



Process Metrix Mobile Laser Contouring System (LCS) for Converter Lining Thickness Monitoring



Process Metrix
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USA





Process Metrix – A History of Instrumentation Development

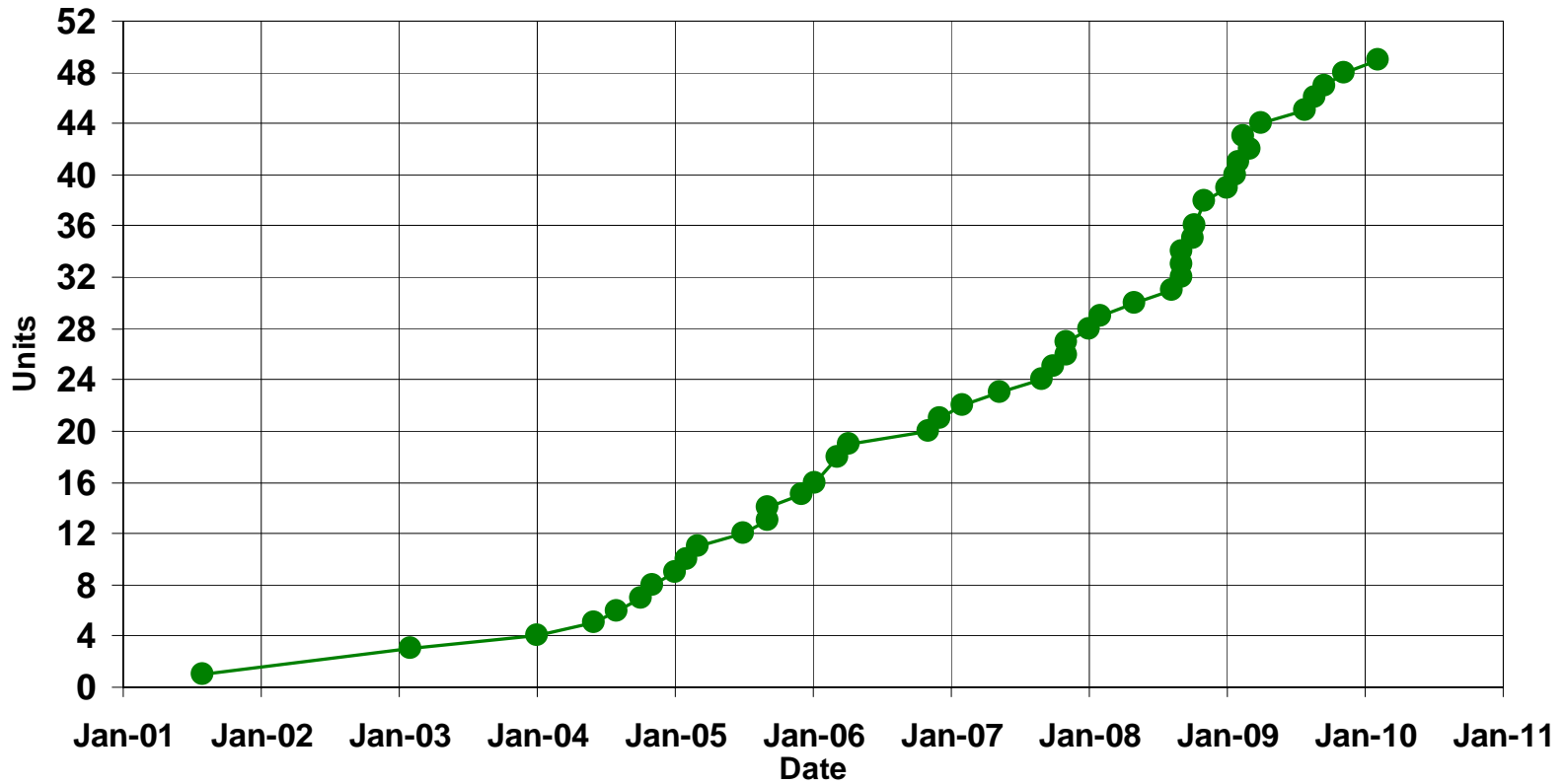
- Insitec Measurement Systems –
 - Founded in 1985, laser-based particle size instruments
 - Close associations with gov't labs, \$5M in government research
 - 1993 - development of instrumentation for steel industry: Two color pyrometry (temperature), spectroscopy (off-gas control), range finding (refractory thickness measurement)
- Insitec sold to Malvern, PLC in 1997 –
 - Principles stay on to support technology transfer
- Process Metrix started January, 2000 -
 - Same group of people
 - Focus on steel sensors, particles, continued gov't funding
 - LCS released in 2001
 - Next-gen particle sensor released in 2004
 - Sales growing rapidly as market penetration increases



