Stringless 3D System Presentation

Overview

- What is it?
  - Customer Benefits
  - Conventional vs. 3D Work Approach

Applications

- Mainline Slipforming
- Curb & Gutter
- Sidewalk/Barrier
- Trimming (fine grade)

System Details

- Components/Sensors
- Digital Stringlines (3D Model)
- Practical Field Issues
What is 3D Stringless?

A 3D Machine Control system that simplifies jobsite logistics, reduces costs and improves quality and safety

- Removes stringlines and pins from the jobsite
  - Removes install, maintenance & removal costs
  - Increases working safety, especially at night

- Puts the 3D job design directly onto the machine
  - Eliminates setting-out errors and stringline influences
  - No waiting for setting-out before production
  - No dependency on setting-out – work wherever you have 3D data
  - Increases productivity, quality and performance bonuses

- Controls height, slope (and steer) of machines
  - Delivers a precisely-constructed product
  - Optimises amount of new material needed
  - Reduces over-trimming, overpouring
  - Improves concrete yields and material cost savings
Why are paving contractors “Going Stringless”? Because stringlines…

- …are expensive, time-consuming and error-prone to install - typically US$1.50 per pin, or > US$500 per mile (European figures, excludes surveyor costs)
- …are easily damaged during paving
- …are easily misaligned (errors increase costs)
- …are a significant site safety hazard
- …interfere with site logistics, increase concrete delivery time, haulage costs, and reduce productivity.
- …greatly increase pre-production planning & surveyors workload
What are the advantages of “Going Stringless”?  
Advantages the paving contractors are seeing in 3DMC

- Good site engineers/surveyors are hard to find, and expensive

- Stringlines don’t always ‘model’ the concrete design accurately

- “Go in, pave & get out” ability minimizes machine standing time – ideal for time-critical paving operations (e.g. ‘live’ airports, roads)

- Estimated 50% survey cost reduction - one surveyor or engineer manages the 3D system

- Estimated 20% productivity increase (up to 50% in complex areas)

- Direct construction from CAD design – no intermediate rework

- One 3D model for trimming and paving = material cost savings
Working with Stringline...

- Inspect design – calculate setting-out lists for each lane
- Setup a theodolite, survey each hub or pin position with total station (or GPS if accuracy isn’t important!)
- Hammer (or drill) in each pin, minimum 1 line for each lane of concrete/asphalt
- Check pin alignment & adjust if required
- Survey and set stringline height on each pin (min. 2 men)
- Install & tension clamps and stringlines

- “Eyeball” & adjust stringlines before paving
- Move machine into position, set sensors to stringline
- Check machine position relative to stringlines
- Start Production, monitor machine position
- Ensure (or hope!) nothing disturbs or damages stringlines during paving/milling…
The 3D Advantage

Use digital data, directly from the design

- No staking-out and stringline setup errors

No stakes, hubs or stringlines required

- Eliminates most setting-out costs
- Easier jobsite logistics, truck access
- Work easier in narrow work corridors

No waiting on surveyors, stringline crews, grade checkers etc.

- Improved machine productivity
- Work anywhere you have data, not where the stringlines happen to be ready for
- Work any time of day or night

Increased safety

- No more ‘trip hazards’, ideal for hazardous worksites (e.g. highway lane rentals)

Increased productivity

- More work done right the first time, and faster
Stringless Paving Applications
Mainline Slipforming
Some completed & current Projects

Airports

- **Military**: RAF/USAF Fairford (UK); USAF Kirtland (NM, USA); USAF Lakenheath (UK); Belle Chasse Naval Reserve New Orleans, LO (USA); Homer Regional Airport, LO (USA); Travis USAF Cal USA; El Centro Cal, USA; Virgin Galactic Spaceport, New Mexico; Jacksonville USAF, Florida

- **Civil**: Zurich & Basel International (Switzerland); London Heathrow & Stansted, Edinburgh Intl., Farnborough, Luton Intl. (UK); Paris Charles de Gaulle (France); Atlanta Hartsfield Jackson Intl., Baton Rouge; St Louis; Indianapolis; Toulouse (France); Chicago O’Hare; Guadeloupe (Caribbean); Paris Orly (France); Charlotte, NC, USA; JFK Airport, New York, USA

