UNIVERSITEIT GENT

FACULTY OF ENGINEERING AND ARCHITECTURE

Mechanisch testen *van polymeer en composiet structuren aan UGent:*

praktische handleiding voor bedrijven

http://www.composites.ugent.be/

3 december 2014

P3Lab

ir. Klaas Allaer

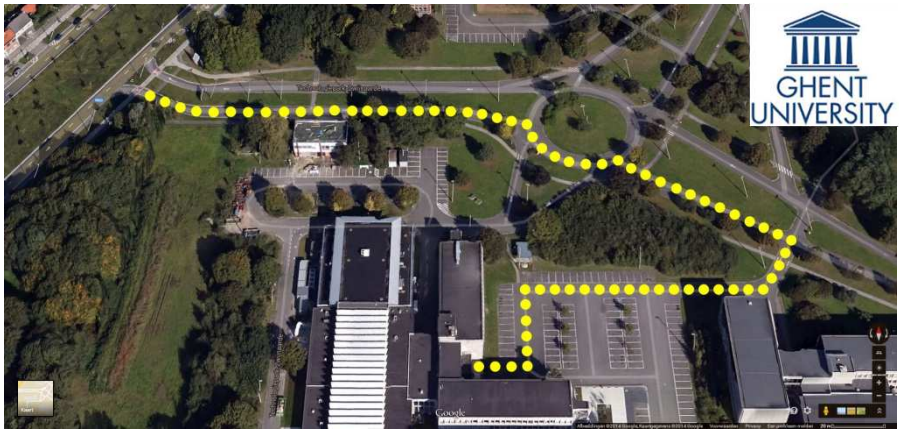
Ghent University – Mechanics of Materials and Structures (MMS)

Group: Mechanics of Materials and Structures (MMS)

- **Expertise**
  - Experimental testing
    (structures / components)
    (static / dynamic / fatigue)
  - Simulation (FE-analyse)
  - Material characterization
    (polymers / composite / metals)
  - Non-Destructive testing (NDT)
    (Ultrasound / Polar scan / Micro-CT / SEM)
- **Application areas:**
  - Aerospace, Automotive, Wind energy, Sport, Plastics, …
- **Focus**: Research and services

Technologiepark-Zwijnaarde 903
9052 Zwijnaarde
Belgium

www.composites.ugent.be



GHENT UNIVERSITY

COMPOSITES at Ghent University

"Bringing *Science* & *Engineering* Together"

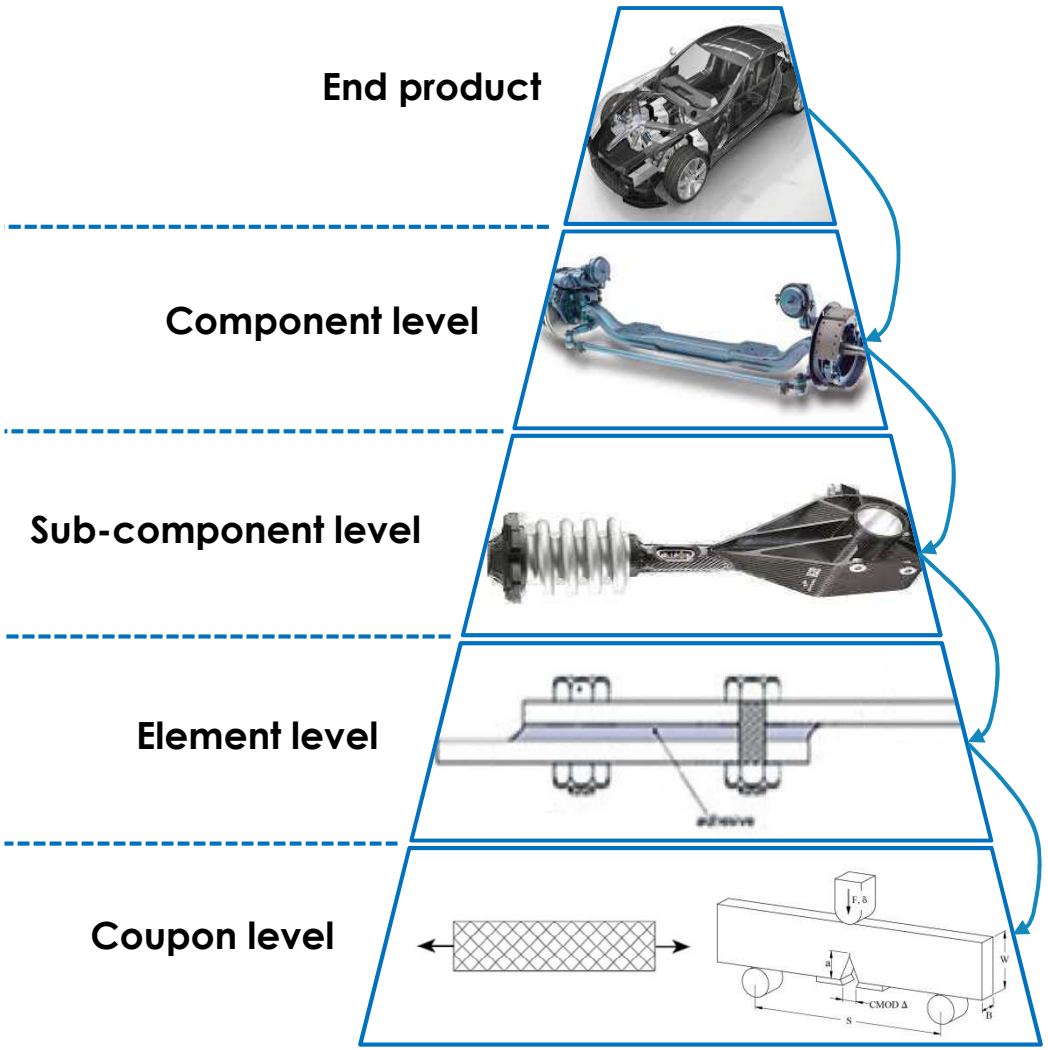
PRESENTATION OVERVIEW

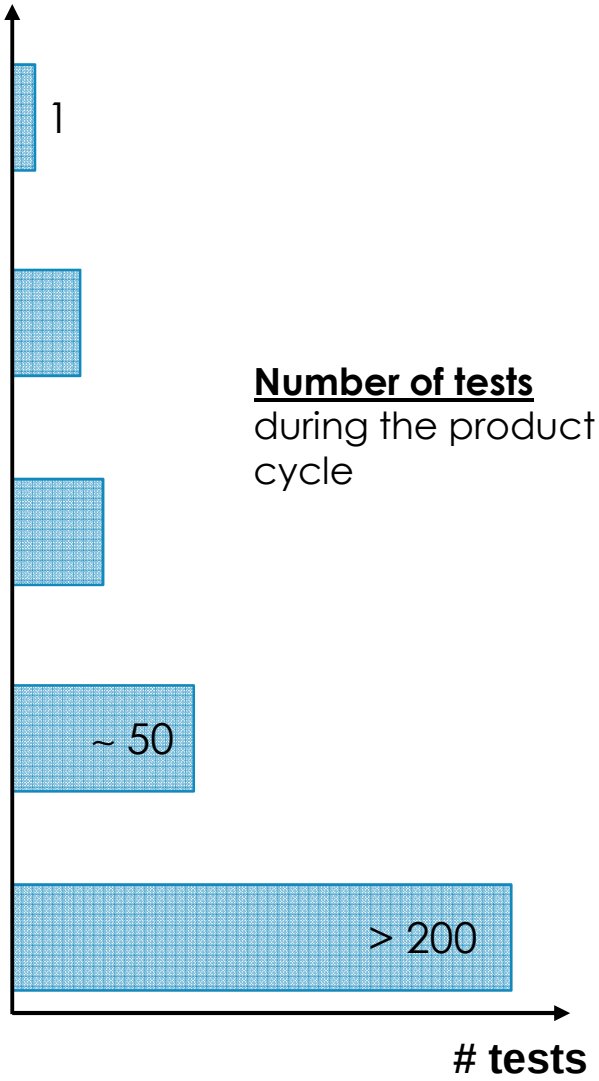
1. **Mechanical testing in the design process**

