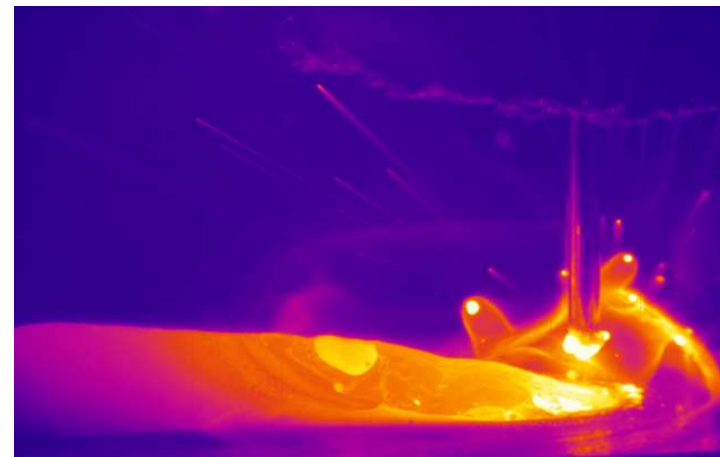




Belgian Welding Institute

*Belgisch Instituut voor Lastechniek
Institut Belge de la Soudure*

Weld Quality Monitoring



Joining your future.



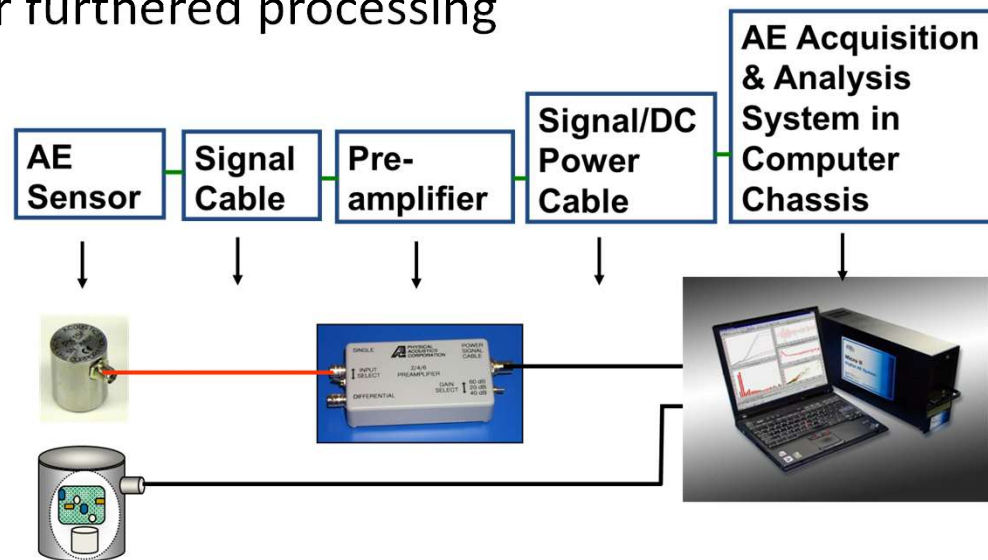
BWI capabilities

Real time weld quality monitoring using :

- ▶ Acoustic emission monitoring
- ▶ Thermography
- ▶ Electric process parameters
- ▶ Spectroscopy
- ▶ Weld profile measurements

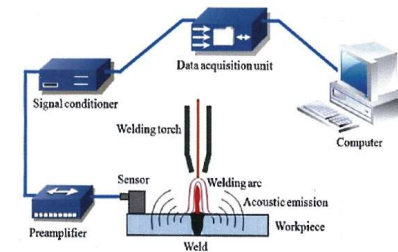
Acoustic emission monitoring

- ▶ Use of low-level sound waves for weld quality monitoring
- ▶ BWI equipment :
 - ▶ Piezoelectric sensors
 - ▶ Low-noise preamplifier
 - ▶ Filters to remove noise
 - ▶ Electronic equipments for furthered processing



