

# Development of Novel Tomography Technique for Ultrasonic Examination of Weld Joints

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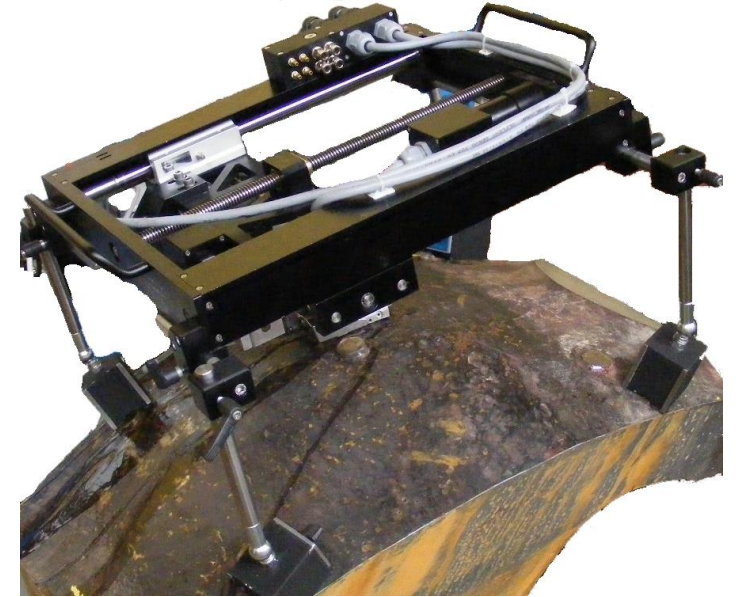
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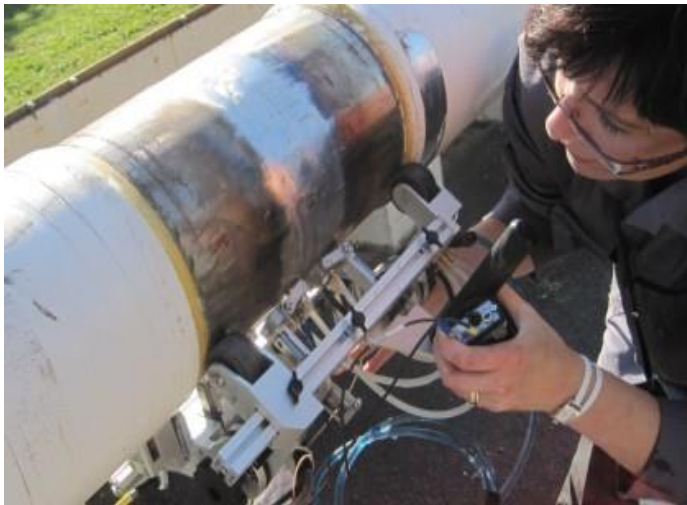
## Introduction

- Ultrasonic non-destructive evaluation and condition monitoring of industrial facilities is the most widely used testing technique.
  - The newest trend of the ultrasonic non-destructive evaluation is 2D and 3D imaging of the inspection volume by means of tomographic reconstruction techniques with quantitative inspection results.
  - The biggest practical handicap of the ultrasonic flaw detection is the irregular / complex shape of the inspection objects due to hindered coupling of ultrasound into the component.
  - “Profiling” and taking into account geometry of the inspection object while ultrasonic testing is a challenging task with significant application potential.
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## Introduction

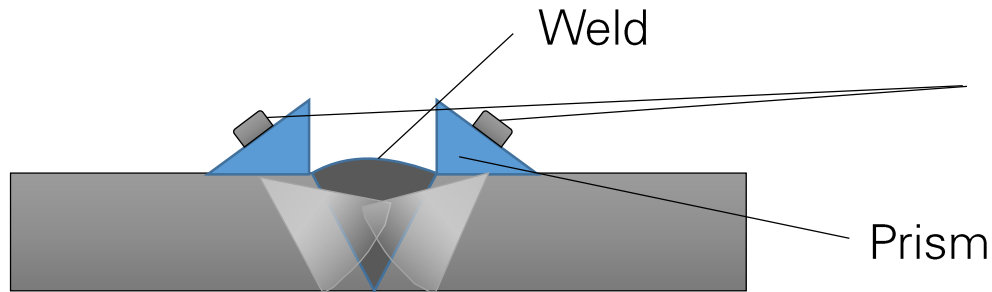


Examples of objects for  
Non Destructive Testing

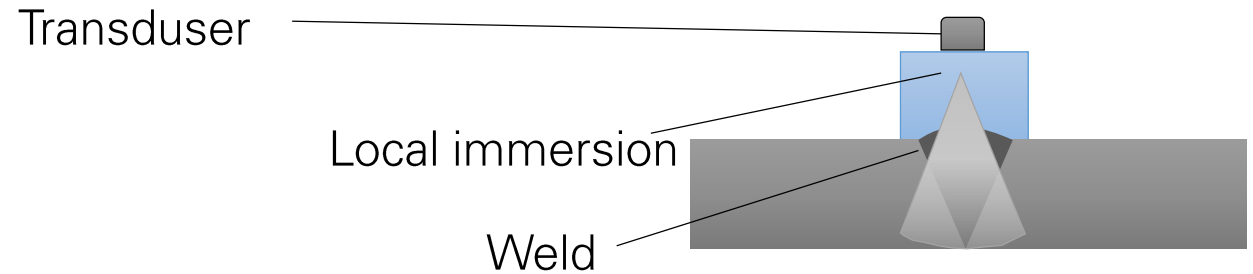


## Task definition: ultrasonic weld testing through the weldcap

Traditional approach:



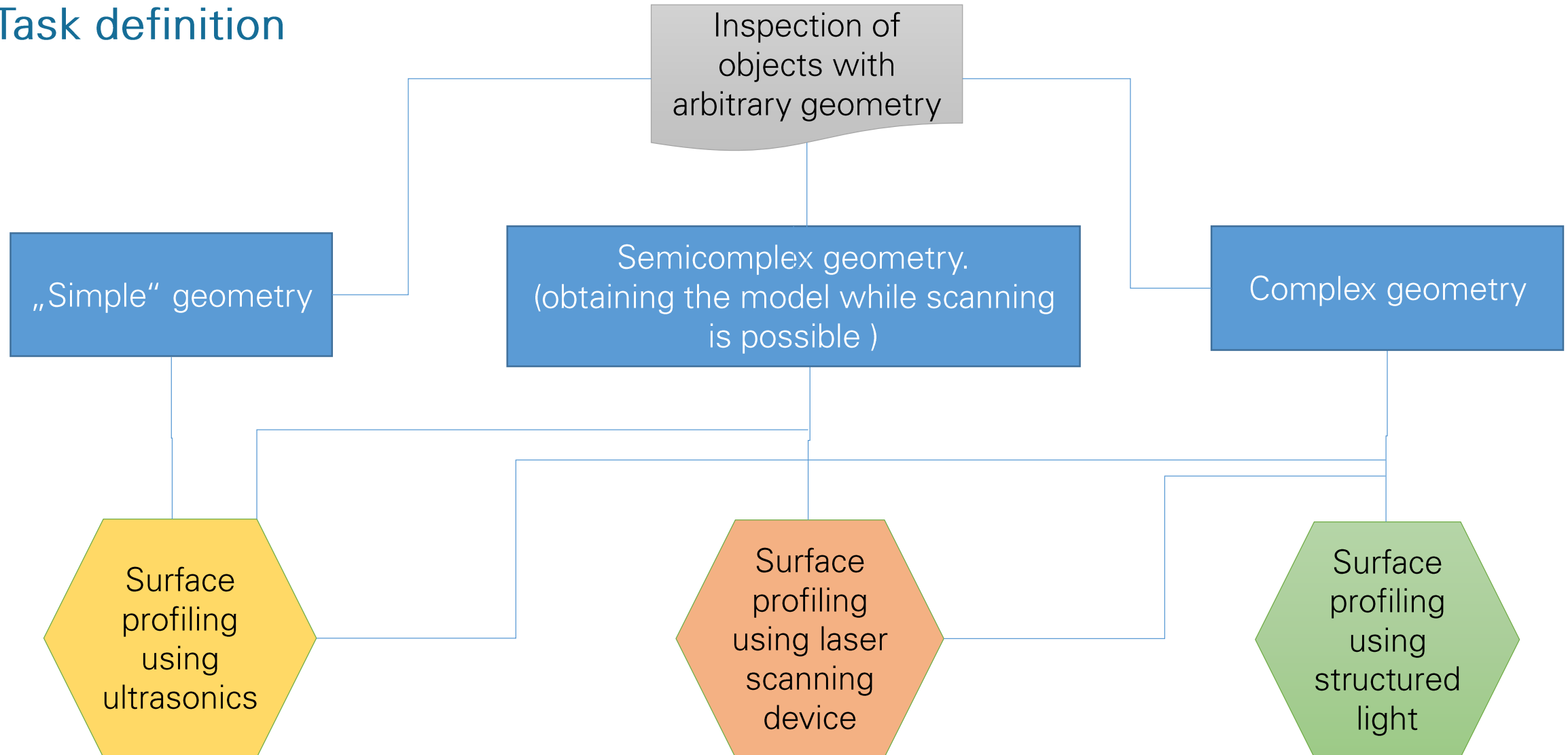
Novel approach:



Three following tasks must be solved for correct spatial representation of the material flaws due testing of the weld seam through the cap while scanning along the weld:

- Accurate capturing weldcap profile by means of optical or ultrasonic measurement
- Simulation of “forth and back” sound propagation through the irregular weld surface by means of ray-tracing technique
- Implementation of tomographic volume reconstruction algorithms on the base of graphic processor units for real-time representation of inspection results by means of dedicated inspection system for industrial pipeline condition monitoring

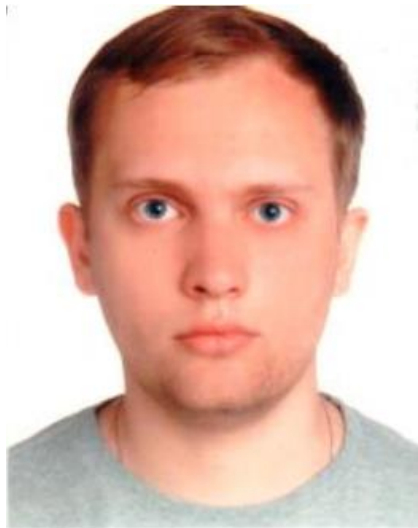
## Task definition



## Collaboration with researchers from IPPT in scope of SMARTNEST project

Surface  
profiling  
using  
ultrasonics

Work done by Alexandr Lozak



Surface  
profiling using  
laser scanning

Work done by Grzegorz Mikulowski.



