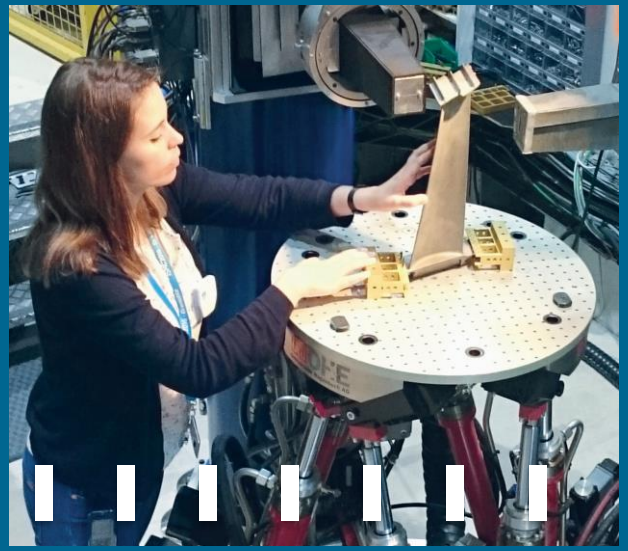
# Developing a TS in a research project - Standardisation of residual stress measurement from large-scale research facilities

**HS Booster webinar, Feb 15, 2024**

Nikolaj Zangenberg
Project Coordinator
Danish Technological Institute



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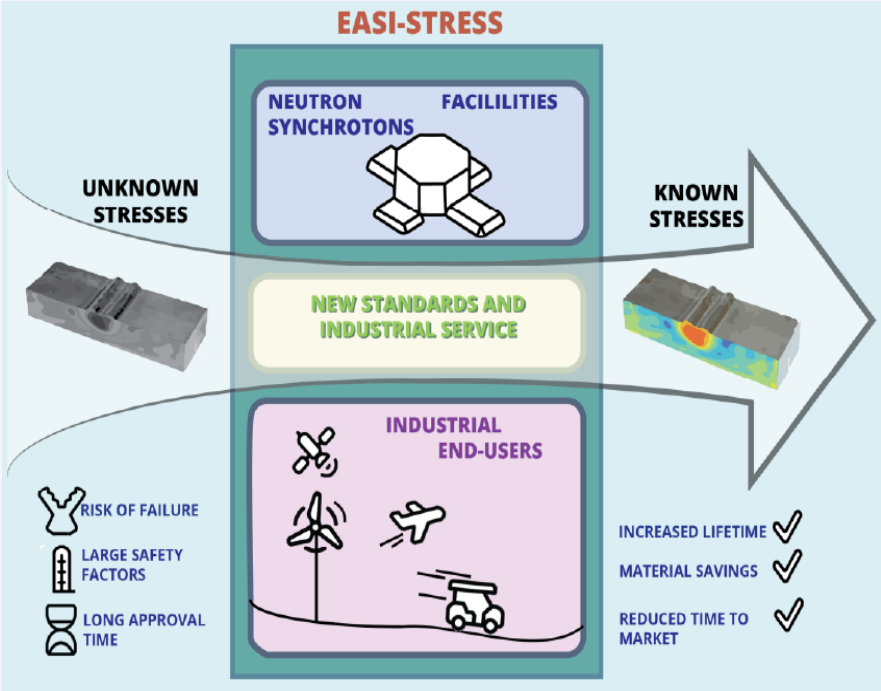
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953219.

EASI-STRESS

# EASI-STRESS: PROJECT GOALS

- Start date: Jan 1st, 2021
- End date: June 30th, 2024
- Budget: EUR 4.5 million



# EASI-STRESS: CONSORTIUM

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DANISH TECHNOLOGICAL INSTITUTE (Coordinator)

The University of Manchester

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Advanced Research Facilities

Helmholtz-Zentrum hereon

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Standardisation Body

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synchrotron x-rays

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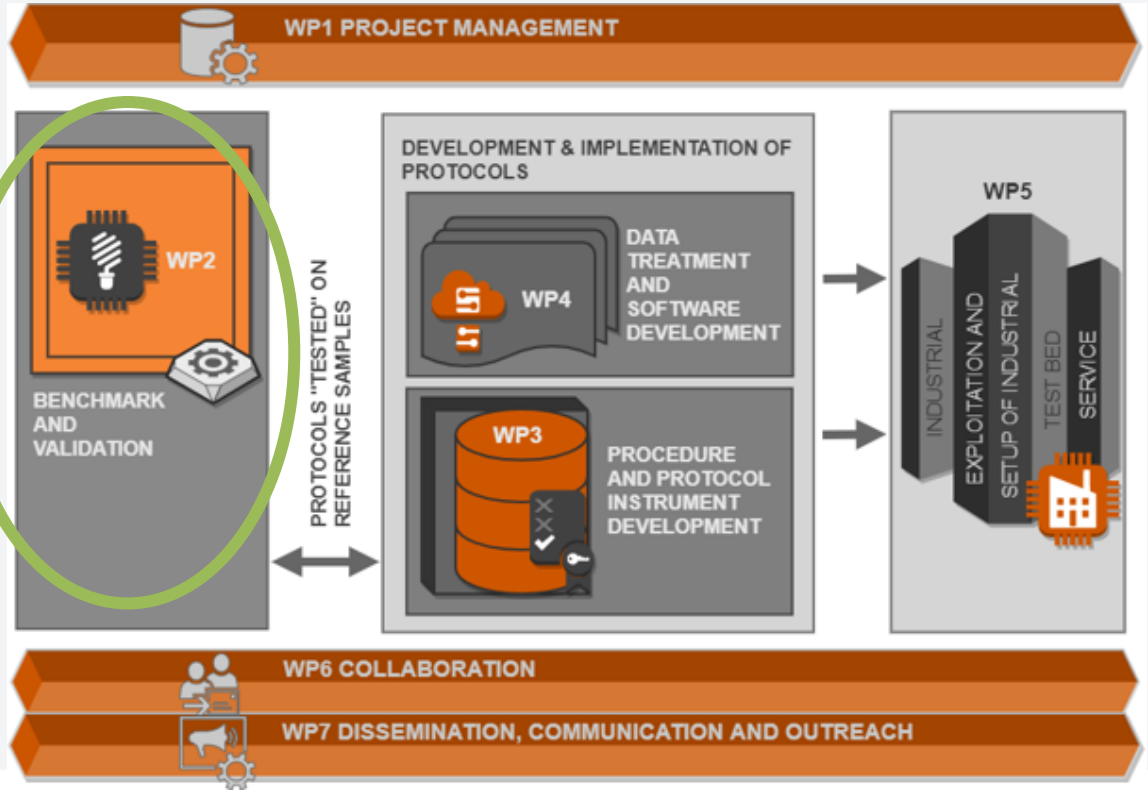
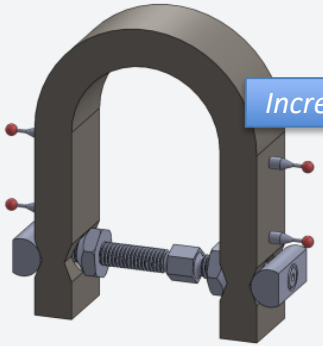
# EASI-STRESS: PROJECT STRUCTURE



