Framework for smart condition reassessment of **Re**claimed **Ti**mber to e**X**tend the service life of long-lived wood products using non-destructive testing and automated data postprocessing.

Funded by the European Union

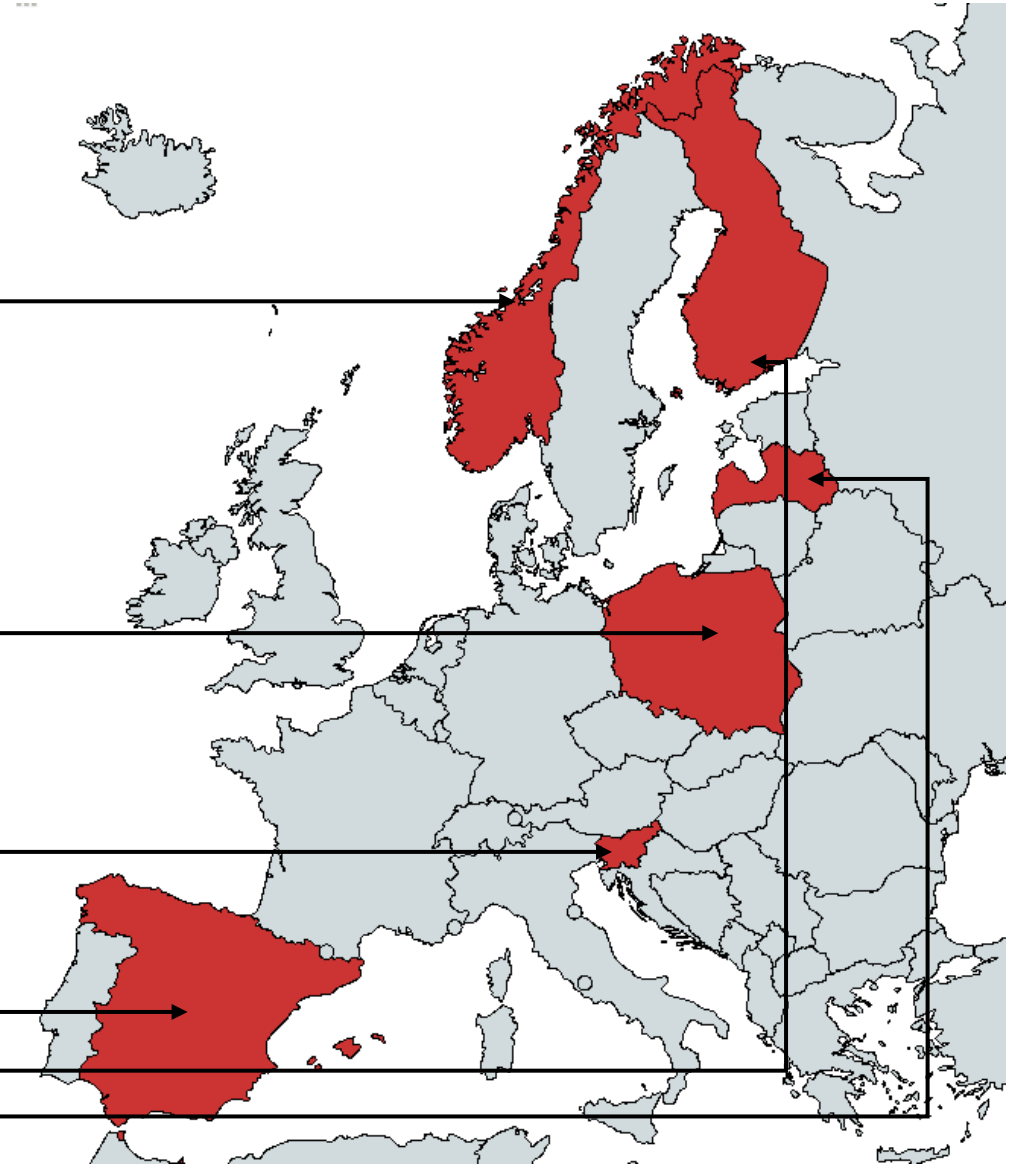
Grant agreement ID: 101094340

ForestValue2

Budget: 1.36 MEUR

8 partners from 5 countries:

- **Norway** –SINTEF, coordinator
  - Rambøll (industrial partner)
  - Trondheim Municipality (public partner)
- **Poland**: Warsaw University of Technology
- **Slovenia**: Slovenian National Building and Civil Engineering Institute
- **Spain**: Universidad Politécnica de Madrid
- **Finland**: Aalto University
- **Latvia**: Vidzemes University of Applied Sciences



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The essential goals of the proposed **TiReX** project are:

- identifying the **set of non-destructive tests (NDTs)** that are most suitable for comprehensive and efficient **condition assessment** (i.e., density, stiffness, strength, fire resistance, defects, moisture content, fibre direction) in wood that is feasible for in-situ as well as laboratory setting

- developing procedures for the **data postprocessing** from NDTs for the highest information value output and combined **risk/reliability quantification** with an extensive metadata template for data repositories

- testing the developed methodology on a **real case study for the adaptive reuse of a 5-story timber office** building

- establishing **circularity quantification** based on the real potential and Life-Cycle Assessment procedure for long-lived timber products, including risk quantification over multiple reuse and recycling/recovery – **timber cascading**

- developing documentation and a **re-certification guideline** for reclaimed timber as the basis for European standardization

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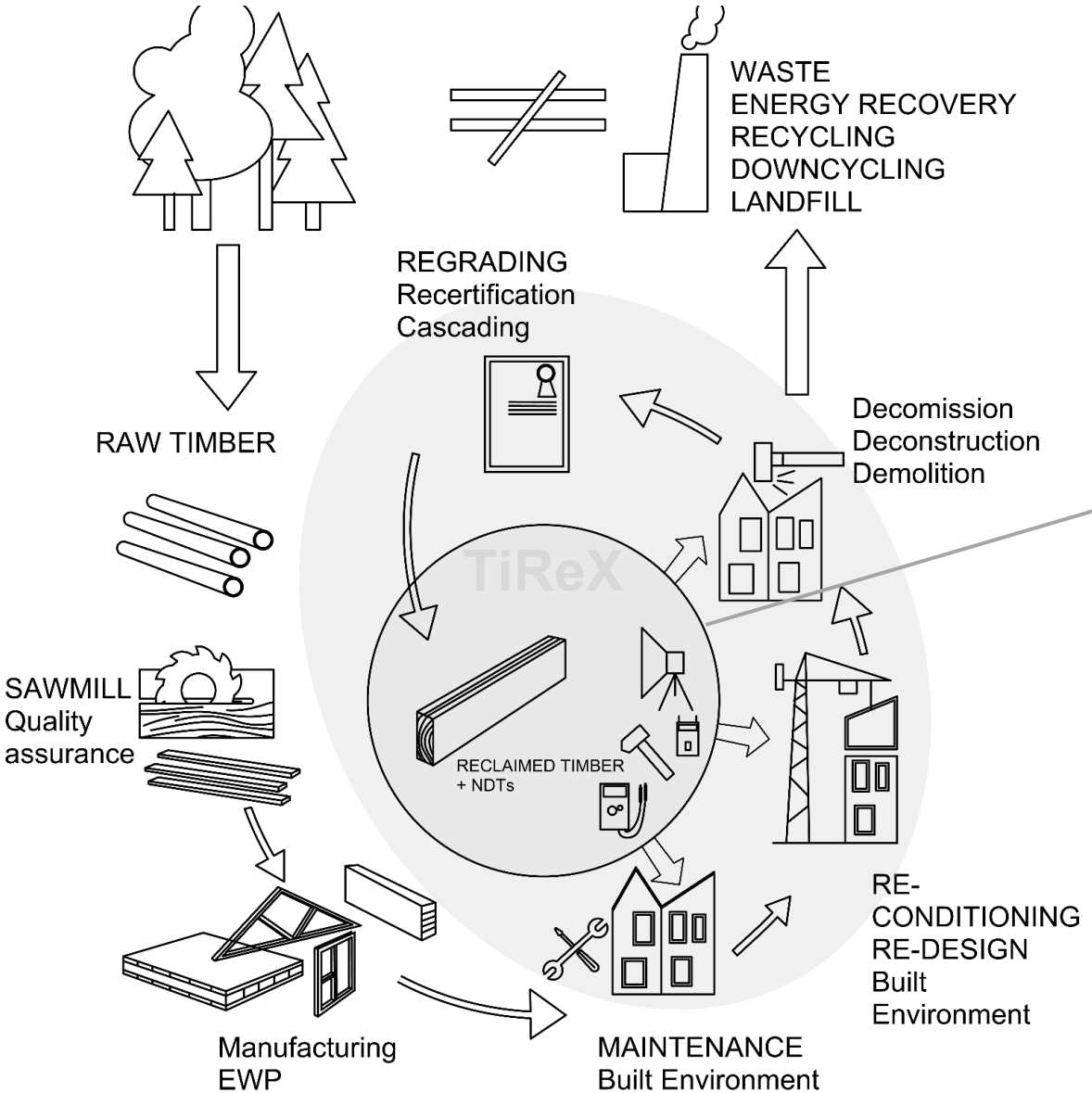

