AGCO
Your Agriculture Company

Guide-Ready Specification

AGCO CONFIDENTIAL
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TABLE OF CONTENTS

1 INTRODUCTION 5

1.1 Purpose 5

1.2 Scope 5

1.3 Assumptions 5

1.4 Definitions and Abbreviations 6

1.5 Target Platforms 7

2 SYSTEM DESCRIPTION 8

2.1 Communication Buses for All Guidance Variations 9

2.1.1 AGCO Proprietary GD Bus 9

2.1.2 Valve Bus (J1939) 10

2.1.3 Implement Bus (ISO11783) 10

2.2 Native Guidance System 10

2.2.1 Guidance Components 12

2.2.2 Machine Components 14

2.2.3 Service Components 18

2.3 AGCO Legacy Systems 18

2.4 '3rd' Party Guidance System 18

3 REQUIREMENTS 20

3.1 Safety Requirements 20

3.1.1 Mechanical System Lockout (Roading Lockout Switch) 20

3.1.2 Operator Presence 21

3.1.3 Curvature Limitation 21

3.1.4 Driver Intervention 22

3.2 Software Requirements 22

3.2.1 Communication Data Rates 22

3.2.2 Steering Controller 22

3.2.3 Vehicle Guidance Configuration Data 25

3.2.4 Sensor Calibration 36
3.2.5 Flashing 37
3.2.6 Diagnostics 37
3.2.7 Vehicle Data 37
3.2.8 ISO11783 Capabilities for 3rd Party Guidance System Support 40

3.3 Electrical Requirements 41
3.3.1 Communication Buses 41
3.3.2 Sensors 42
3.3.3 Bus Harnessing 43
3.3.4 Connectors 44
3.3.5 Machine Internal Electrical Interfaces 47
3.3.6 Guidance Controller Power Requirements and Management 47
3.3.7 Machine Communication Busses Power Management 47

3.4 Mechanical Requirements 48
3.4.1 Steering System Performance 48
3.4.2 AGCO Native Guidance System Mounting 49
3.4.3 Topcon AGI-4 Guidance System Mounting 51
3.4.4 AGCO GNSS Unit Mounting Bracket 52
3.4.5 Guidance Interface Connector Location 52

3.5 Documentation Requirements 52
3.5.1 Documentation Process 52
3.5.2 AGCO "Guide-Ready" Vehicles Tracking Sheet 52

4 REFERENCED DOCUMENTS 54

5 REVISION HISTORY 56

APPENDIX A. GUIDANCE ELECTRICAL SCHEMATICS 57

APPENDIX B. NOVATEL SMART6 ANTENNA PHASE CENTER 62

APPENDIX C. VEHICLE GUIDANCE CONFIGURATION DATA LAYOUT 63

APPENDIX D. AGCO "GUIDE-READY" VEHICLES TRACKING SHEET TEMPLATE 68

APPENDIX E. NATIVE GUIDANCE SYSTEM MESSAGE LIST (GD BUS) 69

APPENDIX F. 3RD PARTY GUIDANCE SYSTEM MESSAGE LIST..... 78

1 INTRODUCTION

1.1 Purpose

Today there are machine variations across the AGCO fleet which offer differences in connections and options. This document is intended to be used by AGCO design centers to drive standardization in forth coming models.

This document describes the requirements for an AGCO machine to be marketed as "Guide-Ready". This designation is intended to signify that the machine has the appropriate features and components to operate AGCO new generation guidance solutions and 3rd party, and shall provide a defined, global feature set across AGCO brands.

NOTICE

ANY NONCONFORMANCE TO THE REQUIREMENTS (DEFINED BY THE USE OF THE WORD "SHALL") INCLUDED IN THIS DOCUMENT MIGHT NEGATIVELY IMPACT THE PERFORMANCE OF GUIDANCE SYSTEMS ON "GUIDE-READY" VEHICLES. IT IS RESPONSIBILITY OF THE DIFFERENT MANUFACTURING SITES TO ENSURE THAT VEHICLES LABELED AS "GUIDE-READY" FULLY MEET ALL THE REQUIREMENTS INCLUDED HEREIN.

This document is broken up into the following main sections: The Introduction (Section 1) is followed by Section 2, which provides a functional description of the different guidance systems within the scope of this document, namely, Native Guidance System, AGCO Legacy Systems and 3rd Party Guidance Systems. Afterwards, all the machine requirements (safety, software, electrical and mechanical) for an AGCO machine to be marketed as "Guide-Ready" are defined in Section 3. Section 4 includes all reference documents the readers can refer to should they wish to have further information. Appendixes A through F provide more detailed information of the requirements specified in Section 3.

1.2 Scope

This document will detail specific features, functions, options, connector requirements, pin assignments, and details to consider during machine design and modifications concerning the operation of AGCO and 3rd party guidance solutions on approved AGCO machines.

1.3 Assumptions

The Guide-Ready Specification sits on top of the ISOBUS-Ready Specification such that in order to be Guide-Ready the machine must already be ISOBUS-Ready in accordance with the AGCO ISOBUS-Ready Specification (Hesse, 2012). Outside the stating of this requirement this

specification will dwell no further on items previously defined in this standard and assume that they are present.

1.4 Definitions and Abbreviations

AEF – Acronym for the Agricultural Industry Electronics Foundation, an independent, industry organization which provides the necessary continuing promotion and support for Agricultural Electronics Standards.

CEA – Common Electronic Architecture

ECU – Electronic Control Unit

Functionality – For the purposes of this document, Functionality (capital F) is defined as an AEF managed feature specification for ISO11783 implementations which may be conformance tested. These may also be referred to as an "AEF Functionality".

GD – Generic Driver; a proprietary AGCO CAN-based protocol.

Generation – AEF Functionality revisions are known as Generations.

GNSS – Global Navigation Satellite System

Guidance System – Generic term for the Guidance product that will interface with the Guide-Ready standard. This term will be used most often to keep this specification independent.

ISOBUS – AEF trademarked name for a device which implements the ISO11783 standard. Different levels of implementation of the standard can be conformance-tested to allow the use of this designation.

MOD – Marktoberdorf; AGCO/Fendt site in Germany

PPS – Pulse Per Second

PVED – Hydraulic Steering Valve

SC – Steering Controller

SCL – Steering Controller Library

SCT – Steering Controller Task

SV – Steering Valve

SWS – Steering Wheel Sensor

TIM – Tractor Implement Management, information sent from and to ISO11783-compliant components through the ISOBUS

TECU – Tractor Electronic Control Unit

UI – User Interface

VD03 – Name of the AGCO Guidance Controller ECU

VT – Virtual Terminal as defined in ISO11783 part 6

WAS – Wheel Angle Sensor

1.5 Target Platforms

The Guide-Ready specification will provide a common interface on which to install Guidance. From the machine perspective, all machines that are going to provide Guidance as an option will be required to comply with all mandatory aspects of this specification.

In parallel, an AGCO Guidance solution is being developed and it will be designed specifically to interface with this standard and thus all machines that comply with it.

It is the responsibility of the machine manufacturing site and the team that owns the respective guidance products to declare and maintain conformance with this standard.

2 SYSTEM DESCRIPTION

The following section will describe the different valid configurations of the Guidance System and their interfaces such that the machine requirements can be then defined. There are 3 main variations of valid Guidance System configurations. The 3 different configurations are summarized as follows:

Native (Developed by AGCO): The Operator interacts with his AGCO Guidance System via an NT0X terminal which is also the machine's primary user interface or optional secondary interface (see Section 2.2).

AGCO Legacy Systems: These are AGCO guidance systems that might not be fully compatible with AGCO Common Electronics Architecture and this standard (see Section 2.3).

3rd Party: The Operator interacts with a 3rd Party Guidance System via an ISO-11783 compliant Virtual Terminal (VT) or a proprietary terminal (see Section 2.4).

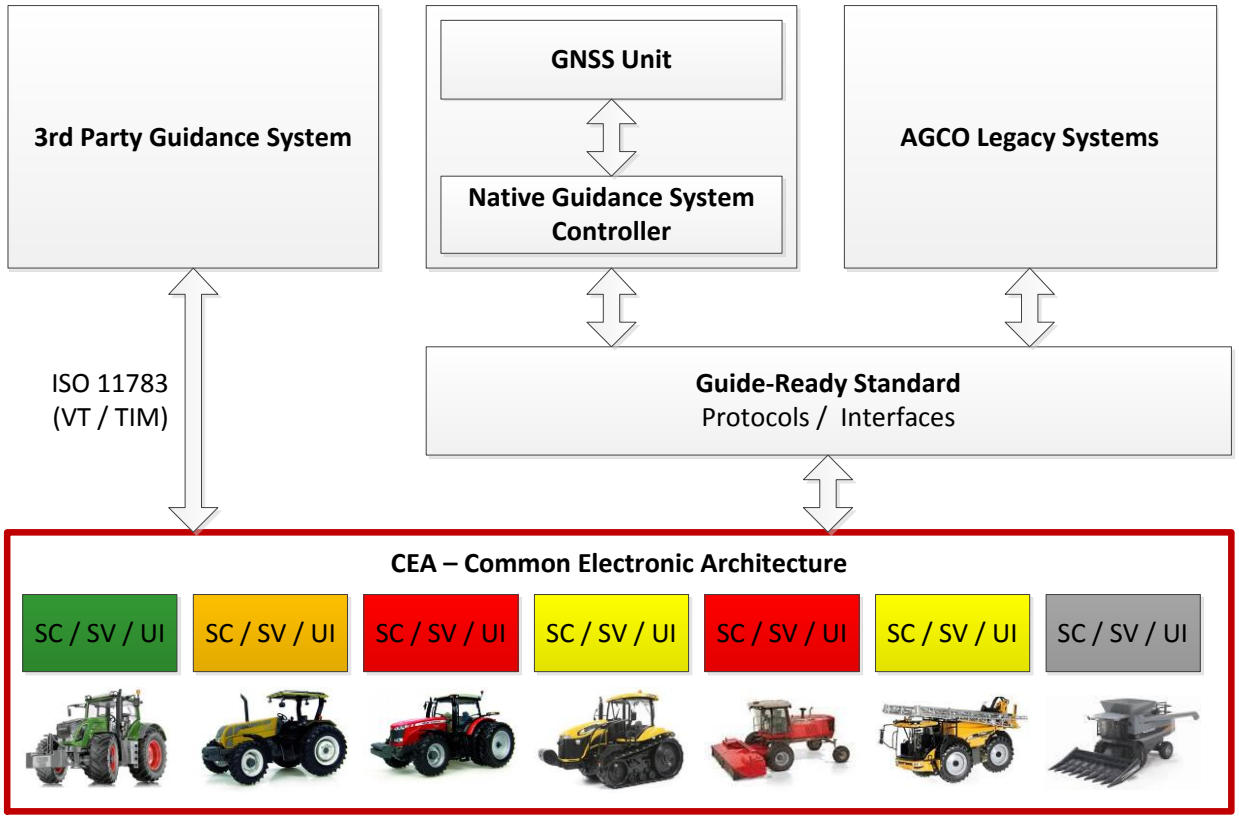


Figure 1: Integration of different kinds of guidance systems

2.1 Communication Buses for All Guidance Variations

Communication between the guidance system (native, legacy and third party) and the machine is done through 3 CAN-based communication buses (see Figure 3):

- AGCO proprietary GD BUS
- J1939 Valve Bus
- ISO11783 Implement Bus

2.1.1 AGCO Proprietary GD Bus

The AGCO Proprietary GD Bus is the main communication interface for the AGCO Native Guidance System. Guidance components like the NT0X family of terminals, the Guidance Controller and the Steering Controller communicate through this bus.

The Communications Driver GENERIC DRIVER Specification (Dittrich, 2012) defines the communication mechanism for the exchange of data between nodes. In the specific case described below the Steering Controller task needs information from several sensors. The Data Exchange Node is used to aggregate the data from different sensors into one GD message represented by a single GD index.

2.1.1.1 GD Data Exchange Node

There are two important reasons to introduce a GD Data Exchange Node as a central instance to manage the information exchange between other GD nodes (see Figure 2):

1. **Information Bundling**: The first task of the GD Data Exchange Node is to gather and bundle all necessary information into a single message. During information bundling, different nodes contribute to the composition of a message and the GD Data Exchange Node gathers all this information and then transmits it within a single message. For example, the Message GD_ID_SCT_MODUL_IN_STATUS (GD Index 12290), which is used to transfer status information to the Steering Controller Task (combination of information from the gearbox and the Multifunctional Armrest), is sent by the Data Exchange Node.

2. **Modularity**: Another benefit to the integration of the GD Data Exchange Node is the modularity that comes with it. The GD Data Exchange Node helps to keep the same interfaces across brands, for GD Nodes like the SCT, which simplifies development and diagnostics.

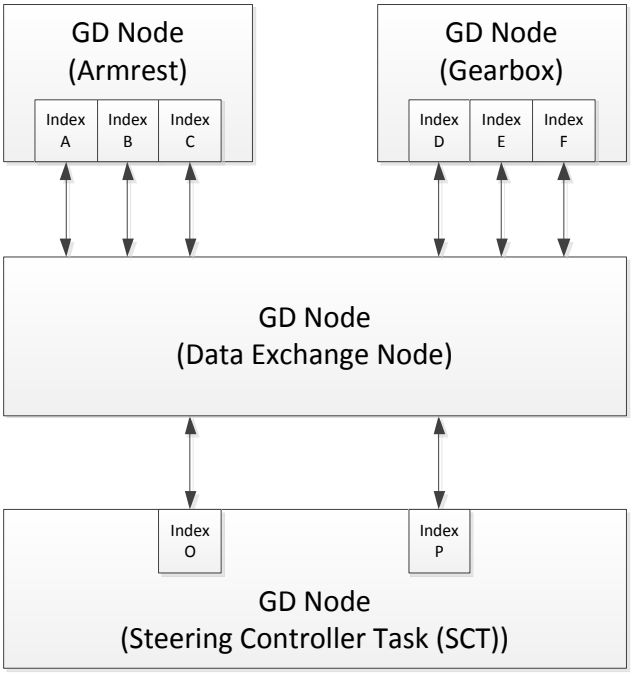


Figure 2: GD Data Exchange Node Integration Example

2.1.2 Valve Bus (J1939)

The Valve Bus is used for valve control and diagnostics. Communication between the Steering Valve and the Steering Controller flows through the Valve Bus.

2.1.3 Implement Bus (ISO11783)

The Implement Bus is the main communication interface between the machine and 3rd Party Guidance Systems; it also serves as communication interface for machine implements.

2.2 Native Guidance System

The Native configuration of the Guidance System is fully developed and supported by AGCO. The complete Native Guidance System (see Figure 3) consists of Guidance Components (blue) and Machine Components (red) which enable guidance. The Guidance Components are developed and maintained by the Native Guidance System Development Team. Each site is responsible for all of their Machine Components.

The Native Guidance System User interface is the NT0X Terminal family. Additionally, communication across guidance components flows through the AGCO Proprietary GD Bus. Lastly, the Native Guidance System interacts with GNSS Units and Radio Modems from different manufacturers. The Native Guidance System Specification describes its functionalities in more detail. Figure 3 below defines a diagram for Native as well as the 3rd Party configuration.

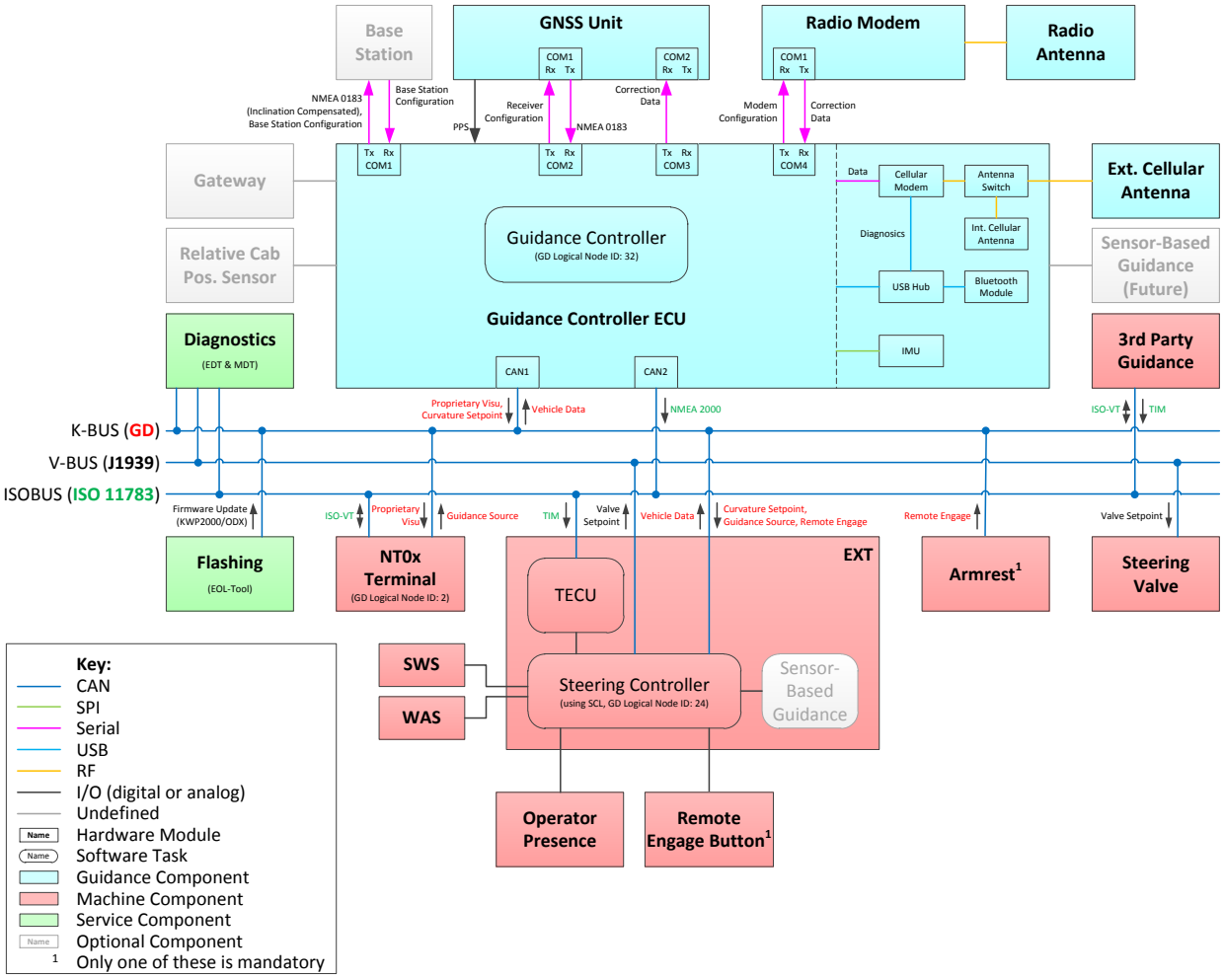


Figure 3: Interface diagram for the Native and 3rd Party Guidance System

Figure 4 defines a high-level boundary diagram for the *Native* configuration. The configuration consists of Guidance Components (blue) and Machine Components (red) which enable guidance.

Later in this document the interfaces will be detailed from software, electrical and mechanical perspectives. The function of each component in the diagrams will now be defined.

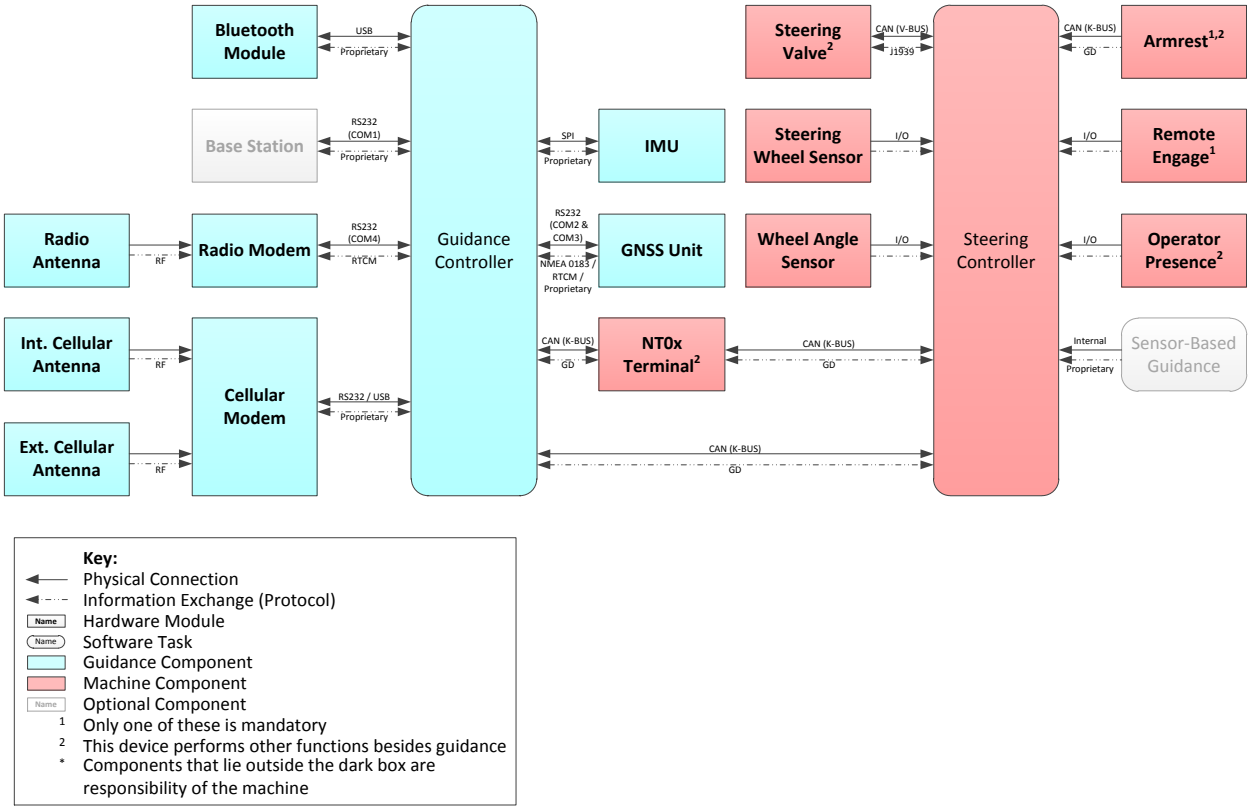


Figure 4: High-level boundary diagram for the Native configuration

2.2.1 Guidance Components

2.2.1.1 Guidance Controller ECU

The primary function of the Guidance Controller ECU is to provide communication and computing support for the Guidance Controller software module which resides within Guidance Controller ECU. Although the Guidance Controller ECU's primary purpose is to serve as a computing and communications platform for the Guidance Controller, it can also be used as a platform for additional software modules.

2.2.1.1.1 Guidance Controller

The Guidance Controller is the main component of the Native Guidance system responsible for taking direction from the user via the Operator Interface as to the desired path, processing the positioning information and issuing steering commands. The Guidance Controller executes its main function (auto-steering) via communication with the Steering Controller sub-system.