2. **Test facilities at MMS**
3. **Case studies**

Building blocks in design – *Need for testing*

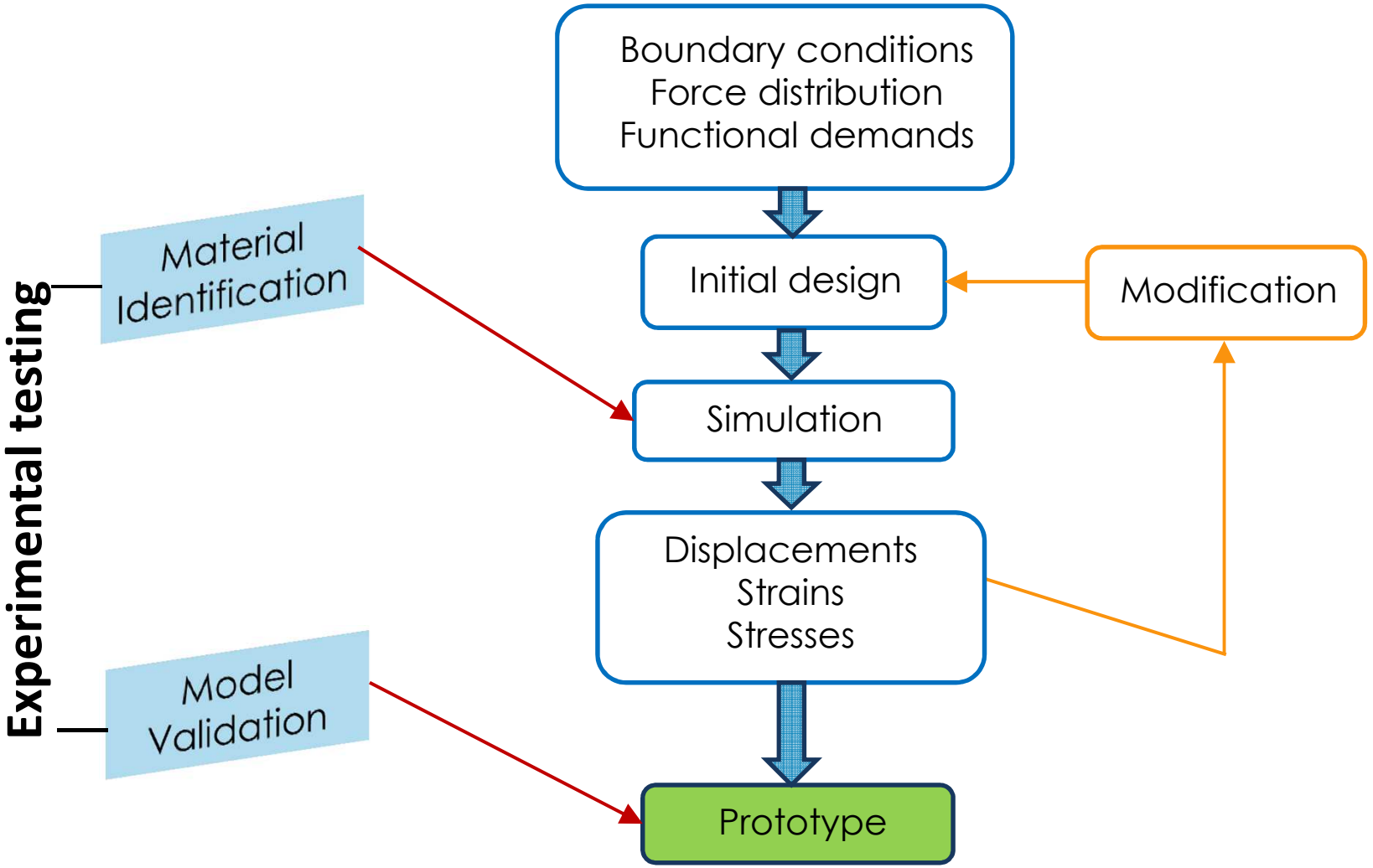
Vb.: Automotive





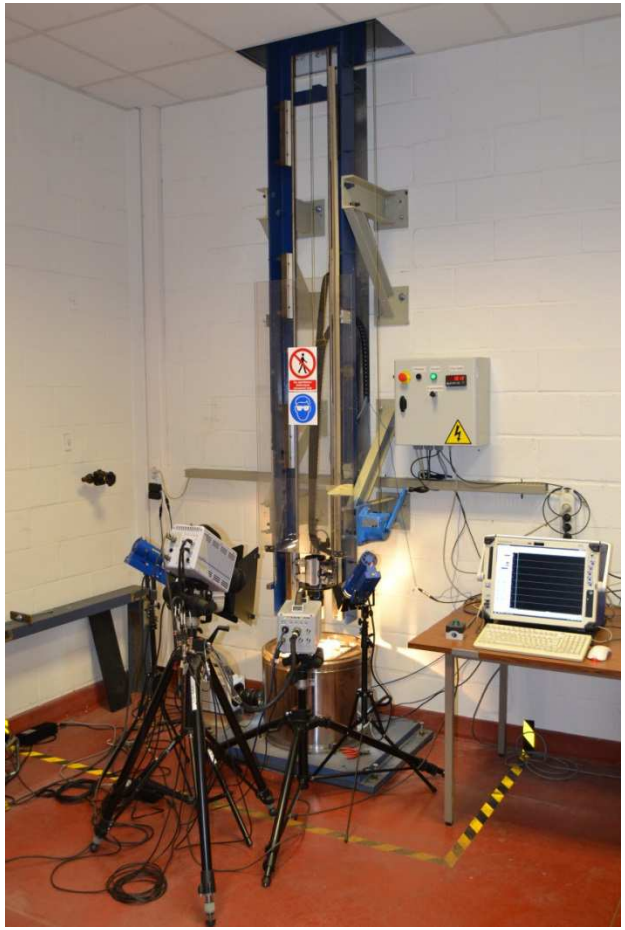
Number of tests during the product cycle

Building blocks in design – *Need for testing*



Facilities for mechanical testing

DYNAMIC IMPACT



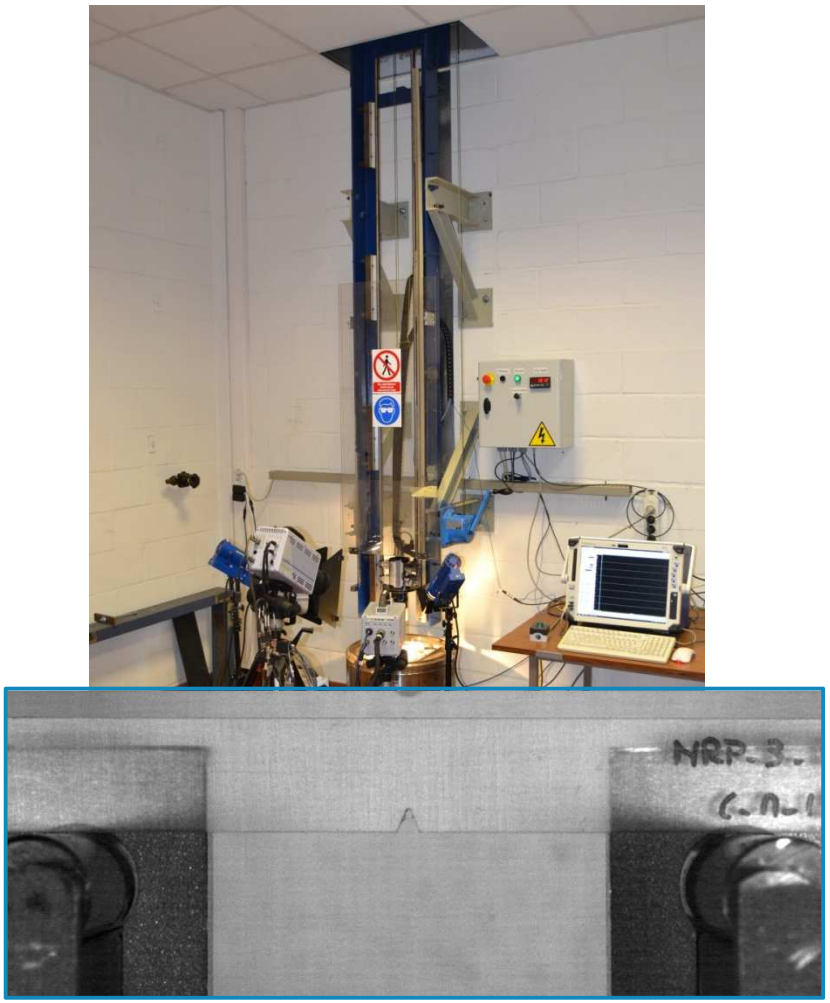
Fully instrumented drop weight impact tester for standard and custom impact experiments.

PROPERTIES

Drop height	10 – 3000 mm
Drop mass	6.57 kg
Velocity range	0.4 – 7.0 m/s
Energy range	0.6 – 200 J
Peak force	22 kN
Data acquisition • Force • Displacement • Acceleration • Strains	Tot 1.000.000 samples/sec

Facilities for mechanical testing

DYNAMIC IMPACT



Fully instrumented drop weight impact tester for standard and custom impact experiments.

