

# Intelligent Railway Wheelset Inspection Using Phased Array Technology

By DTEC GmbH and Olympus IMS - 13 May, 2021



*For a Safer and Smarter Railway*

DTEC GmbH is an NDT equipment supplier located in Frankfurt Rhein-Main, Germany. The company specializes in turnkey solutions for flaw detection in railway wheelsets and train condition monitoring.

Using an advanced phased array ultrasonic testing (PAUT) technique and machine vision, DTEC GmbH has created intelligent automated systems that provide inspection services for railway safety.

DTEC GmbH's automated inspection system solutions are used to perform:

- Wayside wheel inspection
- In-service wheel and axle inspection when wheelsets are on train
- Routine wheel and axle maintenance phases when wheelsets are dismantled from the train

In railway maintenance depots and workshops, specialized automated [wheel inspection systems \(WIS\)](#) detect manufacturing flaws, defects, and fatigue cracks in high-speed train, locomotive, and rolling stock wheels and axles. These advanced WIS systems use Olympus' [FOCUS PX](#) PAUT instrumentation.

“The Olympus FOCUS PX makes our star product, the [Underfloor Wheelset Ultrasonic Testing System \(UW-UT, or UFPE in German\)](#), an excellent solution for modern railway maintenance depots. It enables them to inspect wheels for fatigue cracks without needing to remove the wheelset from the vehicle,” says Dr. Eric Peng, Chief Engineer at DTEC GmbH.



*DTEC GmbH's Underfloor Wheelset Ultrasonic Testing System (UW-UT)*

## The Challenge: Inspecting Wheelsets without Dismounting Them

On trains, wheelset components are subjected to the highest loads. Both wheels and rails are susceptible to rolling-contact fatigue (RCF), which is when cracks grow due to the contact stresses between a rolling wheel and the rail. RCF can induce spalling (flaking) and shelling defects in the wheel tread. Some subsurface and inner defects can develop circumferentially and cause the wheel rim to lose chunks of material. Bulk material loss is dangerous and can result in a derailment. Monitoring the rail-wheel contact and the continuous cycling stress of the axles can help avoid component defects before they cause a failure.

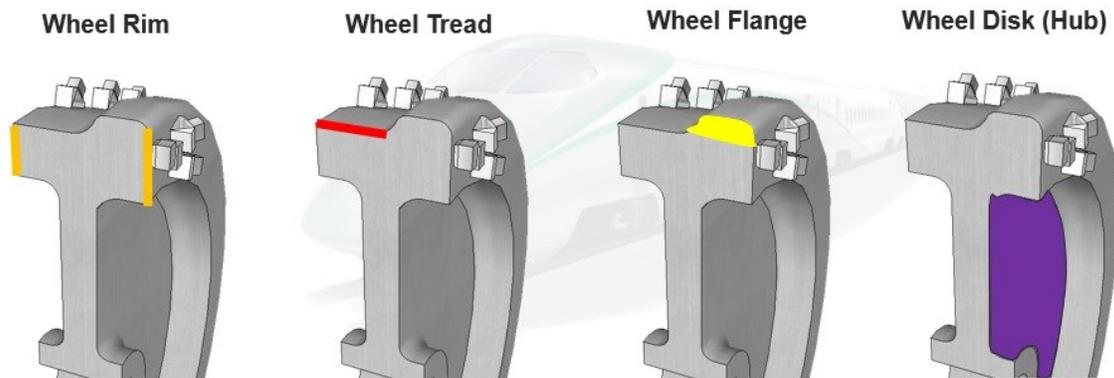
Railway operators can use conventional [ultrasonic testing \(UT\)](#) to conduct periodic NDT inspection of train wheels. However, with the manual UT method, inspectors are unable to achieve full 360-degree-circumferential flaw detection of wheels, mainly because of the complicated structure of train cars' undercarriage.

Compounding the inconvenience of manual UT, this kind of inspection work is normally scheduled during the night shift to limit the impact on the vehicle's operation time. In

some cases, the wheelsets must be removed from the vehicle, which exponentially increases workload time and cost. The challenge DTEC GmbH faced was to implement an efficient, accurate, reliable, and automatic UT system for wheel inspection while keeping the wheels on the vehicle.

