

P545 Autonomous Cart



Cart Overview

- The P545 Cart is designed to allow students to explore embedded system design and development through the control of an autonomous vehicle.



Cart Overview

- ❑ The vehicle is controlled in autonomous mode from a student's laptop which is connected to cart through a standard Ethernet port.
 - ❑ The laptop will run a "driver" program that receives information about the cart's state from a command server running on the cart.
 - ❑ The driver program sends information back to the cart command server to initiate changes in the cart's control parameters (turning radius, speed, etc).
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Cart Control Frame

- ❑ Control Frames are exchanged at 20 hz between the driver and the cart.
 - ❑ Command frames are plain comma delimited ASCII.
 - ❑ Example:
 - {MsgLength=0474, VehMsgCount=00000006, TimeStamp=00000000329, CmdTurnRadius=0.0005, StatusTurnRadius=0.17993, StatusSteeringPosLimitError=none, CmdVehSpeed=01.500, StatusVehSpeed=00.000, StatusPercentThrottle=004.00, StatusVehSpeedLimitError=none, GPSPat=3910.93526, GPSLon=-08631.36226, GPSSpdE=0.00, GPSSpdN=0.02, GPSEstimatedPositionError=1.8, GPSStatus=active, StatusSystemMode=auto, StatusErrorCode=000, StatusCom=ready, 7F}
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Cart Modes

□ Basic Cart Modes

- **Manual:** In this mode, the safety driver is in full control of the vehicle. The electronic vehicle control systems are disconnected from cart through relay logic. This mode can be entered by releasing the manual/automatic button, pushing the brake pedal, or pressing the ESTOP button.
 - **Automatic:** In this mode, the electronic control system is allowed to control the speed of the vehicle and manage the cart's steering system. This mode is entered when the safety driver presses and holds the manual/automatic button.
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Manual/Automatic Button

- Button must be held down to remain in autonomous mode.



ESTOP Button

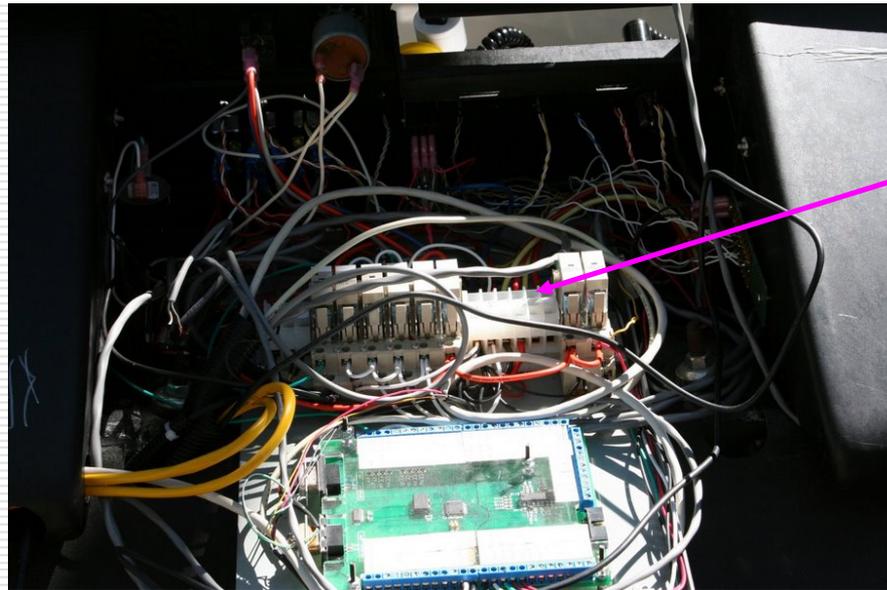
- Pressing the ESTOP button disables autonomous mode