Surface  
profiling using  
structured  
light

Work done by Piotr Pawlowski

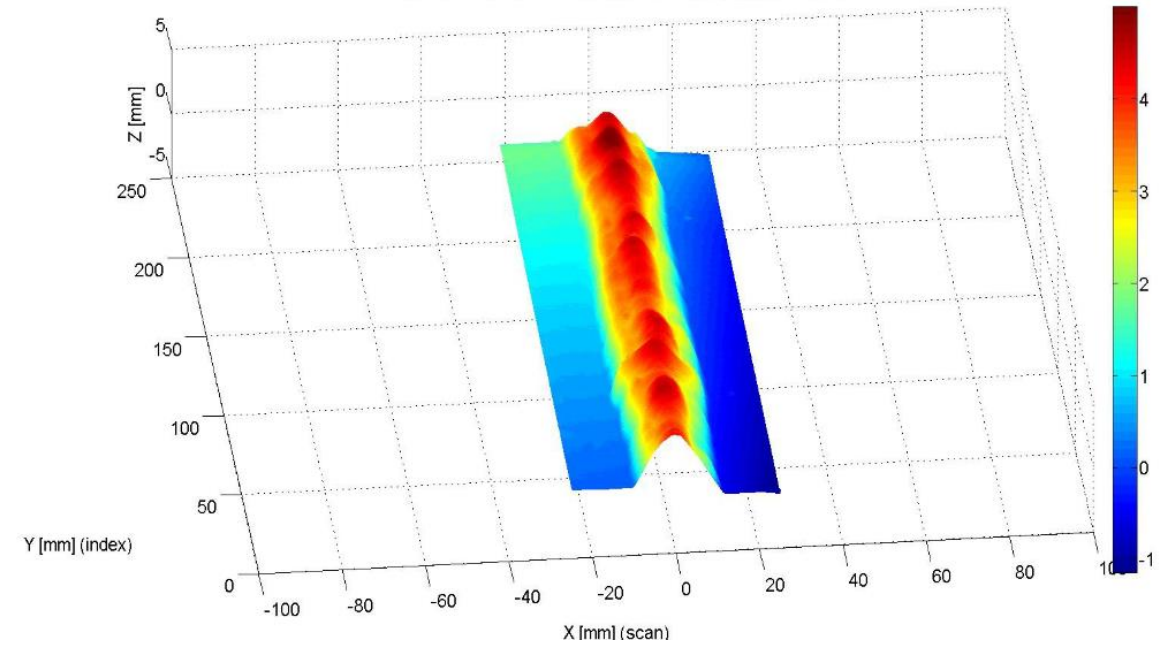
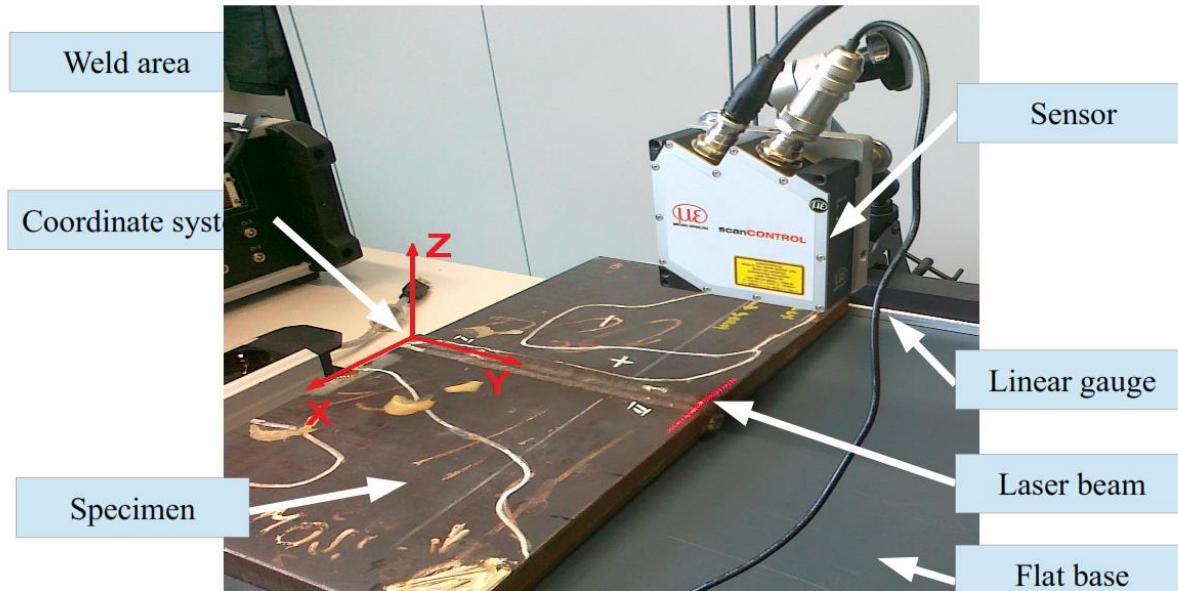




## Collaboration with researchers from IPPT in scope of SMARTNEST project

Surface  
profiling using  
laser scanning  
device

Accurate reinforcing bead profile capturing by means of optical measurement.