ADDITIONAL ACQUISITION

3	Photron High-Speed cameras	Max. 250.000 fps

Facilities for mechanical testing

TENSION, COMPRESSION, BENDING

Instron 5800R

Instron 5569

Force range	10 N – 100 kN
Climate chamber	-100 °C → +350 °C

Setups	Tension / compression Fracture toughness 3P en 4P bending Compression after impact Custom design

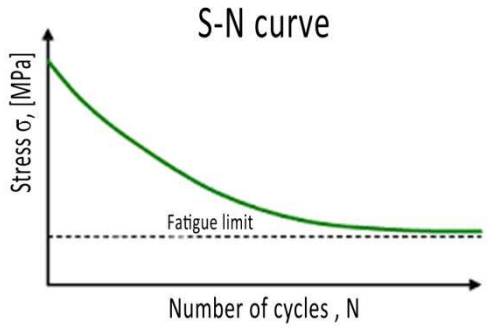
ADDITIONELE ACQUISITIE

Measuring strain	Extensometers Strain gauges Optical fibres Online camera monitoring (Digital Image Correlation)

\+ **Preparation** of samples (dogbones, Charpy notch, …)

Facilities for mechanical testing

FATIGUE
(TENSION, COMPRESSION, BENDING, CRACK GROWTH)



Instron 8801

Force range	5 kN – 100 kN
Setups	Tension / compression Fracture toughness Crack growth Custom design

ADDITIONAL ACQUISITION

Measuring strain	Dyn. extensometers Strain gauges Optical fibres Online camera monitoring (Digital Image Correlation)

\+ **Preparation** of samples (dogbones, Compact tension, …)

Facilities for mechanical testing

FATIGUE
(TENSION, COMPRESSION, BENDING, CRACK GROWTH)

Instron E10000

Force range	±10 kN
Torsion range	± 100 Nm
Climate chamber	-100 °C → +350 °C

Setups	Tension / compression Crack growth 3P en 4P bending Custom design

ADDITIONAL ACQUISITION

Measuring strain	Dyn. extensometers Strain gauges Optical fibres Online camera monitoring (Digital Image Correlation)

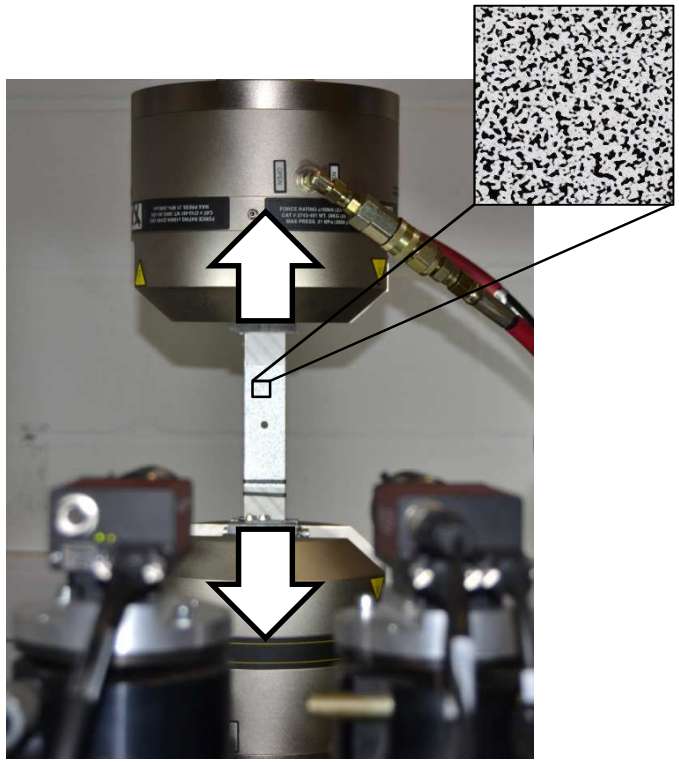
\+ **Preparation** of samples (dogbones, Compact tension, …)

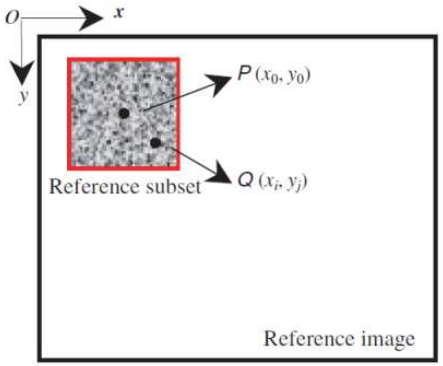
Facilities for mechanical testing

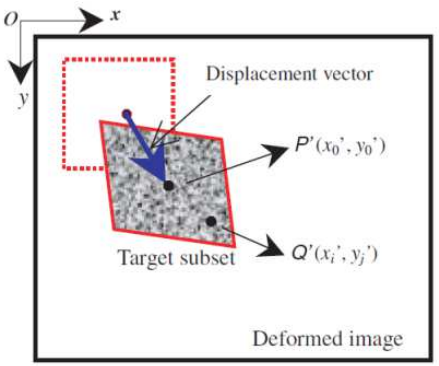
OPTICAL MEASUREMENT TECHNIQUES

Digital Image Correlation

Application	**Online** full-field measuring of displacements and strain
	Static and dynamic
	Contactless







Facilities for mechanical testing

OPTICAL MEASUREMENT TECHNIQUES
Digital Image Correlation

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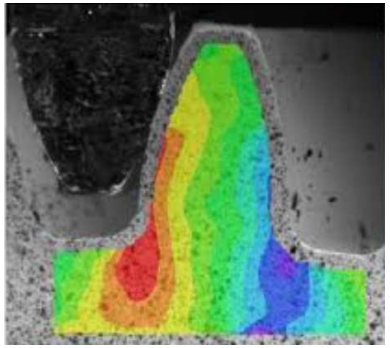