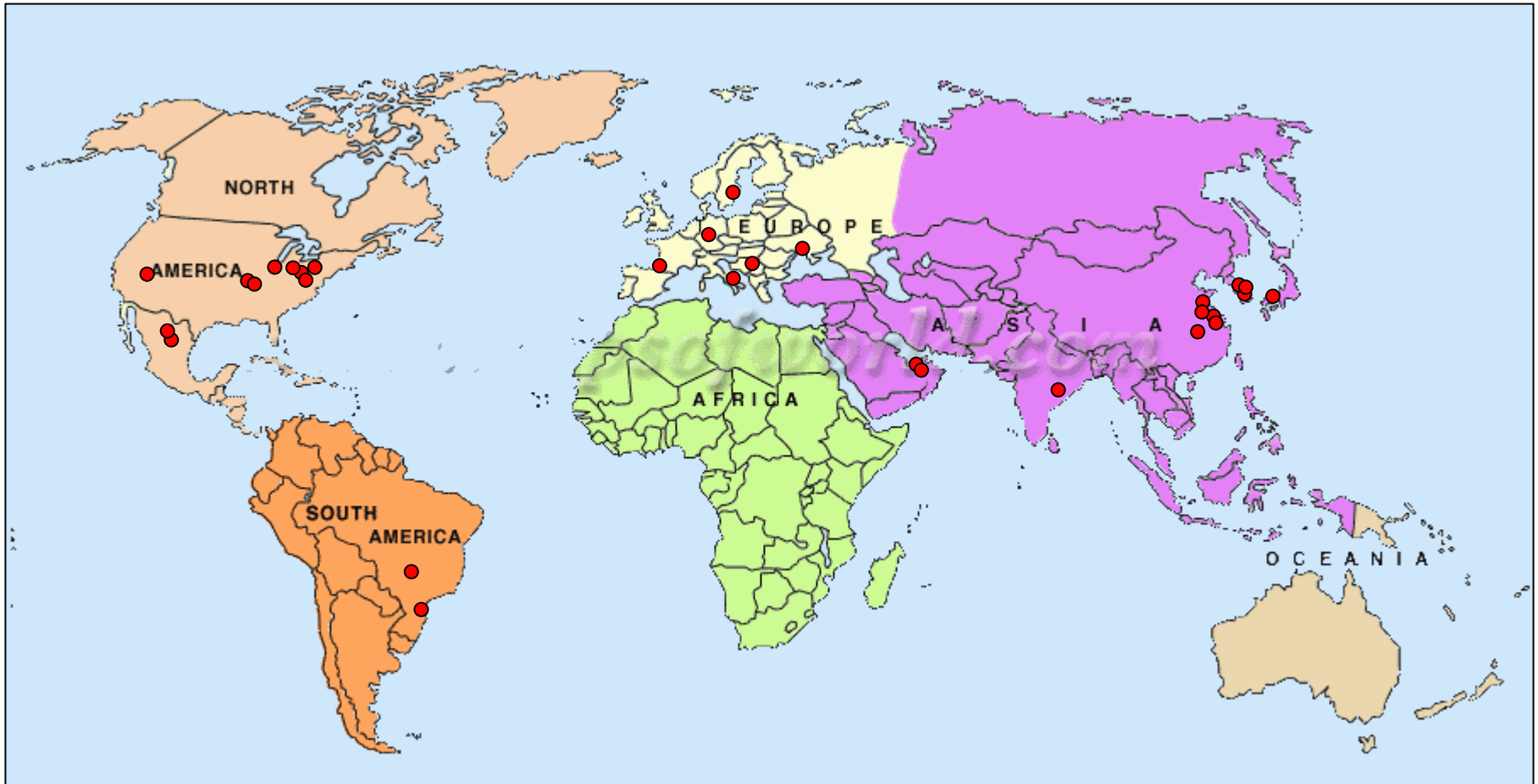
Total Control of All Aspects of our Product

- A talented group-
 - Engineering staff include:
 - Ph.D, M.S. and B.S. degreed mechanical and chemical engineers
 - Electronics technicians
- Process Metrix designs and builds its own:
 - Software - Microsoft Windows-based
 - Hardware –
 - 3-D CAD development tools, including Finite Element Analysis (FEA)
 - San Francisco Bay area job shops fabricate machine parts
 - Electronics –
 - In-house schematic and board layout tools, with modeling capability
 - Boards fabricated using state-of-the-art tooling in Silicon Valley
- Each instrument is hand assembled in our factory, tested, and verified following strict quality control procedures

