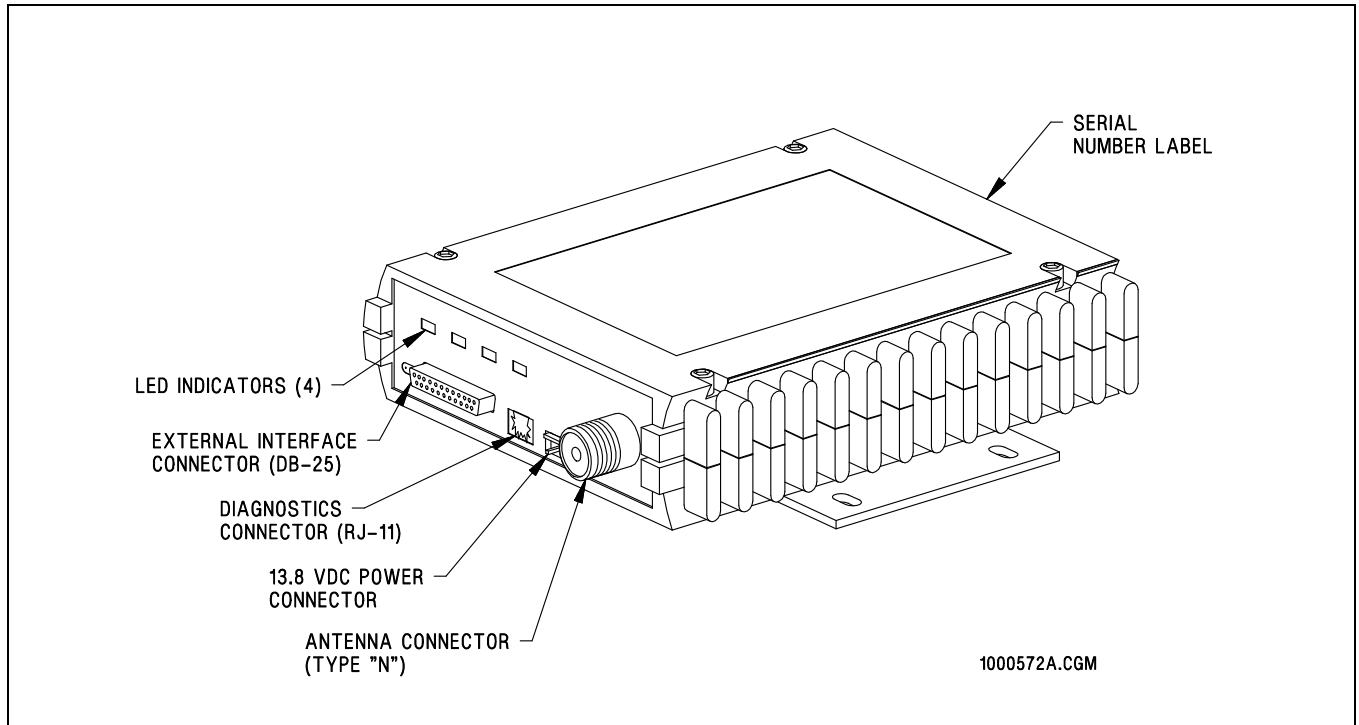
1.8.12.6   MDS Configuration Software

The configuration software provides detailed operational diagnostics. After downloading and installing the software from the MDS web site, connect a laptop PC's serial port to the radio's diagnostic port using a DB9 to RJ11 cable (provided with radio).

After running the software communications will be established to Comm Port 1.

1.8.12.6.1   Settings:

Got to the "Settings" tab and verify the following settings:

Time Out Timer	30 sec (OFF)
Soft Carrier Dekey	4 ms
Device Type	DCE
CTS Delay	10 ms
PTT Delay	3 ms
Unit Address	7119
Data Rate Format	9600 baud, 8 bits, Odd parity, 1 stop bit (9600 801)
Power Control	33 dBm

Modem Type	9600
Frequency	See Field Wiring drawings to determine operating frequencies.
Emphasis	OFF
Data Key Mode	OFF
Cont. Key Mode	OFF
Buffer Mode	Fast Byte Throughput
TX Audio Level	Auto
RX Audio Level	-10dBm

NOTE Compare the settings with an operating unit, if available.

1.8.12.7 Transmitter Test

1. Verify that the antenna is connected to radio (coaxial connector).

2. Using the Radio Configuration Software pull down the "Radio" menu and select Diagnostic Maintenance and Calibration.

3. Select "Key Radio Tab"

4. Check power output. The output should indicate -33db to -30db.

1.8.12.8 Receiver Test

1. Verify that the antenna is connected to radio (coaxial connector).

2. Using the Radio Configuration Software pull down the "Radio" menu and select Diagnostic Maintenance and Calibration.

3. Check the "Received Signal Strength Indicator" - gives the current db signal level that the vehicle is receiving from the Base Station. Normal readings are from -80 (for corners of system) to -60 db (close to base station antenna).

1.8.12.9 Voltage Checks

1. Using the Radio Configuration Software pull down the "Radio" menu and select Diagnostic Maintenance and Calibration.

2. The supply voltage level received from the vehicle is 12.0 volts.

3. The regulator voltage level should be about 6 volts.

1.8.12.10 Setting Operating Frequencies

Normally, the frequencies licensed for your system will be programmed into the modems at the factory or by Savant Automation. The frequencies can be revised by pulling down the "Radio" menu and selecting program frequencies. Do not change the frequency by more than 1 MHZ.