## UT Inspection Requirements on High-Speed Train Wheels

Speed is a critical function of high-speed trains, but so are safety and stability. The wheels, as a key component of a high-speed train vehicle, require a lot of attention during maintenance—the tread, flange, rim, and disk must be thoroughly inspected to ensure their integrity. “To cover all critical wheel areas with their irregular surfaces requires a system of different ultrasonic skills,” says Eric.



*Critical wheel areas with their irregular surfaces*

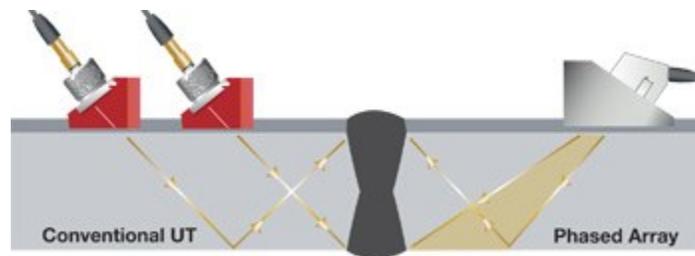
Table 1 shows the light-maintenance UT inspection coverage requirements for high-speed train wheels, including the required UT probe types, configuration, and coupling. According to Eric, “At the beginning, we thought about using 62 total conventional UT probes in the system to do the job. However, there is not enough space in the undercarriage area for such a probe arrangement.”

Table 1

Probe Types	Coupling Position	Targeted Area	Targeted Defects
Dual elements	Wheel tread	Wheel rim Wheel disk	Inner defect Circumferential crack
	Wheel back rim	Wheel rim	Inner defect
Angle Beam (Pulse-echo model)	Wheel tread	Wheel rim Wheel disk	Radial crack

Probe Types	Coupling Position	Targeted Area	Targeted Defects
	Wheel back rim	Wheel rim	Crack at chamfer
Angle Beam (Pitch-catch model)	Wheel tread	Wheel disk	Circumferential crack

PAUT uses probes that contain a set (array) of ultrasonic transducers (elements). Ultrasonic phased array systems can potentially be employed in almost any test where conventional ultrasonic flaw detectors have traditionally been used. The benefits of [phased array technology](#) over conventional UT come from its ability to steer, focus, and scan beams using the multiple elements in the array.



*Phased array testing compared to conventional UT. The ability to test welds with multiple angles and depths from a single probe can increase the probability of detecting an anomaly.*

The small footprint of phased array probes and the ability to sweep beams electronically ease the inspection of components where there is limited access for mechanical scanning, such as wheels in the undercarriage. On the downside, phased array probe technology is usually more expensive, and operators may require additional training to use it. However, these costs are frequently offset by the greater flexibility and increased inspection efficiency that PAUT systems provide.

By integrating Olympus PAUT technology, the number of probes that DTEC GmbH’s UW-UT system uses is about half of what would be required using conventional UT transducers. The probe carrying device is more compact, and it is also compatible with the many different wheel types that they need to inspect.

## Wheelset Inspection Solution: An Automated FOCUS PX and FocusPC Driven System

The FOCUS PX data acquisition unit is a high-performance conventional UT and PA instrument designed for automated inspection systems. It has a robust casing—for example, it requires no air intake—and it’s tested to handle long operation hours in harsh production environments. It’s scalable, easy to integrate, and quick to program.



**FocusPC software** offers powerful inspection features, advanced analysis tools, and fully customizable displays. It drives up to four FOCUS PX acquisition units in parallel and can combine the data in a user-defined display. Features of the FOCUS PX and FocusPC system, such as the large data file storage, flexible compression and digitizing rates, and conditional A-scan saving, enable large parts to be inspected without interrupting the inspection sequence.

## Integrated Application: Underfloor Wheelset Ultrasonic Testing System

DTEC GmbH's UW-UT (or UFPE) is a fully automatic ultrasonic wheel inspection system for use during light maintenance. When a train is on the maintenance track, the UW-UT system is run under the train undercarriage to automatically lift and rotate each wheelset.