Highways

- E40 Ghent-Brussels, Belgium (4 x 10km); I-30 Dallas-Fort Worth, USA (4 x 20km); Pacific Coast Highway Australia (4 x 11km); A1, Peterborough UK (2 x 15km); E67 Prague-Wroclaw Czech Republic (30km); E462 Brno (Czech Rep.); I-75 Atlanta, USA; I-95 Coco Beach, Florida, USA

Tunnels

- Sophia Rail Tunnels, Rotterdam, 11km (Netherlands); Channel Tunnel Rail Link, 35km, London (UK), Rail Tunnel Malmo (Sweden), Finnetunnel Erfurt-Leipzig (Germany)
3D for Curb & Gutter

- Providing a precise, smooth, accurate curb for new asphalt is crucial for the quality, rideability, service life and whole-life costs of the new asphalt surface.

- Installing stringline for curb applications is costly and time-consuming, especially for tight radius work

- Traditionally requires pre-survey, hubs and data to be provided to the stringline crew

- This can lead to mistakes, and significant remedial costs & time

- With 3D, machine steer, elevation and cross slope are automatically controlled without stringlines

- 3D improves operational safety on site and increases productivity, accuracy and efficiency
Barrier Stringless Paving

- Restricted access, ‘live’ highway possessions, urban and narrow-corridor or zero-clearance projects.
- Project logistics are made much simpler when you can banish the stringlines. Get your concrete trucks in and out faster, with no risk of damaging the stringlines and stopping production.
- Site safety and setup time for stringlines are also big concerns for projects surrounded by live traffic.
- With 3D your crews have one less thing to worry about when the pressure’s on!
Monolithic & Sidewalk

- Pave any shape in any configuration
- Prepared for Left- or Right-side molds
- 3D is as flexible and reconfigurable as your machine.
- Simply attach your new mold, set the new machine dimensions into 3D and you’re ready to go back to work.
Fine Grade Trimming

- Single sensor configuration reduces cost of 3D equipment
- Contractor can set rough grade approx ½” high then 3D trim to get subgrade within 1/8”
- Exact 3D model of road design is used for both the paver and trimmer
- Contractors have seen substantial decrease in yield loss
Special Applications – Tunnel Paving

Gomaco GT-6300 Commander III 4-track Slipform Paver, 2 x 18km, 1.5m escape walkway, Channel Tunnel Rail Link, London, UK, 2003
Special Applications – Tunnel Paving

Gomaco GT-6300 Commander III 4-track Slipform Paver, 2 x 7km tunnels, ICE Finnetunnel, Erfurt-Leipzig, Germany, Nov 2009
3D Stringless Paving Sensors
Is Position Enough?

No, we need to know both  **Position** (North, East, Height)  
and **Attitude** (crossfall, mainfall, heading)

We’re interested in regulating the **entire mold**, which is a 3D surface 
(plane) - not the same as dozers, graders or asphalt pavers.

A plane is usually defined by a minimum of three points...  
...but we can’t attach three prisms to the mold.  *Impractical for* various reasons (line of sight, cost of instruments, operation etc)

We needed a solution to find the machine’s **Attitude**...
Measuring “Attitude”

High accuracy dual-axis slope sensors provide Crossfall and Mainfall.

Heading is calculated from the ‘history’ and reference to a Steering Reference Line in the project model.
Components

MSS1200 Slope Sensor

- Solid state, no moving parts
- One-step calibration
- Dual axis (cross & long slope)
- CAN Bus 2.0
- Range ± 60°
- Accuracy ± 0.1°
- Temp. Range: -20°C to +60°C
Components
3D Sensors – Total Stations

- 1” accuracy total station
- Fully robotic operation
- Automatic prism tracking
- Simple setup and position fix
- Can be used for any surveying tasks
- 10-12Hz measurement rate
- Backlight & heater for night operation
- Typical working Range ± 100m (300ft)
- Tracking accuracy ±3mm at 100m (300ft)
Components
3D Sensors – GPS (for machine steer option only)

- Machine GPS
- Supports GPS & GLONASS systems for maximum operational time
- Simple setup and position fix routine
- Identical user interface to TPS – no extra training required
- Can be quickly removed from machine and used for any site surveying tasks
- True 20Hz measurement rate
- Typical Tracking Accuracy:
  - Position: ±10mm
  - Height: ±20mm
Choose your sensors wisely!!!!!!