1.8.12.11   Setting Transmit Power

If the output power reading received is above -33db, reduce the power level or contact Savant Automation for assistance. The FCC license for your system is limited to -33db. Use the Radio pull down menu and select "Program Power" to revise the power level.

1.8.12.12   Vehicle Modem Power Problems

If the PWR light is OFF, check fuse F1 (7.5 A) and the power connector to the back of the modem. If there is 12 volts present at the power connector to the modem and the PWR light is off when the connector is firmly installed, replace the modem.

1.8.12.13   Vehicle Carrier Problems

If the CD light is not on continuously (it will flicker during RTS), check the antenna cable for a worn or damaged jacket, as well as the connections at the connectors.

1.8.12.14   Vehicle Request to Send (RTS) Problems

If the RTS light comes ON, but TX does not, the modem has detected a broken wire on the CTS signal wire (see vehicle schematic).

If the CD and RXD lights are on, and the RTS light does not blink at about one second intervals (plus or minus 1/2 second), check the vehicle diagnostic screen for "Blocking Debug". The two digit number in the upper right hand corner of the display is the number of good packets received during the last communications cycle. If the first digit of the packet count on the vehicle you are testing is zero (0E or 05 for example), check/ replace communications components by going down the following list:

●   If other vehicles have normal packet counts, the problem is in this vehicle, otherwise, check the system antenna and RF Base Station.

●   Check antenna cable for damage, especially at each connector. Check that antenna connectors are locked in position.

●   Check modem input power for clean, 12VDC. Also check that the power connector is securely installed.

●   Check the RS-232 cable for physical damage and the connectors at both ends, for broken wires and secure installation.

●   Swap out the modem, re-check packet count.

●   Swap out the antenna (rarely fails, unless physically damaged).

●   Swap out the antenna cable.

1.8.12.15   Vehicle Modem Preventative Maintenance

The radio manufacturer recommends that all vehicle modems be checked, once a year. This can be accomplished by running remote diagnostics from the Base Station. See "RF Base Station - Preventative Maintenance" for more information.

1.8.12.16   RF Base Station - General Operation

Messages to and from the AGVs are communicated with the CSM via an RF Base Station. Each Base Station includes two identical sets of hardware, enabled by selecting 'A' ,'B' on the front panel. Setting this switch to 'AUTO' will allow the diagnostic circuits in the base to automatically switch to the second unit when a failure is detected.

The selected Base Station is connected to a system antenna which has been specifically designed to provide radio coverage for the entire AGV guidepath network.

See page 24 of the MDS 4790 Series Installation and Operation Guide located in the "Vendor Supplied Information" chapter of this manual for LED indicator operation status.

1.8.12.17   RF Base Station - Troubleshooting

If all vehicles have lost communications (NO COM) or if vehicles loose communications in one specific area of the guidepath, there may by a problem with the Base Station or System Antenna.

The quickest way to recover from a failed Base Station is to switch to the backup unit. After switching Base Stations, check a few vehicles for normal packet counts (see 'Vehicle Communications - General', earlier in this chapter). If the problem persists, check to see that the RF Base Station and CSM have supply power. If the problem is isolated to one area of the plant, you may have a damaged system antenna.

To switch to the back-up unit, set the base station configuration mode access level to "User"; see page 56 of the MDS 4790 Series Installation and Operation Guide located in the "Vendor Supplied Information" chapter of this manual.

After the access level is set to "User," then see page 65 of the MDS 4790 Series Installation and Operation Guide located in the "Vendor Supplied Information" chapter of this manual to switch to either Radio "A" or Radio "B."

⚠ CAUTION
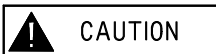
After the problem is corrected, the radio should be switched back to "Auto" mode.

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Figure 27   Base Station

MDS BASE STATION TRANSCEIVER RADIO

1000503B.CGM
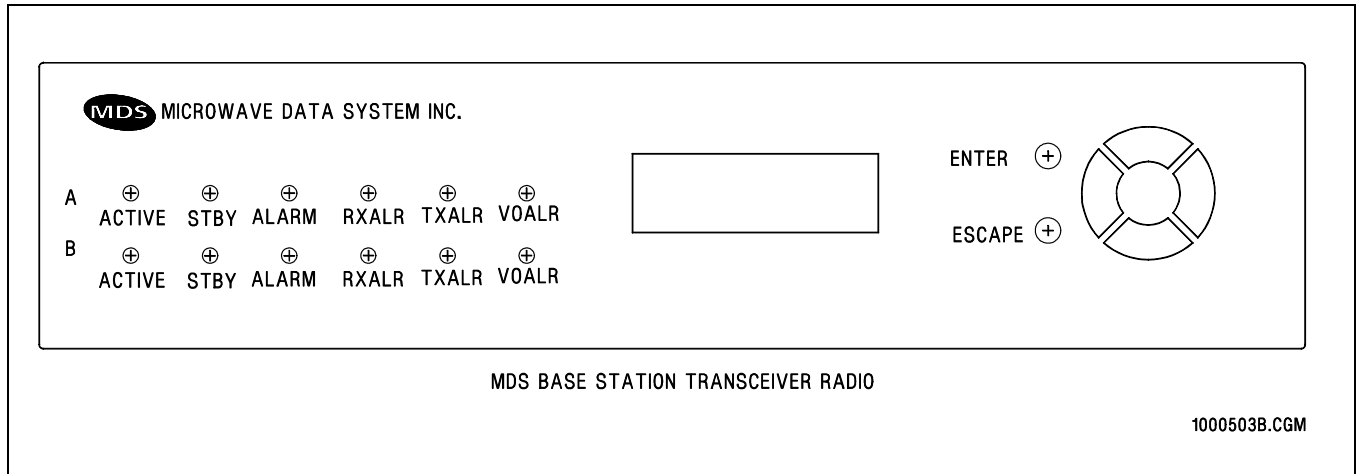
1.8.12.18   System Antenna - Visual Check