ESTOP Button

Cart Relay Logic

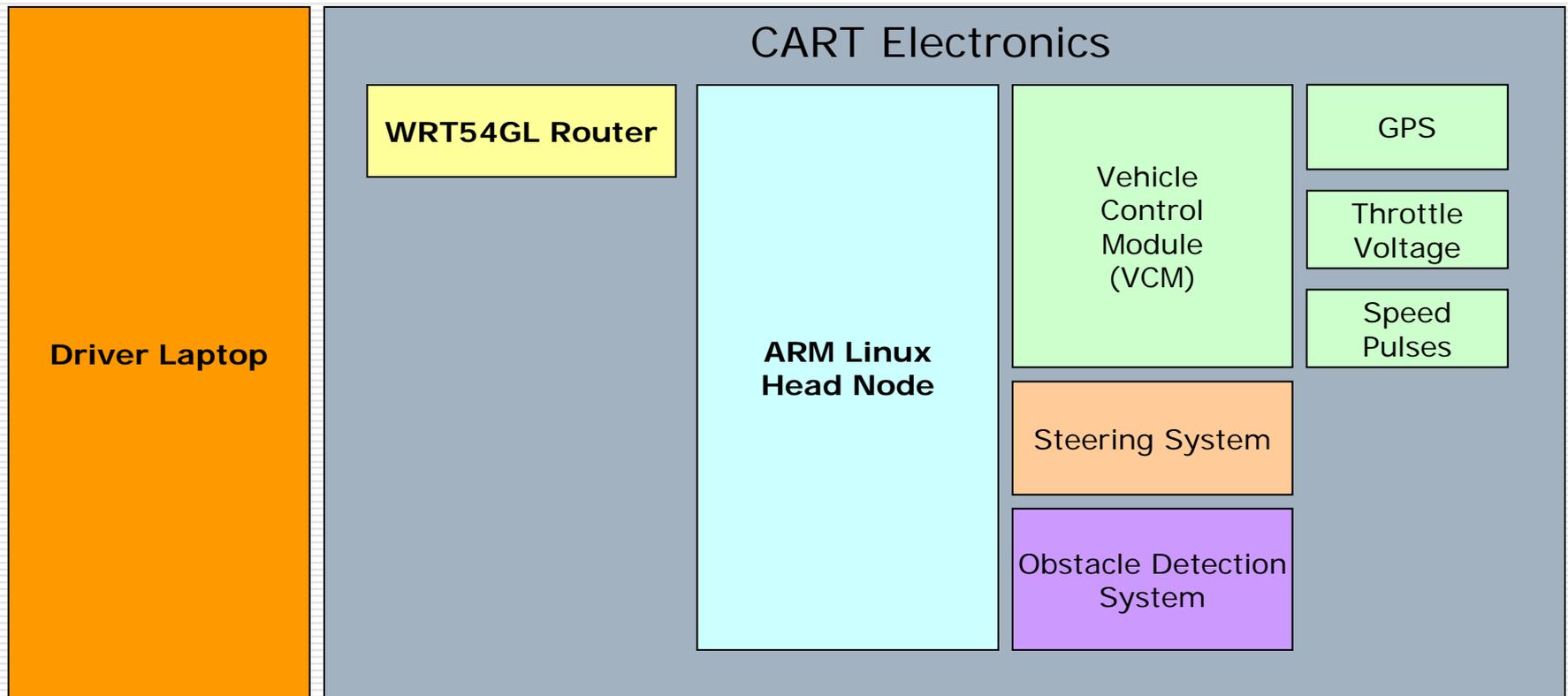
- Relay logic is used to implement manual/automatic button and ESTOP functionality.



Control Relays

Electronic Component Overview

□ Key Cart Component Block Diagram



Driver Laptop

- This student is controlling the cart through his laptop connected to the cart.



Safety driver is mandatory.
Caleb Hess is pictured here.

A notebook
With a wired
Ethernet connection
is used to communicate
With the cart.

WRT54GL Router

- Router used to provide Ethernet connectivity between the cart and the driver.

