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RECONFIGURABLE PROCESSING PLATFORMS FOR REAL-TIME NON-CONTACT RAIL INSPECTION USING EMATS

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Workshop on Knowledge Exchange of RCM on Railway

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SUMMARY

- Electromagnetic Acoustic Transducers (EMATs)
- Field Programmable Gate Array (FPGA)
- Integration Testing: 3 phases
  - Sensing in a simulated environment
  - Sensing in a lab environment
  - Sensing in a field environment: the RiFlex project
- Future Work Plan

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ELECTROMAGNETIC ACOUSTIC TRANSDUCERS (EMATS)

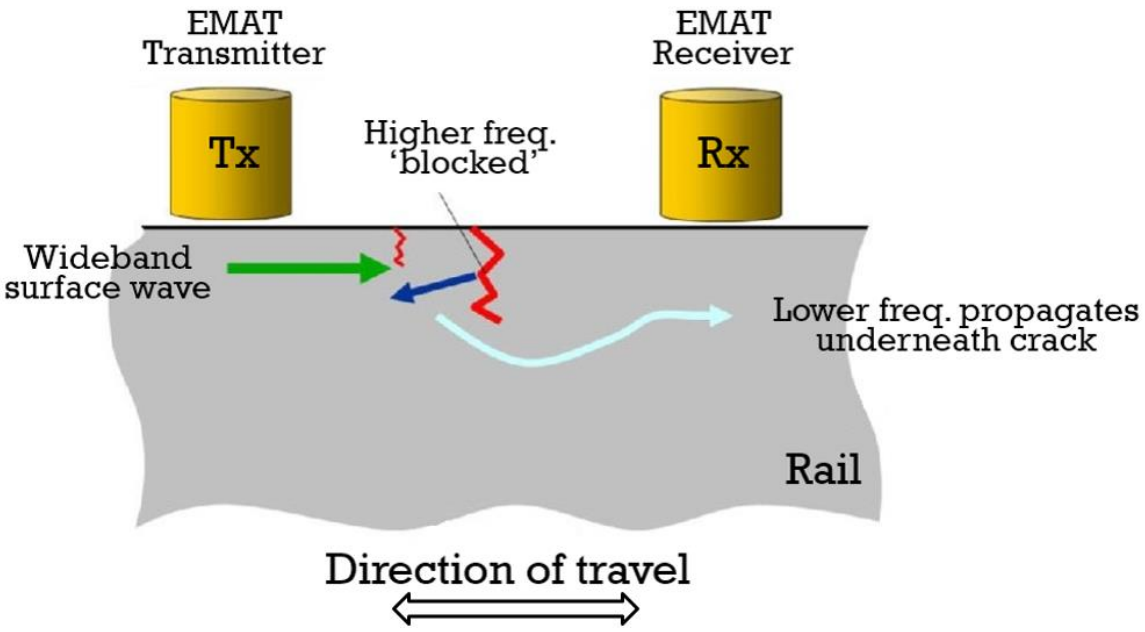

Photo of Rayleigh wave EMATs used in this project designed by TWI

Picture modified from: Introduction of Rail Inspection
http://www2.warwick.ac.uk/fac/sci/physics/research/ultra/research/rail_inspection/

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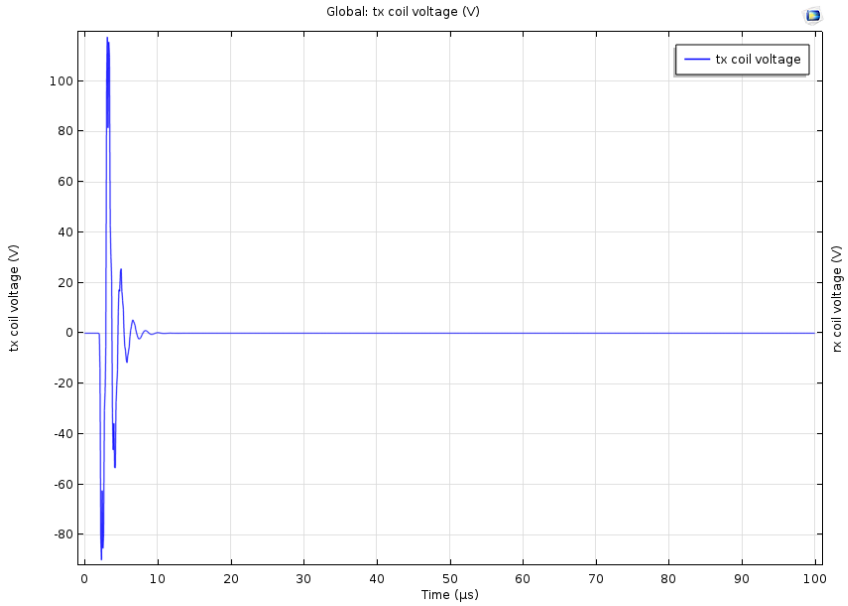
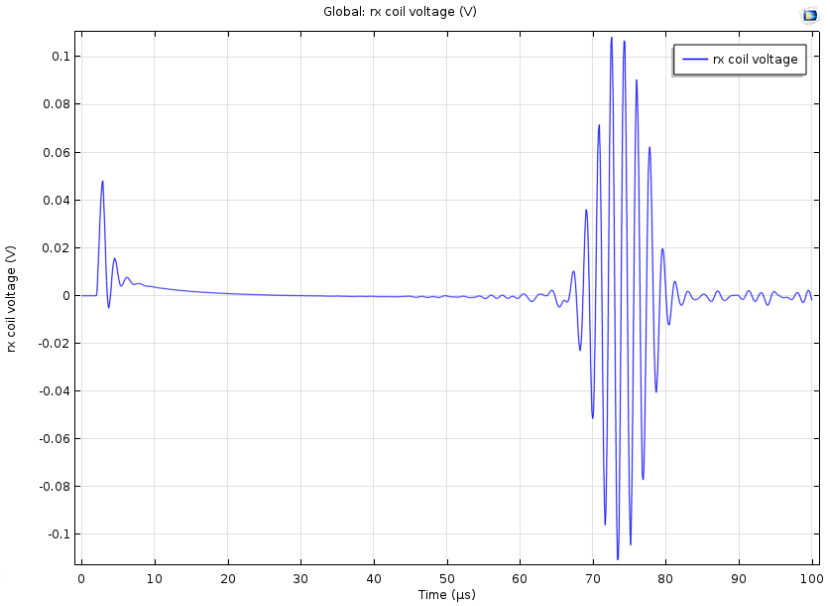
SIMULATION RESULTS (TIME DEPENDENT ANALYSIS)

Tx Coil Voltage



Rx Coil Voltage



- A boundary layer mesh was used to resolve the skin depth near the surface of the conductor ($\delta \approx 20\ \mu m\ @\ f = 625\ kHz, \mu_r = 200, \sigma = 5\text{x}10^6\ \frac{S}{m}$)
- Fine mesh (max = 4 mm) within the conductor was used to ensure the wavelength is properly resolved (speed of sound $\approx 5134\ \frac{m}{s}$)
- Only the magnetostriction forces are assumed to contribute to the body force

