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R&D Laboratory on Industrial Demand

TOLMI

Integrated NDT Systems

Michael Kröning

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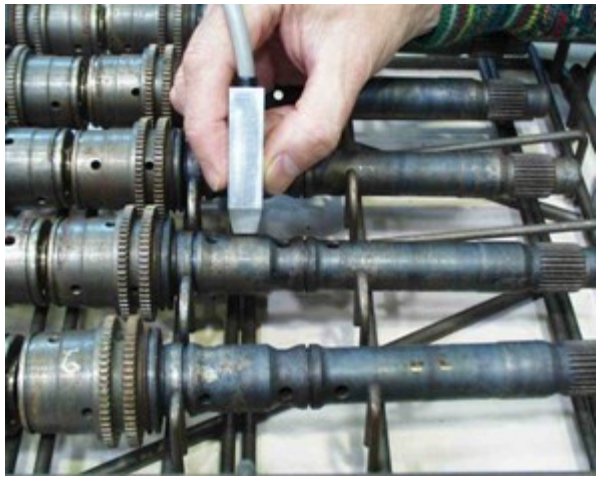
NDT – DRIVEN BY

Technical Safety Requirements, Structural Reliability, Preventive Maintenance, and Off-line Quality Control

Manual weld inspection



Final inspection of components after induction hardening

Final inspection of gear wheels after grinding

Post-manufacturing testing

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PARADIGM CHANGE

by

AUTOMATION (Robotics)

MICROELECTRONICS (Instruments)

COMPUTING (Real-time advanced signal processing)

IT(Asset management; distributed systems;

NDT – DRIVEN BY QUALITY MANAGEMENT

Integrated NDT Systems

MANUFACTURING

End Control ⟺ **Process Control**

MAINTENANCE

In-service Inspections ⟺ **Health Monitoring**

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PRODUCTION INTEGRATED NDT

BENEFITS ⟷ **CHALLENGES**

IN-LINE INSPECTION

- 100% Part Inspection
- International Product Liability
- Controlled Production

R & D

Networks

New Methods

System Engineering

Availability & Maintenance

INTEGRATED PROCESS CONTROL

- Capable Processes
- Defect Prevention
- No Rejections

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AUTOMATION

Mass Production in "Modern Times"

Charlie Chaplin
USA, 1936

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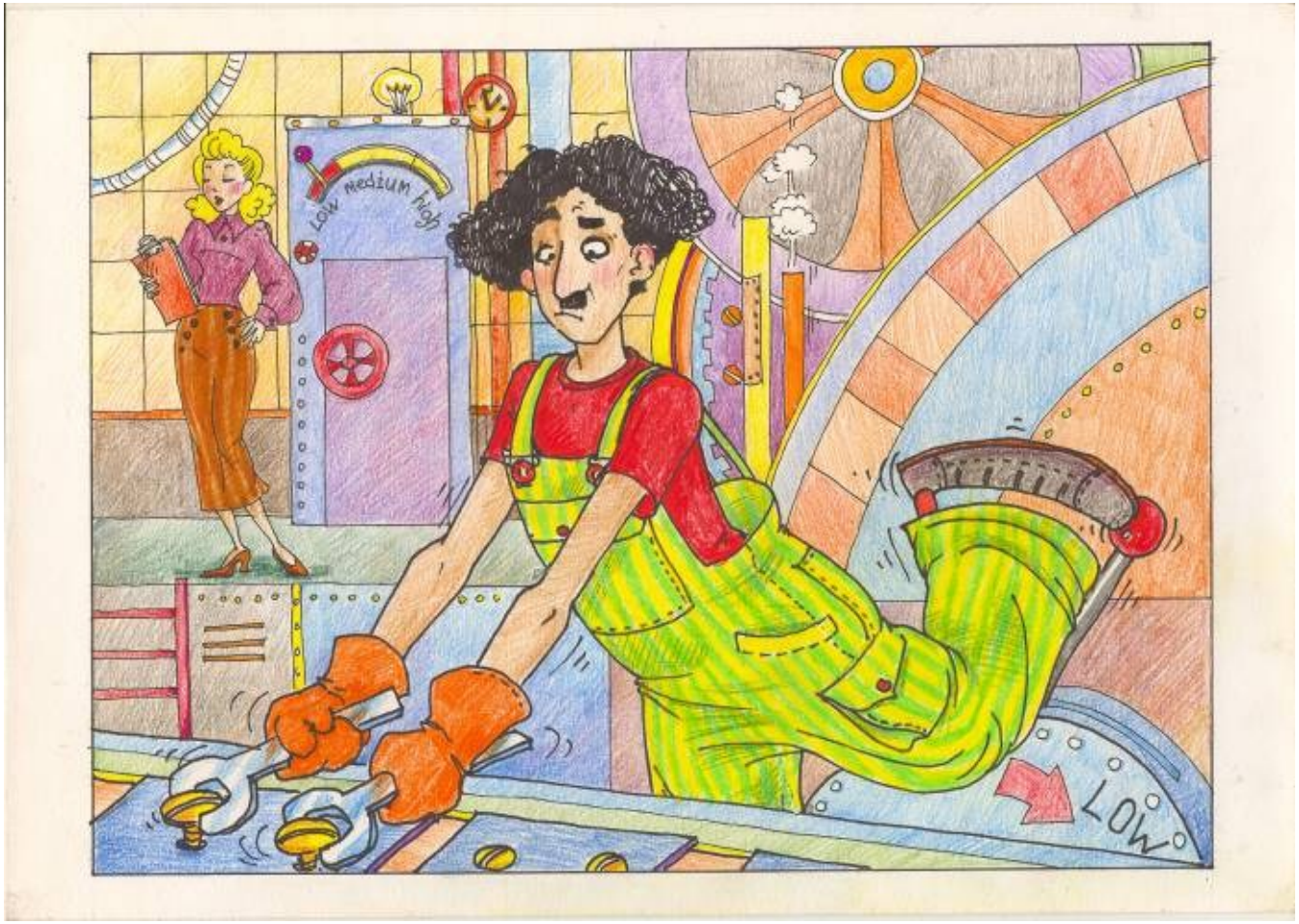

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UT, μ-NDT, NDT Systems

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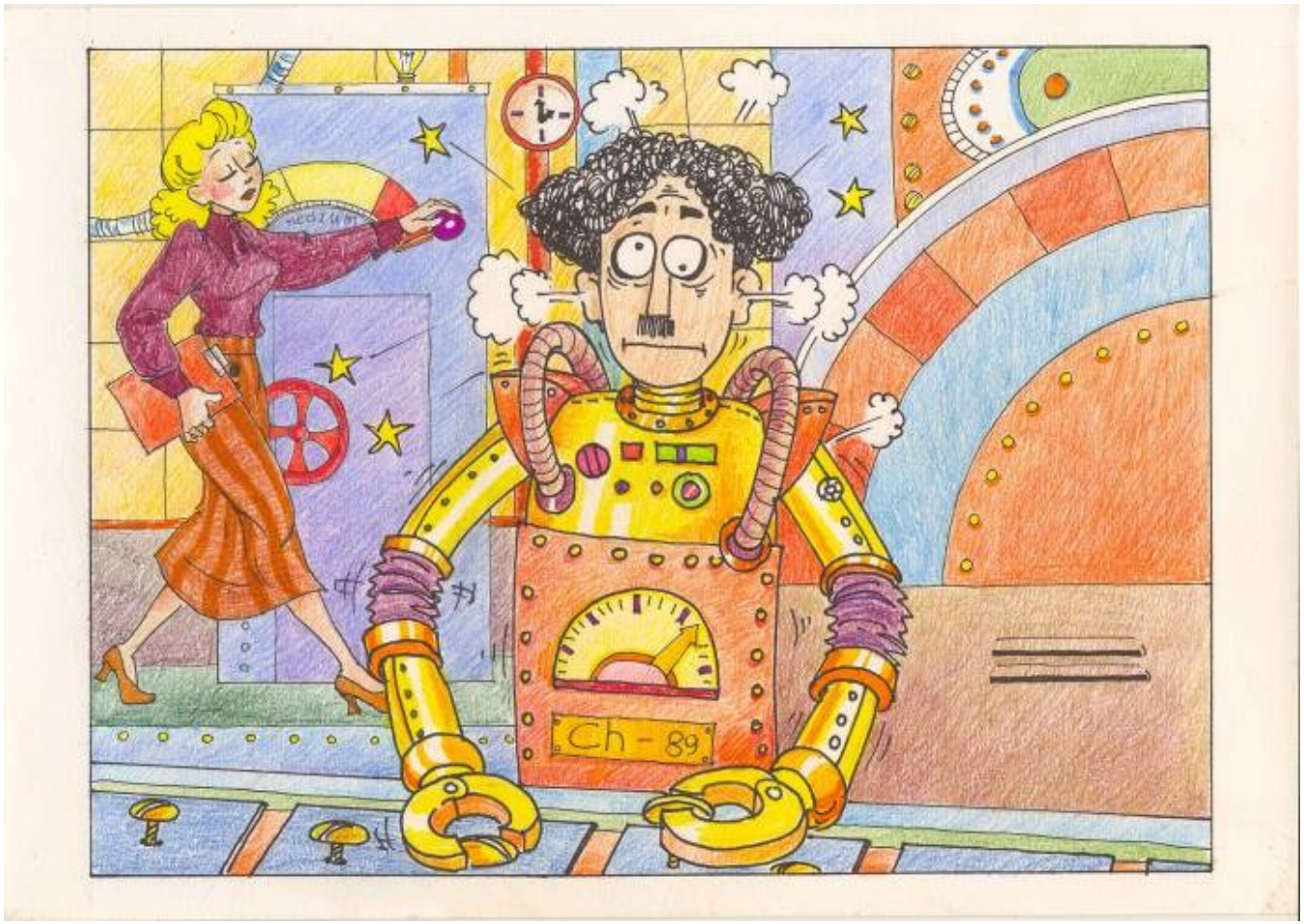