The Guidance Controller is integrated with many machine systems as seen in Figure 3. Most commonly (not all machines may offer all functions), the Guidance Controller interfaces with the following Machine systems/functions:

- Headland Management / Remote Engage
- Dash Light Guidance Status
- Precision Positioning provider (NMEA-0183 / NMEA-2000)
- Remote Communications for Corrections

2.2.1.1.2 Cellular Modem

The Guidance Controller ECU is equipped with a Cellular Modem for receiving NTRIP corrections. The Guidance Controller ECU can have two different modems installed which are both manufactured by Cinterion: PHS8 for 3G/HSPA+ and PVS8 for CDMA2000. The customer is able to change the SIM card used by the Cellular Modem. The integrated cellular modem can be disabled if it is desired to receive NTRIP corrections through the AGCO gateway.

To achieve optimal cellular reception, the Guidance Controller ECU has a built-in Cellular Antenna and the possibility to attach an external Cellular Antenna. The Guidance Controller constantly monitors the reception quality and, if necessary, switches between both antennas using an integrated Antenna Switch.

2.2.1.1.3 Bluetooth Module

The Class 1 Bluetooth Module (WT11i manufactured by Bluegiga) allows short-range communication and data transfer between the guidance controller and other components. The integrated Bluetooth module can be disabled if it is not needed.

2.2.1.1.4 IMU

The IMU (ADIS16334 manufactured by Analog Devices) is a standard component of the Native Guidance System. It is used to compensate for short GNSS outages (dead reckoning) as well as for correcting the position from the GNSS Unit for roll and pitch.

2.2.1.1.5 NMEA-2000

The Native Guidance system utilizes a GNSS Unit and this positioning information could be utilized by other machine components. The Guidance Controller republishes machine position in the NMEA-2000 CAN-based format on the ISOBUS for consumption by other machine or implement systems (National Marine Electronics Association, 2013). The position information from the Native Guidance System is roll/pitch compensated to improve accuracy.

2.2.1.1.6 NMEA-0183

The Native Guidance system utilizes a GNSS Unit and this positioning information could be utilized by other machine components. The Guidance Controller republishes machine

position in the NMEA-0183 format on an RS-232 serial port (COM1) for consumption by other machine or implement systems. The position information from the Guidance System is roll/pitch compensated to improve accuracy.

2.2.1.2 GNSS Unit

The GNSS Unit consists of a GNSS receiver and a GNSS antenna usually located within the same housing. The GNSS Unit provides global positioning information to the Guidance Controller which is the basis for automatic steering. The Native Guidance System is designed to be GNSS agnostic meaning that it can be connected to GNSS Units from approved manufacturers (list of approved manufacturers is included in the Native Guidance System Specification). The Guidance Controller ECU is connected to the GNSS Unit via two RS-232 serial ports (COM2 & COM3).

2.2.1.3 Base Station

A Base Station is a GNSS Unit at an accurately-known fixed location which is used to derive correction information and send it to nearby portable GNSS Unit via a radio link. Corrections are as accurate as the known location of the Base Station and the quality of the Base Station's satellite observations, providing up to centimeter-level accuracy.

One of the methods to configure the GNSS Base Station (e.g. channels, frequency etc.) is through one of the RS-232 serial ports (COM1) of the Guidance Controller ECU. The supported base stations and configuration mechanisms are listed in the Native Guidance System Specification.

2.2.1.4 Radio Modem and Antenna

The Guidance Controller ECU is also able to receive GNSS correction data from a Base Station via a Radio Modem (COM4) to improve the accuracy of the Native Guidance System positioning. The correction data received by the Radio Modem is routed through the Guidance Controller to the GNSS Unit. The Radio Modem configuration is done on an NT0X terminal.

To address the different customer needs for GNSS base stations and radio modems, the Guidance Controller ECU is compatible with different Radio Modem types and manufacturers. The supported radio modems are listed in the Native Guidance System Specification.

2.2.2 Machine Components

2.2.2.1 NT0X Terminal

An NT0X Terminal is the operator interface and allows the operator to configure the Native Guidance System to their specific farming needs. Generally, the terminal is used to define the path to be driven, but it can also cover features such as implement definition and calibration, as well as system performance diagnostics.

The Guidance Controller uses proprietary messages to communicate with an NT0X Terminal and does not support ISO-VT. Therefore, an NT0X Terminal is mandatory within the vehicle to support the Native Guidance System.

2.2.2.1.1 Native Guidance System Configuration

In addition to allowing the operator to configure the Native Guidance System, an NT0X Terminal is also used to configure the hardware modules (i.e. GNSS Receiver, Radio Modem, and Cellular Modem) of the Native Guidance System.

2.2.2.1.2 GNSS Position

The GNSS position is transferred to an NT0X Terminal over the AGCO Proprietary GD Bus.

2.2.2.1.3 Wayline Data Transfer

Waylines are transferred between an NT0X Terminal and the Guidance Controller over the AGCO Proprietary GD Bus.

2.2.2.2 Vehicle ECU (EXT)

The EXT (BODAS SRC36-20/31 manufactured by Bosch/Rexroth) is usually the main ECU of the vehicle. There are alternatives available like the “EXT light”. The EXT hosts the Tractor ECU (TECU) software module and the steering controller software module which has different capabilities as show in in Section 2.2.2.2.1.

2.2.2.2.1 Steering Controller

The Native Guidance System executes its primary function, which is auto-steering the machine, by sending steering commands (set point curvature commands) to the steering system. The Steering Controller is a software task within the Vehicle ECU (EXT) responsible for the execution of the steering commands to control the steering valve. The Guidance Controller issues CAN-based messages with the desired curvature of the vehicle to the Steering Controller, and the Steering Controller executes the message given that specific criteria are met which permit Automatic Steering. The steering controller generally consists of a Steering Controller Library (SCL) and a Steering Controller Task (SCT).

The core functionality for automatic steering (state machine and control loops) is bundled within the Steering Controller Library (SCL), which is developed at MOD (Miller, 2013). The Steering Controller Library contains safety functionality and parameters such as maximum velocity and a maximum steering curvature as a function of vehicle speed, which are needed for homologation purposes.

On the other hand, the Steering Controller Task (SCT) is responsible for taking the curvature commands from the Guidance Controller, actuating the steering valves, and converting the electric signals (mA) from the sensors into actual angles (degrees) using sensor-

specific conversion factors. The support of different steering components like Wheel Angle Sensors (WAS), Steering Wheel Sensors (SWS), speed limits and types of steering valves is responsibility of the SCT. Additionally, machine-specific steering configurations such as TwinTrac or Reverse Station are supported by the SCT. Therefore, the Steering Controller Task shall be implemented and customized at each site (See Figure 5). MOD shall deliver a template of the Steering Controller Task to be adapted at each site.

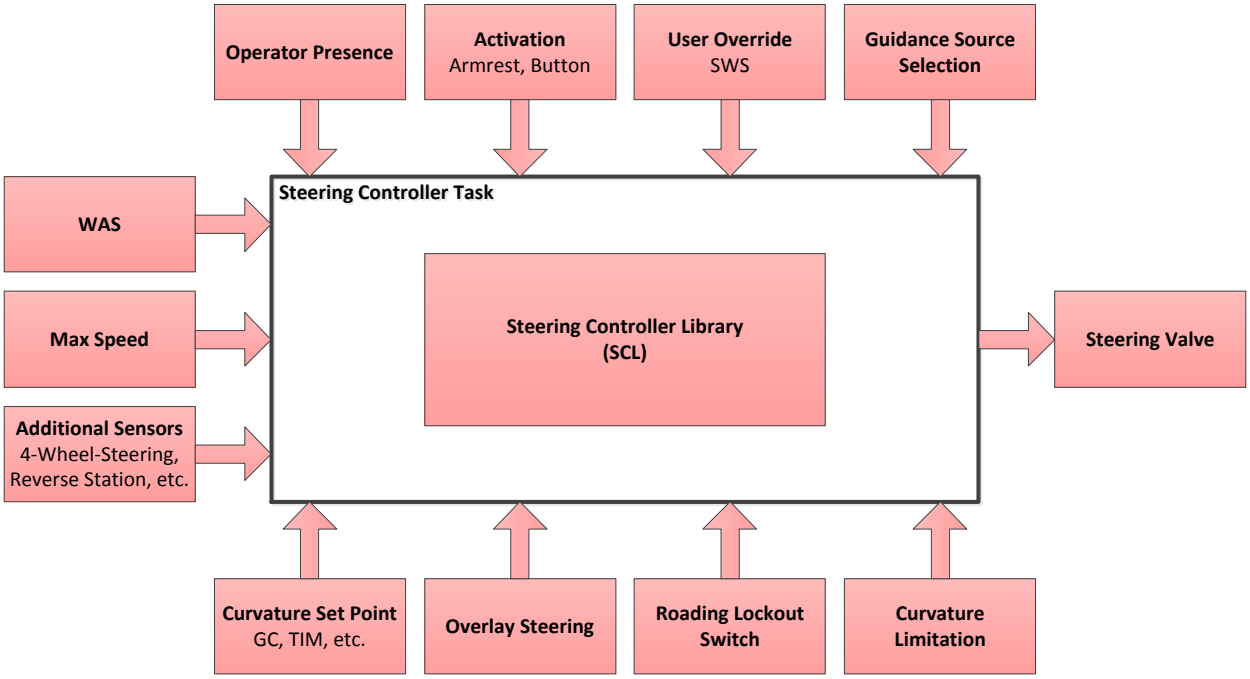


Figure 5: Steering Control Library integration

More detailed information about the tasks performed by the SCT and the SCL, as well as the implications for the sites is given in section 3.2.2. Zero-turn and articulated machines might not have a SCL or a SCT as previously defined, section 3.2.2.5 details the requirements for steering controller variations for these machines.

2.2.2.2.2 Vehicle Data

The Guidance Controller has to know what kind of machine it is currently installed on and also has to have information about geometry and kinematic parameters of this vehicle. This information is called Vehicle Data and shall be stored in the non-volatile memory within the Vehicle ECU (EXT).

2.2.2.2.3 Tractor ECU (TECU)

The Tractor ECU (TECU) is the Control Function (CF) that provides the gateway between the network's Valve Bus (J1939) and Implement Bus (ISO11783). The TECU is responsible for the communications between the tractor and the other CFs on the Implement Bus (ISO11783).

2.2.2.2.4 Sensor-Based Guidance (Optional)

In addition to the input from the Guidance Controller, the Steering Controller might also use the input from sensors such as feeler, edge, camera, etc. for automatic steering. The system specification of the Native Guidance System describes the integration of these sensors into the system.

2.2.2.3 Steering Wheel Sensor

The Steering Wheel Sensor (SWS) is used for the detection of manual steering interventions. It may also be used to control the variable steering rate while driving manually.

2.2.2.4 Wheel Angle Sensor (Optional)

The Wheel Angle Sensor (WAS) serves as an input for the control loop for the steering controller; it provides the turning angle of the wheels on the steering axle. This sensor is located on each of the vehicle steering axles. Zero-turn machines like track tractors and windrowers do not have this sensor since they do not have a steering axle. The pivot angle of an articulated machine serves the same purpose as that of the Wheel Angle Sensor on wheeled machines.

2.2.2.5 Auto-leveling sensor (Optional)

The Auto-leveling sensor measures roll and pitch angles of vehicles with an installed Auto Leveling System (ALS) like combines. When driving on a slope the ALS levels out the vehicle which induces an offset to the Native Guidance System; this offset is then communicated to the Guidance Controller (see Section 3.2.7.9) for offset compensation.

2.2.2.6 Remote Engage (Optional)

The Guidance System can be engaged and disengaged remotely via a switch/button located in the Operator Interface, for example in the Multifunctional Armrest, and/or be integrated as part of a headland management system.

2.2.2.7 Operator Presence

To ensure functional safety, the presence of the machine operator shall be monitored. This shall be accomplished by a sensor, for example, within the driver seat. AGCO Operator Presence and Awareness Messaging (Hesse, 2011) provides guidelines for the implementation of Operator Presence in AGCO machines.

2.2.2.8 Steering Valve

Native Guidance Systems shall support all Steering Valves defined within the CEA Module Book. The performance of the Steering Valve together with the additional steering actuators will influence the maximum allowed speed for guidance for the corresponding vehicle.

2.2.2.9 Cab Relative Positioning Sensor (Optional)

An integrated cab suspension can degrade the performance of a guidance system, if the positioning unit is (as usual) mounted of the roof of the cab and the machine is driven on undulating terrain. The positioning error caused by the suspension could be eliminated when the relative position and attitude change between the chassis and cab are known. For this purpose, different sensor concepts are conceivable, however, not yet implemented. In a future version of this standard, such a sensor concept could be introduced at least as an optional component.

2.2.2.10 Gateway (Optional)

The Gateway permits short-range and remote wireless communications to data streams on the internet. The AGCO Native Guidance System needs a communication platform for receiving NTRIP corrections; until the AGCO gateway is released, the Guidance Controller shall have its own internal cellular modem. The definition of the interface between the AGCO Native Guidance System and the Gateway is included in the Native Guidance System Specification.

2.2.3 Service Components

All machines must comply with the AGCO Service-Ready Specification (Russel, 2013).

2.2.3.1 Flashing

Software flashing shall be done using the CEA AGCO service platform.

2.2.3.2 Diagnostics

Diagnostics shall be done using the CEA AGCO service platform.

2.3 AGCO Legacy Systems

The definition of the requirements for a machine to be “Guide-Ready” is independent of the strategy to integrate AGCO legacy systems (Topcon and older) into “Guide-Ready” machines. The exact integration strategy of AGCO legacy systems developed by Topcon (AG3000 and VarioGuide) is currently under discussion.

2.4 ‘3rd’ Party Guidance System

3rd Party Guidance Systems are ISOBUS-compliant aftermarket systems that do not interface directly with the internal communication buses like the GD bus. There are two main differences in how 3rd party systems operate compared to the Native Guidance System. Firstly, the operator interface may or may not be part of the machine, and secondly the 3rd Party Guidance System communicates its steering commands to the TECU through the Implement Bus (ISO 11783). Nevertheless, sites are responsible for ensuring machine safety when integrating 3rd Party Guidance System.

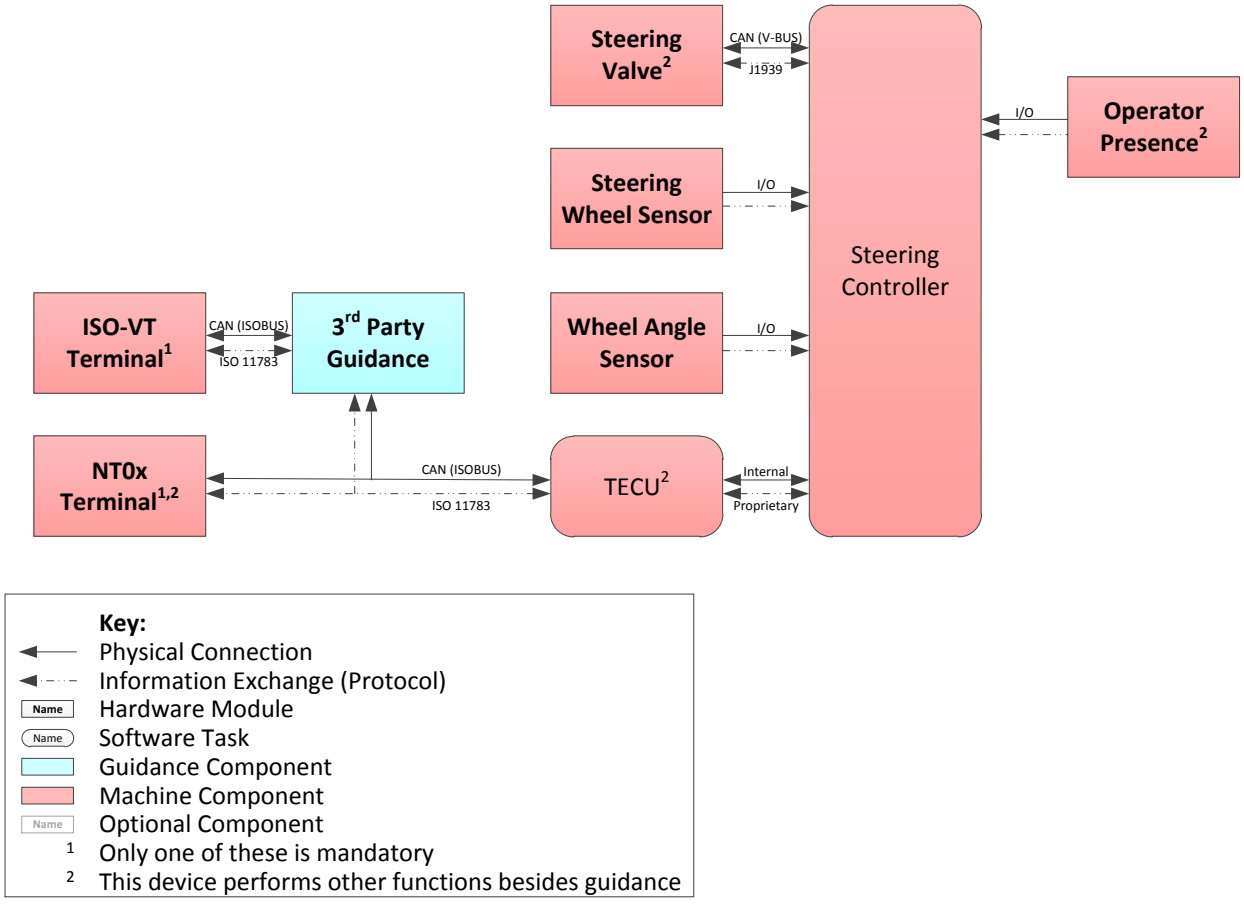


Figure 6: High-level boundary diagram for the 3rd Party Guidance System configuration

3 REQUIREMENTS

The following section will define the requirements of the machines in order to become 'Guide-Ready'. Requirements are organized in the following subsections:

- Safety Requirements – This section will specify the requirements to ensure the proper function and safety of the Native Guidance System installed on "Guide-Ready" machines.

- Software Requirements – This section will specify all messages from the Native Guidance System to the machine and vice versa.

- Electrical Requirements – This section will specify all electrical requirements including wiring, connectors, and power requirements for both the Native Guidance System and associated sensors.

- Mechanical Requirements – This section will cover mounting and sizing requirements of the Native Guidance System and the GNSS Unit.

- Documentation Requirements – This section will specify requirements to ensure manufacturing sites create and maintain proper engineering documentation of machine configurations meeting the requirements specified in this document.

3.1 Safety Requirements

The Steering Controller of the vehicle is responsible for the major tasks regarding functional safety. Within the Steering Controller the following tasks are implemented:

3.1.1 Mechanical System Lockout (Roading Lockout Switch)

The machine should be equipped with a mechanical system lockout. This requirement is fulfilled through the use of a mechanical, electrical and/or electronic means used to communicate if the machine is on the road. The machine shall provide an ISO 11783-7 message (PGN 44032) indicating the state of such a system in the format specified in ISO 11783-7 (A.28.7) for a 3rd Party Guidance System.

The Steering Controller shall not request curvature commands from the Guidance Controller while the machine is on the road.

3.1.2 Operator Presence

The machine shall be equipped with an operator presence system as required by ISO 10975:2009 for operator-controlled tractors and self-propelled machines equipped with Auto-guidance systems (ISO 10975:2009, 2009). This requirement is fulfilled through the use of a mechanical, electrical and/or electronic means used to detect if an operator is no longer in the operator station. The machine shall provide a message on the Implement Bus (PGN 65324) or GD Bus (GD Index 12290) indicating the operator presence in the operating station in the format specified in the AGCO Operator Presence and Awareness messaging standard (Hesse, 2011). The Steering Controller shall disengage Auto Steering if an operator is not present in the operating station.

3.1.3 Curvature Limitation

The Native Guidance System shall limit steering curvature to prevent the vehicle from rolling over due to a severe steering maneuver. See Figure 7 for an example of the Native Guidance System steering curvature limitation functionality. Since the necessary limitations may differ widely from vehicle to vehicle, each AGCO site shall define vehicle-specific curvature limitation parameters for each of their vehicle types. Additionally, machines with forward and reverse drive capability (i.e. TwinTrac and Reverse Station) shall have the same curvature limitation parameters for both steering configurations.

The steering curvature limitation curve (blue line) shown below shall consist of five sampling points P1 to P5. The single points shall be part of the Steering Controller Task and stored within the non-volatile memory of the Vehicle ECU (EXT) (see Section 3.2.3). Between the five sampling points (P1 to P5) a linear interpolation shall be used. At speeds lower than x1 the maximum allowed curvature shall be y1. At speeds higher than x5 the maximum allowed steering curvature shall be y5.

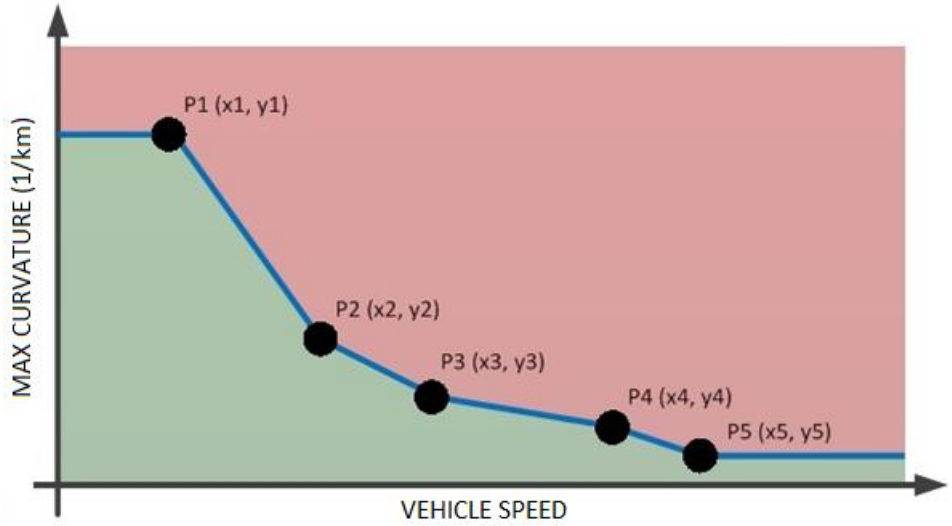


Figure 7: Maximum Allowed Steering Curvature as a Function of Vehicle Speed

The steering curvature limitation functionality is integrated in the Steering Controller Library (SCL). Therefore, the custom (modified by each site) Steering Controller Task (which uses the SCL) shall read out the x and y values for the five sampling points from the non-volatile memory of the Vehicle ECU (EXT) and then update the initialization structure for the SCL with this information. The steering curvature limitation inside the SCL works in two ways:

- Red zone: During manual operation, steering actions can be taken that result in speed vs. curvature red-zone operation. For example, when the driver activates automatic steering during a sharp turn. When this is the case, the SCL shall not limit the steering command to the blue line but shall only accept steering commands lower than the actual steering curvature. Consequently, the vehicle shall move to the green zone in a controlled way.
- Green zone: Usually, the machine should be in the green zone during automatic steering. If the Guidance Controller sends a steering curvature command which is in the red zone, then the SCL shall limit the steering curvature to the green zone before putting it into the valve controller.