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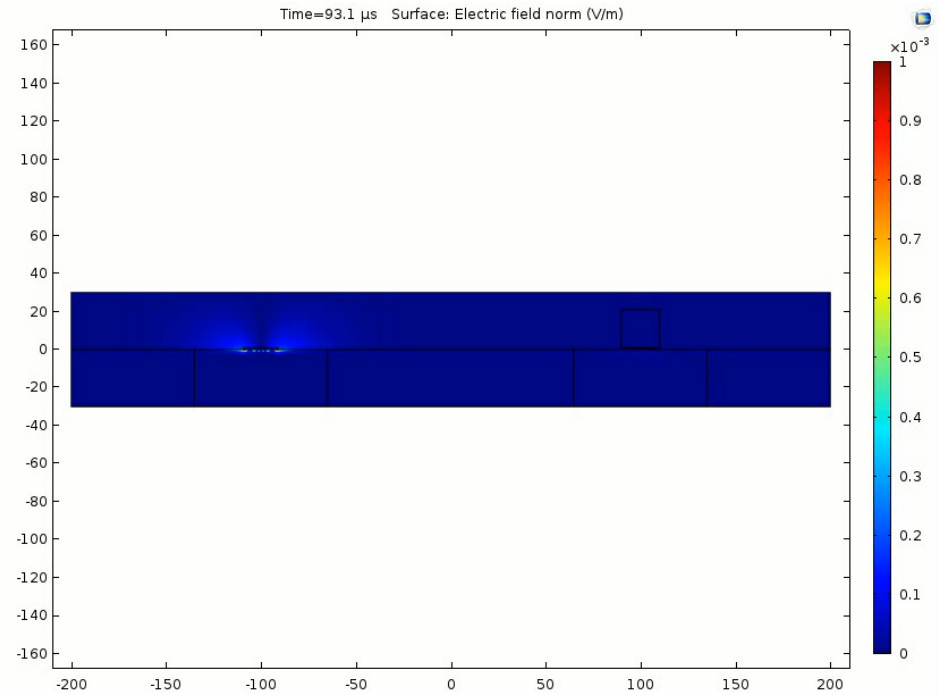
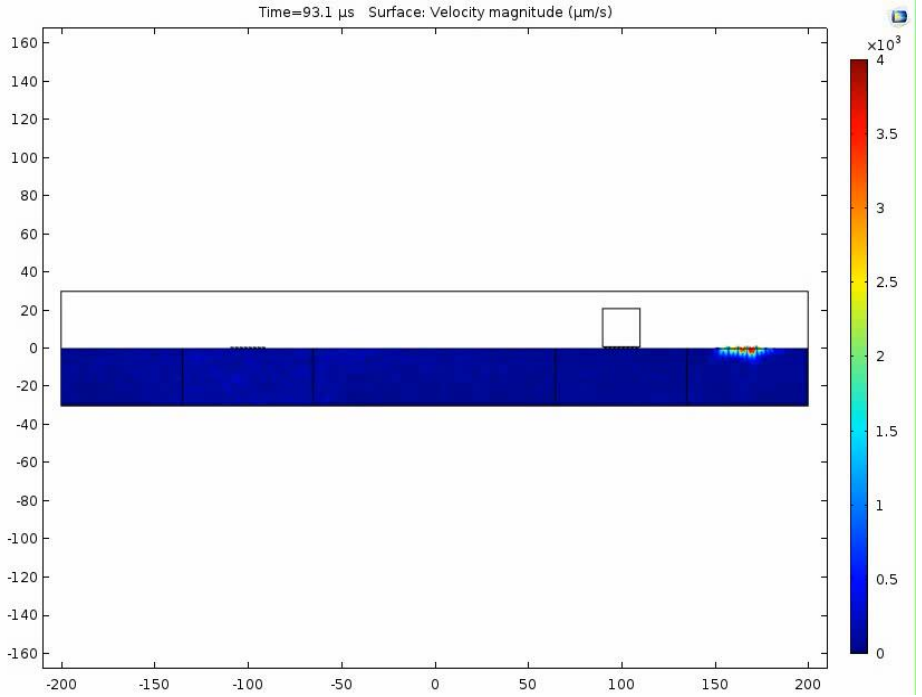
ELECTROMAGNETIC ACOUSTIC TRANSDUCERS (EMATS)

Electric Field



Rayleigh Wave Velocity



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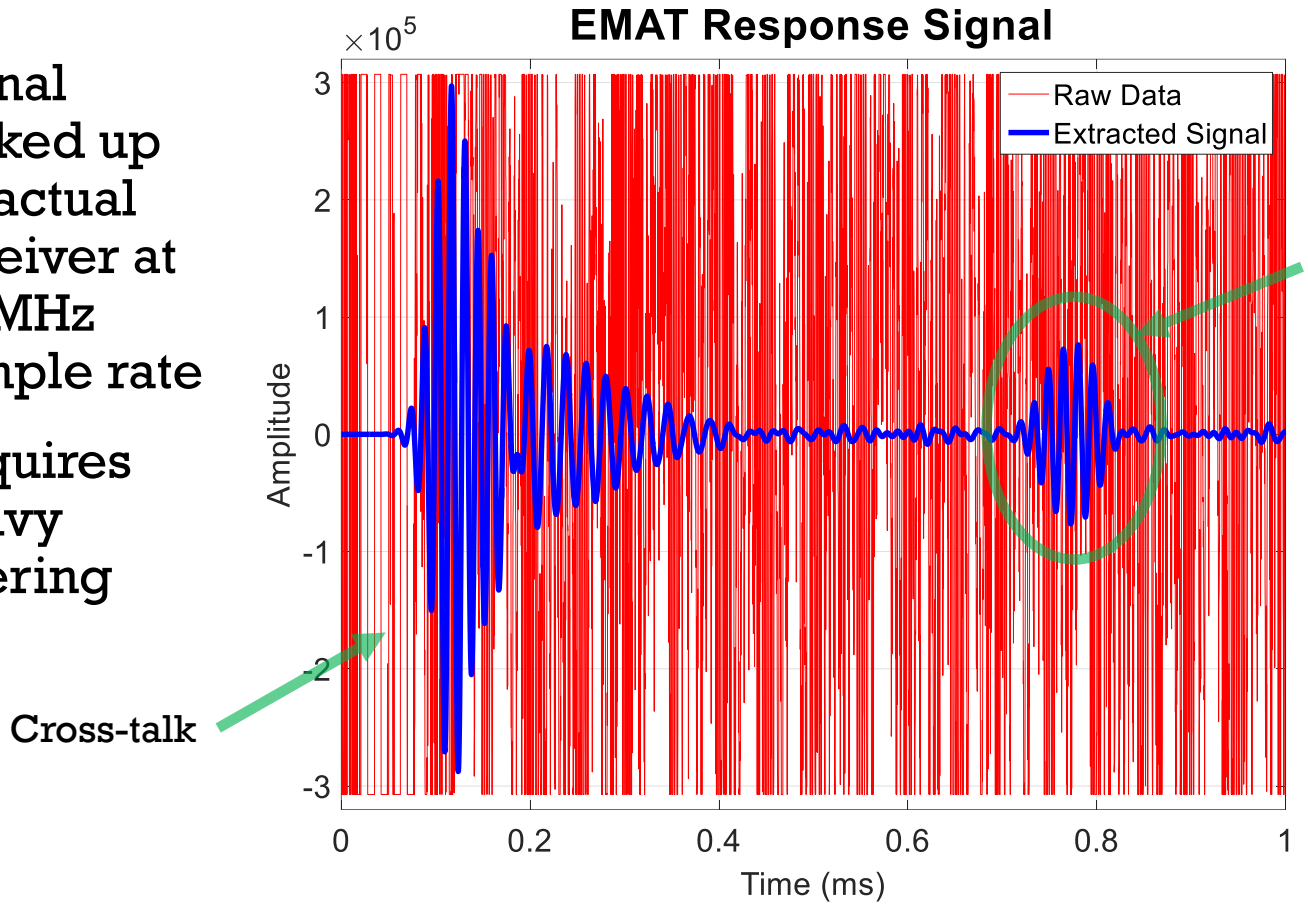
ELECTROMAGNETIC ACOUSTIC TRANSDUCERS (EMATS)