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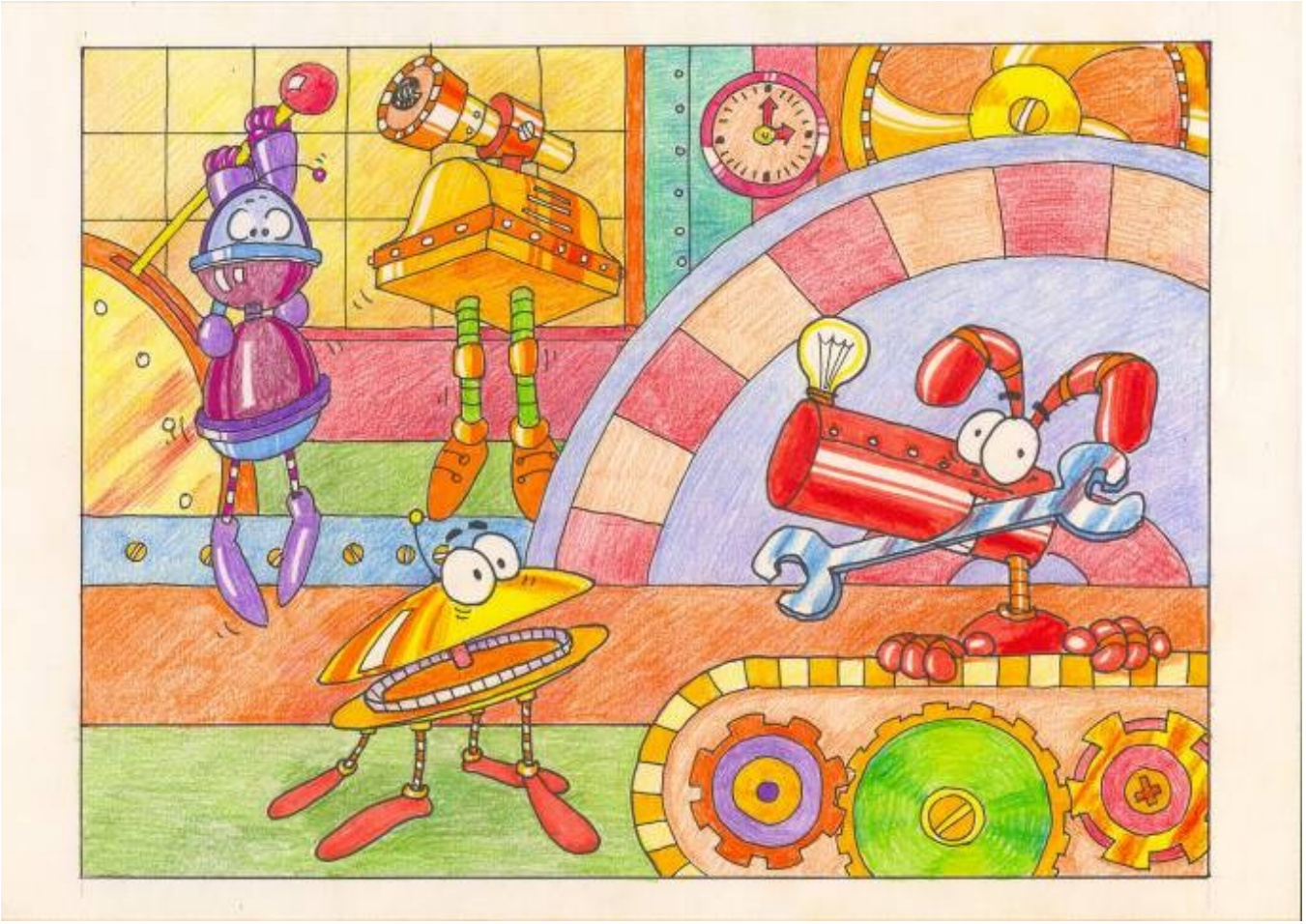

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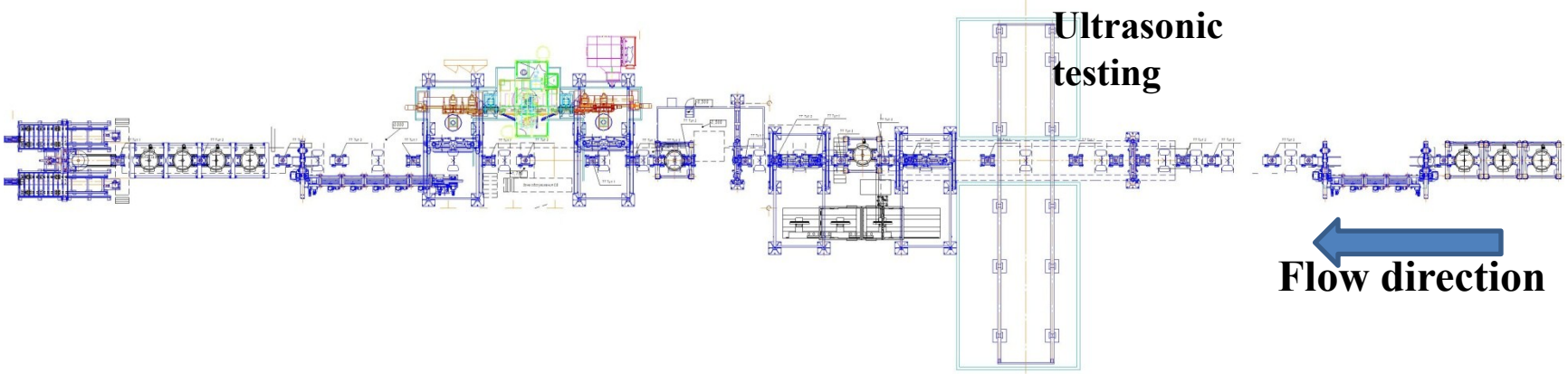
Integrated NDT Systems

Automated Final Inspection Line (FIL) for Railroad Wheels at OAO NTMK Wheels and Tires Shop



- Chemical treatment of the wheel surface.
- Identification of wheel marking.
- Control of wheel geometry
- Visual inspection of surface defects
- Ultrasonic inspection of internal flaws.
- Magnetic particle inspection
- Hardness testing of the wheel rim butt-end.
- Roto-blast hardening of the wheel disk.
- Anticorrosive protective coating of wheels.

9 Process Steps

Line Cycle: 70sec/wheel

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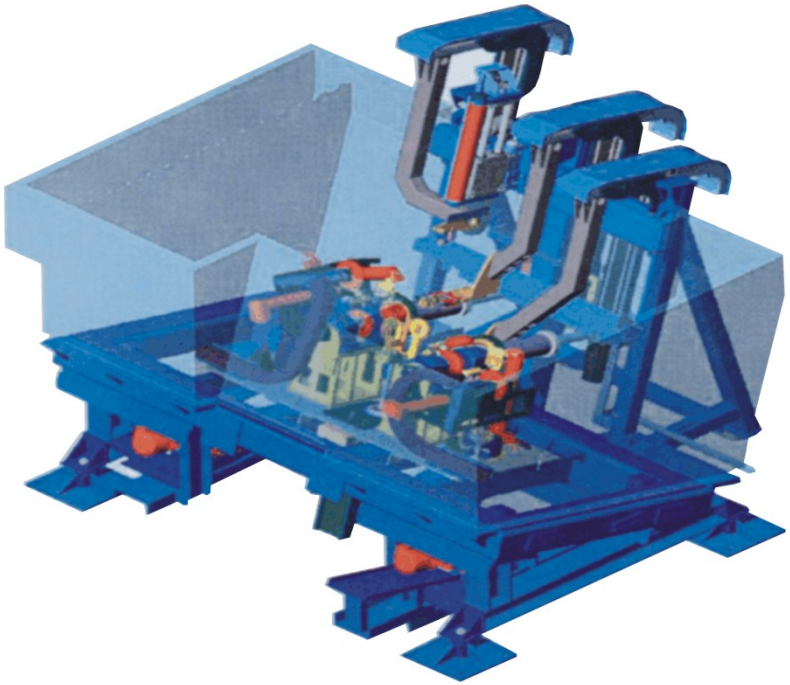