If all vehicles begin to exhibit poor communications (low packet counts), or if one specific area in your plant has a majority of vehicles with low packet counts, the problem may be a damaged antenna.

1.8.12.18.1   Dipole Antennas

If your system uses this type of antenna (white fiberglass pole, about 4 feet long, hung up-side-down), check to see that there is no physical damage to the antenna itself, or to the lead cable, going back to the Base Station.

1.8.12.18.2   YAGI Antennas

This is a horizontal bar with multiple perpendicular tube shaped "elements". Check for physical damage to the antenna or its lead cable.

1.8.12.18.3   Cables (Lead-in and Radiating) and their associated Connectors

Inspect all cables for breaks, kinks, or other physical damage. Check all connectors for damage and ensure that they are securely installed. Note that a kinked cable can cause severe problems! Have the antenna cable checked for reflected power and remove the kink, using a Savant Automation recommended splice connector if significant power has been lost due to reflection.

1.8.12.19   RF Base Station - Preventative Maintenance

About every three months, switch to the alternate set of Base Station equipment. Watch system operation, carefully, when this switch is performed to verify that you have not just switched to faulty equipment! After you have verified the alternate equipment, switch back to 'AUTO' to enable automatic diagnostic

circuits. The base will operate on the unit last selected before switching to AUTO (A or B).

The manufacturer recommends that Base Station equipment be tested and adjusted at the following times.

- During installation (by Savant Automation).

- After the first six months of operation.

- After the second six months of operation.

- Yearly, after the first full year.

At installation, each vehicle modem will be checked using a remote diagnostic facility program. These measurements should be used as a basis for comparison during subsequent testing. The Base Station diagnostics circuitry should be checked at the intervals stated above, before vehicle modem tests are initiated. A trained RF service technician must be employed to perform this testing. Contact Savant Automation Parts and Service for assistance in locating this service in your local area.

1.8.12.19.1   Maintenance Log

It is highly recommended that a log of maintenance performed, by who, on what date, be setup as soon as the system is commissioned. The RF system operation is critical to the AGV system operation and should be carefully maintained for optimal service.

1.8.12.19.2   FCC License Requirements

As a part of the initial system engineering, an FCC license was obtained for your system. This license has been given to your company's project contact person and is good for a five year period, after which, your company will be contacted by the FCC for a renewal.

1.8.12.20   Constant System Monitor (CSM)

The Constant System Monitor (CSM) is responsible for receiving blocking information from each vehicle and broadcasting that information back to all vehicles. In addition to providing this "repeating" function, the CSM also sends vehicle status information to AGView and, if applicable, a vehicle manager computer. Finally, the CSM can receive and repeat commands from an upper level computer to specific vehicles.

1.8.12.20.1   Troubleshooting

If the CSM fails, ALL vehicles will stop and display "NO COM" on the main status screen.

● Check the RF base station first. Try switching receiver and transmitter to the backup units. If the vehicles do not resume activity, continue troubleshooting. Otherwise, if an RF base module appears to be bad, get it repaired and back on-line as soon as possible.

● To determine if a fault occurred with the base station, check the Front Panel LED status. See page 67 of the MDS 4790 Series Installation and Operation Guide located in the "Vendor Supplied Information" chapter of this manual.

● If your system has a second, redundant CSM, switch to the backup unit and observe whether the vehicles resume activity.

● Check CSM power. In the fixed equipment chapter of this manual, there is a drawing showing the CSM panel. Check the power on the LED on the front panel.

● If power supplies are active to the CSM computer, try resetting the computer by pressing the reset button located on the front panel. Normal operation, the speaker will emit a beep, just like a desktop PC shortly after reset is pushed. The CSM then checks its RAM memory and loads its program. About 15 seconds after pressing reset, the vehicles should resume operation.

● If, during the reset operation in the last step, you did not hear the beep from the speaker, check the connections at the back of the CSM computer. If connections are OK, you have a defective computer.

● If the CSM appears to start up properly, check base station LED status. If fault LEDs are not lit, replace the CSM computer.

● If you replace the CSM computer, it boots up with the initial beep, but still does not work, re-load the software.

● Last test before calling Savant Automation Service Hotline, recheck all cables between the RF base station, CSM and vehicle manager, if applicable.

1.9   AGV Guidance/Navigation Performance Testing

Perform the following tests on a monthly basis or when a guidance and/or navigation problem is suspected.