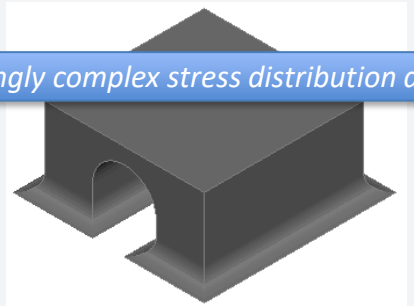
# BENCHMARK SAMPLES

Reference samples manufactured and measurements with several techniques.
Purpose:

- Benchmark different measurement techniques (round robin samples)
- Investigate range of challenges
- Validate applicability as reference/calibration samples for standards



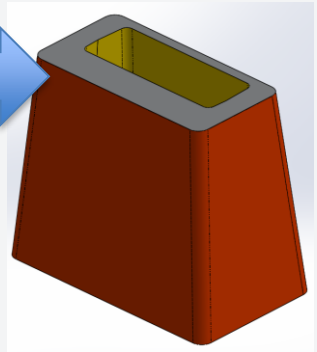
U-flexures/ U-bends
(S355 stainless steel)



Additively manufactured
arches (316 steel)

*Increasingly complex stress distribution and microstructure inhomogeneity*

Inconel GTAW welded
plates *(NeT project)*



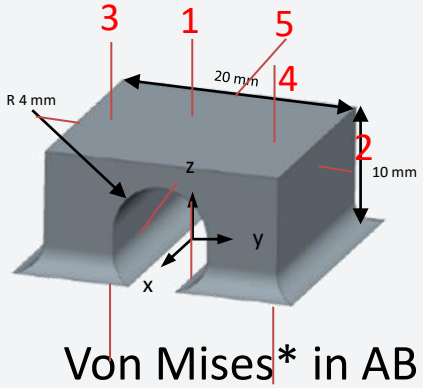
Cast wedge (AlSiMg)

# MEASUREMENT SUMMARY

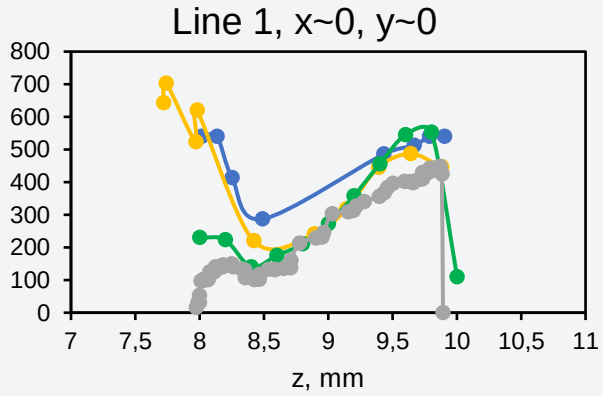
| Technique | U-forms | AM Arches | Weldment | Wedges |
|---|---|---|---|---|
| Neutron D | Flexures ○<br>Bend ○ | As-built ○<br>Heat treated ○ | Completed by NeT ○ | ○ |
| Sync XRD | Flexures ○<br>Bend ○ | As-built ○<br>Heat treated ○ | ○ | ○ |
| Contour method | Bend ○ | As-built ○<br>Heat treated ○ | Completed by NeT ○ | ○ |
| Lab XRD | Bend ○ | As-built ○<br>Heat treated ○ | N/A | N/A |
| Hole drilling | Bend ○ | As-built ○<br>Heat treated ○ | N/A | ○ |
| Process models | ○ | ○ | ○ | ○ |

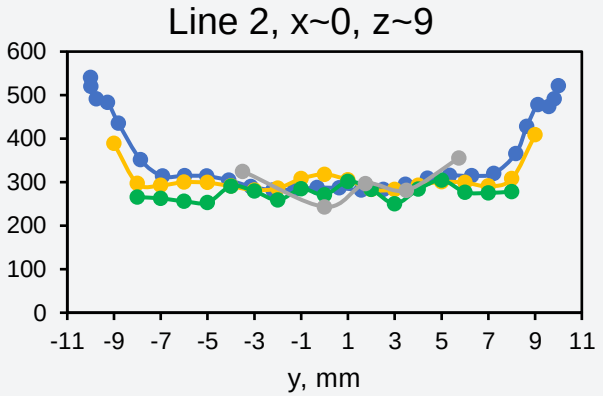
○ Nearing completion (publication ready)
○ Incomplete/pending
○ Caveat