IN-LINE WHEEL INSPECTION
1 Wheel/min

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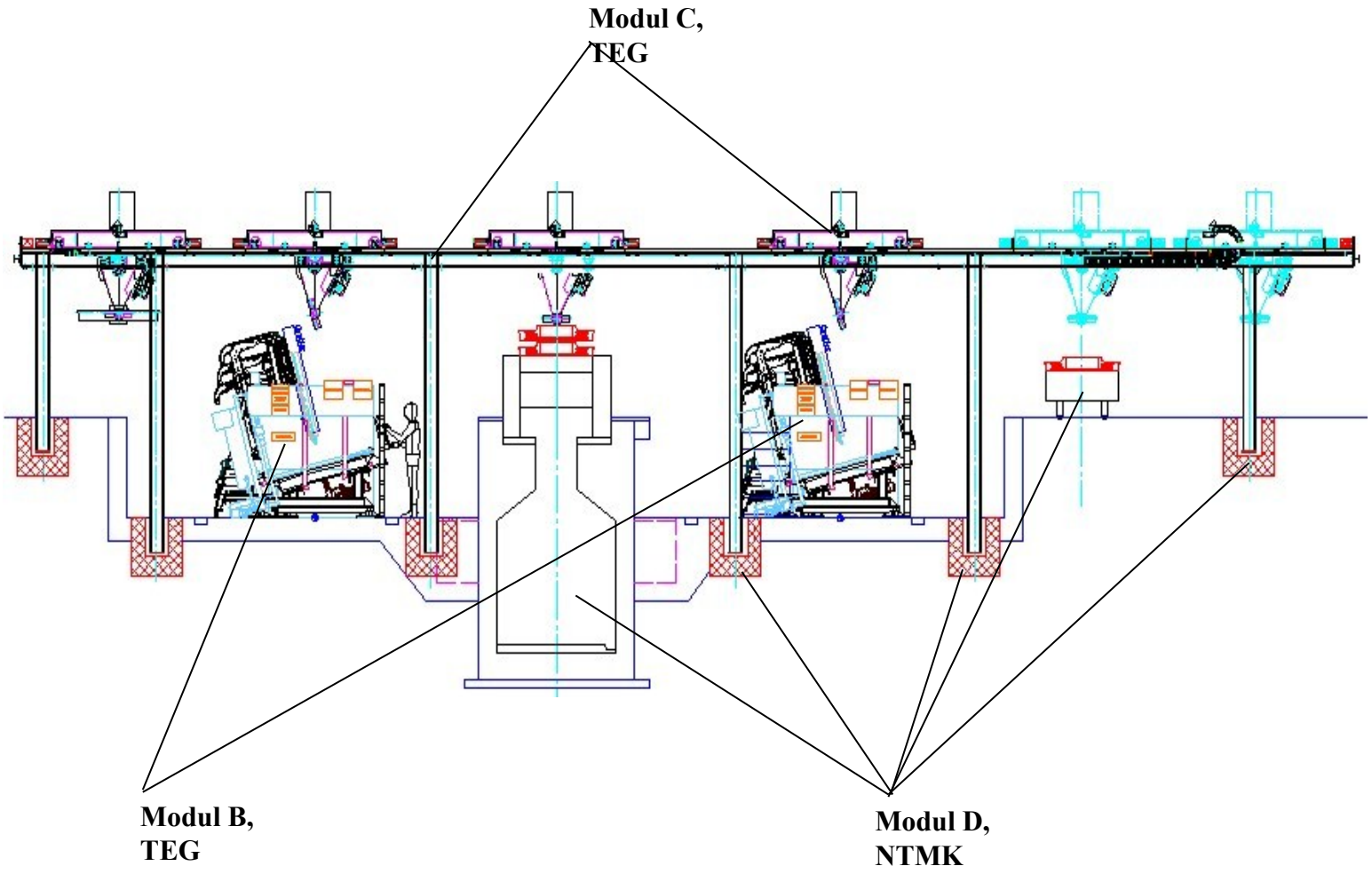

Wheel Inspection System

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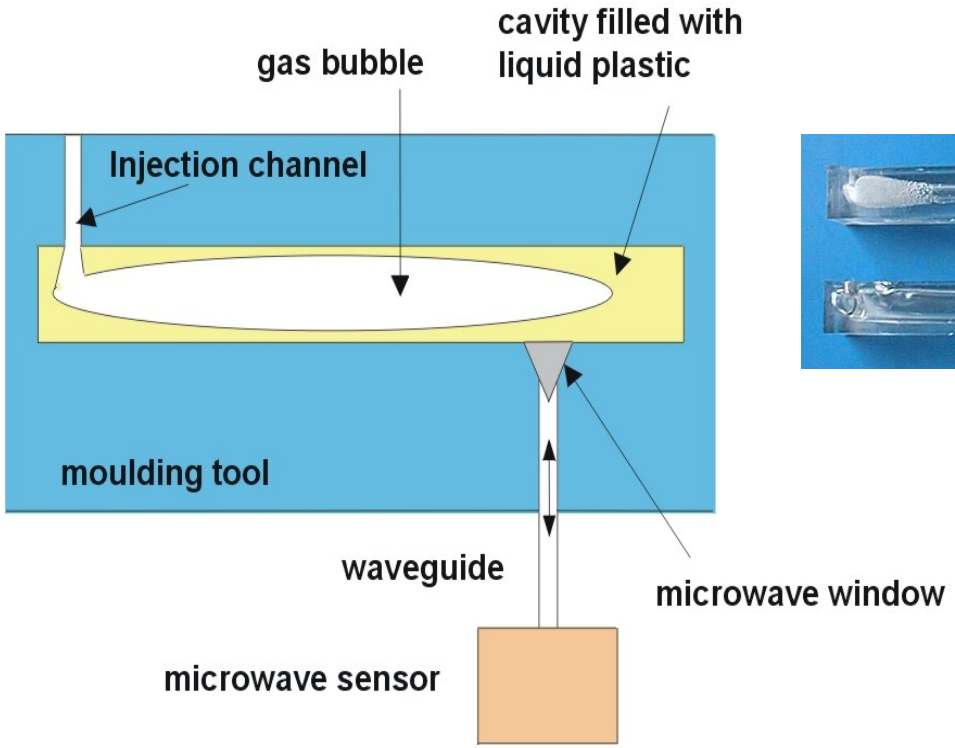
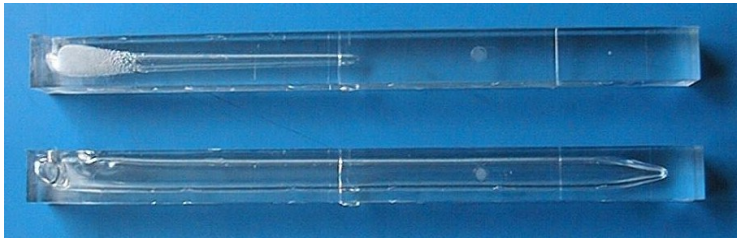
Controlled Mass Production

Injection molding of plastics with gas injection (GIT)





reject

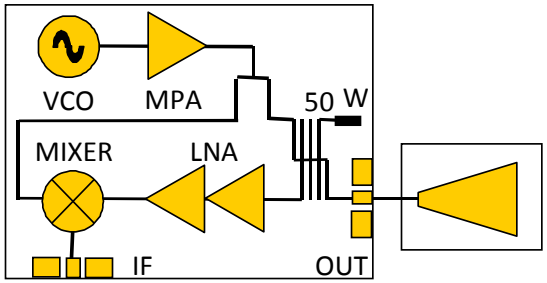
accept

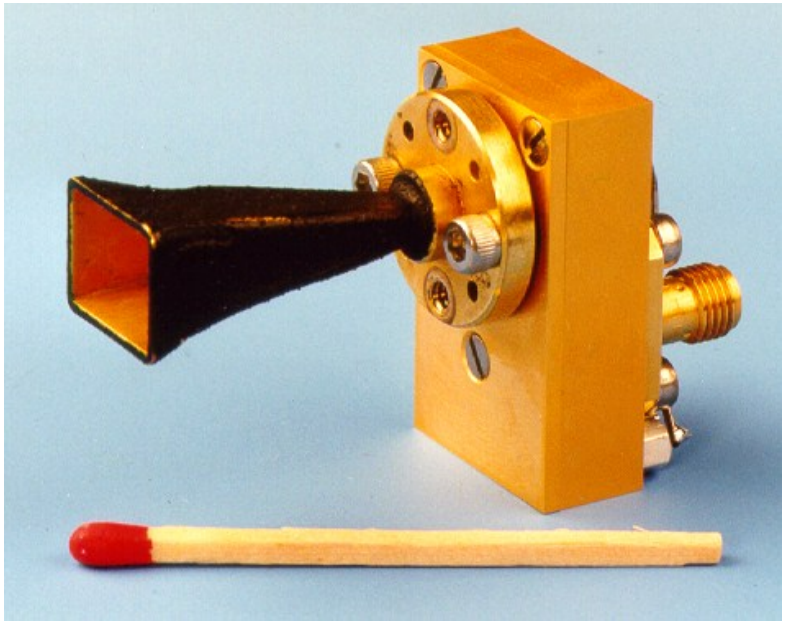
Integrated NDT Systems

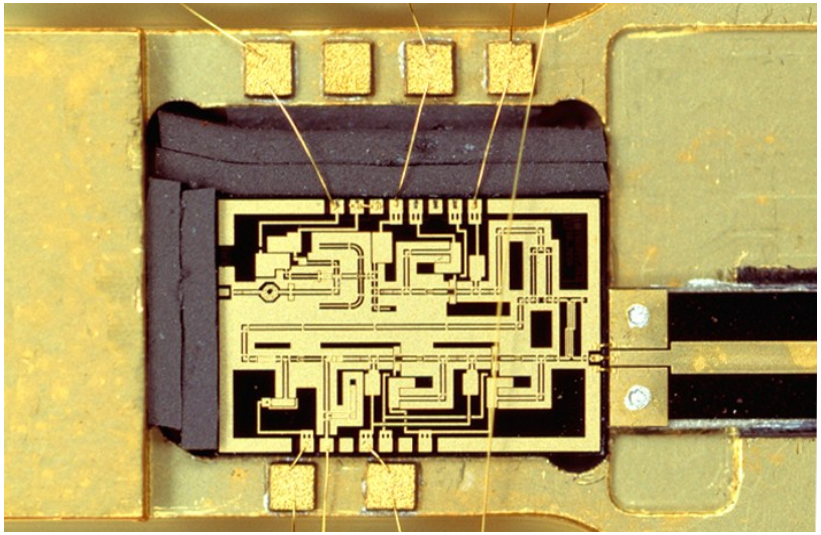
Controlled Mass Production

Monolithically Integrated 94 GHz FMCW Radar Chip

VCO – Voltage Controlled Oscillator
MPA – Medium Power Amplifier
LNA – Low Noise Amplifier
IF – Intermediate Frequency

