Raven SmarTrax™ 3D

Legacy Auto-Steering on the Raven Proprietary CAN Network

A Comprehensive Overview

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What is SmarTrax 3D?

Legacy auto-steering on the Raven proprietary CAN network

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SmarTrax 3D

- SmarTrax 3D is a legacy Raven auto-steering system.
  - It operates over Raven's proprietary CANBUS communication protocols.
- It takes a GNSS correction source, compensates it for changes in terrain, and then steers the machine to a set guidance path.
- The control method can either be hydraulic or mechanical.
- Importantly, SmarTrax can only be as accurate as the GNSS source, and it cannot perform better than the capabilities of the machine.

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Raven Proprietary CANBUS

- A Raven proprietary CAN system uses Raven-specific communication protocols.
  - It is not an ISO system.
- It only works with Raven CAN devices.
  - It does not support other manufacturers' devices unless specifically coded to work on the CANBUS.
  - Raven CAN devices include field computers like the Cruizer II, Envizio Pro, Viper Pro, and Viper 4, and CAN ECUs like AutoBoom, SmarTrax, and Sidekick Pro.

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System Overview and Components

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General Business

Field Computer (Display)

User interface

- This is where users interact with other devices in the system.
- Field computers compatible with SmarTrax:
  - Cruizer and Cruizer II
  - Envizio Pro and Envizio Pro II
  - Viper Pro
  - Viper 4 and Viper 4+
  - CR7 (but not CR7+)
- Guidance line types used with SmarTrax will depend on the field computer's capabilities and software version.

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The CR7+ does not have the functionality necessary for communicating with SmarTrax. Only the original CR7 will work with SmarTrax.

Another thing to mention about the field computer is that the options for SmarTrax settings are coded into the field computer software. Unlike an ISO object pool, the SmarTrax screens are completely dependent on what is available in the field computer software version. We have included a note on software at the end of this presentation.

General Business

GNSS Receiver

Navigation

Phoenix 300

600S

Envizio Pro
Internal Receiver

- SmarTrax is compatible with any GNSS receiver capable of configuring NMEA message output.
- Can be either an external receiver or an internal receiver built into the Raven field computer.
  - Example Raven external receivers are Phoenix 200, Phoenix 300, and 600S. These are receivers from the same component era as SmarTrax.

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We will discuss the required NMEA message settings later. If you are only reading this presentation, we say NMEA out loud as “KNEE-muh.” And yes, that does put the letters out of order, but it is easier to say it that way. ☺

RTK Requirements

To use RTK with SmarTrax, the following requirements must be met:

- RTK capable GNSS receiver with RTK unlock
  - If using a third-party receiver, the NMEA message output requirement still applies.
- RTK capable SmarTrax node
  - We can send an RTK signal to any SmarTrax node, but not every SmarTrax node can perform at an RTK level of accuracy.
- Active RTK subscription (Slingshot / third party / CORS network)

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General Business

SmarTrax Node

Steering controller

- The SmarTrax node is the electronic control unit (ECU) for SmarTrax steering.
- The node takes the GNSS signal from the receiver, compensates it for changes in the terrain, and then passes the terrain-compensated signal to the field computer.
  - There are inertial sensors built into the SmarTrax node that measure the roll, pitch, and yaw of the machine.

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The guidance path is set in the field computer, and then the SmarTrax node controls the machine's steering along that guidance path.

The inertial sensors will be a key thing to keep in mind for installation, calibration, and operation.

General Business

Steering Mechanism

What drives the machine

- The steering mechanism can either be a hydraulic valve or a mechanical drive unit (MDU).
  - The hydraulic valve directly controls the machine's hydraulic steering system.
  - The MDU installs onto the steering column under the steering wheel.
- Some machines can be "steer-ready." SmarTrax may work on a steer-ready machine if it has been validated to work and has a tune-set for the valve.

Hydraulic Valve

SmarTrax MDU

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There are many different types of hydraulic valves compatible with SmarTrax steering. There are some Raven aftermarket examples on the next slide.

For compatible steer-ready machines, SmarTrax will tie into the machine's existing hydraulic control valve for control.

Example Raven Hydraulic Blocks

334-0003-064

063-0131-129

334-0003-089

334-0003-066

063-0131-130

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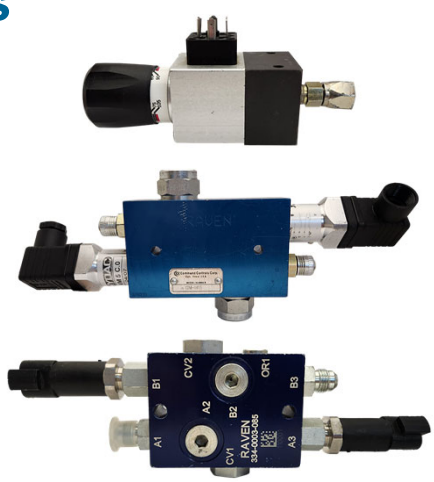
Flow & Pressure Switches

Used on some SmarTrax installations

- Hydraulic check valves used for detecting a change in flow or pressure when the steering wheel is manually turned
- Disengages the system when a change in flow or pressure is detected
- Allows SmarTrax to auto-steer when there is no change in flow or pressure



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Sensors

Real-time feedback for wheel position or machine heading

- Some sensors are used to measure the current wheel or steering angle of the machine.
  - Steering Position Sensor (SPS)
  - Wheel Angle Sensor (WAS)
- Can also use the yaw reading from the inertial sensors built into the SmarTrax 3D node. This reading will be used the place of an SPS or WAS.

Rotary Steering Sensor

Linear Steering Sensor

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WAS and SPS are recommended in low-speed operations and with front boom sprayers. The internal yaw reading from the node will have difficulty with these scenarios.

Cabling

Connecting it all together

Cables that make up the SmarTrax system:

1. Field computer / console cable
2. Chassis cable
   - Can be a SmarTrax-only chassis cable or a “regular” chassis cable used with other systems like product control
3. SmarTrax node cable
   - Some node cables come as a “tee” cable to connect between field computer cable and chassis cable
4. SmarTrax tee cable (when applicable)
   - Sometimes used when also using product control in a system with a “regular” chassis cable. Typically installs between field computer cable and chassis cable.