- Signal picked up by actual receiver at 50 MHz sample rate
- Requires heavy filtering



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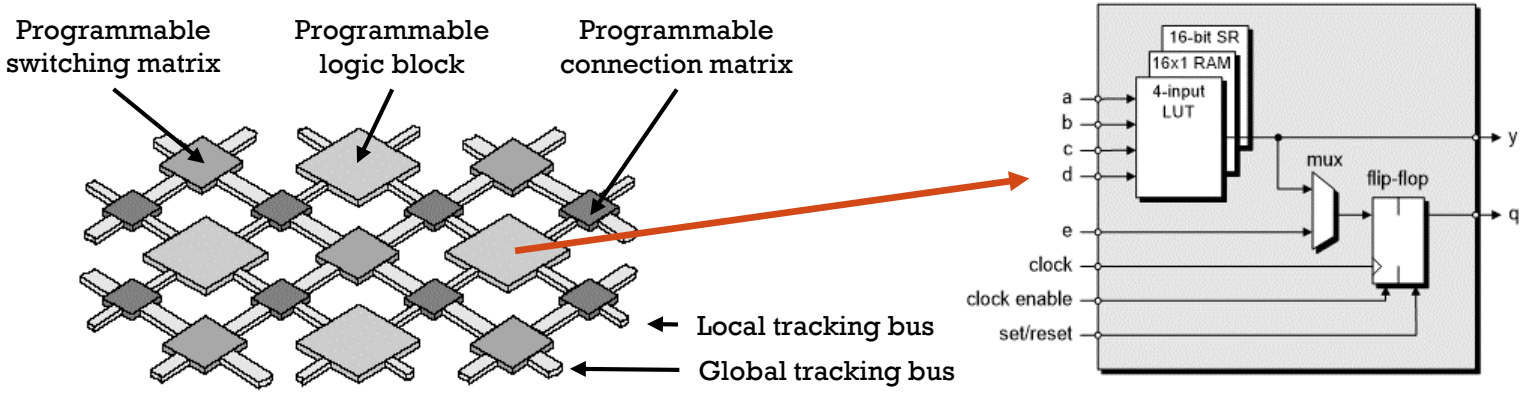
FIELD PROGRAMMABLE GATE ARRAY (FPGA)

- Field Programmable Gate Array (FPGA)
- Reconfigurable logic gates
- Good flexibility: suitable for parallel processing of multiple signals with wide bandwidth



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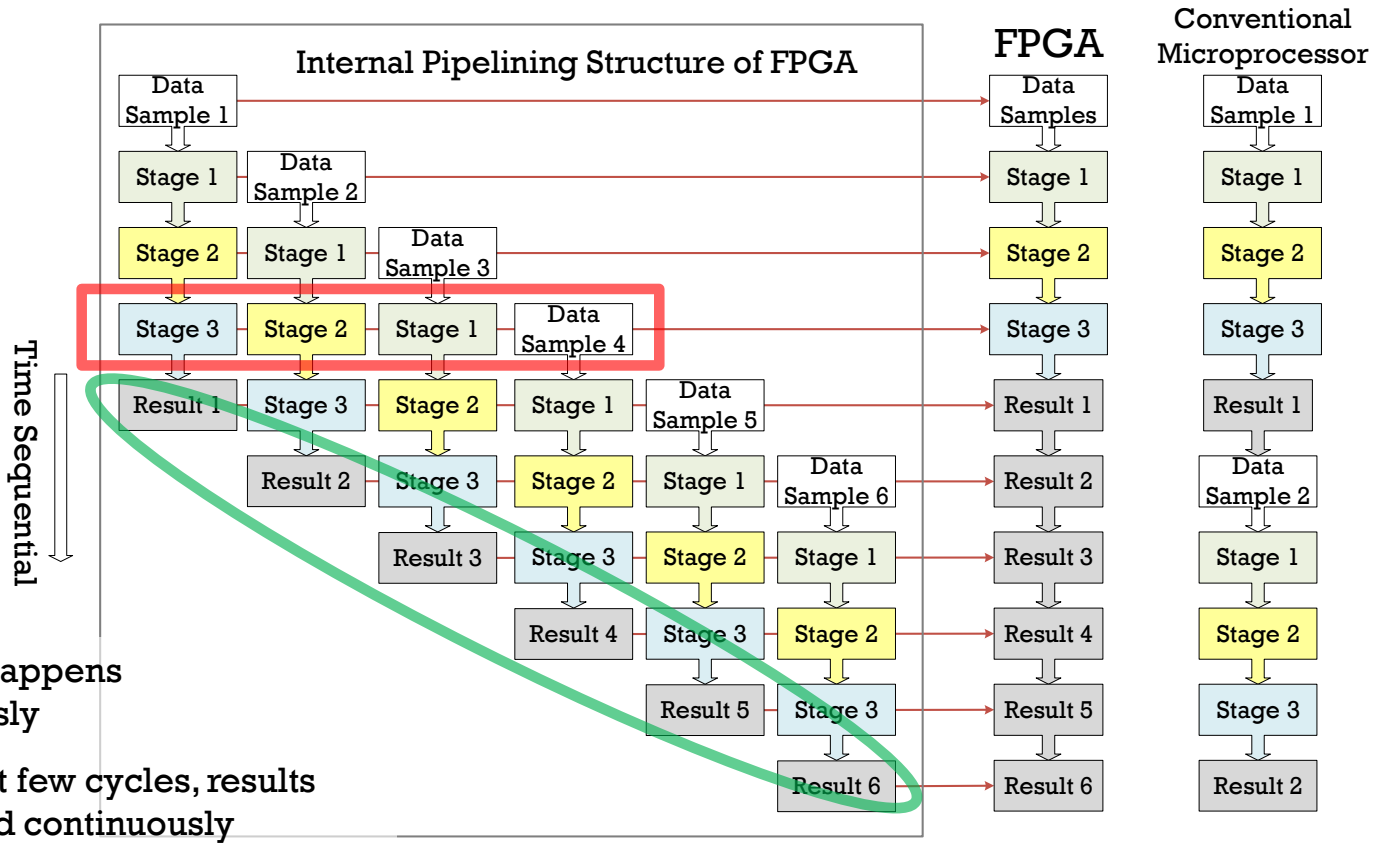
PROCESSING PIPELINING STRUCTURE



Each stage happens simultaneously

After the first few cycles, results are produced continuously

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PROCESSING CAPACITY

- Digilent Genesys Virtex-5 FPGA Development Board
- Supports real-time processing of sample rate up to 200MHz

Home / By Product Status / Active / Genesys Virtex-5 FPGA Development Board (LIMITED TIME) >> See Genesys2

