Precision Agriculture: Vehicle Control Systems

3D Neurosurgical image navigation school work tuned me into navigation in general. GPS applications for agriculture drew me to Trimble, where we produced early market leaders in steering aids and automatic steering systems.

My first win was a differential GPS receiver coded to drive a "lightbar" steering aid. User interface, multiple pattern options, and, "curve" offset through novel curve segmentization and offset algorithm.

Patent Granted: "Light Bar with Tilt Sensor (US 6567747 B1)

Differential Reciever Application: Steering-to-Path aid for Human Operator

Trimble First:
Agriculture App on GPS Receiver

The following Trimble product literature advertises the Trimble Parallel Swathing System used by agricultural vehicle operators to drive parallel to a last-driven (or flown, in the case of crop-dusting) path.

Mike developed entire guidance application and user interface (both front-panel and remote switch box for safe use while operating a vehicle) on an existing GPS platform. He worked closely with the 4-member platform team.

The straight-line guidance application shipped within 8 months. Algorithms and interfaces for the curved-path guidance application shipped a few months later.

From Trimble web site...

Lightbar for parallel swathing applications, Optional data logger for record-keeping

The *AgGPS®* Parallel Swathing Option and *AgGPS* Parallel Swathing Option Plus provide farm equipment operators with precision guidance for driving straight rows during field preparation, planting, and product applications. The systems work when you need to work—ensuring the job gets done. You can work at night or under low visibility conditions, extending operational hours for crop protection, lime and fertilizer applications, tilling, and seed bed preparation. Both systems use a lightbar that connects directly with your *AgGPS* receiver and is mounted on the dashboard or ceilings of vehicle cabs.

This specific addition sold as additional option on base GPS unit, producing $150+ million accumulated revenue in near-decade of product life-cycle.

Trimble Agriculture Parallel Swathing System

PSO Patterns

Precision (sub-inch) GPS and Inertial Sensor Driven Automatic Steering Systems

Designed inner steering control loop and operator override

detection scheme for the first automatic tractor steering system leveraging Trimble's precision (sub-inch) GPS and inertial measurement unit.

My product design work included digital board design and IO for the black box below, mixed-signal IMU sampling circuitry, and thermal regulation block for an inertial measurement unit (also inside the box).

Ag Industry Trail-blazer: Automatic Steering

From top left: Virtual Terminal Display, TRIMCOMM 900 Radio, GPS Antenna, Navigation Controller, External Keypad and Data Logger (RDL), AgGPS 214 Receiver, Lightbar

THE COMPONENTS

AgGPS 214 Rover Receiver RTK GPS receiver pinpoints the tractor's location in the field to the centimeter level.

Navigation Controller Embedded Controller Unit (ECU), mounted on the tractor chassis, controls Autopilot operation. It also contains the electronic components used to measure tractor roll.

Display Easy-to-use graphical display mounted in the tractor cab allows the operator to interface with the Autopilot system. Multiple views of field operations set per operator preference.

Lightbar Electronic display uses bright color light emitting diodes (LEDs) and a text display to allow the operator to visually track performance or position the tractor manually.

External Keypad and Data Logger Movable keypad with data storage on a compact flash card puts control conveniently at the operator's finger tips.

GPS Antenna The antenna for the AgGPS 214 Rover receiver ensures maximum GPS accuracy and availability.

TRIMCOMM 900 Rover Radio License free high-performance 900 MHz radio receives corrections from a GPS base station.

Autopilot Hydraulic Valve Electric-over-hydraulic valve, connected to the tractor's steering circuit, is used by Autopilot to steer the tractor. (Not required on fly-by-wire vehicles.) The system is engineered with safety over ride.

Steering Position Sensor Wheel-position sensor, connected to the front axle, measures the turn angle of the front wheels. (Wheeled vehicles only.)

Base Station Base station for AgGPS 214 RTK GPS receiver includes the MS750 Base receiver, TRIMCOMM+ 900 Base radio, and L1/L2 GPS antenna.

Contributed core algorithms for tractor guidance and steering patterns still sold in 2016. This small team introduced GPS+Inertial tractor steering to the Ag market.