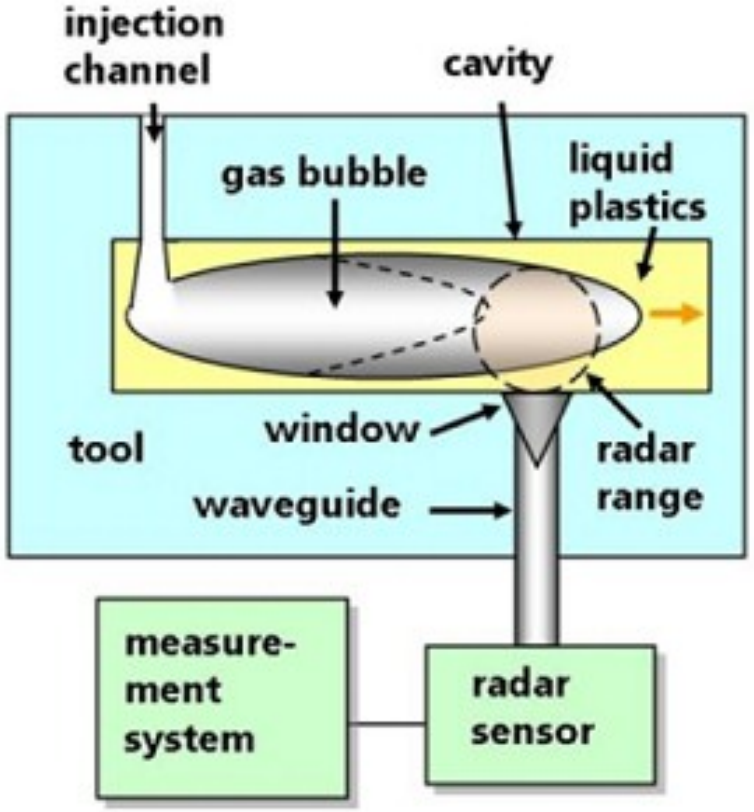




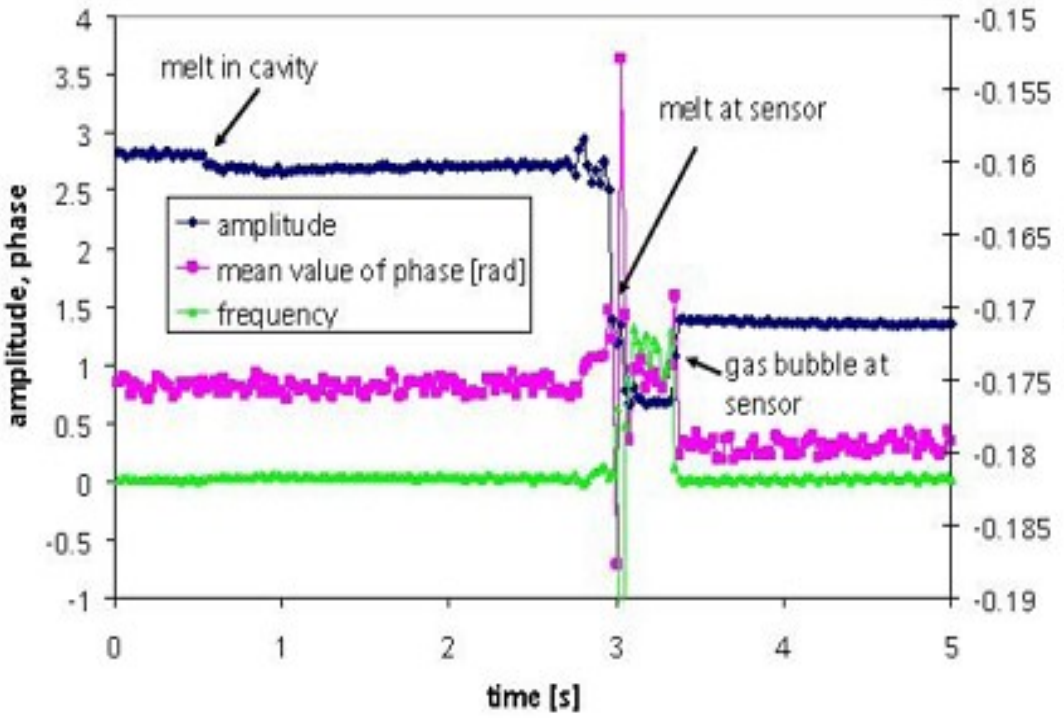


94 GHz radar module, frequency-modulated, (developed by Fraunhofer IAF)

Controlled Mass Production



Layout of GIT process monitoring with radar sensor



Process steps identified by characteristic signal changes

PI NDT – a tool of automated quality controlled production:

Process and/or in-line Integration
Automation
Information Management
Real-time quantitative data processing
High reliability and availability
Remote system maintenance

Management Controlled Quality Costs

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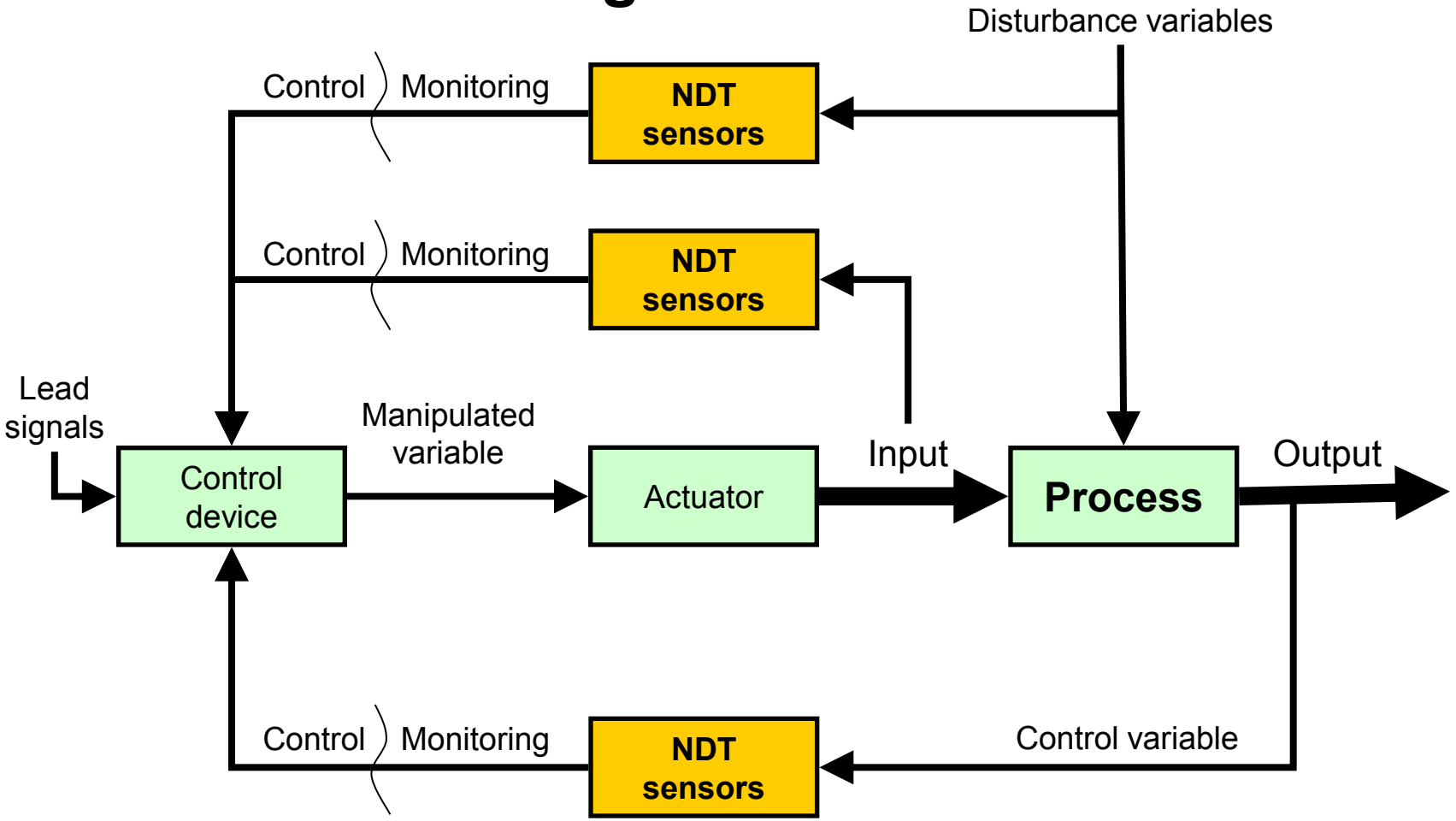
Tasks	Benefits
Process analysis and modeling	Fast collecting of process and quality data -> Fast and inexpensive modeling and validation
Process monitoring	Only good material goes “out the back door” Fast detecting and locating of process disturbances Process limits can be completely exploited
Process optimization and control	Automated data acquisition, analysis, interpretation -> Avoiding human error sources Establishing and maintaining the process optimum in respect to quality and costs Fully automated, self-controlled production