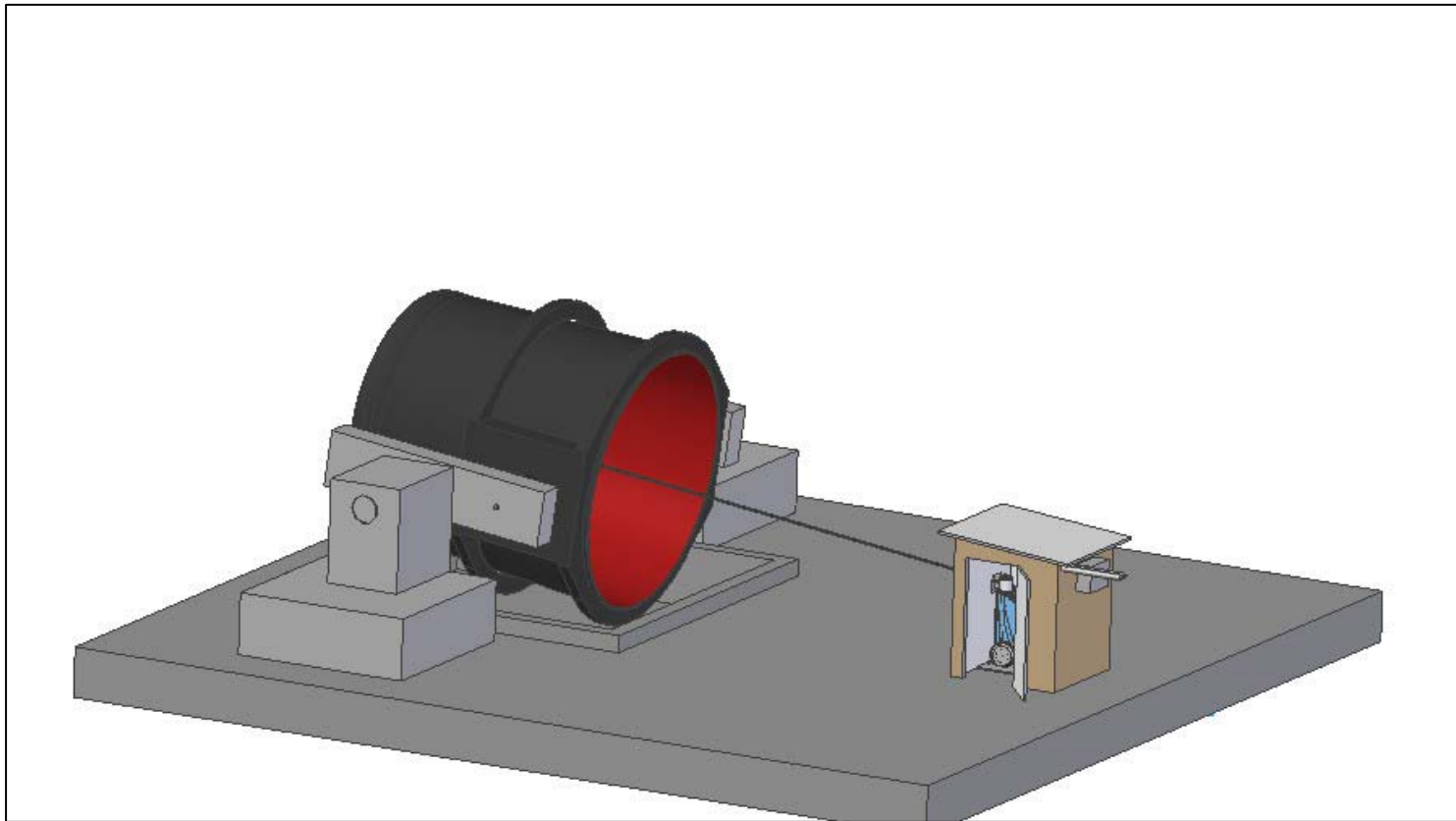
LCS Sales Show Rapid Market Uptake