Acoustic emission monitoring – related projects

- ▶ **SOUNDWELD** : Acoustic monitoring as an in-process quality assurance method for pressure welding processes
- ▶ **SUBJECT** :
 - ▶ Feasibility of acoustic emission monitoring (AEM) for quality assurance for joining of similar and dissimilar metals
- ▶ **GOAL** :
 - ▶ Application of AEM on 3 welding processes:
 - ▶ Friction spot welding
 - ▶ Resistance spot welding
 - ▶ Electromagnetic pulse sheet welding
- ▶ **TOPICS** :
 - ▶ Relation between joint properties and process parameters
 - ▶ Development of an in-process quality assurance system
 - ▶ Cases studies based on demonstrators
- ▶ **Partners** :
 - ▶ BWI, KULeuven, DVS-FV, TFF & AGT (Univ. of Kassel)



Acoustic emission monitoring – related projects

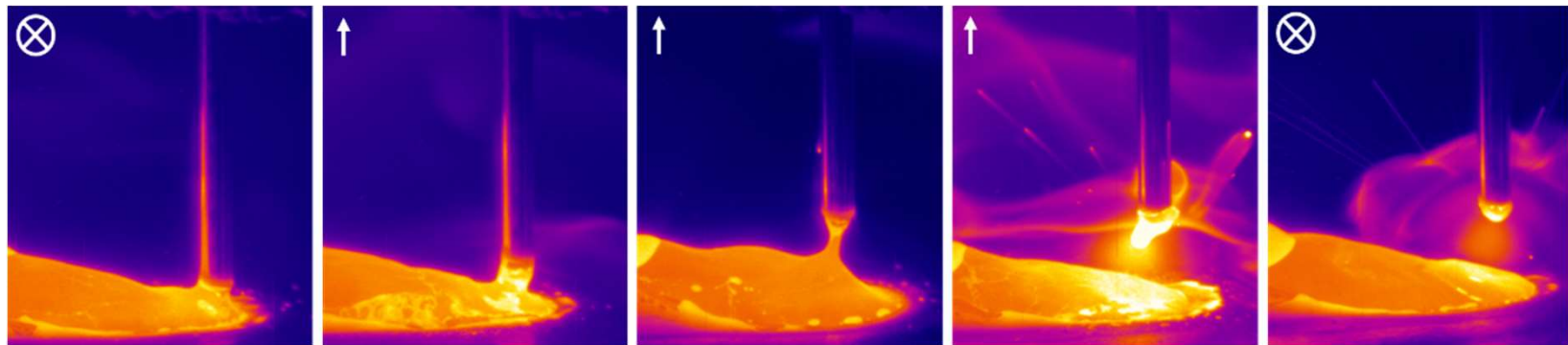
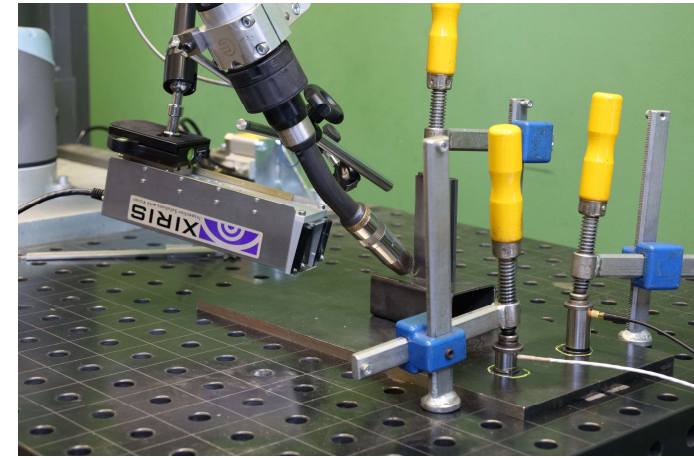
- ▶ AVANGARD : Advanced manufacturing solutions tightly aligned with business needs : Investigation of AEM for arc welding (MIG/MAG)
- ▶ GOALS FOR QUALITY MONITORING :
 - ▶ To investigate the reproducibility of the AEM signals
 - ▶ Predictions of the weld imperfections based on the sound of the weld and the process parameters (current and voltage) using AI models
 - ▶ To develop a non-destructive weld quality monitoring system based on AEM