3.1.4 Driver Intervention

The Steering Controller Task shall detect driver interventions to the steering wheel. For Valtra machines with TwinTrac reverse drive, the Steering Controller Task shall manage driver interventions to both steering wheels. Since the Native Guidance System will cover very different vehicle kinematics and steering systems, it is not possible to specify in detail exactly when a driver intervention leads to a deactivation of automatic steering. Therefore, each site shall be responsible to define and implement their specific driver intervention detection.

3.2 Software Requirements

The Native Guidance System depends upon software and messages of other machine systems and also provides messages to be consumed by other machine systems. Appendix E contains all the messages (GD Indexes) between the Guidance Controller and the other components of the Native Guidance System.

3.2.1 Communication Data Rates

Communication through the machine buses shall be at a data rate of 250 kbit/s in accordance with ISO11783-2 for the Implement Bus, J1939-15 for the Valve Bus, and the latest specification for the AGCO proprietary Generic Driver (GD).

3.2.2 Steering Controller

The Steering Controller Task monitors the vehicle state (User Override, Operator Presence, Maximum Speed, etc.) as well as the vehicle components (Steering Valve, SWS, WAS,

etc.) as described in section 3.2.2.1. Likewise, the Steering Controller Library receives a data structure from the Steering Controller Task and decides whether or not to allow guidance. The input structure to the SCL is explained in sections 12.2 and 13.1 of the SCL documentation (Miller, 2013).

3.2.2.1 Guidance Engagement & Disengagement Conditions

Sites shall be responsible for defining the machine conditions that the Steering Controller Task verifies for engaging guidance. These conditions shall include at a minimum:

- Operator Presence sensor: Sensor diagnostics and sensor output
- Access of the non-volatile memory: Error during reading of parameters or last settings
- Steering Wheel Sensor: Sensor diagnostics and driver intervention
- Machine speed: Within Limits, Sensor diagnostics and calculation error

The following additional conditions might be verified depending on the type of machine, these conditions are not mandatory:

- Wheel Angle Sensor: Sensor diagnostics
- Pilot Pressure Valve: Valve diagnostics
- PVED Valve: Valve diagnostics
- Remote Engage: Sensor diagnostics
- Conditions related to machine-specific steering configurations (i.e. TwinTrac, Reverse Station, Overlay Steering)

The Native Guidance System development team recommends engaging / disengaging the Native Guidance System from the armrest or Remote Engage button.

3.2.2.2 Guidance Engagement

When the machine operator makes the request to pre-activate auto steering through the user interface (e.g. remote engage, armrest, terminal, etc.), GD Index 12290 is sent to notify the Steering Controller Task (SCT). The SCT shall verify that all steering conditions are met (see section 3.2.2.1); if they are, the Steering Controller Library (SCL) shall change the state of the Steering System from "STATUS_ON" to "STATUS_PRE_ACTIVE" (GD Index 12304). When the Guidance Controller (GC) detects this change and verifies that all guidance conditions are met, the GC sends a curvature and activation command to the SCT (GD Index 12314) and the state of the Steering System changes from "STATUS_PRE_ACTIVE" to "STATUS_ACTIVE". The SCT shall be responsible for notifying the machine operator of auto steering status. Figure 8 shows the steering command process for the Native Guidance System.

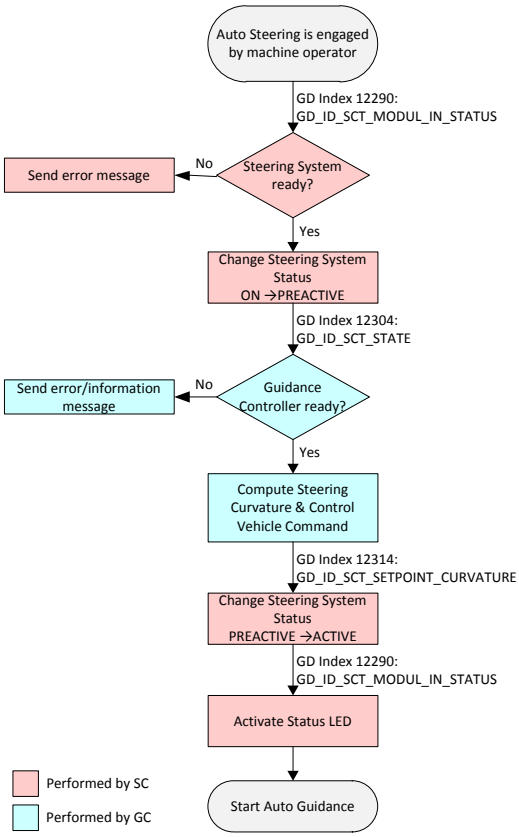


Figure 8: Steering Command Flowchart for Native Guidance System

3.2.2.3 Steering Command

Machine steering control is achieved with a feedback control loop between the Guidance Controller (GC) and the Steering Controller (SC). In this feedback loop (See Figure 9), the GC sends a steering curvature command to the SC (GD Index 12314), which likewise actuates the machine to achieve the desired steering curvature and provides feedback of the machine steering curvature (GD Index 12328).

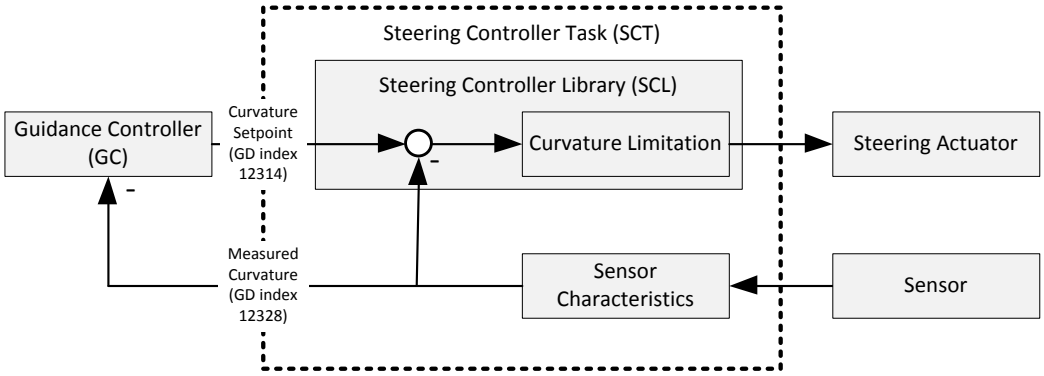


Figure 9: Cascaded Steering Control Loop

3.2.2.4 Steering Response

The Steering Controller Task shall respond to the curvature command from the Guidance Controller with the machine steering curvature (GD Index 12328).

3.2.2.5 Steering Controller Variations

Zero-turn and articulated machines might not have a SCL or a SCT as previously defined. These sites shall be responsible for developing their own steering controller with the same software interface and functionality as that of the SCT as previously defined (see section 3.2.2). The complete software interface is listed in Appendix E. Additionally, these sites shall be responsible for developing their own control algorithms and safety parameters.

3.2.3 Vehicle Guidance Configuration Data

In order for the Native Guidance System to provide accurate auto-steering commands, the Guidance Controller must factor vehicle type, geometry and kinematics parameters (for a complete list see Appendix C) into its auto-steering curvature command calculations. There are a number of different types of machine platforms and the Native Guidance System may or may not be a transferrable system. Therefore at boot up, the Native Guidance System must query the machine type and all relevant machine characteristics from the Steering Controller Task, which reads vehicle configuration data from the non-volatile memory of the Vehicle ECU (EXT) and sends it to the Guidance Controller. The sites shall store and maintain this information on each machine using the End-Of-Line (EOL) tool or a corresponding software tool.

One kilobyte of Vehicle ECU (EXT) non-volatile memory shall be reserved for the Native Guidance System to hold the guidance configuration data. Sites have the freedom to decide where to host the data within the EXT, the start memory address and the memory type (e.g. EEPROM or flash memory) shall be defined by the sites. However, sites shall keep the memory layout specified in Appendix C.

MOD will provide the template for the SCT, which provides the necessary information to properly respond to the GC request for the Vehicle Guidance Configuration Data. When sites get the template from MOD they will have the option to modify the process of retrieving configuration data from memory. However, sites shall be responsible for properly transferring this data to the GC with GD Block Transfer.

3.2.3.1 Memory Layout

The memory block containing the Vehicle Guidance Configuration Data shall be divided into the following partitions:

Version: A version field is defined to identify the current version of the Guidance Configuration Data layout. The version number shall increase by one (e.g. from version 0 to version 1) with each new layout revision.

Vehicle Type: Vehicle type shall be defined by brand, model, type and VIN.

Vehicle Geometry: All geometric parameters shall be stored in the Guidance Configuration Data. Some of these parameters are mandatory, some are not. See Section 3.2.3 for more detailed information.

Vehicle Dynamics: Parameterization values for the Native Guidance System shall be stored in the Guidance Configuration Data.

3.2.3.2 Data Integrity

As shown in Appendix C every partition of the Vehicle Guidance Configuration Data closes with a checksum which shall be verified by the Guidance Controller. Generator polynomial 0xA001 shall be used to calculate the CRC-16 checksum. The checksum shall be calculated over all fields of each partition including those currently not in use to support future parameters.

3.2.3.3 Machine Geometry Characteristics

The next sections will detail additional specific requirements for each of the machine types. The following geometry definitions are based on ISO 11783-10:2009. Definitions are extended to accommodate additional values and vehicles types:

Table 1 Machine Geometry Characteristics

		Front Wheel	Rear Wheel	Zero-Turn	Articulated	Four-Wheel
A	Reference Point	x[1]	x	x	x	x
B	Navigation Reference Point	x	x	x	x	x
C	Front Control Point (Hitch)	o	x	-/x[2]	o	o
D	Front Control Point (Towed)	o	-	x/-[3]	o	o
E	Secondary Axle	x	x	-	x	x
F	Guidance Controller Position	x	x	x	x	x
G	GNSS Antenna Position	x	x	x	x	x
H	Rear Control Point (Towed)	o	o	o	o	o
I	Rear Control Point (Hitch)	o	-	o	o	o
J	Turning Pivot Point	-	-	-	x	-
K	Additional Working Height	-	-	-	-	o
L	Third Axle	o	-	-	o	-
	Track Width	x	x	x	x	x

A. The Reference Point serves as the origin of the vehicles' coordinate system. It is generally located in the center of the non-steered axis. In the case of track tractors and machines with two non-steered axles, the Reference Point is located in the rear axle.
B. The Navigation Reference Point is the projection of the reference point onto the ground. The tire size and therefore B_Z is modifiable by the operator.
C. The Front Control Point (Hitch) is located midway between the front 3-point hitch arm balls/sockets.
D. The Front Control Point (Towed) is located at the center of the front tow hitch.
E. The Secondary Axle is the axle without the Reference Point. The distance between both axles shall be stored within the Vehicle Guidance Configuration Data.
F. The Guidance Controller Position is defined at the reference position of the IMU inside the Guidance Controller. See VD03 hardware specification for more details (Sensor-Technik Wiedemann GmbH (STW), 2014). In addition to the position of the Guidance Controller, its orientation shall also be stored within the Vehicle Guidance Configuration Data.
G. The GNSS Antenna Position is defined at the phase center of the GNSS antenna. As an example, see Appendix B for the position of the antenna phase center of the NovAtel SMART6 GNSS Unit. The location of the GNSS Antenna Position (G_X, G_Y, G_Z) is modifiable by the operator.

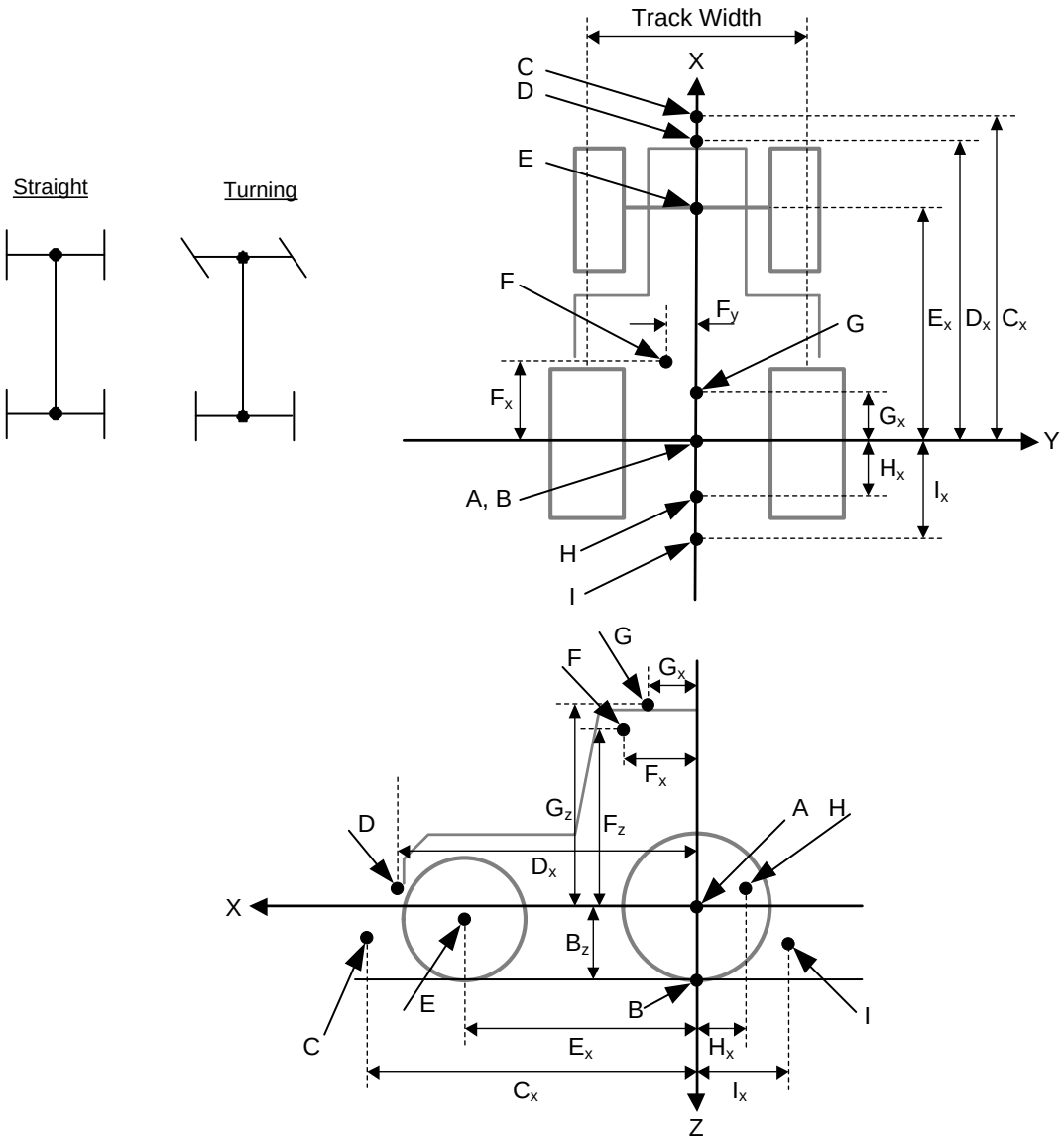
[1] x: required, o: optional, -: not applicable
[2] Track tractor: not applicable, Windrower: required
[3] Track tractor: required, Windrower: not applicable

H. The Rear Control Point (Towed) is located at the center of the rear tow hitch.
I. The Rear Control Point (Hitch) is located midway between the rear 3-point hitch arm balls/sockets.
J. For articulated machines the Turning Pivot Point is the rotation point of the machine.
K. The Additional Working Height is the raised height offset of the machine. (Four-Wheel steering machines like sprayers are able to change their working height when they are on the field)
L. Third Axle: Vehicles with front articulated steering may have a third axle. This is always the axle in the center.

Track Width: Track width is needed for all machines. The Track Width is measured from center point to center point of the wheels or tracks of the Reference Point axle. The Track Width is modifiable by the operator.

Dog-Walk and Crab Steer: Currently, no CEA machines with Dog-Walk Steering or Crab Steering are under development. Therefore, this version of the Guide-Ready Specification will not cover Dog-Walk nor Crab Steer machines. The Native Guidance System development team shall be involved during the development of a future CEA dog-walk and/or Crab Steer machines so that this specification can be expanded to cover these additional vehicle types.

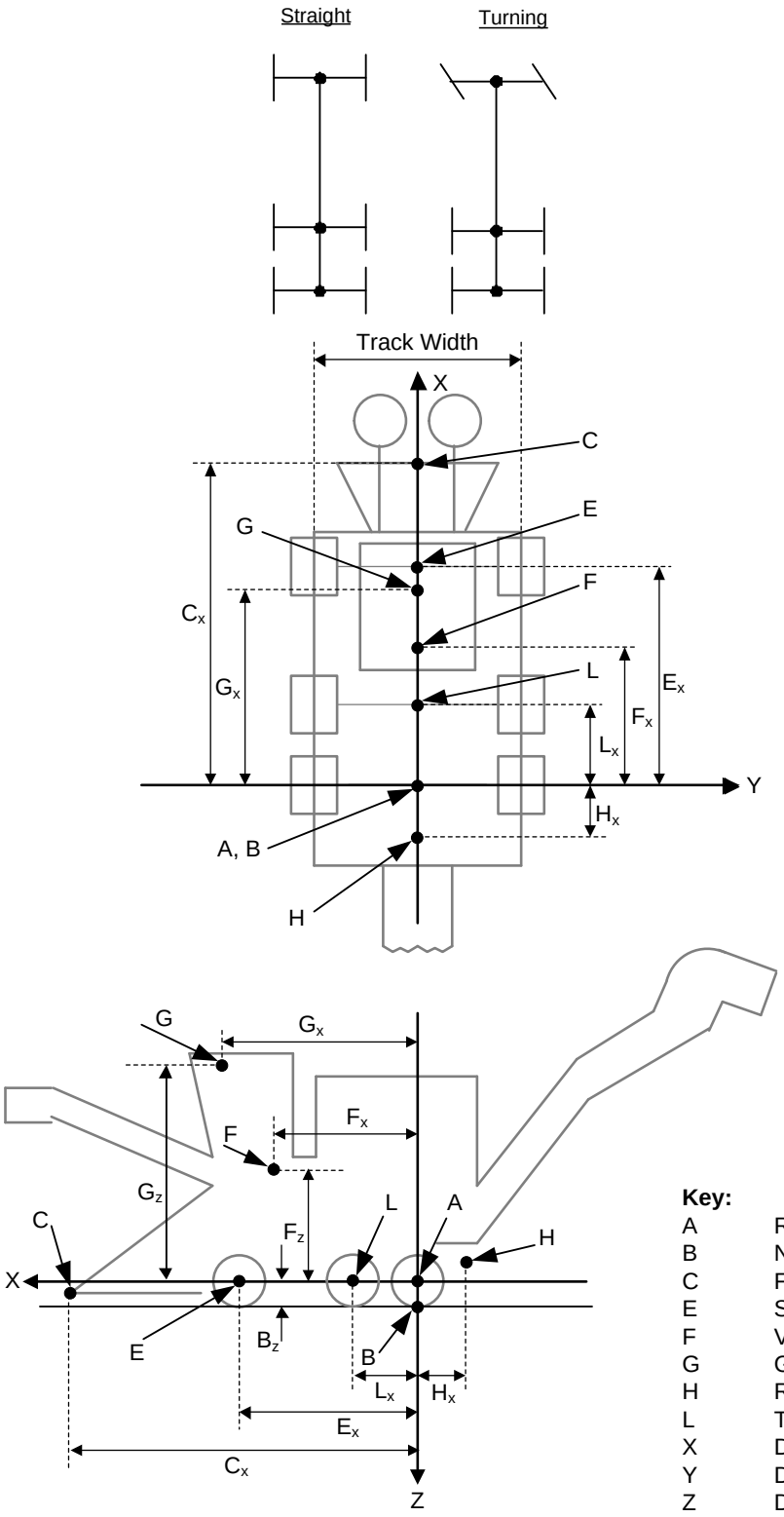
The following drawings explain how to measure the single geometry values that shall be stored within the Vehicle Guidance Configuration Data. All dimensions shall be defined by a signed value measured in millimeters. To keep the following drawings as simple as possible, the Guidance Controller ECU is shown on the x axis of the vehicle. The installation location for this ECU can deviate.



