EMAT-based Advanced NDT Applications for the Aluminium Industry

TIT-005-R1

Innerspec and its strategic partners have the know-how and geographical reach to fulfill any NDT need

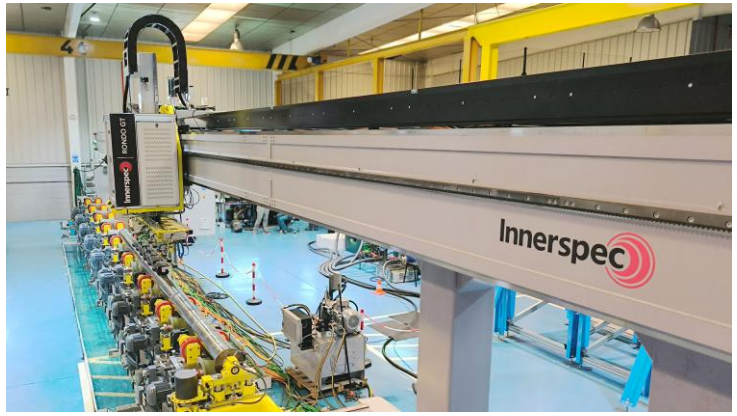
- US company headquartered in Forest VA (USA) and Madrid (Spain) with offices in UK, China, Mexico, Bahrain and Australia
- Representatives and distributors throughout the world
- 56 patents for NDT applications and equipment
- World leader in EMAT with hundreds of integrated systems installed in 27 countries, and the most complete line of portable equipment
- Fastest-growing manufacturer of industrial and aerospace NDT solutions
- Consulting, training, and advanced inspection services

INNOVATIVE SME
Valid until Jul 23rd 2024

Our Products and Services

Leader in EMAT, Specialist in UT/PAUT, EC/ECA, LM, and other advanced techniques

- **Integrated systems** for manufacturing
- Specialized NDT **portable equipment** for In-Service solutions
- **Advanced Inspection Services**
- **Research & Development**



INNOVATIVE SME
Valid until Jul 23rd 2024

Innerspec has the technology, the experience, and references from hundreds of systems installed

Innerspec

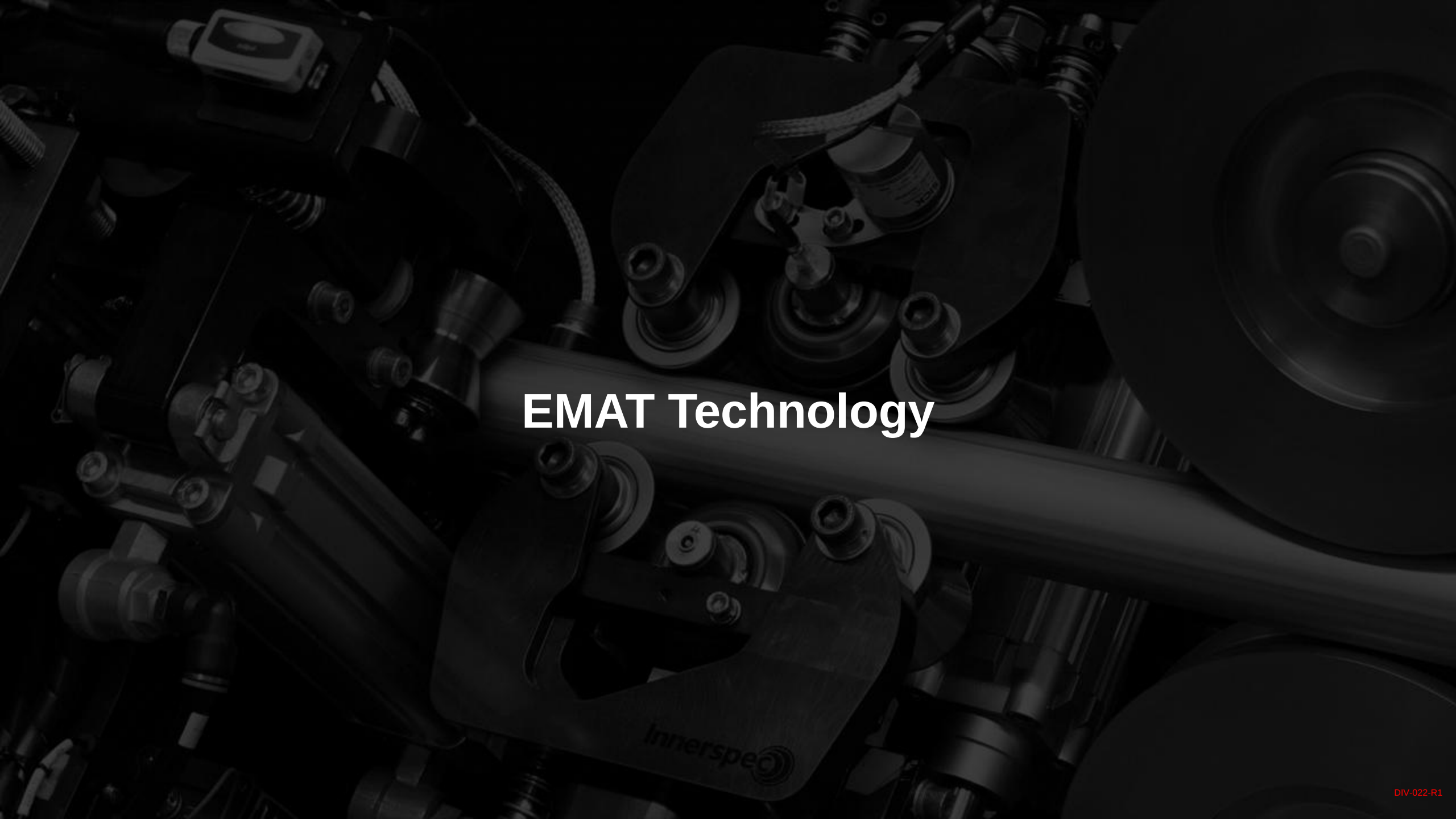
Off-line and in-line systems installed in industrial environments with millions of hours of inspection

R&D resources to tailor the technology to each particular application

Experience in turnkey, fully-automated solutions, that require minimum operator involvement

Top references from world-class manufacturers in a variety of industries

INNOVATIVE SME
Valid until Jul 23rd 2024



EMAT Technology

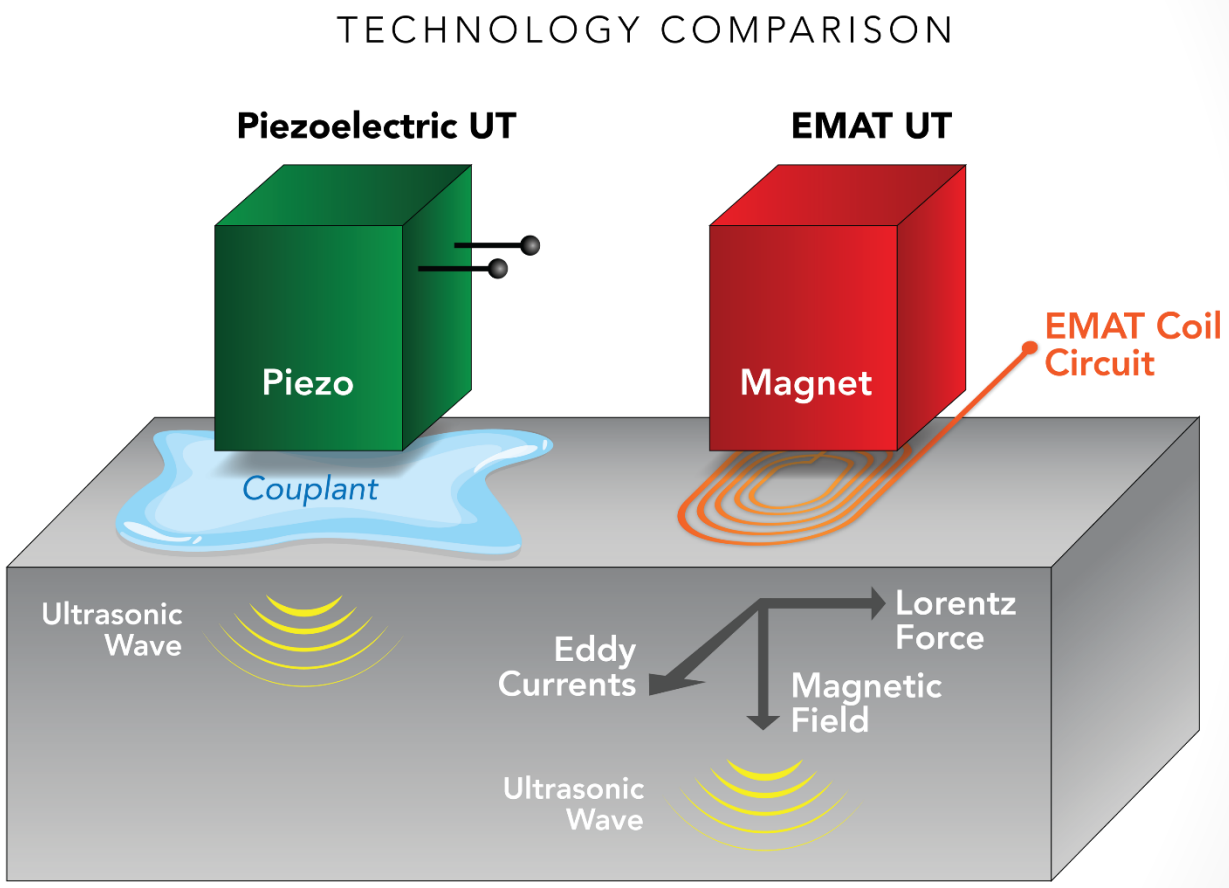
Electro Magnetic Acoustic Transducer (EMAT) is an ultrasonic technique that generates the sound through electromagnetic induction