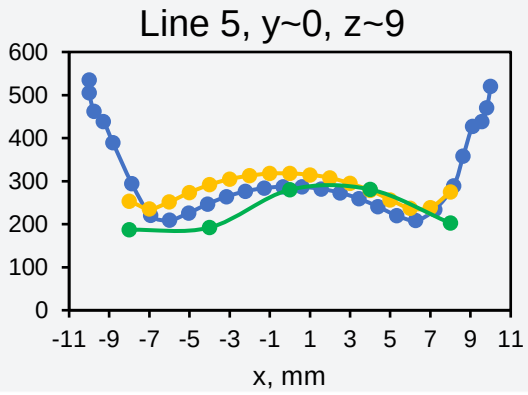
# SIMULATION VERSUS EXPERIMENTAL

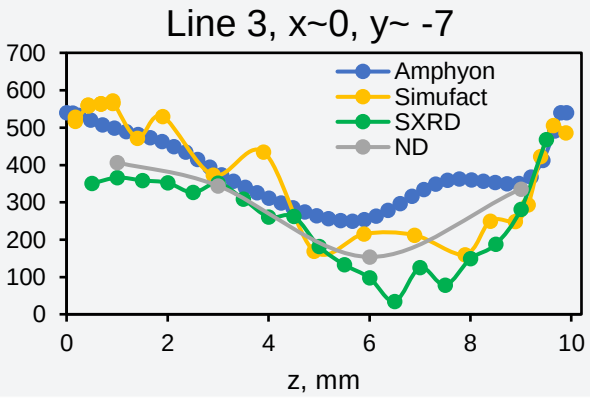


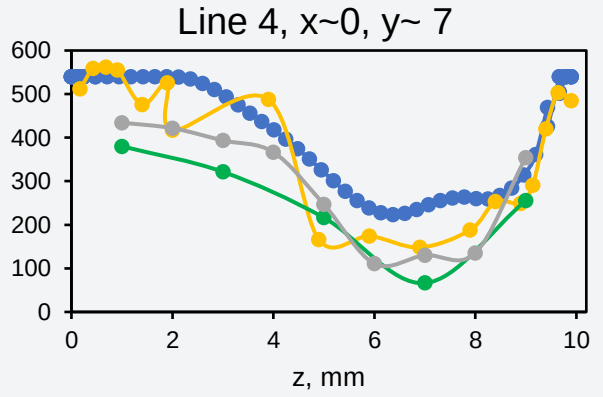

Von Mises* in AB

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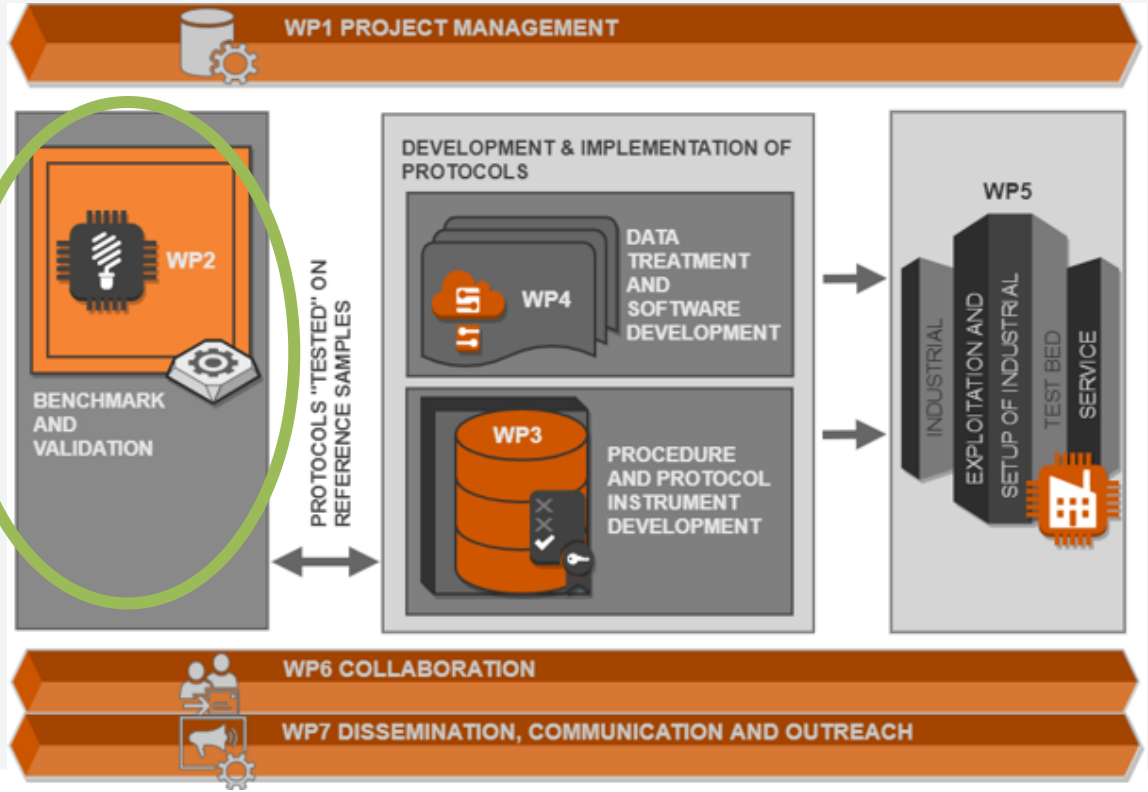
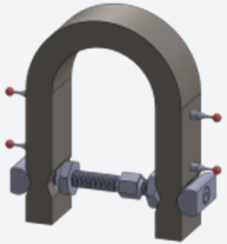
# EASI-STRESS: PROJECT STRUCTURE





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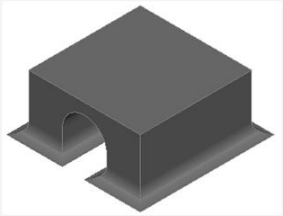