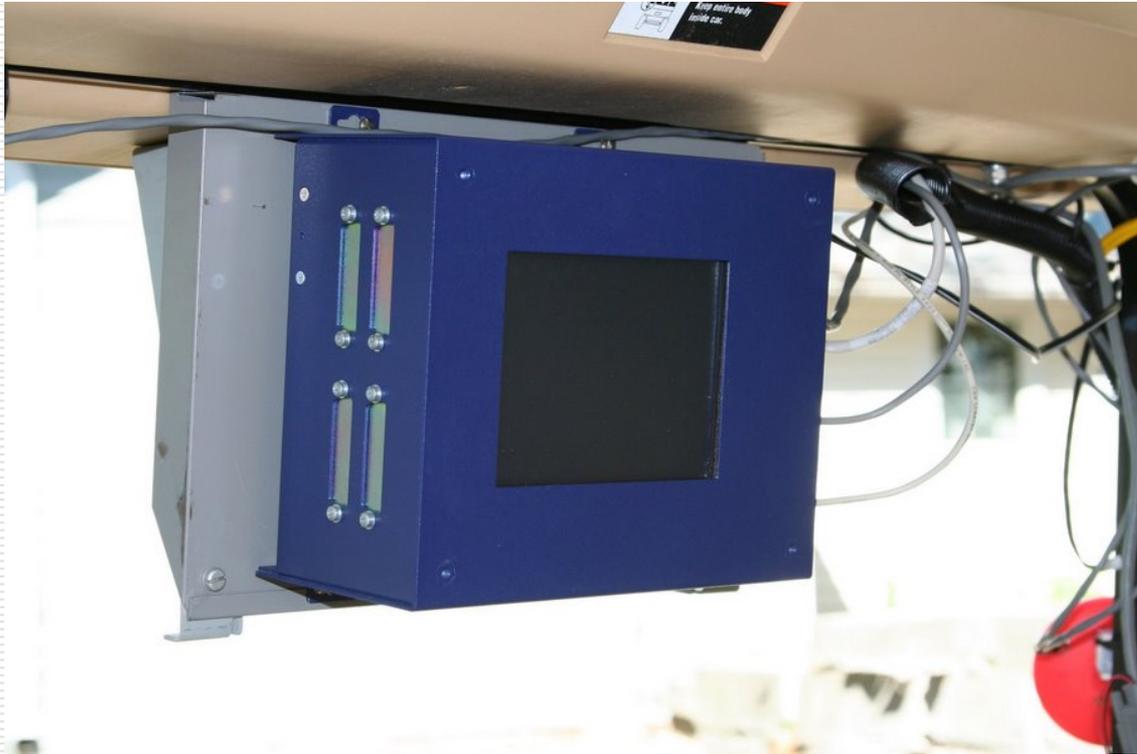


WRT54GL Router

- ❑ Standard Linksys device running DD-WRT v23 SP2 firmware.
 - ❑ This version of DD-WRT is based on a 2.4.34 linux kernel.
 - ❑ DHCP Server
 - Cart Communication Node is at 192.168.1.200.
 - ❑ Client Wireless Mode
 - The router access point functionality has been disabled in favor of using the wireless portion of the device in client mode.
 - Router maintains a connection to the IU VPN. Permits IU network access while using the cart.
 - Allows remote access to the cart while it is in storage at the Woodlawn house (across from the Informatics building).
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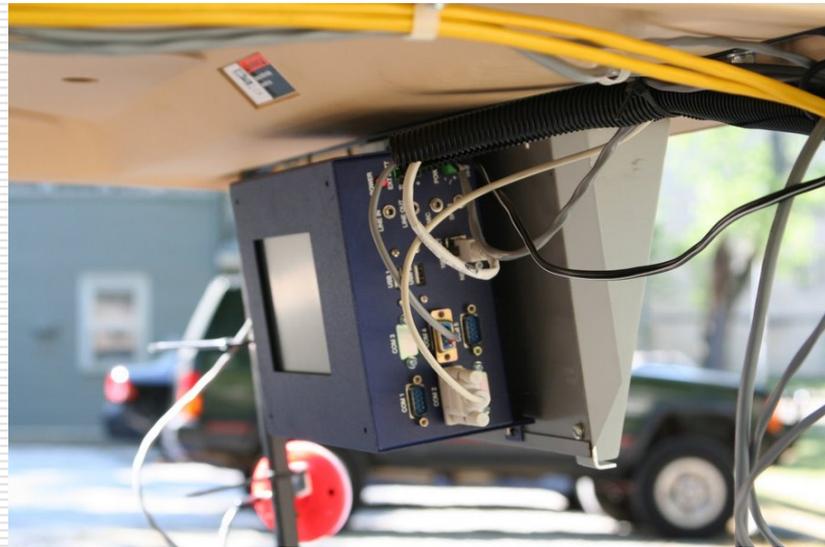
ARM Linux Head Node

- 400Mhz Linux node.