Thermography

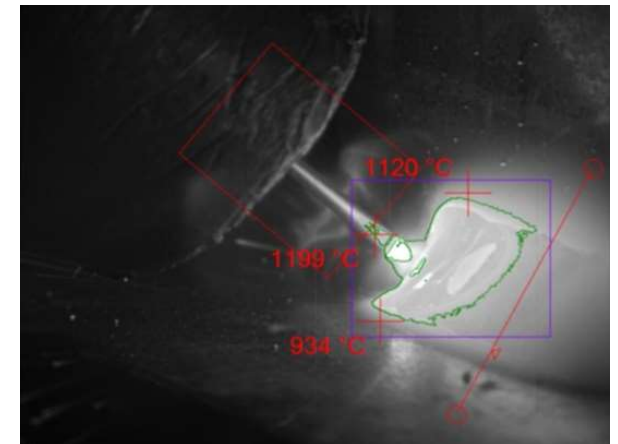
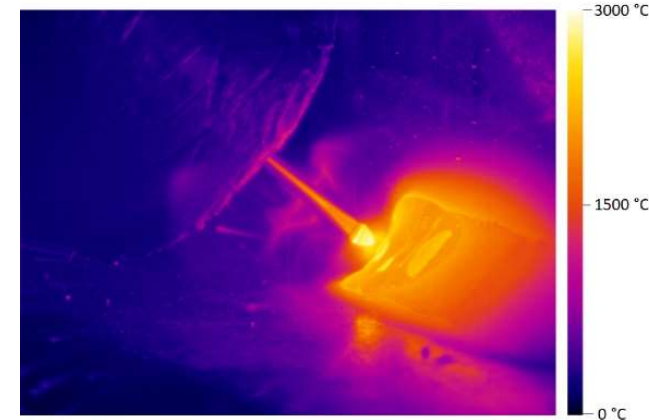
Non-destructive testing of welds using thermography :

- ▶ Equipment : XIR-1800 thermal camera
- ▶ Short-Wave InfraRed (SWIR) spectrum camera
- ▶ Enhanced imaging of metal joining processes beyond what is visible using standard thermal or visible-light cameras
- ▶ Clear view of the weld pool
- ▶ Software tools for analysis



Thermography – related projects

- ▶ AVANGARD : Advanced manufacturing solutions tightly aligned with business needs : Investigation of thermography for arc welding (MIG/MAG)
- ▶ GOALS FOR QUALITY MONITORING :
 - ▶ To produce test specimens with realistic weld defects using different welding parameters
 - ▶ To apply thermography techniques to inspect the specimens and detect the weld defects
 - ▶ To evaluate the potential of active thermography for weld quality assurance in terms of accuracy, reliability, speed and cost-effectiveness



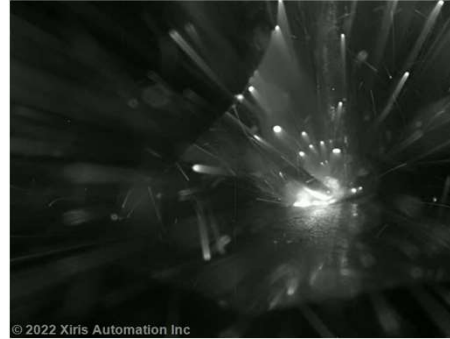
Thermography – related projects

▶ AVANGARD

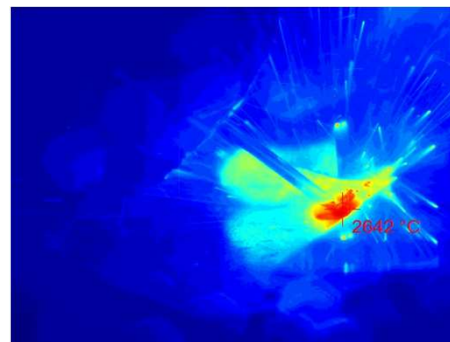
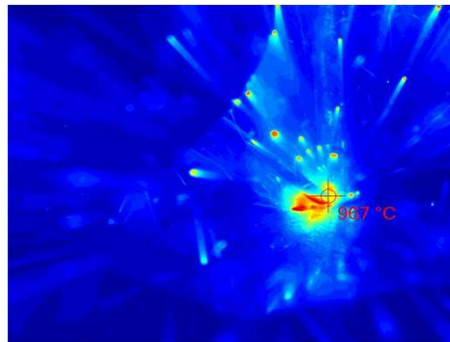
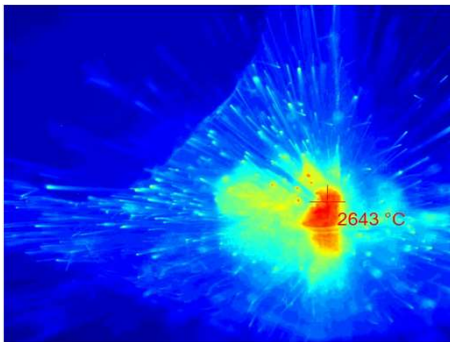
Standard Process