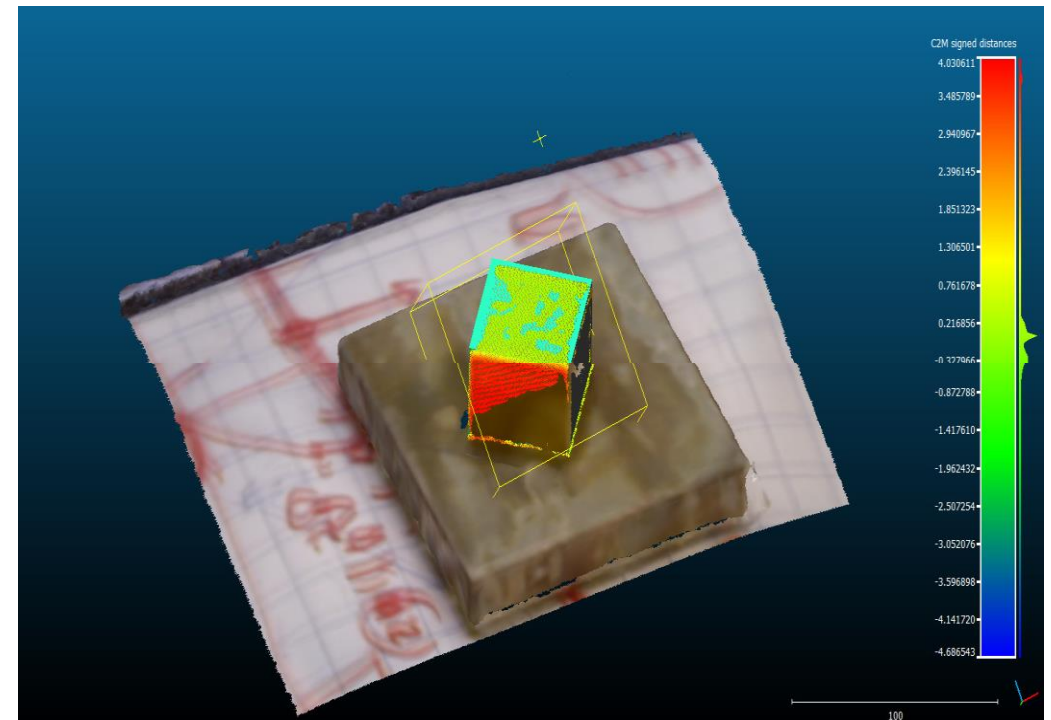
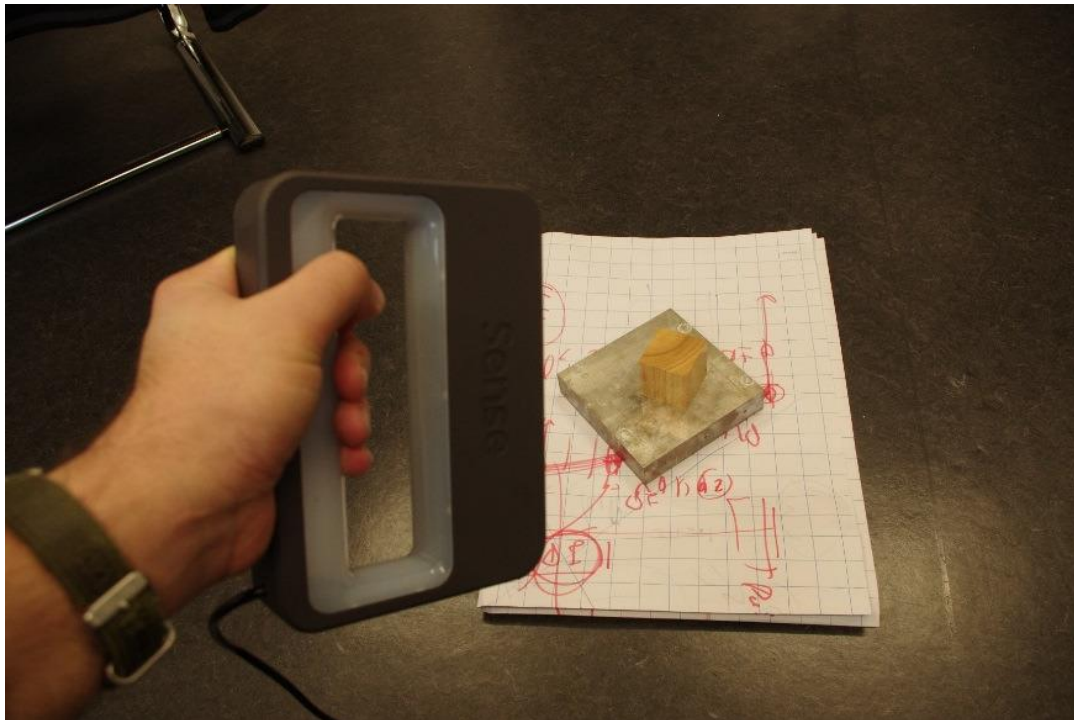




## Collaboration with researchers from IPPT in scope of SMARTNEST project

Surface  
profiling using  
structured  
light

Obtaining 3D model of objects using structured light.



## Profiling of object surface by means of ultrasound

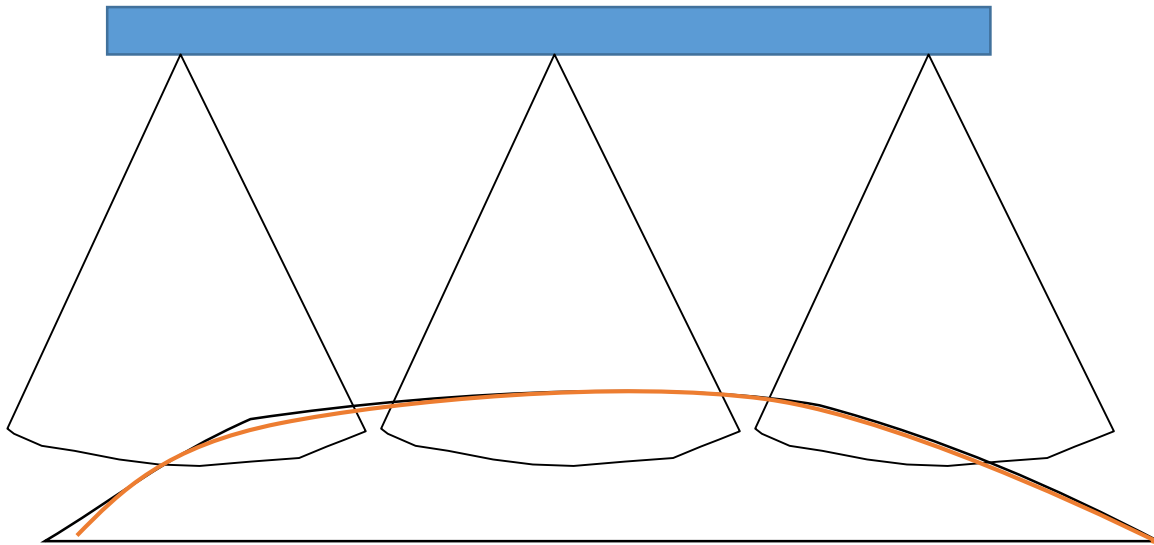
Surface  
profiling  
using  
ultrasonics

Algorithm of surface profiling:

- 1) Parametrization of search sector
  - 2) Calculation of Compound B Scan in water
  - 3) Application of averaging polynom
  - 4) Searching "best normal" incident angle considering sector scan
  - 5) Calculation of Look Up Table (LUT) and reconstruction
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## Profiling of object surface by means of ultrasound