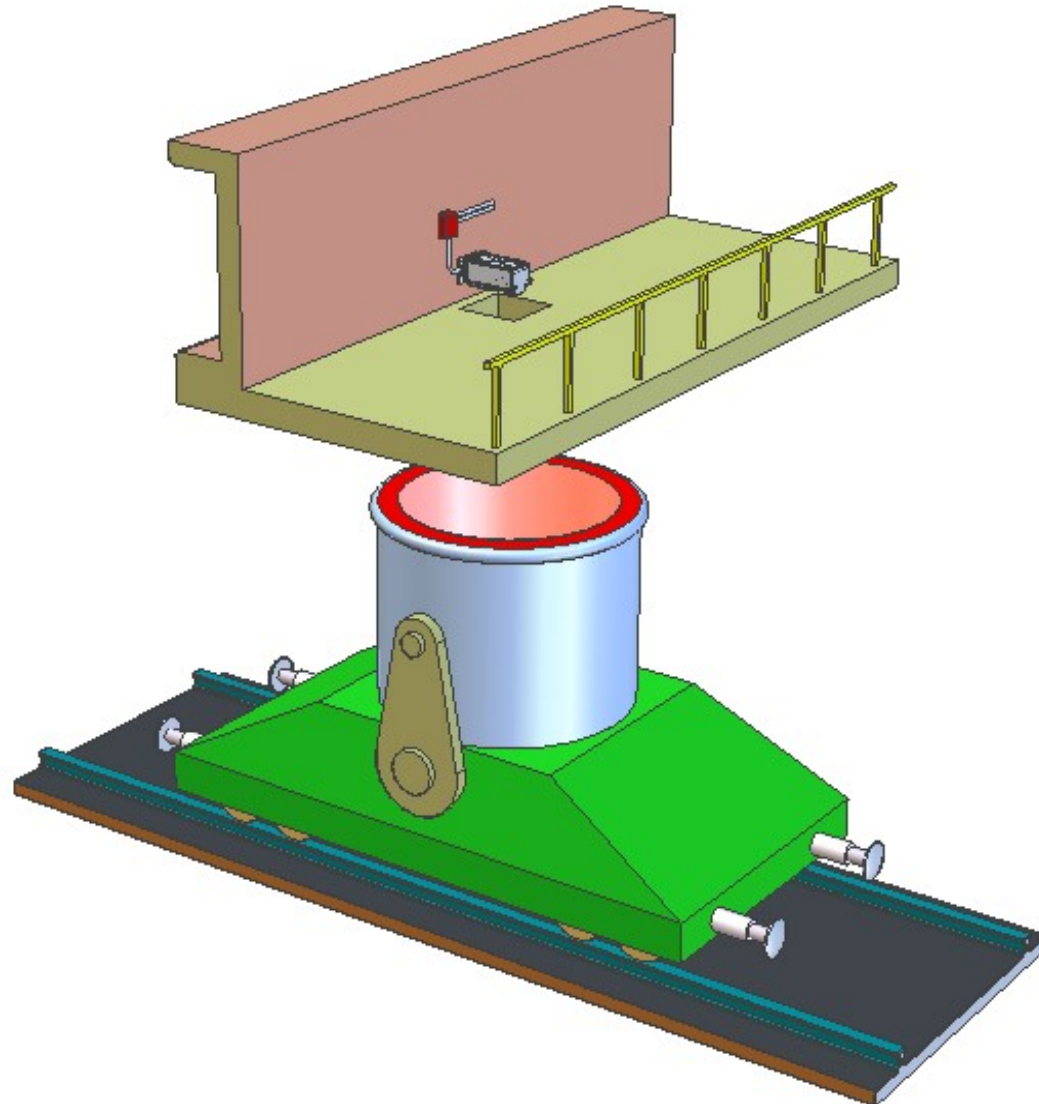
A World-Wide Installed Base Serves Converters, Ladles, EAF's and AOD's