Key:

A	Reference Point
B	Navigation Reference Point
C	Front Control Point (Hitch)
D	Front Control Point (Towed)
E	Secondary Axle
F	VD02
G	GNSS Receiver
H	Rear Control Point (Towed)
I	Rear Control Point (Hitch)
X	Device X Axis (Positive Direction)
Y	Device Y Axis (Positive Direction)
Z	Device Z Axis (Positive Direction)

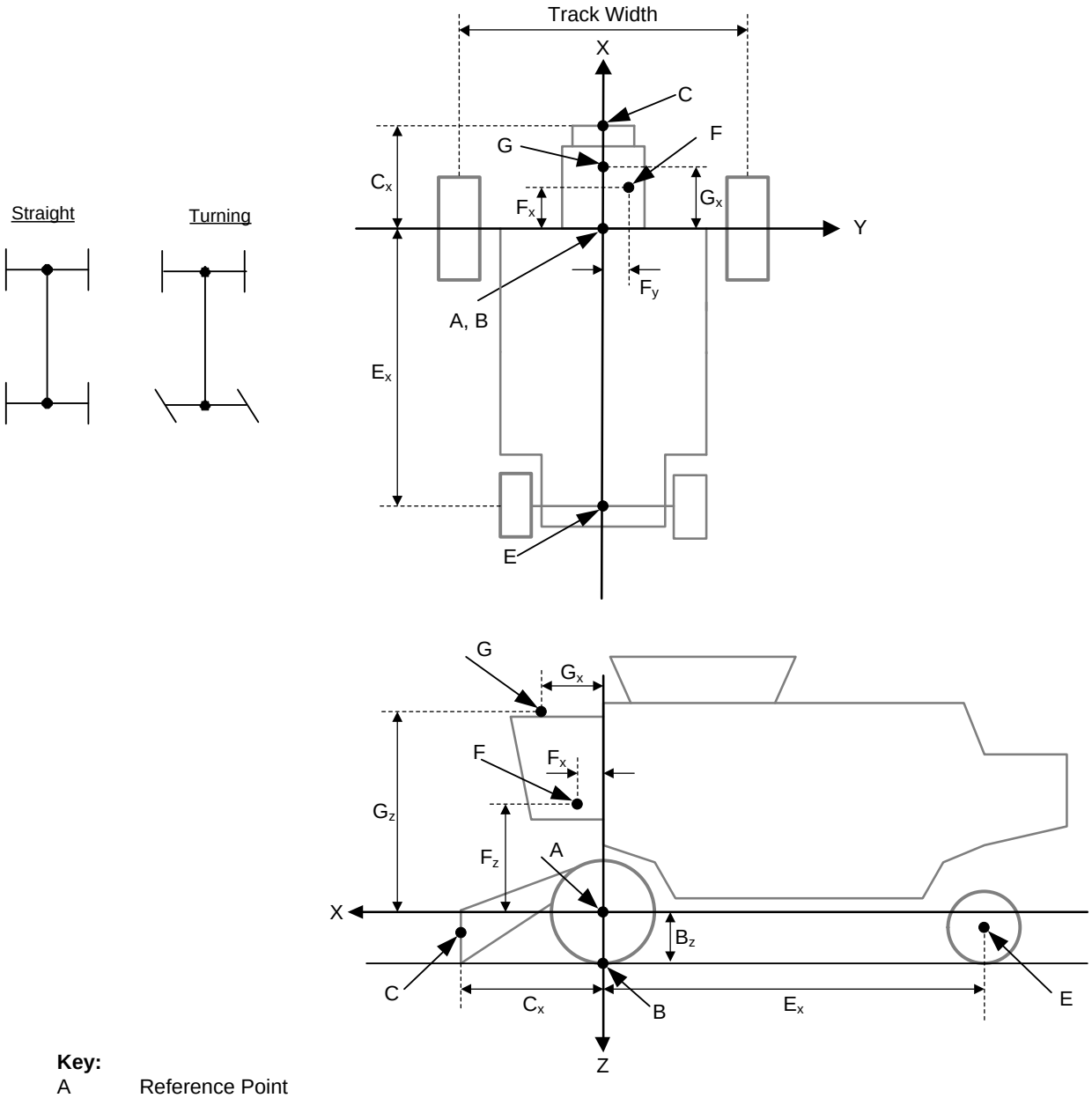
Figure 10: Front Steering Machine Coordinate System (Tractor)



Key:

A	Reference Point
B	Navigation Reference Point
C	Front Control Point (Hitch)
E	Secondary Axle
F	VD02
G	GNSS Receiver
H	Rear Control Point (Towed)
L	Third Axle
X	Device X Axis (Positive Direction)
Y	Device Y Axis (Positive Direction)
Z	Device Z Axis (Positive Direction)

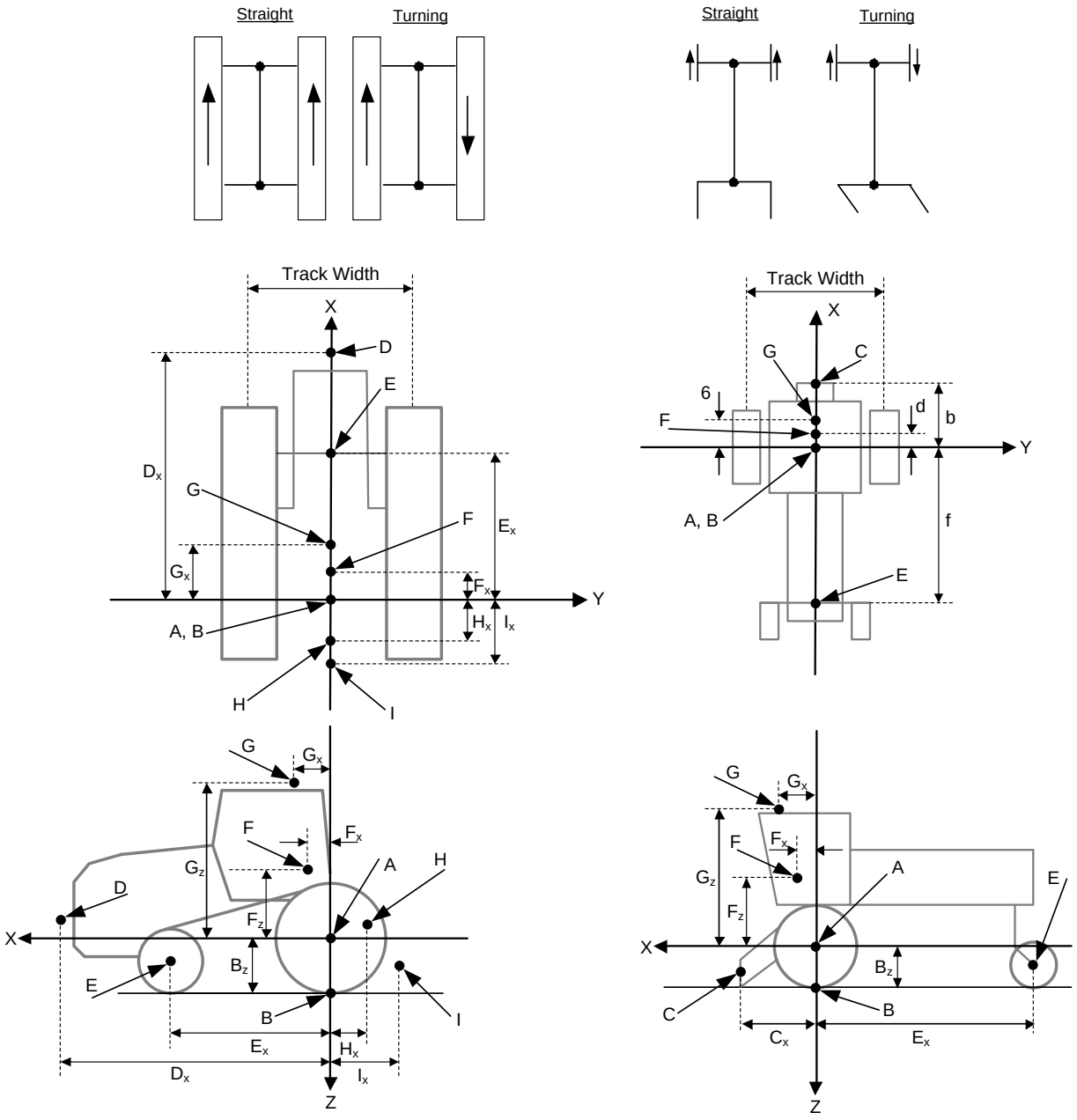
Figure 11: Front Steering Machine Coordinate System (Sugar Cane Harvester)



Key:

A	Reference Point
B	Navigation Reference Point
C	Front Control Point (Hitch)
E	Secondary Axle
F	VD02
G	GNSS Receiver
X	Device X Axis (Positive Direction)
Y	Device Y Axis (Positive Direction)
Z	Device Z Axis (Positive Direction)

Figure 12: Rear Steering Machine Coordinate System (Harvester & Combine)



Key:

A	Reference Point	G	GNSS Receiver
B	Navigation Reference Point	H	Rear Control Point (Towed)
C	Front Control Point (Hitch)	I	Rear Control Point (Hitch)
D	Front Control Point (Towed)	X	Device X Axis (Positive Direction)
E	Secondary Axle	Y	Device Y Axis (Positive Direction)
F	VD02	Z	Device Z Axis (Positive Direction)

Figure 13: Zero-Turn Machine Coordinate System (Track Tractor & Windrower)

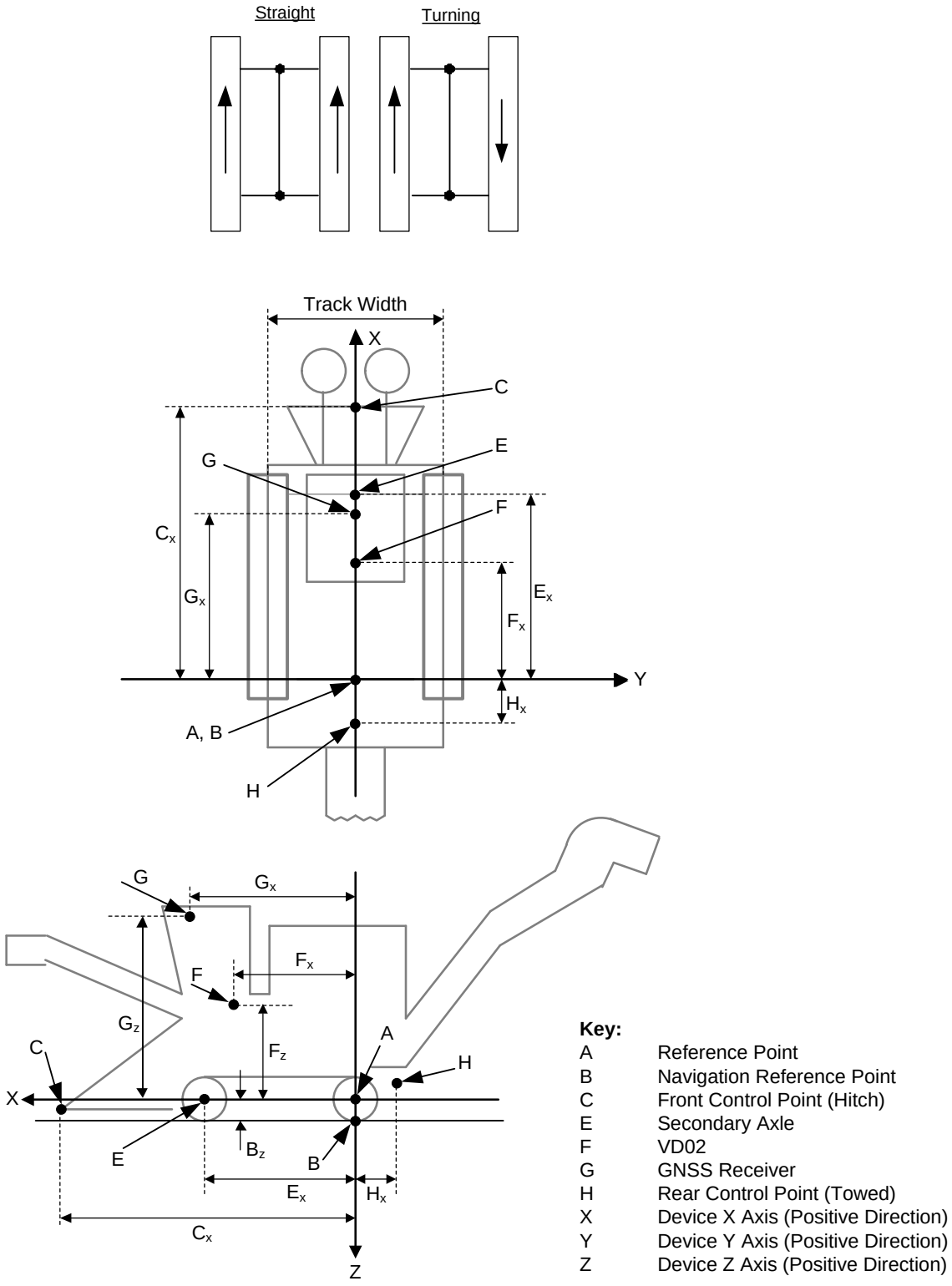
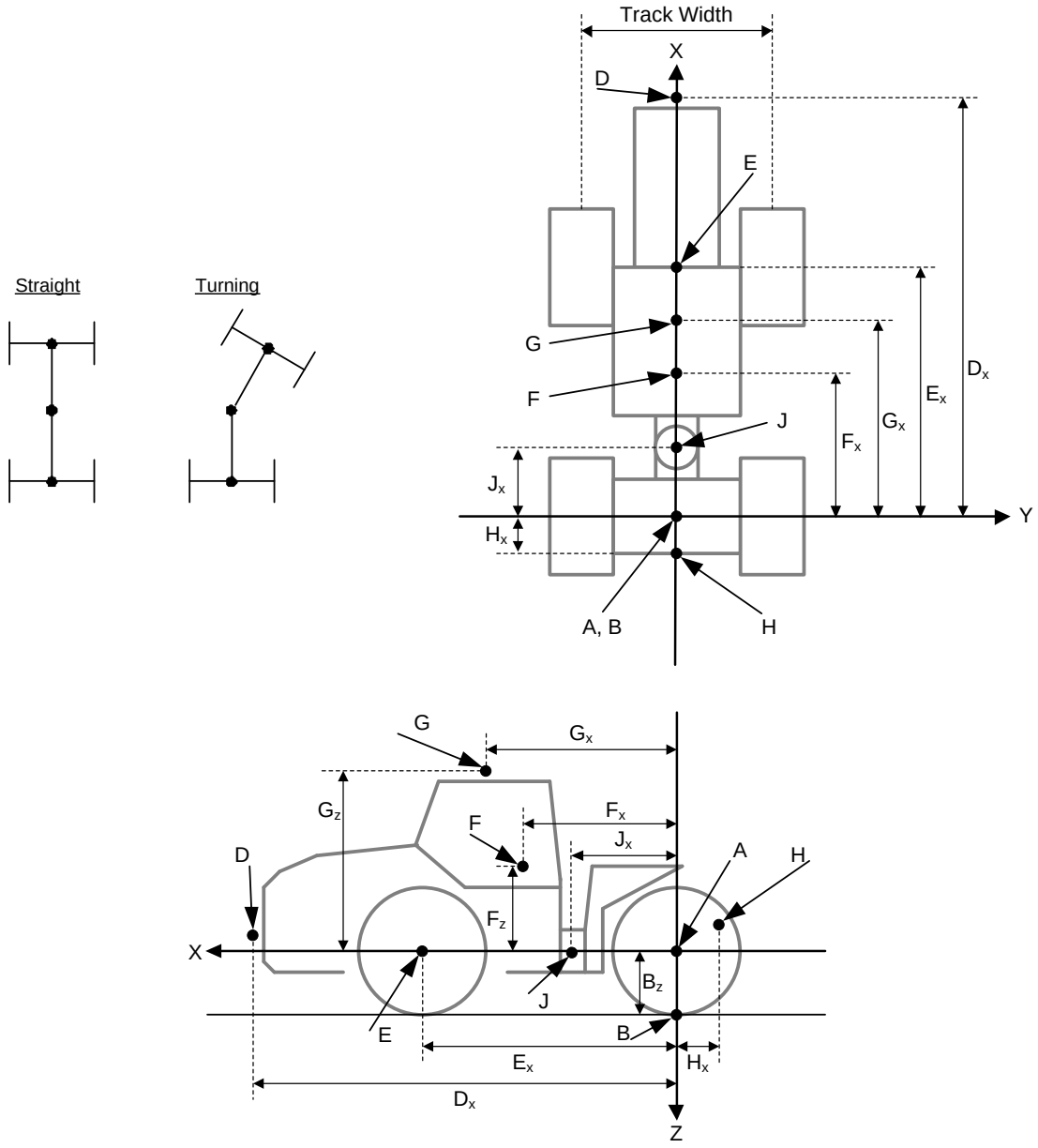


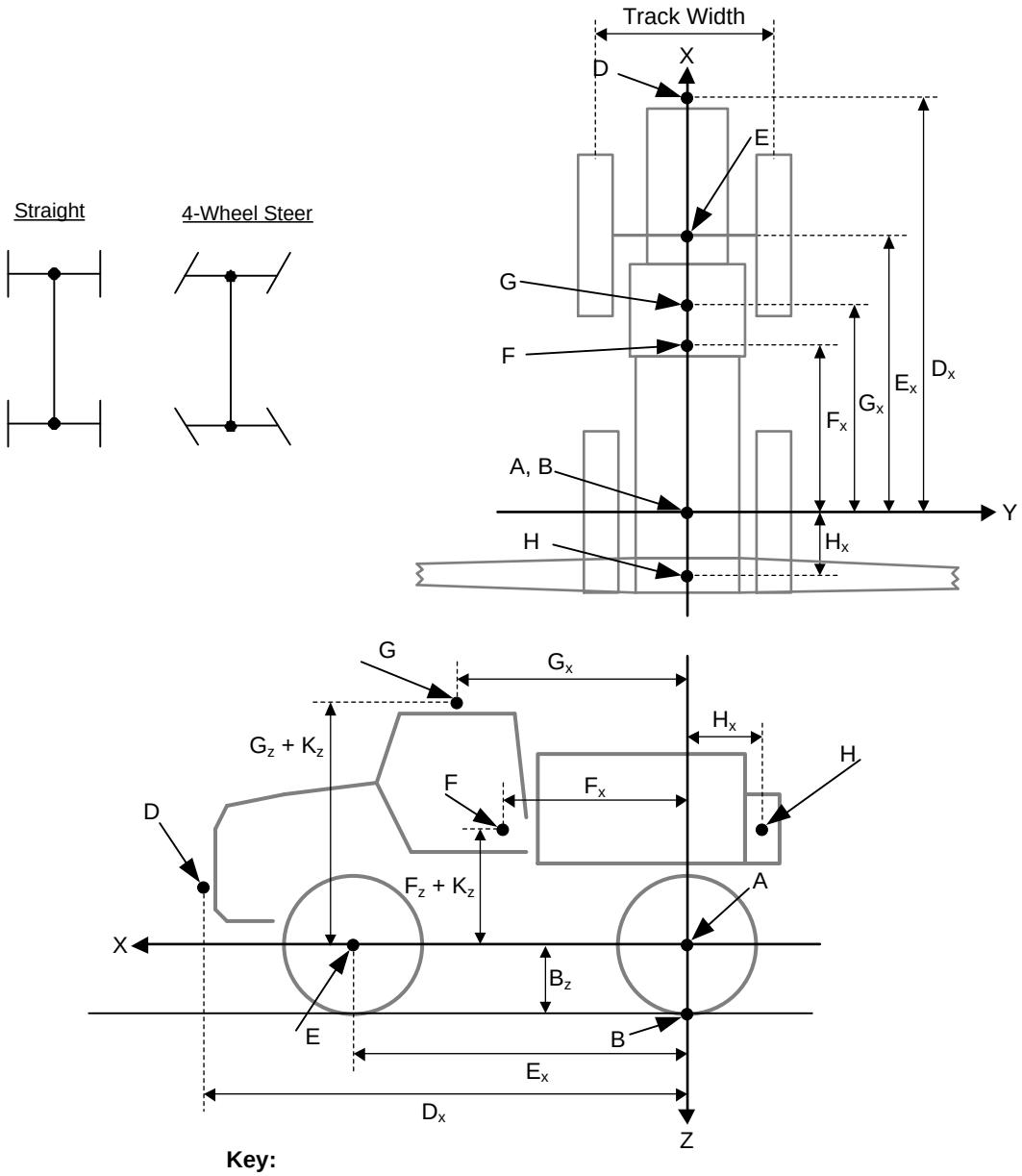
Figure 14: Zero-Turn Machine Coordinate System (Sugar Cane Harvester)



Key:

A	Reference Point
B	Navigation Reference Point
D	Front Control Point (Towed)
E	Secondary Axle
F	VD02
G	GNSS Receiver
H	Rear Control Point (Towed)
J	Turning Pivot Point
X	Device X Axis (Positive Direction)
Y	Device Y Axis (Positive Direction)
Z	Device Z Axis (Positive Direction)

Figure 15: Articulated Machine Coordinate System



Key:

A	Reference Point
B	Navigation Reference Point
D	Front Control Point (Towed)
E	Secondary Axle
F	VD02
G	GNSS Receiver
H	Rear Control Point (Towed)
K_z	Additional Working Height
X	Device X Axis (Positive Direction)
Y	Device Y Axis (Positive Direction)
Z	Device Z Axis (Positive Direction)

Figure 16: Four-Wheel Steering Machine Coordinate System (Sprayer)

3.2.3.4 Modification of Geometry Parameters

The operator has the ability to change the following Vehicle Guidance Configuration Data parameters. These parameters shall be saved at the designated locations in the non-volatile memory by the Steering Controller Task (see Appendix C):

- Reference Point Height (B_Z)
- Position of the GNSS Antenna (G_X, G_Y, G_Z)
- Track Width

Once the operator is done making changes to the geometry parameters listed above, an NT0X shall use the following global GD Indexes to transmit the modified geometry parameters to the Steering Controller Task:

- GD_ID_SCT_MODIFIED_REFERENCE_POINT_HEIGHT
- GD_ID_SCT_MODIFIED_GNSS_ANTENNA_X_OFFSET
- GD_ID_SCT_MODIFIED_GNSS_ANTENNA_Y_OFFSET
- GD_ID_SCT_MODIFIED_GNSS_ANTENNA_Z_OFFSET
- GD_ID_SCT_MODIFIED_TRACK_WIDTH

Then, an NT0X Terminal shall notify the Steering Controller Task (GD Index 12588) that new parameters are available. Afterwards, the Steering Controller Task shall store the received Vehicle Guidance Configuration Data parameters in the non-volatile memory and notify the Guidance Controller (GD Index 12589) that the geometry information stored in the non-volatile memory has changed.

3.2.4 Sensor Calibration

3.2.4.1 Steering Wheel Sensor (SWS)

Sites shall be responsible for calibration of the SWS and for storing its maximum and minimum values in the non-volatile memory.

3.2.4.2 Wheel Angle Sensor (WAS) and Pivot Angle Sensor (PAS)

Sites shall be responsible for calibration of the WAS/PAS and for storing the value of the right lock, the left lock and the center in the non-volatile memory. The center shall be defined as the forward-drive position. The accuracy of the center calibration is essential for the performance of the Native Guidance System and shall be within ± 0.2^{o} for wheeled machines. WAS/PAS calibration shall be performed after assembly and when the steering left/right locks have been modified.

3.2.4.3 Zero-Turn Machines

Sites shall be responsible for calibration of the sensors which are relevant for the steering system. The accuracy of the center calibration is essential for the performance of the Native Guidance System. Sensor calibration shall be performed after assembly.

3.2.5 Flashing

The vehicle shall comply with the latest version of the AGCO Service-Ready Specification for software flashing.

3.2.6 Diagnostics

The vehicle shall comply with the latest version of the AGCO Service-Ready Specification for machine diagnostics.

3.2.7 Vehicle Data

Guidance Controller, Steering Controller, and Diagnostics need information about the vehicle in order to be fully functional. The vehicle shall provide the following data sets, which are required by at least one of these modules; via the corresponding interfaces (sender and receiver of these data sets are listed in Appendix E):

3.2.7.1 Operator Presence

Each site is responsible for sending operator presence information using AGCO Operator Presence and Awareness messages to the Steering Controller Task, which then shall react to this information as described in Section 3.1.2.

3.2.7.2 Vehicle Speed

All vehicles shall use the global GD message **GD_ID_SCT_VEHICLE_SPEED** (GD Index 12439) to send the wheel-based speed and the travel direction of the vehicle. For a further description of this GD message Appendix E.

3.2.7.3 Movement Status

All vehicles shall use the global GD message **GD_ID_SCT_VEHICLE_MOVEMENT** (GD Index 12440) to send “Vehicle Distance Moved since Ignition ON” information (KL15 signal). For a further description of this GD message see Appendix E.

3.2.7.4 Parking Brake

All vehicles shall use the global GD message **GD_ID_SCT_PARKING_BRAKE** (GD Index 12441) to send the status of the vehicle parking brake. For a further description of this GD message see Appendix E.

3.2.7.5 Steering Mode

The machine shall inform the Native Guidance System about the Steering Mode which is currently in use by transmitting GD index **GD_ID_SCT_STEERING_MODE** (see Appendix E). The machine shall also communicate its ability to change Steering Mode(s) using the same index.

3.2.7.6 Front-Wheel / Rear-Wheel Steering

Vehicles with Front-Wheel Steering or Rear-Wheel Steering shall use the following global GD messages to communicate WAS output data (see Appendix E):

- GD_ID_SCT_WAS_RAW_VALUE
- GD_ID_SCT_WAS_SENSOR_ANGLE
- GD_ID_SCT_WAS_MEDIAN_ANGLE
- GD_ID_SCT_WAS_MEDIAN_CURVATURE
- GD_ID_SCT_WAS_MEDIAN_ANGLE_MAX

3.2.7.7 Articulated Steering

Pivot sensor outputs for articulated machines shall be communicated using the same global GD messages as those defined for Front-Wheel / Rear-Wheel Steering.