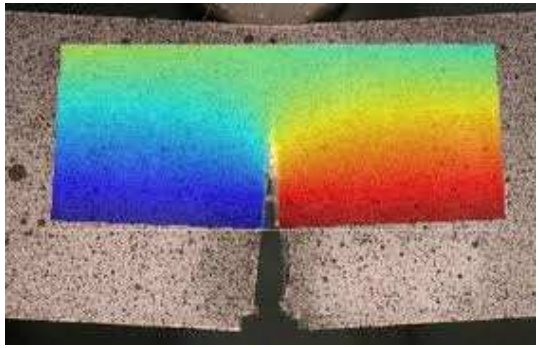

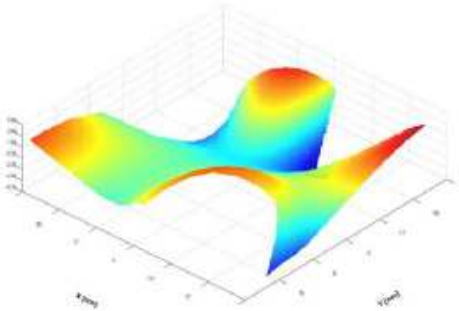

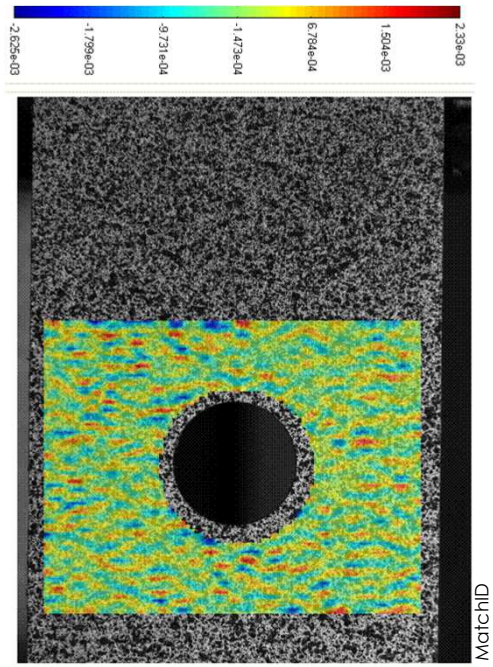

Facilities for mechanical testing

OPTICAL MEASUREMENT TECHNIQUES
Digital Image Correlation

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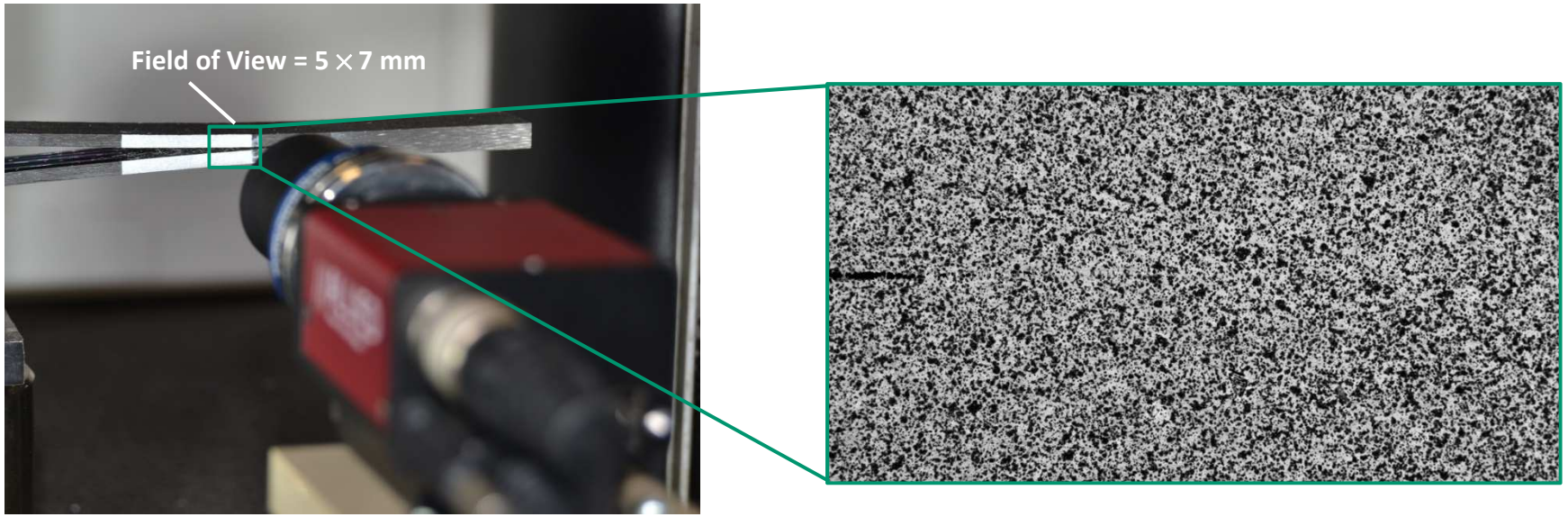
Fracture toughness testing of carbon reinforced epoxy composite



Facilities for mechanical testing

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Digital Image Correlation

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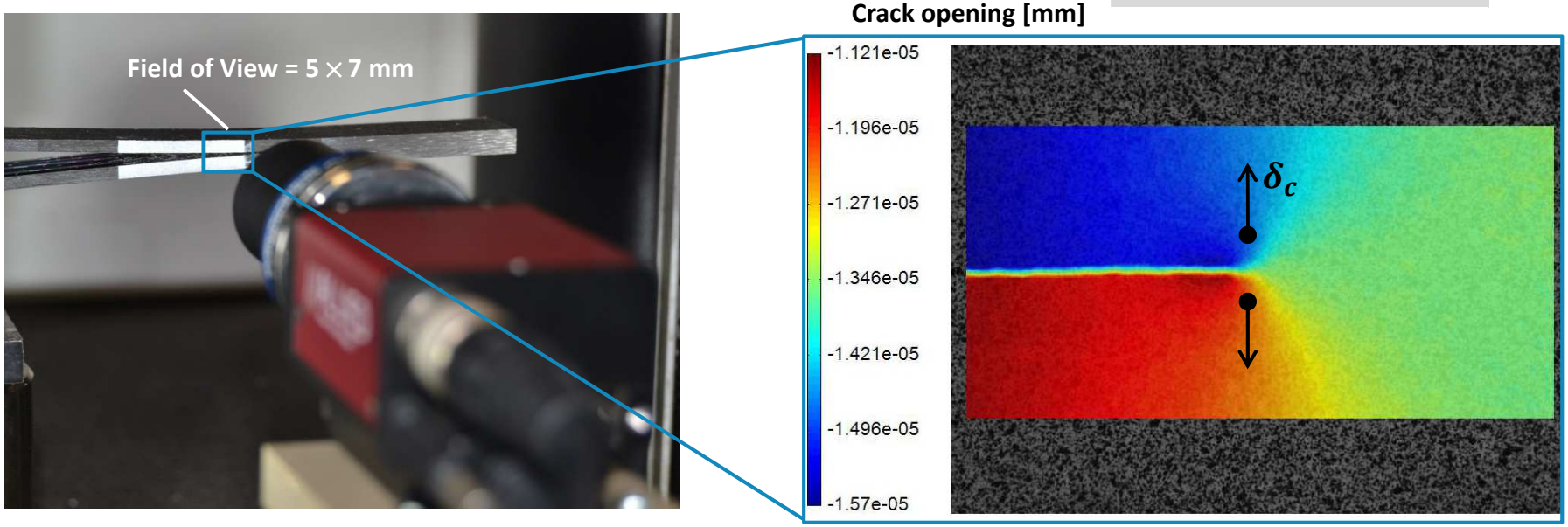

Facilities for mechanical testing

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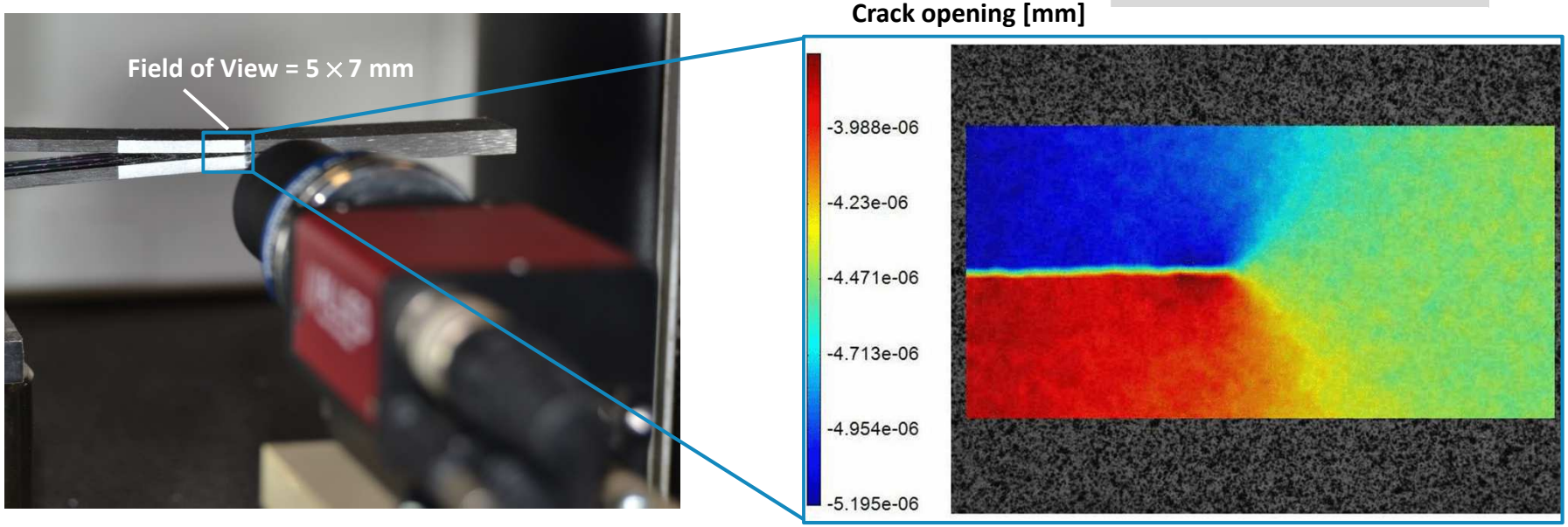


CASE STUDIES

HOW WE MADE IT HAPPEN

CASE STUDY #1: LAZER HELMETS

Impact tests on EPS foams

CASE STUDY #2: BEKAERT

Compression tests on steel wires

CASE STUDY #3: HONDA

Impact tests on carbon reinforced epoxy composites

Project Objective – Case study #1: Densification properties of EPS foams for simulation of foam dynamic compressive behaviour + measuring energy absorption properties of EPS foams.