At the same time, twin robots position PA probes on both wheels. In less than one minute, and with one rotation of the wheelset, the FOCUS PX instrument acquires the ultrasonic data and transfers it to the customized WIS software program. A minute after that, the automatic inspection report is ready for the operator to review.



*UW-UT system on a calibration reference wheelset (left) and an on-vehicle wheelset inspection (right).*

Key features of DTEC GmbH's UW-UT system:

- Automatic positioning and inspection
- UT data acquisition:  $\leq 1$  min/wheelset

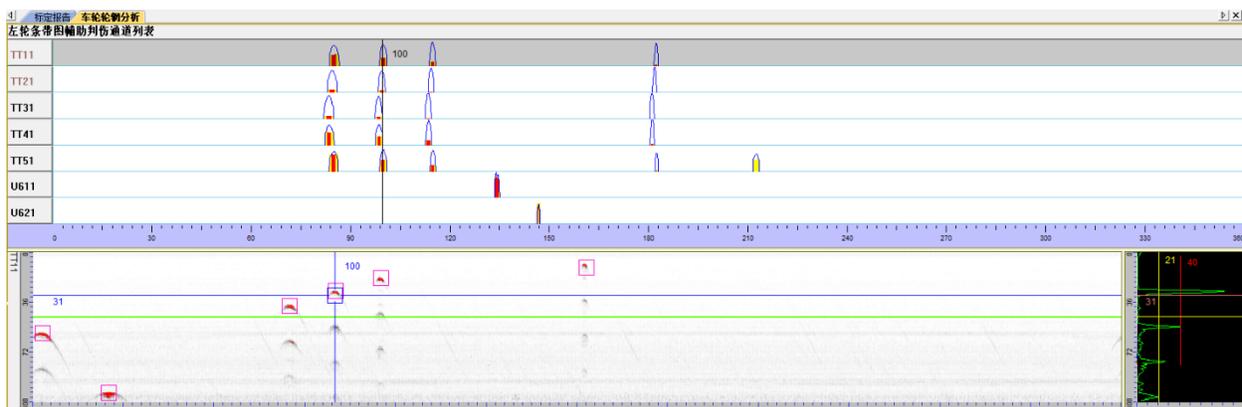
- A/B-scan, bar chart, wheel side view data analysis
- Flaw detection ability:
  - Equivalent defect in wheel rim:  $\geq 2$  mm FBH
  - Equivalent crack on wheel rim: 10 mm $\times$ 3 mm
  - Equivalent crack on wheel disk: 15 mm $\times$ 3 mm
  - Equivalent defect in wheel disk:  $\geq 3$  mm SDH