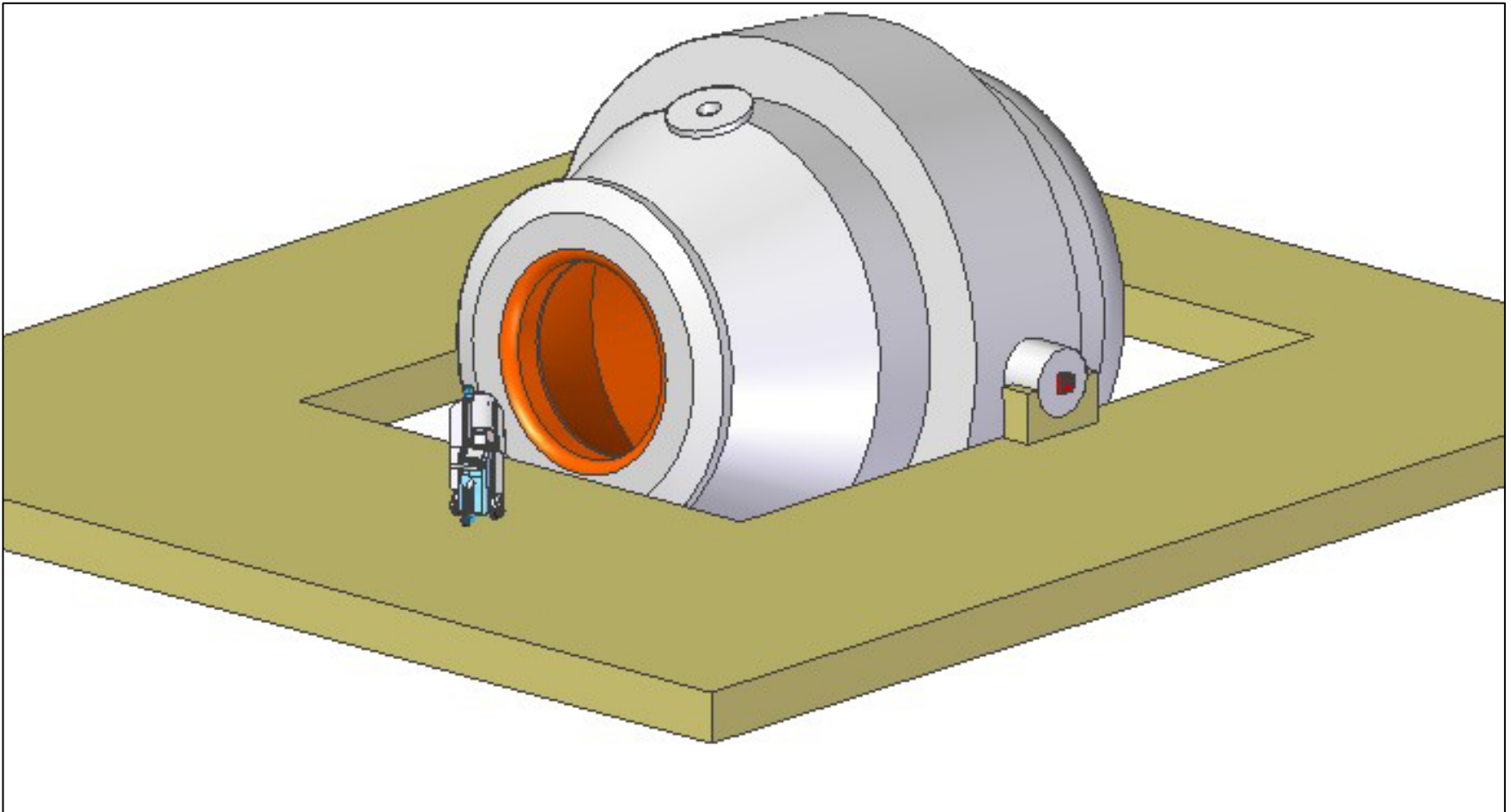
Installation at Slide Gate Maintenance Station (Bao Steel, Posco, REP)



Measurement on Transfer Car (DEW, POSCO)