Oil



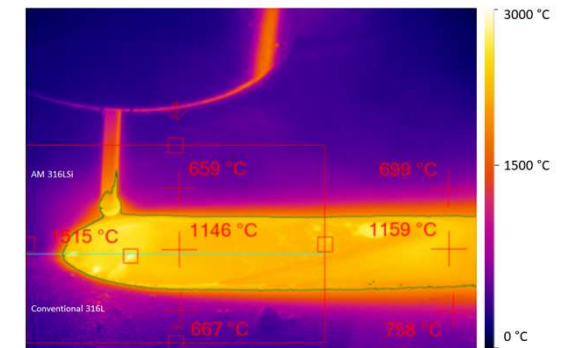
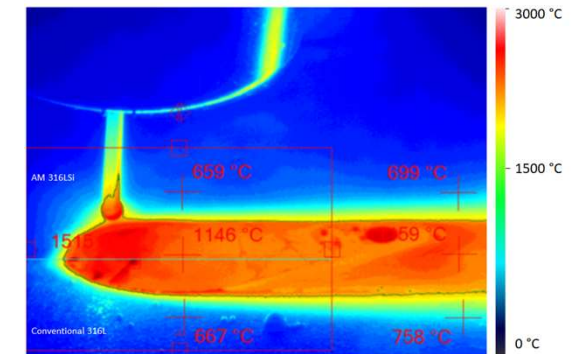
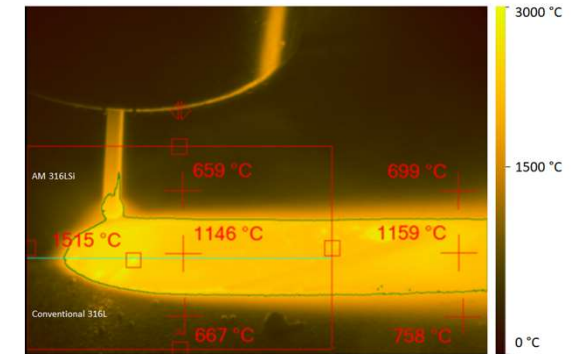
Gap 2.5 mm



Very stable process
AVG Weld Pool
Temperature: 1450 °C

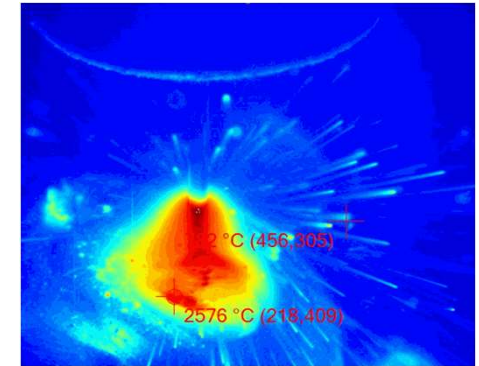
Unstable process
AVG Weld Pool
Temperature: 1000 °C

Unstable process
AVG Weld Pool
Temperature: 1275 °C



Thermography – related projects

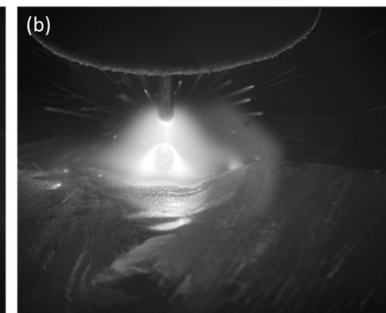
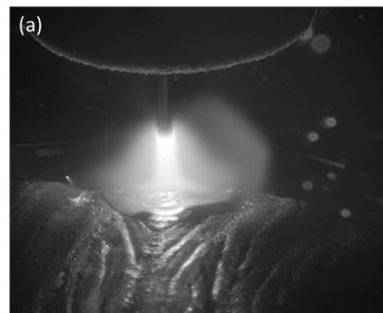
▶ WAALU: WAAM of high strength aluminium alloys