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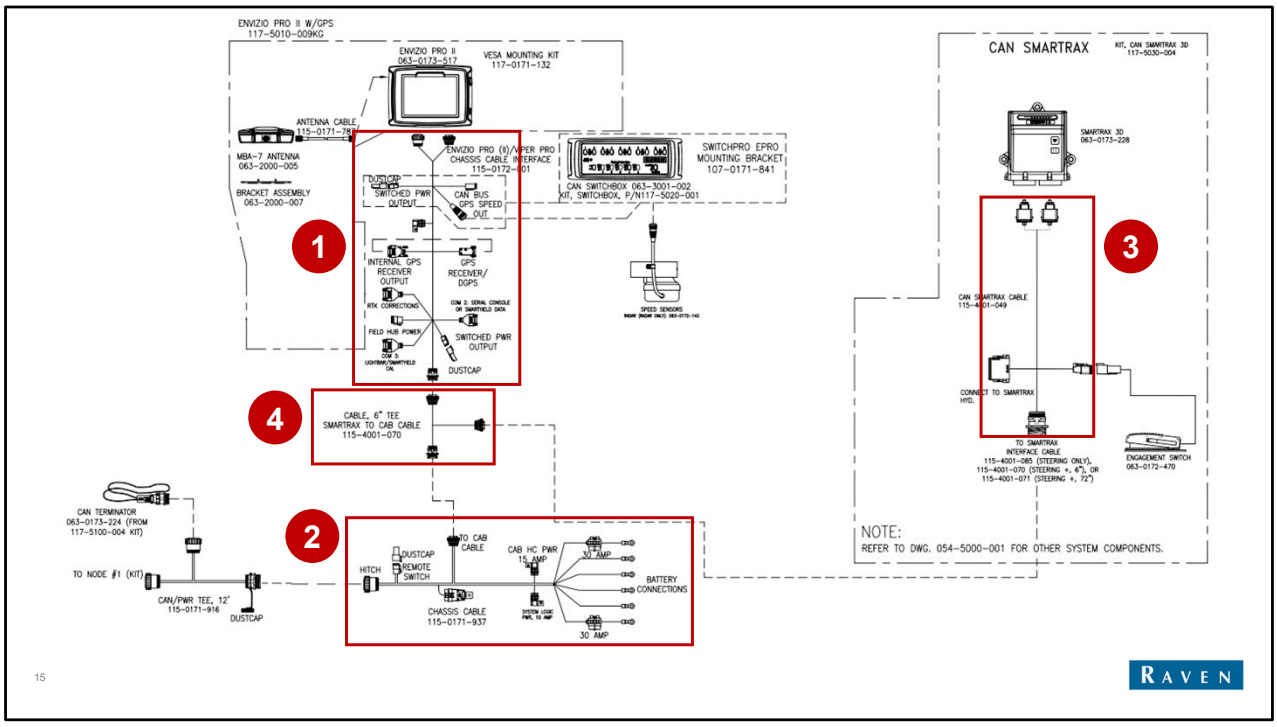
System drawing example is on the next slide.



The cables mentioned in the previous slide are called out in this system diagram.

This diagram also has most of the components we covered in the previous slides. However, it does not depict the steering mechanism or the steering sensor. These components would connect to a cable harness specific to the installation, and that harness would connect where it reads “Connect to SmarTrax Hyd.” in the CAN SmarTrax area of the diagram.

Installation

Best practices

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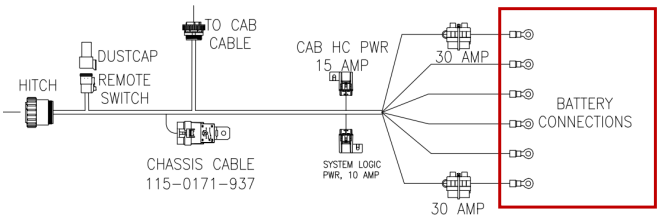
We cover the main best practices to follow when installing a SmarTrax system. Detailed information may be found in the installation manuals.

General Business

Chassis Cable

Gen 2 and newer cabling



Connect directly to the battery.

Do not connect to a power bar or other auxiliary power source.

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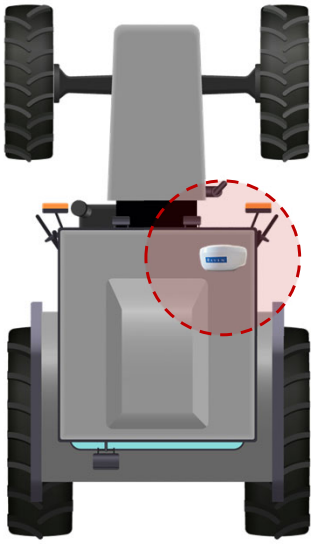
The chassis cable is used with Gen 2 and newer cabling. Gen 1 systems have each component getting its power separately.

Antenna Clearance

- Do not block the antenna's view of the sky.
- Keep other devices and antennas away from the GNSS antenna.
- If using magnet mounts, clearly mark the mount location in case the antenna gets moved.



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Node Mounting

- Very important to get this right!
- Do not use rubber washers or any other type of shock absorber.
  - It will introduce a “whiplash” effect on the node and will cause erratic steering performance.
- Secure the node with all three mounting points.
- Make sure one arrow is pointing straight **forward** (direction of machine travel), and another arrow is pointing straight **down**.
- We recommend installing it so you can easily see the diagnostic lights.

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Machine Condition

- Check for and address any issues with the machine.
  - Steering column if using SmarTrax MD
  - Hoses for hydraulic steering
  - Tire pressure
  - Main linkages
- You will want the machine in good working condition before calibrating SmarTrax.

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General Business

GNSS Signal Routing Examples

Featuring generations of Raven cabling

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The components shown at the top of this slide represent the difference between external GNSS (top) and internal GNSS (bottom). Understanding the GNSS signal paths is important for installation and troubleshooting if something goes wrong.

The next several slides will have examples of the different generations of Raven cabling with internal and external GNSS receiver options. The colors shown in the arrows and the legend in the upper-right corner will help us visualize the signal path for the CAN communication between the field computer and SmarTrax. Here, we are referring to the GNSS “IN” and “OUT” as they relate to the SmarTrax node. This does not always apply to what is shown on connector labels. For example, the GNSS IN above is really a combination of the receiver’s output and the steering node’s input. Here it is easier to simplify these connections as they relate to SmarTrax.

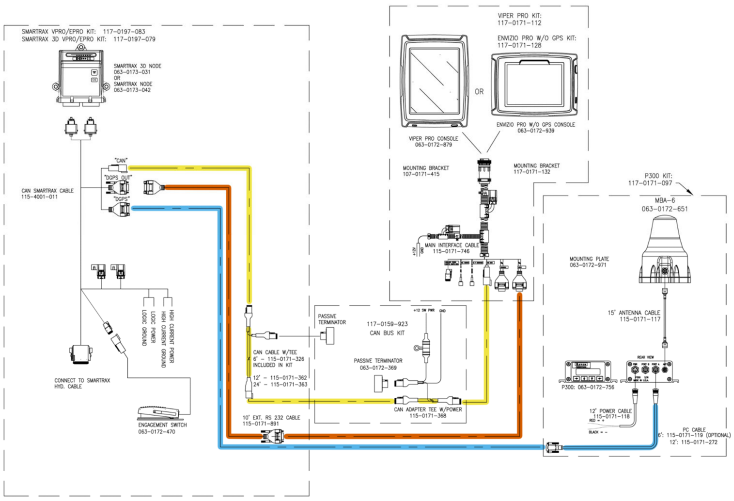
Many of the system diagrams will have the 115-4001-085 Steering Only chassis cable for the Gen 2 systems. There will be a couple examples of systems with chassis cables capable of connecting to product control.