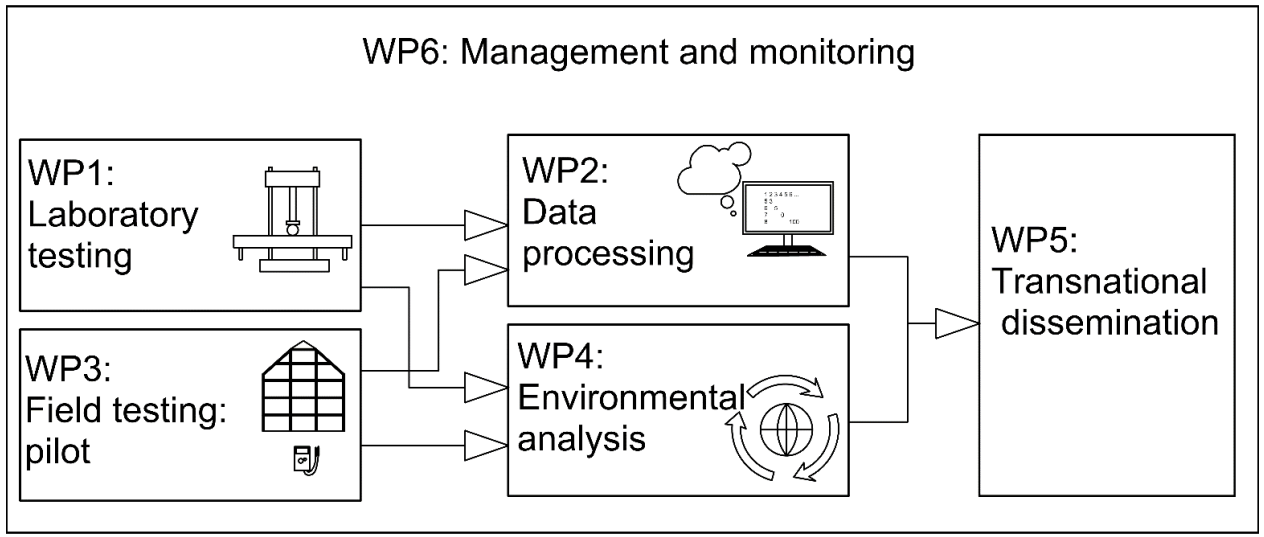

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WP1. Laboratory testing of reclaimed timber specimens. *UPM*

- T1.1 Reclaimed timber inventory
- T1.2 NDTs procedure
- T1.3 Grading criteria
- T1.4 Performing NDT and destructive testing
- T1.5 Fire testing: ignition, fire spread, charring rate

T1.6 Test data processing, digitalisation and sharing for WP2 tasks

WP2. Advanced data processing *WUT*

- T2.1 Numerical wood material model for assisting in NDTs result interpretation

T2.2 Timber test models for simulation of NDTs and destructive testing

- T2.3 Analytical and simplified models for NDTs result interpretation and data processing