Test/Function	Troubleshooting Section Number
Check the track error	See section 1.8.3
Check the Magnet Sensor Calibration.	See section 1.8.4.2
Verify the Automatic Steer Control. Verify that both the front and rear steer angle encoders are calibrated.	See section 1.8.6.1
Perform the Ground Track Sensor Diagnostic Test. Verify the calibration of the GTS Absolute (Angle) Encoder.	See section 1.8.7.1
Verify the distance measuring encoder (DME) counts of both the front (drive) and rear (GTS) encoders.	See section 1.8.7.2.3
Perform the Static Gyro Test.	See section 1.8.8.3
Perform the Gyro Zero Bias Test	See section 1.8.8.4

1.10   AGV Diagnostic Message Code Details

The following table lists the error code messages that are displayed when and AGV fault causes the error. The table also lists the potential causes and resolutions that are required to correct the fault.

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AGV DIAGNOSTIC MESSAGES

TYPE Column Definitions and Abbreviations –

- Blank – the vehicle will continue to operation and try to recover from the condition on its own.

- OC or SOC – the vehicle will do nothing without operator intervention.

- SOL – the vehicle will do nothing without operator intervention and the vehicles horn will sound intermittingly and ambler lights will flash.

- SOH – the vehicle will do nothing without operator intervention and the vehicles horn will sound intermittingly and red lights will flash.

TYPE: H = Hardware Fault   O = Operational Error   P = Program Error   T = Table Error

CERRTA   V05 - 05 Jul 06 - Error codes

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
100		INVALID TYPE IN TABLE	A floor code table entry has a type flag that requires a "decision / block pointer", but there is none.	Probable program or table error. Contact Savant Automation at 800-951-2487.
102		TOO MANY TRANSMIT BLOCKS	Too many special blocks have been turned on and left on.	Probable program or table error. Contact Savant Automation at 800-951-2487.
105		INVALID CODE RECEIVED	A code was received from the navigation computer that could not be found in the vehicle's tables. This could result if a code was omitted from the tables.	Probable program or table error. Contact Savant Automation at 800-951-2487.
107		INVALID DOP DELAY TYPE	An invalid delay parameter was used for delayed blocking or a delayed decision point action.	Probable program or table error. Contact Savant Automation at 800-951-2487.
112		INVALID TYPE IN DECODE	A table pointer that should point to a blocking table entry points to something else.	Probable program or table error. Contact Savant Automation at 800-951-2487.
113		INVALID POINTER IN DECODE	A floor code table entry has a type flag that requires a DECISION / BLOCK POINTER, but there is none.	Probable program or table error. Contact Savant Automation at 800-951-2487.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
115		NO DESTINATION ENTERED	The vehicle received a code before it was given its first destination.	Program a destination into the AGV before sending it on its way.
117		PRIORITY TABLE ERROR	A blocking table entry points to a convergance or crossing priority list which does not contain the corresponding normal or crossing block from that blocking table entry.	Probable program or table error. Contact Savant Automation at 800-951-2487.
119		BYPASS TABLE PATH ERROR	An invalid path was selected in the process of attempting a bypass.	Probable program or table error. Contact Savant Automation at 800-951-2487.
120		NO INITIAL BLOCKING ENTRY	The first code the vehicle received after power up or operation in manual was a non-blocking floor code whose floor code table entry has a "last block" entry but not a "current block" entry.	Probable program or table error. Contact Savant Automation at 800-951-2487.
122		INITIAL BLOCK OCCUPIED	The vehicle was put on the path after power up or operation in manual at a location with another vehicle approaching too closely. (The "last block" is occupied.)	Stop the trailing AGV long enough for the forward AGV to travel far enough ahead to put approximately two train lengths of distance between the two of them.
129		INITIAL BLOCK OCCUPIED	The vehicle was put on the path after power up or operation in manual at a location with another vehicle approaching too closely. (A "special block" is occupied.)	Allow the other AGV to pass, ensuring that there is enough clearance between the two to prevent a collision. Once the first AGV has passed, start the second one.
130		NO DECISION POINT POINTER	A floor code table entry is flagged as a decision point, but does not have a "decision / block pointer".	Probable program or table error. Contact Savant Automation at 800-951-2487.
131		NO PROGRAMMING POINTER	A decision table entry does not have a guidance program pointer.	Probable program or table error. Contact Savant Automation at 800-951-2487.