Digilent FPGA

Genesys Virtex-5 FPGA Development Board (LIMITED TIME) >> See Genesys2

$899.00

SKU:
410-138

Quantity:
1

ADD TO CART

WISHLIST

Share

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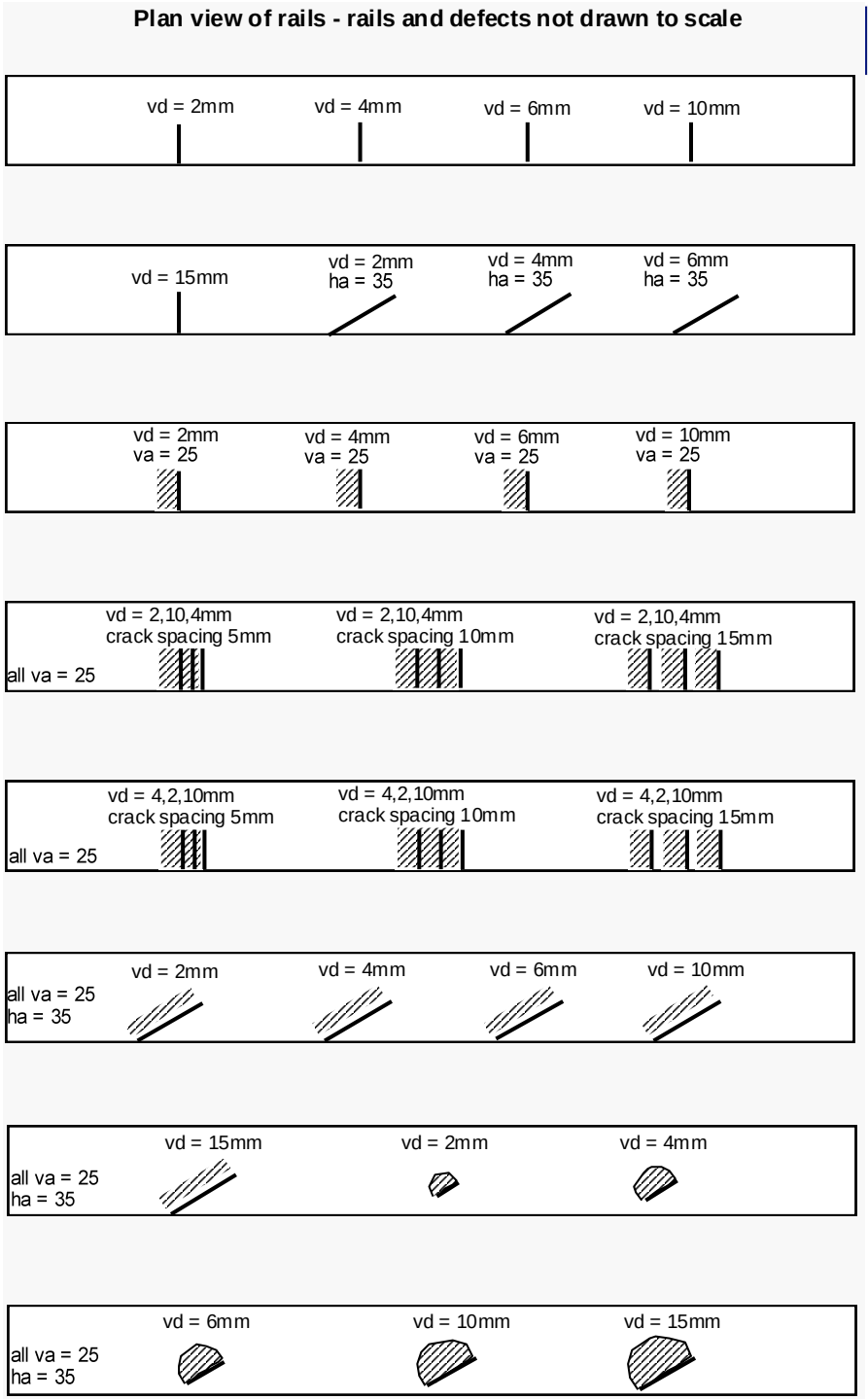
LAB ENVIRONMENT

- Spinning rail facility
- ~4m diameter
- Up to 80 km/h in both directions (2 revs/sec)
- Running rail + defects
- Transducer mounting system

LAB ENVIRONMENT

- Calibrated Defects



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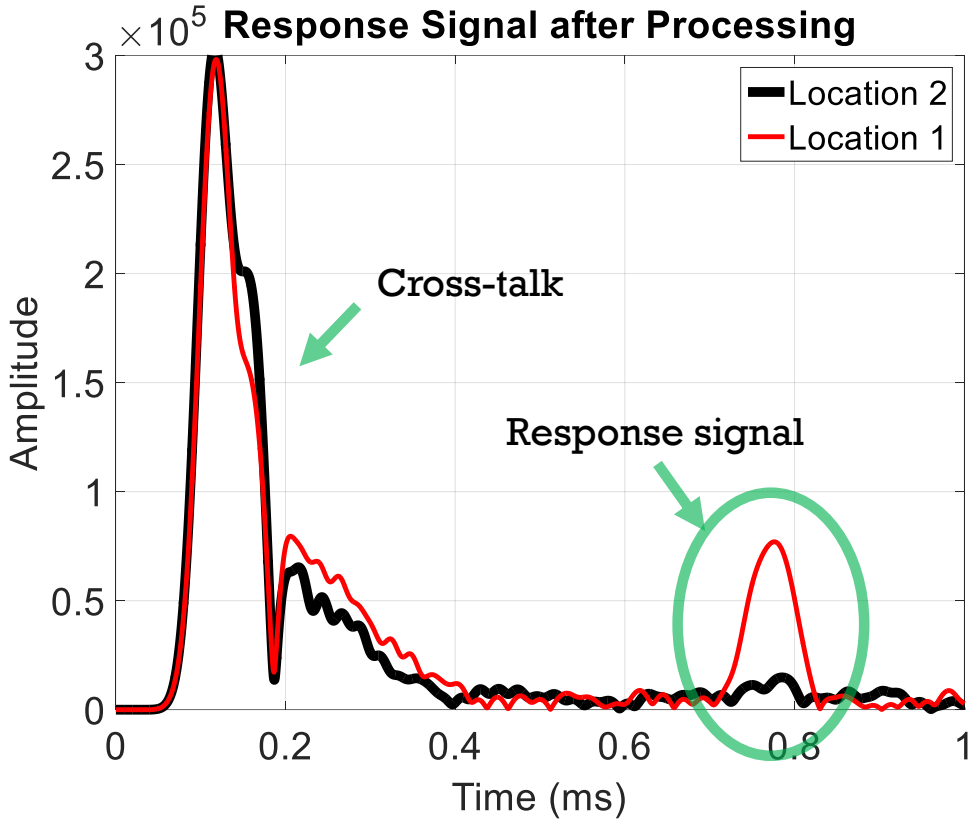
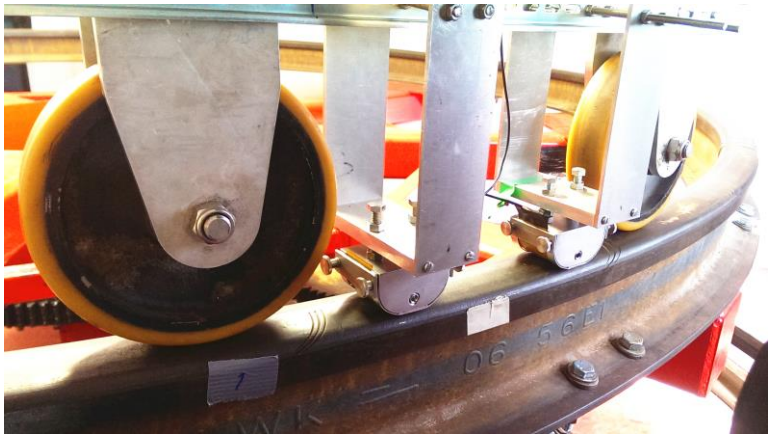
LAB TEST RESULTS