Advantages:

- Dry, non-contact inspection
- Insensitive to surface conditions
- Easier probe deployment
- Unique wave modes

Challenges:

- Only applicable to metals
- Inefficient: high-power required
- Lower signal-to-noise than conventional UT
- Large sensors



INNOVATIVE SME
Valid until Jul 23rd 2024

EMAT enjoys all the benefits of UT plus other particular advantages

Ultrasonic Technique: • Volumetric Inspection • One-Side Access • Meets UT Standards • Safe

Ultrasound is Generated in the Part Inspected

Dry Inspection (no couplant)

- Easy to Automate and Integrate in Production
- No Couplant Induced Errors
- High Inspection Speeds (up to 60 m/s)
- Capable of High and Sub-Zero Temperatures

Insensitive to Surface Conditions

- Capable of Inspecting Rough, Dirty (Oily/Wet), Oxidized or Uneven Surfaces

Easier Probe Deployment

- No Signal Variations from Probe to Probe
- Small Changes in Probe Angle do not Affect Results (e.g. part curvature)

Unique Wave Modes

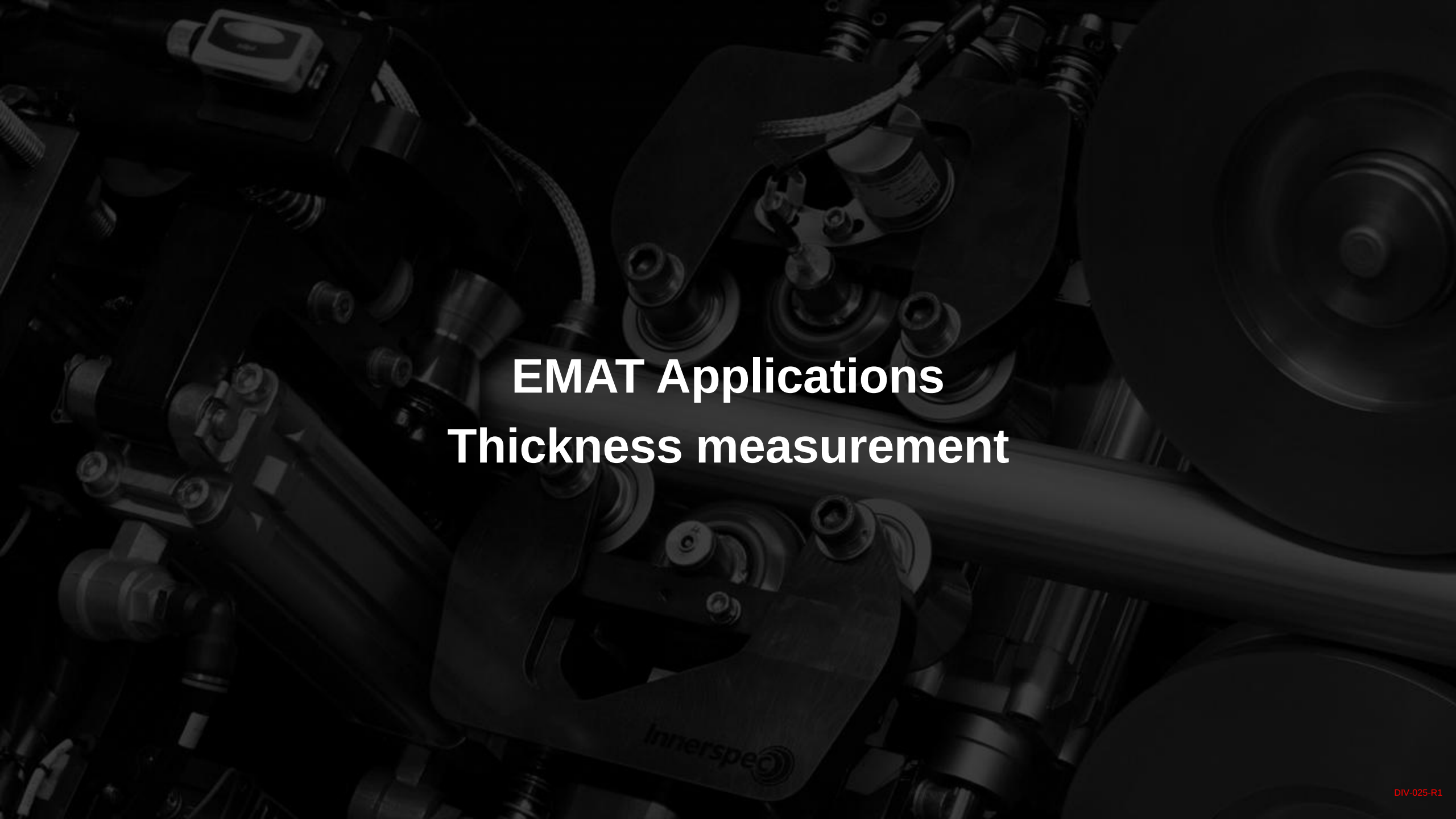
- Capable of Generating Horizontally Polarized Shear Wave Energy
- Highly efficient for guided waves due to frequency selectivity

Challenges

- More Power Required
- Lower Signal-to-Noise & Resolution
- Larger Sensors

INNOVATIVE SME
Valid until Jul 23rd 2024

INN-043-R1



EMAT Applications
Thickness measurement

EMAT is ideally suited for thickness measurement of conductive parts in industrial environments

Characteristics:

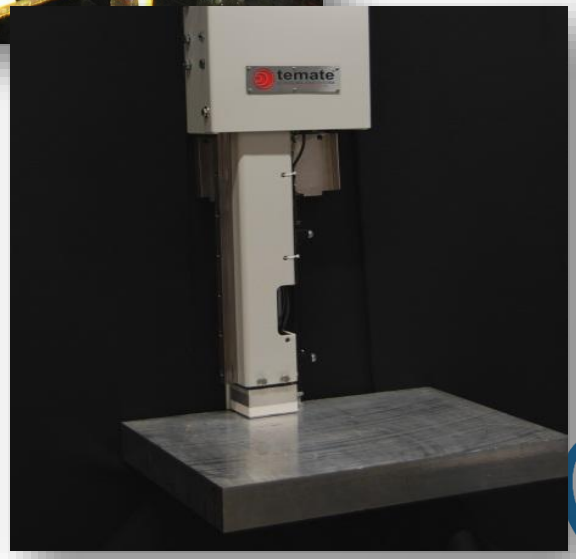
- Lack of couplant permits inspection of very hot and very cold materials
- Impervious to surface conditions
- Sensors are less sensitive to mechanical alignment and have very consistent performance
- Capable of Inspection at great speeds

Characteristics	Isotope	X-Ray	Laser Optical	Piezo UT	Laser UT	EMAT UT	Dry Piezo
High-Accuracy & Resolution	✓	✓	✓	✓	×	✓	✓
Suited for Rough Environments	✓	✓	×	✓	✓	✓	✓
Safety	×	×	✓	✓	×	✓	✓
One-Side Access	×	×	×	✓	✓	✓	✓
No-Contact (High & Cold Temp)	✓	✓	✓	×	✓	✓	×
No Couplant	✓	✓	✓	×	✓	✓	✓
Distance to Part (mm)	66-200	150-1000	100	Water Column	50	1-7	Wheel
Cost 1-100 (1 is lowest)	10	20-100	5-10	10	100	10	10

The TEMATE TG-IL is the ideal solution for aluminum ingots and hot slabs

Application: Aluminum Ingots Profiling

- Measures thickness of aluminum ingots before scalping
- Also detects cracks and voids!



Application: Hot Aluminum Slabs

- Measures thickness of aluminum slabs on both sides of a reversing mill
- Sensors are deployed from inside a protective cover when the ingot is in position
- Surface temperature of the material up to 540°C
- Integrated temperature correction for maximum accuracy
- Measures thicknesses up to 205mm with 0.25% resolution
- No-contact, no-maintenance sensors with no wear
- Perfect for finding ends of ‘alligator’ voids for optimum trimming

INNOVATIVE SME
Valid until Jul 23rd 2024

The TEMATE TG-IL is also ideal for aluminum thin strip gauging

Application: Gauging During Rolling

- Measures thickness of aluminum strip on the rolling mill
- One side access
- Cost effective
- No radiation; 100% safe

Application: Wedge Measurement

- Measures thickness of aluminum strip on both edges
- Minimized trimming of coils
- Data available to cold mill for threading
- Eliminates downtime of Cold rolling mills caused by uneven coil thickness
- Reduces the length of the cut needed at end of a coil to the absolute minimum