Basic Oxygen Furnace – Fast Measurement of the Converter for Process Control

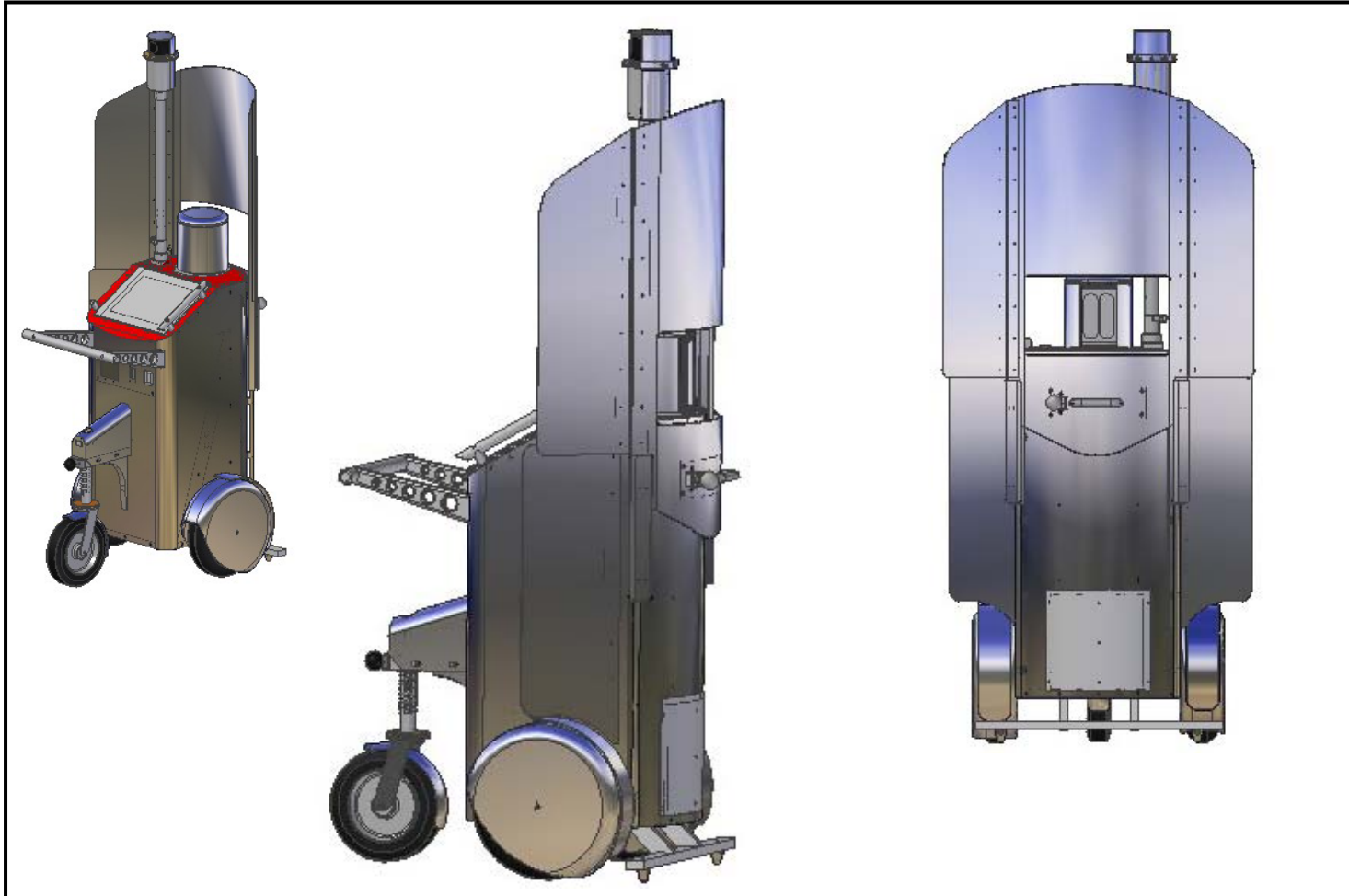




LCS Cart - Efficient Design for Robust, Mill-Worthy Service

- Battery power (12 & 24 volt operation)
 - 2-3 hour battery life, smart charger allows operation (e.g. printing) while charging
- Fanless PC with touch screen - no keyboard
 - Automatic wireless data download to Panasonic Toughbook Laptop
- Two-axis on board inclinometer - measures cart tilt
- Retractable heat shielding for cart and personnel
- 3 USB, 1 Ethernet ports: Easy peripheral connection/ LAN connectivity
- Large diameter (40 cm/16") wheels easily negotiate rough surfaces

Mobile Cart Version 6.0 – Simple Construction, Robust design





Achieving Fast Measurement Time with the Mobile Cart

- Purpose-built Hardware and Software For The Mill Environment-
 - Laser Tracking System automatically locates cart for each setup
 - Radio link automatically sends converter tilt information to cart from high accuracy inclinometer
 - Single mouse-click measurement control
 - Fast range measurement head - **8,000 samples/second**
 - Fast data analysis (1-3s)

GOAL: SINGLE SETUP MEASUREMENT AT ONE converter TILT

- Measurement time - **25-30 seconds per setup**
- Full converter characterization - **6 minutes at 750,000-1,000,000 points, 4-6 setups**



Cart Laser Tracking System: Key to Fast, Single-Setup Measurements

- Commercially available system used in warehouse automation applications
- Cart mounted, rotating laser beacon sequentially illuminates three reflectors located *behind* the instrument.
- Time between reflector illuminations coupled with reflector location in defined operating area determine cart position
 - Position accuracy - 1 cm
 - Heading accuracy - 0.05 degrees
 - System updates 10 times per second - **FAST**
- Patented algorithm for determining position

