Leica machine control system
for graders with MOBA GS 496
Leica Machine Control System for Grader

Description of the system

Traditionally string lines are used to guide Graders in most road construction operations, in both line and level. This represents an expensive outlay in survey operations and also creates significant logistical problems. The Leica machine control system allows direct navigation in a previously defined project, without the expenditure of staking out string lines. The system controls the blade of the grader in both height and cross slope. An automatic Leica total station (all TCA/TCRA models of the TPS1100 series or TCA 1800) measures the exact 3D position of the prism on the machine. This position is transferred via radio to a ruggedised PC on the machine. To determine positions, the Leica GPS System 500 is also very well suited. With their layouts being the same in principal, it is easy to interchange total stations and the GPS System. Combined with the measured values of the tilt sensors on the machine, the position and bearing of the grader is continuously determined. By comparing these values to the project data stored in the PC, corrections for height and tilt are calculated and continuously transmitted to the blade controller.

Components of the system

The system consists of hardware and software components developed either by Leica Geosystems or by its partner (MOBA Mobile Automation GmbH). The most important components are listed below:

- System computer (suitable for machines) with colour touch screen
- Application LMGS-G for Graders v2.0
- Automatic total station (all TCA/TCRA models of the TPS1100 series as well as TCA 1800)
- GPS System 500 (reference station SR530, rover station MC500 on the machine)
- MOBA Grader Control System GS 496 (with control panel and multi sticks, control unit, rotation compensator, cross- and longitudinal tilt sensor, hydraulic unit)
- 2-axis mast tilt sensor
- required accessories such as 360° precision prism, TCPS26 radio modems, data transfer cables, batteries, etc.

The automatic total station and the GPS sensors are important system components:

TPS1000 series instruments must be provided for this machine control with optimised firmware. A new motor regulation has been implemented, which almost eliminates aiming errors, which has greatly improved the tracking of moving targets. This firmware also allows normal use of the instruments for survey tasks, however only with selected application programs. Firmware version 3.00 can also be installed as retro-fit on existing instruments. On these instruments, all application programs with a version number of min. v3.00 must be installed. For use with the machine control system, the special on-board application "Leica Machine Guidance (MGUID, v3.02)" was developed.

TPS1100 series instruments must be installed with system firmware version 2.00 (or higher) for this application. This is a prerequisite for the the search procedures of the total station in conjunction with the machine control system. Since it is standard software, all application programs are also compatible. For TPS1100, there is also the special on-board application "Leica Machine Guidance (MGUID, v2.00)" required.

The reference station does not require any changes and is used with the default settings for real-time operations. The rover station on the machine only needs a configuration file (lmgs.cnf), that automatically modifies the settings and assures correct communication. The file is on the CD-ROM supplied with the system and is loaded on site into the sensor by the system supporter.

A complete list of the system components with description, can be found in the price list for grader machine control system.

Functions of the system

The following functions, which permit optimal use of the system, are available:

- Project selection
- Loading and editing project data (reference point file, design data file )
- Plotting of the project data
- Free stationing or known-point setup
- Automatic control of orientation and stationing
- Easy definition of the machine geometry
- Tracking-function at TC(R)A 110x / TCA 1800 for continuous measurement data
- Calculation of the design correction values for controlling the blade
- Setting parameters for matching the behaviour of the machine
- Display of the deviations in position and height as well as display of design cross slope and actual chainage
- Display of the number of available satellites and the GPS quality
- Selection of reference lines for calculation of the offsets to the blade edge
- Recording/storing logfiles
- Automatic recognition of the working direction (can be switched to manual)
- Definition of 3 search points spread over the project
- Automatic compensation of mast tilt
- Adjustable window sizes for search areas
- Helpful hints and warning messages are displayed on the machine computer to minimize driver error.

**Applications**

The machine control system has been developed for use with various graders that are, or can be, equipped with the MOBA GS 496 automatic blade control.

The system is designed to grade surfaces with high accuracy. It is used primarily on civil engineering projects, such as:
- Roads/Highways
- Railways
- Runways at airports

The machine control system for graders can be used on most types of machines. It only needs a clarification which hydraulic components are to be controlled.

The connection to the machine is made by an industry-standard CAN-bus system of the MOBA GS 496.

**Technical Data**

Various parameters determine the performance of the system. The technical features of the hardware used are decisive for the accuracy, but can be influenced appreciably by the ambient conditions. Also the material (e.g. stone size) has a measurable impact on the accuracy. The accuracies and ranges listed below therefore relate to average atmospheric conditions.

The accuracy attained by the system is affected in practice by the machine control system.