Location 1



Location 2

Defect

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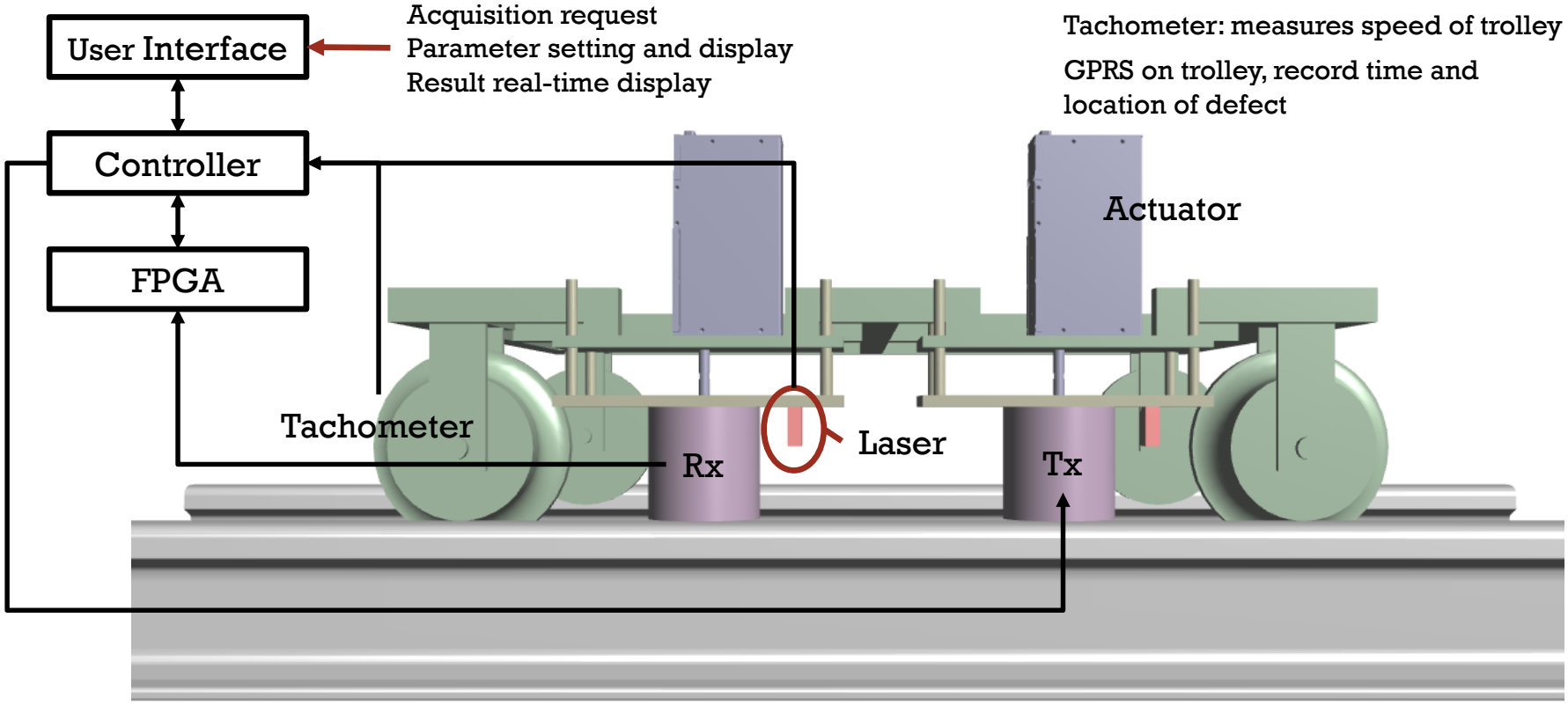
IMOSS RIFLEX TROLLEY

Laser + actuator: maintains distance between transducers and the rail

Tachometer: measures speed of trolley

GPRS on trolley, record time and location of defect



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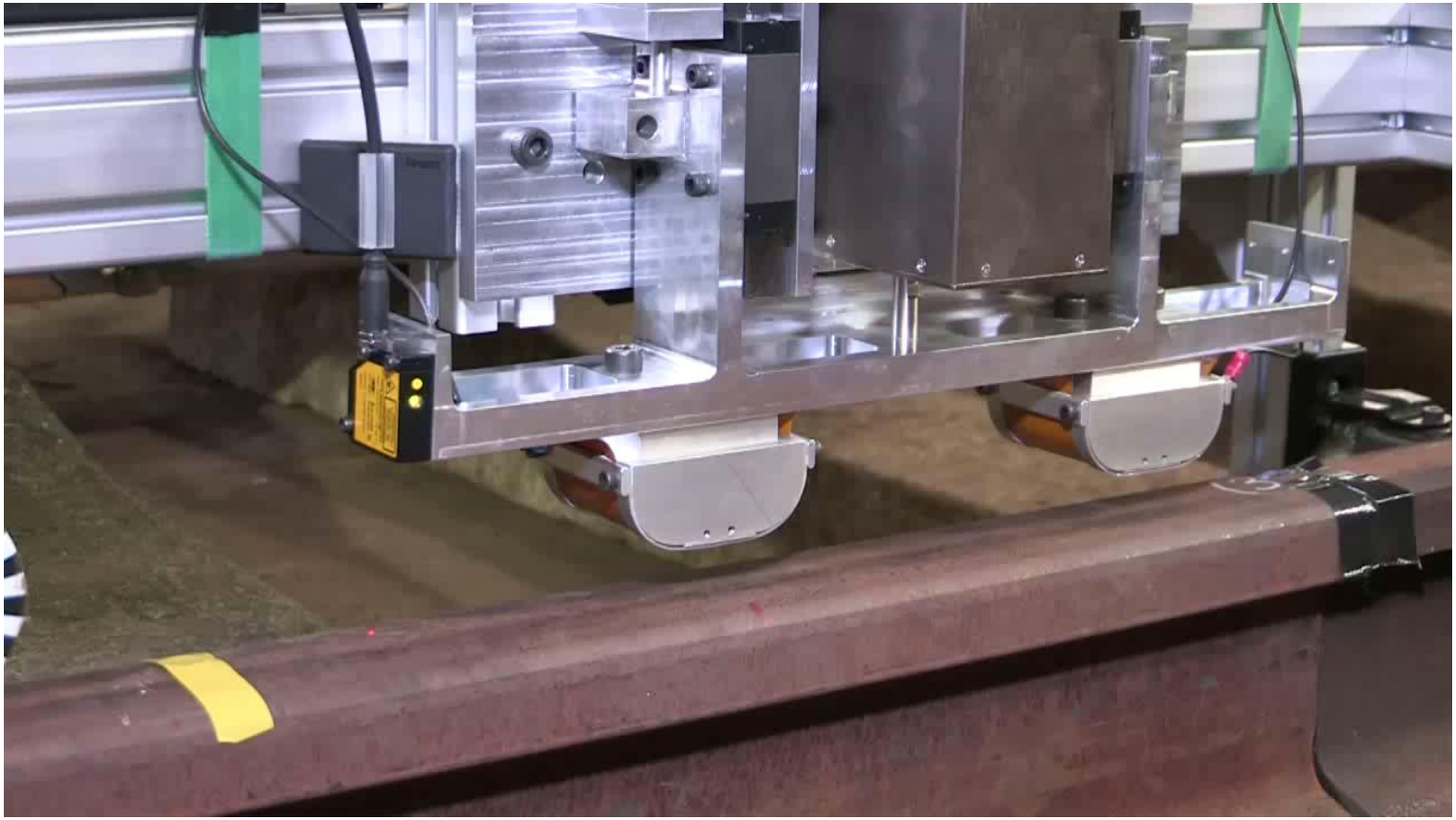
TROLLEY DEMONSTRATION