Increased reliability, increased productivity, reduced costs

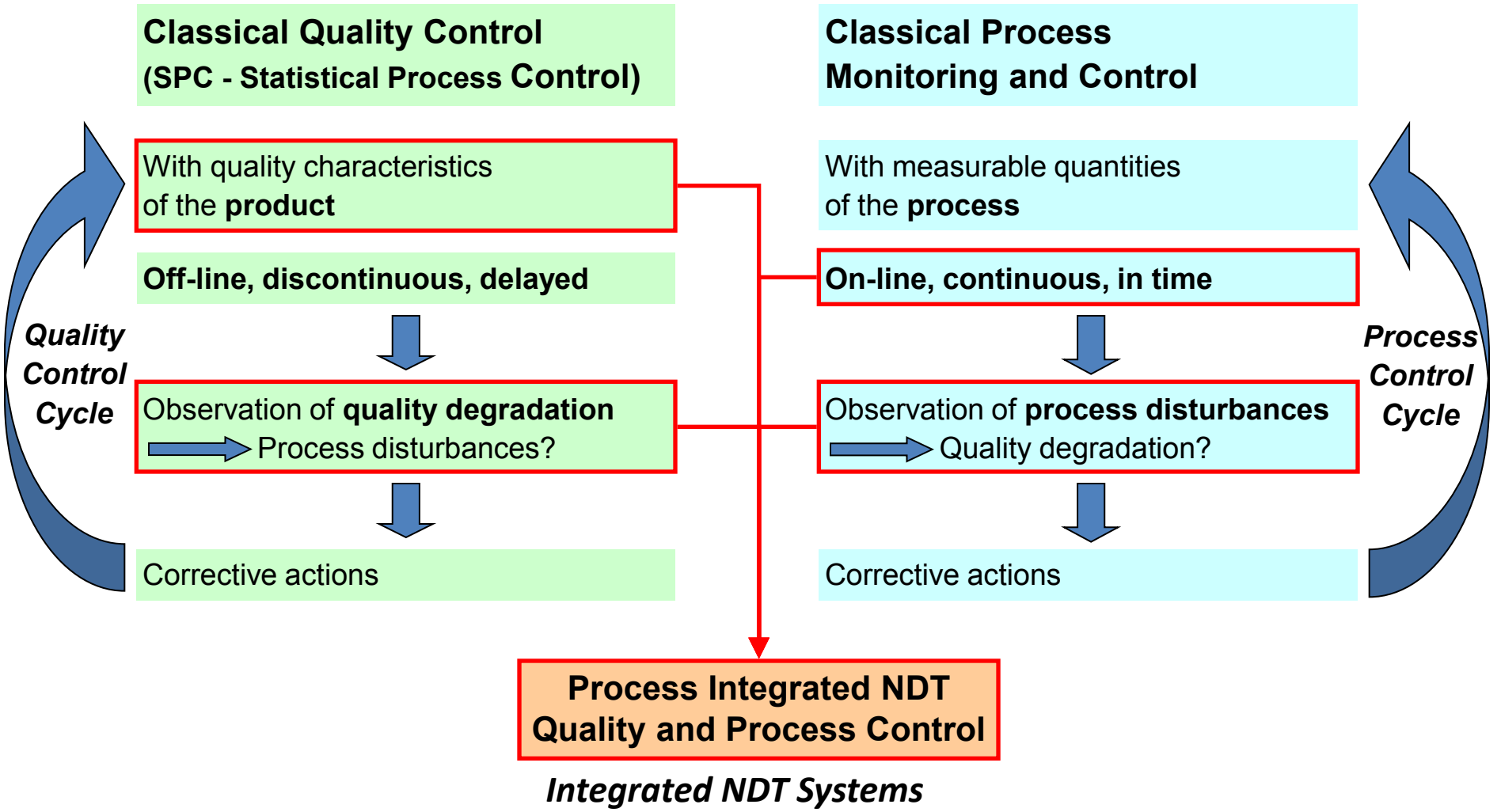
Integrated NDT Systems

PI NDT: Process Integrated NDT



Integrated NDT Systems

PI NDT: Quality and Process Control



Feedback Control in Thin Strip Production

- Production of steel strips of several kilometers length with uniform mechanical properties

- Feedback control of process parameters like oven temperatures, strip feed, etc.

Micro-Magnetic Sensor on a robotic arm above the moving strip

In-line monitoring of mechanical properties (Rm, Rp0.2, hardness)

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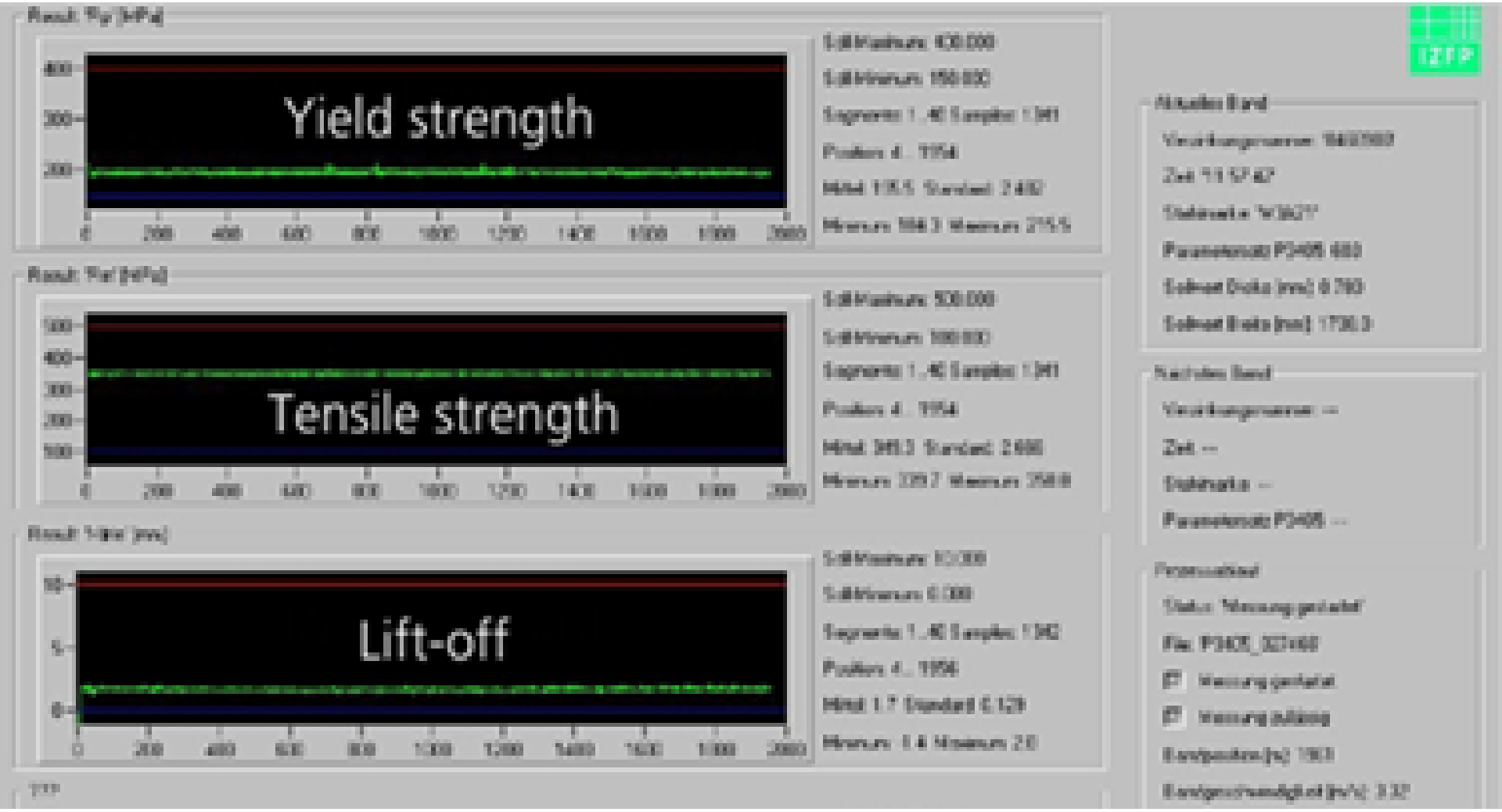
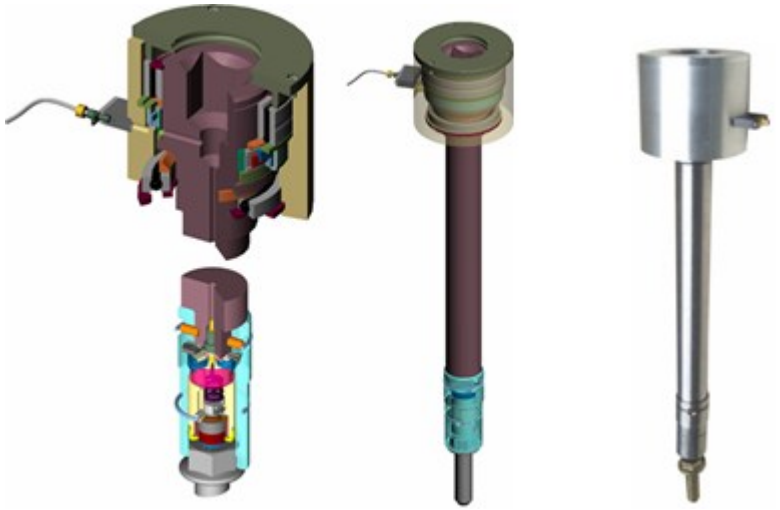
PI NDT: Quality and Process Control



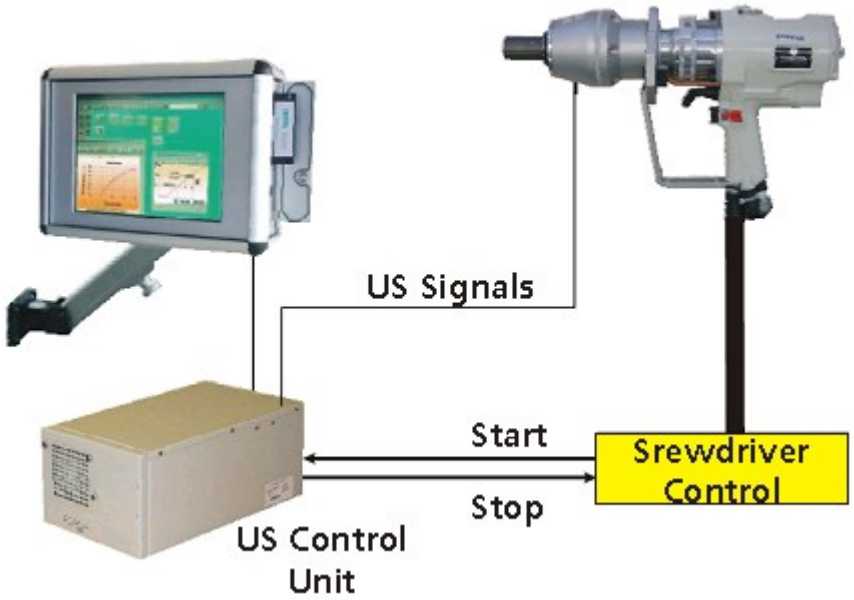
Integrated NDT Systems

Task: Control of Power Screwdrivers
Precise determination of pre-stressing force
as the control variable for power screw-driver control

