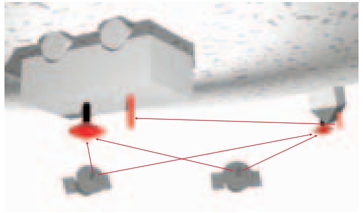
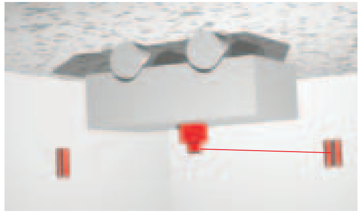
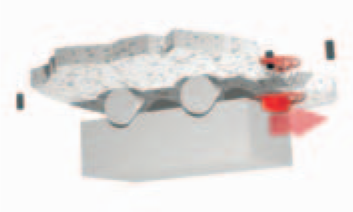


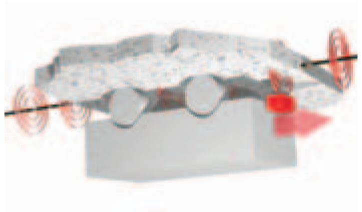
Satellite Navigation:
GPS, GLONASS, GNSS



Optical Systems:
Laser, Line and Pattern Recognition



Electromagnetic Reference Marks:
Transponders and Magnets



Electromagnetic Guidelines:
Guide Wire and Metal Bands

Electromagnetic Guidelines:

Guide Wire etc.

Metal bands within or on the ground are very useful for track guidance of vehicles (e.g. AGV). Sensors mounted in the front of the vehicle recognize changes in the magnetic field of the metal band and thus recognize deviation from the ideal course. However, these signals are rather weak and metal in the ground (e.g. steel building mats) may influence them.

Alternating current (AC) carrying Guide wires (approx. 10 kHz; 100 mA) generate stronger signals. Therefore this technology has been widely accepted for industrial applications and even for high-speed passenger vehicles.

Guide wire technology is highly accurate and has the highest update rate among the described systems.

Electromagnetic Reference Marks:

Transponders etc.

Vehicles equipped with rotary encoders on the wheels, steering potentiometers and / or inertial guidance do not necessarily require continuous track guidance. In this case it is sufficient to set electromagnetic reference marks in certain patterns (e.g. 3 m apart). These reference marks can be either magnets or inductive transponders.

Whenever the antenna crosses a reference mark, it recognises its lateral displacement to either side of an ideal line with reference to the center of the reading antenna. This measure enables correction of any deviation from the ideal course.

Inductive transponders are activated by an electromagnetic field from the reading antenna. These transponders then transmit their code to the reading antenna, which transfers it to the interpreter for decoding and evaluation This is a significant advantage when compared to non-coded magnets.

Electromagnetic reference marks may be used for track guiding vehicles (two dimensional) as well as determination of position for rail-mounted systems (one-dimensional) e.g. overhead monorails. It is therefore possible to achieve highly accurate positioning.

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Comparison of all systems in a table on the last page of this brochure. →

Positioning / Navigation

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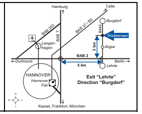

Götting KG
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Germany

03/1998

System / Criteria	Continuous Guidelines			Reference Marks (Virtual Guidelines)		Entire Area	
	Optical Systems (e.g. Lines)	GuideWire	Metal Band	Optical Marks	Transponders (Magnets)	Laser Scanner	DGPS (Realtime Kinematic)
Indoor / Outdoor	ind.	ind. & outd.	ind. (outd.)	ind.	ind. & outd.	ind.	only outd.
Suitability in dirty Environments	-/--	++	++ (•)	--	++ (•)	-	++
Reliability / Security	+	++	+	+/•	+	+	+/-
Infrastructure Installation Costs	++/+	•/-	•	++	++/+	++	++/+
Flexibility	+/•	•	+/•	++/+	+	++	++
Typical Accuracy (+/- mm)	2	2	3-20	3-10	3-30	20	<= 50
Examples All kinds of indoor AGVs							
RTG / VC and outdoor AGVs							
People Mover							
Trains / Rail mounted vehicles							
Overhead Monorails, container locating, conveyor belt, storage and retrieval equipment for shelves and racks							
Public transport, emergency & service vehicles							
Logistics and materials handling							
Personnel positioning, e.g. people who may be in danger							

Suitability

++ = very good
\+ = good
• = average
\- = rather poor
-- = poor

We are working on it

Today

Frantic, unreliable, hazardous, stressful. Stop and go instead of continuous flow of traffic.