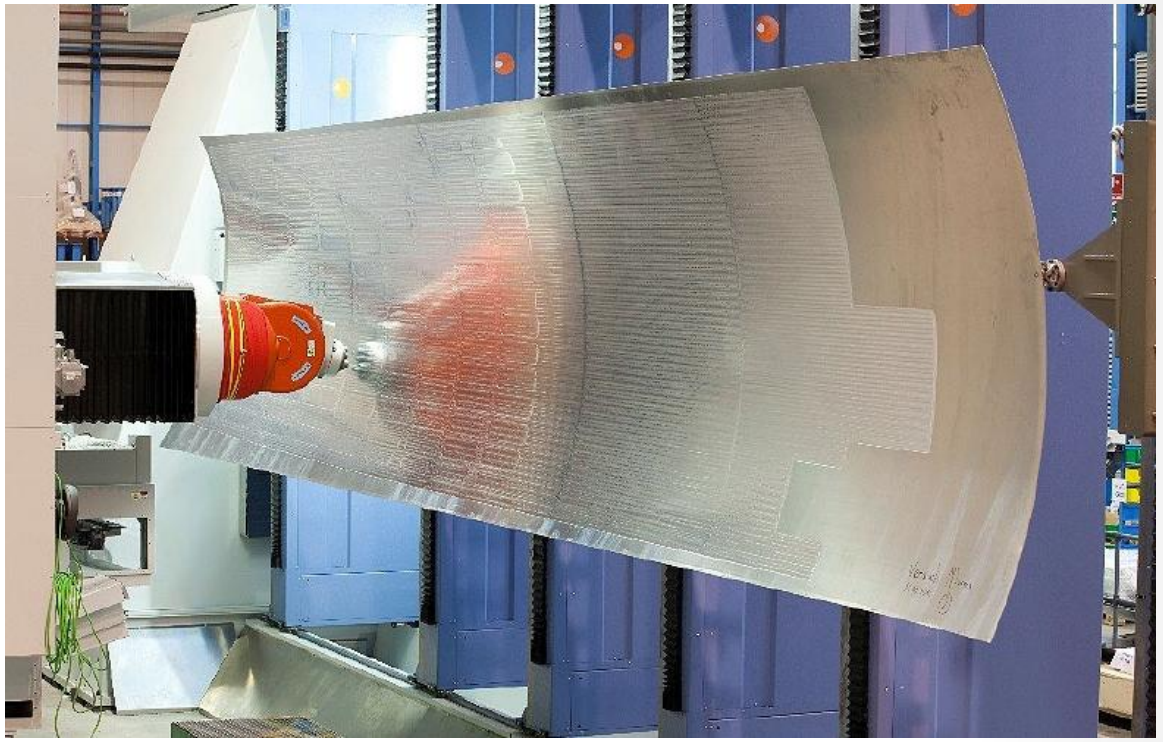
INNOVATIVE SME
Valid until Jul 23rd 2024

INN-102-R1

The TEMATE TG-IL is the perfect solution for thickness measurement of aluminum parts during Mechanical Milling

Application: Measurement during Mechanical Milling

- Mechanical Milling is substituting Chemical Milling in aerospace Aluminum fuselage parts, due to obvious environmental advantages
- Provide thickness measurement results, smoothly integrated in CNC machines
- One side access, from the tool side or the bottom side
- No contact, up to 3 mm lift-off
- No couplant
- Option to use small sensors to fit into the pockets
- Real-time communication via Profinet or others

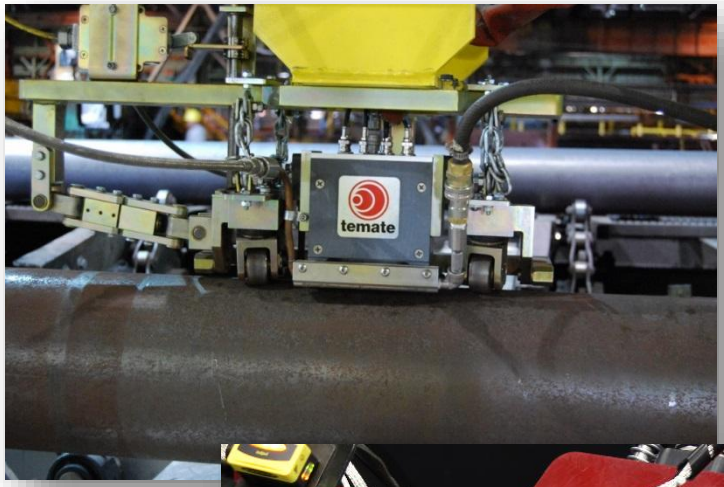


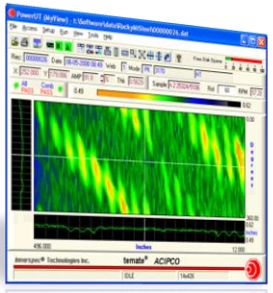
INNOVATIVE SME
Valid until Jul 23rd 2024

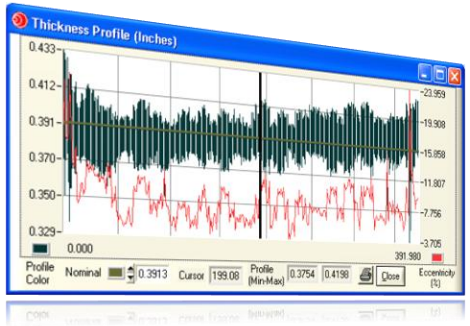
The TEMATE TG-IL with EMAT or DCUT is perfect for measuring tube wall thickness

Application: Tubes

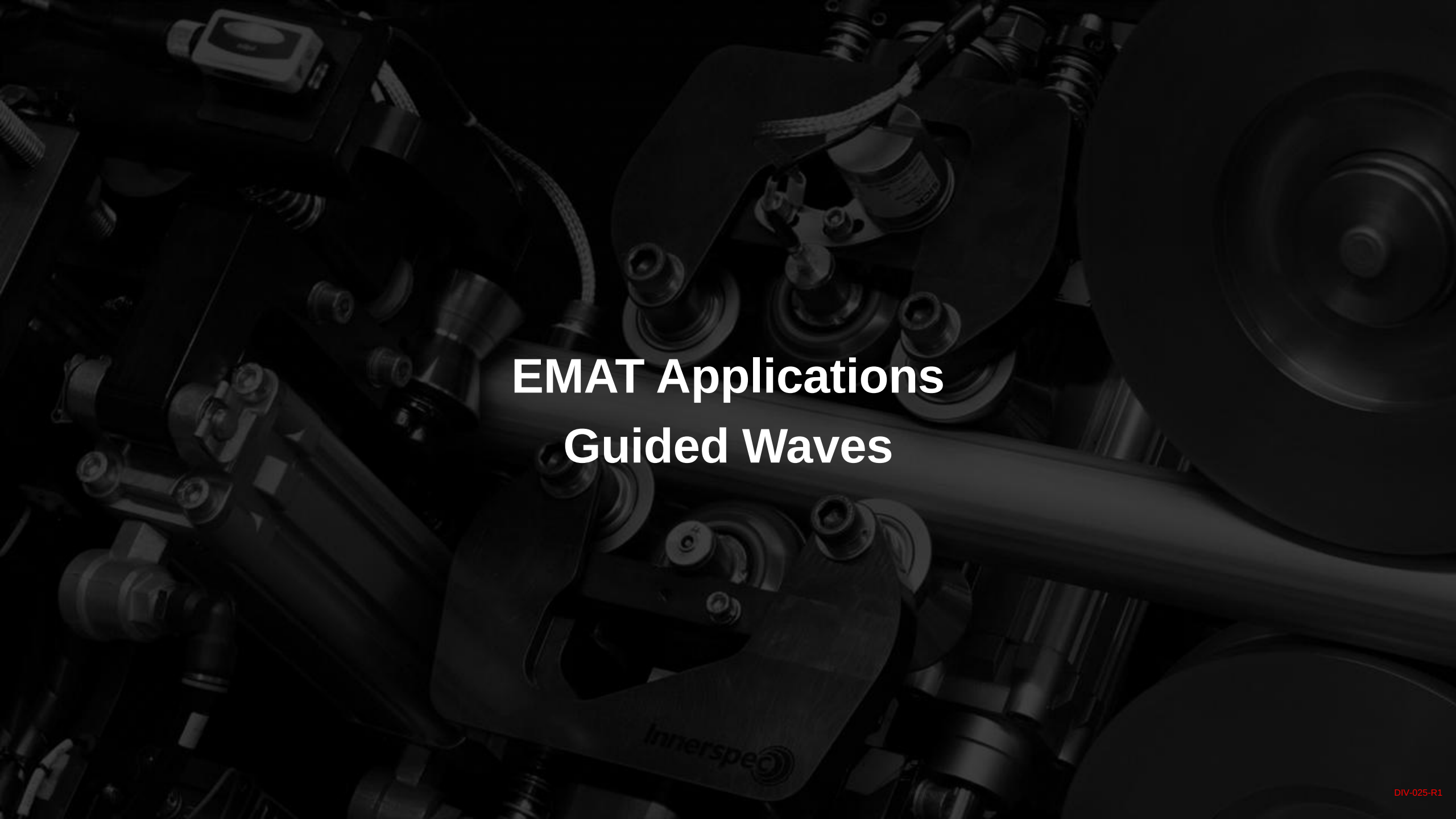
- Integrated system with one, two or four sensors taking lines of measurement or 100% coverage (rotating tube and traversing sensor).
- Ambient and high-temperature probes for continuous measurement of materials up to 750°.
- Thickness accuracy of +/-0.0003” (0.008mm).
- 100% dry. No water mist or gel couplant
- Real time results of ovality and eccentricity at 1m/s
- Works for all metals (including austenitic SS), plastics and composites
- Results available in strip-chart, C-Scan and max-min thickness and eccentricity profiles







INNOVATIVE SME
Valid until Jul 23rd 2024

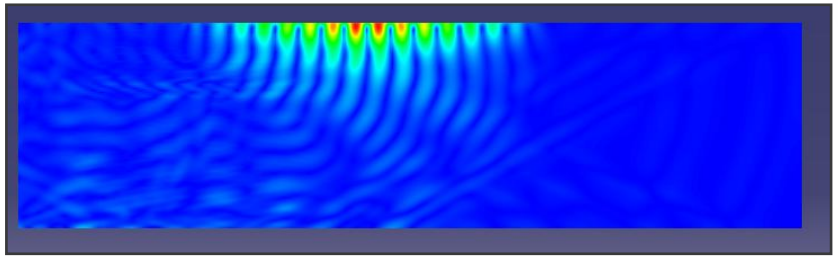


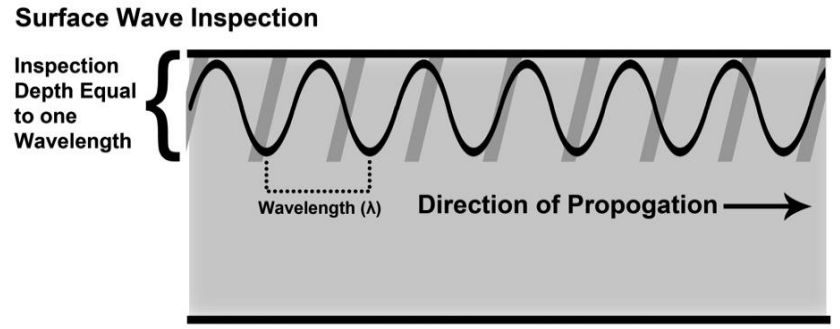
EMAT Applications
Guided Waves

Surface waves are very well suited for detecting small surface and near-surface defects and cover large areas