Use of the XIR-1800 thermal camera during WAAM manufacturing of Al alloys:

- Formation of welding imperfections
- Effect of the deposition path strategy on the weld bead geometry during manufacturing
- Weld Pool / Arc behaviour during change of parameters for simple/complex geometries

Formation of cathodic points for the oxide cleaning during the processing of aluminium alloys via WAAM



Images captured during the manufacturing of aluminium alloy via WAAM with different heat input, indicating the susceptibility of solidification cracking formation when using low heat input (A). The centre solidification lines cannot be observed when using optimized parameters (B).

Spectroscopy and electric parameter monitoring

► Use of a combination of sensors



Microphone

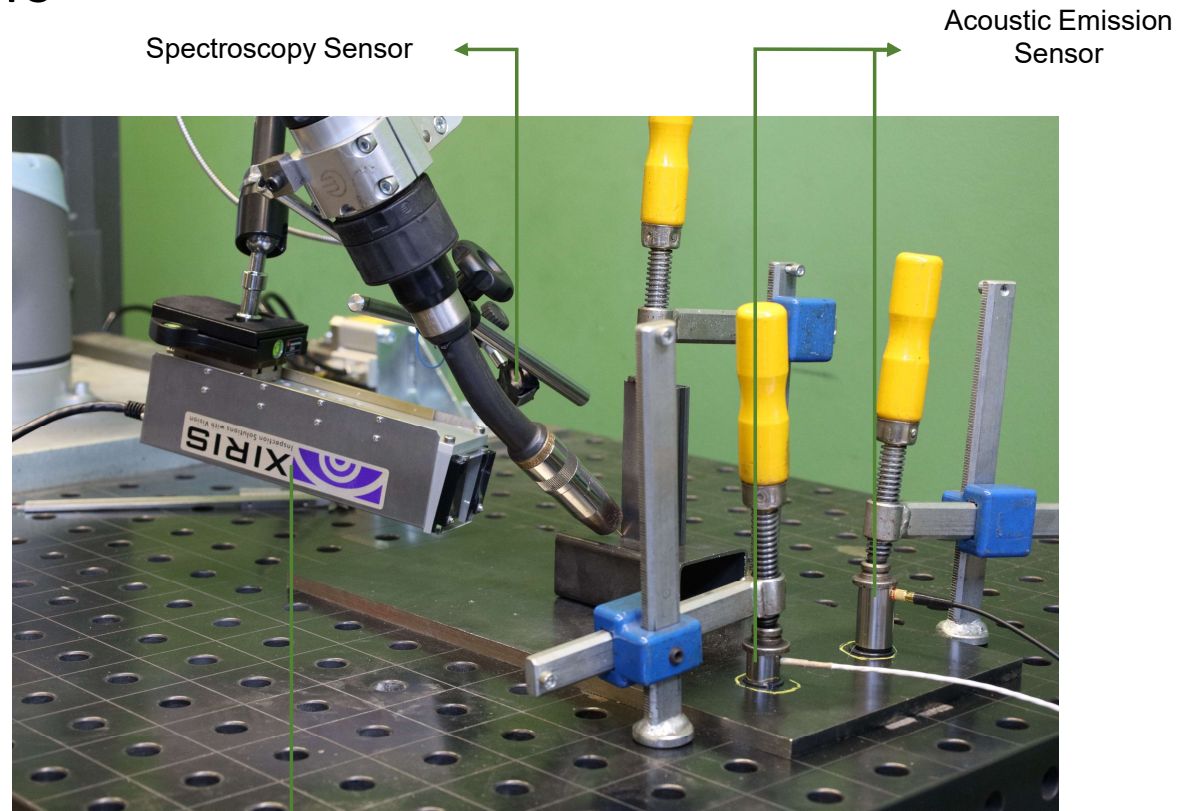
Acoustic Emission
Sensor #1

Spectrometer

Acoustic Emission
Sensor #2

Additional Signals:

- Current
- Voltage



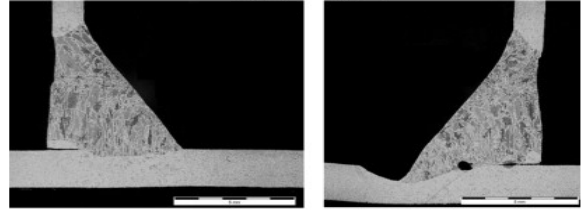
Spectroscopy Sensor

Acoustic Emission
Sensor

Thermal Camera

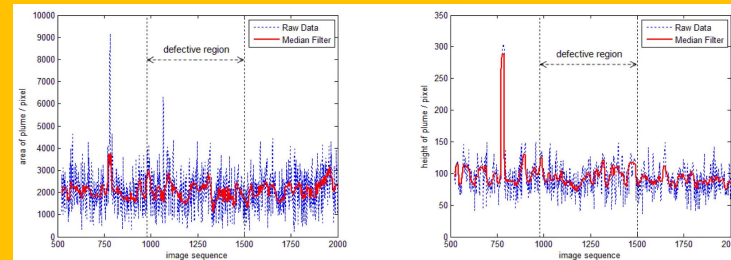
*Extra Not Visible Sensors:
Current, Voltage,
and Wire Feed Speed

Spectroscopy and electric parameter monitoring



Weld tests achieving approved and reproved results based on the ISO 5817 acceptance criteria

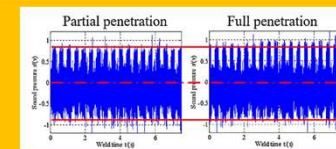
Correlation of detected defects with signals (based on AEM, spectroscopy, and electric parameters data)



Detection of the exact point with defect

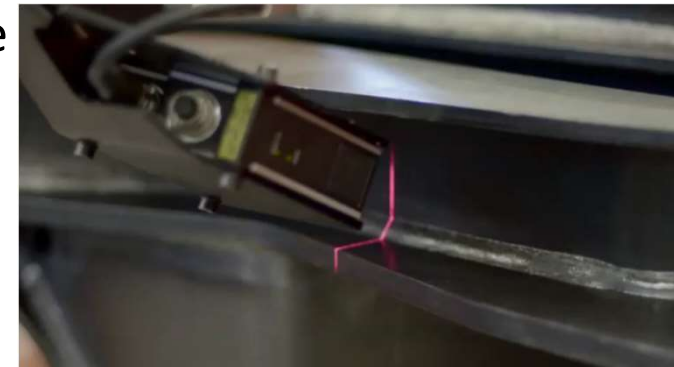


Possibility to fix the parameters in real time avoiding defect propagation



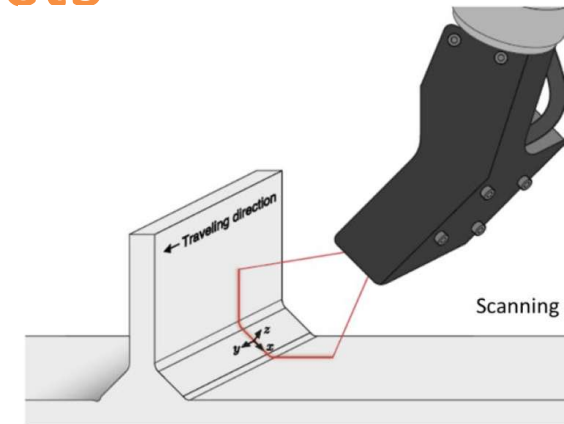
Weld profile measurements

- ▶ Laser measurement of the weld geometry
- ▶ Digitalisation of visual testing of welds (e.g. according to ISO 5817)
- ▶ Use AI for the evaluation of the measurements
- ▶ Determination of acceptance criteria for laser scanning of welds
 - ▶ guidelines for weld quality assessment and acceptance
 - ▶ destructive testing to adapt the visual testing acceptance criteria with an addendum for digital inspection
- ▶ Propose changes for the existing standards when using laser measurement of the weld geometry
- ▶ Equipment : Keyence LJ-X8000