Economically inefficient.

Near Future

Possible transport systems: No accidents, no traffic jams. Automated controlled flow of traffic at 100 km/h and 1 m distance between vehicles. Increasing mobility for handicapped and elderly. Driverless transportation of goods possible, length of trips planable to the second.

Economically highly efficient.

Pictures kindly provided by:
AEG Cegelec (1), Eurotunnel (1), Fraunhofer IML & IPA (2), General Electric (1), Mannesmann Demag (1), Mercedes-Benz Omnibusse (2), Preussag-Noell (2), Tetzlaff Verlag (1), TÜV Automotive GmbH (1), Götting KG (5)

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Positioning / Navigation

Positioning / Navigation

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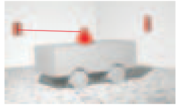
Optical Systems:

Laser etc.



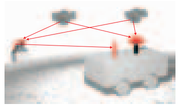
Optical systems are extremely well suited to applications combining a clean environment with a free line of sight between sensors and reference patterns. Some of the first AGVs were optically guided by simple lines on the ground. Today's cameras and image recognition techniques allow processing of more complex marks and reference patterns.

The Laser Scanner is probably one of the most important – best known being the barcode scanner which has achieved the highest circulation. When used for navigation, the laser rotates around its vertical axis (approx. 8 rotations per second). Its emitted beam is reflected by reference marks and redetected by the scanner. The angle between the vehicle's longitudinal axis and the reference mark's position is then determined allowing trigonometrical calculation of the vehicle's position.

A navigation Laser Scanner allows independent navigation of an indoor AGV.

Satellite Navigation:

GPS etc.



Since the mid 1990s, affordable and reliable satellite navigation systems have been available. They enable a mobile station (Rover) to determine its current position anywhere in the world. Unfortunately, dependent on geographic region, there are differing transmission errors. Using a reference station that transmits reference data to the Rover via RF can eliminate these errors. This method allows accuracies of 3 - 5 m to be achieved.

It is possible to boost this accuracy even further (to 2 - 10 cm) by evaluating the carrier signal's phase. Adding additional sensors to the vehicle, stabilizes these accuracies, allowing automated guidance. However, the antenna on the Rover (and, of course, on the reference station) must be able to 'see' the satellites at all times.

For times when sight connection to satellites is obstructed inertial guidance or odometric systems have to be integrated.

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See inside pages for a few examples of described systems. →

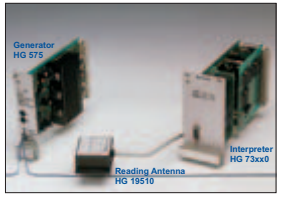
Electromagnetic Guidelines:

Guide Wire and Metal Bands

For continuous transport, AGVs, busses and container carriers; any system which is bound to a specific track

++ Safe track guiding (People Mover)
++ Extremely high accuracy (lateral y)
++ Not influenced by ice, snow, dirt, concrete, etc.

– Possibly influenced by metal in the ground (such as steel reinforcement)
– Longitudinal information (x) only in combination with additional sensors
– Relative costly installation of guide wire



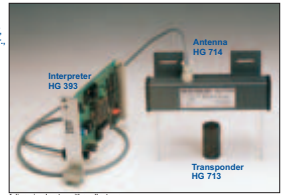
Electromagnetic Reference Marks:

Transponders and Magnets

1 dimensional: scheduled transport with Overhead Monorails, AGV, busses and container carr., railmounted vehicles
2 dimensional: track guiding AGV, container carriers

++ Not influenced by ice, snow, dirt, concrete, etc.
+ High accuracy in x (and y) directions (i.e. direction of travel)
+ Relatively low cost installation of transponders

