OMNITECH ROBOTICS

# COMPASS

## Compact Outdoor Multipurpose Pose Assessment System (COMPASS)

*Leading the way for Unmanned Ground Vehicle Controls*

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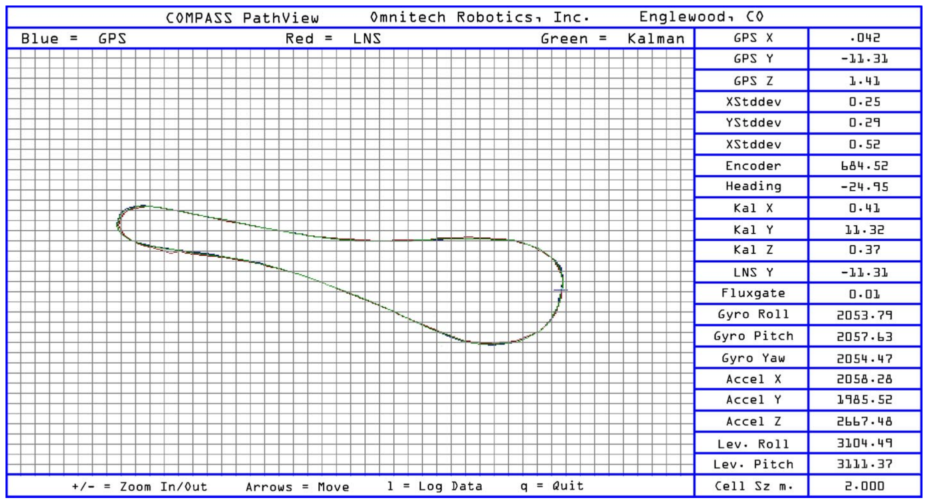


## COMPASS Overview

This datasheet introduces the COMPASS as it is used with the Standardized Robotic System (SRS). These products are optimized for providing remote control, teleoperated control, or autonomous control of ground or above water vehicles.

The SRS can be combined with the optional COMPASS subsystem to provide either a GPS-based coordinate display of a vehicle's position or semi-autonomous control.

The COMPASS uses a suite of position and orientation sensors fused into a single, statistically-optimal estimate of position, orientation and velocity using a Kalman filter with a state estimator. The pose estimation sensor suite includes GPS (Global Positioning System), INS (Inertial Navigation System), and LNS (Land Navigation System). It is packaged as a rugged box.

The SRS is a kit consisting of modular components for converting any vehicle to remote control, teleoperated control, or semi-autonomous control. The SRS is a generic control system and can be applied to both ground vehicles and watercraft. The SRS is highly modular in hardware and software and uses a serial control bus called Controller Area Network (CAN) to provide scalability of the design. In short, the SRS is a state-of-the-art control system and conversion kit for converting any vehicle to teleoperated control. With optional components like Omnitech's COMPASS and a GPS/LNS/INS based navigation aid, the SRS can provide complete semi-autonomous navigation and control. The SRS with the COMPASS navigation option provides a proven, off-the-shelf, Non-Developmental Item (NDI) solution for any teleoperated or semi-autonomous vehicle control system.

The main components of the SRS include an Operator Control Unit (OCU), a Vehicle Control Unit (VCU), High Integration Actuators (HIA), a System Input/Output (SIO) device, a Video Multiplexer Unit (VMU) and a Pan/Tilt Unit (PTU).

### Features

- COMPASS integrates a high accuracy Global Positioning System (GPS), a Land Navigation System (LNS) and an Inertial Navigation System (INS) integrated with a Kalman filter to provide highly accuracy vehicle position and orientation estimates.

- The COMPASS is intended for used with the SRS, a modular kit of components for converting any vehicle to remote control, teleoperated control or semi-autonomous control.

## COMPASS Hardware

The COMPASS has been made in three sensor combination configurations to support the trade-off situation posed by the need for robust, autonomous, robotic navigation. A sensor suite which provides reliable autonomous navigation ideally needs to be able to compensate for the possibility of the short-term loss of reliability or for the failure of any one sensor.

