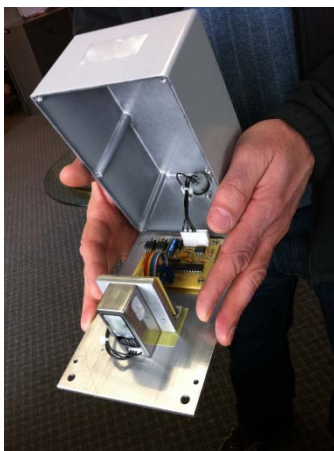


Vehicle Navigation for Automatic Guided Vehicle/Cart Systems

Navigation technology is critical to AGV/AGC system performance. Savant offers unique internal navigation on all its guided vehicle and guided cart models. Savant Automation Virtual Path navigation uses a solid state inertial sensor to determine AGV heading and positional information. This is ideal for all environments especially where magnetic/optic floor tape or laser targets are not feasible or desirable.



Savant 'Virtual Path' navigation maintains sub-inch tracking accuracy. The onboard inertial sensor and virtual path are maintenance-free. Unlike rotational laser navigation sensors or floor tape, Savant's inertial sensor and virtual path are not subject to costly wear-out or damage replacement. The 'Smart' onboard controller

performs navigation, path routing and traffic control, communications, drive control, load deck or work piece logic control and safety functions allowing each vehicle to operate with or without a central system controller.

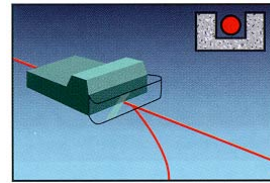
Benefits of Savant Internal Navigation

- Non-wire, 'tape & target-free' autonomy
- Inertial sensor has no moving parts to wear. It's not a costly navigation wear item
- Eliminates periodic replacement of rotating laser head at ~\$8,000/vehicle every few years
- Operates on uneven, rough floors, and ramps
- No line of sight/blocked target or tape maintenance issues

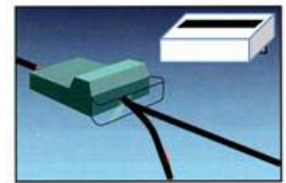
Savant internal Virtual Path navigation is in its 4th generation. All Savant AGVs and AGCs employ this technology allowing complete intermingling of paths and vehicle types as needed by the user.

Savant is a full service AGV system supplier. Manufacturing of vehicles & controls, software, system installation and aftermarket support are executed in-house. Our business dates back to 1954 and our staff averages over 20 years experience in the AGV market.