General Business

Gen 1 – External

CANBUS
GNSS IN
GNSS OUT

ENVIZIO PRO/VIPER PRO/SMARTRAX 3D W/PHOENIX 300



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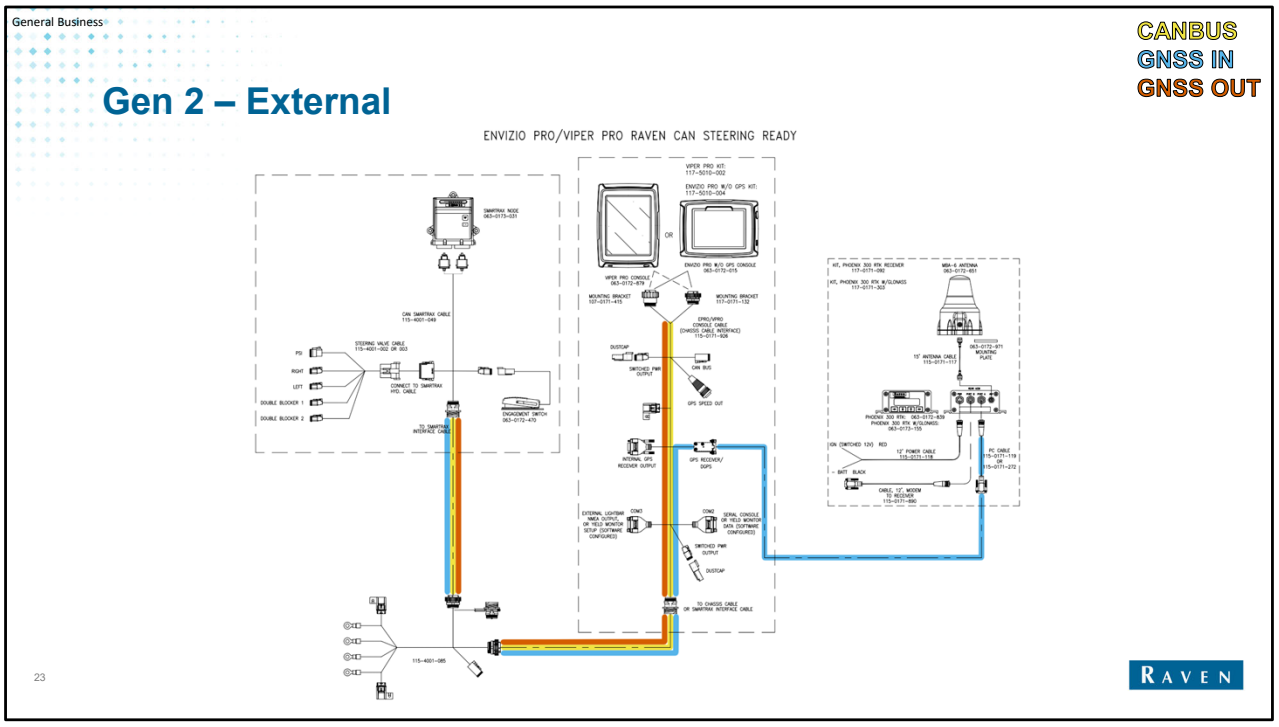
In this Gen 1 system, the GNSS signal goes from the receiver directly to the SmarTrax node. The node provides terrain compensation and then routes the signal to the field computer. Here we are labeling the “GNSS IN” and “GNSS OUT” as they relate to the SmarTrax node.

“Gen 1” of Raven cabling has each component getting its power separately. In the drawing, you can see the power wires for the field computer, GNSS receiver, CAN network (on the CAN power tee cable), and SmarTrax. Future generations of cabling will have *most* components getting their power from the main chassis cable. The exception is typically the GNSS receiver.



In this Gen 2 system, the GNSS signal now goes directly to the console cable via the “GPS Receiver / DGPS” connector. It then passes through the chassis cable to the SmarTrax cable. Here the node filters the signal for terrain compensation and then passes the signal back to the field computer through the same cabling. Everything is integrated into the Gen 2 cables.

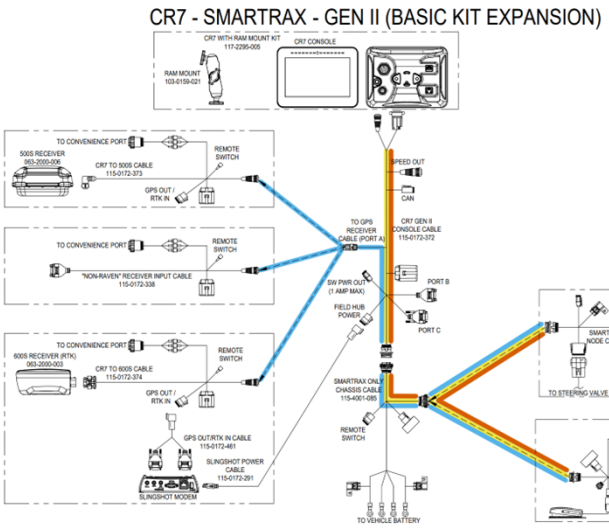
Here you can see the main power leads for the system are on the 115-4001-085 chassis cable. The Phoenix 300 receiver still uses its own power wires.

A Viper 4 can adapt to Envizio Pro / Viper Pro cabling with the 115-0172-023 adapter cable. A CR7 can also adapt to the cabling with the 115-0172-390 adapter cable.