3.2.7.8 Four-Wheel Steering

In the case when the WAS is attached to the front axle, the machine shall use the same global GD messages as a front steering machine. For the WAS attached to the rear axle, the machine shall use these additional global GD messages (see Appendix E):

- GD_ID_SCT_SECONDARY_WAS_RAW_VALUE
- GD_ID_SCT_SECONDARY_WAS_SENSOR_ANGLE
- GD_ID_SCT_SECONDARY_WAS_MEDIAN_ANGLE
- GD_ID_SCT_SECONDARY_WAS_MEDIAN_CURVATURE
- GD_ID_SCT_SECONDARY_WAS_MEDIAN_ANGLE_MAX

3.2.7.9 Auto Leveling System

An Auto Leveling System (ALS) can be installed on combines to compensate for the slope of the land. With an installed ALS, the vehicle is able to tilt in x and y directions in the vehicle coordinate system. The roll movement may result in a lateral positioning error (see Figure 17 and Figure 18). The pitch movement may result in a longitudinal positioning error. In order to compensate for these errors, the ALS shall communicate both offsets on the GD bus using the following messages (see Appendix E).

- GD_ID_SCT_ALS_X_OFFSET
- GD_ID_SCT_ALS_Y_OFFSET

All offsets shall be expressed as signed values in millimeters.

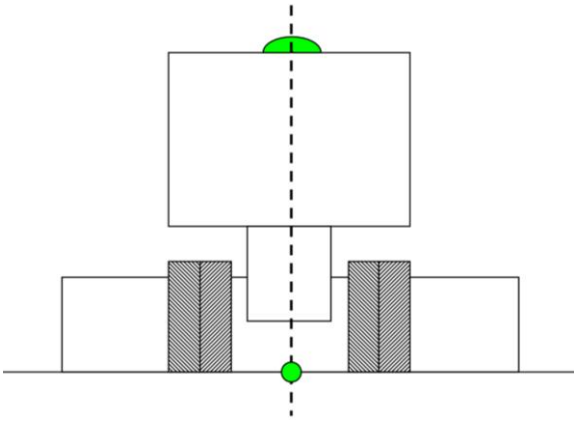


Figure 17: Deactivated ALS

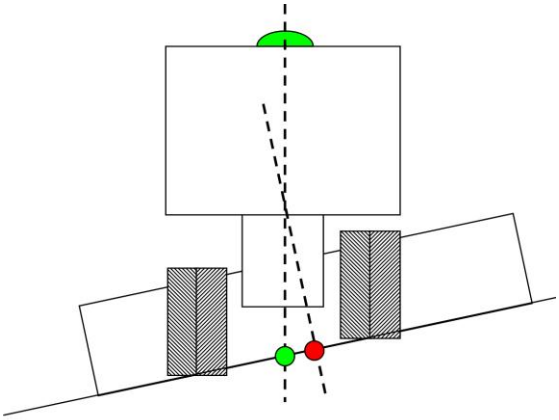


Figure 18: Activated ALS resulting in a lateral offset

3.2.7.10 Additional Working Height

Vehicles like sprayers may operate at different working heights. Since this changes the vehicle geometry, the vehicle shall report when this mode is enabled by transmitting **GD_ID_SCT_ADDITIONAL_WORKING_HEIGHT** message on the GD bus (see Appendix E). The additional height (K_z) shall be stored within the non-volatile memory of the Vehicle ECU (see Section 3.2.3.3 and Figure 16).

3.2.7.11 Vehicle Payload

The weight of machines like combines and sprayers changes while they are being loaded (harvesting) or unloaded (spraying). This change on machine payload changes the dynamic characteristics of the machine. Therefore the actual and the maximum payload of the machine can be used as an input for tuning of the guidance system steering parameters.

Since the same volume of harvested crop can result in different weights for example due to different moisture contents, the machine shall calculate or estimate the actual payload weight based on their different sensor inputs.

Machines shall define their maximum payload[4] and the vehicles curb weight[5] in the Guidance Configuration Data (see **MAX_VEHICLE_PAYLOAD** and **VEHICLE_CURB_WEIGHT** in Appendix C) and shall communicate their current payload[6] by using GD index

[4] The maximum payload shall be calculated by multiplying the capacity of the machine tank (e.g., in bushels or cubic meter) with the estimated maximum payload density.

[5] Total weight of the machine with standard equipment, all necessary operating consumables (e.g., motor oil and coolant), a full tank of fuel, driver (75 kg) while not loaded with cargo.

[6] The current vehicle shall be calculated by multiplying the measured current payload volume with its measured or estimated density.

GD_ID_SCT_VEHICLE_CURRENT_PAYLOAD (see Appendix E). Figure 19 provides an overview about all necessary data sets and calculations.

If a machine does not carry payload or is not able to measure its current payload volume, the corresponding value in the Guidance Configuration Data and the status bit of GD index **GD_ID_SCT_VEHICLE_CURRENT_PAYLOAD** shall be set to zero.

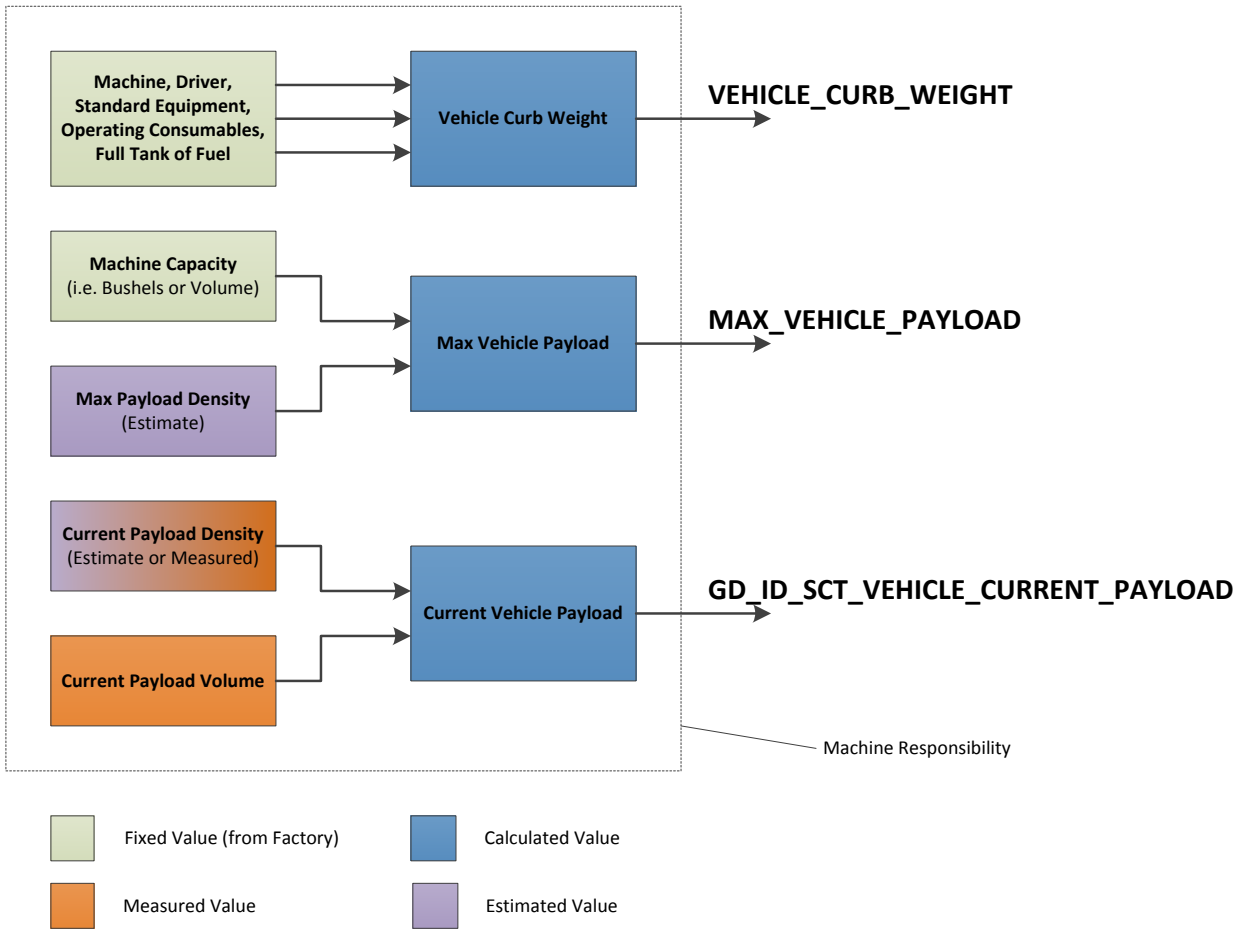


Figure 19: Vehicle Payload Calculations

3.2.8 ISO11783 Capabilities for 3rd Party Guidance System Support

3.2.8.1 ISO 11783-6:2010 (Virtual Terminal) Compliance

The Operator shall interact with a 3rd party Guidance System via an ISO 11783-6:2010 compliant Virtual Terminal (VT) or a proprietary terminal. The ISO 11783-6:2010 compliant Terminal can either be an NT0X Terminal or be part of the 3rd Party Guidance solution.

3.2.8.2 ISO 11783-9:2012 (Tractor ECU) Compliance

The Tractor ECU (TECU) functions as a gateway (see ISO 11783-4) between the tractor and the Implement Bus. The TECU shall act as a security checkpoint for 3rd Party Guidance systems. The Tractor ECU shall support the ISOBUS compliance certification message (PGN 64834), in particular, the compliance certification type TECU class parameters. In cases where it is desired that only specific 3rd Party Guidance Systems have access to the Steering Controler, the TECU shall be responsible for controlling flow access of guidance commands to the Steering Controller.

In order to support guidance, the TECU shall acknowledge all the guidance messages defined in section 4.4.2.7 of ISO 11783-9-2012 (PGN 44288 and PGN 44032 included in Appendix F).

Only 3rd Party Guidance Systems, which have successfully passed the AEF conformance test for ISOBUS Automation described in the Functional Safety Requirements for Automation in ISOBUS Systems (AEF International Guideline 007, 2013), shall interface with an AGCO machine on the Implement Bus (ISO 11783). The TECU shall be responsible for the verification of this requirement for 3rd Party Guidance Systems.

3.3 Electrical Requirements

3.3.1 Communication Buses

In order to support all the different guidance systems within the scope of this document (Native Guidance System, AGCO Legacy Systems and 3rd Party Guidance Systems), it is required that machines are equipped with the following communication buses:

3.3.1.1 AGCO Proprietary GD Bus

Machines shall be equipped with an AGCO Proprietary GD Bus which shall meet all the requirements defined in the Communications Driver GENERIC DRIVER Specification (Dittrich, 2012).

3.3.1.2 Valve Bus (J1939)

Machines shall be equipped with a Valve Bus which shall meet the network requirements specified in the different sections of the SAE J1939 standard as follows:

Physical layer	(SAE J1939/13, 2011; SAE J1939/15, 2008)
Data link layer	(SAE J1939/21, 2010)
Network layer	(SAE J1939/31, 2010)
Application layer	(SAE J1939/71, 2013; SAE J1939/73, 2013)
Network management	(SAE J1939/81, 2011)

3.3.1.3 Implement Bus (ISO11783)

Machines shall be equipped with an Implement Bus which shall meet the network requirements specified in the different sections of the ISO 11783 standard as follows:

Physical layer	(ISO 11783-2:2012, 2012)
Data link layer	(ISO 11783-3:2007, 2010)
Network layer	(ISO 11783-4:2011, 2011)
Application layer (Implement Network)	(ISO 11783-7:2009, 2011)
Network management	(ISO 11783-5:2011, 2011)
Virtual Terminal	(ISO 11783-6:2010, 2012)
Tractor ECU (TECU)	(ISO 11783-9:2012, 2012)
Task controller and management information system data interchange	(ISO 11783-10:2009, 2012)
Mobile data element dictionary	(ISO 11783-11:2011, 2011)
Diagnostics services	(ISO 11783-12:2009, 2011)
File server	(ISO 11783-13:2011, 2011)

For all electrical requirements regarding ISOBUS harnessing and connectors see the AGCO ISOBUS-Ready Specification.

3.3.2 Sensors

The following requirements apply to all sensor types listed within this section:

- All sensors shall provide diagnostic information included in the signal to the Steering Controller Task.
- Sensor cables shall be at least 20 AWG (area 0,5mm²)
- All sensors shall function in a manner that is absolute, touch-free, and hysteresis-free.
- All sensors shall comply with all global AGCO environmental and electrical specifications.

In addition, the following are sensor specific requirements:

3.3.2.1 Wheel Angle Sensor (WAS)

Front Steering, Rear Steering and Four-Wheel Steering machines shall be equipped with Wheel Angle Sensors that conforms to the following requirements as a minimum:

Table 2 Wheel Angle Sensor Parameters

Parameter	Requirement
Output Signal (I_o)	4 mA – 20 mA proportional to the angle of rotation
Output Signal Accuracy	± 1.6%
Angle of Rotation	Shall cover the full rotation range of the vehicle

Minimum Angle of Rotation Resolution	0.1^{o}

3.3.2.2 Pivot Sensor

Articulated machines shall be equipped with a Pivot Sensor that conforms to the following requirements as a minimum:

Table 3 Pivot Sensor Parameters

Parameter	Requirement
Output Signal (I_o)	4 mA – 20 mA proportional to the angle of rotation
Output Signal Accuracy	± 1.6%
Angle of Rotation	Shall cover the full rotation range of the vehicle
Minimum Angle of Rotation Resolution	0.1^{o}

3.3.2.3 Steering Wheel Sensor (SWS)

The machine shall be equipped with a Steering Wheel Sensor that conforms to the following requirements as a minimum:

Table 4 Steering Wheel Sensor Parameters

Parameter	Requirement
Output Signal (options)	4 mA – 20 mA proportional to the angle of rotation
	PWM with duty cycle proportional to the angle of rotation
Output Signal Accuracy	± 1.0%
Angle of Rotation	0^{o} – 360^{o}
Minimum Angle of Rotation Resolution	0.35^{o}

3.3.3 Bus Harnessing

3.3.3.1 Implement Bus (ISO11783)

The physical media of the Implement Bus (ISO11783) shall be designed in accordance with the AGCO ISOBUS-Ready Specification.

3.3.3.2 Valve Bus (J1939)

The physical media of the Valve Bus shall be designed using unshielded twisted pair. The designations of the individual wires are CAN_H and CAN_L.

Each end of the main signal line of the linear bus shall be terminated with an appropriate resistance to provide correct termination of the CAN_H and CAN_L conductors. This termination resistance should be connected between the CAN_H and CAN_L conductors. The termination resistance shall have a resistance of 120 ± 5% Ω and a power rating of at least

0.5 W. Connector receptacle part number DT04-3P-EP10 (Deutsch) may be used for bus termination.

3.3.3.3 AGCO Proprietary GD Bus

The physical media of the AGCO Proprietary GD Bus shall be designed in accordance with the requirements of the Valve Bus (J1939).

3.3.4 Connectors

3.3.4.1 Implement Bus (ISO11783)

Each ECU connected to the Implement Bus shall comply with the electrical specifications defined in section 6.1 of ISO11783-2 standard throughout its operating range. Connections on the implement bus shall be standardized with the connectors specified in ISO11783-2.

3.3.4.2 Valve Bus (J1939)

Each ECU connected to the Machine Implement Bus shall comply with the electrical specifications defined in section 5.1 of J1939-11 standard throughout its operating range. Connections on the Valve Bus shall be standardized with the connectors specified in J1939-13 and J1939-15.

3.3.4.3 AGCO Proprietary GD Bus

Each ECU connected to the AGCO Proprietary GD Bus shall comply with the electrical specifications defined in the latest AGCO Generic Driver specification.

3.3.4.3.1 Diagnostics

The machine shall provide one diagnostics connector located in the tractor cab in an easily accessed location for diagnostics on the AGCO Proprietary GD Bus in accordance with the requirements of the AGCO Service-Ready Specification.

3.3.4.4 Guidance Controller Connector

The Machine shall provide a primary interface 29-pin connector Part Number 1-963449-1 manufactured by TE Connectivity. The location of the Guidance Controller Connector shall be defined by each manufacturing site so that the location requirements specified in section 3.4.2.1 are met. The pin configuration of the connector shall be as follows:

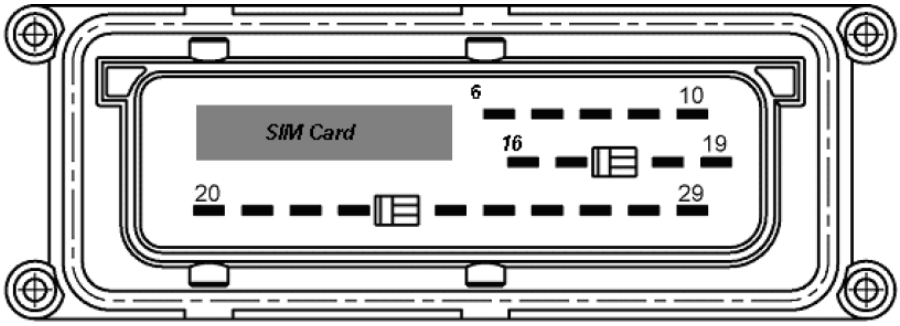


Figure 20: Pin out of the Guidance Controller Connector

Table 5 Guidance Controller Pin out Assignment

PIN ASSIGNMENTS	
Pin 1 – Pin 5	no PIN
Pin 6	RS232-GND
Pin 7	Power Out
Pin 8	KL30 / +UB
Pin 9	GND
Pin 10	KL15 / IGNITION
Pin 11 – Pin 15	no PIN
Pin 16	RS232 5 TX
Pin 17	PPS Input
Pin 18	RS232 1 RX
Pin 19	RS232 1 TX
Pin 20	CAN1 LOW
Pin 21	CAN1 HIGH
Pin 22	CAN2 LOW
Pin 23	CAN2 HIGH
Pin 24	RS232 2 RX
Pin 25	RS232 2 TX
Pin 26	RS232 3 RX
Pin 27	RS232 3 TX
Pin 28	RS232 4 RX
Pin 29	RS232 4 TX

3.3.4.5 Guidance Interface Connector

Guidance connections shall be standardized with the connector receptacle part number HD34-18-20SN manufactured by Deutsch. The Guidance Interface Connector shall be the only electrical interface between the machine and the different guidance configurations: Native Guidance System (GNSS Unit, Guidance Controller and Radio Modem) and Topcon AGI-4. The pin configuration of the connector shall be as follows:

Table 6 Guidance Interface Connector

PIN ASSIGNMENTS	
Pin 1	GD-BUS LOW
Pin 2	GD-BUS HIGH
Pin 3	KL30 / +UB
Pin 4	V-BUS LOW
Pin 5	V-BUS HIGH
Pin 6	GND
Pin 7	RS232 GND
Pin 8	PWR GNSS UNIT
Pin 9	PPS INPUT
Pin 10	RS232 2 RX
Pin 11	RS232 2 TX
Pin 12	RS232 3 RX
Pin 13	RS232 3 TX
Pin 14	RS232 4 RX
Pin 15	RS232 4 TX
Pin 16	RS232 1 RX
Pin 17	RS232 1 TX
Pin 18	ISOBUS LOW
Pin 19	ISOBUS HIGH
Pin 20	KL15 / IGNITION

Appendix A includes the electrical schematics of the different locations and configurations of the Native Guidance System and Topcon AGI-4 Guidance System, and how they interface with the machine.

3.3.4.6 3rd Party Guidance System ISOBUS In-Cab Connector

Approved 3rd Party Guidance Systems shall use the 9 pin ISOBUS in-cab standard connector to connect to AGCO machines defined in the latest AGCO ISOBUS-Ready Specification.

3.3.4.7 Radio Modem Connector

The machine shall provide connector part number DT06-6S by Deutsch (and compatible versions) as electrical interface for the different radio modems supported by the Native Guidance System. Appendix A shows recommended electrical schematics for the connection between the Native Guidance System and the radio modem. The radio modem connector shall be pinned out as follows:

Table 7 Radio Modem Connector

PIN ASSIGNMENTS	
Pin 1	PWR
Pin 2	RESERVED (Plug)
Pin 3	RESERVED (Plug)
Pin 4	RS232 TX

Pin 5	RS232 RX
Pin 6	GND

3.3.5 Machine Internal Electrical Interfaces

Sites shall be responsible for defining the internal electrical interfaces (MACHINE connections 1-12 on the left-hand side of the electrical schematics defined in Appendix A) for the following signals:

- Valve Bus
- Ignition, PWR and GND
- GD Bus
- Implement Bus
- Serial (RS-232)

3.3.6 Guidance Controller Power Requirements and Management

The machine power system shall provide at least 2 A of direct current at 9-16 VDC power to the guidance controller while it is in the active state to ensure its full functionality. In the range of 5.5-9 VDC the Guidance Controller ECU will only work with limited functionality, in which case the cellular modem, Bluetooth and gyro will not work. The Guidance Controller ECU comes with a specified overvoltage protection of up to 26 VDC for duration of 5 minutes and reverse polarity protection down to -16 VDC for 5 minutes. A 5 Amp fuse shall be installed in the power line to Guidance Controller.

The state (active/inactive) of the guidance controller shall be controlled by the state of the ignition key and the maximum amount of power that it is allowed to consume after the ignition key is switched to the off position.

The guidance controller shall be powered directly from the machine main battery power; it shall be active when the ignition key is switched to the on position. Once the ignition key is switched to the off position, it will measure its power consumption and shall transition to the inactive state once its power consumption reaches the programmed threshold.

3.3.7 Machine Communication Busses Power Management

3.3.7.1 Implement Bus (ISO11783)

Power requirements and management shall be compliant with all the requirements specified in the AGCO ISOBUS-Ready specification

3.3.7.2 Valve Bus (J1939)

The Valve Bus shall be active when the ignition key is in the ON position and inactive when the ignition key is in the OFF position.

3.3.7.2.1 Valve Bus diagnostics power

Valve Bus J1939 shall not provide power to any component connected to its network. Components connected to the Valve Bus shall be responsible for acquiring their power input from an internal source.

3.3.7.3 GD BUS

The GD BUS shall be active when the ignition key is in the ON position and inactive when the ignition key is in the OFF position.

3.3.7.3.1 GD Bus diagnostics power

AGCO Proprietary GD Bus shall not provide power to any diagnostics component connected to its network. Diagnostics components connected to the AGCO Proprietary GD Bus shall be responsible for acquiring their power from an internal source.

3.4 Mechanical Requirements

3.4.1 Steering System Performance

The machine steering system shall spend less than 7.5 ms to achieve each curvature delta. For example, the steering system shall spend less than 750 ms if it is desired to change the curvature from 60 km^{-1} to 160 km^{-1}. A normalized line (line with a slope of 7.5 ms/curvature created from a range of curves) showing current measured performance of steering curvature versus time is shown in the graph in Figure 21.

For a given curvature on the x axis of the graph, a corresponding time to reach a commanded curvature shall be in the area shown in green (Green Zone). Steering response times in the Red Zone above the 7.5 ms/curvature are not allowed. The graph shows the absolute value for curvature response time and applies to both right and left turns. Machines with forward and reverse drive capability (i.e. TwinTrac and Reverse Station) shall have the same steering performance for both steering configurations.