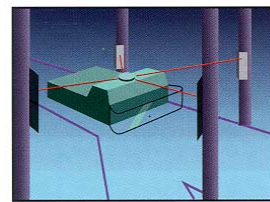
Mainstream AGV/AGC Navigation History



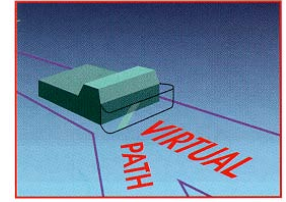
Wire ~1954



Tape ~1960



Laser/Target ~1985

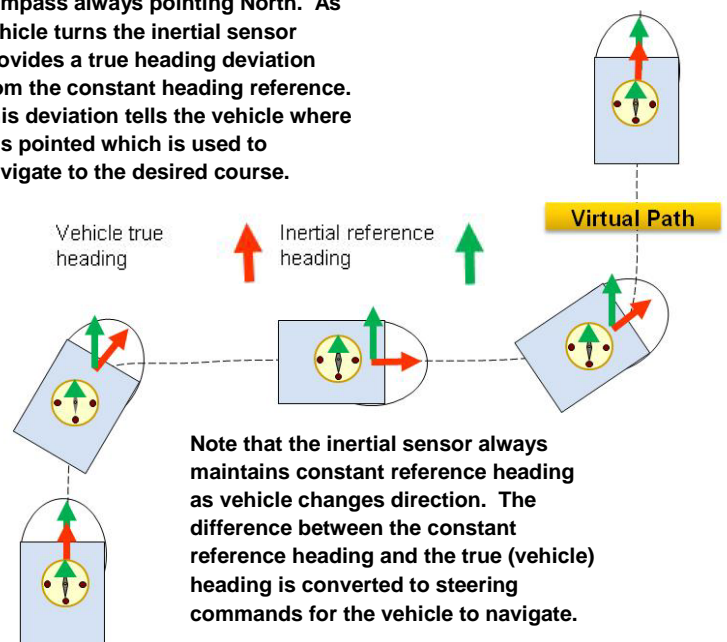


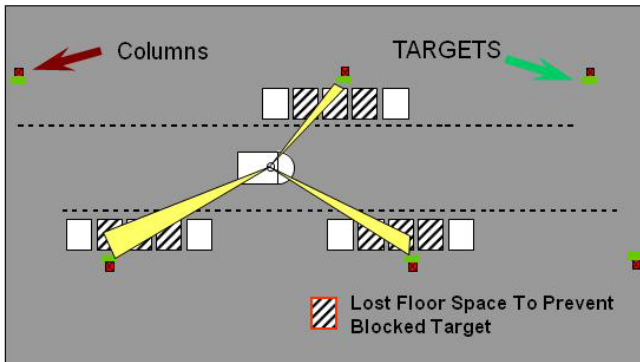
Inertial-Internal -1994

Inertial Navigation Principle

Simplification of how an Savant AGV or AGC navigates with an inertial sensor technology.....

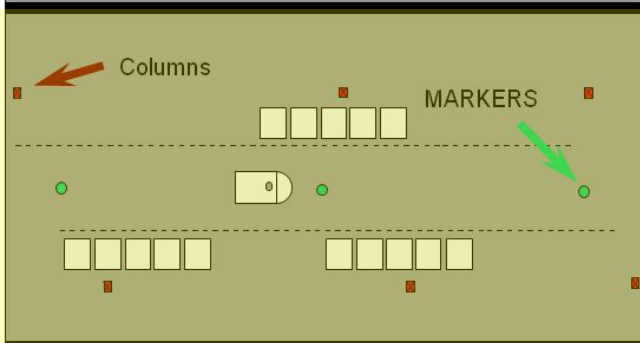
AGV/AGC inertial sensor acts similar to a compass. It maintains a constant heading reference like a compass always pointing North. As vehicle turns the inertial sensor provides a true heading deviation from the constant heading reference. This deviation tells the vehicle where it is pointed which is used to navigate to the desired course.





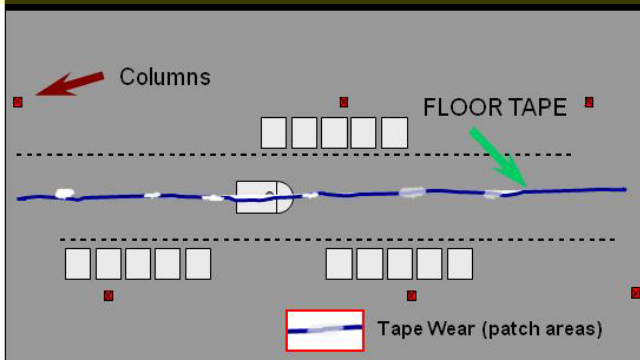
Laser (Target) Navigation

- Targets at fixed elevation estimated ~7' must have clear line of sight
- Target size: ~16" x 6"
- Targets spaced every 20-50 feet, on both sides of path (x2)
- Targets surveyed post installation
- Laser navigation is augmented with distance measuring (wheel encoders)
- Tracking accuracy $\pm 1"$, nominal



Savant Inertial (Internal) Navigation

- Markers (magnet) flush with floor
- Marker size ~0.75"d x 0.25"l
- Markers spaced one every 25-50 feet along path
- Markers surveyed post installation
- Inertial navigation is augmented with distance measuring (wheel encoders)
- Tracking accuracy $\pm 1"$, nominal



Tape (Magnetic/Optical) Navigation

- Sticky tape affixed to cleaned floor
- Station, branch and action markers (tape, RFID tag, plates) affixed to floor
- Marker size ~ 2" x 3"
- Markers and tape moved with path changes
- Path patched with new tape as needed
- Markers subject to damage
- Tracking accuracy $\pm 1"$, nominal

Key Inertial/Internal Navigation Advantages vs. Laser/Target

- ❖ Immune to bouncing or tipping due to uneven or cracked floors which can lead to missed targets stopping vehicle, also capable of operating on grade changes between buildings (i.e. ramps) and outdoors
- ❖ Immune to "line of sight" blocked target issues which stop vehicle, especially in high density aisle storage areas
- ❖ Does not require installation of additional target mounting posts in large open areas
- ❖ Not susceptible to operator damage or sabotage

Key Inertial/Internal Navigation Advantages vs. Floor Tape

- ❖ Immune to torn/missing tape spots that stop vehicle
- ❖ Zero floor maintenance....unlike tape that wears and easily damages requiring costly weekly patching
- ❖ No floor code markers (RFID tags, tape, plates) to get damaged
- ❖ No limit to size or complexity of the guide path network