General Business

Gen 2 – External

CANBUS
GNSS IN
GNSS OUT



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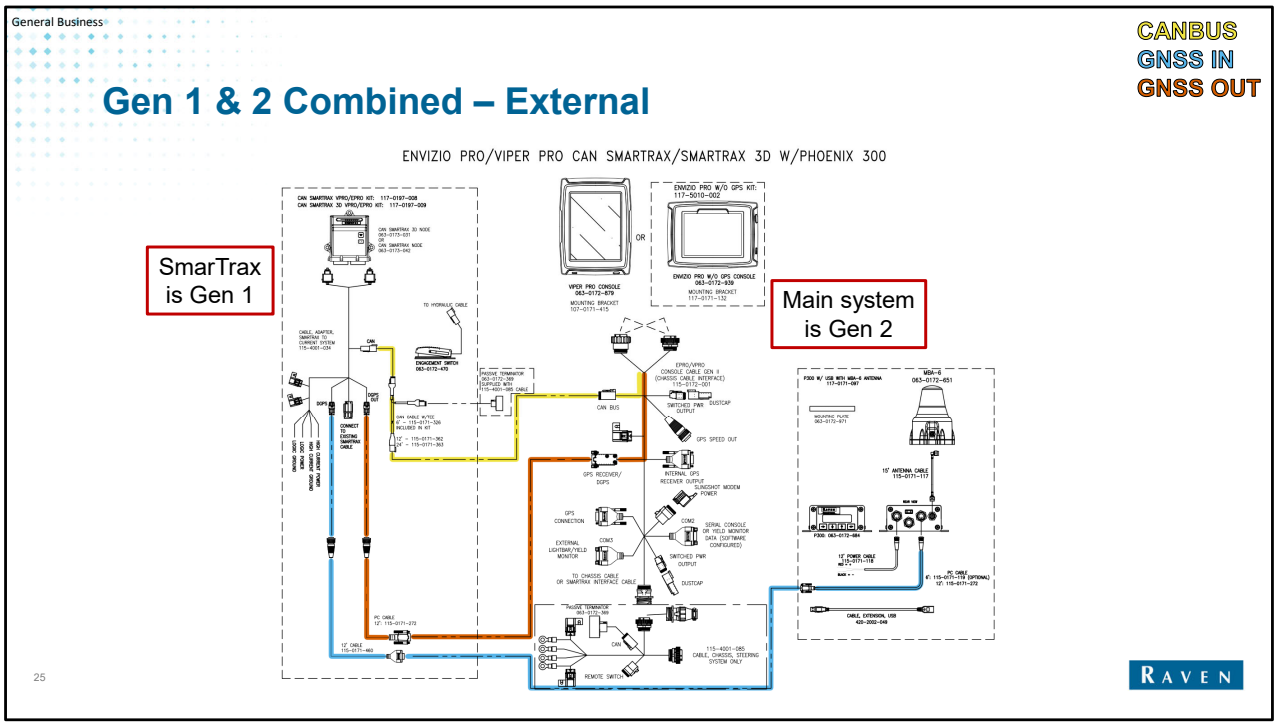
Same situation as the previous Gen 2 cabling slide. This drawing demonstrates different external receiver options as well as options between hydraulic and mechanical drive SmarTrax systems.

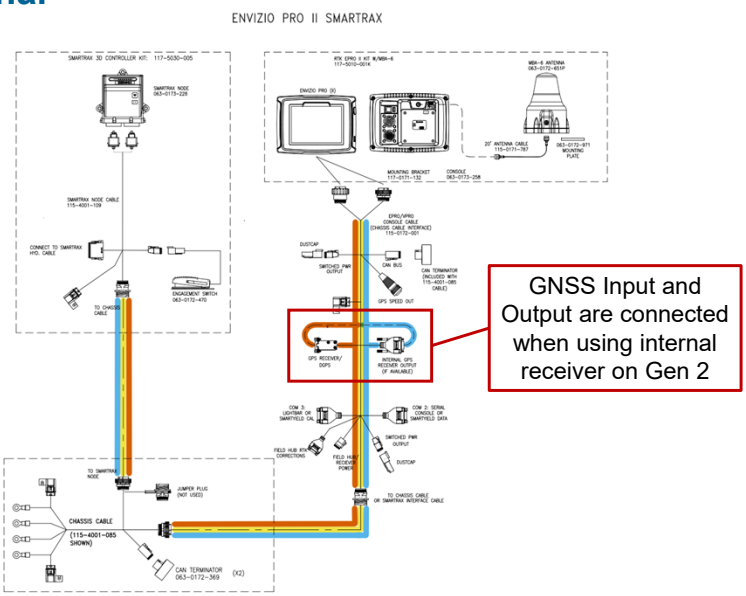


The console cable and chassis cable are both Gen 2, but the SmarTrax cable is Gen 1. The GNSS signal will be routed through the cabling in the same way as a fully Gen 1 system. This is because the SmarTrax cable does not connect to the chassis cable or a SmarTrax interface cable like it would in a fully Gen 2 system.

General Business

CANBUS
GNSS IN
GNSS OUT

Gen 2 – Internal



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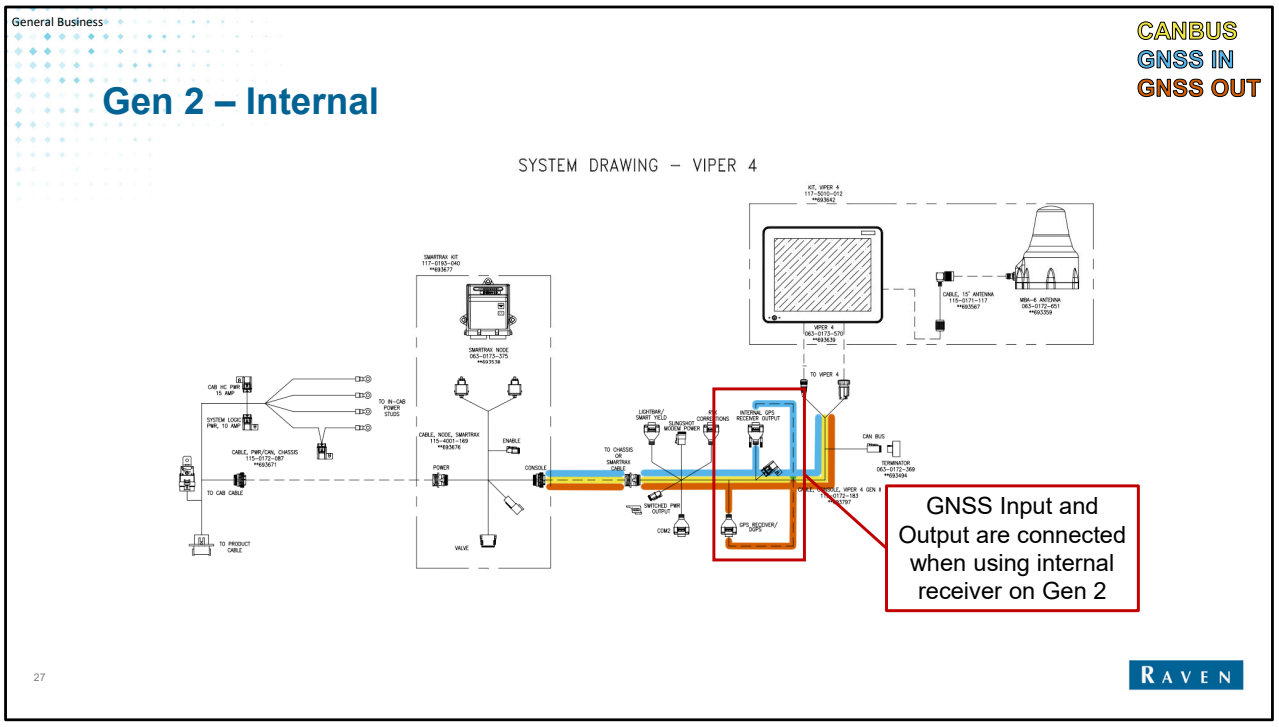
In this Gen 2 system, the receiver is built into the Envizio Pro II so we must connect the “Internal GPS Receiver Output” and “GPS Receiver / DGPS” connectors together. This creates the same signal “loop” we would have had with an external receiver.