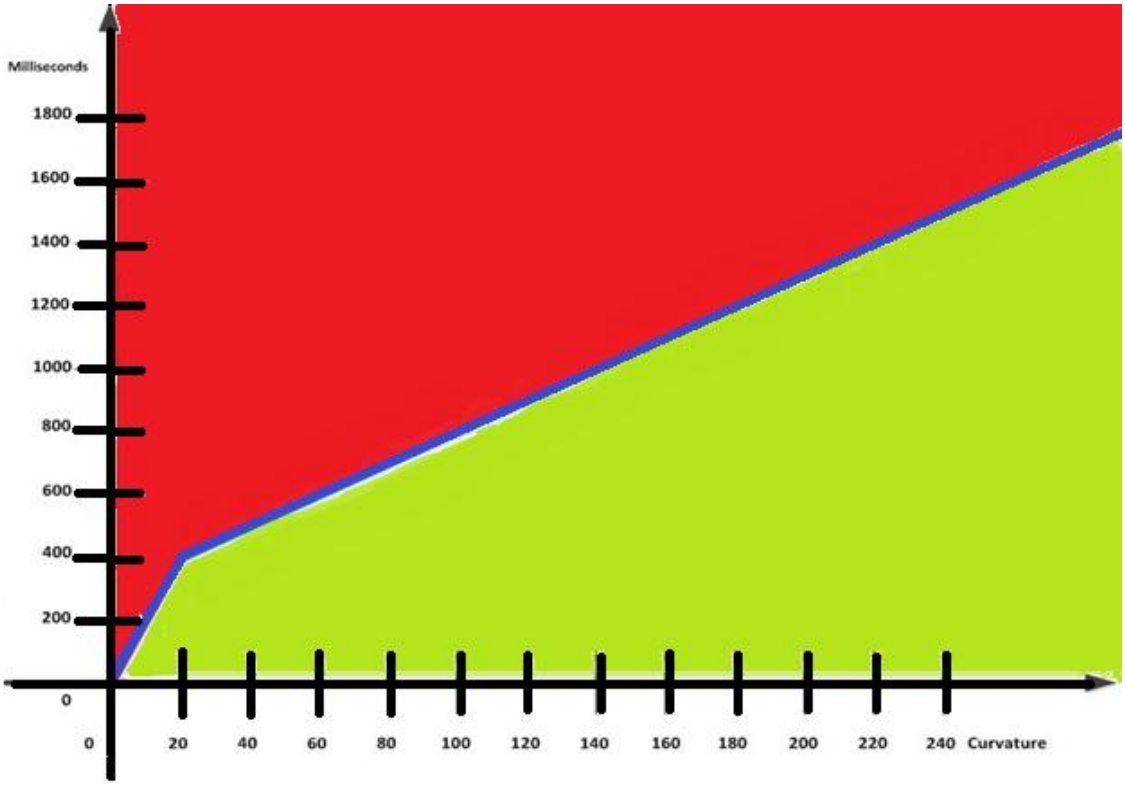


Figure 21: Steering System Performance

3.4.2 AGCO Native Guidance System Mounting

The Native Guidance System team should be involved during the integration of the Native Guidance System into the different machines. Sites shall be responsible for complying with maximum vehicle height regulations for countries to which guidance-equipped vehicles are to be delivered.

3.4.2.1 Guidance Controller ECU

The Guidance Controller ECU shall be mounted in a work accessible location inside the vehicle cab. Work accessible location is defined as a location that meets the following criteria:

- A location that allows for free range of movement in the performance of installation, service or SIM card removal tasks.
- A location that does not interfere with normal operator movement.
- A location that does not negatively restrict system performance.

The Guidance Controller ECU (VD03) is equipped with several wireless communication interfaces (i.e. Bluetooth and 2G/3G). Metal shielding (e.g. a Falling Object Protection Structure (FOPS)) may impair or block these wireless communication paths. If shielding is necessary, the external Cellular Antenna shall be placed properly to bypass the metal shielding. When the

VD03 is installed on a mounting plate, the range of Bluetooth communication below the plate will be reduced to 3 meters. Likewise, when the VD03 is protected by a metal shield, the range of Bluetooth communication will be reduced to 3 meters in all directions.

3.4.2.1.1 Distance to the GNSS Receiver

The distance between the Guidance Controller and the GNSS receiver should not exceed 2 linear meters to ensure adequate data transmission.

3.4.2.1.2 Center of Mass

It is recommended that the Guidance Controller be located nearest the center of mass of the machine.

3.4.2.1.3 Guidance Controller Normality

The Guidance Controller, which has an integrated IMU, shall be mounted either perpendicular or parallel to the travel direction of the vehicle (X axis), but never at an angle with respect to the travel direction (X axis) as shown in Figure 22.

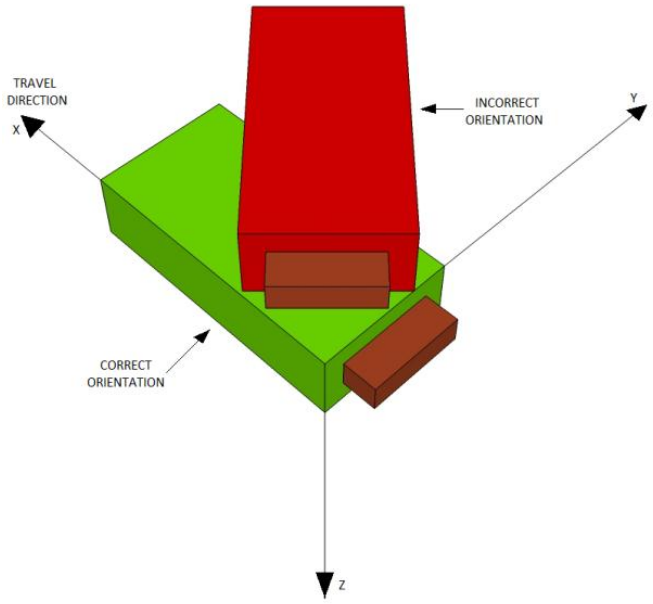


Figure 22: Orientation of Guidance Controller

3.4.2.2 GNSS Antenna

All satellite-based signals propagate by line-of-sight, which means that GNSS Antenna must have an unobstructed line of sight to the sky; such a clear view allows the antenna to track the maximum number of satellites. Installations with obstructed views may experience multipath, reduced reception quality and may not be able to track the maximum number of satellites.

Therefore, in order to achieve the best positioning performance, the GNSS Antenna shall be mounted on the highest stabilized unobstructed point of the vehicle along the X axis (Y = 0) (see Figure 23). The objective is to see the horizon freely through 360° with a vertical observation of 5° to 90° above the horizon.

As the received GNSS signal is very sensitive to noise and interference generated by other onboard transmitters, it shall be ensured that the GNSS Antenna is placed as far away as possible from any radar (if available) and that the GPS antenna is free from direct view of the radar beam. It is also important that the MF/HF and other VHF transmitter antennas are kept as far away as possible from the GNSS Antenna.

In case of an external GNSS Antenna, antenna cabling should be of an appropriate quality, with properly fitted coaxial connectors. Sharp bends, kinks and unnecessary connections should be avoided. Additionally, antenna cables should be kept separate from other cables which may cause electrical interference, for example, power cables and radio transmitter cables.

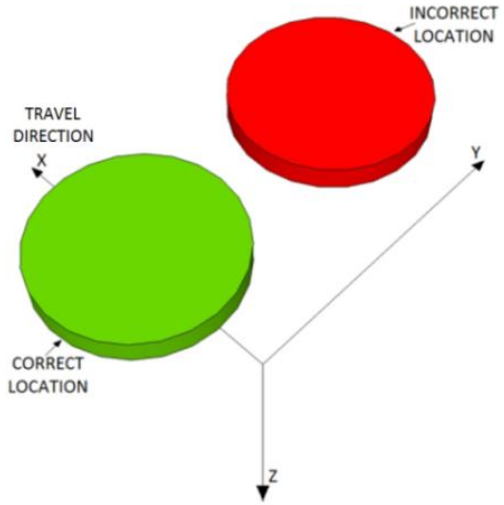


Figure 23: GNSS Antenna Location

3.4.2.3 Radio Modem

The CEA Guide Radio Antenna shall be mounted on a stabilized point of the vehicle such that radio signal reception is not inhibited. The distance between the Radio Modem and the Radio Antenna shall not exceed 2 meters.

3.4.3 Topcon AGI-4 Guidance System Mounting

Topcon AGI-4 Guidance Systems shall be mounted on the highest stabilized point of the vehicle using the AGCO standard bracket (KIT-AGI-4 ROOF MOUNT) for mounting 3rd Party Guidance Systems.

3.4.4 AGCO GNSS Unit Mounting Bracket

Sites shall design their GNSS Unit mounting bracket considering their machine characteristics. These brackets shall support all approved GNSS Units compatible with the AGCO Native Guidance System. The list of approved GNSS receivers is defined in the AGCO Native Guidance System Specification.

3.4.5 Guidance Interface Connector Location

In order to mount the Native Guidance System GNSS Unit or the Topcon AGI-4 Guidance System on the highest stabilized unobstructed point of the vehicle (see section 3.4.2.2), the Guidance Interface Connector shall be located in one of the following locations:

- Near the machine sunroof (if available) inside the cab
- On the cab roof interfacing with the outside
- On top of the grain tank

Appendix A gives examples of possible mounting configurations of the guidance components.

3.5 Documentation Requirements

3.5.1 Documentation Process

Manufacturing sites shall establish and maintain records to provide evidence of conformity to the requirements specified in this document. Records shall remain legible, readily identifiable and retrievable.

Manufacturing sites shall ensure that the Native Guidance Development Team has access to documentation (e.g. drawings, part lists, specifications, Steering Controller Task implementation, etc.) of all vehicle implementations designed to comply with the requirements specified in this document. The documentation can be in any form or type of medium. Guidance-related documentation shall be controlled by the sites.

Where implementations designed to comply with the requirements specified in this document are changed, sites shall ensure that relevant documents are amended and the Native Guidance System Development Team is aware of the changed implementations.

3.5.2 AGCO “Guide-Ready” Vehicles Tracking Sheet

For future system maintenance, the Guidance Development Team needs to know what vehicle types the Native Guidance System has been installed on. Therefore, sites shall provide the Guidance Development Team a list of the different types of ‘Guide-Ready’ machines produced at the sites. The list shall include portions of the Guidance Configuration Data stored in the non-volatile memory along with the VIN number format and the version of this document

these machines are compliant to. The template for recording the information can be found in Appendix D.

4 REFERENCED DOCUMENTS

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5 REVISION HISTORY

Table 8 Revision History

Version	Date	Author(s)	Comment
0.1	2012-04-13	Nick Hesse	Initial creation
0.2	2013-03-18	Paul Matthews	First Complete Definition
0.3	2013-08-09	Diego Diaz diego.diaz@agcocorp.com Keith Johnson keith.johnson@agcocorp.com Tobias Nothdurft tobias.nothdurft@agcocorp.com Theo Vogler theo.vogler@agcocorp.com	First Draft for Global Review
0.4	2013-10-22	Diego Diaz diego.diaz@agcocorp.com Keith Johnson keith.johnson@agcocorp.com Tobias Nothdurft tobias.nothdurft@agcocorp.com Theo Vogler theo.vogler@agcocorp.com	Second Draft for Global Review
1.0	2013-12-04	Diego Diaz diego.diaz@agcocorp.com Keith Johnson keith.johnson@agcocorp.com Tobias Nothdurft tobias.nothdurft@agcocorp.com Theo Vogler theo.vogler@agcocorp.com	Initial Release

APPENDIX A. GUIDANCE ELECTRICAL SCHEMATICS

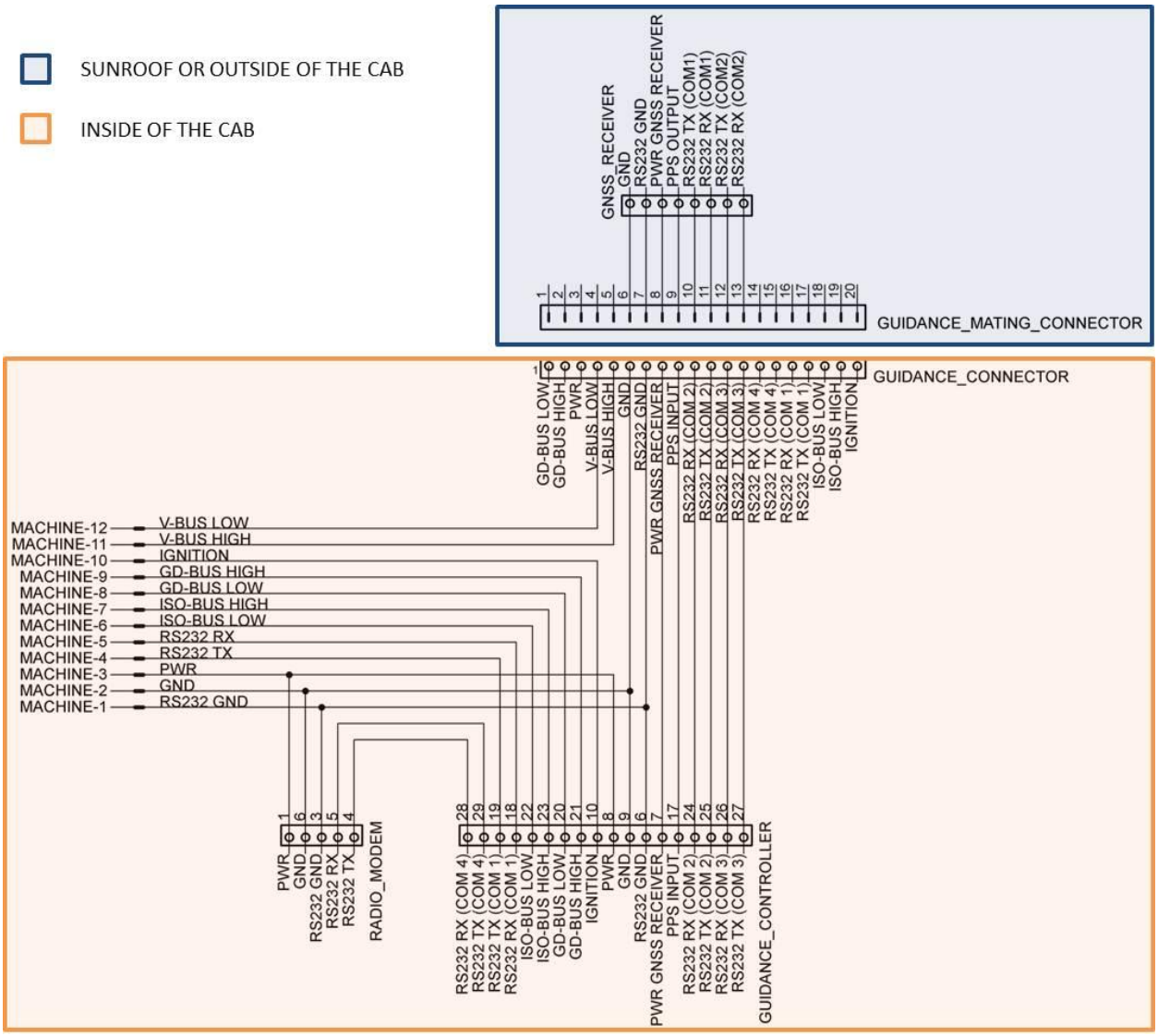


Figure A1. Native Guidance System electrical schematic and component location (GNSS Unit on the sunroof or outside the cab)

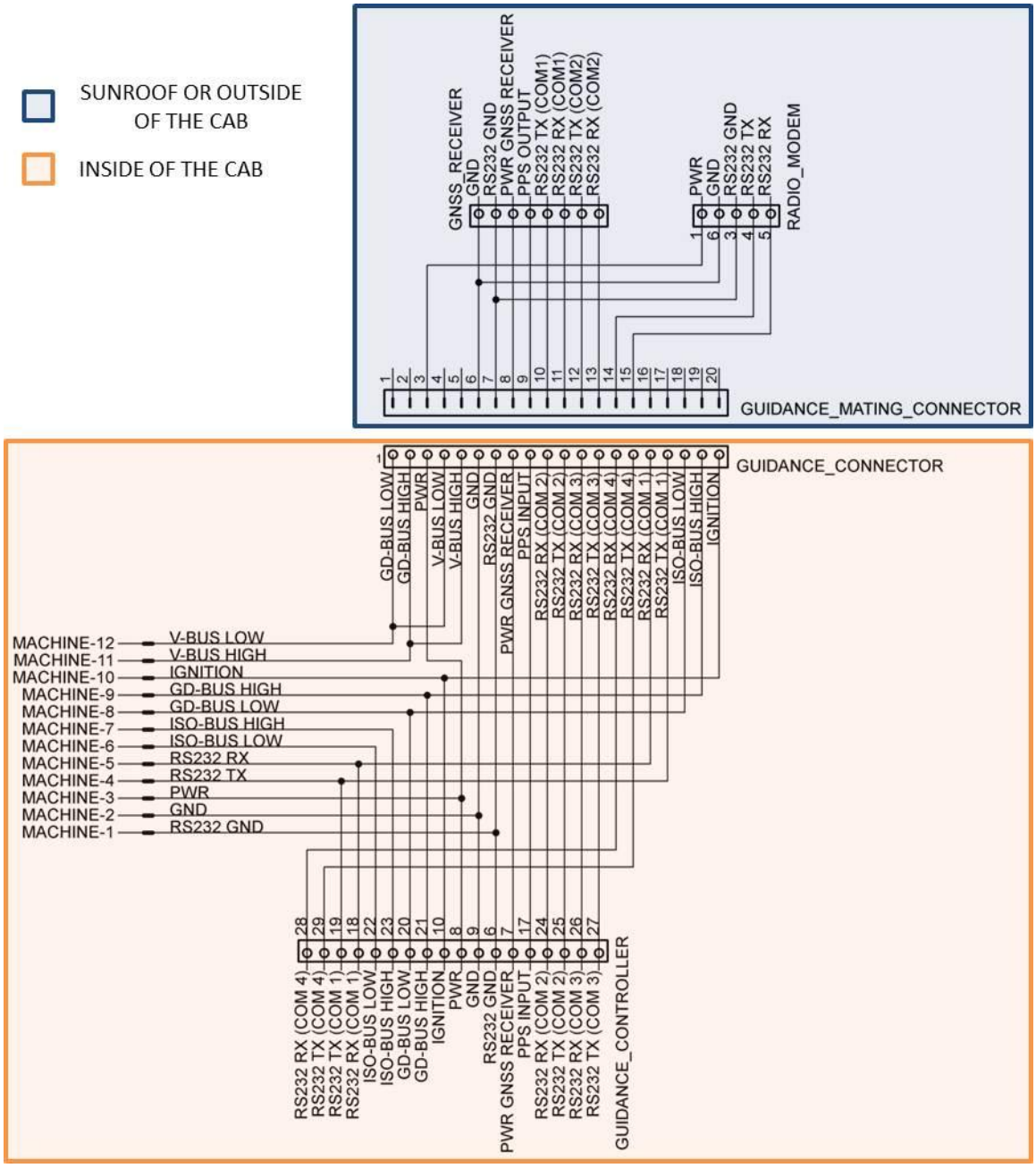


Figure A2. Native Guidance System electrical schematic and component location (GNSS Unit and Radio Modem on the sunroof or outside the cab)

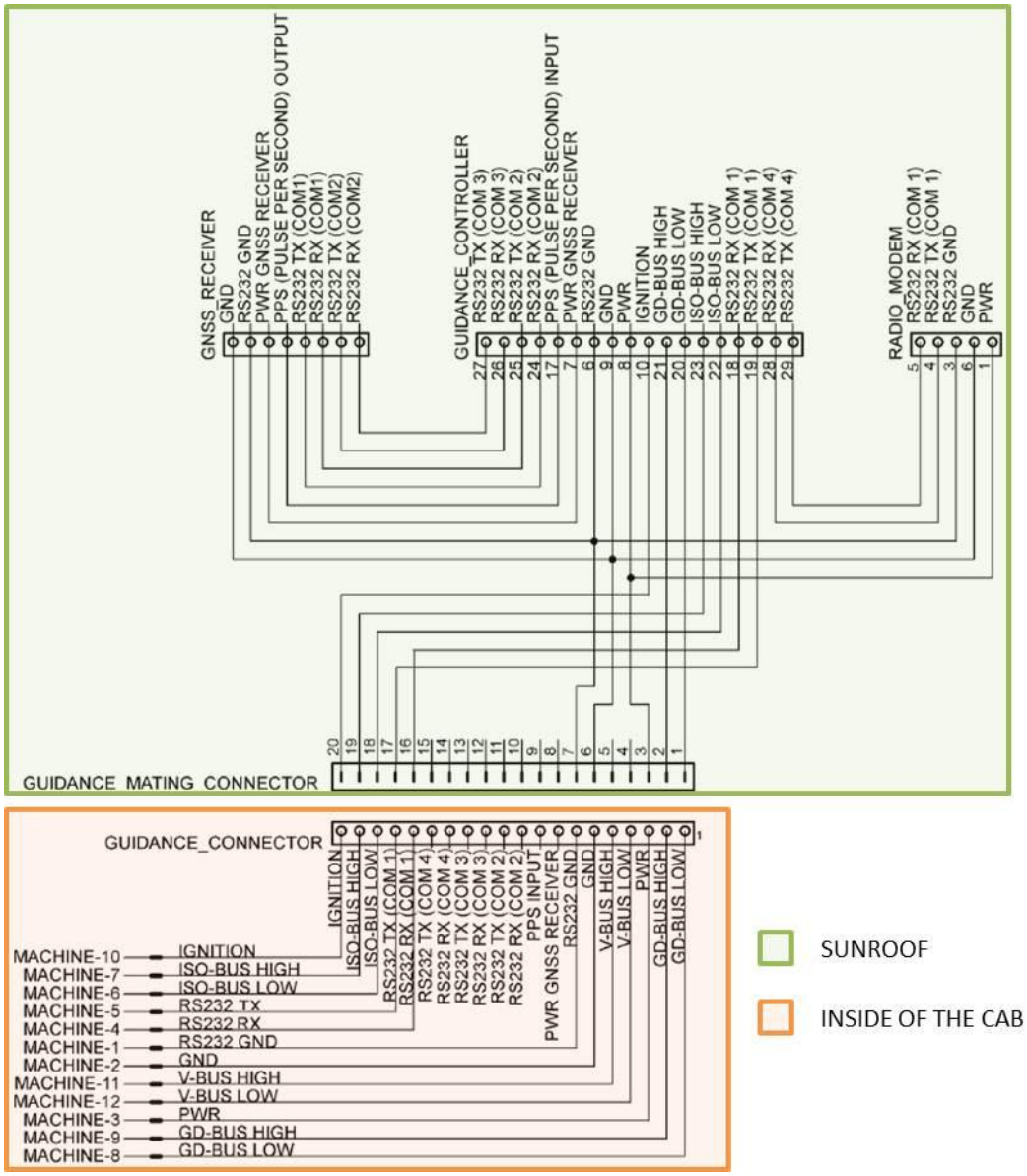


Figure A3. Native Guidance System electrical schematic and component location (GNSS Unit, Radio Modem and Guidance Controller ECU on the sunroof) (Option 1)