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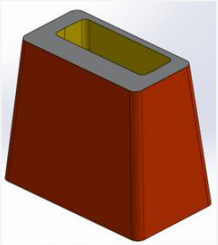
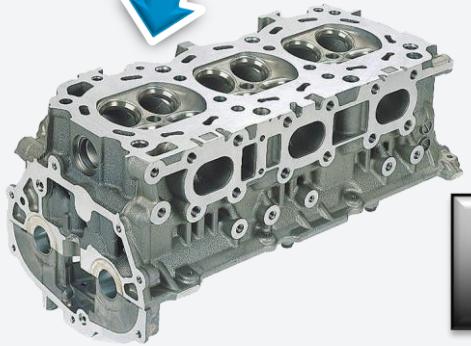


Cast wedge (AlSiMg)

From ”simple”
benchmark samples



To real industrial
case components

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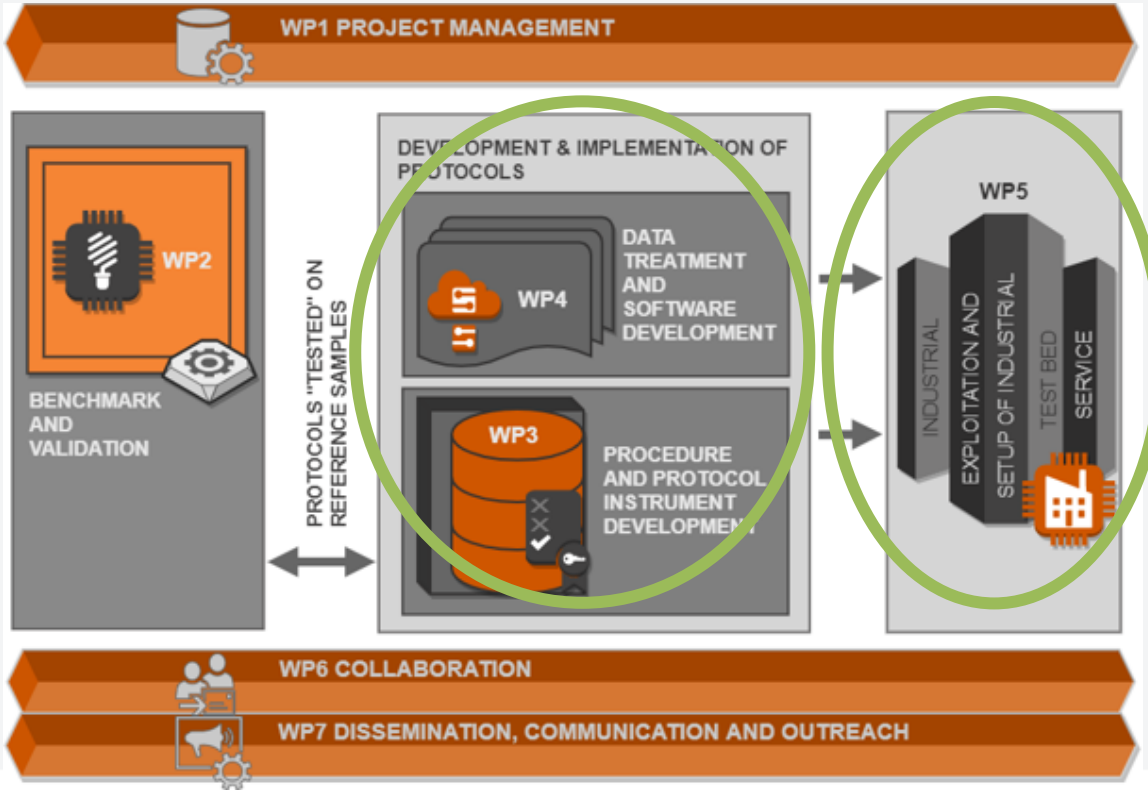
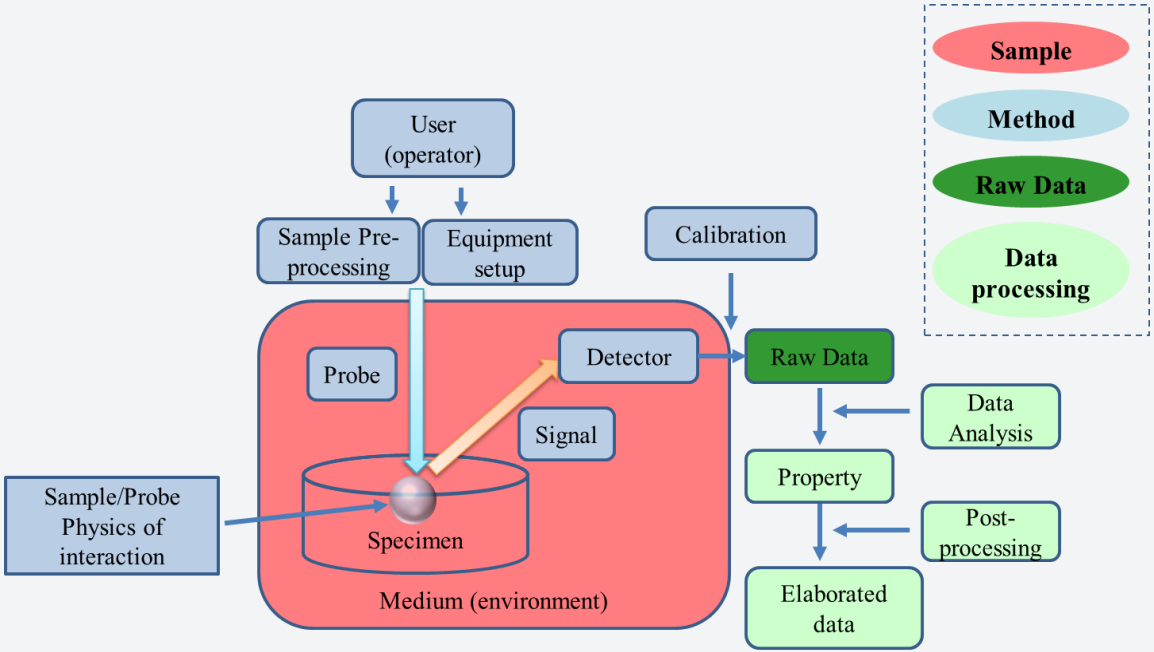
# EASI-STRESS: PROJECT STRUCTURE