Surface waves:

- Surface waves (a.k.a. Rayleigh waves) travel the surface of a solid material penetrating to a depth of one wavelength
- Combine both a longitudinal and transverse motion to create an elliptic orbit motion
- Normally used for detecting defects 0-5mm from the surface
- Sensitive to defects approx.1/10th of a wavelength
- Can detect defects far away from the source. Typical applications cover 10-1500mm ahead of the transducer



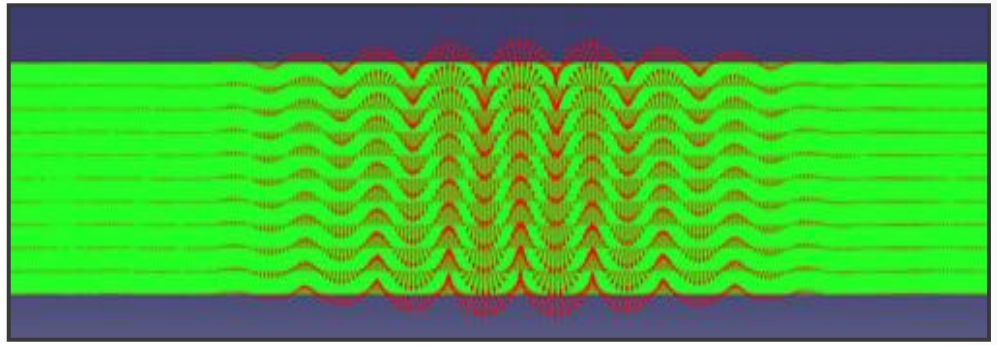


INNOVATIVE SME
Valid until Jul 23rd 2024

Lamb and Shear Horizontal (SH) waves can penetrate and detect defects anywhere within the boundaries of the material

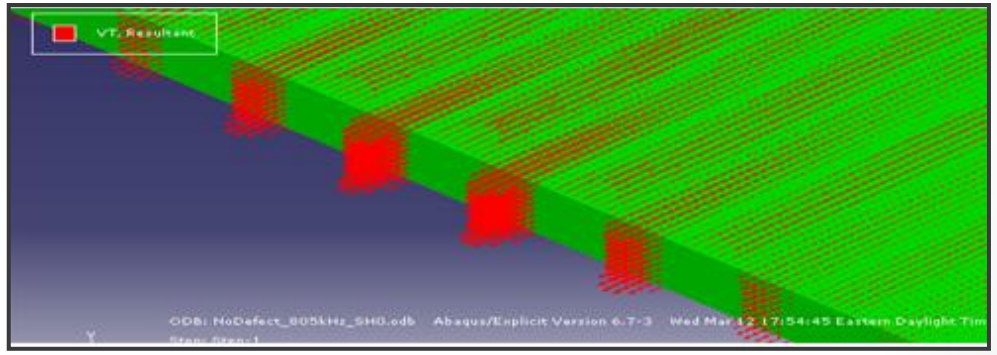
Lamb Waves

- Like surface waves, Lamb waves combine a vertical and a transverse motion to create an elliptical wave
- Symmetric and asymmetric modes can be used to increase sensitivity to different types of defects



Shear Waves

- Perpendicular to the wave direction on horizontal plane (“non-leaky”)
- Only available with EMAT for practical purposes



Can detect defects from a few cm to meters away from the transducer

INNOVATIVE SME
Valid until Jul 23rd 2024

Surface Inspection

Surface waves are the ideal solution for surface inspection of aluminum ingots and plates

Application: Aluminum Ingots

- Ideal for surface and near surface cracks
- Capable of covering large surfaces with a few sensors
- Cost effective alternative to machine vision with fewer false positives and fewer missed negatives

Application: Aluminum Plates

- Inspection of the ‘dead zone’ missed by UT inspection at immersion tanks
- Capable of covering large surfaces with a few sensors
- Cost effective alternative to machine vision with fewer false positives and fewer missed negatives

INNOVATIVE SME
Valid until Jul 23rd 2024

Volumetric Inspection

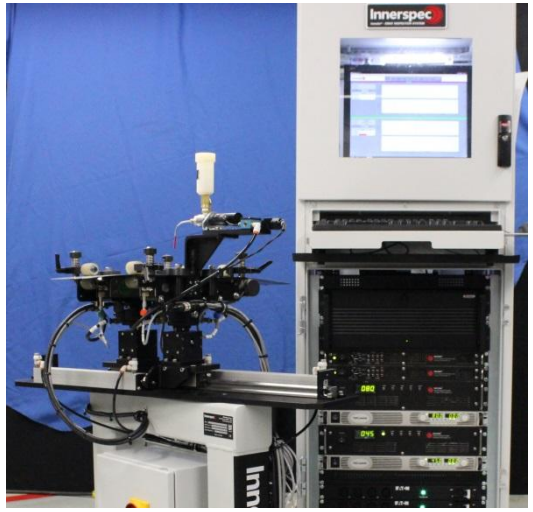
Lamb and Shear Horizontal (SH) waves are the ideal solution for volumetric inspection of aluminum and laminated (bonded) sheet

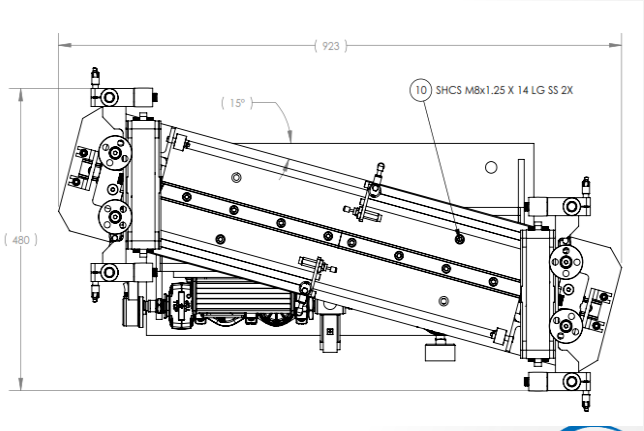
Application: Aluminum Thin Sheet

- 100% full volumetric inspection
- Multi-channel system for different gage materials
- Detects surface and internal defects at production speeds
- Custom designed for each customer's specific requirements

Application: Laminated (Bonded) Sheet

- For two, three or more layered bonded material
- Detects lack of bond and poor bond in any of the layers
- Detects defects at production speeds
- Custom designed for each customer's specific requirements

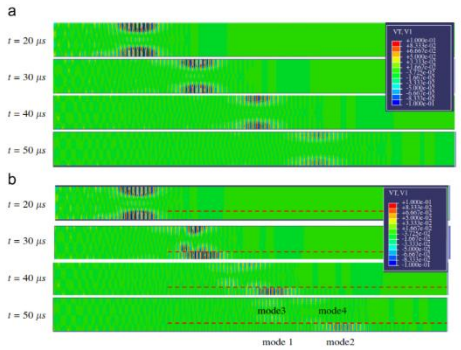


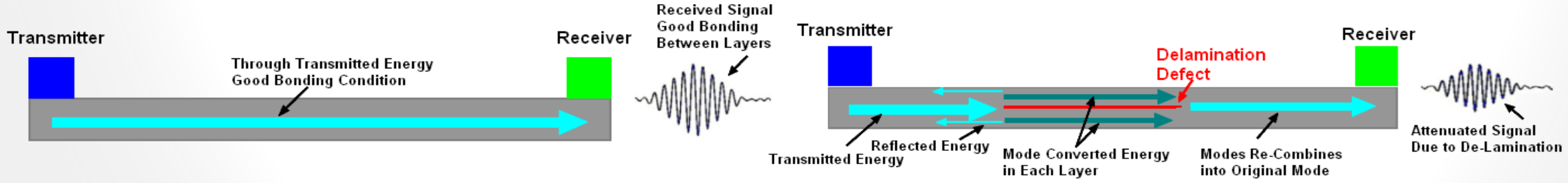


INNOVATIVE SME
Valid until Jul 23rd 2024

TEMATE ST-LA - Inspection of Multilayer Laminated Strip Material

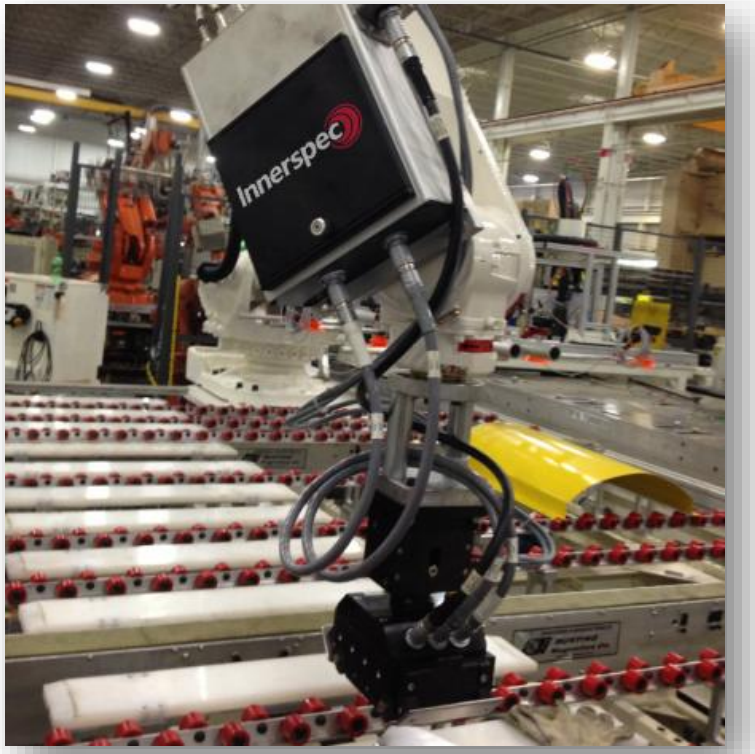
- Non-contacted guided waves technique to detect surface and internal defects on multilayer strip material
- Permits inspection of single and multi-layer composites and detects laminations in any of th layers
- Applicable to coin stock, steel-aluminum bimetals and other layered materials up to 10mm thick
- Multi-channel system