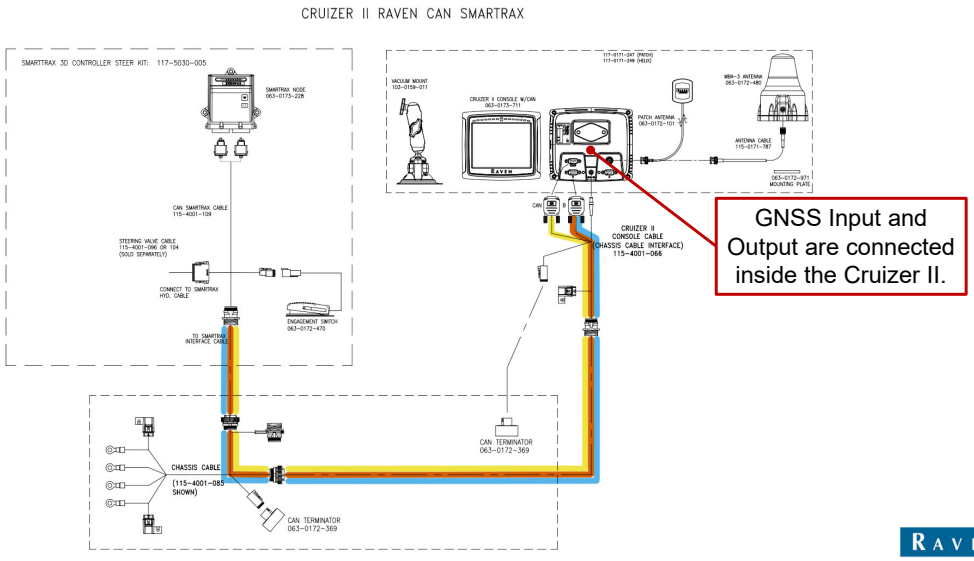


Viper 4 with an internal GNSS receiver on Gen 2 cabling works the same way. This SmarTrax node cable is an example of a node cable that tees between the field computer cable and the chassis cable.

General Business

CANBUS
GNSS IN
GNSS OUT

Gen 2 – Internal



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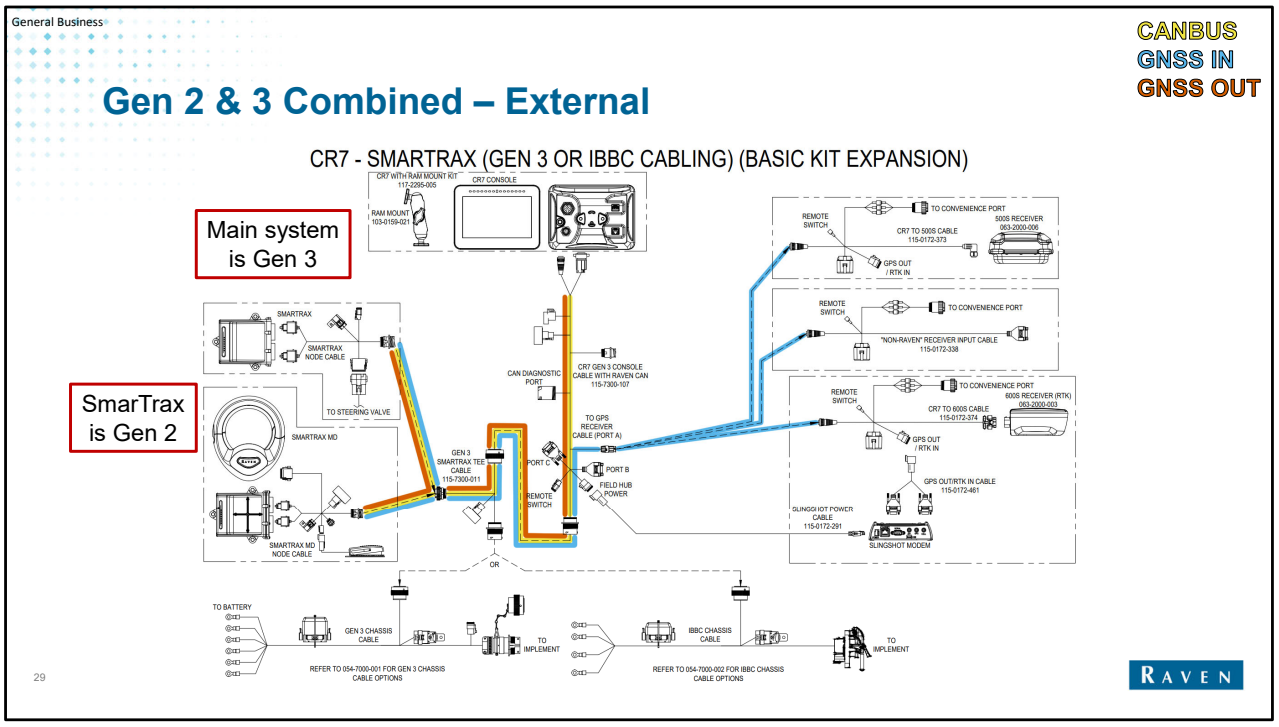
This system is similar to the other Gen 2 systems with an internal receiver. However, instead of needing to connect any “GPS In” and “GPS Out” connectors together, that connection is made inside the Cruizer II.



This Gen 3 system works the same as Gen 2 as far as SmarTrax is concerned. In fact, the SmarTrax node cable will be from the Gen 2 architecture and connects to the Gen 3 system with the Gen 3 SmarTrax tee cable. There is no true Gen 3 version of SmarTrax.

External GNSS still goes into the console cable and then gets passed to the SmarTrax node through a SmarTrax tee cable. Gen 3 is a combination of Gen 2 CANBUS and ISO cabling.