Laser Tracking System Measures Cart Position and Heading Automatically

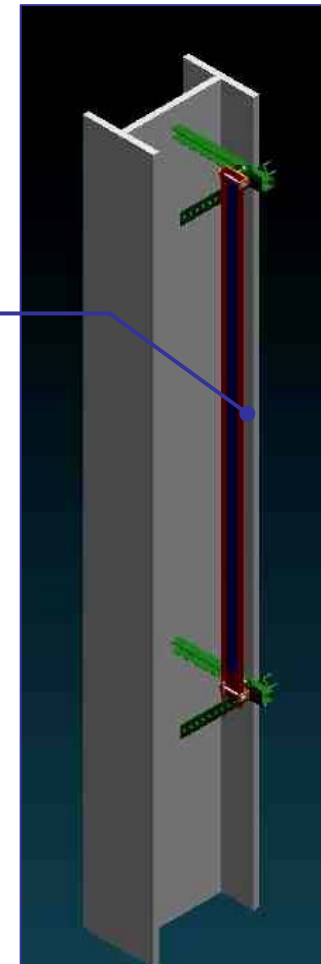
Rotating Laser
Transmitter &
Receiver



Reflectors mounted to
building structure
across charge aisle

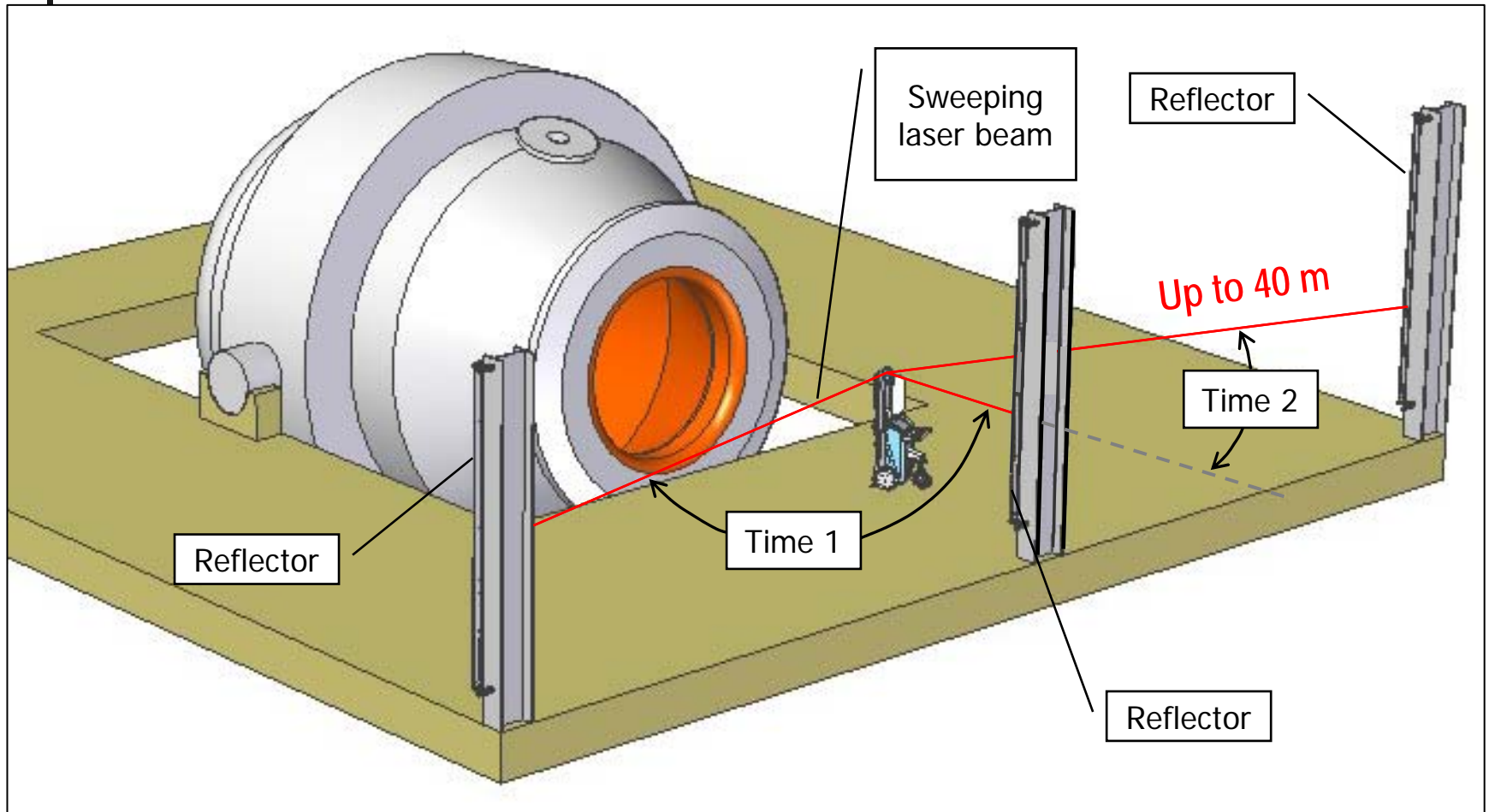
Reflector

Tracking System
Mounted on Cart



12 Ft
(4m)

Laser Tracking— Position Determined by Timing

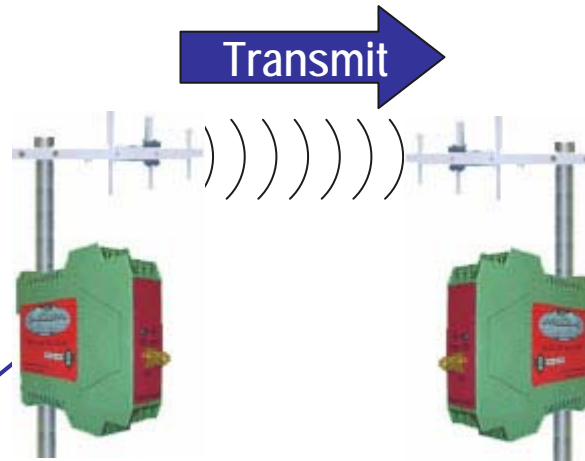


Converter Tilt Automatically Transmitted to Cart Using RF Link

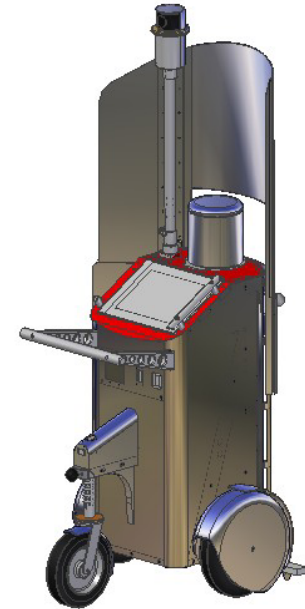


Measure

Transmitter mounted in mill



Radio Frequency (RF) Link



Laser Contouring System

Receiver located in cart



Documenting Accuracy

- Tracking System
 - Fluctuating angular values displayed during measurement indicate reflectors must be cleaned
 - Measurement taken in foot floor mount confirm measurements against survey
 - Also allow monthly validation of measurement accuracy
- Range finding head
 - Again, with cart in foot floor mount, measure location of center of specific reflector. Range to target in horizontal direction should be constant
- Cart inclinometers
 - MEMS device for high accuracy and stability
 - Calibrated using 0.01 degree accuracy level



Reliability and Performance of the Riegl Z210i-HT

- Oldest Riegl system in our customer base purchased in 2001
- 23 heads installed
 - Only two problems observed in entire fleet
- No observed performance degradation with age
- Recommended service after 5000 hours of operation (laser on time). Process Metrix provides head for exchange.
- Allowable temperature range of operation: 18-50 °C. Head shuts down automatically when outside of this range.



Measurement Spatial Resolution

- Depends on multiple factors: Point density, laser beam diameter, distance between vessel and scanner
- LCS system offers three measurement resolutions: 0.2°, 0.1°, 0.05°

Point Spacing (mm) vs. Resolution and Range			
	Measurement Resolution (Deg)		
Range (m)	0.2	0.1	0.05
4	14.0	7.0	3.5
7	24.4	12.2	6.1
12	41.9	20.9	10.5

- Finite beam diameter of 40 mm (or 40x20 mm) limits feature resolution



Accuracy of the Range Measurement

- Single point measurement accuracy is ± 10 mm
- High point density facilitates spatial averaging for improve thickness accuracy