Steel and Aluminum thin welds

- Provides volumetric inspection of FSW and laser welds in blanks and tubes
- Detects and discriminates between planar and point defects
- Capable of inspection speed of 1m/s
- One system supports up to three sensor heads
- Most proven and reliable system in the market

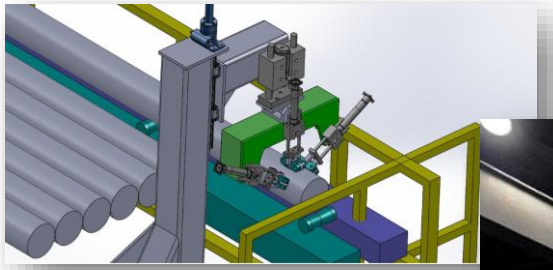


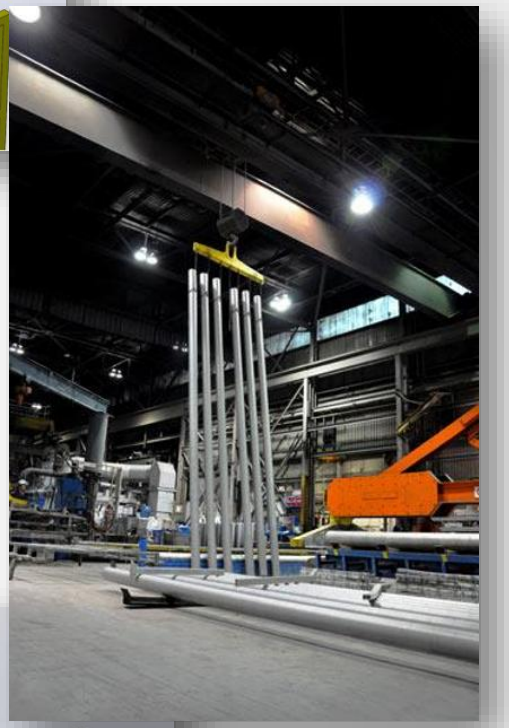
Innerspec

INNOVATIVE SME
Valid until Oct 8th 2021

Aluminum Round Ingots

- Detects centre line crack using normal beam
- Detects surface and sub-surface crack before or after scalping using Shear Vertical waves
- Reduces scrap as it indicates the length until where the end of the ingot should be cut
- Can be combined with thickness profiling of ingots
- Complies with ASTM E127 standard for detection of flat bottom holes





Aluminum Ingots (scalped)

- System is designed for in-process, automated flaw detection inspection of scalped aluminum ingots using EMAT ultrasonic transducers
- Surface: detects surface breaking cracks greater than 1mm deep and greater than 5cm in length oriented in the longitudinal orientation
- Volumetric: 100% full volumetric inspection


Residual Stress Measurement

Residual Stress Measurement with EMAT

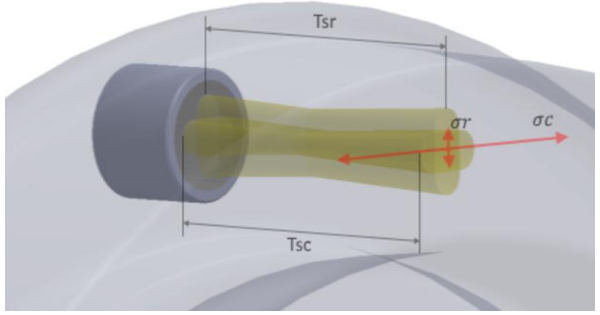
- An EMAT sensor generates two orthogonal polarized ultrasonic beams at 0 and 90 degrees.
- The time that both ultrasonic beams take to travel through the thickness of the wheel is measured and used to calculate the birefringence:

$$\text{Birefringence ‰ (B)} = \frac{(TOF_{S1} - TOF_{S2})}{\left\{\frac{TOF_{S1} + TOF_{S2}}{2}\right\}} x1000$$

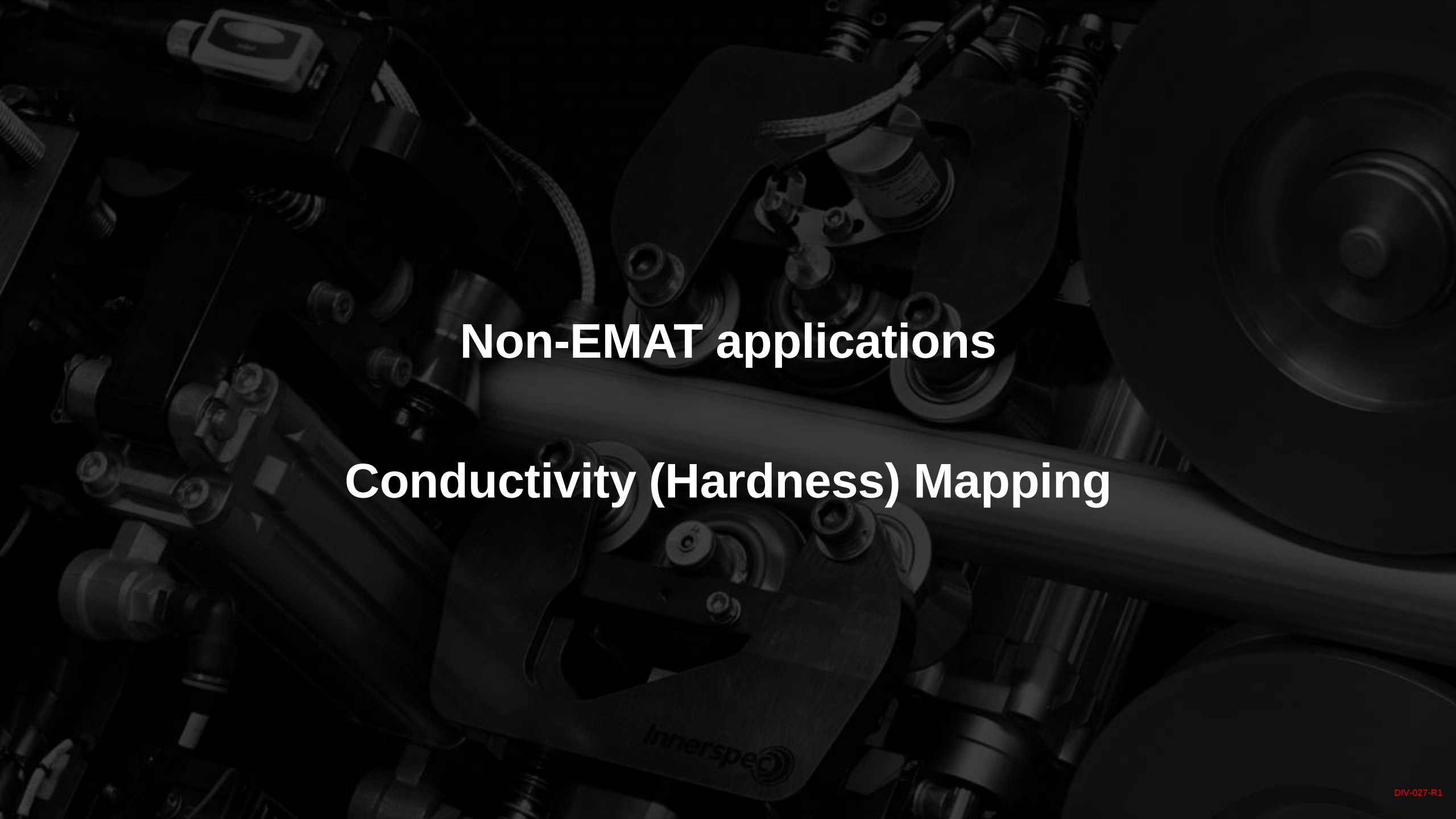
- Internal stress is directly correlated with stress by:

$$\text{Stress} = kxB + \sigma_0$$

*k and σ_0 are dependent on the material and can be calculated empirically to provide absolute stress measurements.