T2.4 Statistical analysis of the data, result visualisation

WP3. Pilot project: adaptive reuse *SINTEF*

- T3.1 Field NDT measurement plan and implementation
- T3.2 Laboratory sample testing
- T3.3 Performance evaluation based on test data

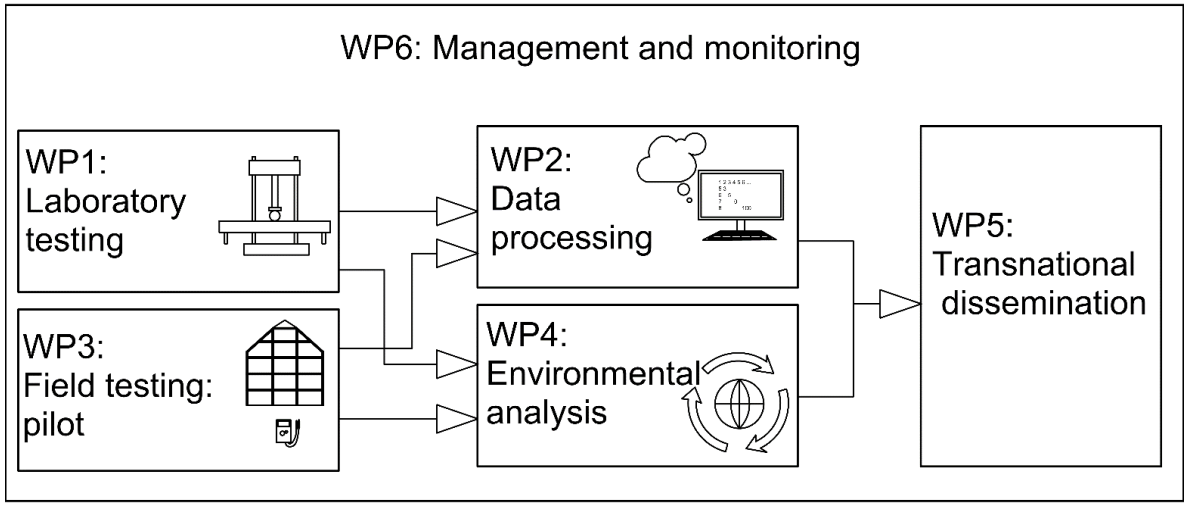
T3.4. Environmental analysis

WP4. Environmental analysis: life cycle assessment (LCA), *Aalto*

- T4.1: Materials stock and flow analysis
- T4.2: Inventory data analysis

T4.3: LCA and LCC for recovered wood and primary wood

T4.4: Impact of the cascading utilisation



WP5. Dissemination and communication *VUAS*

WP6. Project monitoring and management. *SINTEF*

WP1. Laboratory testing of reclaimed timber specimens.

T1.1 Reclaimed timber inventory

INTERNATIONAL CAMPAIGNED OF TESTING RECLAIMED TIMBER

PARTNER	Country	Type	Provenance	GOAL	Species	Cross-section	Length	Source	Collected	Tested
UPM	Spain	Floor beams	Navarre Basque C.	200	European oak	135x150	3300	Deconstruction	98	98
					Pine	150x150	3000	Deconstruction	0	0
ZAG	Slovenia	Beam	Upper Carniola	50	Norway Spruce	70-170/70-200	2500-3800	Deconstruction	50	All visual graded, tests in Dec.
SINTEF	Norway	Beam/column	Trondheim	200	Norway Spruce	100-280	1700-4100	Deconstruction	94	54
			Bergen		Scots pine	150-220	3800-3900	Deconstruction	4	4
WUT	Poland	Beam	Mazovia	200	Spruce	75-280	2300-6300	Deconstruction	135	100

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WP1. Laboratory testing of reclaimed timber specimens.
T1.1 Reclaimed timber inventory

WP1. Laboratory testing of reclaimed timber specimens.
T1.2 NDTs procedure
T1.3 Grading criteria