Setup and Calibration

General information and best practices

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Communication Settings

- Before you can proceed with calibration, you will need to configure the communication pathways for the GNSS receiver to SmarTrax, and then for SmarTrax to the field computer.
- We will only cover the generally required settings for the GNSS receiver to SmarTrax in this document.
  - Refer to the calibration and operation manuals for specific information.

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NMEA Messages and Baud Rates

GNSS Receiver to SmarTrax

SmarTrax needs to receive GGA, VTG, and ZDA as shown on the right.

Message	Value	Description
GGA	10 Hz	location information
VTG	10 Hz	speed over ground
ZDA	0.2 Hz	date and time

Set the baud rate as follows:

- 19200 – Receiver to SmarTrax
- 115200 – SmarTrax to field computer
- The 600S requires both to be set to 115200.

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Software Requirements to Use 600S

There are minimum software requirements for using a 600S receiver with SmarTrax and either an Envizio Pro or Viper 4.

Minimum Software Requirements for 600S		
Component	**Version**	**Description**
SmarTrax Node	7.4.45	Needed to pass messages along
Envizio Pro	3.10	Needed to configure 600S
Viper 4	2.1.8	Needed to configure 600S

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General Business

Field Conditions for Calibrating

Before getting started

- Calibrate on flat terrain. Gradual slopes are fine.
- Calibrate on solid ground.
  - Not muddy or snowy
  - No crushed rock
  - If gravel, hard-packed is okay
- Can use a concrete or paved lot but should take extra care in fine tuning after calibration.

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Very soft soil, whether it is just very loose dirt, mud, or covered in snow, can introduce extra error in the steering calibration process. It causes wheel slippage, and it can also cause the machine to need to work harder to steer through it.

Loose gravel and crushed rock can add error through jittery reactions in addition to slippage and extra effort like with loose soil or mud.

If you must calibrate on concrete or any sort of paved surface, you may need to dial down the minimum effort when you fine tune the system. These surfaces add more resistance to the tires, requiring extra effort when turning.

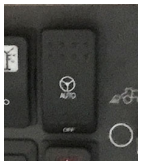
Calibration Wizard

What to expect

You will need to configure the following items with the wizard:

- Machine type
- Control device
- Disengage setting
- Engage switch
- Node orientation
- SPS / WAS
- Machine and antenna measurements
- 3D / Tilt compensation

Don't forget to turn on the road switch if one is installed!



SmarTrax MDU has a road switch on the back.

Then you can calibrate the system for hydraulic or mechanical control.

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Machine Type and Control Device

- Machine type
  - This is where you will pick the specific type of machine such as a rear boom self-propelled sprayer, front-steer tractor, articulated tractor, etc.
- Control Device
  - SmarTrax MD if using mechanical drive
  - Raven Hydraulic if a SmarTrax hydraulic valve is controlling the vehicle steering
  - Steer-Ready if SmarTrax is connected to an optional steering control system that was installed at the factory

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Engage and Disengage

- Disengage type (transducer vs flow switch)
  - Pressure transducer will have a disengage setting that can be adjusted.
  - If using a flow switch, you may need to adjust the steering switch pressure on the hydraulic block.
- Engage switch
  - With the engage switch in the Off position, SmarTrax will look for a change in status for the type of switch you have installed (foot switch or rocker switch).

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General Business

Node Orientation

You tell SmarTrax which arrow is pointing forward, and it will automatically detect which arrow is pointing down.

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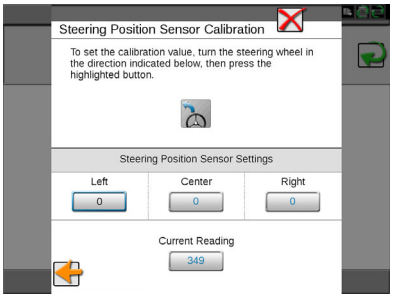
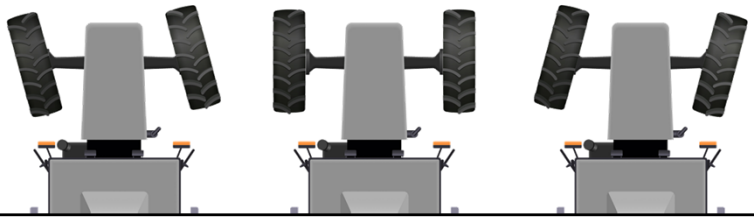
Node orientation gets set during calibration and the forward and down arrows must keep pointing forward and down. This is why securely mounting the node, and without rubber washers, is so important.

General Business

SPS or WAS

- If an SPS or WAS is installed, you must calibrate it.
  - The SmarTrax MDU will have a built-in sensor. It will be part of the calibration process.
- You will calibrate the Left, Center, and Right positions for the sensor.
  - It is highly recommended to be moving while doing this part of the calibration. It will make it easier to get accurate measurements for the sensor.





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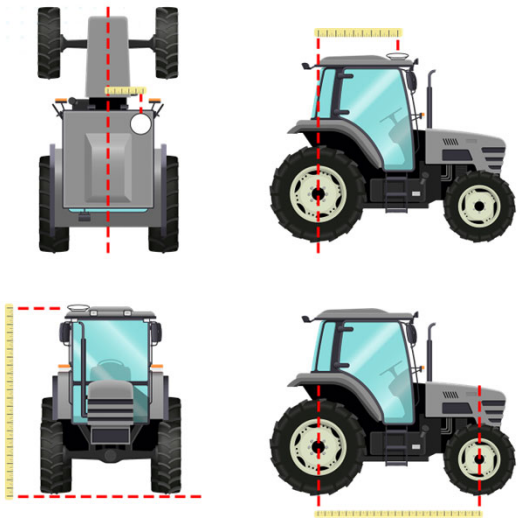
The range of the SPS/WAS values is limited to 10-1010 to prevent damage to certain types of sensors. Ensure the sensor is mounted securely to prevent damage during operation. The difference between the Left and Center values and Center and Right values must exceed 100.

Measurements and Offsets



- Need to know where the antenna is on the machine
  - Left/Right
  - Fore/Aft
  - Height
- Also need to know the machine dimensions
  - Used to position the fixed axle of the machine and the application point where they need to be

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3D Compensation

- On the Viper Pro, this is called “Tilt Calibration.”
- Place flags or markers outside of each rear wheel and aligned with the axle.
- We recommend driving forward and then making a turn in the shape of a light bulb.
  - It does not matter which way you turn around. Just be sure to only turn in one direction.
- Bring the machine back to the wheel markers but facing the opposite direction. You can proceed once all the numbers go back to the normal text color.