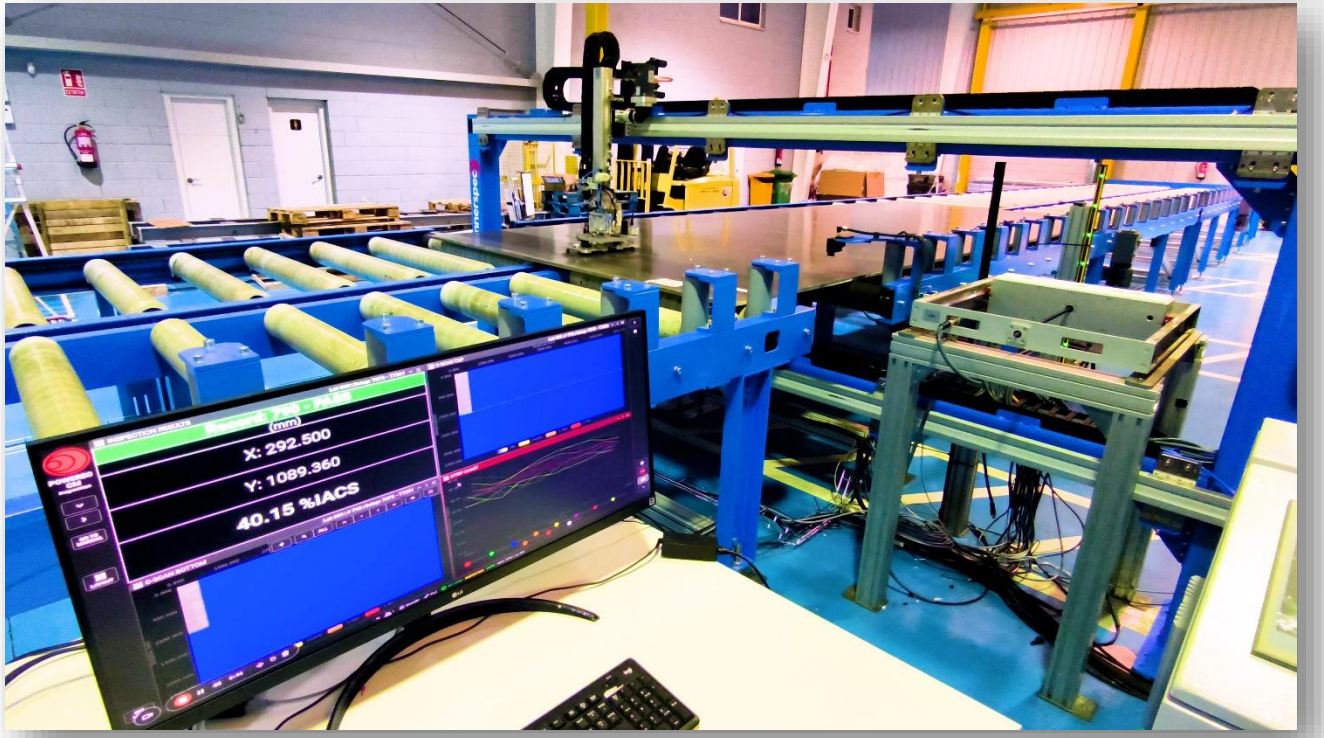


INNOVATIVE SME
Valid until Jul 23rd 2024

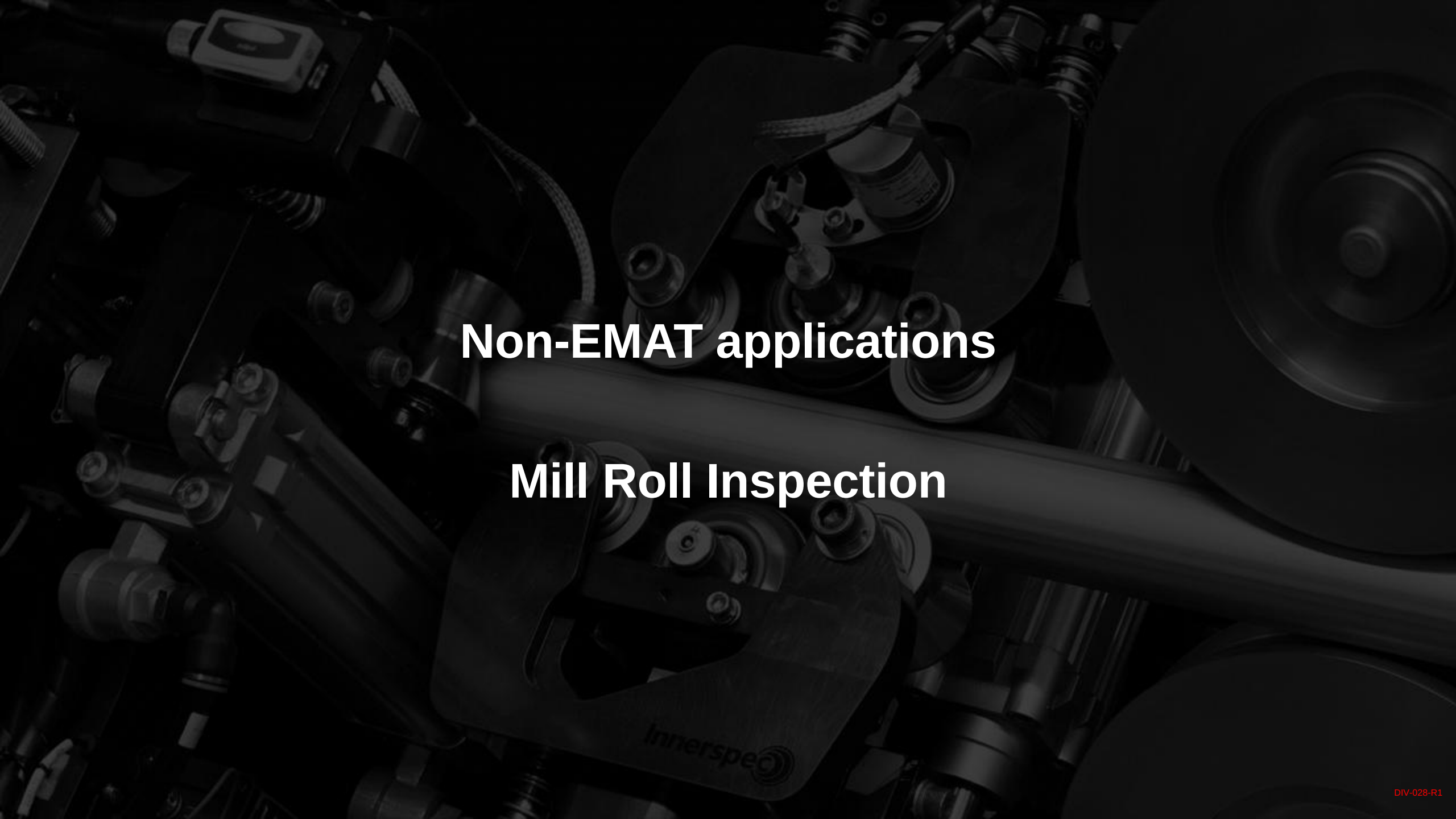

Non-EMAT applications
Conductivity (Hardness) Mapping

Innerspec developed the first and only Automated system for conductivity mapping of aluminum plates

- Integrated system with eddy current sensors measuring the conductivity of aluminum plate surfaces
- Confirms proper quenching
- Sensitivity of not less than +/-0.3% IACS
- Provides C-scan and X/Y location data
- Fully integrated with plate handling or stand-alone inspection cell
- Automatic calibration between plates
- Meets MIL-STD-1537C, EN 2004-1:1993 and ASTM E1004-02 standards for coverage and accuracy