1. GENERAL (code, species, source, year)
2. GEOMETRY (nominal)
3. VISUAL (knots, slope of grain)
4. ACOUSTIC (stress waves, ultrasound)
5. VIBRATIONS (longitudinal + transverse, mass)
6. DENSITY (resistograph, volume+mass, IML-Resi, Pilodyn)
7. MECHANICAL DESTRUCTIVE
8. DRY OVEN DENSITY

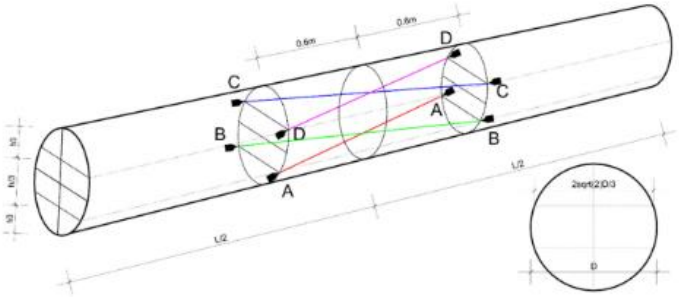


Fig. C1 Pundit measurements (Katarzyna-SINTEF)

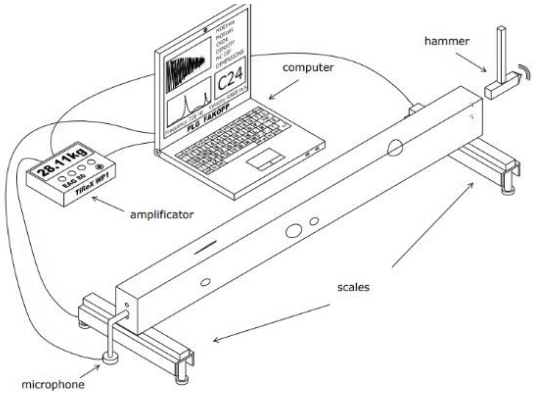
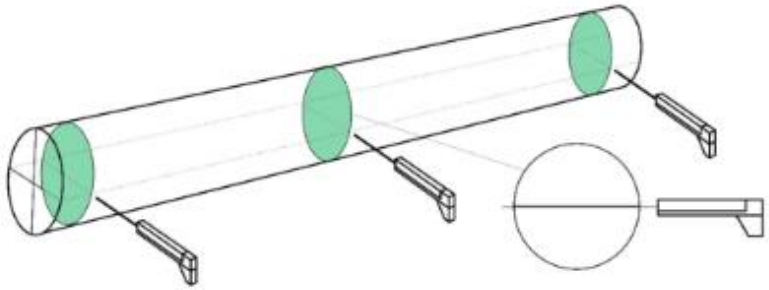


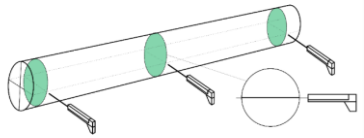
Fig. 8 Portable Lumber Grader with balances (adapted from Llana 2016)

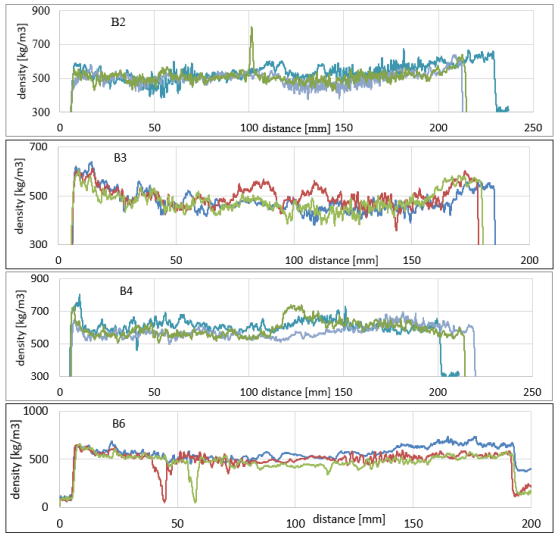


WP1. Laboratory testing of reclaimed timber specimens.