ARM Linux Head Node

- ❑ Arcom Viper Embedded Control board.
- ❑ 400Mhz Intel Xscale (ARM) Processor.
- ❑ Runs a Debian Linux variant based on a 2.6.16 kernel.
- ❑ Includes a touch panel LCD Monitor with a 320x240 pixel resolution.
- ❑ Peripherals are connected through 3 unallocated serial ports.

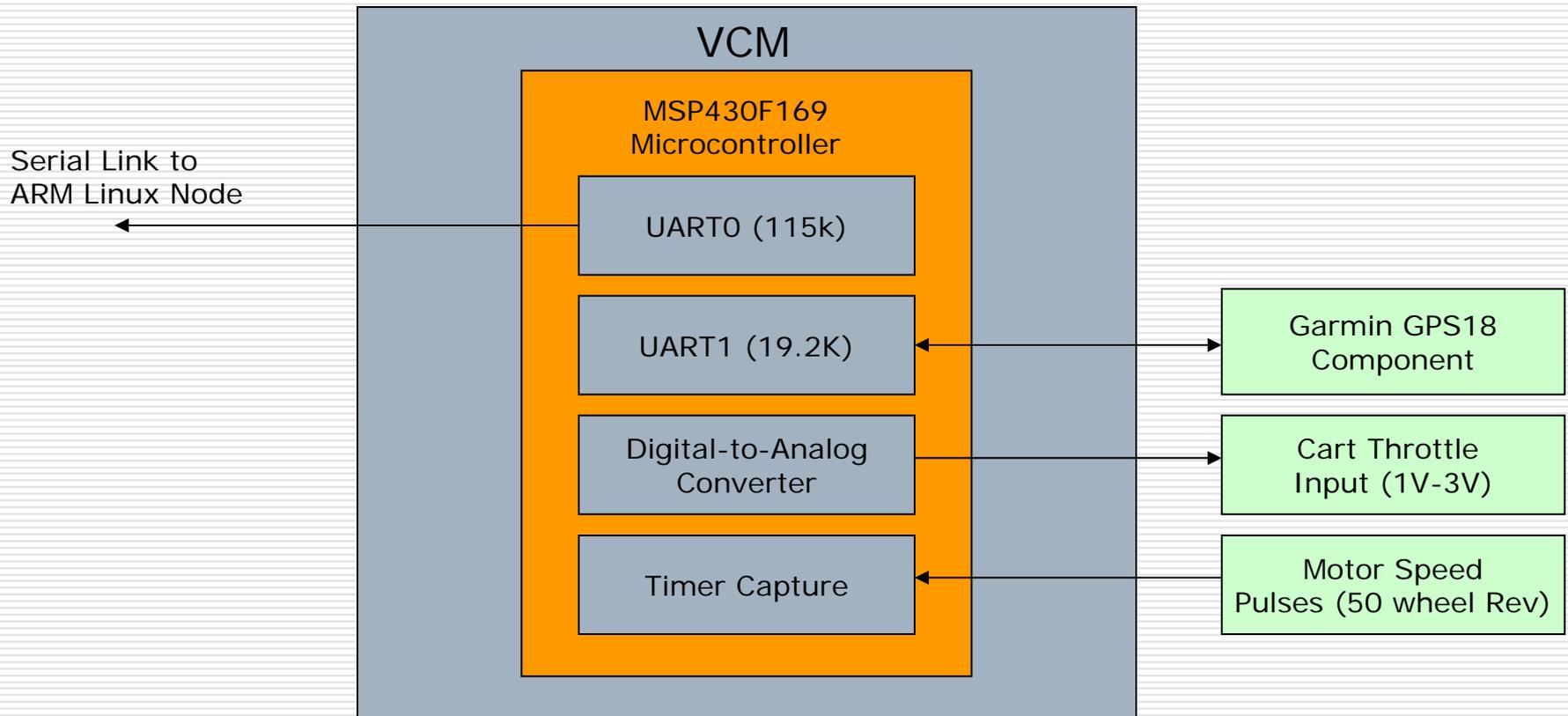


Vehicle Control Module (VCM)