## The Results: Powerful PAUT Inspection and Data Management

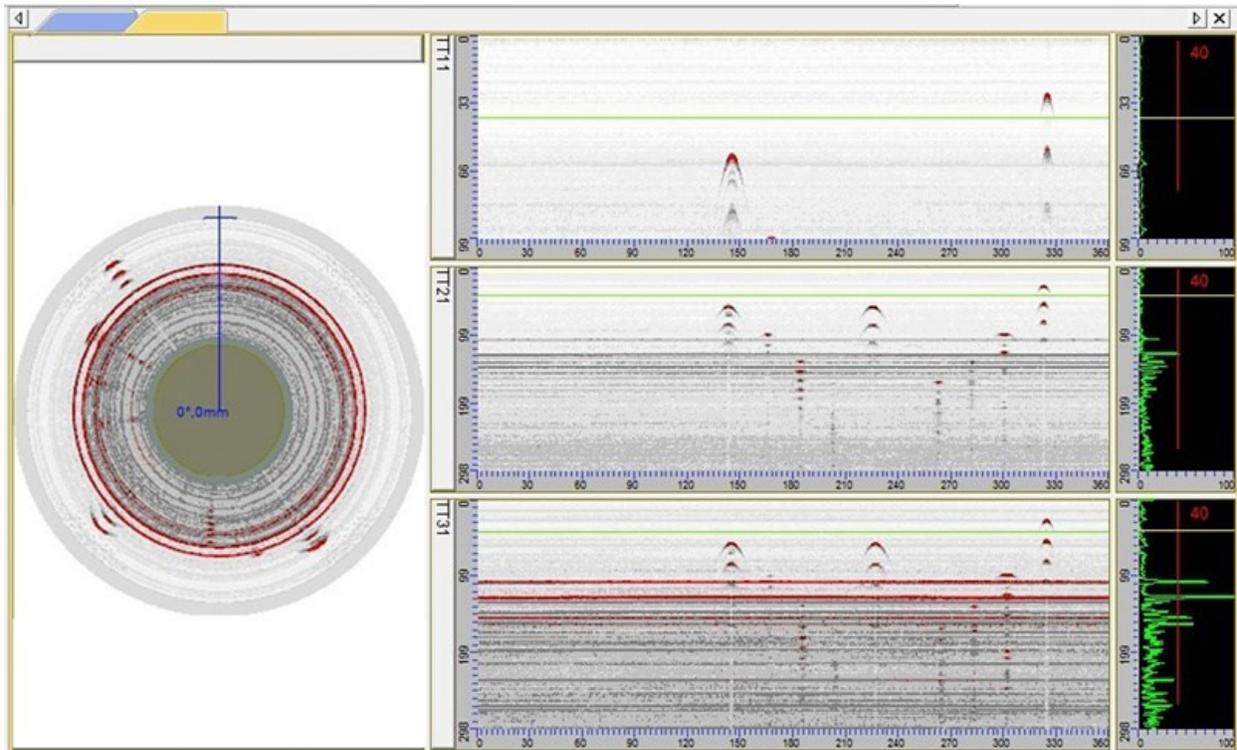
In the UW-UT system, for every 1 mm rotation of the wheel tread, multiple ultrasonic beam sets (or focal laws) are simultaneously triggered to perform 50 A-scans for each wheel. For a 920 mm diameter wheelset inspection, the total number of A-scans is about 30,000. It requires a powerful instrument such as the Olympus FOCUS PX unit to execute this data acquisition and data transfer in real time.

Because there is such a large volume of data collected with each inspection, DTEC GmbH has set up specialized data management for their operators:

- A bar chart is used for channels where an automatic alert can be applied, and an operator can select bars to receive related B-scan and A-scan data.
- For channels where a manual confirmation is required—for example, the channels for a wheel disk—a wheel side view is created by combining several B-scans, which are corrected according to the wheel diameter.
- Operators can easily see whether there is a defect in a wheel using the bar chart and wheel side views, then they use the A-scans and B-scans to determine defect details, such as location, depth, and severity.
- When the operator uses the mouse to click-and-drag a window around a defect on a B-scan, these data (location, depth, etc.) are calculated automatically.



*Bar chart, A- and B-scan associated analysis*



*Wheel side view, A- and B-scan associated analysis*

Fully automated, advanced PAUT technology and powerful data management make DTEC GmbH's UW-UT system intelligent and easy to operate. Since 2009, 130 UW-UT systems have been installed in the field, successfully detecting numerous wheel fatigue cracks. After removing the cracks with a lathe, these wheels can be safely put back into service.



*Wheel fatigue crack findings (left) before and (right) after tread reprofiled*

# Applying the Phased Array Ultrasonic Technology to Other Railway Wheelset Maintenance

DTEC GmbH also developed the [Dismounted Wheelset Ultrasonic Testing \(DW-UT\)](#) system. The ultrasonic technologies used in this equipment are like those in the UW-UT system, but this time applied to dismounted wheelsets.



*Dismounted wheelset and solid axle ultrasonic testing systems*

By employing Olympus technology and instrumentation, DTEC GmbH has succeeded in producing efficient, intelligent, and automated solutions to help ensure safer and smarter railways.

Please visit DTEC GmbH website <https://dtec-gruppe.com/> for more information on [Ultrasonic Testing Solutions](#) and [Trackside Check Point Solutions](#), or continue reading attached our company brochure.