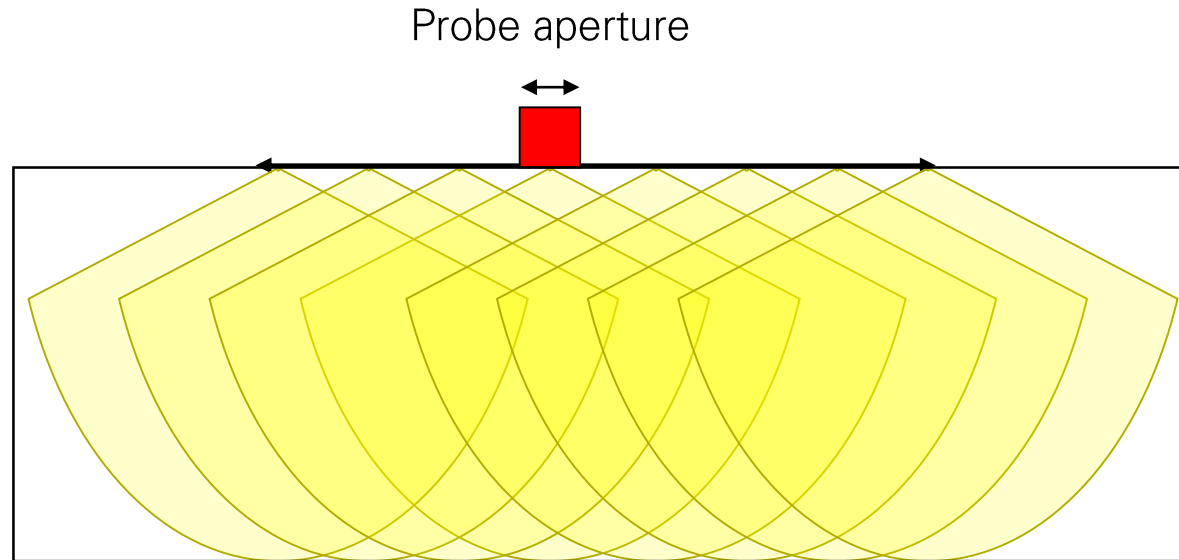
### 1) Parametrization of "search" sector



Surface gate			
Start	11,00	<input type="button" value="↑"/>	<input type="button" value="↓"/>
Length	6,00	<input type="button" value="↑"/>	<input type="button" value="↓"/>
Material gate			
Start	10,00	<input type="button" value="↑"/>	<input type="button" value="↓"/>
Length	25,00	<input type="button" value="↑"/>	<input type="button" value="↓"/>
Surface search			
Threshold (%)	95,00	<input type="button" value="↑"/>	<input type="button" value="↓"/>
Algorithm			
	In B-Scan (Zero A-Scan)	In A- Scans (Best A-Scan)	
Front	<input checked="" type="radio"/>	<input type="radio"/>	
Maximum	<input type="radio"/>	<input type="radio"/>	

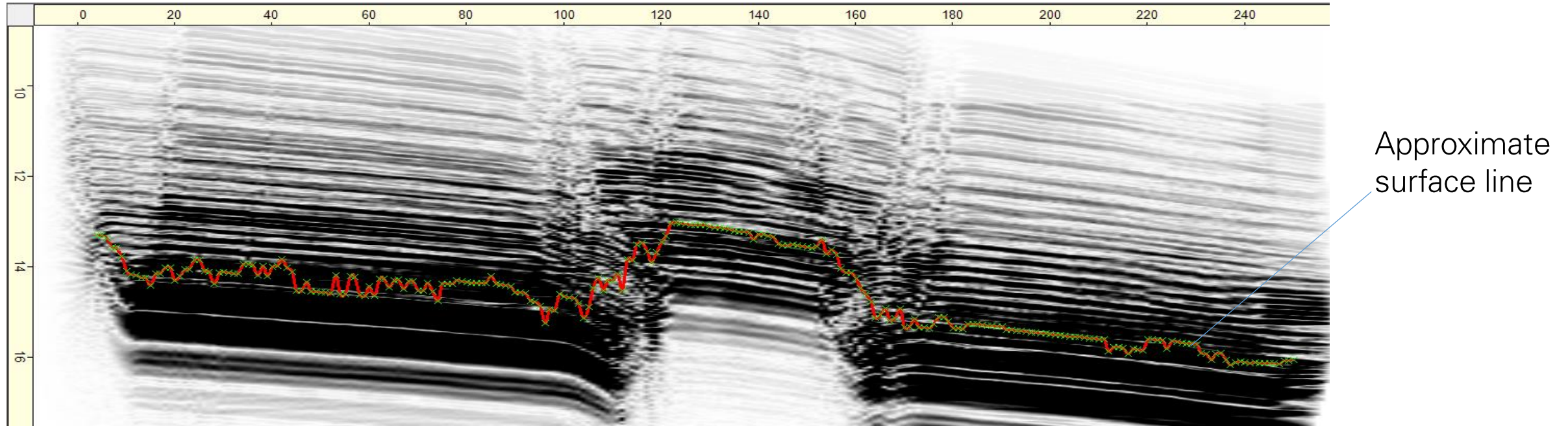
## Profiling of object surface by means of ultrasound

Compound B scan definition



## Profiling of object surface by means of ultrasound

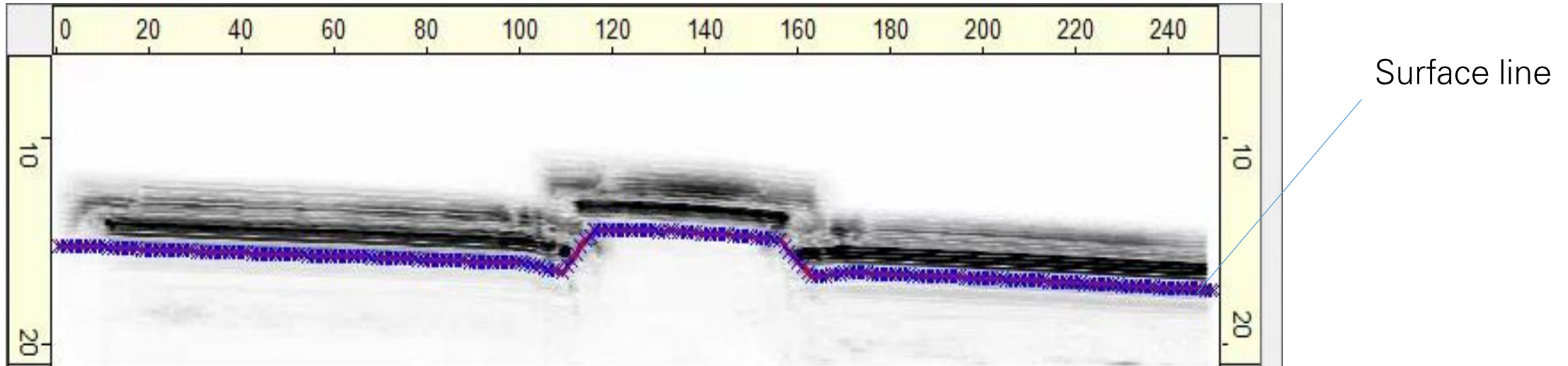
### 2) Calculation of Compound B Scan in water



Example of non processed surface.