2008 Return To Trimble

After some year away from the above efforts to work on some novel and interesting optical telecommunications and medical electronics I re-engaged precision
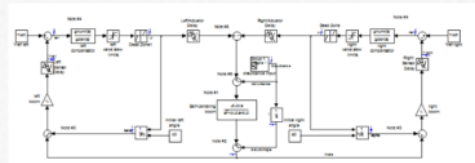
In-cab interface products and features

2008: Next-Gen Embedded Linux Platform Development

Primary user interface and controllers.
Main contributors to ~$400M Annual Revenue.
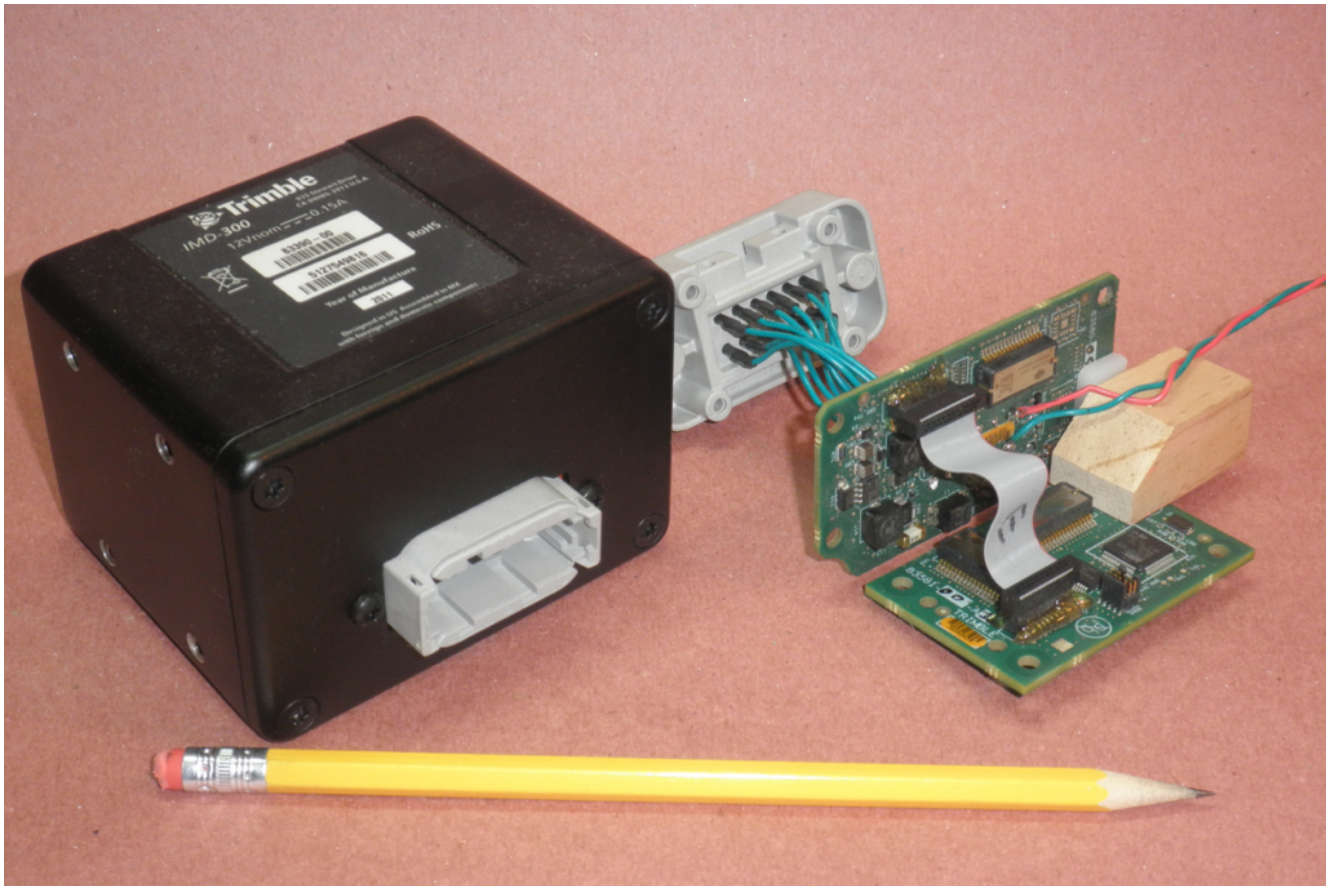
Machine Control and Sensors
6-Axis IMU development and steering system auto-calibrations

Heavy-vehicle dynamic modeling, control system design, implementation, and field prove-out at customer sites: steering, depth, and height control systems.
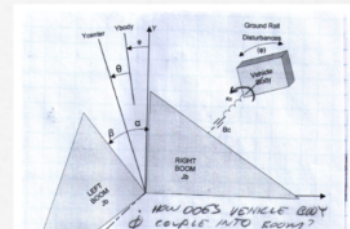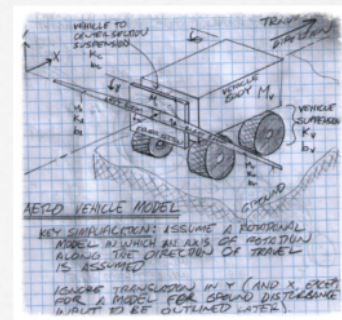
Embedded Sensor Firmware

Inertial Measurement System: 6-Axis accelerometer and Gyro Package for strap-down vehicle steering and implement control