# CWA FOR CHARACTERIZATION DATA : CHADA




CEN WORKSHOP AGREEMENT

CWA 17815

October 2021

ICS 07.120; 17.020

English version

Materials characterisation - Terminology, metadata and classification

This CEN Workshop Agreement has been drafted and approved by a Workshop of representatives of interested parties, the constitution of which is indicated in the foreword of this Workshop Agreement.

The formal process followed by the Workshop in the development of this Workshop Agreement has been endorsed by the National Members of CEN but neither the National Members of CEN nor the CEN-CENELEC Management Centre can be held accountable for the technical content of this CEN Workshop Agreement or possible conflicts with standards or legislation.

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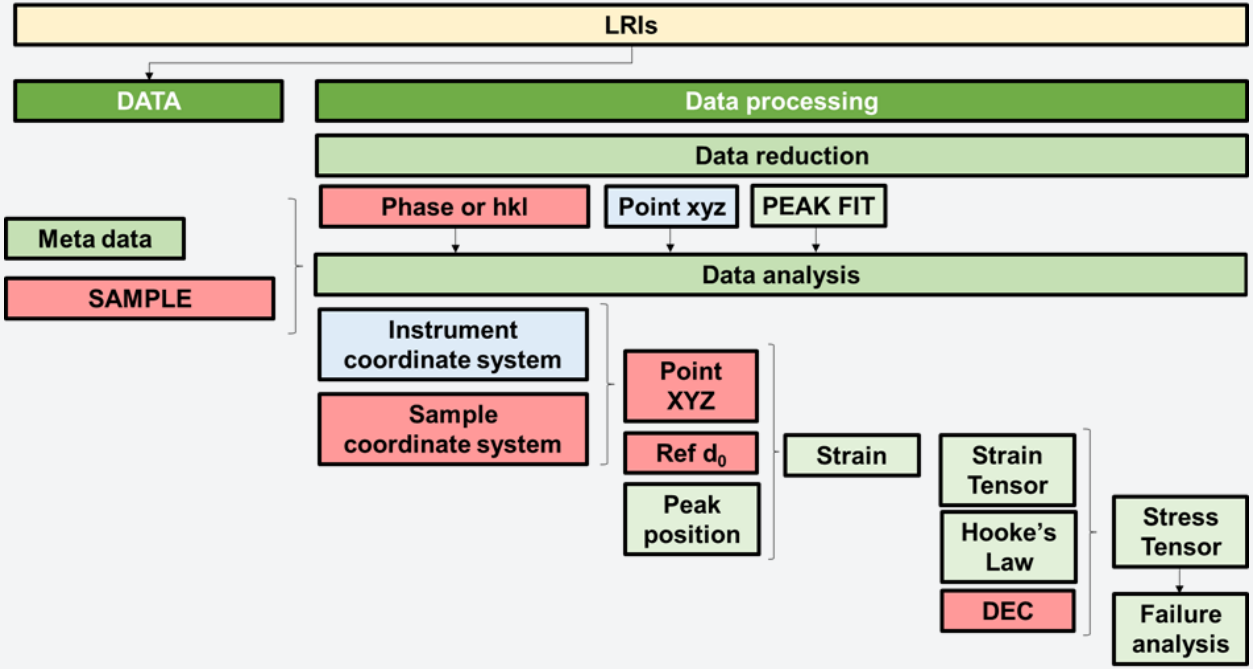
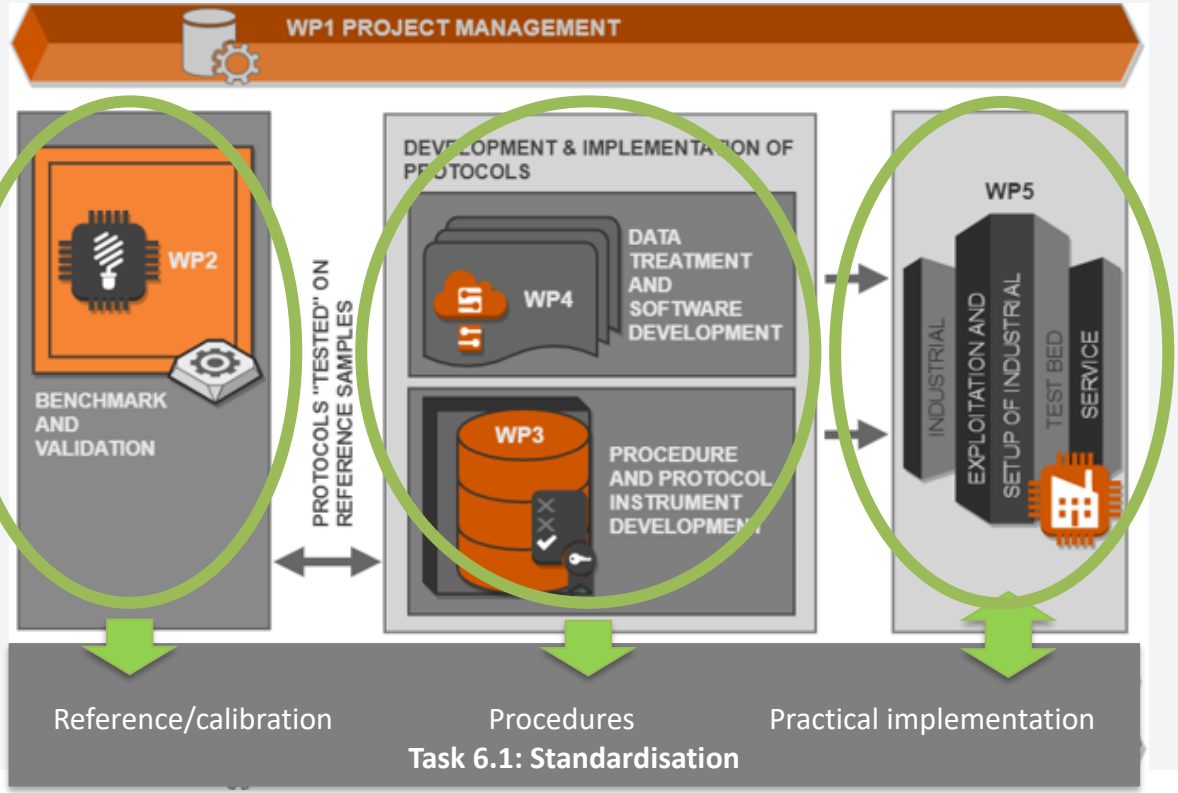
EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