## Profiling of object surface by means of ultrasound

### 3) Application of averaging polynom

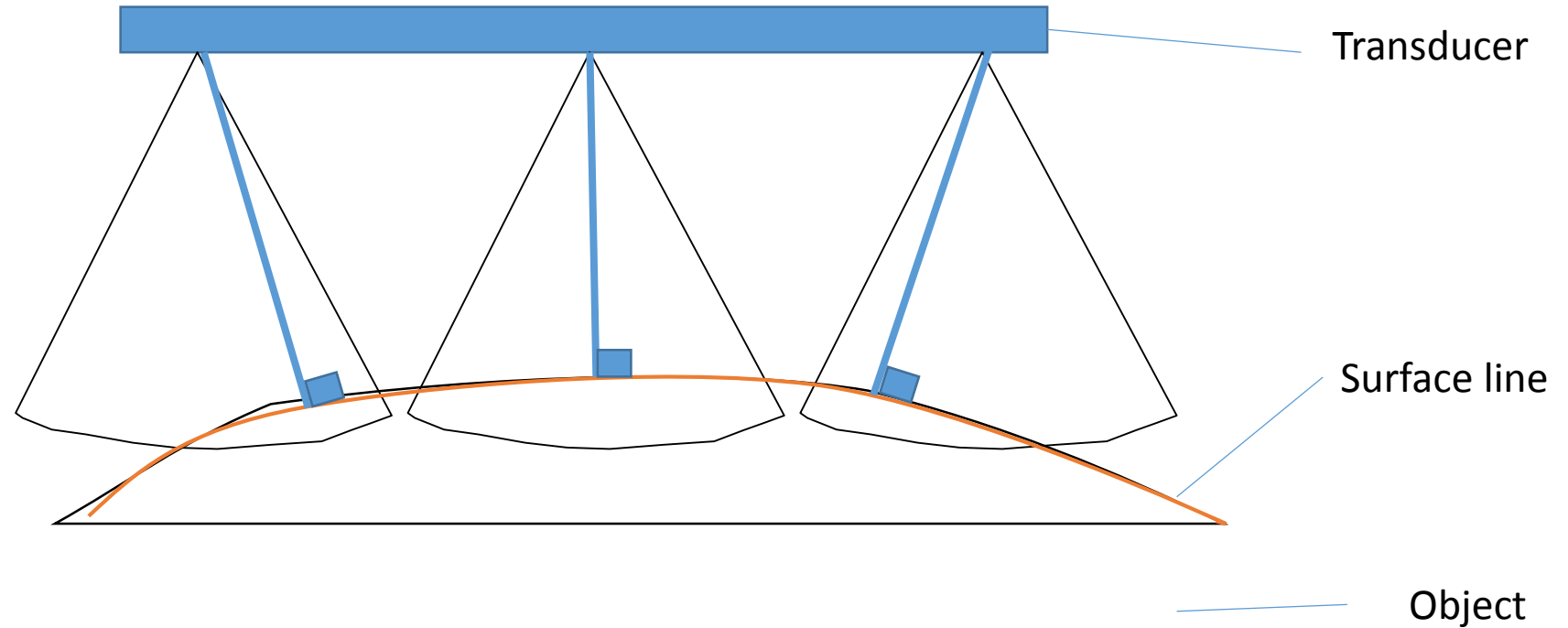


Example of processed surface using averaging polynome.



## Profiling of object surface by means of ultrasound

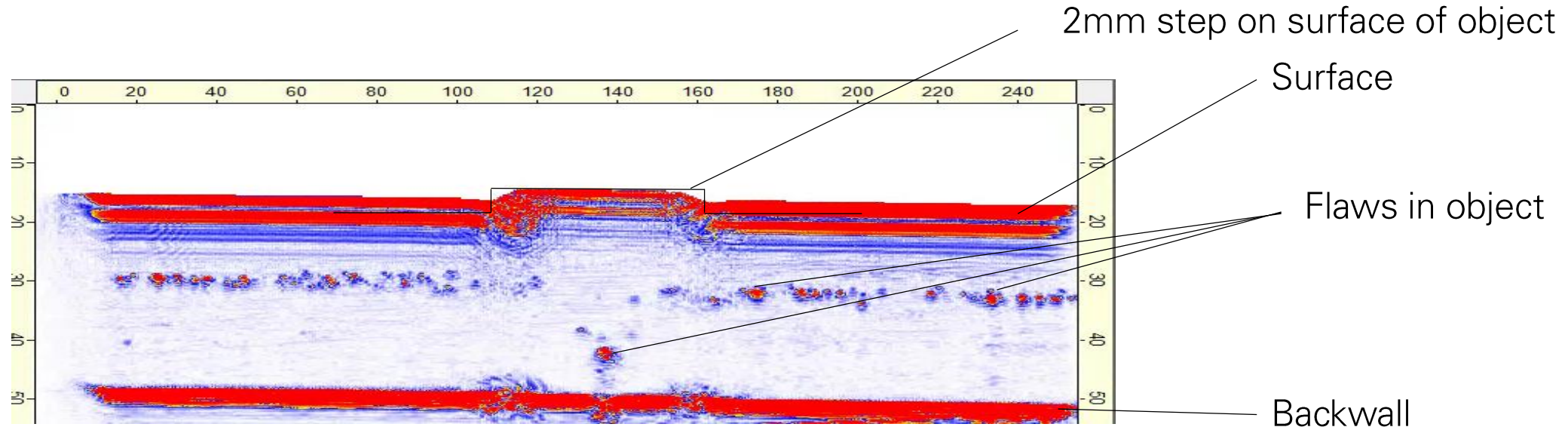
4) Searching “best normal” incident angle considering sector scan



Selection of optimal angle for further reconstruction of material.