Solution: Monitoring of screw elongation instead of screwing torque



Ultrasonic sensor integrated into the screwnut of a power screwdriver



US screwdriver Control system

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HEALTH MONITORING

BENEFIT
through
Continuous Degradation Monitoring

- Maintenance when needed
- Optimized System Availability
- Maximal System Exploitation
- Advanced Maintenance Strategies

CHALLENGE
for
System Development

- No false calls
- Validated PoD
- No Degradation of Structure and System Operation
- Redundancy of System Safety

Integrated NDT Systems

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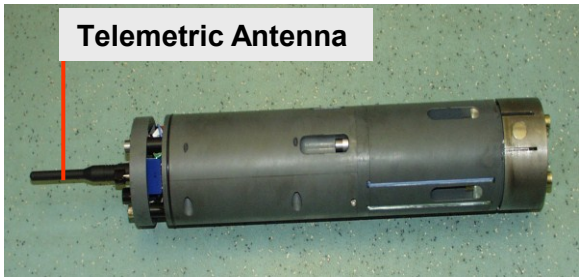
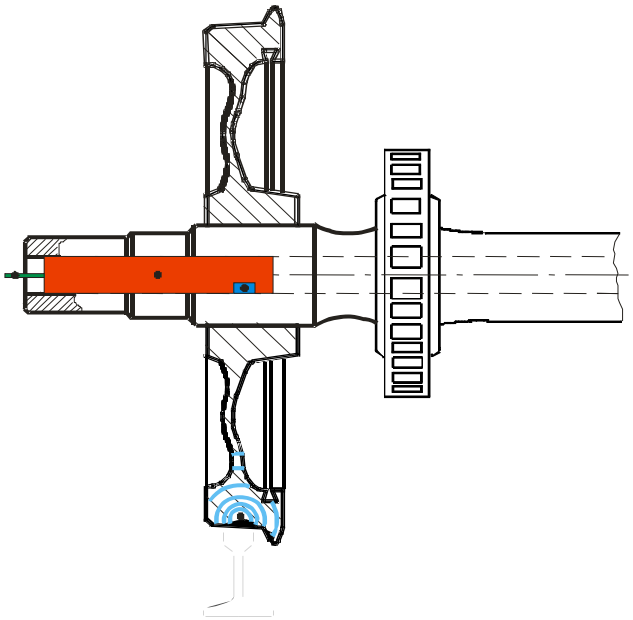
HEALTH MONITORING





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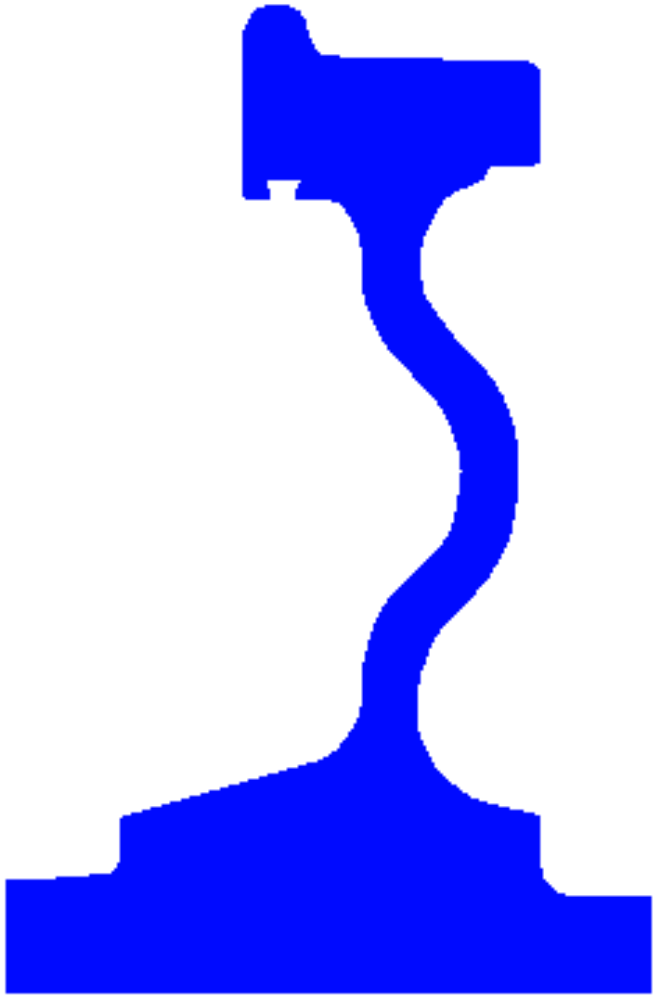
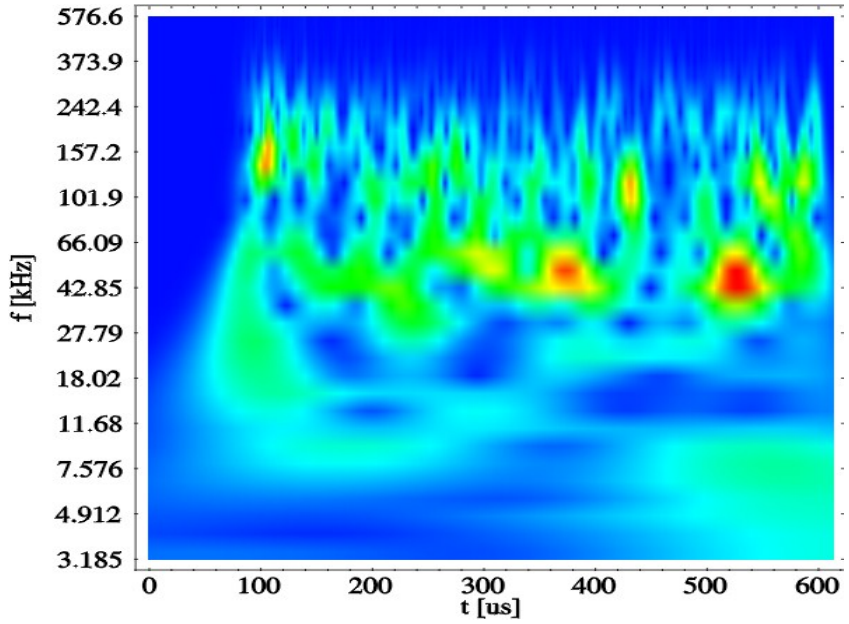


Integrated NDT Systems

HEALTH MONITORING

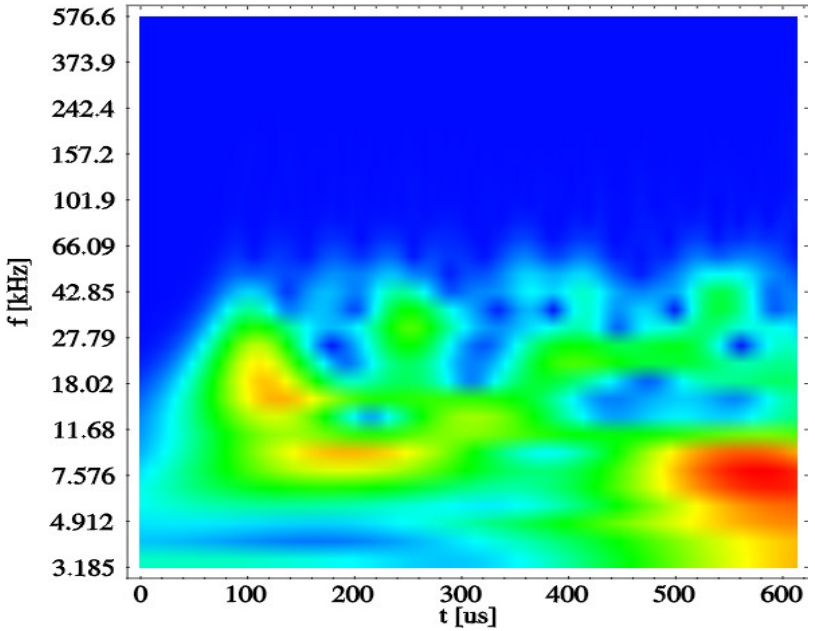
Modeling helps to understand wave generation and propagation as part of the sensing principle

narrow crack (0.25 mm)



S = 0.25 mm

open crack (2.0 mm)