T1.4 Performing NDT and destructive testing

RINNTECH
Resistograph 650-EA





WP1. Laboratory testing of reclaimed timber specimens.
T1.5 Fire testing: ignition, fire spread, charring rate *ZAG*

TEST MATRIX → SAMPLE CUTTING → SAMPLE CLIMATIZING → TESTING IN ZAG

BENCH-SCALE
HEAT FLUX x3
DEGRADATION x3
REPETITIONS x4

BENCH-SCALE
HEAT FLUX x1
DEGRADATION x3
REPETITIONS x4

LARGE-SCALE
FIRE CURVE x1
SIZE x2
COOLING x2
REPETITIONS x4

SLOVENIA
NORWAY
POLAND
SPAIN

SENDING

SLOVENIA

BENCH-SCALE

LARGE-SCALE

WP1. Laboratory testing of reclaimed timber specimens.
T1.5 Fire testing: ignition, fire spread, charring rate *ZAG*

TEST MATRIX → SAMPLE CUTTING → SAMPLE CLIMATIZING → TESTING IN ZAG

BENCH-SCALE
HEAT FLUX x3
DEGRADATION x3
REPETITIONS x4

BENCH-SCALE
HEAT FLUX x1
DEGRADATION x3
REPETITIONS x4

LARGE-SCALE
FIRE CURVEx1
SIZE x2
COOLINGx2
REPETITIONS x4

SLOVENIA
NORWAY
POLAND
SPAIN

SENDING

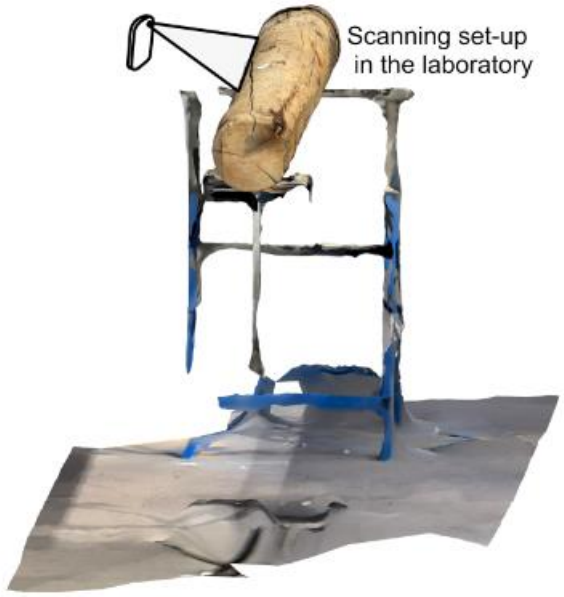
SLOVENIA

BENCH-SCALE

LARGE-SCALE

WP2. Advanced data processing *WUT*

T2.3 Analytical and simplified models for NDTs result interpretation and data processing



LIDAR scan
iPhone: Scaniverse

Preprocessing
iPhone: Scaniverse

Export to .OBJ
iPhone: Scaniverse+email

Import to CAD:
Rhinoceros3D

Geometry cleaning and mesh to solid transformation
CAD: Rhinoceros3D

Export to .IGES
Rhinoceros3D

Data extraction
Grashopper3D

Import to FEA software
DS Abaqus

Geometry simplifaction
Grashopper3D

non-imaging NDT measurements:
ultrasound
drill resistance
moisture content
weight
...
longitudinal vibrations
transverse vibrations
ground penentrating radar