INNOVATIVE SME
Valid until Oct 8th 2021

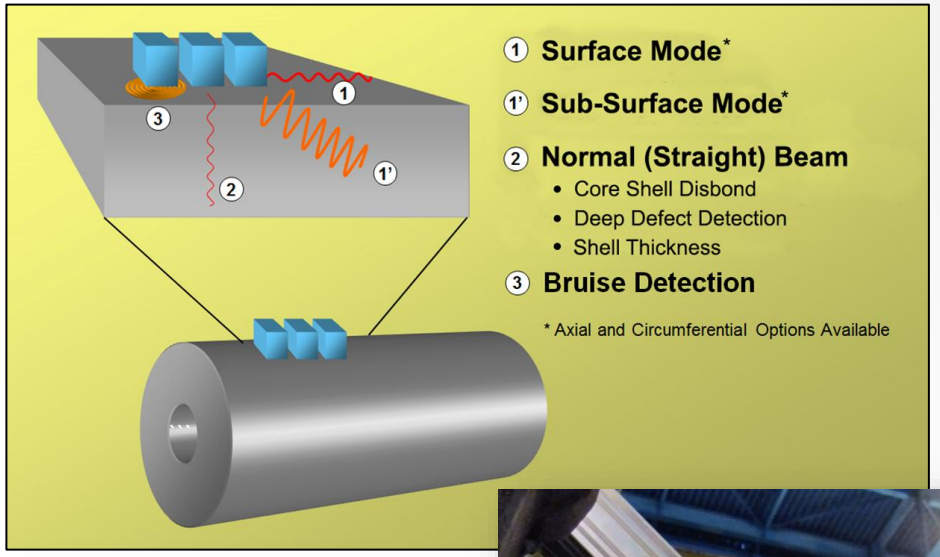


Non-EMAT applications

Mill Roll Inspection

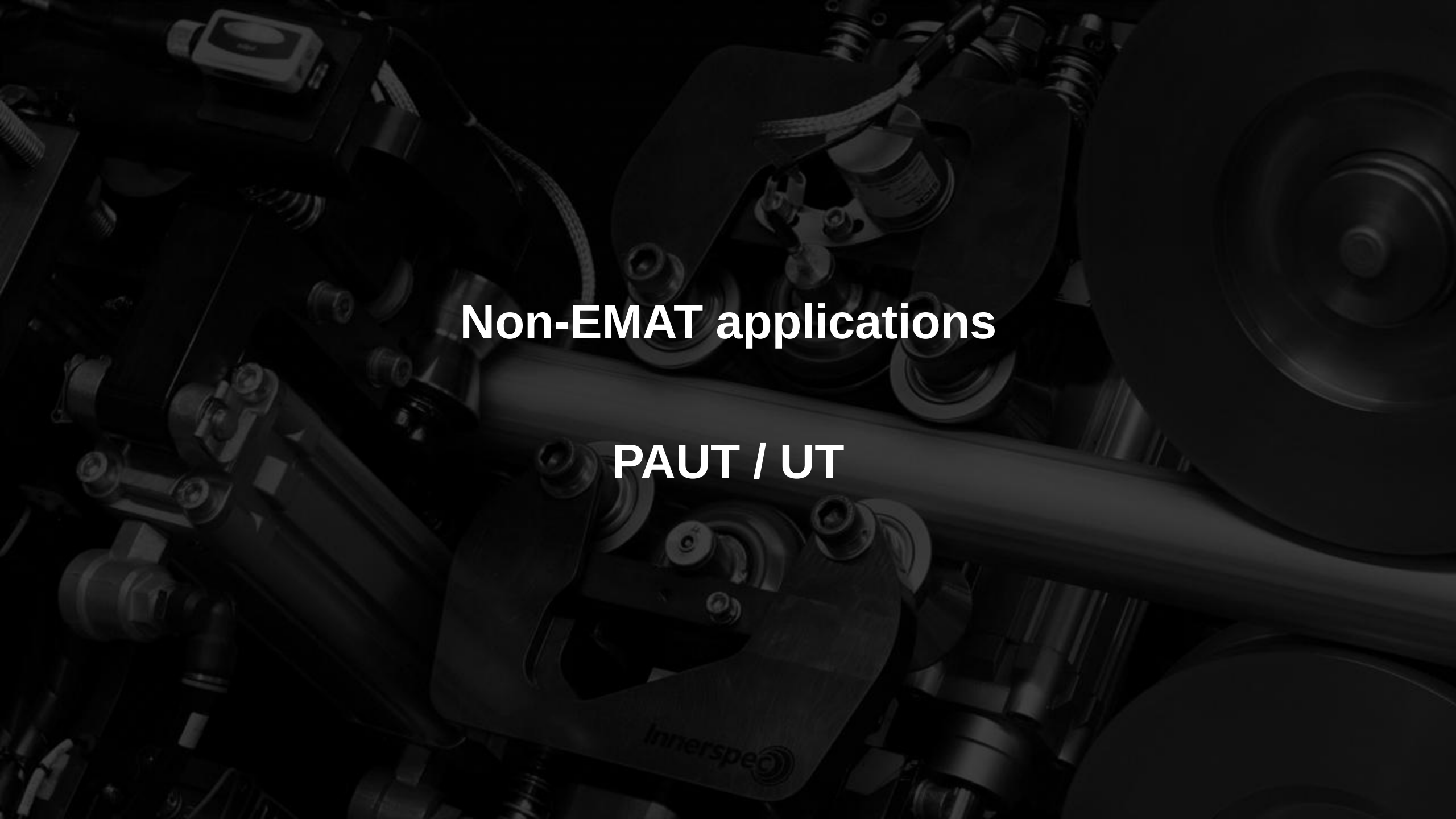
Innerspec's ROLLMATE uses patented technology to provide a unique solution for Inspection of steel mill rolls and aluminum casters

- ROLLMATE is the most complete and reliable system in the market for inspection of cast and forged mill rolls.
- In addition to the standard surface and sub-surface module, it can be complemented with core-shell disbond and bruise/hardness detection sensor modules
- Surface inspection (0-2mm)
- Integrated shear wave sub-surface inspection (2-58mm)
- Detection of surface defects as small as 0.1 mm in all directions
- Inspects cast and forged rolls of any alloy, and is not affected by roll chemistry, magnetization, and other roll conditions
- Fully automated, installs on any grinder. Performs inspection while grinding
- Optional shell inspection using normal beam UT
- Optional and dedicated bruise/hardness sensor
- Up to 24 UT and 4 EC channels inspecting simultaneously
- Actuator and caliper mounted options



INNOVATIVE SME
Valid until Jul 23rd 2024

INN-111-R1


Non-EMAT applications
PAUT / UT

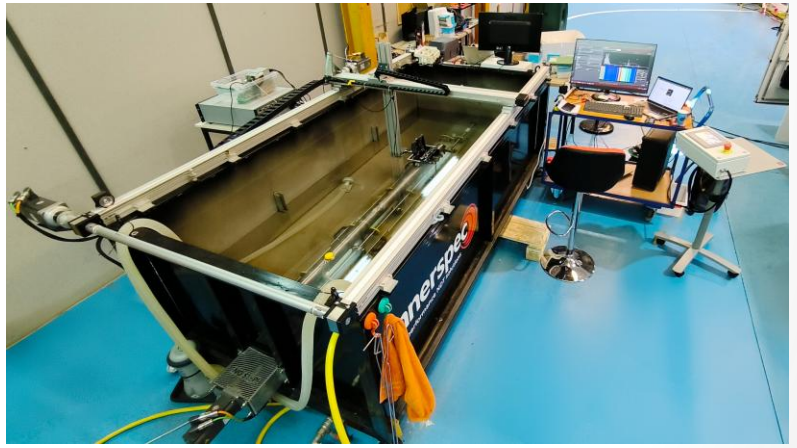
PAUT & UT Applications (Industrial): Customized solutions based on the most advanced Software for Industrial NDT



Full Bar and Tube Inspection Applications


ERW & SAW Weld Inspection Applications

Mill Roll Applications

Immersion Tank Applications

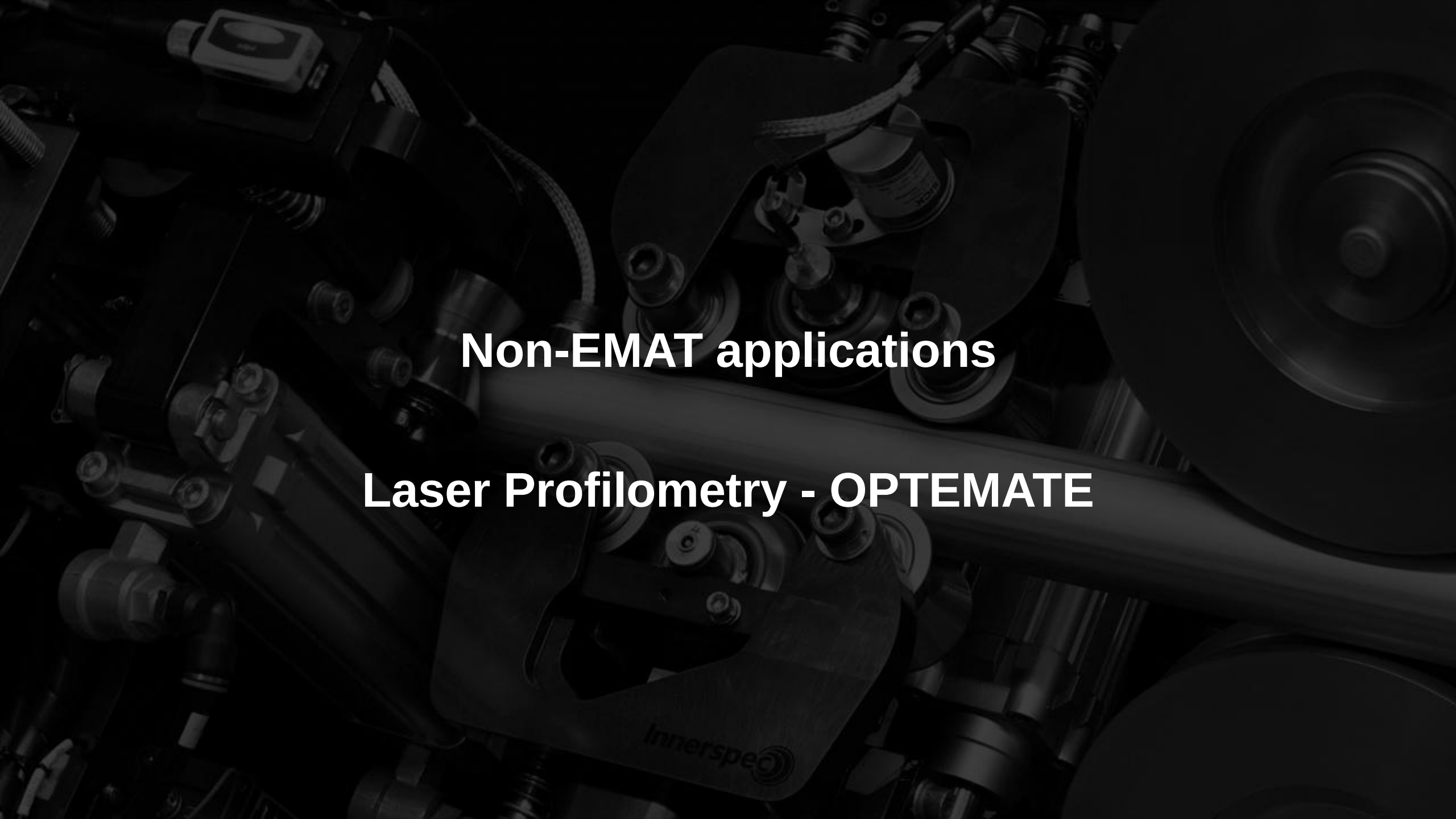
INNOVATIVE SME
Valid until Jul 23rd 2024

PAUT & UT Applications (Aerospace): State-of-art robotic NDT systems optimized for ultrasonic inspection

- Configurations:
  - Single Robot on Pedestal, Gantry or Linear Track
    - PE Local and Total Immersion
    - TTU with Yoke
    - TAURUS Turntable
    - TAURUS Tank
  - Twin Robot Linear Track
    - Dual PE
    - TTU with Twin Robot
  - CHORUS Custom
    - Combination of Any of Above
    - Options for Both Robots to Work Independently