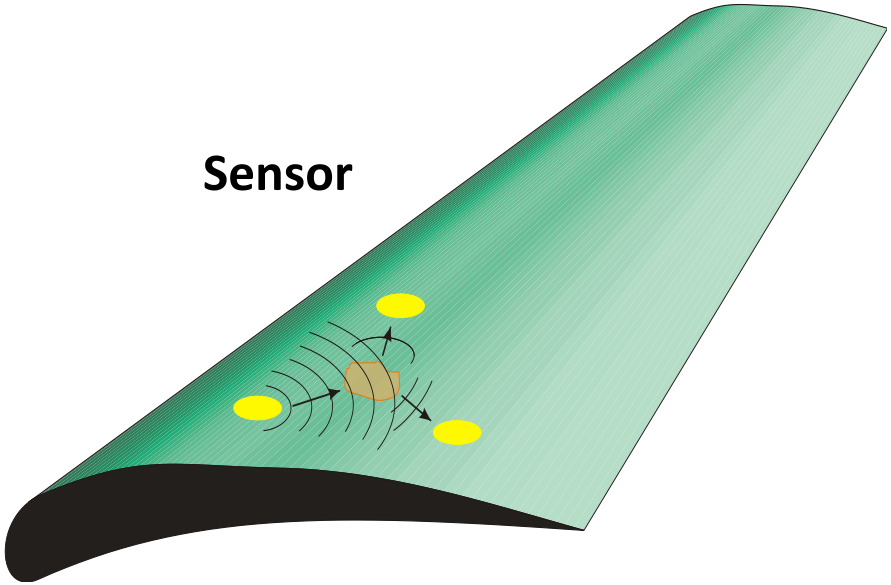
S = 2.0 mm

Calculated Sonograms

Integrated NDT Systems

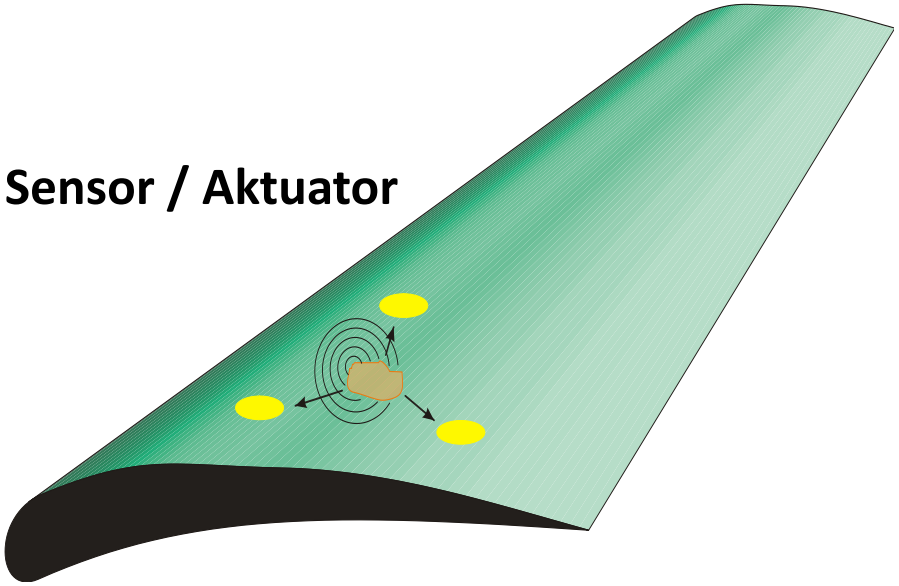
HEALTH MONITORING

Condition Based Maintenance



passive (acoustic emission)

SHM with guided waves



active (ultrasound pulse echo)

Structure Integrated Sensor System

Plastics with embedded piezoelectric fibers

Fiber thickness < 100µm

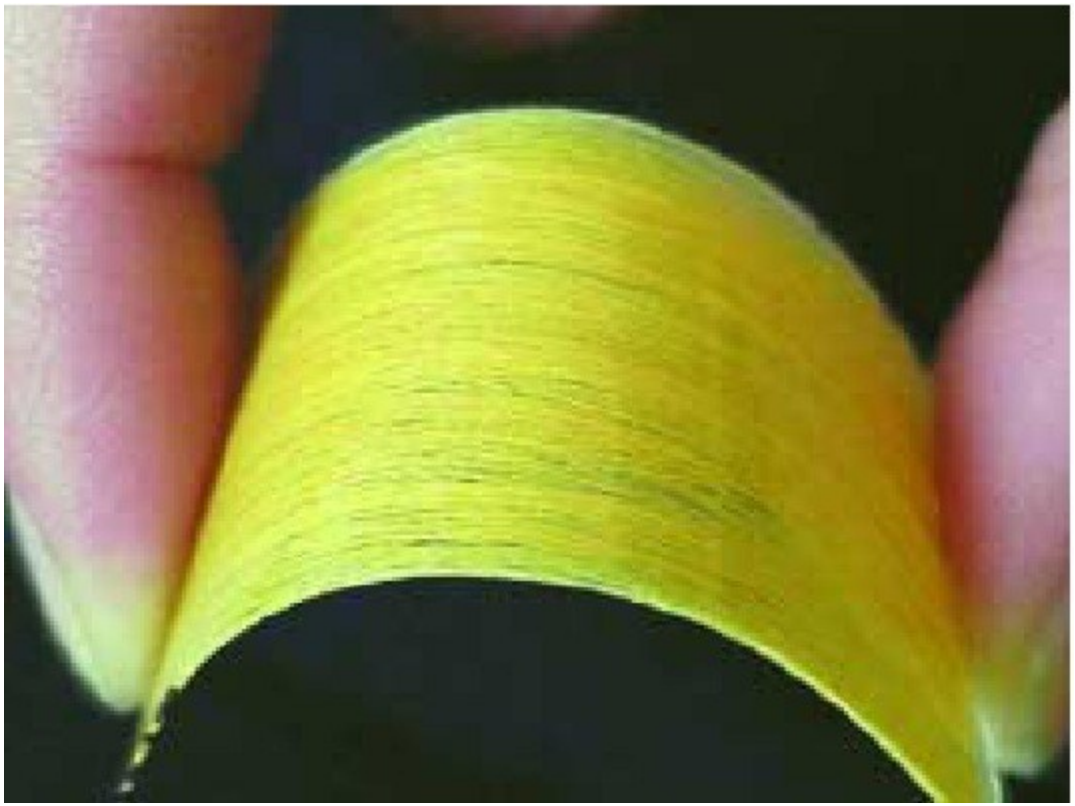
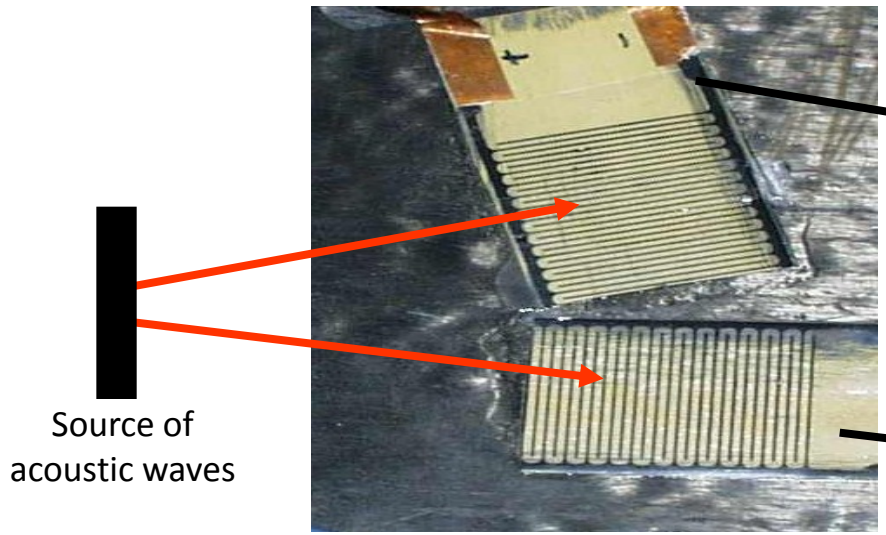


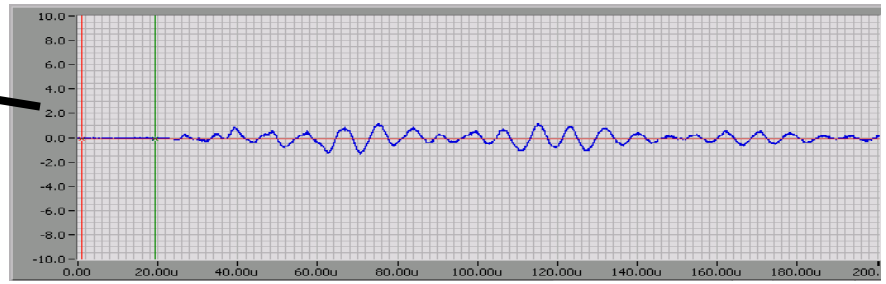
Image courtesy of Fraunhofer-ISC, Würzburg

HEALTH MONITORING

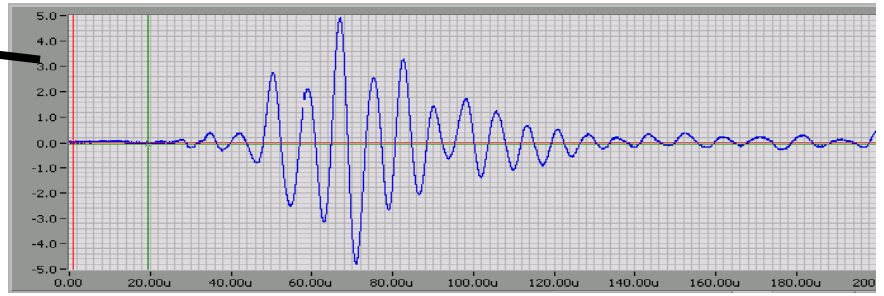
The sensors are sensitive to the orientation of the incoming wave ...