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Steering Calibration

- The machine should have hydraulics at operating temperature and be at operating RPMs.
- If calibrating a sprayer, have the booms racked.
- Do not have any trailers or implements connected. We need to calibrate the baseline for the machine only.
- If calibrating in a small area, or if obstacles are present, be prepared to disengage steering and try again.
  - Try to limit the amount of stops and starts during the calibration. If you need to restart multiple times, then you may need to find a more ideal place to calibrate.

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Fine Tuning

What to do after calibration

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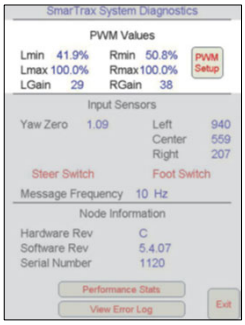
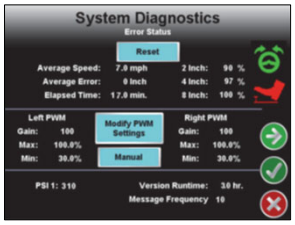
Check the Steering Gains





- Before adjusting other settings, check the gains first.
  - Look for a large difference between the left and right gains (30% or greater). This could indicate a bad calibration or an issue with the machine.
  - It is better to fix the issue and then recalibrate instead of chasing settings.
- Steering gains are locked with SmarTrax. This is why we start adjustments with the PWM values.

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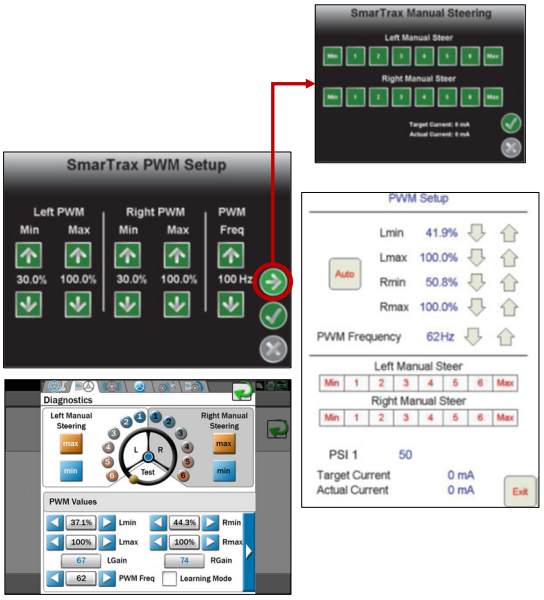
General Business

Adjust PWM Values

- Check and adjust the PWM values before making changes to Sensitivity and Line Acquire.
  - Use the “Min” manual steering buttons to test the minimum output.
- Make small changes to the Mins and then wait 30 seconds before you try out the change.
  - This will make sure the setting has been “taken” by SmarTrax.
- You will not usually need to adjust the Maxes. They may be set to 100% from the calibration.



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It is not unusual to have a difference between the left and right, especially on an older machine. However, a large difference can indicate an issue with the machine or that something occurred during calibration (turning up a steep incline, wheel slippage, etc.).

The SmarTrax PWM values determine the voltage level or duty cycle (%) that is sent to the solenoid on the steering valve to engage the hydraulics. The Min and the Max are set based on the initial calibration. Mins will vary by machine, but they normally range between 20-45. Values around 20 are typically found in steer-ready machines and machines with very light/sensitive steering. Values of 40 and above are normally found in harder steering machines or machines with larger tires. The Max will typically be in the high 80 to 100 range.

When steering a machine manually through the SmarTrax screens on a field computer, it is good to know that the Min button will apply at the Min PWM setting while the Max applies at the Max PWM setting. The other manual options are numbered 1 through 6. Each number will apply by the following approximate values: 1 is 20%; 2 is 30%; 3 is 40%; 4 is 60%; 5 is 80%; 6 is 100%.

We fine tune the PWM values first because Sensitivity and Line Acquire work within these values. You should only need to adjust the PWM values right after a calibration or at the beginning of a season. From there, you can adjust Sensitivity and Line Acquire as needed between different operators, fields, and more.

General Business

Sensitivity (OL Sensitivity)

It should keep the machine on the line without needing to make any major corrections and very few minor corrections.	
If too low, it will slowly weave along the line, slightly to the left and then slightly to the right while crossing the guidance line as it weaves.	
If too high, it will aggressively jerk back and forth along the line. The machine will mostly likely turn constantly as it tries to stay on the line.	

Sensitivity is active when the machine is within 24 inches of the guidance line.

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For software versions below 7.0, the Sensitivity setting is not compensated for changes in speed.

General Business

Line Acquire (LA Aggressiveness)

It should approach the line smoothly without overshooting or steering too sharply.	
If too low, it will be “lazy” in acquiring the line, which can often cause it to overshoot or drive past the line. If it overshoots, it can take longer to get back onto the line.	
If too high, it will try to get to the line quickly, often causing oversteering. It could possibly even “wobble,” meaning the machine may turn back and forth as it continues to move closer to the line.	

Line Acquire is active when the machine is farther than 24 inches from the guidance line.

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For software versions below 7.0, the Line Acquire setting is not compensated for changes in speed.

Recalibrate vs Reset SmarTrax

Recalibrate Hydraulics

- Will allow you to perform the steering calibration again.
- No need to redo machine and antenna measurements.
- Use this if you only need to recalibrate steering.

You can also recalibrate terrain compensation at any point.

Reset SmarTrax

- Will completely reset SmarTrax settings and calibrations.
- Write down all measurements before resetting!
- You will then go through the calibration wizard again.
- Use this more as a last resort or as part of troubleshooting.

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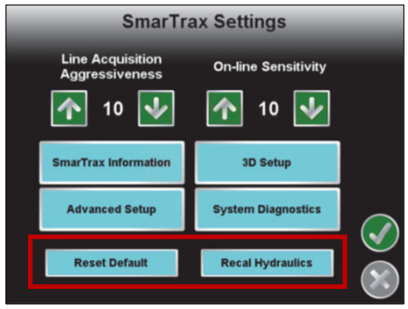
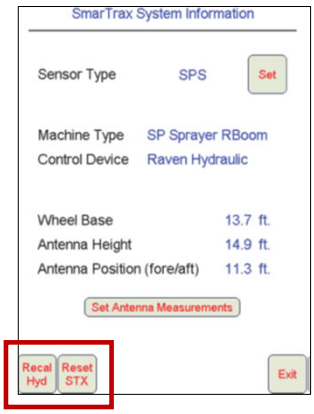
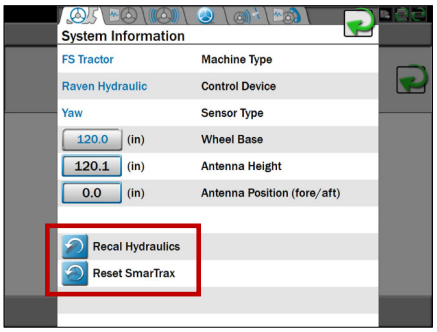
Cruizer II and Envizio Pro