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NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
132		SPECIAL BLOCK ERROR	The special blocking flag is set for a floor code but there is no "decision / block pointer", or too many special blocking functions were requested, or an invalid combination of special blocking function code and block number was supplied.	Probable program or table error. Contact Savant Automation at 800-951-2487.
133		BAD PATH NUMBER	The vehicle computer's guidance program for a decision point returned an invalid path number.	Probable program or table error. Contact Savant Automation at 800-951-2487.
137		PROCESS FLAGS ERROR	The floor code table DP flag does not agree with the type byte that is pointed to by the "decision / block pointer".	Probable program or table error. Contact Savant Automation at 800-951-2487.
138		BYPASS STACK OVERFLOW	A "bypass list" expression contains too many intermediate values to be evaluated.	Probable program or table error. Contact Savant Automation at 800-951-2487.
139		BYPASS STACK UNDERFLOW	A "bypass list" expression contains an operator for which there are not enough operands.	Probable program or table error. Contact Savant Automation at 800-951-2487.
140		INVALID BYPASS OPERATOR	A "bypass list" expression contains an invalid operator.	Probable program or table error. Contact Savant Automation at 800-951-2487.
141		BAD LOW BATTERY DEST.	The vehicle tried to route itself to the low battery destination, but could not add the low battery destination to its program queue. This could be a table error, or it could result if the vehicle completes its mission in a condition in which it can not enter the battery change area (eg: towing a trailer.)	If your system is configured such that an AGV is not allowed to enter the battery station with trailers or a with loaded deck, remove the trailers or load from the AGV and try again. If this is a repeatable problem, contact Savant Automation at 800-951-2487.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
142		BAD DEFAULT DESTINATION	The vehicle tried to route itself to the default destination, but could not add the default destination to its program queue. This could be a table error, or it could result if the vehicle completes its mission in a condition in which it can not enter the default destination area (eg: towing a trailer.)	If your system is configured such that an AGV is not allowed at the default destination with trailers or a with loaded deck, remove the trailers or load from the AGV and try again.
201	SOH	NOT A THRU PATH	The vehicle read a station code which was configured to generate this message if the vehicle was not programmed to that station. It was not. This should only happen as the result of manual intervention, such as driving the vehicle in manual or re-programming it.	Manually drive the AGV to a section of path that will enable it to get to its intended destination. If this message is displayed without manual intervention, contact Savant Automation at 800-951-2487.
202		BAD GO/STOP CALL NUMBER	STOP1 or RUN1 was invoked with an invalid parameter.	Probable program or table error. Contact Savant Automation at 800-951-2487.
204		BAD OUTPUT/PHYSOU CALL	OUTPUT or PHYSOU was invoked with an invalid parameter.	Probable program or table error. Contact Savant Automation at 800-951-2487.
205		BAD VEHICLE ID	The vehicle is configured for VID 0 or a VID larger than the legal maximum.	Configure the AGV's Vehicle ID correctly as directed in the Maintenance Manual.
206	SOH	ZERO SPEED SENSE ERROR	Zero speed is at the wrong level.	Verify Zero-Speed Sensor (if equipped) is operational, clean, and calibrated per Maintenance Manual.
207		BAD TRANSMIT BLOCK	The vehicle read a bad block number from its tables.	Probable program or table error. Contact Savant Automation at 800-951-2487.
208	SOH	FRONT DME CALIBRATION FAILURE	The vehicle measured a bad distance between two codes in response to the start DME calibration check action.	Verify DME encoder is operational, clean, and calibrated per Maintenance Manual.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
209	SOH	LOADED VEHICLE NOT ALLOWED	A loaded vehicle tried to go somewhere that loaded vehicles are forbidden.	Don't program vehicles to that area when they are loaded. Make sure that loads are properly removed from vehicles before releasing them from unloading stations.
214	SOH	OBJECT OPTIC FAILURE	The object optics did not detect an object within the required distance of starting the object optic test.	Adjust or repair object detector(s) to ensure that they see the expected target in the Object Optic Test area.
215	SOH	FRONT DME NOT RUNNING	DME indicates that the vehicle is not moving when it should be.	Determine why the AGV is not running (brake stuck on, Speed Control board failure, Front DME Encoder failure, etc.)
216	SOH	OVERSPEED DETECTED	The vehicle has detected that it is traveling too fast.	Troubleshoot Speed-sensing encoder, Speed Control Board, or Motor Controller as appropriate.
217	OC	SPEED CONTROL FAULT	The vehicle's speed control board has indicated a fault.	Troubleshoot Speed-sensing encoder, Speed Control Board, or Motor Controller as appropriate.
218	SOH	SPEED BOARD NOT RECEIVED	The vehicle computer is not receiving data from the speed controller.	Troubleshoot the speed control board and CAN bus.
219	OC	BUMPER COLLAPSED	The AGV's laser bumper has detected an object, or there's a fault in the E-Stop/Bumper circuit.	Remove any objects that are in the laser bumper's field of view, or troubleshoot the E-Stop circuit as appropriate.
220	SOH	UNEXPECTED BRAKE ON	The vehicle software sensed that the brake was on when it should be off.	Troubleshoot mechanical braking components, brake interlock switches, or the braking controls as appropriate.
221	SOH	MOTOR OVER TEMPERATURE	The drive motor got too hot.	Allow motor to cool down. If the problem is repetitive, replace heat sensor / thermostat, or determine cause of over-heating and repair.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
222	OC	BEACON RECEIVER OUTPUT ON	The beacon receiver was checked to verify that it is off when no beacon should be present. The input is on.	
225	OC	EXPECTED IP DOES NOT MATCH	The IP found by the NAV computer doesn't match the IP entered by the operator.	Re-Initialize the AGV, taking care to enter the I.P. number that correlates with the Initialization Point about to be crossed.
228		UNEXPECTED BRAKE OFF	The vehicle software sensed that the brake was off when it should be on.	Troubleshoot mechanical braking components, brake interlock switches, or the braking controls as appropriate.
229		BATTERY BACKED RAM RESET	This message is generated on reset if the battery backed RAM is corrupted or out of date.	This message is expected the first time the AGV is started after AGV software, the computer board, or the RAM back-up battery is changed. If this error is consistant on every power up, check that jumper W25 is in the 2 to 3 position. If it is, replace the RAM back-up battery, making sure that its connections and contact points are clean. If this does not resolve the problem, replace the computer board.
These are errors reported by the steer controllers:				
230	SOH	FRONT STEER NOT RECEIVED	The vehicle computer is not receiving data from the front Steer Controller.	Internal debug message. Contact Savant Automation at 800-951-2487.
233	SOH	FRONT STEER: NO SISTER RECEIVE	The Steer Controller is not receiving data from the other Steer Controller.	Internal debug message. Contact Savant Automation at 800-951-2487.
235	SOH	FRONT STEER: NO NMC RECEIVE	The Steer Controller is not receiving data from the NAV computer.	Internal debug message. Contact Savant Automation at 800-951-2487.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
236	SOH	FRONT STEER: MISS TARGET TOO LONG	The steering system took too long to reach the commanded angle of steer. See also message 237 below.	Check steering components for binding, wear, or other conditions that would dampen its response time.
237	SOH	FRONT STEER: PEAK OVER CURRENT	Over-current condition in steering components. This condition is likely annunciated by message 236 above.	See message 236 above. If this message is repeatable, contact Savant Automation at 800-951-2487.
240	SOH	REAR STEER NOT RECEIVED	The vehicle computer is not receiving data from the rear Steer Controller.	Internal debug message. Contact Savant Automation at 800-951-2487.
243	SOH	REAR STEER: NO SISTER RECEIVE	The Steer Controller is not receiving data from the other Steer Controller.	Internal debug message. Contact Savant Automation at 800-951-2487.
245	SOH	REAR STEER: NO NMC RECEIVE	The Steer Controller is not receiving data from the NAV computer.	Internal debug message. Contact Savant Automation at 800-951-2487.
246	SOH	REAR STEER: MISS TARGET TOO LONG	The steering system took too long to reach the commanded angle of steer. See also message 247 below.	Check steering components for binding, wear, or other conditions that would dampen its response time.
247	SOH	REAR STEER: PEAK OVER CURRENT	Over-current condition in steering components. This condition is likely annunciated by message 246 above.	See message 246 above. If this message is repeatable, contact Savant Automation at 800-951-2487.
249		STEER RESET FAILED	An attempt to reset Steer Controllers failed.	Internal debug message. Contact Savant Automation at 800-951-2487.
251		NAV-INVALID PATH SELECTED	The path selected is not valid at this location. Normally caused when an AGV is manually driven to a section of guidepath, and the path it is set to guide on is not present in the floor at that location.	Select a different path, or drive the AGV to a different section of path. If this is a repeatable problem at a specific location, contact Savant Automation at 800-951-2487.
252		NAV-BAD INIT,MUST PASS 2 PTS	The AGV was switched from MANUAL to AUTO mode without passing two magnets.	Re-Initialize the AGV, taking care to drive over both magnets prior to placing the AGV into Automatic.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
253		NAV-BAD INIT, INVALID MAG PR	Two I.P. magnets were passed, but they were not found in the initialization point database.	Make sure that the two magnets being used to initialize the AGV are valid as Initialization Points. If this is a repeatable problem at a specific location, contact Savant Automation at 800-951-2487.
254	OC	NAV-OFF PATH	The AGV is off the path. A navigational failure or operator intervention has caused the AGV to miss seeing an expected NAV magnet. Or, a DME encoder problem is sending incorrect distance- related data to the NAV computer. Or, the NAV computer believes that the AGV has strayed too far (left or right) of the established path.	Manually drive the AGV over the next magnet to see if it captures the path. If it doesn't, select a different path or drive the AGV to a different section of path. Check for a steering component failure that has caused the AGV to stray off the path. Check DME and Ground Track encoders for binding, damage, dirt; repair and calibrate as necessary. Calibrate steering encoders. Check magnet sensor calibration. If this is a repeatable problem at a specific location, ensure that in-floor navigation magnets have not been physically damaged. If they have, replace them. If this is a repeatable problem at a specific location with all AGVs, and a navigation magnet is not the problem, contact Savant Automation at 800-951-2487.
255		NAV-OVERTRAVEL W/O UPDATE	The NAV computer believes the AGV traveled too far (typically more than 50 feet) without detecting an update magnet.	Manually drive the AGV over the next magnet to see if it captures the path. If it doesn't, select a different path or drive the AGV to a different section of path. Check DME and Ground Track encoders for binding, damage, dirt; repair and calibrate as necessary. Check the Magnet Sensor for damage; check calibration it if there is no apparent physical damage.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
256		NAV-MISSING MAGNET	An update magnet was expected, it is overdue by 6 inches.	Manually drive the AGV over the next magnet to see if it captures the path. If it doesn't, select a different path or drive the AGV to a different section of path. Check DME and Ground Track encoders for binding, damage, dirt; repair and calibrate as necessary. Check the Magnet Sensor for damage; check calibration it if there is no apparent physical damage.
257		NAV-HARDWARE FAILURE	A hardware failure was detected.	Possible program error. Contact Savant Automation at 800-951-2487.
258		NAV-SOFTWARE FAILURE	A navigation software failure was detected.	Possible program error. Contact Savant Automation at 800-951-2487.
260		NAV-BAD HEADING	Heading error is greater than 30 degrees.	Check steering and ground-track sensor encoders for damage, binding. Re-calibrate and test AGV.
261		NAV-MAG POSITION ERROR	The position received from the magnet sensor showed error of greater 6 inches.	Manually drive the AGV over the next magnet to see if it captures the path. If it doesn't, select a different path or drive the AGV to a different section of path. Check DME and Ground Track encoders for binding, damage, dirt; repair and calibrate as necessary. Check the Magnet Sensor for damage; calibrate it if there is no apparent physical damage. Check steering encoders for damage or binding; repair and calibrate.
263	OC	NAV-MAG SENSOR NO COMM	Magnet sensor unit is not communicating with the navigation computer.	Check cable to Magnet Sensor for damage. If no damage is apparent, replace Magnet Sensor and calibrate the replacement.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
264	OC	NAV-STEER OFFSET EXCEEDED	The steer angle calculated does not match the steer angle sent from the encoder. Steer alignment, steer board or gyro problem indicated.	Check steering and ground track sensor encoders for damage, binding. Re-calibrate and test AGV. Replace steering board and/or gyro.
265	SOH	NAV-MESSAGE TIMEOUT	No communications from the navigation computer for 4 seconds.	Turn off the AGV, then re-start it. If the message re-appears, replace the NAV computer.
266	OC	NAV-HEADING SENSOR NO COMM	The heading sensor unit (gyro) is not communicating with the NAV computer.	Check cables going to/from gyro. Replace gyro.
267	OC	NAV-DME ENCODER FAILURE	The NAV computer has received unexpected data from the rear (Ground Track Sensor) DME Encoder.	Check the rear DME Encoder (part of the Ground Track Sensor assembly) for physical damage or binding. Repair or replace as necessary. Check AGV's acceleration (is it getting up to speed quickly enough?) Troubleshoot DME encloder, Speed Controm board, or Motor Controller as appropriate. Check mechanical brake for drag.
268	OC	NAV-COLLISION DETECTED	Navigation components have detected a sudden velocity/heading change such as would occur when the AGV is struck by a forklift or other object.	Check for, and repair any physical damage to the AGV. Place the AGV back on the path and re-start it.
269	OC	NAV-Drive Control Failure	Points to any of a number of drive controller faults, including over-heated, lost communications with NAV computer, dragging brake or steer components that cause the drive controller to overheat or draw too much current, or over-speed caused by DME, ground track sensor, gyro or magnet sensor problems.	