Parallel to fiber orientation: low sensitivity

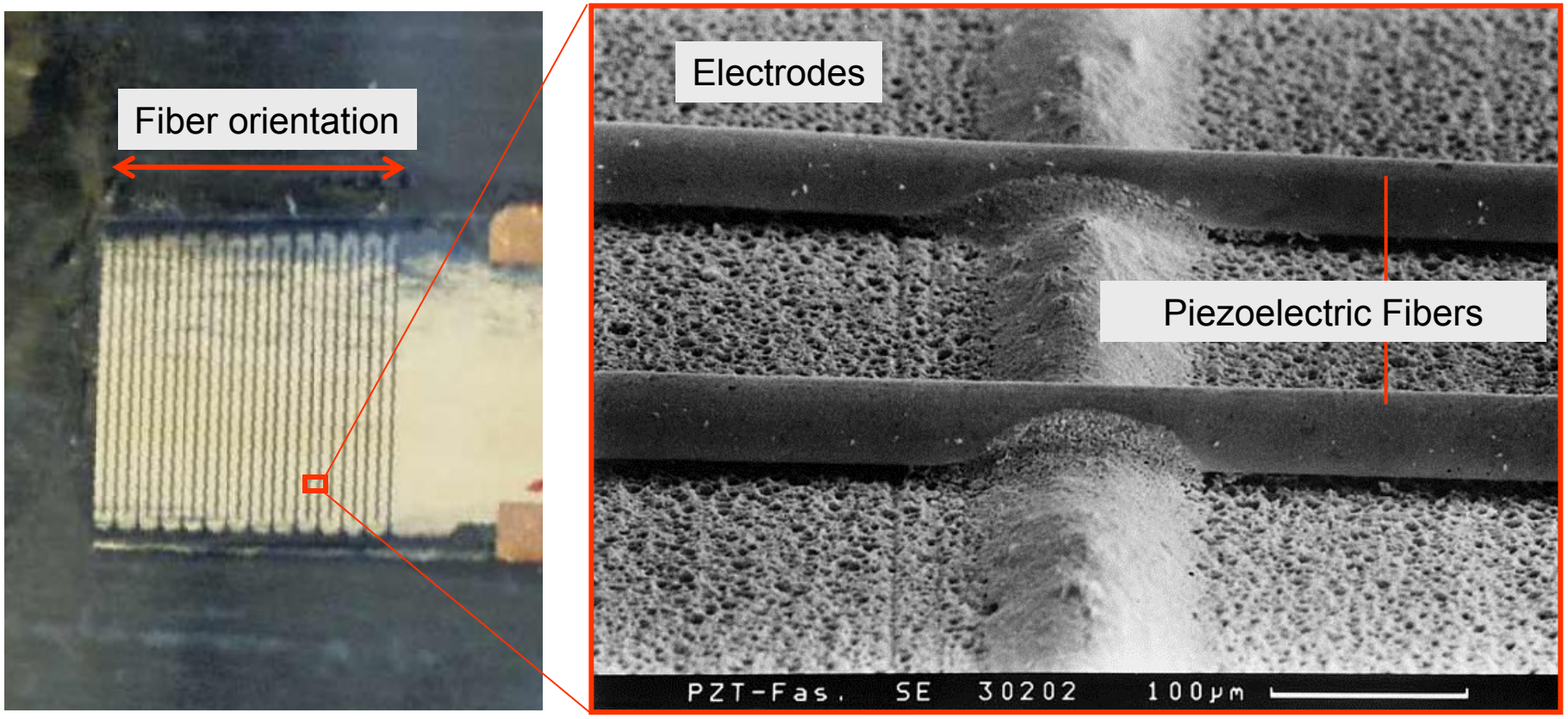


Perpendicular to fiber orientation: high sensitivity



... and thus, providing new opportunities for flaw detection

ULTRASONIC PIEZOFIBER SENSOR STRUCTURE



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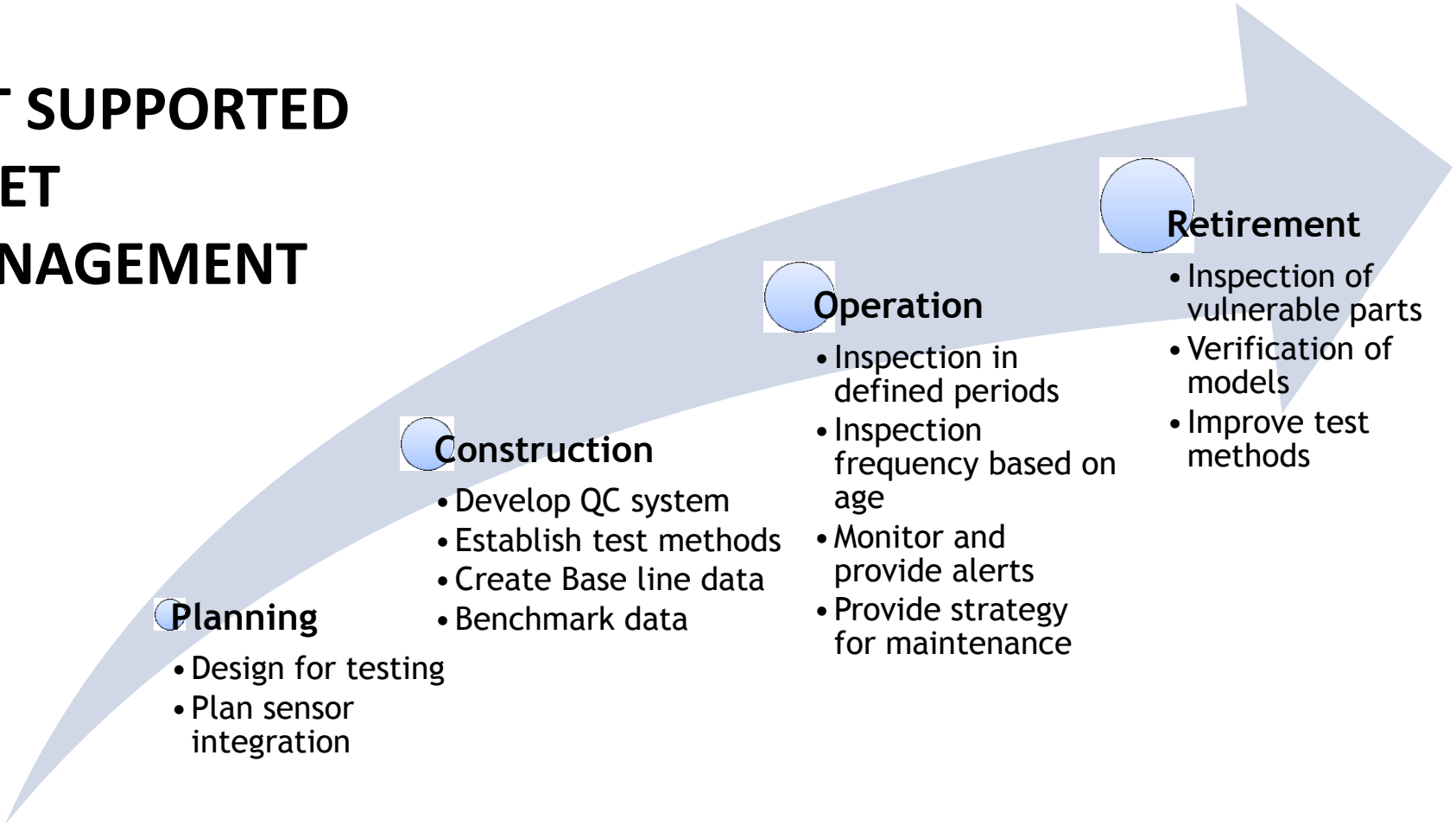
PRODUCTION INTEGRATED NDT

NDT in Asset Management

Integrated NDT Systems

NDT in life cycle management

NDT SUPPORTED ASSET MANAGEMENT



Integrated NDT Systems

NDT SUPPORTED ASSET MANAGEMENT

GAP

At present, NDT data is typically not part of any enterprise IT solutions

NDT SUPPORTED ASSET MANAGEMENT

- Typically offline activity
- Summary data is input into an enterprise system
- Significant productivity and cost improvements could be realized through integration with EAMs

NDT SUPPORTED ASSET MANAGEMENT

- Critical portion of Asset Management activity not captured
- Significant upside potential for first mover

EAM Software

Figure 1. Magic Quadrant for Power-Generating Company EAM Software, 2007

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NDT SUPPORTED ASSET MANAGEMENT

Market Size

- US $ 1.3 billion in 2007
- US $ 1.8 billion by 2012
- Utilities account for a significant portion

Thank you!

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Day 2:	Organization and Networks	Speaker
9.00	Welcome Address with Minutes of Last Day	NN
9.30	Recommended Laboratory Structure of Activities	Kröning
10.00	Human Resources – Ethics, Responsibilities, Education, Training and Certification	Klimenov
10.30	Coffee Break	
11.00	Methods I - ET, MT, PT, TT, VT	Vavilov
11.30	X-ray, Betatron	Klimenov
12.00	UT, µ-NDT, NDT Systems	Kröning
12.30	Open Round Discussion (Questions)	all
13.00	Lunch Break	
14.00	Applied Technologies and Capability Networks	Kröning
14.30	Knowledge Strategies and Education	Klimenov
15.00	Coffee Break	
15.30	Added Value Chain in Applied Science	Vavilov
16.00	R&D Driven by Demand – a Project Analysis	Kröning
16.30	Concluding Minutes	to be appointed
17.00	End of Second Day	

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Day 3:	CASE STUDIES & NEXT STEPS	Speaker
9.00	Welcome Address with Minutes of Last Day	NN
9.30	Case Studies: Betatron for NDT	Klimenov
10.00	Advanced UT and New Instruments	Kröning
10.30	Coffee Break	
11.00	Thermography for Surface Characterization	Vavilov
11.30	NDT System for In-line NDT	Kröning
12.00	International Cooperation Practice	Klimenov
12.30	Open Round Discussion (Questions)	all
		NN
13.00	Lunch Break	
14.00	Next Steps and Seminar Evaluation	
16.00	End of Third Day	