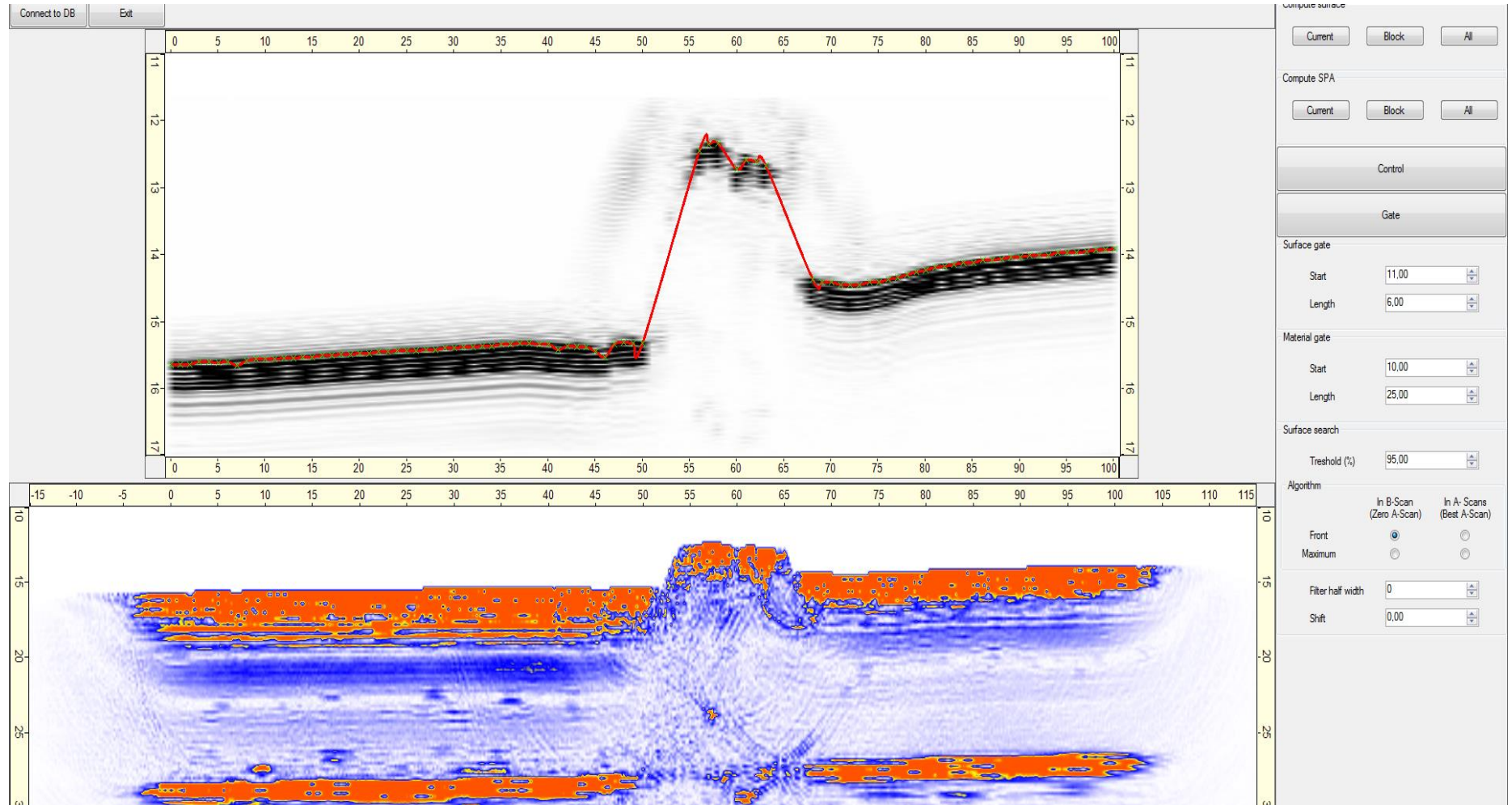
## Profiling of object surface by means of ultrasound

### 5) Calculation of Look Up Table (LUT) and reconstruction



Result of material reconstruction with defined and processed surface..

# CAP Wizard



For evaluating and practical application of the developed image reconstruction algorithms a software package „CAP Wizard“ has been developed.