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NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
280		BATT MON-NEW CONFIG. LOADED	The Can Bus Battery Monitor (CBBM) returned the wrong configuration data on initialization. It was reconfigured successfully.	If this is message is seen on a repeatable basis, note details and contact Savant Automation at 800-951-2487.
281		BATT MON-NO CONFIG. DATA	This computer could not get configuration data from the CBBM.	Replace Battery Monitor assembly.
282		BATT MON-CANNOT CONFIGURE	The Can Bus Battery Monitor (CBBM) returned the wrong configuration data on initialization. It could not be configured correctly.	Replace Battery Monitor assembly.
291	OC	CANIO PCB 1 Offline	CAN I/O PCB 1 is not communicating.	Check cables, connections and wiring to/from the PCB. Replace the PCB if necessary.
292	OC	CANIO PCB 2 Offline	CAN I/O PCB 2 is not communicating.	Check cables, connections and wiring to/from the PCB. Replace the PCB if necessary.
293	OC	CANIO PCB 3 Offline	CAN I/O PCB 3 is not communicating.	Check cables, connections and wiring to/from the PCB. Replace the PCB if necessary.
299	OC	CAN-BUS WARNING	Shorted or open CAN bus.	CAN bus should read 60-ohms. Check CAN board LEDs to see if any device is "flooding" that CAN board with messages. This would indicate a defective device.
350		REQUEST DISPATCH IGNORED	A dispatch was requested when the vehicle either didn't have control of a zone, or was in the wrong mode to accept the request.	
351		FIXED EQIP REQUEST IGNORED	Fixed equipment communication was attempted when the vehicle either didn't have control of a zone, or was in the wrong mode to accept the request.	
352		WAITING FOR FIXED EQUIP	The vehicle is waiting for the fixed equipment.	