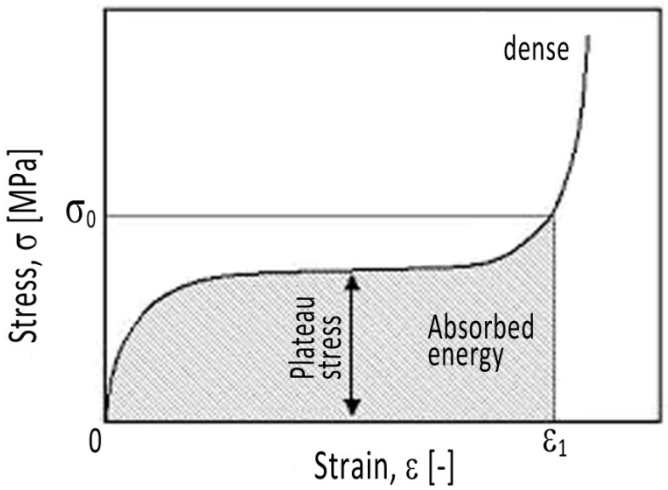
LAZER HELMETS

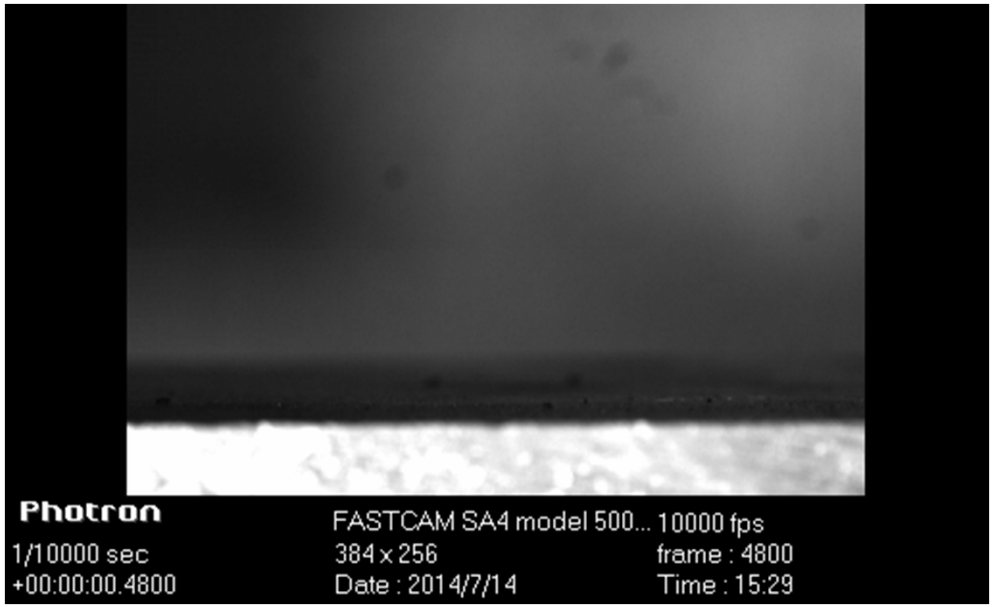
Material choice?

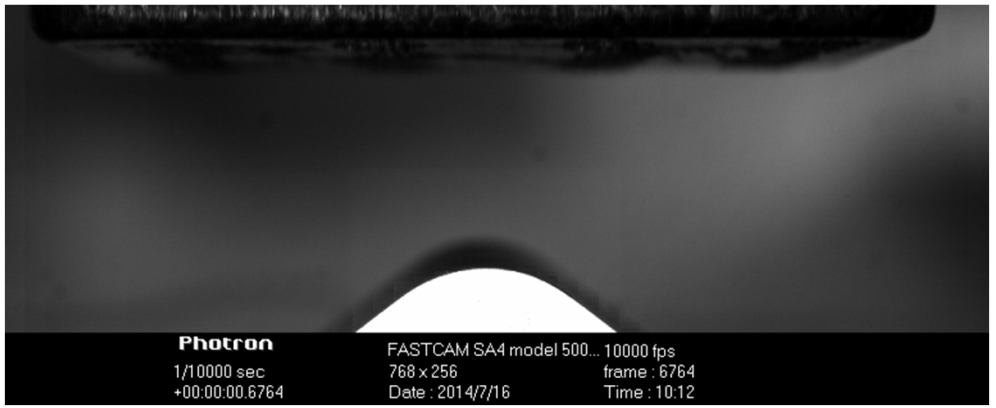
└ Foams with the **highest level of energy absorption**

Dynamic impact testing at different energy levels.

Project Objective – Case study #1: Densification properties of EPS foams for simulation of foam dynamic compressive behaviour + measuring energy absorption properties of EPS foams.



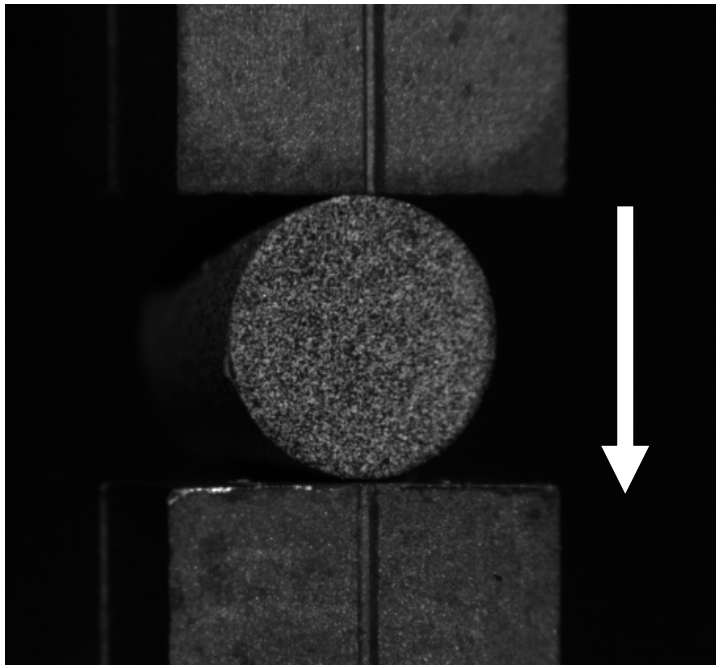




Project Objective – Case study #2: Experimental measuring of 3-dimensional strain field during compression tests on 3 mm diameter steel wired for calibration of plastic material model.

BEKAERT

Customised design of experimental setup and jigs



Material behaviour?

Deformation of steel wires under compressive loading conditions?

Online full-field measuring of 3-dimensional strain fields.

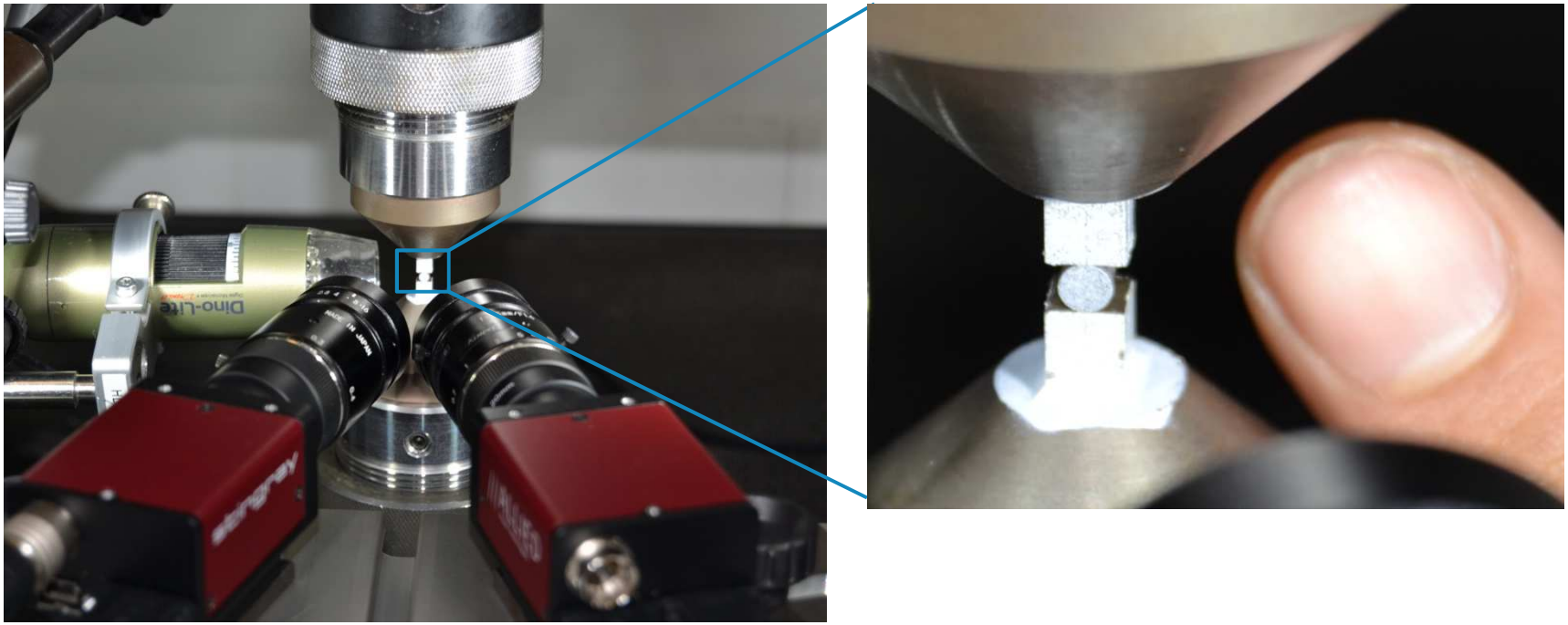
Project Objective – Case study #2: Experimental measuring of 3-dimensional strain field during compression tests on 3 mm diameter steel wired for calibration of plastic material model.