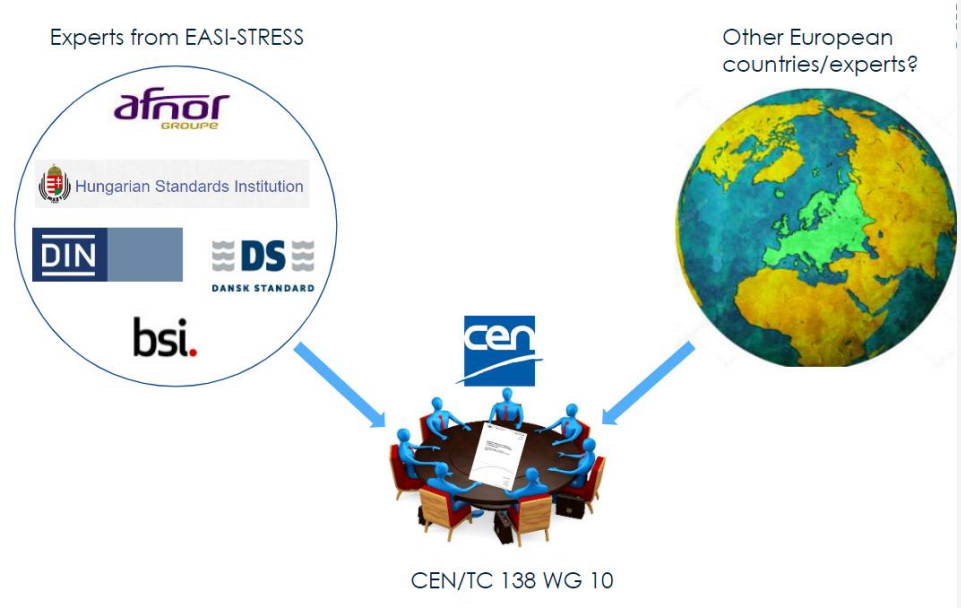
# CHADA ADOPTED TO SYNCHROTRON AND NEUTRON DIFFRACTION STRESS MEASUREMENT : WORKFLOWS

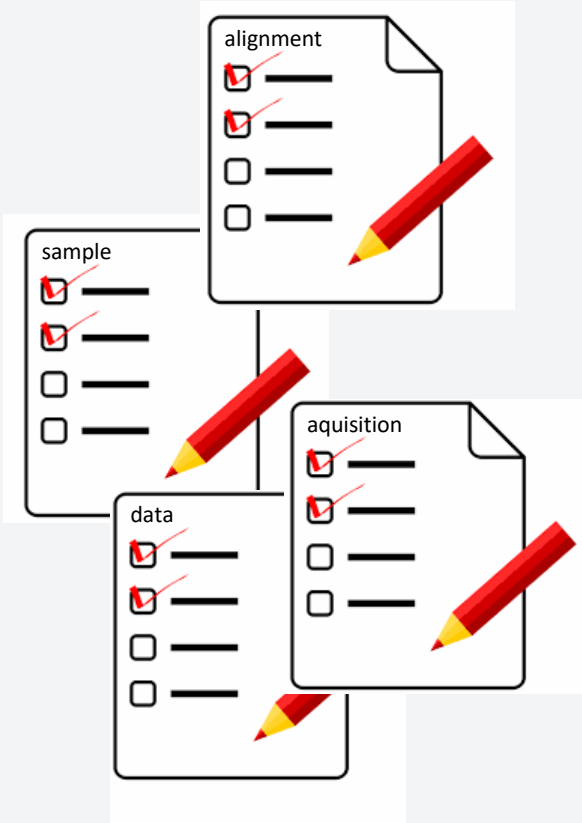


# EASI-STRESS: PROJECT STRUCTURE



# EASI-STRESS STANDARDISATION EFFORT




Why?