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
353		CANT DISPATCH: NOT IN REMOTE	A dispatch was requested when the vehicle was not in Remote Mode.	
400		TRANSFER MECH. FAILURE	A hardware fault was detected in the transfer mechanism before a transfer was attempted. The vehicle can move, but cannot transfer loads.	
401	OC	FAILURE DURING TRANSFER	A hardware fault was detected after a transfer was started but before it was finished. (Usually, this is the result of a timeout.) The vehicle cannot move without operator intervention.	
402	SOH	FAILURE BEFORE TRANSFER	The vehicle missed an accurate stop or handshake. The vehicle can move and retry the transfer.	
403	OC	OPERATOR INTERVENTION	A stop button was pressed during part of a station cycle when it aborted the station cycle.	
404		WAITING FOR ENABLE	A required handshake or other enable signal was not present when the vehicle arrived at a station, or it went away while it was still needed.	The vehicle will wait for the signal to appear and then finish the station operation.
405		CANNOT COMPLY	The vehicle arrived at its destination with the wrong load status for the load operation it was programmed to do there. The vehicle can move and do the correct transfer.	
406	OC	VEHICLE OVERSHOT STOP	The vehicle station cycle required the vehicle to stop in a specific area outside the load stand but its distance measuring indicates that it went too far. The vehicle cannot move without operator intervention.	