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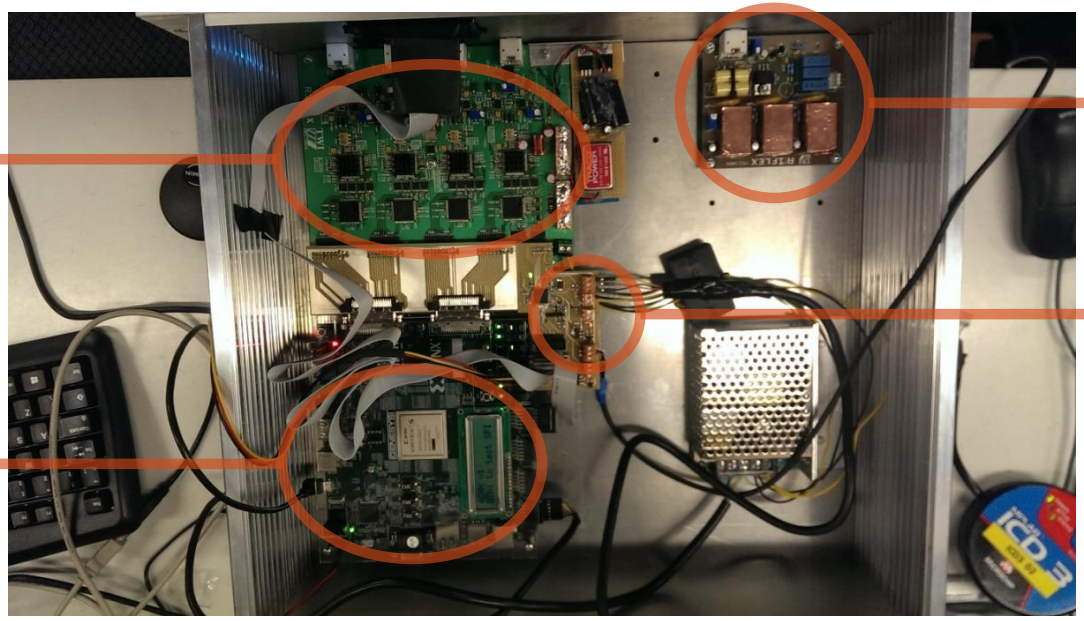
SYSTEM LAYOUT



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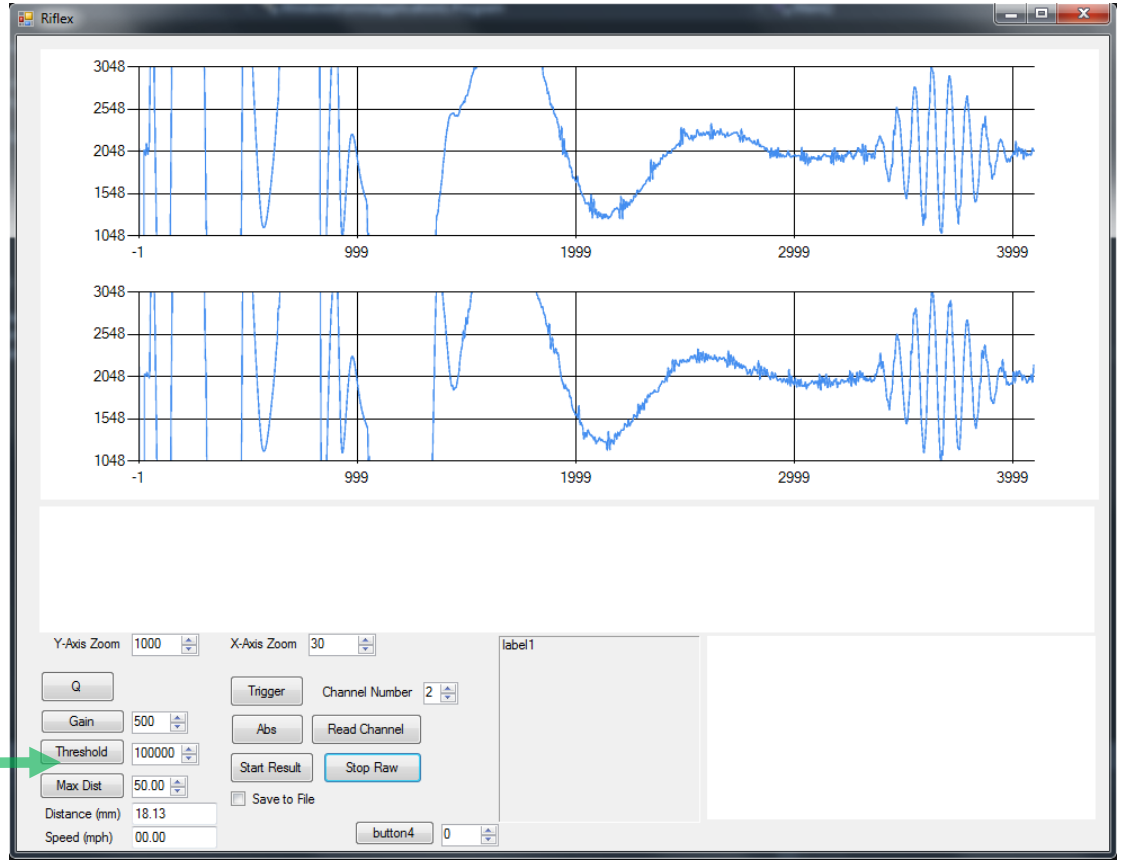
USER INTERFACE 1

- Debug mode
- Shows response signal from requested channels



Control buttons: set gain, threshold values, etc.