Viper Pro



Viper 4



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Troubleshooting

What to do if something doesn't work

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General Business

Troubleshooting Checklist

- ❑ Machine
  - ❑ Loose linkages
  - ❑ Low tires
  - ❑ Other mechanical issues
- ❑ Settings
  - ❑ PWM values
  - ❑ Aggressiveness and/or Sensitivity
- ❑ Installations
  - ❑ Are the hoses secure?
  - ❑ Is the node mounted properly?
- ❑ Measurements
  - ❑ Are the antenna measurements correct?
- ❑ GNSS Information
  - ❑ High HDOP?
  - ❑ What is the Mode / GGA Quality?
- ❑ Node
  - ❑ What are the lights doing?
- ❑ Valve
  - ❑ Can you steer manually using the field computer?

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This is the basic troubleshooting checklist we would use if we were troubleshooting a system. There is more information on troubleshooting in the SmarTrax calibration and operation manual. The troubleshooting section will have information on error messages and operation issues along with possible causes and how to correct the problem.

General Business

Node Lights

Light	Description
Logic Power	Lit when +12 volts is supplied to the node.
HC Power	Lit when High Current Power is supplied to the node.
Micro 1 Hz	Flashes once per second during processor activity.
CAN Rx	Flashes to indicate CAN or Cruizer messages are being received by the node. Typically flashes rapidly.
CAN Tx	Flashes to indicate CAN or Cruizer messages are being transmitted from the node. Flash speed varies.
Diag 1	Indicates the node is receiving valid GGA messages. Must be lit to engage SmarTrax.
Diag 2	Lit when terrain compensation is activated. Does not indicate terrain compensation is actively being used.

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Diag 1 light:

- Cannot be used to verify if the field computer is receiving the GNSS signal. This light only indicates if the SmarTrax node is receiving the signal from the GNSS receiver.
- If node is getting the signal but the field computer is not, check settings and cabling between node and field computer.

The HC Power light is not used with steer-ready installations or with SmarTrax MD.

Software Updates

General recommendations

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A Note on Software

- In general, it is recommended to be at the latest software version for all legacy devices in a Raven SmarTrax steering system.
- Exceptions include:
  - Using a Cruizer display serially connected to the SmarTrax node (instead of CAN communication)
    - Serial communication is supported in SmarTrax versions 6.0.41 and below and version 6.0.82.
  - Controlling a SmartSteer mechanical drive unit with a SmarTrax node
    - SmartSteer is supported in SmarTrax versions 6.0.41 and below and version 6.0.82.

Example system drawing on next slide

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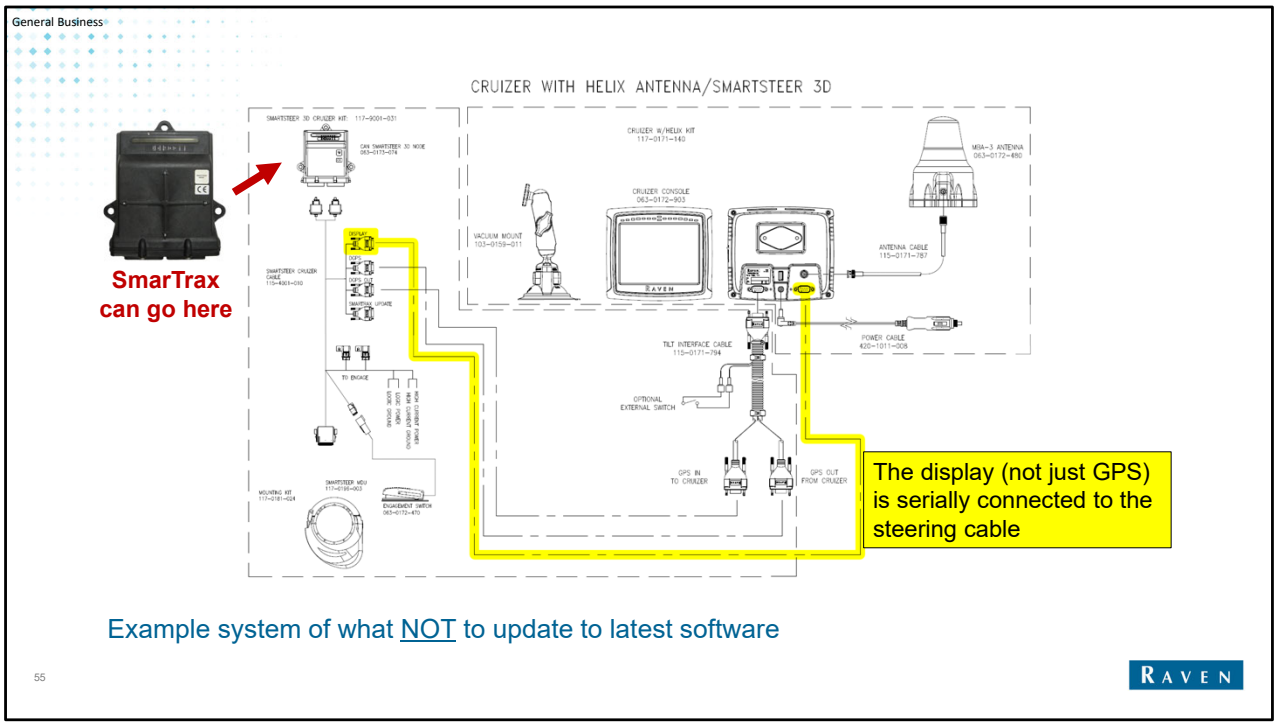

This system drawing is an example of a Cruizer being serially connected to a SmartSteer node. The 115-4001-010 cable also works with the SmarTrax node, so this also can be an example of using the SmarTrax node with a SmartSteer MDU.

The main thing to remember on this slide is that the connection between the steering cable and the display is using serial. Notice how this is labeled as “Display” on the steering cable. This is different than the “GPS IN” and “GPS OUT” connections being serial for GNSS communication which is typical for SmarTrax systems. In more recent SmarTrax systems with Cruizer II, Envizio Pro, Viper Pro, and Viper 4, the display connection uses CAN. You can go back to the Cruizer II Gen 2 cabling slide to see it is using CAN communication even though the connector going into the Cruizer II is a serial connector. This Cruizer system is using serial communication throughout.

Raven SmarTrax™ 3D

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