Sensor selection specific for the application & tolerances at hand!

TPS  VS  GPS
3D Stringless Sensors
Options for Curb & Gutter, RCC & Mainline Pavers

1-TPS (single total station)

- **Gomaco** “Offset” (Curb & Gutter, barrier) single-steer concrete paver (GT-3200)
- **Gomaco** RCC Screed Pavers

2-TPS (dual total station) or TPS + GPS

- **Gomaco** GT3600, GT6300, GT3400 3-Track concrete pavers with all-track-steer

2-TPS (dual total station)

- **Gomaco** Commander III, GP-2600, GHP-2800, GP4000 4-Track concrete pavers with all-track-steer
Stringless System for Gomaco Pavers
System Components

Prism
Machine Computer
Radios
Slope Sensors
Reference Point

TPS #1 (Guidance)
TPS #2 (Guidance)
TPS #3 (As-builts & Leapfrog)
Reference Point

Prism
PZL-1 (Positioning Zone Laser)

- Transmits Unique Laser Zone Signal
- 500 Foot Diameter
- Auto-Leveling
- 4 Channel Operation
- Alkaline Batteries, NiMH Rechargeable, & External Power
MMGPS Features

MMGPS is unique in the market...

- Multiple machines and rovers controlled by a single laser.
- Up to 4 lazers in a row. Covers a height differences up to 40m.
- Dual Elevation Control is more precise than Single Elevation & Slope Control.
- Lasers are easy to handle and set-up (paving crew).
- Same system can be used on multiple machines...grader, dozer, trimmer, paver etc.
PZS-MC
(Positioning Zone Sensor for Machine Control)

- Receives & Decodes the Laser Zone Signal
- 360° beam Detection
- Rugged, Shockproof Design
- IPX6 Waterproof
- DC8V~DC32V Power Supply
3D-MC Platform

- GPS receiver(s) safely inside
- Internal 900Mhz or UHF modem
- Support for mmGPS
3D-MC Platform

GX-60

• Used in 2D & 3D applications
• Touch screen
• Windows XP
• Operator selectable views
G21 / G22
Curb & Gutter – 3D-mmGPS

1. PZS-MC Sensor
2. GX-60 Control Box
3. MC-R3 GPS Receiver
Wide-track Concrete Paver - 3D-mmGPS

1. PZS-MC Sensor
2. GX-60 Control Box
3. MC-R3 GPS Receiver
J.K. Williams

- Location: Sydney, Australia
- Machine: Gomaco Commander III
- Application: Housing Development
1 TCA Option – 1-Track-Steer C&G

360° Prism

Machine
Computer, Radios

Reference
Point (Hub)

Slope
Sensor

Rear Steer
disabled

Total Station #1
(Guidance)

Reference
Point (Hub)

Total Station #2
(As-builts &
Leapfrog)

GOMACO
1 TCA Option – 1-Track-Steer Trimming

- Reference (Hub)
- Machine Computer
- Radios
- 360° Prism
- Slope Sensor
- Total Station #1 (Guidance)
- Total Station #2 (As-buils & Leapfrog)
2 TCA Option – All-Track-Steer C&G or Barrier

- 360° Prisms
- Machine Computer
- Radios
- Total Station #1 (Guidance)
- Total Station #2 (Guidance)
- Total Station #3 (As-builts & Leapfrog)
- Reference Point (Hub)
- Reference Point (Hub)
- Rear Steer enabled
- Slope Sensor
“GPSAssist” Option – For C&G & Barrier

- GPS Rover Antenna
- 360° Prism
- Machine Computer
- Radios
- MNS1200
- Rear Steer enabled
- Reference Fixpoint (Hub)
- Total Station #1 (Guidance)
- Total Station #2 (As-builts & Leapfrog)
Measurement – “GPSAssist” Option

GPS Reference Station (onsite or CORS)