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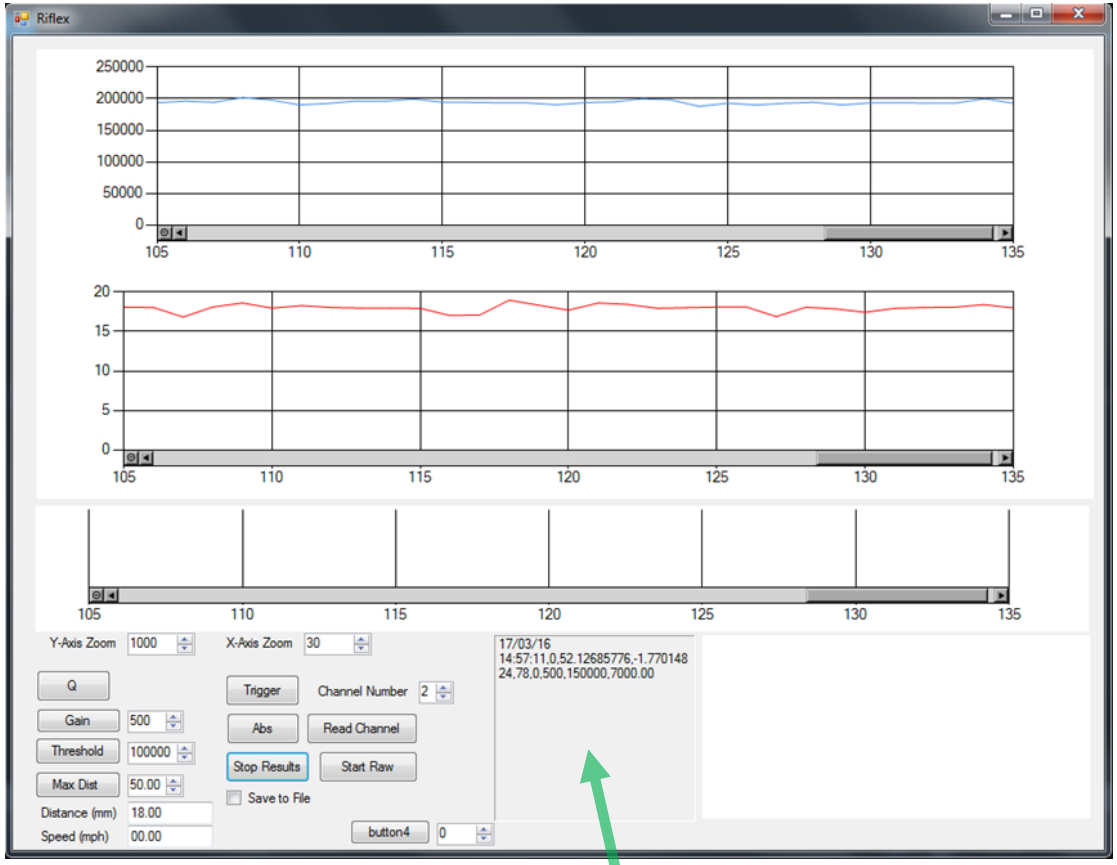
USER INTERFACE 2

- Inspection mode
- Shows real-time inspection results, lift-off and speed reading
- Records time and location info when a defect has been detected



System status

UNIVERSITY OF BIRMINGHAM BCRRE

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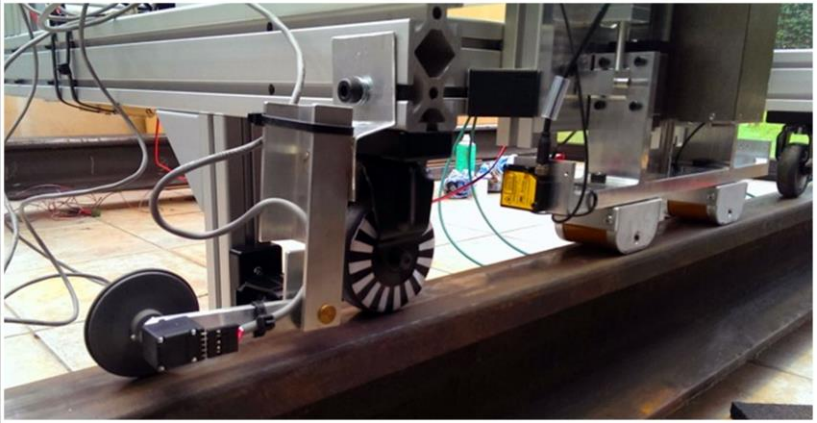
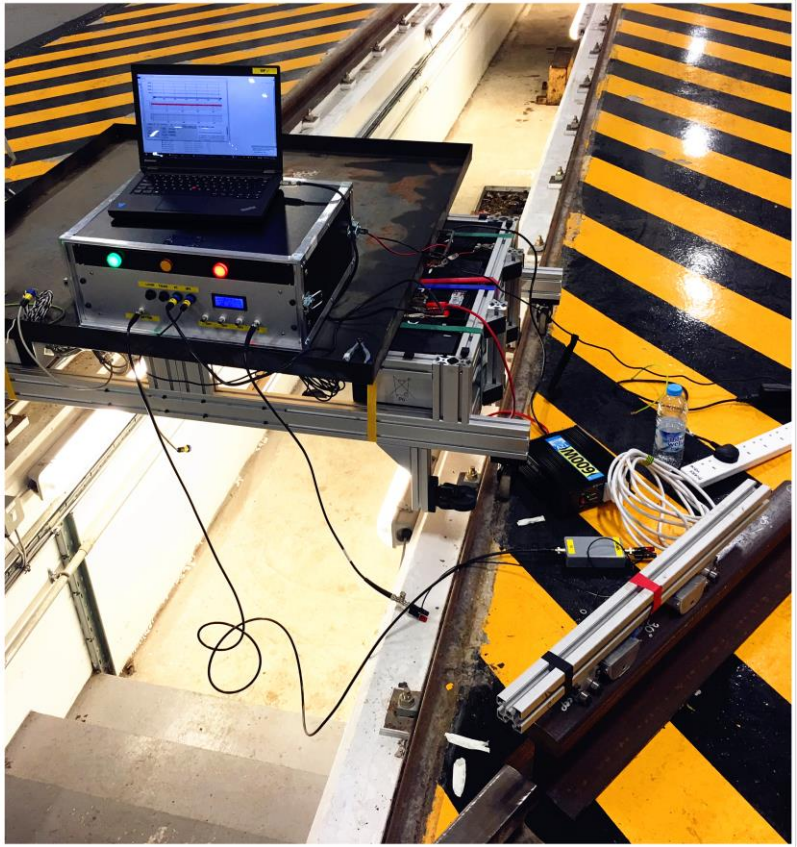
INITIAL FIELD TEST

Brussels



Long Marston



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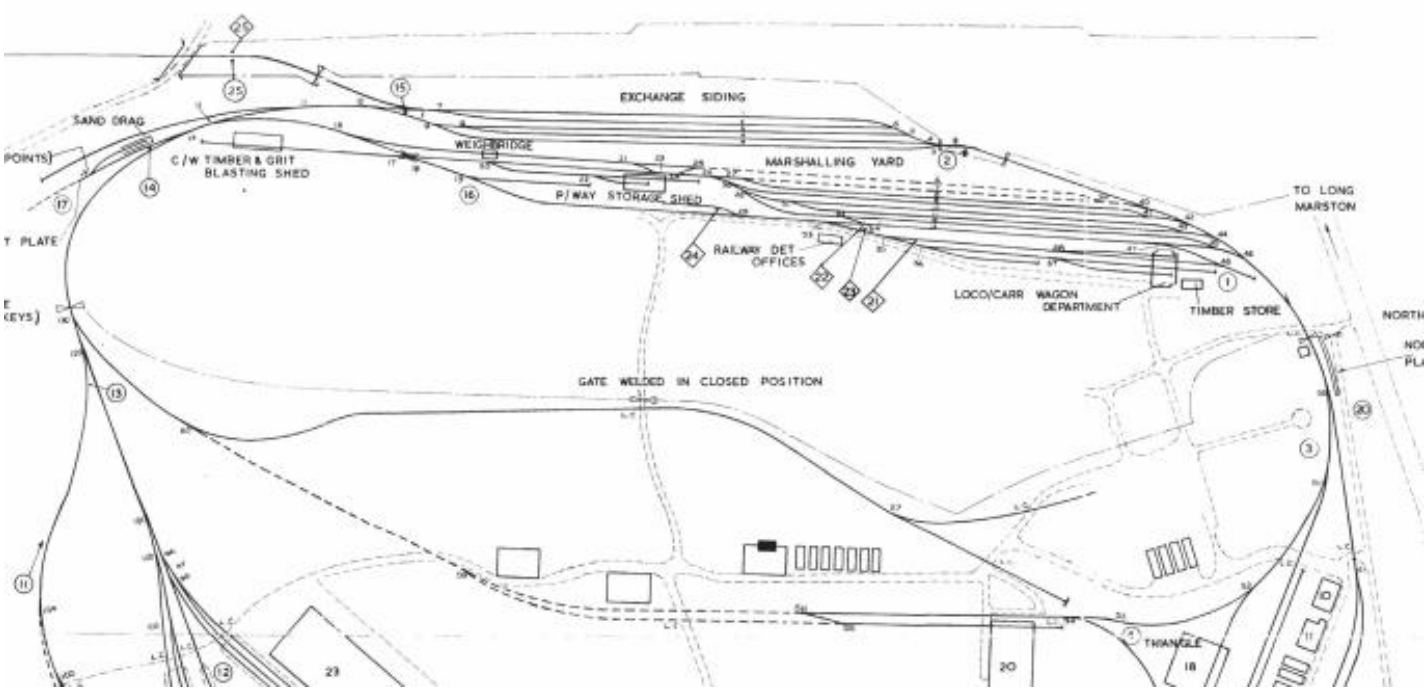
FIELD ENVIRONMENT