- Custom IUCS hardware based on the MSP430 controller.
 - Head Node Communication
 - Connects to ARM linux node via an RS232 serial port.
 - GPS Data Management
 - Parses GPS serial data from a Garmin GPS 18.
 - Vehicle Throttle
 - Outputs a digital voltage to control the throttle.
 - Vehicle Speed Measurement
 - Measures the period of speed pulses from the the cart motor.
 - Implements a PID loop to control the speed of the cart at the desired set point.
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Vehicle Control Module Features

- Basic block diagram of the VCM feature usage.



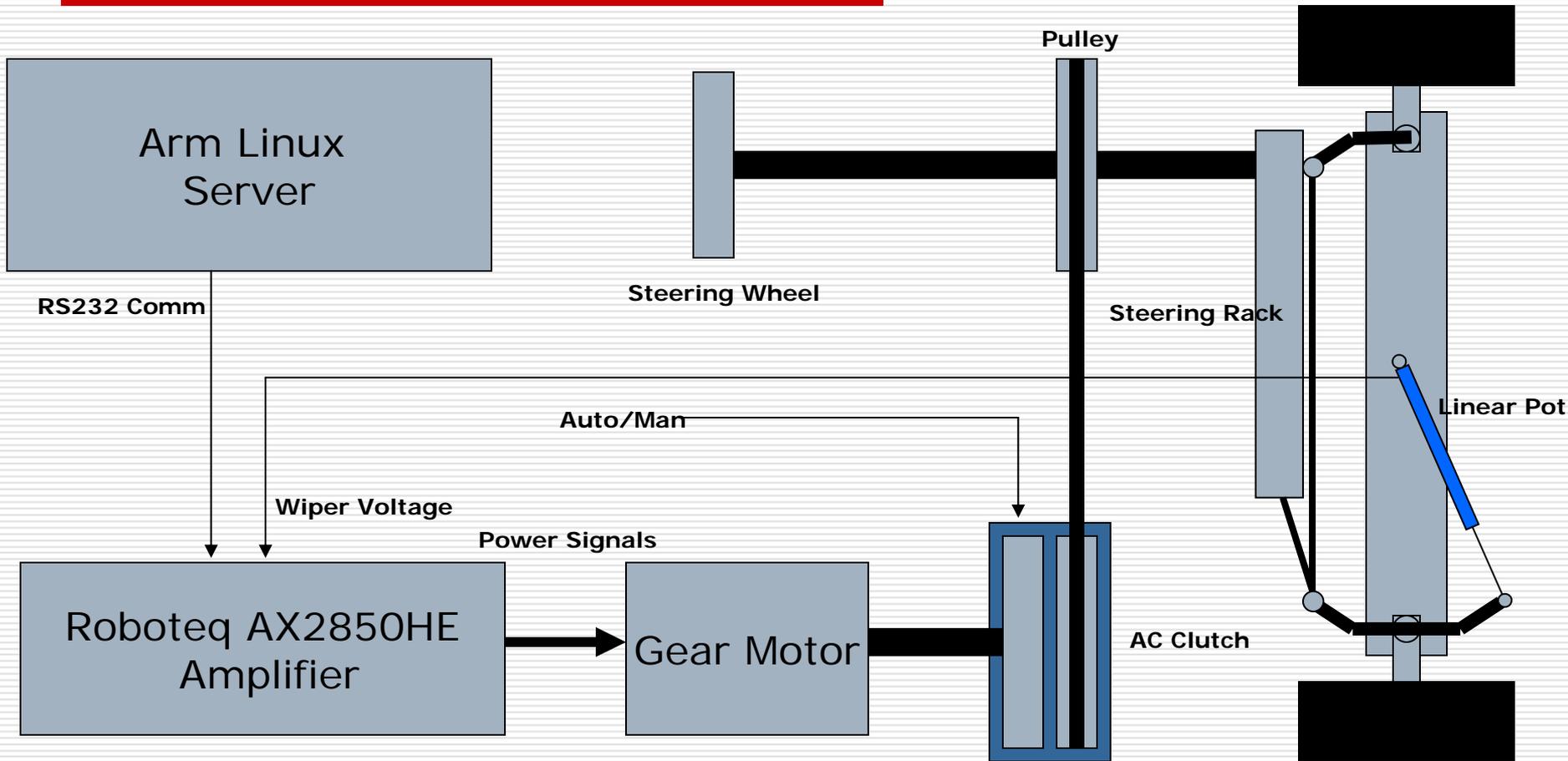
GPS

- Garmin GPS18 5hz puck with RS232 serial output.



GPS Puck

Steering System Block Diagram

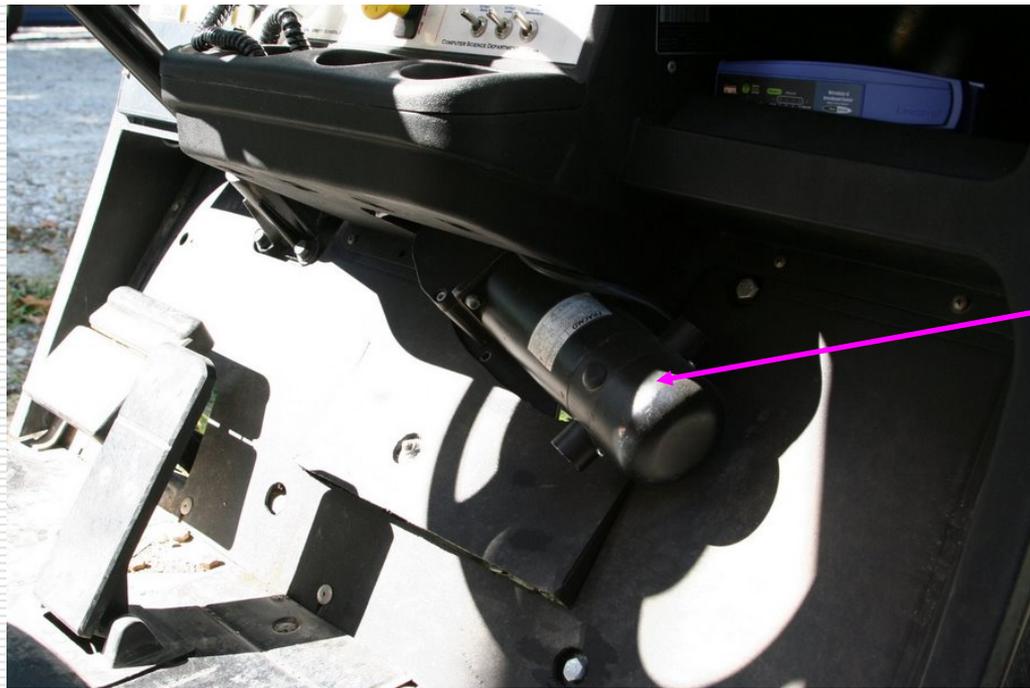


Steering System Components

- Steering Actuator
 - Wheel Chair Gear Motor
 - AC Clutch and Pulley
 - Automotive Air Conditioning System
 - Amplifier
 - Dual Channel 120 Amp Motor Controller
 - Linear Potentiometer
 - Provides a resistance that is proportional to the length of the device.
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Steering Actuator