Preprocessing FEA
DS Abaqus

FEA preprocessing
Karamba3D

Running FEA
DS Abaqus

FEA running
Karamba3D

Postprocessing FEA
DS Abaqus

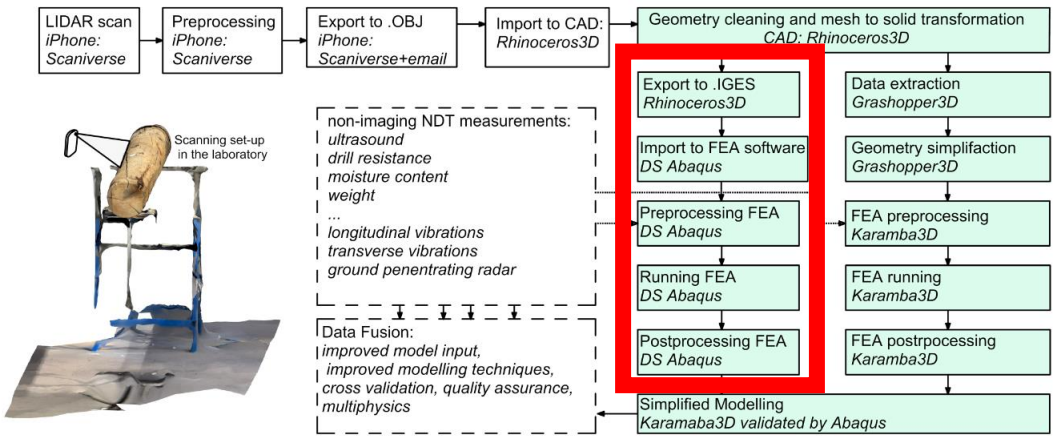
FEA postrpocessing
Karamba3D

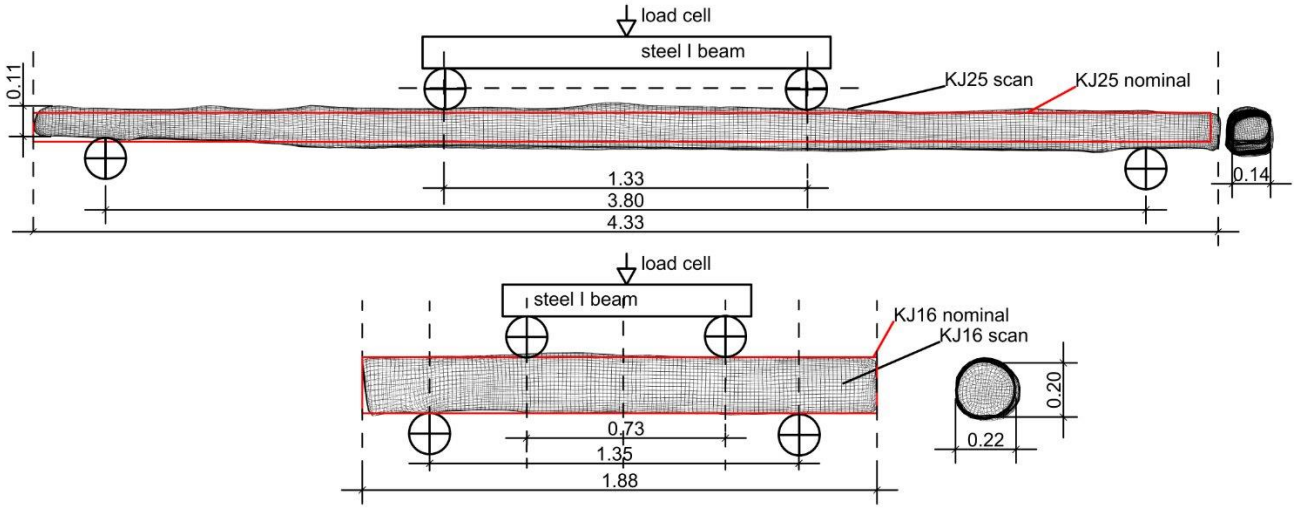
Data Fusion:
improved model input,
improved modelling techniques,
cross validation, quality assurance,
multiphysics