– Possibly influenced by metal (such as steel reinforcement)
– Antenna can sometimes be rather large
(–) Weak signals, thus easily influenced by "man made noise"



1 dimensional system with small antenna

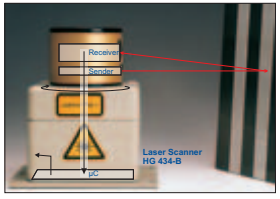
Optical Systems:

Laser, Line and Pattern Recognition

Navigation of Automated Guided Vehicles (AGV); mainly indoor

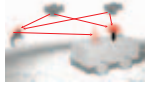
++ Extremely flexible
+ High accuracy
+ Low cost infrastructure installation

– Inappropriate in dusty, dirty, foggy, snowy environments etc.
– Reflecting marks / guidance lines have to be "visible" to the scanner



Satellite Navigation:

GPS, GLONASS, GNSS



Allows rough positioning of cars, trucks, tractors, busses or trains.
Accuracy of up to ±3 cm for track guidance, levelling work in civil engineering

Accuracy: 5 m for logistics in general, buses, trains
0,5 m for storage and container tracking
<0,05 m for navigation

++ Available "world wide"
+ Highly flexible

– Obstruction possible
– – Not for indoor applications

Extremely effective:
Inductive track guiding of in-company transport

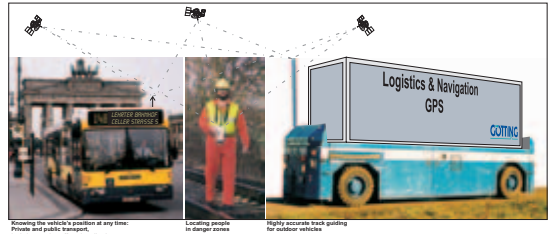
Highly reliable:
Wire guided busses are appropriate for public environments (more flexible than trams/trolleys)

1 dimensional positioning with transponders for railbound transport (shown: Overhead Monorail positioning with vehicle identification)

2 dimensional positioning and track guiding using transponders for taking strain off the drivers (shown: Rubber Tired Gantry Crane RTG)

Optical track guiding using colored tape fixed to the ground suitable for low-cost or temporary installations (e.g. vehicle crashes)

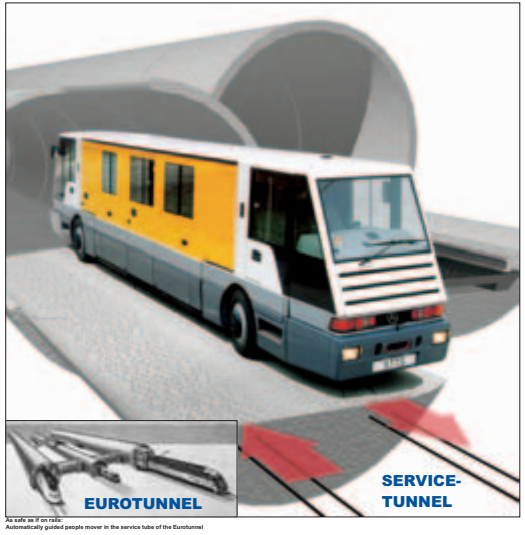
Flexible navigation is essential for service vehicles (e.g. optical pattern and obstacle recognition)



Knowing the vehicle's position at any time: Private and public transport, logistics, service, off-road applications

Locating people in danger zones

Highly accurate track guiding for outdoor vehicles



As safe as if on rails:
Automatically guided people mover in the service tube of the Eurotunnel

Security in logistics:
Positioning and track guiding using transponders (on the chassis and within the bridge; for identification of vehicles (e.g. trucks))

Laser Scanner for independent navigation (indoor AGV (forklift))

Satellite positioning for logistics: No containers lost

Your competent partner for

- positioning and navigation
- wireless data communication systems.

PEOPLE
Overhead Monorail
AGVs
On- & Off-Road Service Vehicles
TRAINS
RTGs

In co-operation with our **partners** we provide general contractor services anywhere in the world in

- plant and vehicle engineering
- logistics & EDI
- servicing.

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