Standards are the language of industry

# EASI-STRESS: CONSORTIUM (POINT #3)

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# STANDARDISATION EFFORT – SUPPORTED BY EASI-STRESS

May 2022: New Work Item Proposal submitted

Oct-Dec 2022: Formal opening of TC138/WG10

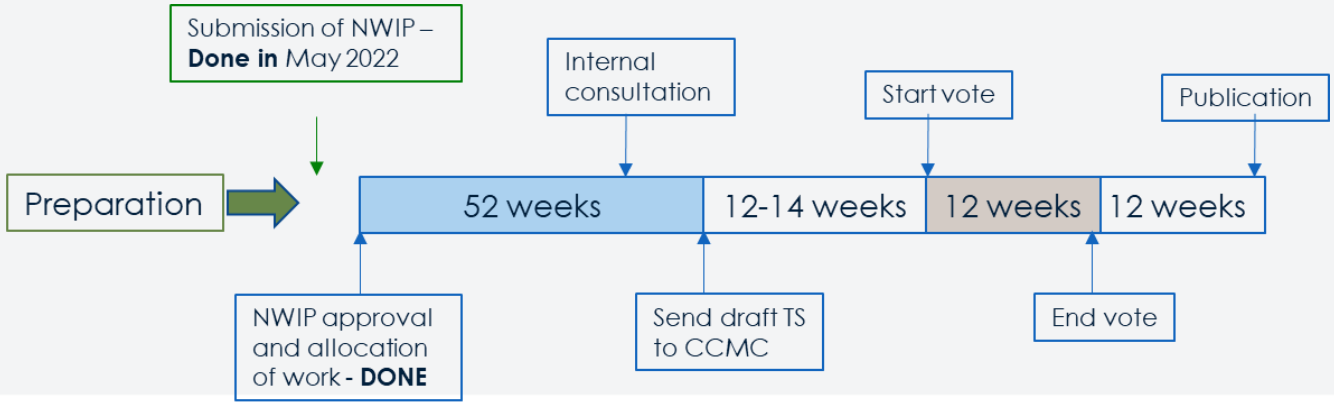
Jan 2023: First WG10 meeting

Oct 2023: Working Draft sent to CEN TC 138 for input

- based on input from EASI-STRESS work packages

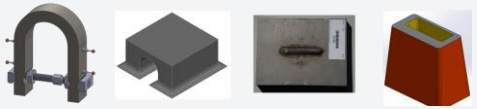
Jan/Feb 2024: Final draft sent to TC138 for vote

max. 52 weeks



# INTEGRATION OF EASI-STRESS WORK INTO WG10

**The following EASI-STRESS deliverables will be used as background to draft the TS:**



Benchmark samples (WP2)

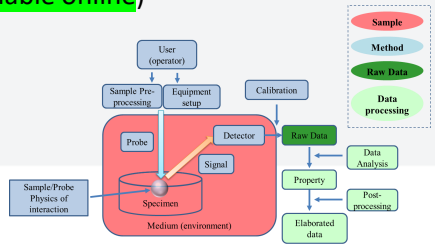
- D2.1 Benchmark samples and relevant information for their manufacture developed (approved – available online)
- D2.2 Development of best practice in correlation of modeled and measured stress data This includes details to consider during modelling and experiments and reporting formats (approved – available online)
- D2.3 Round-robin results from laboratory techniques and synchrotron and neutron facilities (approved – available online)

Measurement procedures (WP3):

- D3.1 Report on technical specifications as identified in collaboration with the industrial users and at the interface with WP2, WP4 and WP5 (approved – available online)
- D3.2 Report on SOPs for instruments dedicated to bulk analysis and to near-surface analysis (approved – available online)

Software and data treatment (WP4):

- D4.1 Report on definition of a common framework to handle experimental parameters in algorithms (approved – not public)
- D4.2 Technical report with the mathematical formalisms equations dedicated technical drawings and diagrams that describes coordinate systems variables workflows for data processing and that includes the description of the experimental parameters to be included in FE-modelling software (approved – available online)

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# THE SYNCHTROTRON XRD TECHNICAL SPECIFICATION

## Clause 1-4: Scope, Normative references, Terms and definitions, Symbols and abbreviated terms

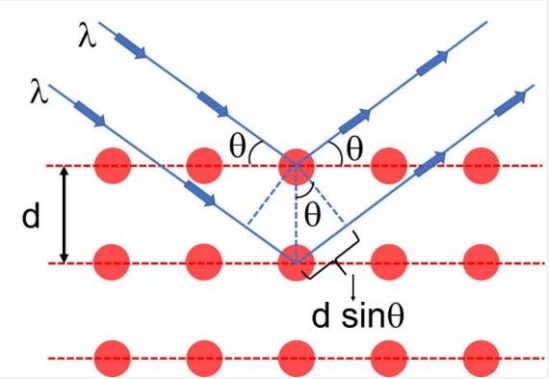
*Compare and align with:*

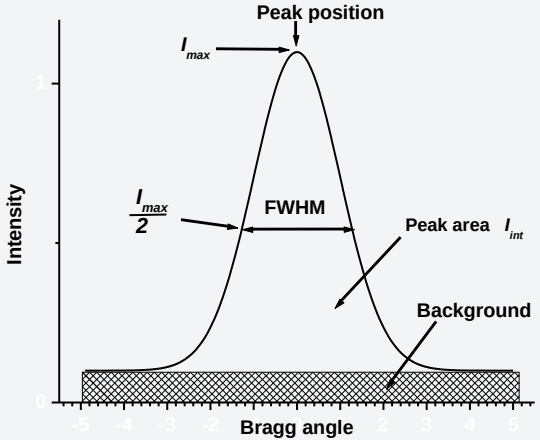
- *EN 15305 Non-destructive testing - Test method for residual stress analysis by X-ray diffraction*
- *ISO 21432:2019 Non-destructive testing — Standard test method for determining residual stresses by neutron diffraction*
- *ASTM E837 Test Method for Determining Residual Stresses by the Hole-Drilling Strain-Gage Method*
- *ASTM E2860 Test Method for Residual Stress Measurement by X-Ray Diffraction for Bearing Steels*
- *HS-784 (SAE International) Residual Stress Measurement by X-Ray Diffraction*

# THE SYNCHTROTRON XRD TECHNICAL SPECIFICATION

Clause 1-4: Scope, Normative references, Terms and definitions, Symbols and abbreviated terms