It was a goal during sensor selection to complement an “internal” sensor with an “external” sensor. While an internal sensor typically has the advantage of being generally more compact and allowing for fast dynamic response, it often suffers from unbounded accuracy drift. In contrast, using an external sensor to aid the internal inertial sensors, such as a GPS to aid an INS, can help bound drift errors. As an example, for a COMPASS system where accuracy was an important design criterion, the following sensors were chosen:.

- Differential, carrier-phase GPS
- 3-axis accelerometer
- 3-axis rate gyro
- Wheel encoder
- Fluxgate compass
- 2-axis inclinometer

These sensor configurations allow for the redundancy needed to adequate accuracy.

The GPS system chosen for this application was the Novatel RT-20 coupled with the Novatel 3151R as the base station for differential corrections. This GPS system can provide better than 20-cm accuracy. The base station GPS unit was packaged with a wireless transceiver in a compact ruggedized unit.

The fluxgate magnetometer, manufactured by KVH, provide robot orientation information. The sensor takes ten measurements of the earth's magnetic field every second, providing an accuracy of 0.5 degrees. This sensor is useful to initialize the orientation (yaw) of the vehicle, after which it is updated with information from the rate gyros and the vehicle's heading (calculated as the vector between the most recent two positions).

The inclinometers, manufactured by Lucas, provide roll and pitch information. These sensors, as with the magnetometer, provide readings which are useful because they provide an absolute measurement to initialize the system with, which can be updated by the more accurate rate gyros.

The three-axis rate gyros and accelerometers, which allow for six DOF strapdown inertial navigation, are packaged together in one inertial sensor-cluster manufactured by Systron Donner.

These sensors are combined with a CPU and a purpose-built high resolution analog/digital converter. The processor executes a proprietary, Kalman-filter sensor-fusion algorithm to provide a statistically-optimal pose estimate from the sensor suite.

### Other Sensor Options

Additionally, two other suites of sensors have been used in the COMPASS system. For an application to an MI tank the wheel encoder was replaced by a Doppler radar velocimeter, manufactured by Dickey-John, to provide speed data. This eliminates encoder measurement error, which would be caused by frequent track slippage, by measuring the actual speed of the vehicle, acting as a “fifth wheel”, instead of measuring the displacement of the tracks.

Also, as a lower-cost alternative, the three-axis rate gyros and accelerometers were replaced with a fiber optic gyro, manufactured by Andrews. This gyro provides rate gyro information for one (yaw) axis. Since this application did not require extremely accurate data for roll and pitch, this maintained accuracy integrity for position and yaw. Additionally, since this application was applied to a tracked bulldozer, the wheel encoder was also replaced by a Doppler radar velocimeter.

## COMPASS Software and Sensor Filtering

A CPU housed in the COMPASS unit gathers all sensor information and uses a proprietary Kalman filtering scheme to fuse the sensor information. Kalman filtering is a relatively common solution to the problem of computing an optimal estimate of a robot's state. Utilizing a Kalman filter provides a statistical robust approach to sensor fusion, which provides both a state estimator and the state covariances (error estimates). The COMPASS filtering system uses a model of the dynamics of the robot and a model of the sensor measurements for general navigation mechanization.

A modular approach to software design for the system allow the COMPASS to be optimized for a particular application. It is possible to change the sensor selection to optimize the system to a new specification for cost or performance or to continually update the sensor to new, state-of-the-art sensors as they become available. Additionally, it is possible to change the dynamic model of the robot to allow the COMPASS to be easily applied to any robotic vehicle.

## COMPASS Performance

The COMPASS, in its most accurate sensor configuration, can typically provide position estimation accuracy in the 10 cm range and orientation estimation accuracy in the 1.5 degree range, while providing output of six DOF position and orientation estimates, as well as the covariances of the estimates, at update rates up to 50 times per second. We provide COMPASS in three different configurations.