# **DTEC**<sup>®</sup> GmbH

*For a Safer and Smarter Railway*



## **TURN-KEY SOLUTIONS**

- TRACKSIDE CHECK POINT / TUNNEL
- SERVICE DEPOT & WORKSHOP INSPECTION

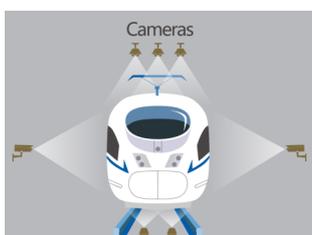
# TRACKSIDE CHECK POINT / TUNNEL SOLUTIONS



Check Point / Tunnel, installed at the trackside, consists of many modular function units, and is designed to carry out various inspections and measurements for a moving train. This includes monitoring of the wheel profile, detection of wheel cracks by ultrasound, measuring of brake pad and pantograph carbon strip, as well as fault recognition for other visible key components, such as lost bolts, adhering foreign objects by machine vision.

Thanks to years of development and application experiences in the field, our trackside monitoring solutions have proved to be robust for the use under a wide variety of field conditions and for various types of railway vehicles.

## FEATURES & FUNCTIONS



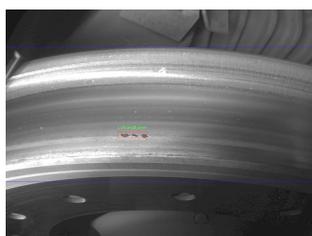
- Full Vehicle Machine Vision
- 3D, Artificial Intelligence
- Predictive Maintenance



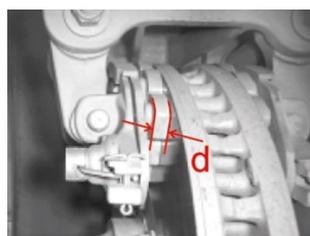
- Wheel Profile, Diameter
- Equivalent Conicity
- Other EN/DIN parameters



- Wheel Crack Detection
- Arrayed Ultrasonic Probes
- Superior to EMAT Solution



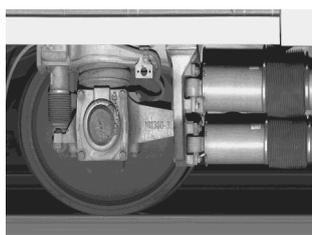
- Wheel Tread Monitor
- Flat Detection
- Spalling Detection



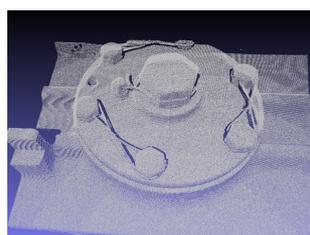
- Brake Condition Monitor
- Pad Thickness
- Brake Installation Check



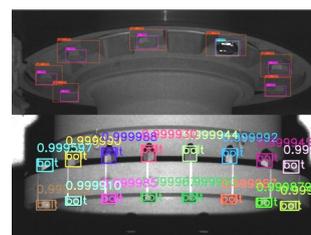
- Pantograph Monitor
- Carbon Strip Wear
- 3D-based Fault Detection



- Top-, Side-, Bottom View
- Components Monitor
- Missing Parts Check



- 3D Condition Monitor
- Parts Dimension Check
- Fault Recognition



- Pattern Recognition
- Data Mining, Failure Prediction
- Smart Asset Management

## SERVICE DEPOT & WORKSHOP SOLUTIONS



Our Underfloor Wheelset Ultrasonic Testing System (UW-UT) is designed to perform highly efficient, accurate, and highly reliable wheelset inspections under the train. With our Underfloor Vehicle Bogie Machine Vision System (UVB-MV) using Artificial Intelligence, 3D imaging, and robotic automation techniques, we are moving the asset management into a new era of smart maintenance.

We also offer mobile UT inspection systems for hollow axles (HA-UT) and solid axles (SA-UT), as well as Dismounted Wheelset Ultrasonic Testing System (DW-UT), a gantry system widely used in heavy maintenance workshops.