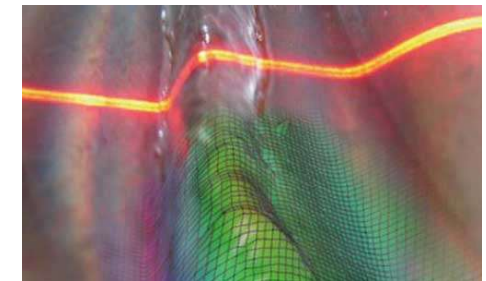
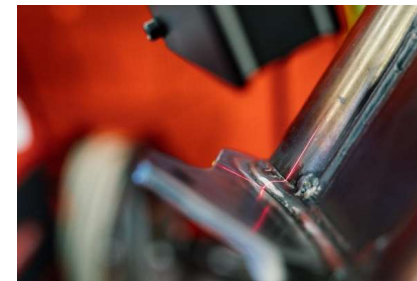
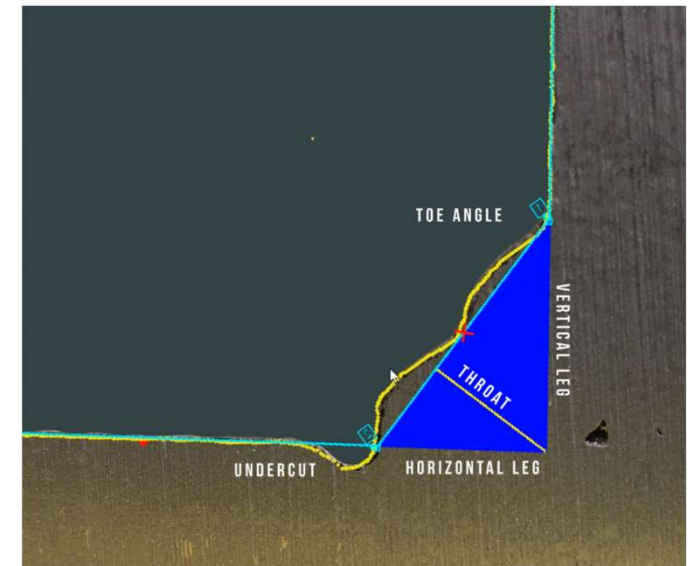
Weld profile measurements – related projects

- ▶ SIMS : Sustainable Surfaces by Intelligent Solidification in Manufacturing Systems
- ▶ SUBJECT
 - ▶ Development of a smart manufacturing system based on optical laser scanning sensors, combined with new Machine Learning algorithms, to identify and optimise critical surfaces, like stress concentration areas
- ▶ GOAL
 - ▶ Better understanding of the influence of the weld topology on the fatigue resistance of welded structures
- ▶ TOPICS
 - ▶ Model to predict critical crack initiation areas in the manufactured products and to predict the fatigue life.
 - ▶ Specification of acceptance criteria for the new weld geometry measurement method, and propose guidelines for a better fatigue life of welded or AM products.