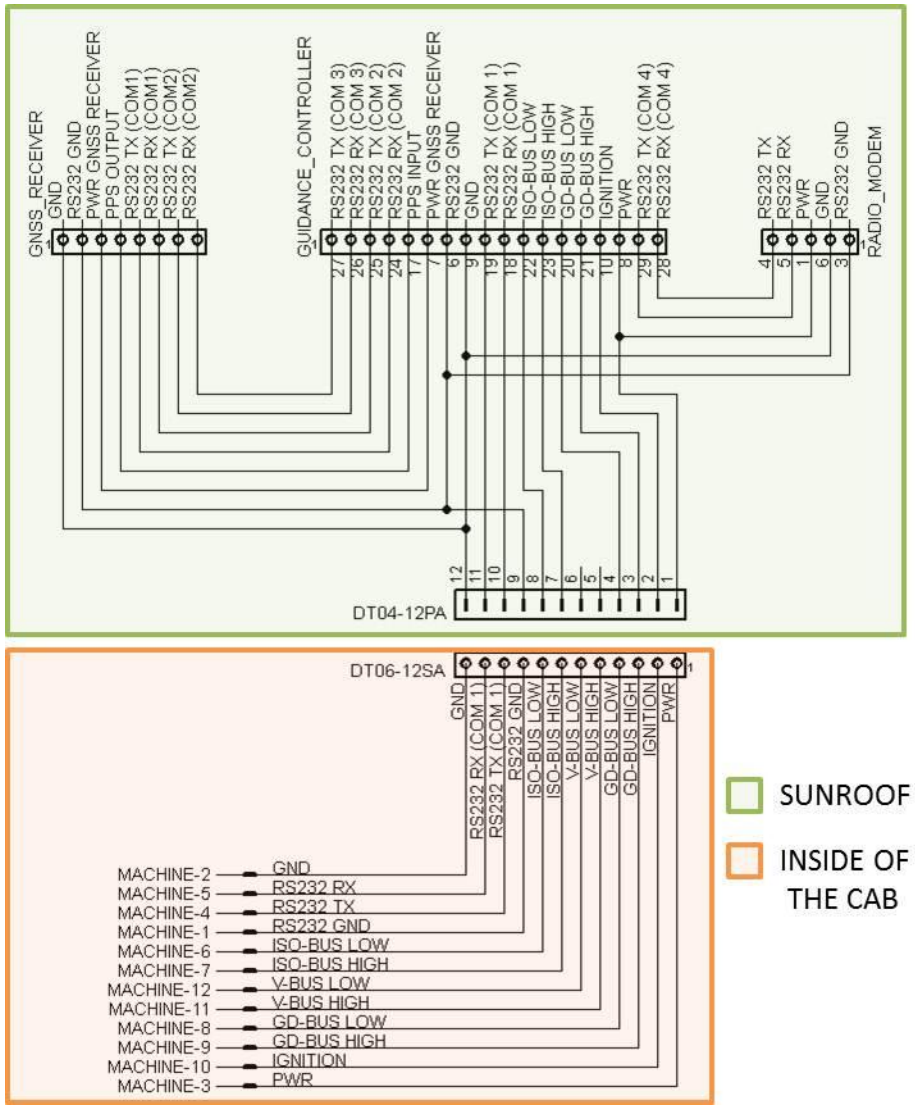


Figure A4. Native Guidance System electrical schematic and component location (GNSS Unit, Radio Modem and Guidance Controller ECU on the sunroof) (Option 2)

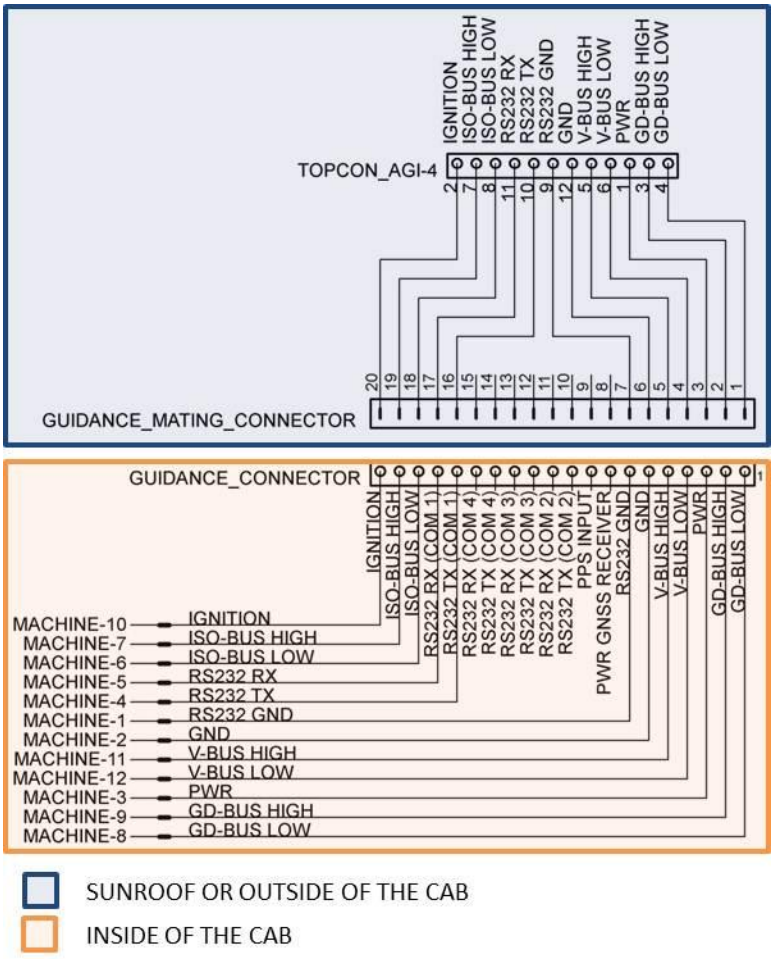
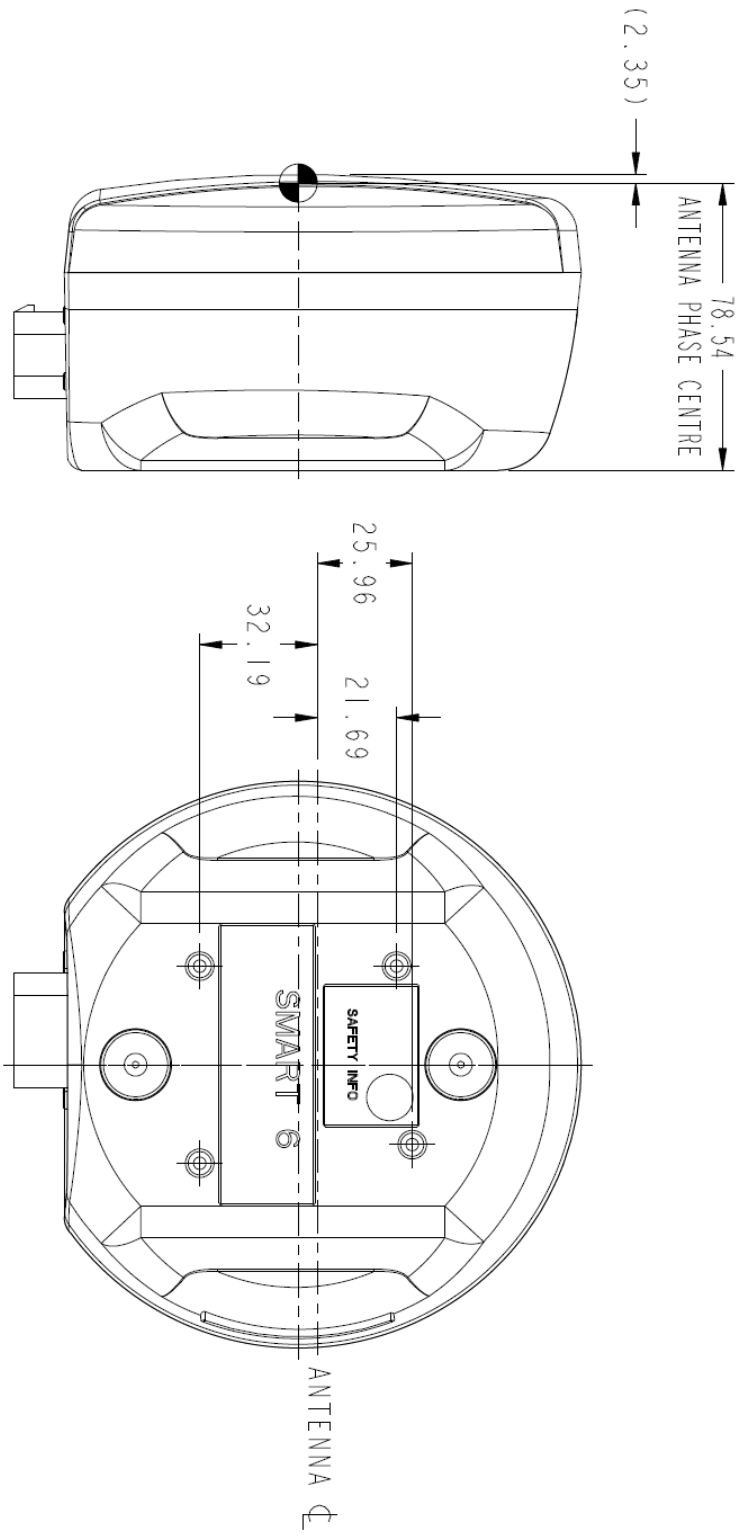


Figure A5. Topcon AGI-4 Guidance System electrical schematic and component location

APPENDIX B. NOVATEL SMART6 ANTENNA PHASE CENTER



APPENDIX C. VEHICLE GUIDANCE CONFIGURATION DATA LAYOUT

Reference: The memory layout below corresponds to version 1.0 of the file that defines parameters and data relative to Native Guidance System (CEA_Guide_Memory_Layout_V1.0.xls). Please contact the authors of this document (listed in Section 5) for the latest version of the memory layout file.

Name (EEEP_ADR_CEA_GUIDE_...)	Address Offset (hex)	Length (byte)	Data Type	Min	Max	Default	Factor	Unit	Comment
Version									
VERSION_LAYOUT_MAJOR	0	2	UINT16	1	1	1	-	-	Major version of the Vehicle Guidance Configuration Data layout: This value shall be increased when entries are moved and/or deleted
VERSION_LAYOUT_MINOR	2	2	UINT16	0	0	0	-	-	Minor version of the Vehicle Guidance Configuration Data layout: This value shall be increased when new entries are added
VERSION_GRS_MAJOR	4	2	UINT16	1	1	1	-	-	Major version of the implemented Guide-Ready Standard
VERSION_GRS_MINOR	6	2	UINT16	0	0	0	-	-	Minor version of the implemented Guide-Ready Standard
VERSION_RESERVED	8	10	UINT16	0	0	0	-	-	Reserved field for future "Version" parameters
VERSION_CHECKSUM	12	2	UINT16				-	-	CRC checksum of "Version" fields. Checksum shall be calculated over all "Version" fields including those currently not in use to support forward compatibility!
Vehicle Type									
BRAND	14	2	UINT16	0	5	0	-	-	0=Unspecified, 1=Fendt, 2=MF, 3=Valtra, 4=Challenger, 5=Santal
MANUFATURING_LOCATION	16	2	UINT16	0	10	0	-	-	0=Hesston, 1=Jackson, 2=Canoas, 3=Mogi das Cruzes, 4=Santa Rosa, 5=Riberao Preto, 6=Marktoberdorf, 7=Hohenmölsen, 8=Soulathi, 9=Breganze, 10=Grubbenvorst, 11=Beauvais
MODEL	18	10	ASCII				-	-	Model name to determine the exact vehicle type together with the Brand ID: 527…530 = Fendt X1015 (with different engine power)
TYPE	22	2	UINT16	0	8	0	-	-	0=Unspecified, 1=Tractor, 2=Track Tractor, 3=Combine,

									4=SPFH, 5=AED, 6=Sprayer, 7=Windrower, 8=Sugar Cane Harvester
VIN	24	17	ASCII				-	-	Vehicle Identification Number; Coding goes along with SAE J1939-71 JAN2008 / SPN 237
VEHICLE_TYPE_RESERVED	35	25	UINT16	0	0	0	-	-	Reserved field for future "Vehicle Type" parameters
VEHICLE_TYPE_CHECKSUM	4E	2	UINT16				-	-	CRC checksum of "Vehicle Type" fields. Checksum shall be calculated over all "Vehicle Type" fields including those currently not in use to support forward compatibility!
Vehicle Geometry									
REFERENCE_POINT_HEIGHT	50	2	UINT16	0	65535	0	0.001	m	Height above ground level (variable, set by terminal)
REFERENCE_POINT_HEIGHT_BACKUP	52	2	UINT16	0	65535	0	0.001	m	Height above ground level (backup for factory reset)
SECONDARY_AXLE_OFFSET	54	2	INT16	-32768	32767	0	0.001	m	Offset to non-Reference Point Axle
THIRD_AXLE_OFFSET	56	2	INT16	-32768	32767	0	0.001	m	Offset to third axle if existing; 0 = non existing
FRONT_CONTROL_POINT_X_OFFSET_HITCH	58	2	INT16	-32768	32767	0	0.001	m	Offset between front three-point hitch and reference point; 0 = non existing
FRONT_CONTROL_POINT_X_OFFSET_TOWED	5A	2	INT16	-32768	32767	0	0.001	m	Offset between front tow hitch and reference point; 0 = non existing
REAR_CONTROL_POINT_X_OFFSET_HITCH	5C	2	INT16	-32768	32767	0	0.001	m	Offset between rear three-point hitch and reference point; 0 = non existing
REAR_CONTROL_POINT_X_OFFSET_TOWED	5E	2	INT16	-32768	32767	0	0.001	m	Offset between rear tow hitch and reference point; 0 = non existing
GNSS_RECEIVER_X_OFFSET	60	2	INT16	-32768	32767	0	0.001	m	Offset between GNSS antenna phase center and reference point (variable, set by terminal)
GNSS_RECEIVER_Y_OFFSET	62	2	INT16	-32768	32767	0	0.001	m	
GNSS_RECEIVER_Z_OFFSET	64	2	INT16	-32768	32767	0	0.001	m	
GNSS_RECEIVER_X_OFFSET_BACKUP	66	2	INT16	-32768	32767	0	0.001	m	Offset between GNSS antenna phase center and reference point (backup for factory reset)
GNSS_RECEIVER_Y_OFFSET_BACKUP	68	2	INT16	-32768	32767	0	0.001	m	
GNSS_RECEIVER_Z_OFFSET_BACKUP	6A	2	INT16	-32768	32767	0	0.001	m	
VD03_X_OFFSET	6C	2	INT16	-32768	32767	0	0.001	m	Offset between center of VD03 ECU and reference point
VD03_Y_OFFSET	6E	2	INT16	-32768	32767	0	0.001	m	
VD03_Z_OFFSET	70	2	INT16	-32768	32767	0	0.001	m	
VD03_ORIENTATION	72	2	UINT16	0	7	0	-	-	Orientation of VD03 ECU; aligned to … 0=x axis (connector facing negative x direction), 1=y axis, 2=negative x axis, 3=negative y axis, 4=x axis, 5=y axis, 6=negative x axis, 7=negative y axis; 0…3=bottom facing downwards, 4…7=bottom facing upwards
TURNING_PIVOT_X_OFFSET	74	2	INT16	-32768	32767	0	0.001	m	X offset between turning pivot and reference point.

TRACK_WIDTH	76	2	UINT16	0	65535	0	0.001	m	From center to center of wheels or tracks of the Reference Point Axle (variable, set by terminal)
TRACK_WIDTH_BACKUP	78	2	UINT16	0	65535	0	0.001	m	From center to center of wheels or tracks of the Reference Point Axle (backup for factory reset)
ADDITIONAL_WORKING_HEIGHT	7A	2	UINT16	0	65535	0	0.001	m	Additional height of a sprayer when in field mode
VEHICLE_GEOMETRY_RESERVED	7C	54	UINT16	0	0	0	-	-	Reserved field for future "Vehicle Geometry" parameters
VEHICLE_GEOMETRY_CHECKSUM	B2	2	UINT16				-	-	CRC checksum of "Vehicle Geometry" fields. Checksum shall be calculated over all "Vehicle Geometry" fields including those currently not in use to support forward compatibility!
Vehicle Dynamics									
AUTO_LEVELING_SYSTEM	B4	2	UINT16	0	2	0	-	-	0=No ALS Installed, 1=Roll Compensating ALS Installed, 2=Roll&Pitch Compensating ALS Installed
MIN_FORWARD_SPEED	B6	2	UINT16	0	7778	27	0.001	m/s	Minimum allowed forward speed. Driving slower in forward direction will deactivate the guidance system.
MIN_BACKWARD_SPEED	B8	2	UINT16	0	7778	27	0.001	m/s	Minimum allowed backward speed. Driving slower in reverse direction will deactivate the guidance system.
MAX_FORWARD_SPEED	BA	2	UINT16	0	7778	7778	0.001	m/s	Maximum allowed forward speed. Driving faster in forward direction will deactivate the guidance system.
MAX_BACKWARD_SPEED	BC	2	UINT16	0	7778	7778	0.001	m/s	Maximum allowed backward speed. Driving faster in reverse direction will deactivate the guidance system.
MAX_CURVATURE	BE	2	UINT16	0	65535	0	0.25	1/km	Maximum curvature of the vehicle. Coding goes along with ISO 11783-7:2009 chapter A 28.1
MAX_STEERING_ANGLE_CHARACTERISTICS_X1	C0	2	UINT16	0	65535	65535	0.001	m/s	X value (speed) for 1st sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_Y1	C2	2	UINT16	0	65535	65535	0.25	1/km	Y value (curvature) for 1st sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_X2	C4	2	UINT16	0	65535	65535	0.001	m/s	X value (speed) for 2nd sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_Y2	C6	2	UINT16	0	65535	65535	0.25	1/km	Y value (curvature) for 2nd sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_X3	C8	2	UINT16	0	65535	65535	0.001	m/s	X value (speed) for 3rd sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_Y3	CA	2	UINT16	0	65535	65535	0.25	1/km	Y value (curvature) for 3rd sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_X4	CC	2	UINT16	0	65535	65535	0.001	m/s	X value (speed) for 4th sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_Y4	CE	2	UINT16	0	65535	65535	0.25	1/km	Y value (curvature) for 4th sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_X5	D0	2	UINT16	0	65535	65535	0.001	m/s	X value (speed) for 5th sampling point of steering curvature limitation curve
MAX_STEERING_ANGLE_CHARACTERISTICS_Y5	D2	2	UINT16	0	90	90	0.25	1/km	Y value (curvature) for 5th sampling point of steering curvature limitation curve
ENGAGED_TIME	D4	2	UINT16	0	65535	30	-	second	Time in second the system will stay activated during standstill: 0…65534 = time in sec.; 65535 (0xFFFF) = endless

MAX_LINE_ACQUISITION_ANGLE	D6	2	UINT16	5	90	60	-	degree	Maximum allowed angle offset between the vehicle heading and the planned trajectory
LINE_ACQUISITION_VIRTUAL_POSITION_FORWARD	D8	2	UINT16	0	20	0	-	m	Distance from the Navigation Reference Point (B) to a virtual position in front of the vehicle when driving forward. This virtual position is used for line acquisition. This value helps the Guidance System to identify the intended wayline during line acquisition. (0 = deactivated) Default value is 2.7 m in front of the front axle.
LINE_ACQUISITION_VIRTUAL_POSITION_BACKWARD	DA	2	INT16	-20	0	-3	-	m	Distance from the Navigation Reference Point (B) to a virtual position in the rear of the vehicle when driving backwards This virtual position is used for line acquisition. This value helps the Guidance System to identify the intended wayline during line acquisition. (0 = deactivated)
STEERING_SENSIVITY	DC	2	UINT16	100	2000	800	0.001	-	Steering controller aggressiveness during wayline following (factor)
DEAD_TIME_STEERING_VALVE	DE	2	UINT16	0	65535	0	0.001	second	Duration until the steering valve reached 90% of a 10° step in operating temperature driving at 10 kph
DEAD_TIME_ARRAY	E0	2	UINT16	1	20	2	-	-	FIFO buffer size for Smith predictor for dead time compensation
DIR_CORR_ACQUISITION	E2	2	UINT16	100	5000	800	0.001	-	This factor describes the weighting between distance and heading offset to the wayline during wayline acquisition. The higher this value is the higher is the resulting steering aggressiveness.
DIR_CORR_LINE	E4	2	UINT16	100	5000	1000	0.001	-	This factor describes the weighting between distance and heading offset to the wayline during wayline following. The higher this value is the higher is the resulting steering aggressiveness.
MAX_ANGLE_SPEED_LOW	E6	2	UINT16	0	65535	2222	0.001	m/s	MAX_ANGLE_SPEED_LOW is the lower speed limit for the adjustment of the controller values to the vehicle speed. Below this limit the values DIR_CORR_LINE and STEERING_SENSIVITY are used as they are and the maximum steering angle is not limited. If the vehicle speed is above MAX_ANGLE_SPEED_HIGH, the values MAX_DIR_CORR_HIGH and STEERING_SENSIVITY are multiplied with MAX_STEERING_SENSIVITY_HIGH and the maximum steering angle is limited to MAX_ANGLE_HIGH. For vehicle speeds between MAX_ANGLE_SPEED_LOW and MAX_ANGLE_SPEED_HIGH a linear interpolation of the value MAX_STEERING_SENSIVITY_HIGH is used (0% at MAX_ANGLE_SPEED_LOW and 100% at MAX_ANGLE_SPEED_HIGH). Also a linear interpolation is used for the limitation of the steering angle between the maximum steering angle and MAX_ANGLE_HIGH for speeds between MAX_ANGLE_SPEED_LOW and MAX_ANGLE_SPEED_HIGH.
MAX_ANGLE_SPEED_HIGH	E8	2	UINT16	0	65535	6111	0.001	m/s	See MAX_ANGLE_SPEED_LOW

MAX_ANGLE_HIGH	EA	2	UINT16	1	90	10	-	degree	Maximum allowed steering angle at a vehicle speed over MAX_ANGLE_SPEED_HIGH. This value is DEPRICATED and will be replaced by MAX_STEERING_ANGLE_CHARACTERISTICS!
MAX_SENSIVITY_HIGH	EC	2	UINT16	100	5000	1000	0.001	-	Factor for STEERING_SENSIVITY at a vehicle speed over MAX_ANGLE_SPEED_HIGH
MAX_DIR_CORR_HIGH	EE	2	UINT16	100	5000	450	0.001	-	Factor for DIR_CORR_LINE at a vehicle speed over MAX_ANGLE_SPEED_HIGH
MAX_VEHICLE_PAYLOAD	F0	2	UINT16	0	65535	0	-	kg	Maximum payload i.e. of the grain tank in case of a combine / of the tank in case of an applicator
VEHICLE_CURB_WEIGHT	F2	2	UINT16	0	65535	0	-	kg	Total weight of the machine with standard equipment, all necessary operating consumables (e.g., motor oil and coolant), a full tank of fuel, driver (75 kg) while not loaded with cargo.
VEHICLE_DYNAMICS_RESERVED	F4	64	UINT16	0	0	0	-	-	Reserved field for future "Vehicle Dynamics" parameters
VEHICLE_DYNAMICS_CHECKSUM	134	2	UINT16				-	-	CRC checksum of "Vehicle Dynamics" fields. Checksum shall be calculated over all "Vehicle Dynamics" fields including those currently not in use to support forward compatibility!