**Performance features of the components**

<table>
<thead>
<tr>
<th>Total station</th>
<th>TC(R)A 1101</th>
<th>TC(R)A 1102</th>
<th>TC(R)A 1103</th>
<th>TC(R)A 1105</th>
<th>TCA1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle measurement</td>
<td>0.5 mgon (1.5&quot;)</td>
<td>0.6 mgon (2&quot;)</td>
<td>1.0 mgon (3&quot;)</td>
<td>1.5 mgon (5&quot;)</td>
<td>0.3 mgon (1&quot;)</td>
</tr>
<tr>
<td>deviation at 200m</td>
<td>1.5 mm</td>
<td>2 mm</td>
<td>3 mm</td>
<td>5 mm</td>
<td>1 mm</td>
</tr>
<tr>
<td>Distance measurement</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>static</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>dynamic</td>
<td></td>
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</tr>
<tr>
<td>Target recognition</td>
<td></td>
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<tr>
<td>Radial target speed</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>with distance-tracking</td>
<td>Max. 30 km/h</td>
<td>Max. 30 km/h</td>
<td>Max. 30 km/h</td>
<td>Max. 30 km/h</td>
<td>Max. 15 km/h</td>
</tr>
<tr>
<td>Target recognition</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Tangential speed</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>with distance-tracking</td>
<td>Max. 15 km/h</td>
<td>Max. 15 km/h</td>
<td>Max. 15 km/h</td>
<td>Max. 15 km/h</td>
<td>Max. 10 km/h</td>
</tr>
<tr>
<td>Angle speed when locked in with distance-tracking*</td>
<td>Max. 12 gon/s</td>
<td>Max. 12 gon/s</td>
<td>Max. 12 gon/s</td>
<td>Max. 12 gon/s</td>
<td>Max. 10 gon/s**</td>
</tr>
<tr>
<td>Range (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circular prism</td>
<td>3000 (static)</td>
<td>3000 (static)</td>
<td>3000 (static)</td>
<td>3000 (static)</td>
<td>1000 (static)</td>
</tr>
<tr>
<td>360° prism</td>
<td>800 (dynamic)</td>
<td>800 (dynamic)</td>
<td>800 (dynamic)</td>
<td>800 (dynamic)</td>
<td>500 (dynamic)</td>
</tr>
<tr>
<td>1500 (static)</td>
<td>1500 (static)</td>
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<tr>
<td>500 (dynamic)</td>
<td>500 (dynamic)</td>
<td>500 (dynamic)</td>
<td>500 (dynamic)</td>
<td>500 (dynamic)</td>
<td>350 (dynamic)</td>
</tr>
<tr>
<td>Search for target point</td>
<td>automatic</td>
<td>automatic</td>
<td>automatic</td>
<td>automatic</td>
<td>automatic</td>
</tr>
</tbody>
</table>

* with onboard application Machine Guidance (MGUID)
** without distance-tracking (only lock-in)

1) Light haze, visibility about 15 km; or weak sunlight, slight heat shimmer.
GPS System 500 (Base line accuracy*):

The following specifications are based on measurements processed using SKI software and are given as baseline rms (root mean square).

<table>
<thead>
<tr>
<th>Operation</th>
<th>Differential phase SR530/MC500</th>
<th>Differential code SR530/MC500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Choke Ring</td>
<td>3 mm +0.5 ppm</td>
<td>30 cm</td>
</tr>
<tr>
<td>Static</td>
<td>5 mm +1 ppm</td>
<td></td>
</tr>
<tr>
<td>Rapid Static</td>
<td>5 mm +1 ppm</td>
<td></td>
</tr>
<tr>
<td>Stop &amp; Go</td>
<td>10 mm +1 ppm</td>
<td></td>
</tr>
<tr>
<td>Kinematic</td>
<td>10 mm +1 ppm</td>
<td>30 cm</td>
</tr>
</tbody>
</table>

* Dependent on number of satellites tracked, constellation geometry, observation time, ephemeris accuracy, ionospheric disturbance, multipath and resolved ambiguities.

Tilt sensor

(Standard deviation)

- Measurement principle: Liquid sensor
- Measurement range: ± 60º
- Accuracy: 2 ‰
- Measuring frequency: 0 - 100 Hz
- Interface: CAN
- Type of protection: IP 67

Complete system

(Standard deviation)

<table>
<thead>
<tr>
<th>System</th>
<th>TPS System</th>
<th>GPS System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height accuracy of machine position</td>
<td>5 mm / 200 m</td>
<td>10 - 50 mm</td>
</tr>
<tr>
<td>Position accuracy of machine position</td>
<td>10 mm / 200 m</td>
<td>10 - 50 mm up to 10 km</td>
</tr>
<tr>
<td>Measuring frequency</td>
<td>5 – 9 Hz</td>
<td>10 Hz</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-20°C ... 50°C</td>
<td>-20°C ... 50°C</td>
</tr>
<tr>
<td>Temperature range IPC</td>
<td>-20°C ... 50°C</td>
<td>-20°C ... 50°C</td>
</tr>
<tr>
<td>Voltage</td>
<td>24 V</td>
<td>24 V</td>
</tr>
</tbody>
</table>