Clause 5: Summary of synchrotron XRD measurement method



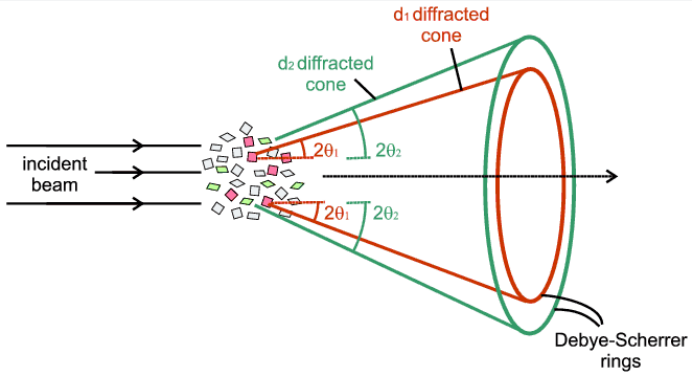



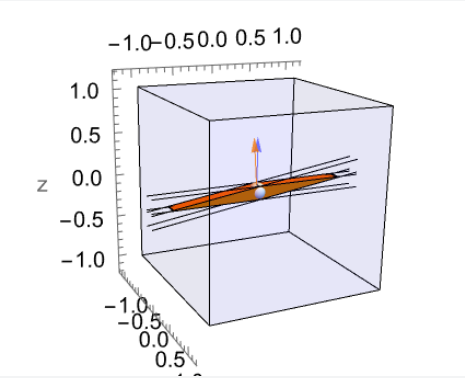
# THE SYNCHTROTRON XRD TECHNICAL SPECIFICATION

Clause 1-4: Scope, Normative references, Terms and definitions, Symbols and abbreviated terms

Clause 5: Summary of synchrotron XRD measurement method

Clause 6: Preparation of measurement and calibration



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Clause 5: Summary of synchrotron XRD measurement method

Clause 6: Preparation of measurement and calibration

Clause 7: Measurement and recording requirements

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Clause 6: Preparation of measurement and calibration

Clause 7: Measurement and recording requirements

Clause 8: Data analysis and stress calculation

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Clause 6: Preparation of measurement and calibration

Clause 7: Measurement and recording requirements

Clause 8: Data analysis and stress calculation

Clause 9: Reporting

# THE SYNCHTROTRON XRD TECHNICAL SPECIFICATION

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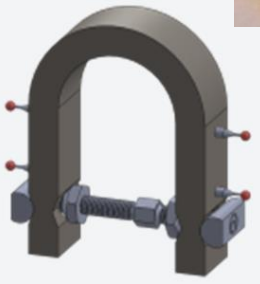
Clause 8: Data analysis and stress calculation

Clause 9: Reporting

Annex: Proposals for benchmark samples



# EASI-STRESS STRATEGY TOWARDS AM STANDARDS

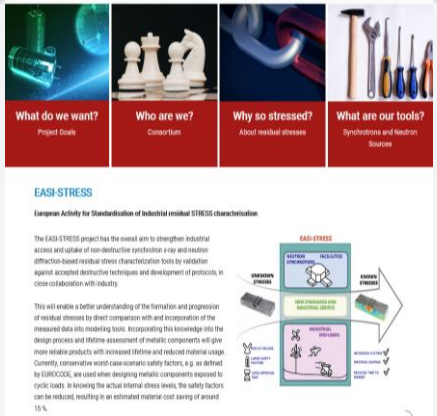
| Engagement in standardisation work | Level of engagement |
|---|---|
| CEN TC 138 (*NDT*), WG10 (*Diffraction*) has been initiated by EASI-STRESS to develop a TS for residual stress measurement using synchrotron XRD where specific reference to AM will be made. | LEVEL 3: Recommendation/requirement to employ residual stress measurement in qualification |
| CEN TC 438 (*Additive Manufacturing*): Volum-e has the role of chairman of TC 438 and will work to propose the inclusion of residual stress measurement standards (and the TS from TC 138) as tools to assess stresses in AM. | LEVEL 3: Recommendation/requirement to employ residual stress measurement in qualification |
| ISO TC 261 (*Additive Manufacturing)*: Residual stress NDT measurements will be brought into attention to the WG3 “Test methods”. | LEVEL 1: Mention of residual stresses as a parameter of relevance in the standards |
| ECSS: OHB will emphasize the relevance of NDT residual stress measurements in alignment with residual stress simulations for the prediction of residual stresses in revision of ECSS-Q-ST-70-80C *(Processing and quality assurance requirements for metallic powder bed fusion technologies for space applications)* | LEVEL 2: Mention of NDT measurement of residual stresses as a possibility |
| ASM: DTI will participate in the ASM Residual Stress Technical Committee. | LEVEL 2: Mention of NDT measurement of residual stresses as a possibility |

# MAIN LEARNINGS AND ADVISE

- Standardisation is on a different planet than research
- Take care of the timing (project plan vs. CEN process)
- Choose consortium partners strategically
  - does your project have critical mass to drive a standardisation process?
  - are you covered geographically?
  - are the partners aware of their roles in the process?
- Map the alternatives for your technology (will someone oppose your standardisation process?)

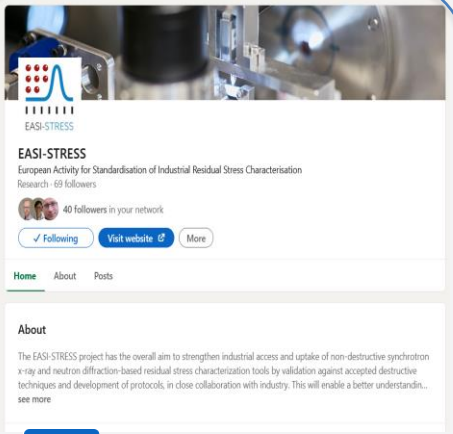
# ENGAGING STAKEHOLDERS

Ensuring broad industrial adaptation of the new techniques




Homepage: [www.easi-stress.eu](http://www.easi-stress.eu)

Form for registration of interest




LinkedIn Showcase

Public webinars to share technical insights

Thank you …