BEKAERT

Customised design of experimental setup and jigs

Use of **conventional measurement techniques**?

Solution:
3D Digital Image Correlation



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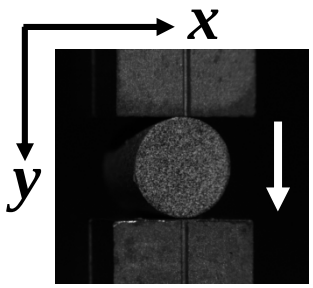

Use of **conventional measurement techniques**?

└ Solution:
3D Digital Image Correlation

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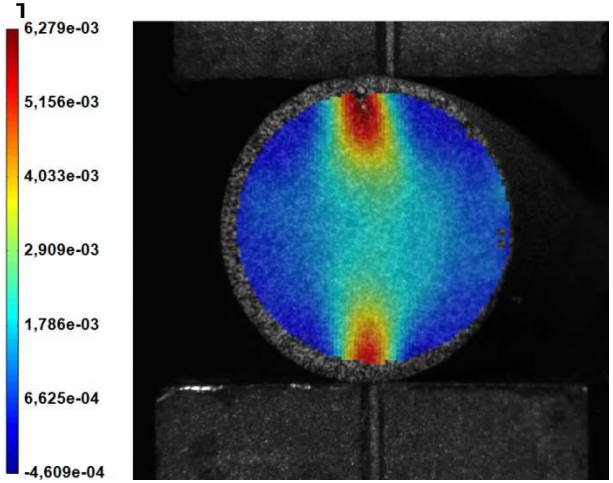

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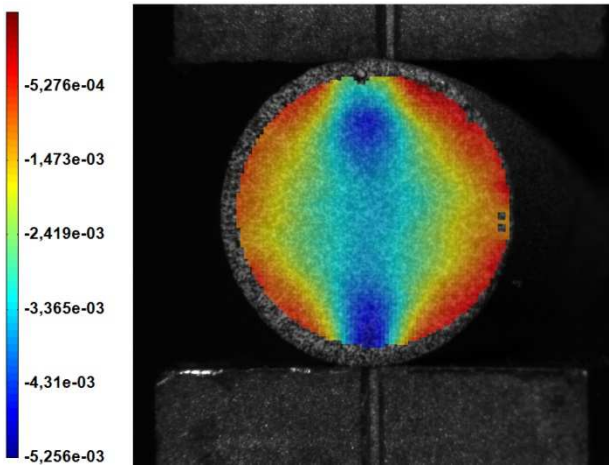

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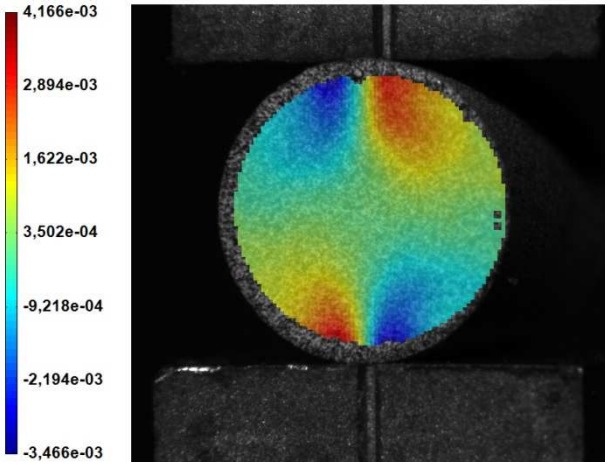

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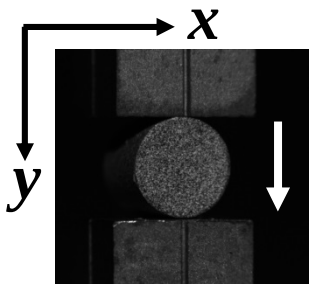

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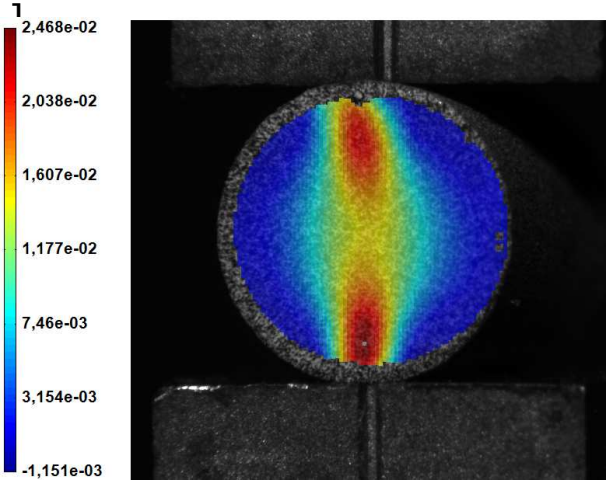

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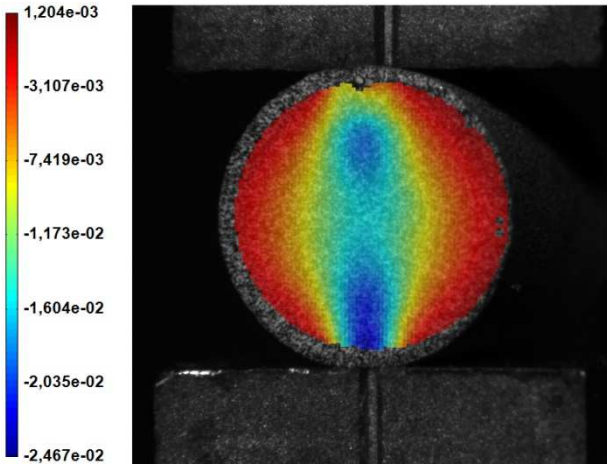

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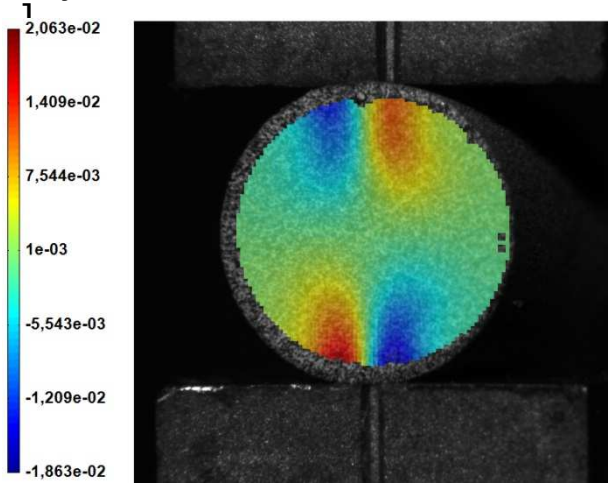

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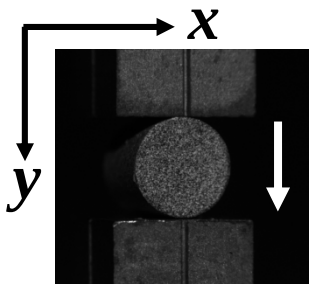

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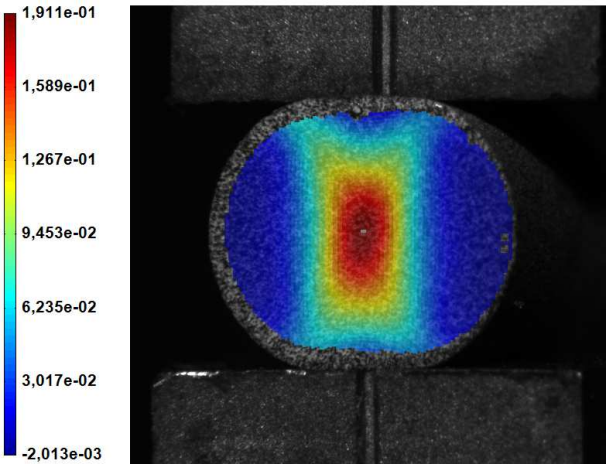