- Rail Alliance
- Long Marston
- 5 km testing loop



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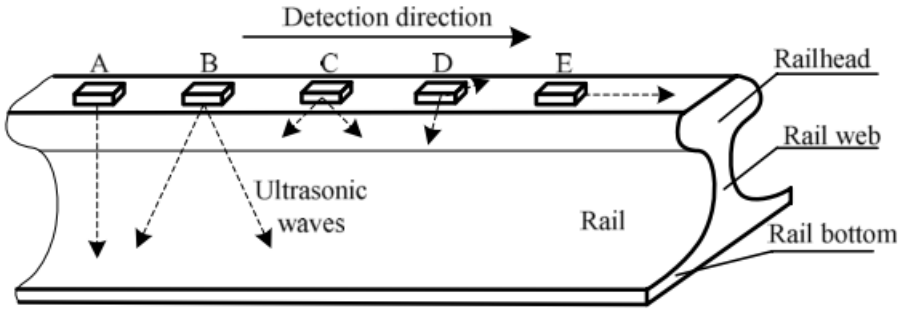
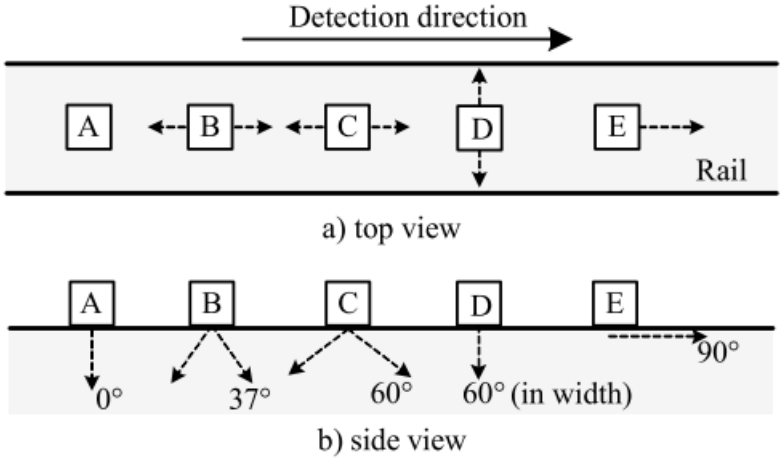
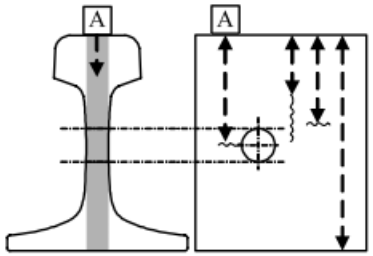
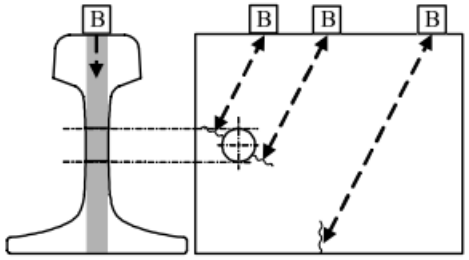
POTENTIAL: FLAW LOCALIZATION SYSTEM



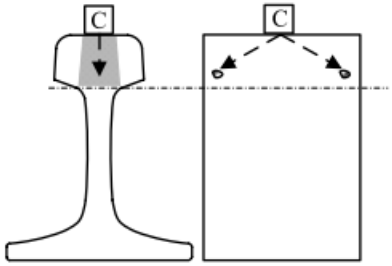




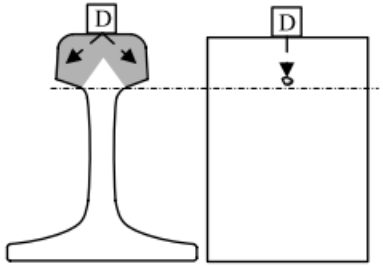
a) probe A (0°)



b) probe B (37°)



c) probe C (60°)



d) probe D (60°)

Kang, L. (2010) Rail flaw detection system based on electromagnetic acoustic technique. 2010 5th IEEE Conference on Industrial Electronics and Applications, pp. 211–215

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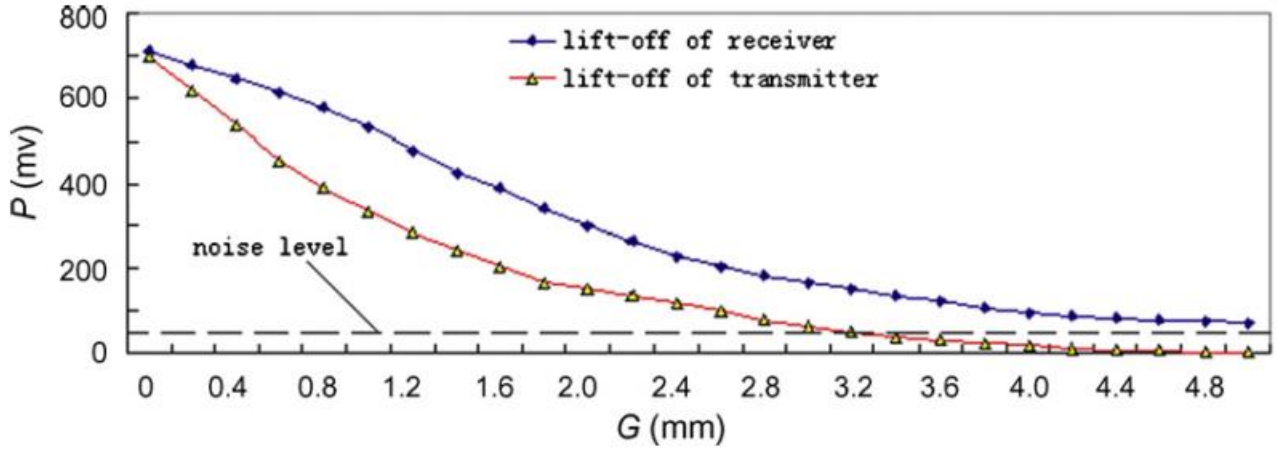
LIMITATIONS: LIFT-OFF

Peak value of received signals at different lift-off values. The diagram shows the peak value of received signal decreases as lift-off value increases for both transmitter coil and receiver coil.



- Speed limit: sensitivity of laser and response speed of actuator

Huang, S., Zhao, W., Zhang, Y., et al. (2009) Study on the lift-off effect of EMAT. Sensors and Actuators A: Physical, 153 (2): 218–221

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  - Prof. Clive Roberts
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