- For statistically independent measurements, error is reduced by $1/\sqrt{n}$, where n is number of samples
- Spatially averaging 10 measurements reduces error to less than 4 mm
- Have observed measurement repeatability error of less than 2 mm



Comprehensive Software For Data Collection and Analysis

- Data collection, instrument control and status indication
- Message logging
- Campaign Manager
- On-board error messaging
- 3-D data processing using triangle mesh
- Automatic outlier point removal
- Presentation of raw and reduced data
- 2-D Slice displays
- Bottom and wall contour displays
- Summary table
- Wear rate calculator
- Level 2 output
- Data export to CSV format
- Password-protected access control
- Bath height and slag height calculator
- Report output generator
- Surface temperature calibration and display module
- Configuration Manager



System Installation Steps

- Uncrate and assemble instrument at site
- Install tracking system reflectors
- Survey reflector and converter positions with LCS system
- Install hardware (inclinometer, foot floor mount, etc.)
- Configure software
 - Calibrate locating system
 - Input ladle/converter geometry (from as-bricked profile)
- Commission system
- Train personnel
- As vessels are relined:
 - Measure steel shell and use as thickness reference



Comprehensive Service/Support

- LCS systems include one year warranty
- After warrantee expires, Process Metrix offers a comprehensive service/support plant
- Qualified and trained engineers from our local distributors provide local service and support
- Service plan includes:
 - Twice yearly (minimum) visits to verify performance and operation
 - Unlimited telephone and website support
 - All software upgrades (as released)
 - Replacement of all systems components that fail through normal use
 - Ongoing training at customer site

In Summary....



- The LCS product is engineered for mill service and has a proven reliability record
- The system provides the highest quality data in the shortest time – Industry Wide
- Software system provide advanced functions using simple user interfaces
- System is manufactured in the USA, and includes the highest quality components available
- Service and support provided locally by our trained distributors and globally by Process Metrix engineering staff