GPS RTK Corrections via Radio Link (cm accuracy fix)

c. 20km max (12.5 miles) with repeater

c. 20,000km (12,500 miles)

GPS Rover (Position/Orientation only)

c. 200m (600ft)

Total Station (Guidance & Accurate Height)
Stringless Control System for Placer/Spreaders

System Components

- Machine
- Computer
- Radio
- Slope Sensor
- 360° Prism or GPS available also depending on desired accuracy!
- Reference Point
- Theodolite #1
  - (Guidance)
- Theodolite #2
  - Optional for Leapfrog
- Reference Point
TCA Option only - Mainline Pavers

Machine Computer

360° Prism

Radios

Slope Sensor

Total Station #1 (Guidance)

Total Station #2 (Guidance)

Total Station #3 (As-builts & Leapfrog)

Reference (Hub)

Reference (Hub)
Why two Total Stations for Mainline Pavers?

Machine width & frame flex
String-line control ‘emulation’
Maintains correct mold alignment

Two total stations provide two independent front & rear control; to the centre point of the mold at the rear (P1) and front (P2) of the machine

We get an accurate heading

Benefit: Fully independent front and rear control (draft, level, position etc)
Replacing the Stringline by Modelling the Project…
How to gather the existing surface Information?

Question number 1: How accurate do we need to be? This can only be defined by you! How inaccurate can you afford to be based on yield?
Traditional methods
Are there any new technologies available to do this more accurately and safely?
A few modern technologies you may consider!
What do these new technologies provide me? Data, data, data!!! Is there ever too much?

The better we know our existing surface the more accurately we can redesign, reconstruct and control materials and processes for our new surface!
How do we make a 3D Design?
The D45 Model

- D45 file contains “virtual stringlines” (in the project coordinate system).

- Simple ASCII text file; data can be extracted from almost any CAD system, or created/edited in a spreadsheet

- Complete Freedom! The model can represent existing stringline data, slab edges (“virtual slabs”), or any arbitrary offset (position and/or height)

- Machine can pave anywhere, any time, as long as the D45 is prepared
Replacing the Stringline - 3D Design Modelling
The D45 Model approach!

Cross-Section
Coordinate (Easting X, Northing Y, Height Z)
Working Offset (Position)
D45 Modelling

What does the machine operator see?
Before you order the Concrete Trucks!

Preferable Pre – project check list!

1. Establish Control FIRST!
2. Maintain control network and have quality check continuously throughout the entire time frame of the project!
3. Know or define where the existing project (roadway) is today X,Y,Z
4. Know where the proposed project will be upon completion (model of proposed) – Your yield is at stake!
5. Make corrective actions to the surface prior to paving if necessary!
Practical Issues…
In the field!
Practical Issues
Checking concrete (or subgrade) level and position

- The third theodolite together with a prism measures the surface “as-built” behind the machine

- Errors (and adjustments) shown on theodolite

- Report stored on 3D computer
Practical Issues
Adjusting the Machine

- If the level needs adjusting...
- ...just like stringline control we can adjust all leg heights, and draft independently, without stopping paving
Practical Issues
Adjusting the Machine

- If position needs adjusting...
- ...just like stringline control, we can adjust position at front and rear independently, without stopping paving.
Practical Issues
Moving the Theodolites (‘Leapfrogging’)

- Maximum Range Theodolite-to-Paver is <= 200m (*depends on conditions)
- We don’t want to stop the paver for too long!
- Before maximum range is reached, move 3rd Theodolite to new position & setup (Position & Orientation Fix).
- Press ‘Swap Theodolite’ on computer
- System switches control from #2 (or #1) to #3 Theodolite automatically
- Move ‘old’ Theodolite to new position, setup and repeat procedure
- Ensure enough Reference Points visible for Setup (Position & Orientation Fix)

* - temperature, humidity, air quality
“Leapfrogging” Part 1
All Theodolites in “Start” Position
“Leapfrogging” Part 2
Move Theodolite #3, Setup, Transfer Control (#2 → #3)
“Leapfrogging” Part 3
Move Theodolite #2, Setup, Transfer Control (#1 → #2)
“Leapfrogging” Part 4
Move Theodolite #1, Setup, Transfer Control (#3 → #1)
Thank you for your attention!

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