CHORUS
Comprehensive High-Output Robotic Ultrasonic System

INNOVATIVE SME
Valid until Jul 23rd 2024

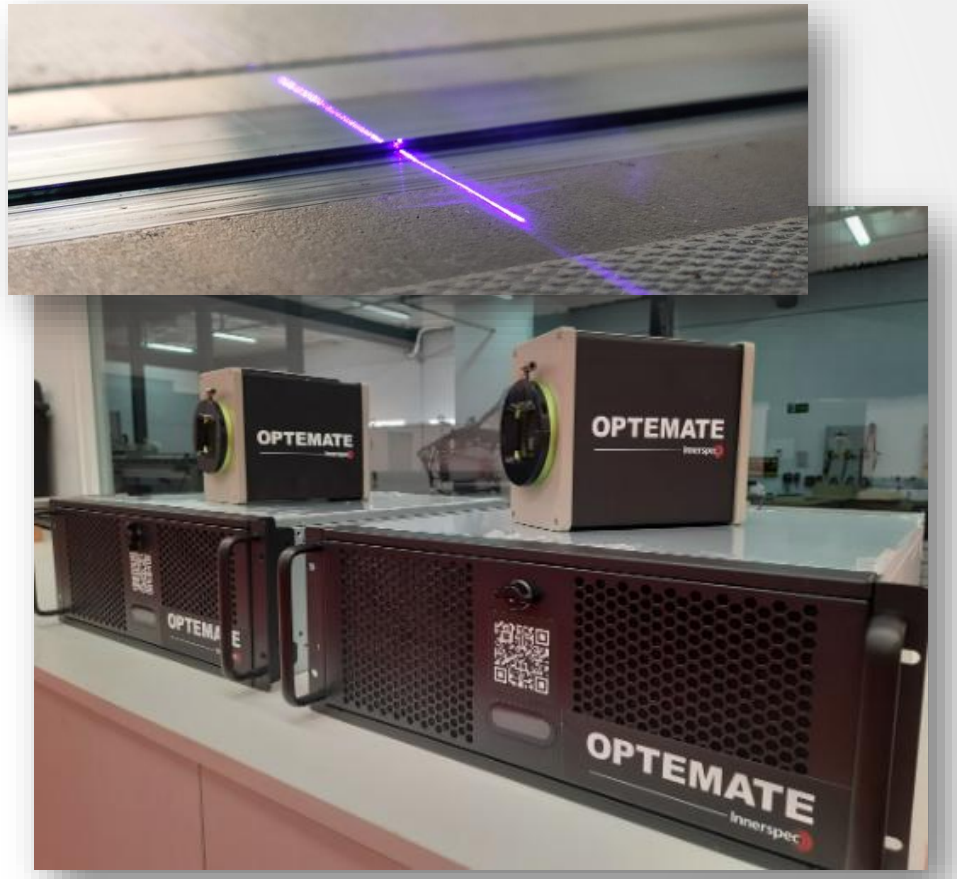


Non-EMAT applications

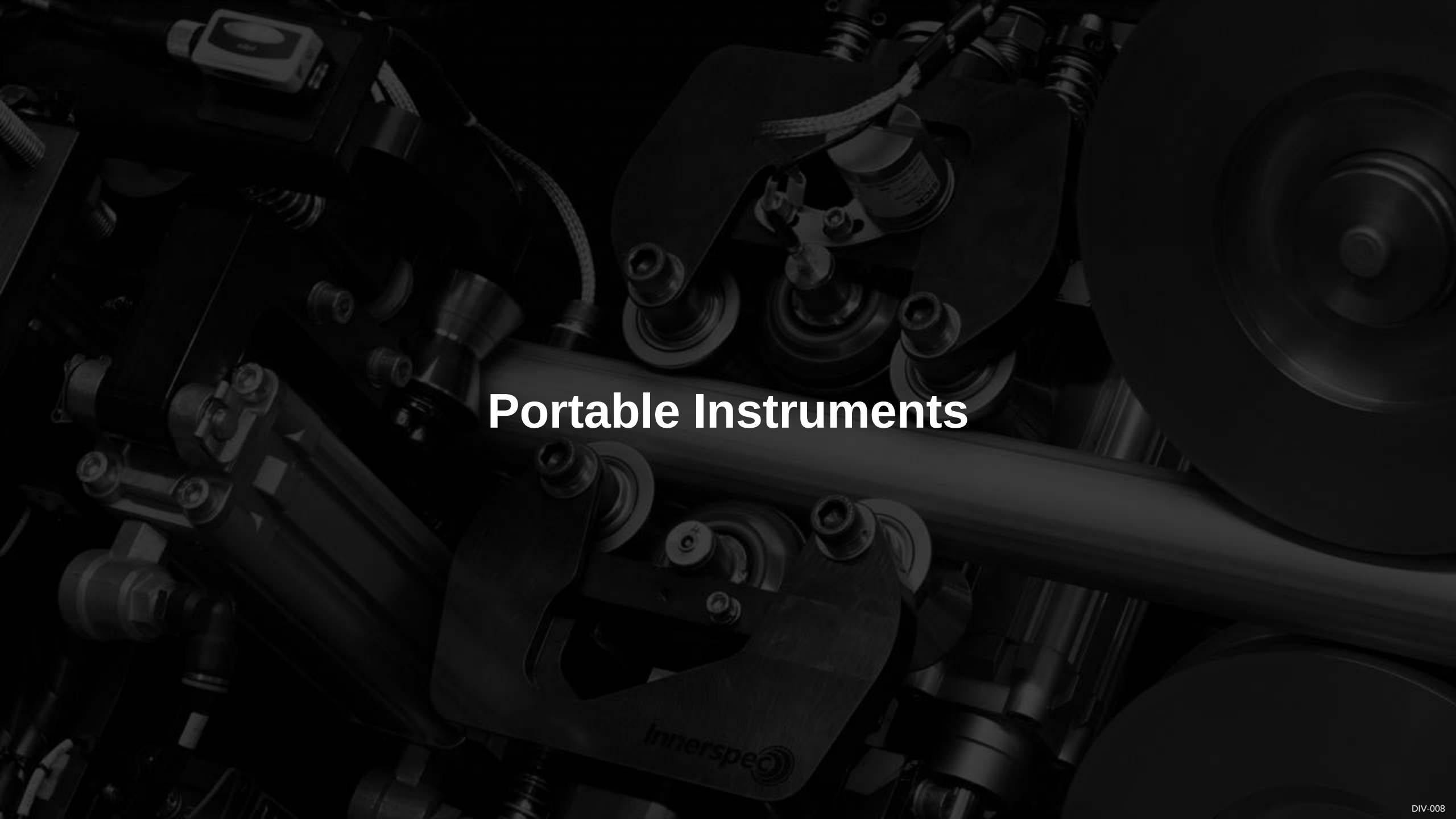
Laser Profilometry - OPTEMATE

OPTEMATE : Industrial Grade Laser Profilometry-based Inspection System

- Non-contact Laser Profilometer developed In-House by Innerspec
- Developed as a complement to existing TEMATE weld-inspection platform but can be used as standalone system for diverse applications
- Flexibility to adapt to different applications and customer requirements. (Commercial profilometers are more closed solutions with small room for customization)
- Possibility to modify and fine-tune measuring algorithms
- Seamless integration with Innerspec software suites
- OPTEMATE is already installed in various laser welding production lines in the automotive industry
- Running fully automatically in 24/7 Operation
- Fully integrated with Line PLC's and MES systems (Hand-shaking, transmission of results, statistical logging etc.)
- Additional Process Control Features



INNOVATIVE SME
Valid until Jul 23rd 2024


Portable Instruments

Innerspec currently offers two EMAT and one EC portable instruments for in-service inspections

- VOLTA – EMAT
  - 2 Channel high-power EMAT system
  - Designed for MRUT, LRUT, weld inspection and thickness measurement

- CODA – EMAT & Conventional UT
  - 1 Channel high-power EMAT & Conventional UT
  - Designed for normal beam applications such as high-temperature thickness measurement, stress measurement and flaw detection.

- BRIO – EC
  - Multi-channel and ultra-portable EC – ECA instrument
  - Designed for flaw detection, conductivity measurement, and thickness measurement

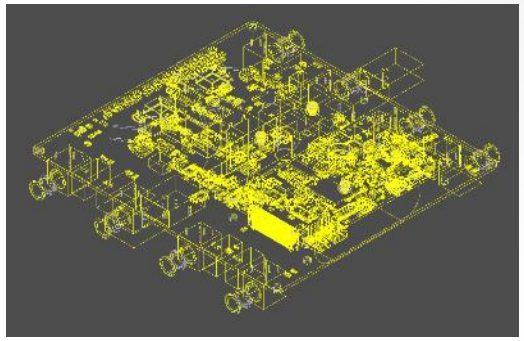
INNOVATIVE SME
Valid until Jul 23rd 2024

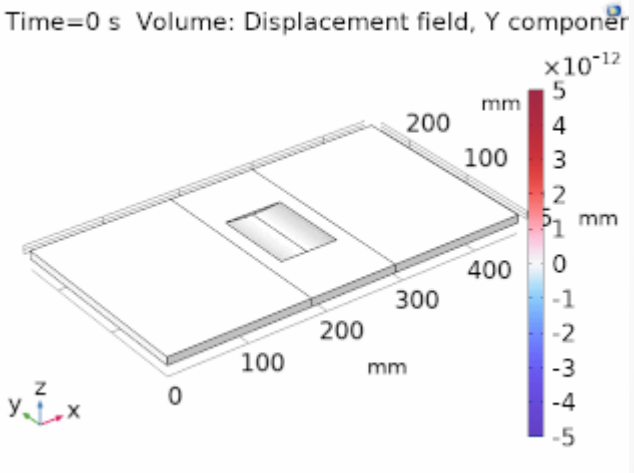
INN-035

Research and Development

Research & Development

- More than 22 years of experience developing **first-of-a-kind NDT applications**
- **Multi-disciplinary approach** with in-house developments covering electronics design, ad-hoc software and hardware, advanced algorithms, including AI research, and testing facilities.
- **Feasibility studies** to solve our customer's enquiries, with top-notch FEA simulation software packages (Comsol, ANSYS, CIVA)
- **Laboratories** with the widest range of EMAT instrumentation worldwide
- Experts in **national** and **international R&D innovation projects**





MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

CDTI Centro para el Desarrollo Tecnológico Industrial

HORIZON 2020

INNOVATIVE SME
Valid until Oct 8th 2021

Thank You
For Your Attention


www.innerspec.com


sales@innerspec.com


www.youtube/user/innerspec


www.linkedin.com/company/innerspec-technologies