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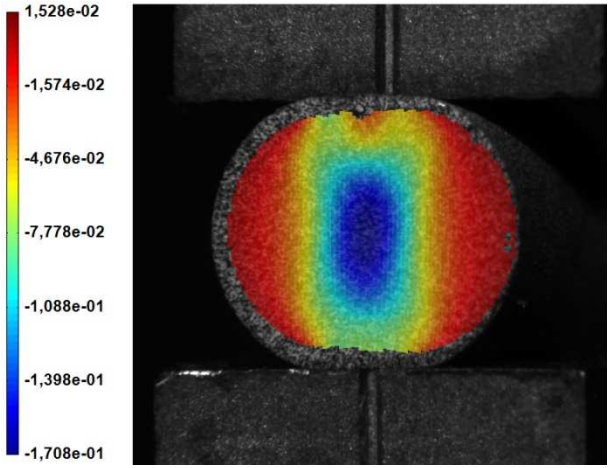

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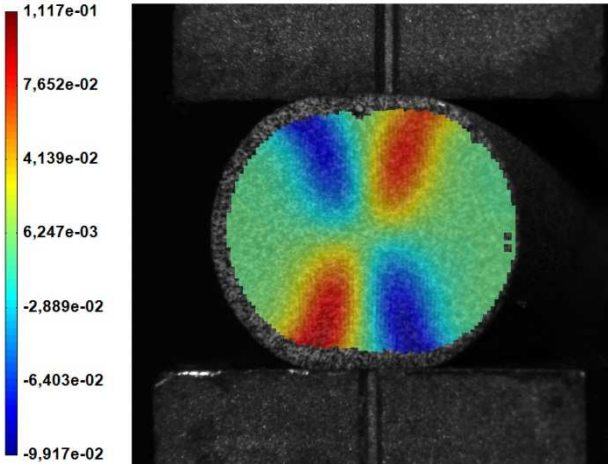

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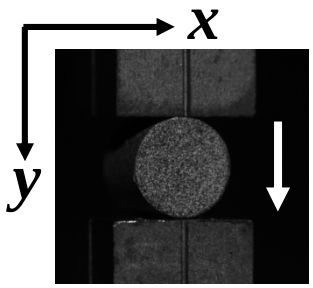

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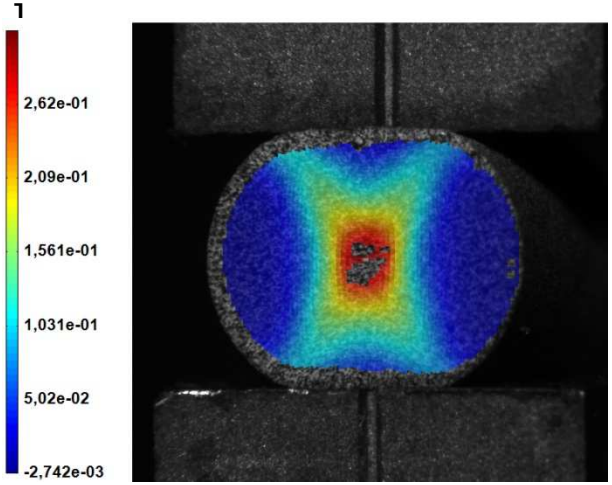

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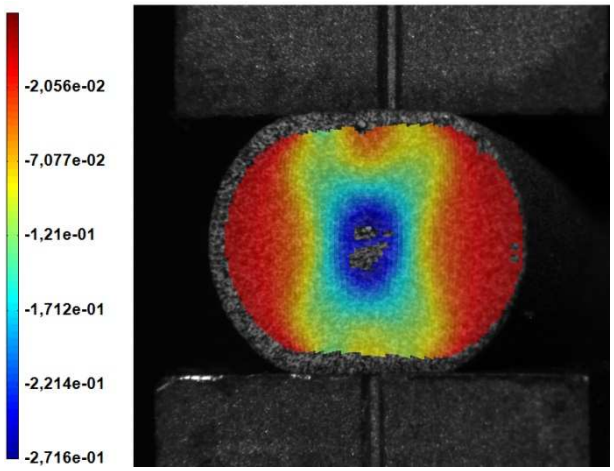

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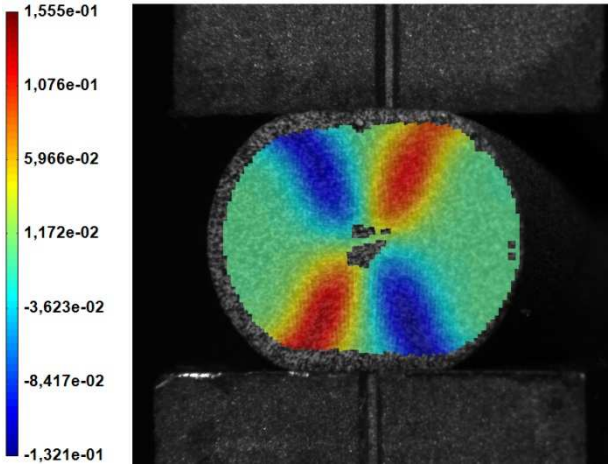
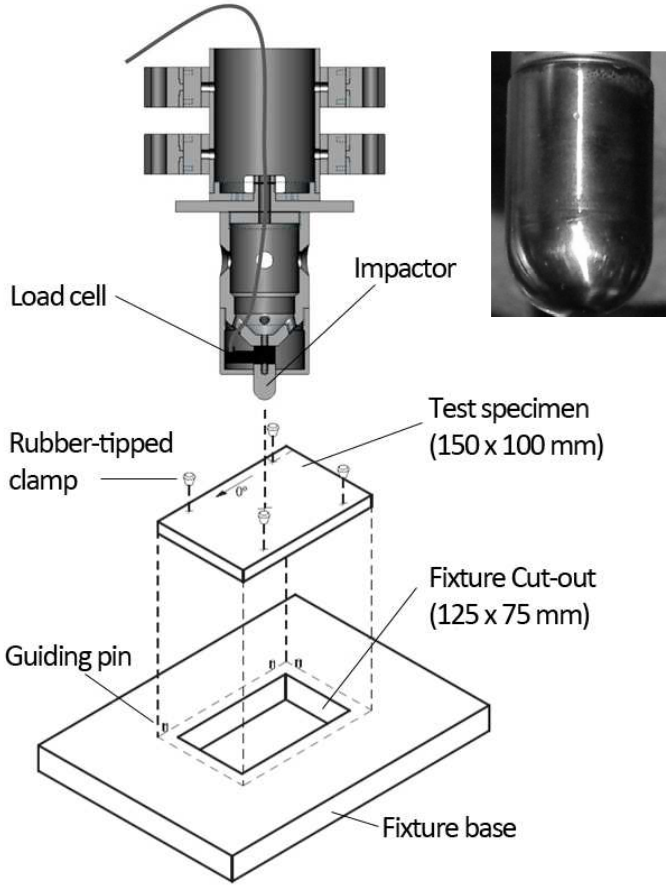


Project Objective – Case study #3: Energy absorption and formation of damage of carbon reinforced epoxy composites under dynamic impact loading conditions.

HONDA



Material behaviour?

└ Effect of low-velocity impact on CFRP composite laminate?

Dynamic impact testing at different energy levels.

Tracking of damage initiation with HS-cameras

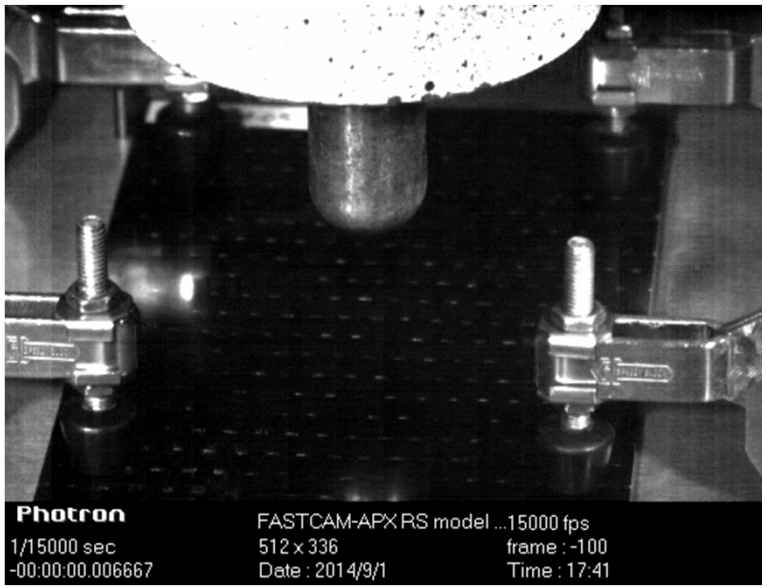
Project Objective – Case study #3: Energy absorption and formation of damage of carbon reinforced epoxy composites under dynamic impact loading conditions.