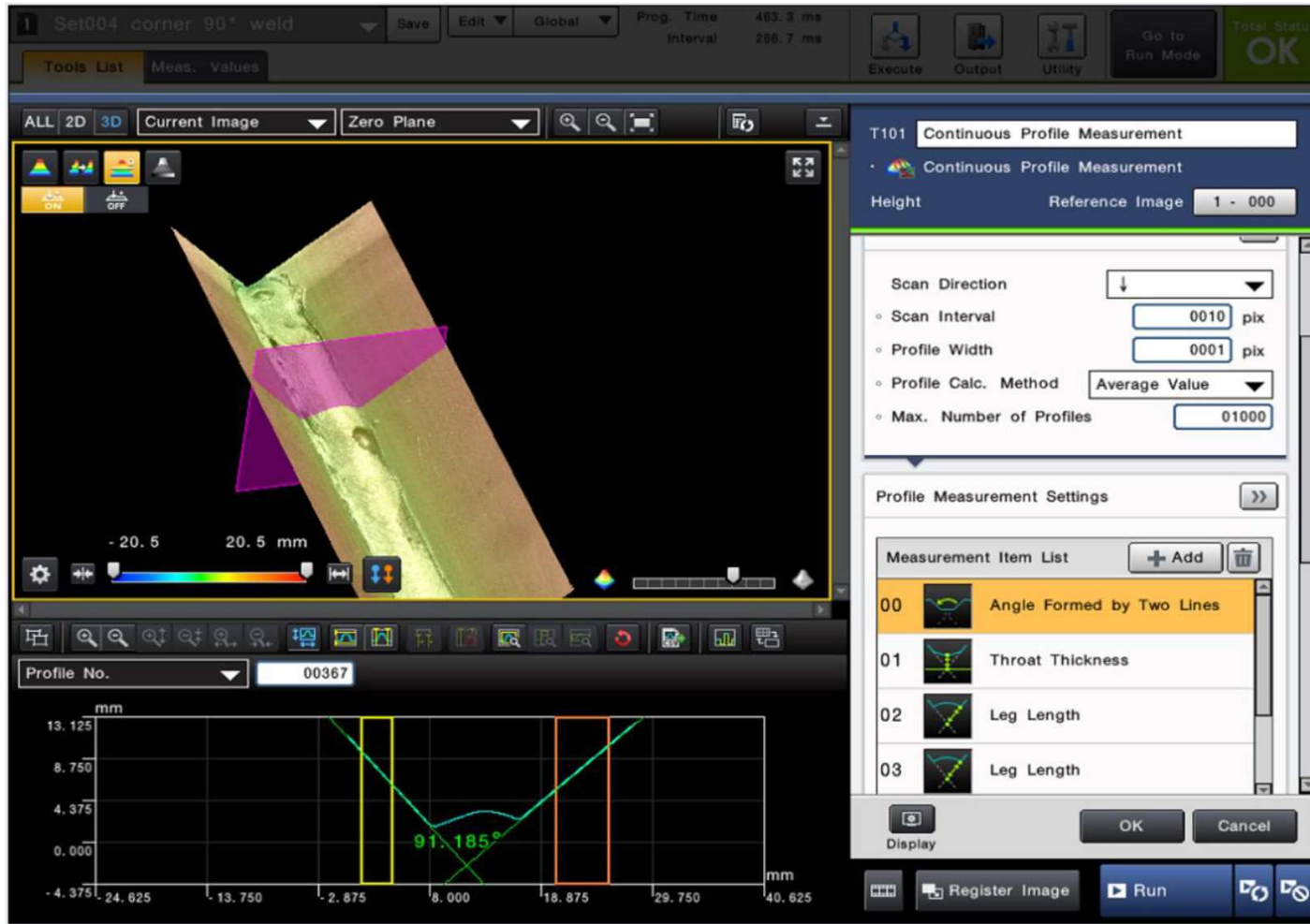


Weld profile measurements – related projects

- ▶ SIMS : Sustainable Surfaces by Intelligent Solidification in Manufacturing Systems
- ▶ TOPICS
 - ▶ Advanced sensor systems
 - ▶ Identification of critical topology aspects
 - ▶ 2 processes : Welding and WAAM
 - ▶ Material characterisation (fatigue) testing
 - ▶ Identify new correlations: topology - fatigue life
 - ▶ Fatigue prediction model & algorithm



Weld profile measurements – related projects

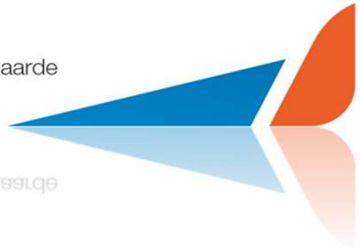




Dr. ir. Koen Faes, EWE
WAAM and Welding R&D

T + 32 9 292 14 03
Koen.faes@bil-ibs.be

Belgisch Instituut voor Lastechniek vzw
Technologiepark-Zwijnaarde 48, B-9052 Zwijnaarde
info@bil-ibs.be | www.bil-ibs.be



info@bil-ibs.be | www.bil-ibs.be
Technologiepark-Zwijnaarde 48, B-9052 Zwijnaarde
Belgisch Instituut voor Lastechniek vzw

Joining your future.