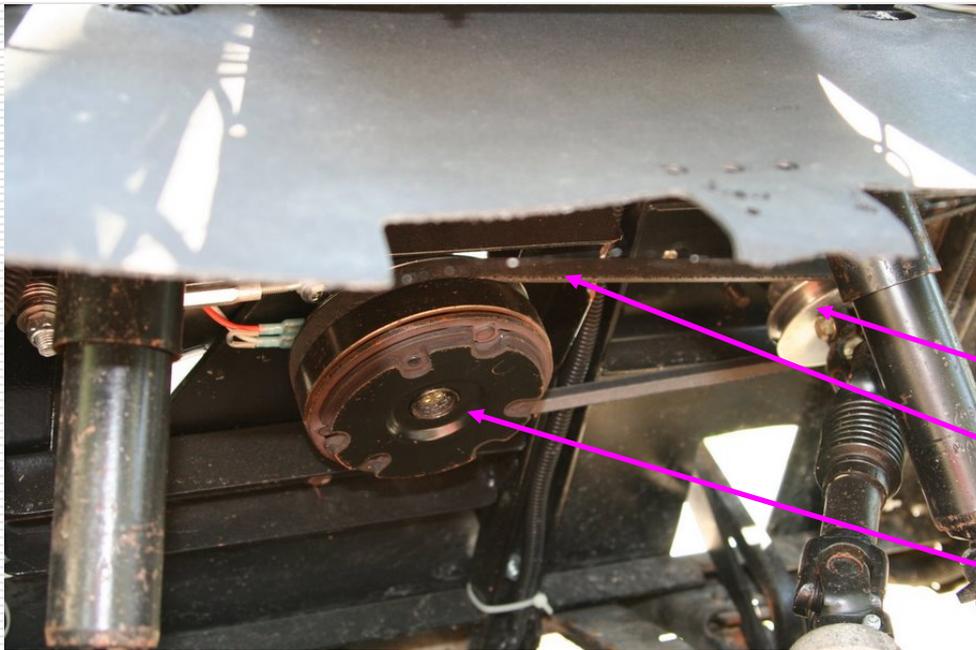
- ❑ Salvaged from a wheel chair. A custom mount was designed for the cart.



Steering
Motor

AC Clutch and Pulley

- An automotive air conditioning clutch is used to electrically control the coupling of the steering motor to the steering wheel shaft via a belt and pulley.



Pulley

Belt

AC Clutch

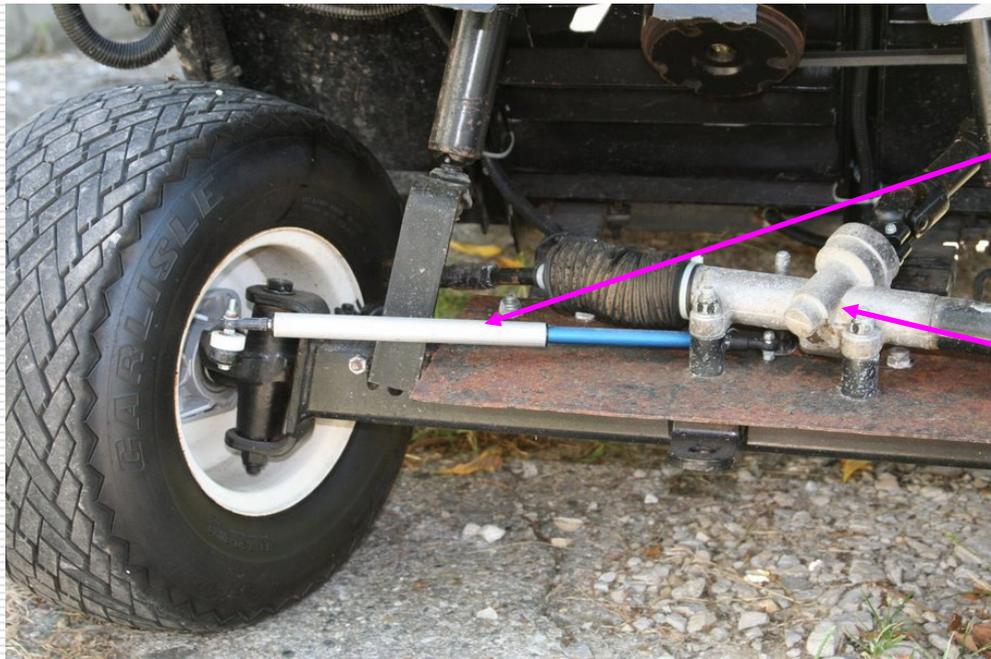
Steering Amplifier

- Allows the front wheels to be positioned based on a commanded turn radius. (Roboteq AX2850 Power Amplifier)



Linear Potentiometer

- Provides a resistance that is proportional to the extension of the device.



Linear
Potentiometer

Steering
Rack