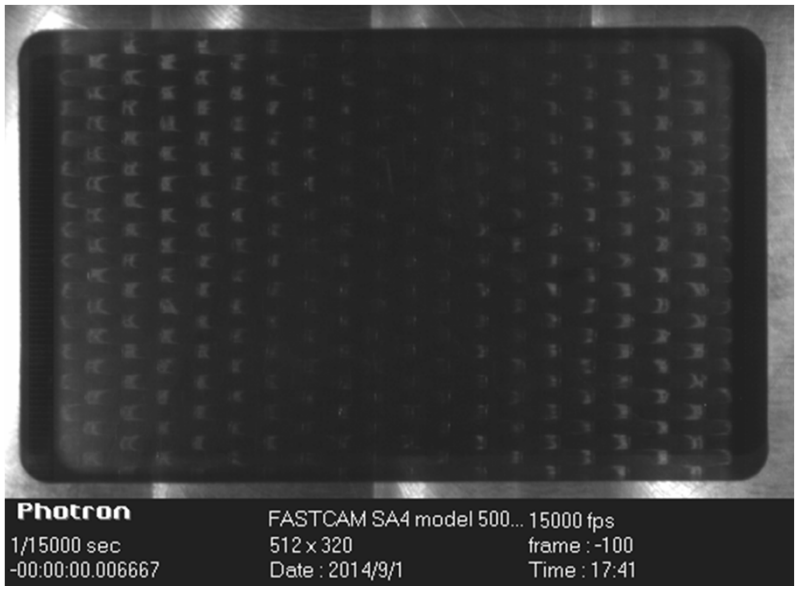
HONDA

CARBON EPOXY

Cross-ply – 32 Joule impact energy

$[0°/90°]_{2s}$





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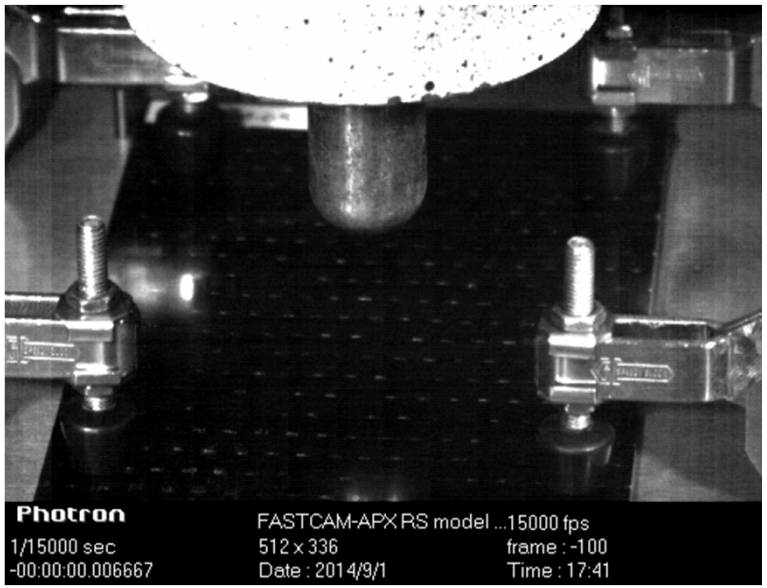

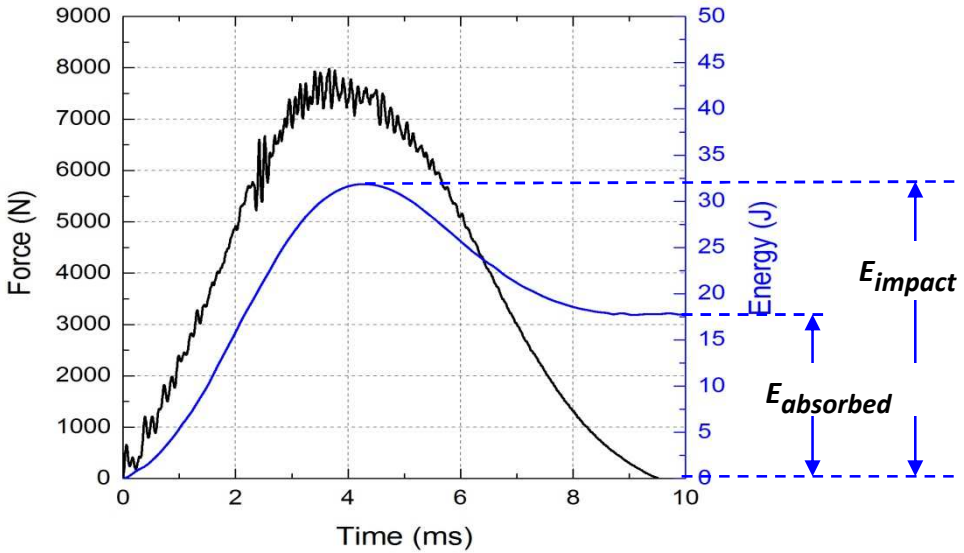

Test Methods

TENSILE:

- Composite materials ASTM D3039
- Sandwich Core Materials ASTM C297
- Open-Hole ASTM D5766
- Plastics ASTM D638

COMPRESSION:

- Composite materials ASTM D3410
- Plastics ASTM D695
- Open Hole ASTM D6484

FLEXURAL:

- Composite materials ASTM D7264
- Four-point bending ASTM D6272
- Plastics D790

SHEAR:

- Composite in-plane shear ASTM D3518
- Short beam shear ASTM D2344
- Shear by Puncture ASTM D732
- Real shear ASTM D7078

PEEL:

- Peel adhesion to rigid substrates ASTM D3330
- T-peel of adhesives ASTMD1876

LAP SHEAR:

- Lap shear adhesively bonded plastics ASTMD3163
- Lap shear adhesive joints ASTM D3528
- Lap shear adhesion for fiber reinforced plastics ASTMD5868

IMPACT:

- Damage resistance ASTM D7136
- Impact testing ASTM D3736
- Charpy impact resistance of plastics ASTM D6610
- IZOD impact resistance of plastics ASTM D256
- Compression After Impact testing ASTM D7137

FRACTURE TOUGHNESS:

- Composite materials Mode I ASTM 5528
- Composite mixed-mode ASTM D6671
- Fatigue crack growth ASTM E399

ANALYTICAL:

- Density of materials ASTM D792
- Fibre volume fractions
- Ignition loss ASTM D2584
- Void content ASTM D2734

Making use of UGent expertise?

- Via dienstverlening
- Via bedrijfsprojecten rechtsreeks bilateraal of via het IWT
- Via KMO-portefeuille voor technologieverkenning
- Via Baekelandmandaten, SBO's, …
- Via deelname aan Europese projecten

kmo-portefeuille
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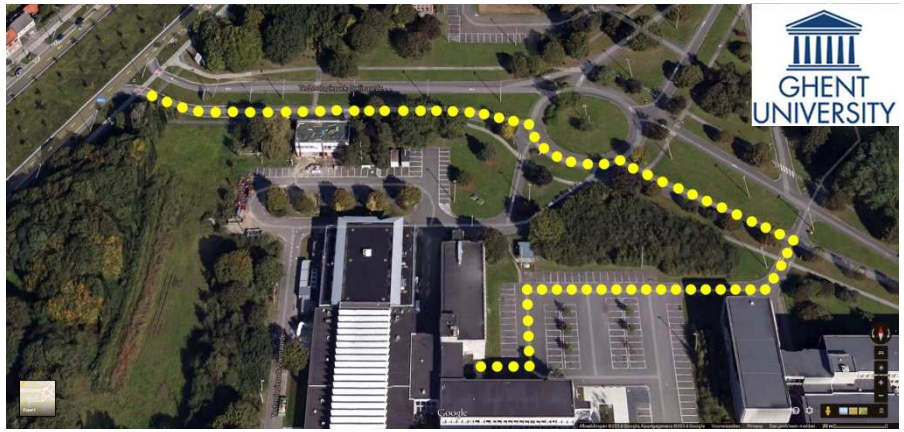

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