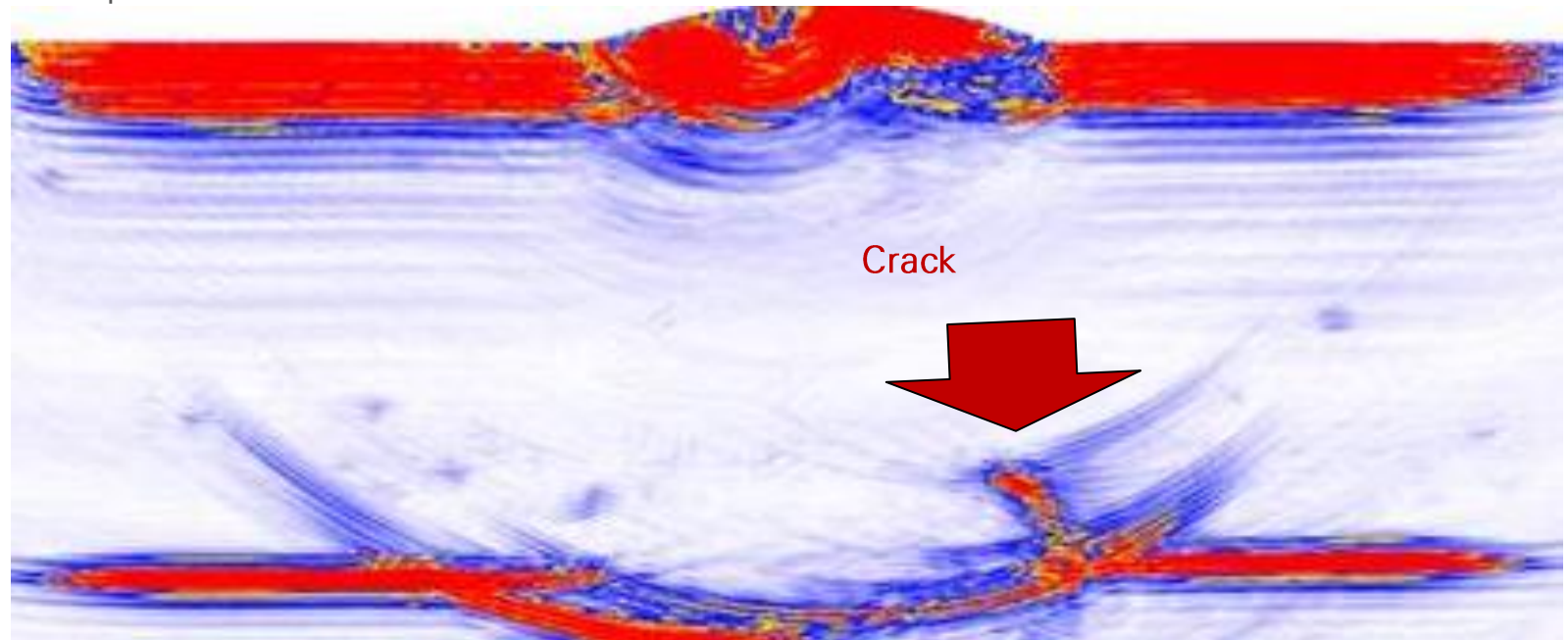
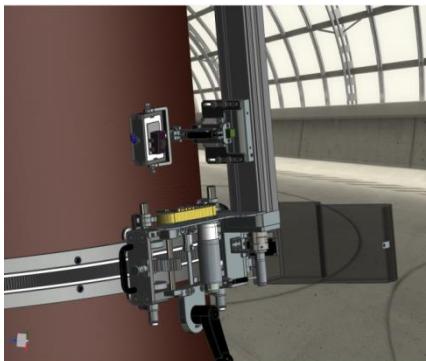
## Potential applications

- Ultrasonic testing of weld seams in power plants, gas and oil pipelines, chemical and petrochemical industry
  - Ultrasonic testing of aircraft and wind craft components made of fiber composites
  - Ultrasonic testing of casting and forging components with irregular surface
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## Potential applications & customers



- Branch: Oil and gas
- Potential customer: Chevron Corporation
- Task: automated inspection of weld joints through the cap
- Customer Profit: Innovative inspection technique and time saving inspection machine

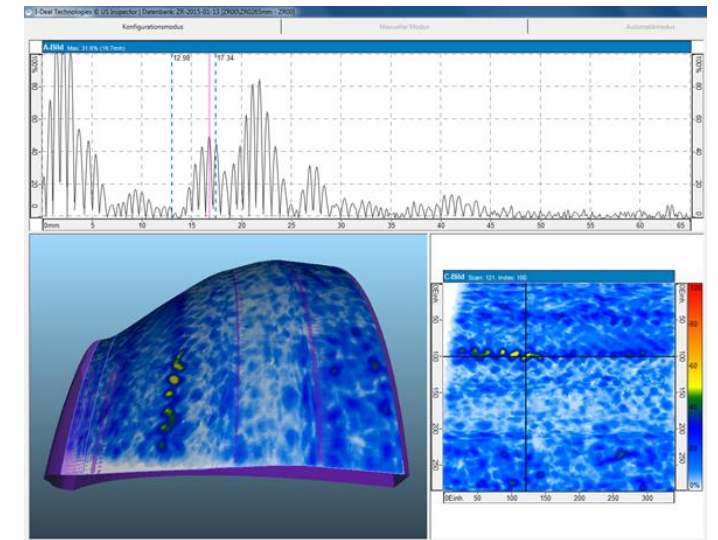
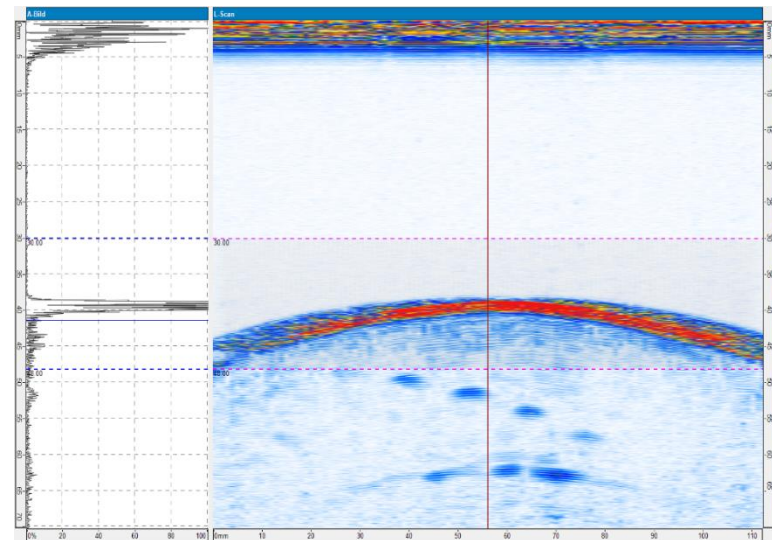




## Potential applications & customers



- Branch: aerospace industry
- Potential customer: MT Aerospace
- Task: automated inspection of CFRP components
- Customer Profit: 3D representation and evaluation of inspection results





## Conclusion

- A novel ultrasonic inspection technique has been developed in scope of SMARTNEST project by involving partners from participating institutions.
  - The developed technological solutions have a multidisciplinary character in ultrasonic and optical measurement techniques, signal processing, image reconstruction and efficient computing.
  - The technology will be disposed in a number of industrial applications. The implemented hardware and software solutions will be integrated in inspection systems for practical use.
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