APPENDIX D. AGCO "GUIDE-READY" VEHICLES TRACKING SHEET TEMPLATE

VEHICLE TYPE	BRAND	MODEL	VIN FORMAT [Example: AGCC0645LDNGL1031]	MANUFACTURING LOCATION	RELEASE DATE	GRS VERSION COMPLIANCE

APPENDIX E. NATIVE GUIDANCE SYSTEM MESSAGE LIST (GD BUS)

Reference: The indexes listed below correspond to version 1.0 of the header file that incudes GD Indexes and data relative to Native Guidance communications (CEA_Guide_GD_Index_List8490_V1.0.h). Please contact the authors of this document (listed in section 5) for the latest version of the header file.

INDEX	SENDER	RECEIVER	PARAMETER	FREQUENCY
Guidance Controller				
16400	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_PATHTOPATHDISTANCE_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16402	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_LINKAGETYPE_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16403	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_LINKAGEFRONT_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16404	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_LINKAGEREAR_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16405	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_MINIMUMRADIUS_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16406	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_OFFSET_SETOFFSET_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16407	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_OFFSET_SETWORKINGWIDTH_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16408	Guidance Controller	Terminal	GD_ID_CEAG_IMPLEMENT_OFFSET_STATUS_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16416	Terminal	Guidance Controller	GD_ID_CEAG_COMMUNICATION_COMMAND_W	Immediate Write
16417	Guidance Controller	Terminal	GD_ID_CEAG_COMMUNICATION_COMMAND_STATUS_R	On Change
16432	Guidance Controller	Terminal	GD_ID_CEAG_PATH_DATA_BLKRW	On Request
	Terminal	Guidance Controller		Immediate Write
16435	Guidance Controller	Terminal	GD_ID_CEAG_PATH_AB_ANGLE_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16436	Guidance Controller	Terminal	GD_ID_CEAG_PATH_AB_DISTANCE_R	On Change
16439	Guidance Controller	Terminal	GD_ID_CEAG_PATH_PIVOT_CENTERPOINT_ACCURACY_R	On Change
16441	Guidance Controller	Terminal	GD_ID_CEAG_PATH_SEGMENT_ACTUAL_R	On Change
16442	Guidance Controller	Terminal	GD_ID_CEAG_PATH_NUMBER_ACTUAL_R	On Change

16443	Guidance Controller	Terminal	GD_ID_CEAG_PATH_LP_SLOPE_R	On Change
16444	Terminal	Guidance Controller	GD_ID_CEAG_PATH_DATA_ACKNOWLEDGE_R	Request
16445	Guidance Controller	Terminal	GD_ID_CEAG_PATH_SMOOTHING_RADIUS_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16448	Guidance Controller	Terminal	GD_ID_CEAG_NUDGEOFFSET_MANUAL_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16448	Guidance Controller	Terminal	GD_ID_CEAG_NUDGEOFFSET_TOTAL_R	On Change
16450	Guidance Controller	Terminal	GD_ID_CEAG_OFFSET_NORTH	On Change
16451	Guidance Controller	Terminal	GD_ID_CEAG_OFFSET_EAST	On Change
16464	Guidance Controller	Terminal	GD_ID_CEAG_AUTOTURN_SETTINGS_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16465	Guidance Controller	Terminal	GD_ID_CEAG_AUTOTURN_DIMENSIONS_R	On Change
16466	Guidance Controller	Terminal	GD_ID_CEAG_AUTOTURN_STATUS_R	On Change
16471	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_POSITION_GNSS_R	On Change
16472	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_CORRECTION_R	On Change
16473	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_INERTIAL_R	On Change
16474	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_STEERING_SUBSYSTEM_R	On Change
16475	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_XTRK_R	On Change
16476	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_HEADINGTOWAYLINE_R	On Change
16477	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_VELOCITY_R	On Change
16478	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_CALIBRATION_R	On Change
16479	Guidance Controller	Terminal	GD_ID_CEAG_STATUSPAGE_SYSTEM_R	On Change
16480	Guidance Controller	Terminal	GD_ID_CEAG_STATUS_XTRK_R	On Change
16481	Guidance Controller	Terminal	GD_ID_CEAG_STATUS_HEADING_R	On Change
16482	Guidance Controller	Terminal	GD_ID_CEAG_STATUS_STEERING_R	On Change
16483	Guidance Controller	Terminal	GD_ID_CEAG_STEERING_SENSITIVITY_LINEACQUISITION_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16484	Guidance Controller	Terminal	GD_ID_CEAG_STEERING_SENSITIVITY_ONLINE_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16485	Guidance Controller	Terminal	GD_ID_CEAG_SYSTEM_STANDBYTIME_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16486	Guidance Controller	Diagnostic	GD_ID_CEAG_SYSTEM_POWERSUPPLY_INPUT_R	On Change
16487	Guidance Controller	Diagnostic	GD_ID_CEAG_SYSTEM_POWERSUPPLY_OUTPUT_R	On Change
16488	Guidance Controller	Terminal	GD_ID_CEAG_SYSTEM_ALTITUDE_GEOIDAL_SEPARATION_R	On Change
16489	Guidance Controller	Terminal	GD_ID_CEAG_STEERING_DISENGAGE_REASON_R	On Change
16496	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_GPS_SATVISIBLE_R	On Change

16497	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_GPS_SATUSED_R	On Change
16498	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_GLONASS_SATVISIBLE_R	On Change
16499	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_GLONASS_SATUSED_R	On Change
16500	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_GALILEO_SATVISIBLE_R	On Change
16501	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_GALILEO_SATUSED_R	On Change
16503	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_VALIDPOSITION_R	On Change
16504	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_POSITION_ACTUAL_BLKR	Onetime
16505	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_DOP_R	On Change
16506	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_TIME_HOURMINUTE_R	On Change
16507	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_TIME_SECOND_R	On Change
16508	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_ANTENNA_INSTALLATION_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16509	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_VELOCITY_R	On Change
16510	Guidance Controller	Terminal	GD_ID_CEAG_GNSS_DISTANCE_R	On Change
16519	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_ROAMING_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16520	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_DUHF2_CHANNELSPACING_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16521	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_DUHF2_PROTOCOL_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16522	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_DUHF2_ERRORCORRECTION_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16523	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_FH915_CHANNEL_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16524	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_FH915_LOCATION_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16525	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_FH915_NETWORKID_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16526	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_OMNISTAR_FREQUENCY_HIGH_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16527	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_OMNISTAR_FREQUENCY_LOW_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16528	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_TYPE_SELECTED_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16529	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_OMNISTAR_BAUDRATE_RW	On Change
	Terminal	Guidance Controller		Immediate Write

16530	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_VBS_EXPIRYDATE_DAYMONTH_R	On Change
16531	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_BARGRAPH_R	On Change
16532	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_VBS_EXPIRYDATE_YEAR_R	On Change
16533	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_HP_XP_EXPIRYDATE_DAYMONTH_R	On Change
16535	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_HP_XP_EXPIRYDATE_YEAR_R	On Change
16536	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_STATUS_R	On Change
16537	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_OMNISTAR_SERIALNUMBER_HIGH_R	On Change
16538	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_OMNISTAR_SERIALNUMBER_LOW_R	On Change
16539	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_AGCO_CHANNEL_RW	On Change
16540	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_AGCO_FREQUENCY_HIGH_R	On Change
16541	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_AGCO_FREQUENCY_LOW_R	On Change
16542	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_AGCO_RADIOTYPE_R	On Change
16543	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_EXTERNAL_SERIALINTERFACE_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16544	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_RADIOINSTALLATION_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16545	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_AGCO_CORRECTIONFORMAT_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16546	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_EXTERNAL_CORRECTIONFORMAT_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16547	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_GPS_SATVISIBLE_R	On Change
16548	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_GPS_SATUSED_R	On Change
16549	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_GLONASS_SATVISIBLE_R	On Change
16550	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_GLONASS_SATUSED_R	On Change
16551	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_GALILEO_SATVISIBLE_R	On Change
16552	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_GALILEO_SATUSED_R	On Change
16553	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_RADIO_CONFIGURABLE_R	On Change
16554	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTK_BASELINE_R	On Change
16555	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_SIGNALLAG_R	On Change
16556	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_FALLBACK_RW	On Change

	Terminal	Guidance Controller		Immediate Write
16557	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_ACCURACY_GNSSANTENNA_R	On Change
16558	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_ACCURACY_VEHICLEREFERENCEPOINT_R	On Change
16559	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_AUTHORISATIONLEVEL_R	On Change
16560	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GSM_NUMBER_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16561	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GSM_PIN_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16562	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_CORRECTIONFORMAT_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16563	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_ACCESSPOINT_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16564	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_IPADDRESS_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16565	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_PORT_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16566	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_MOUNTPOINT_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16567	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_USERNAME_CONNECTIONPOVIDER_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16568	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_PASSWORD_CONNECTIONPROVIDER_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16569	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_NMEA_DATA_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16570	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_TYPE_ACTUAL_R	On Change
16571	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_USERNAME_SIGNALPROVIDER_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16572	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_PASSWORD_SIGNALPROVIDER_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16573	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GSM_GPRS_CONNECTION_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16574	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_GPRS_PIN_BLKRW	On Change
	Terminal	Guidance Controller		Immediate Write
16575	Guidance Controller	Terminal	GD_ID_CEAG_CORRECTIONSIGNAL_RTKNETWORK_MODE_RW	On Change
	Terminal	Guidance Controller		Immediate Write

16576	Guidance Controller	Terminal	GD_ID_CEAG_NMEA_SERIALINTERFACE_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16579	Guidance Controller	Terminal	GD_ID_CEAG_NMEA_DATA_1_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16580	Guidance Controller	Terminal	GD_ID_CEAG_NMEA_DATA_2_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16581	Guidance Controller	Terminal	GD_ID_CEAG_NMEA_DATA_3_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16582	Guidance Controller	Terminal	GD_ID_CEAG_NMEA_DATA_4_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16583	Guidance Controller	Terminal	GD_ID_CEAG_NMEA_DATA_5_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16584	Guidance Controller	Terminal	GD_ID_CEAG_NMEA_OUTPUT_RW	On Change
	Terminal	Guidance Controller		Immediate Write
16606	Guidance Controller	Terminal	GD_ID_CEAG_SENSOR_IMU_ROLL_R	On Change
16607	Guidance Controller	Terminal	GD_ID_CEAG_SENSOR_IMU_PITCH_R	On Change
16608	Guidance Controller	Terminal	GD_ID_CEAG_SENSOR_IMU_YAW_R	On Change
16609	Guidance Controller	Terminal	GD_ID_CEAG_SENSOR_IMU_MOUNTINGBIAS_R	On Change
16610	Guidance Controller	Terminal	GD_ID_CEAG_SENSOR_IMU_DHEADING_R	On Change
16611	Guidance Controller	Terminal	GD_ID_CEAG_SENSOR_IMU_WARMING_TIME_R	On Change
16612	Guidance Controller	Terminal	GD_ID_CEAG_CALIBRATION_TIME_R	On Change
16613	Guidance Controller	Terminal	GD_ID_CEAG_FA_KALIB_IMU_SET_R	On Change
16614	Guidance Controller	Terminal	GD_ID_CEAG_FA_KALIB_IMU_GET_W	Immediate Write
16640	Guidance Controller	Terminal	GD_ID_CEAG_ID_GNSS_ANTENNA_MODEL_BLKR	On Change
16641	Guidance Controller	Terminal	GD_ID_CEAG_ID_GNSS_ANTENNA_PSN_BLKR	On Change
16642	Guidance Controller	Terminal	GD_ID_CEAG_ID_GNSS_ANTENNA_HWVERSION_BLKR	On Change
16643	Guidance Controller	Terminal	GD_ID_CEAG_ID_GNSS_ANTENNA_SWVERSION_BLKR	On Change
16644	Guidance Controller	Terminal	GD_ID_CEAG_ID_GNSS_ANTENNA_BOOTVERSION_BLKR	On Change
16645	Guidance Controller	Terminal	GD_ID_CEAG_ID_GNSS_ANTENNA_COMPILE_DATE_BLKR	On Change
16646	Guidance Controller	Terminal	GD_ID_CEAG_ID_GNSS_ANTENNA_AUTHCODE_BLKW	Immediate Write
16650	Guidance Controller	Terminal	GD_ID_CEAG_ID_CORRECTIONSIGNAL_NTRIP_DELAY_R	On Change
16878	Guidance Controller	Terminal	GD_ID_CEAG_ERROR_ACKNOWLEDGE_W	Immediate Write
16895	Guidance Controller	Terminal / Dashboard	GD_ID_CEAG_LIFE_MSG	
Steering Controller				
12288	Steering Controller	Guidance Controller	GD_ID_SCT_ENABLE	On Change
	Guidance Controller	Steering Controller		Immediate Write

12289	Steering Controller	Terminal	GD_ID_SCT_MODUL_OUT_STATUS	On Change
12290	Data Exchange Node[7]	Steering Controller	GD_ID_SCT_MODUL_IN_STATUS	On Change
12298	Steering Controller	Terminal	GD_ID_SCT_STATUSDISPLAY_TERMINAL	On Change
12303	Steering Controller	Guidance Controller	GD_ID_SCT_TURNING_OFF_REASON	On Change
12304	Steering Controller	Guidance Controller	GD_ID_SCT_STATE	On Change
12305	Steering Controller	Terminal	GD_ID_SCT_VOTED_ACTIVE_CLASS_1	Immediate Write
	Terminal	Steering Controller		On Change
12306	Steering Controller	Terminal	GD_ID_SCT_VOTED_ACTIVE_CLASS_2	Immediate Write
	Terminal	Steering Controller		On Change
12314	Steering Controller	Guidance Controller	GD_ID_SCT_SETPOINT_CURVATURE_CEA_GUIDE	On Change
	Guidance Controller	Steering Controller		Immediate Write
12315	Steering Controller	TECU (ISO11783)	GD_ID_SCT_SETPOINT_CURVATURE_TIM	On Change
	TECU (ISO11783)	Steering Controller		Immediate Write
12316	Steering Controller	Tractor ECU (EXT)	GD_ID_SCT_SETPOINT_CURVATURE_FEELER_GUIDANCE	On Change
	Tractor ECU (EXT)	Steering Controller		Immediate Write
12320	Steering Controller	Diagnostic	GD_ID_SCT_WAS_RAW_VALUE	On Change
12321	Steering Controller	Diagnostic	GD_ID_SCT_WAS_SCALED_VALUE	On Change
12322	Steering Controller	Diagnostic	GD_ID_SCT_WAS_SENSOR_ANGLE	On Change
12323	Steering Controller	Diagnostic	GD_ID_SCT_WAS_MEDIAN_ANGLE	On Change
12324	Steering Controller	Diagnostic	GD_ID_SCT_WAS_MEDIAN_ANGLE_MAX	On Change
12325	Steering Controller	Diagnostic	GD_ID_SCT_WAS_VIRTUAL_ANGLE	On Change
12328	Steering Controller	Guidance Controller / Diagnostic	GD_ID_SCT_WAS_MEDIAN_CURVATURE	On Change
12329	Steering Controller	Guidance Controller / Diagnostic	GD_ID_SCT_WAS_MEDIAN_CURVATURE_MAX	On Change
12334	Terminal	Steering Controller	GD_ID_SCT_WAS_CALIB_COMMAND	Immediate Write
12335	Steering Controller	Terminal	GD_ID_SCT_WAS_CALIB_STATUS	On Change
12336	Steering Controller	Guidance Controller / Diagnostic	GD_ID_SCT_SWS_RAW_VALUE	On Change
12338	Steering Controller	Guidance Controller / Diagnostic	GD_ID_SCT_SWS_LIMITED_ANGLE	On Change
12339	Steering Controller	Guidance Controller /	GD_ID_SCT_SWS_CONTINUED_ANGLE	On Change

[7] The task of this GD Node is to gather all necessary information and to bundle it within this message. This message can only be sent by one node. When more than one node sends this message, the second node overwrites the information sent by the first node (see Section 2.1.1.1).

		Diagnostic		
12340	Steering Controller	Guidance Controller / Diagnostic	GD_ID_SCT_SWS_ROTATIONAL_SPEED	On Change
12352	Steering Controller	Diagnostic	GD_ID_SCT_VALVE_SETPOINT	On Change
12353	Steering Controller	Diagnostic	GD_ID_SCT_VALVE_POSITION	On Change
12366	Terminal	Steering Controller	GD_ID_SCT_VALVE_CALIB_COMMAND	Immediate Write
12367	Steering Controller	Terminal / Diagnostic	GD_ID_SCT_VALVE_CALIB_STATUS	On Change
12368	Steering Controller	Diagnostic	GD_ID_SCT_PILOTVALVE_STATUS	On Change
12388	Terminal	Steering Controller	GD_ID_SCT_OLAY_STEER_FACTOR	On Change
12544	Steering Controller	Terminal	GD_ID_SCT_MIN_SPEED_FORWARD	On Change
12545	Steering Controller	Terminal	GD_ID_SCT_MAX_SPEED_FORWARD	On Change
12546	Steering Controller	Terminal	GD_ID_SCT_MIN_MACHINE_RADIUS	On Change
12547	Steering Controller	Terminal	GD_ID_SCT_MAX_ACQUISITION_ANGLE	On Change
12560	Steering Controller	Guidance Controller	GD_ID_SCT_GUIDANCE_CONFIGURATION_DATA	On Request
12568	Steering Controller	Guidance Controller	GD_ID_SCT_STEERING_MODE	On Change
12569	Steering Controller	Diagnostic	GD_ID_SCT_SECONDARY_WAS_RAW_VALUE	On Change
12570	Steering Controller	Diagnostic	GD_ID_SCT_SECONDARY_WAS_SENSOR_ANGLE	On Change
12571	Steering Controller	Diagnostic	GD_ID_SCT_SECONDARY_WAS_MEDIAN_ANGLE	On Change
12572	Steering Controller	Diagnostic	GD_ID_SCT_SECONDARY_WAS_MEDIAN_ANGLE_MAX	On Change
12573	Steering Controller	Guidance Controller	GD_ID_SCT_ALS_X_OFFSET	On Change
12574	Steering Controller	Guidance Controller	GD_ID_SCT_ALS_Y_OFFSET	On Change
12575	Steering Controller	Guidance Controller	GD_ID_SCT_ADDITIONAL_WORKING_HEIGHT	On Change
12576	Steering Controller	Guidance Controller	GD_ID_SCT_VEHICLE_CURRENT_PAYLOAD	On Change
12598	Steering Controller	Guidance Controller	GD_ID_SCT_ISO_STATE	On Change
12599	Steering Controller	Guidance Controller	GD_ID_SCT_VEHICLE_SPEED	On Change
12600	Steering Controller	Guidance Controller	GD_ID_SCT_VEHICLE_MOVEMENT	On Change
12601	Steering Controller	Guidance Controller	GD_ID_SCT_PARKING_BRAKE	On Change
12608	Terminal	Steering Controller	GD_ID_SCT_CONTROL_MSG_TERMINAL	On Change
12609	Steering Controller	Guidance Controller	GD_ID_SCT_CONTROL_MSG_GUIDEANCE	On Change
12610	Terminal	Steering Controller	GD_ID_SCT_MODIFIED_REFERENCE_POINT_HEIGHT	Immediate Write
12611	Terminal	Steering Controller	GD_ID_SCT_MODIFIED_GNSS_ANTENNA_X_OFFSET	Immediate Write
12612	Terminal	Steering Controller	GD_ID_SCT_MODIFIED_GNSS_ANTENNA_Y_OFFSET	Immediate Write
12613	Terminal	Steering Controller	GD_ID_SCT_MODIFIED_GNSS_ANTENNA_Z_OFFSET	Immediate Write
12614	Terminal	Steering Controller	GD_ID_SCT_MODIFIED_TRACK_WIDTH	Immediate Write
12788	Steering Controller	Tractor ECU (EXT; TeachIn-Master)	GD_ID_SCT_SAFETY_VERSION	On Change

12789	Steering Controller	Tractor ECU (EXT; TeachIn-Master)	GD_ID_SCT_LIB_SAFETY_VERSION	On Change
12792	Steering Controller	Tractor ECU (EXT; TeachIn-Master)	GD_ID_SCT_RECIPE_ACCESS_SETPOINT	On Change
	Tractor ECU (EXT; TeachIn-Master)	Steering Controller		Immediate Write
12793	Steering Controller	Tractor ECU (EXT; TeachIn-Master)	GD_ID_SCT_TI_ACCESS_SETPOINT	On Change
	Tractor ECU (EXT; TeachIn-Master)	Steering Controller		Immediate Write
12794	Steering Controller	Tractor ECU (EXT; TeachIn-Master)	GD_ID_SCT_TI_ACCESS_STATE	On Change
12795	Steering Controller	Tractor ECU (EXT; TeachIn-Master)	GD_ID_SCT_TI_ACCESS_STATE_KL15	On Change
12797	Steering Controller	Tractor ECU (EXT; TeachIn-Master)	GD_ID_SCT_TI_SUB_STATE	On Change
	Tractor ECU (EXT; TeachIn-Master)	Steering Controller		Immediate Write
12799	Steering Controller	Terminal / Dashboard	GD_ID_SCT_LIFE_MSG	On Change

APPENDIX F. 3RD PARTY GUIDANCE SYSTEM MESSAGE LIST

Protocol	PGN/INDEX	SENDER	RECEIVER	PARAMETER	FREQUENCY	REFERENCE
ISO11783-7	44032	Steering Controller	Guidance Controller	Guidance Machine Status	10 Hz	ISO11783-7 B.26.2
ISO11783-7	44288	Guidance Controller	Steering Controller	Guidance System Command	10 Hz	ISO11783-7 B.26.1
ISO11783-7	61474	TECU	Any ECU	Machine Selected Speed	10 Hz	ISO11783-7 B.28.1
ISO11783-7	64835	TECU	Any ECU	Machine Selected Speed Command	10 Hz	ISO11783-7 B.28.2
ISO11783-7	65095	Any ECU	TECU	Maintain Power	As Required	ISO11783-7 B.4
ISO11783-7	65096	TECU	Any ECU	Wheel-based Speed and Distance	10 Hz	ISO11783-7 B.3
ISO11783-7	65039	VT	Any ECU	Language Command	On Request	ISO11783-7 B.21
J1939-71	61451	Steering Controller	Guidance Controller	Electronic Steering Control	50 Hz	J1939-71
J1939-71	61469	Steering Controller	Guidance Controller	Steering Angle Sensor Information	100 Hz	J1939-71
J1939-71	65254	TECU	Any ECU	Time/Date	On Request	J1939-71
J1939-71	65260	TECU	Any ECU	Vehicle Identification	On Request	J1939-71
J1939-71	65324	TECU	Any ECU	Operator Presence State	1 Hz	AGCO ATS 0-1.2 ICD