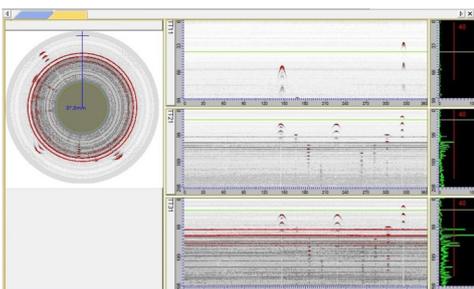
### PRODUCTS LIST

- UNDERFLOOR WHEELSET ULTRASONIC TESTING SYSTEM (UW-UT)
- UNDERFLOOR VEHICLE BOGIE MACHINE VISION SYSTEM (UVB-MV)
- HOLLOW AXLE ULTRASONIC TESTING SYSTEM (HA-UT)
- SOLID AXLE ULTRASONIC TESTING SYSTEM (SA-UT)
- DISMOUNTED WHEELSET ULTRASONIC TESTING SYSTEM (DW-UT)

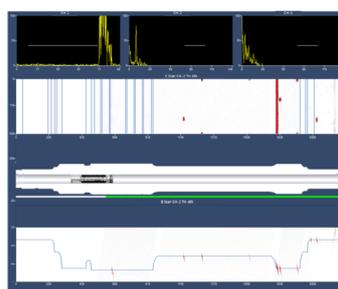


### FEATURES AND BENEFITS

- Advanced Phased Array Ultrasonic Techniques
- Better Inspection Area Coverage and Compatibility, High Efficiency
- Smart Robotic Solutions with Artificial Intelligence and 3D Imaging
- High Accuracy, Reliability, Repeatability, and Robustness
- Increase Inspection Efficiency, Reduce of Human Factors
- Inspection Data Assessment, Support of Smart Train Maintenance
- Key-components Monitoring, Failure Prevention, Safety Assurance
- Reduction of Maintenance Time, Increase of Vehicle Availability



▲ Wheel Ultrasonic Testing



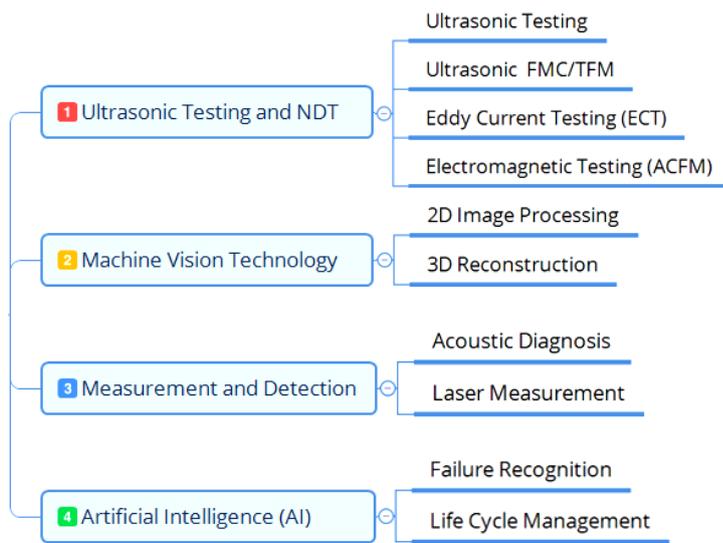
▲ Axle Ultrasonic Testing

▲ Products



## ABOUT US

DTEC GmbH is located in the Frankfurt Rhein-Main region, Germany, with a 4000 square meters facility and office area. With years of experience in advanced ultrasonic testing, and 2D/3D machine vision technologies, we develop railway inspection and measurement solutions installed at the trackside, in maintenance depots, and in railway products manufacturing companies.



## OUR PARTNERS

For a long time, we feel deeply connected with each of our partners in R&D and marketing to provide high-performance products and tailored services for the railway industry. DTEC continuously keeps exploring new partnerships with railway operators, research organizations, suppliers, local representatives, and strategic market partners.



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