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
407	SOH	FENCE OPTIC BEAM BROKEN	The load shifted too far off center. The fence optic near the side of the AGV was blocked, probably by a load that shifted too far to that side. The AGV cannot move without operator intervention.	Reposition the load and restart the AGV. If necessary, reaim the fence optics.
408	SOH	CHARGING ERROR	The charging mechanism did not cycle within the allotted time.	Inspect the AGV's charge mechanism, checking for damage, binding, loose or misadjusted upper and lower limit switches, loose wires, blown fuse, foreign objects in the mechanism, etc. Cycle the mechanism up and down via the AGV's diagnostics screen to verify proper operation. Repair as necessary.
409		NOT CHARGING	A charge cycle is in progress but charge current is not being detected.	Ensure that the Battery Charger is turned on and in automatic mode. Ensure that the in-floor charge contacts and the AGV's charge shoes are clean. Ensure that the AGV's charge fuse is not blown. Ensure that when the AGV drops its charge shoes to the floor, they are sufficiently aligned with the in-floor charge contacts. (Misalignment of shoes to contacts is generally indicative of a Magnet Sensor and/or steering encoders that need to be recalibrated.)
410	SOH	WRONG LOAD STATUS	The AGV completed a load transfer but the load status does not match the cycle. (It completed a pick but it is not loaded, or it completed a drop but it is still loaded.) The AGV cannot move without operator intervention.	Check and adjust load-status devices (photo-eyes, proximity switches, limit switches, etc.) on the AGV to ensure that they see loads present on the AGV, and that they don't report loads that aren't there.

NUMBER	TYPE	DISPLAY	CAUSE	RESOLUTION
411	SOH	HANDSHAKE ERROR	There was an error in the handshake signal received by the AGV that caused it to abort some operation. This could have been a signal received when it should not have been, a signal that did not appear in a reasonable amount of time after the AGV started looking for it, or a signal that went away prematurely. The AGV cannot move without operator intervention.	Verify that the stand is in the correct condition to perform the operation which the AGV was attempting. (There is a load present and correctly positioned if the AGV was trying to pick, there is space available if the AGV was trying to drop, &c.) If possible complete the operation using manual controls, otherwise reprogram the AGV, then press the AGV's start switch. Check and reposition or repair the handshake device[s] as needed.
500	OC	SYNC ERROR: TIMER LOST	The sync frame relative timer value is invalid.	Probable program or table error. Contact Savant Automation at 800-951-2487.
501	OC	TP STACK OVER- OR UNDERFLOW	The CDU Transaction Processor had too many mis-matched pushes and pops.	Probable program or table error. Contact Savant Automation at 800-951-2487.
507	OC	DOUBLE REL TIMER CALL	A second unique task was scheduled at the same sync frame relative time.	Probable program or table error. Contact Savant Automation at 800-951-2487.
606	OC	BAD REL TIMER CALL	Something was scheduled at a sync frame relative time outside the sync frame.	Probable program or table error. Contact Savant Automation at 800-951-2487.
900	OC	RE-STARTED STATION CYCLE	The AGV read the floor code for its current destination while already executing a station cycle.	Possibly there are more than one station codes at this location, or an alternate station code for this destination is too close the to actual station code. Probable program or table error. Contact Savant Automation at 800-951-2487.
901	OC	BUFFER POOL EMPTY	The AGV software used up its buffer pool.	Probable program or table error. Contact Savant Automation at 800-951-2487.

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902	OC	ILLEGAL BUFFER	The AGV software attempted a buffer operation on some memory that was not a valid buffer.	Probable program or table error. Contact Savant Automation at 800-951-2487.
903	OC	ILLEGAL DEQUEUE	The AGV software attempted to remove a buffer that was not on the indicated queue from that queue.	Probable program or table error. Contact Savant Automation at 800-951-2487.
904	OC	ILLEGAL DATA ON THE STACK	One of the wait routines was called with more data on the stack than was there when the task was started.	Probable program or table error. Contact Savant Automation at 800-951-2487.
905	OC	DESTINATION CHANGED	The AGV's destination changed between the time the software first started processing the destination and when TFUNC was entered.	Probable program or table error. Contact Savant Automation at 800-951-2487.
906	OC	ILLEGAL PRIORITY	Some task attempted to reduce its priority below its origional priority by calling PRISET.	Probable program or table error. Contact Savant Automation at 800-951-2487.
907	OC	ACCESSED LOCKED QUEUE	Someone tried to change the program queue while a program queue change was already in progress.	Probable program or table error. Contact Savant Automation at 800-951-2487.
908	OC	BAD MBR CALL DESTINATION	The AGV couldn't be re-programmed to the MBR destination in response to an MBR call.	Probable program or table error. Contact Savant Automation at 800-951-2487.
998	OC	ILLEGAL INSTRUCTION TRAP	An illegal instruction was encountered in the program, and trapped.	Probable program or table error. Contact Savant Automation at 800-951-2487.
999	OC	FATAL SOFTWARE ERROR	The software executed some code that it should never have reached. A hardware problem seems likely.	Probable program or table error. Contact Savant Automation at 800-951-2487.