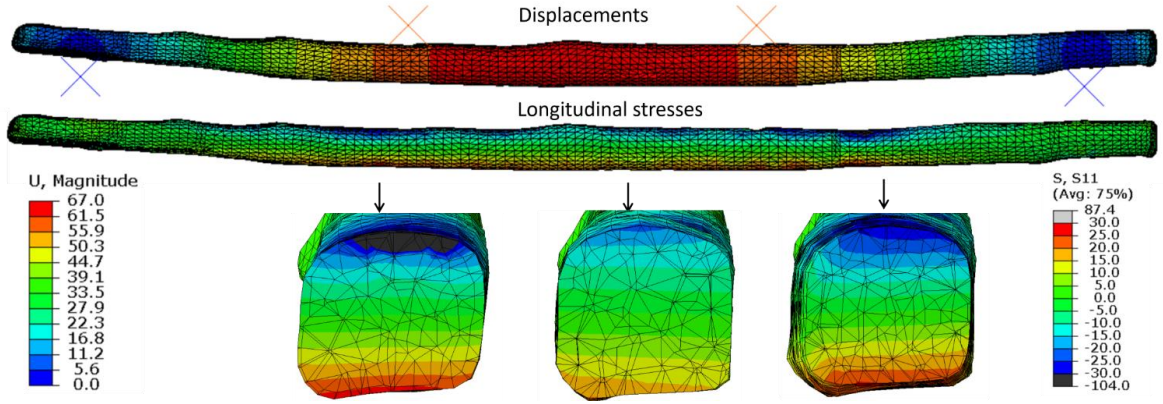
Simplified Modelling
Karamaba3D validated by Abaqus

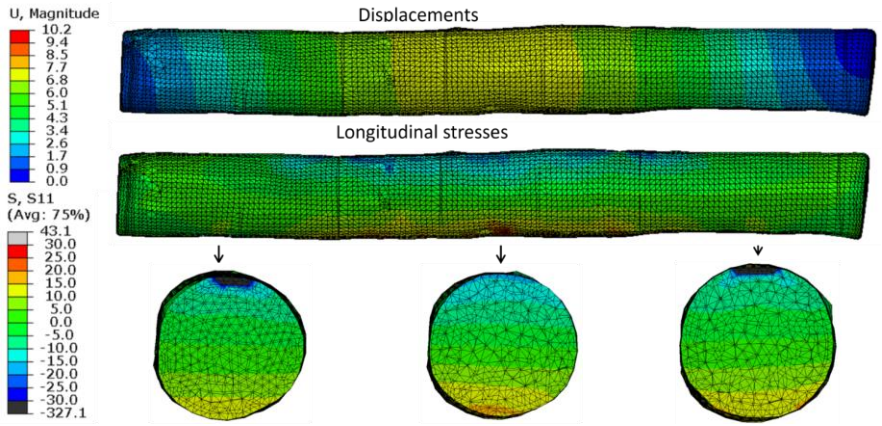
WP2. Advanced data processing *WUT*

T2.3 Analytical and simplified models for NDTs result interpretation and data processing



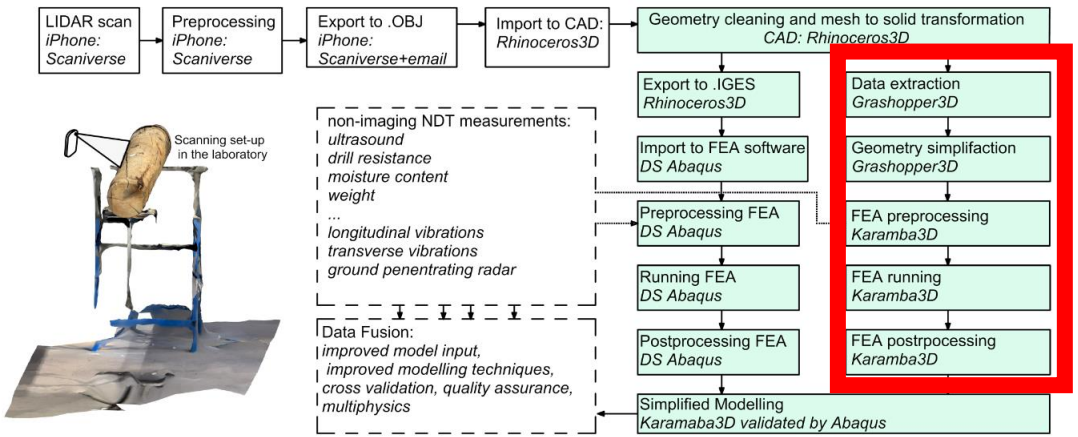


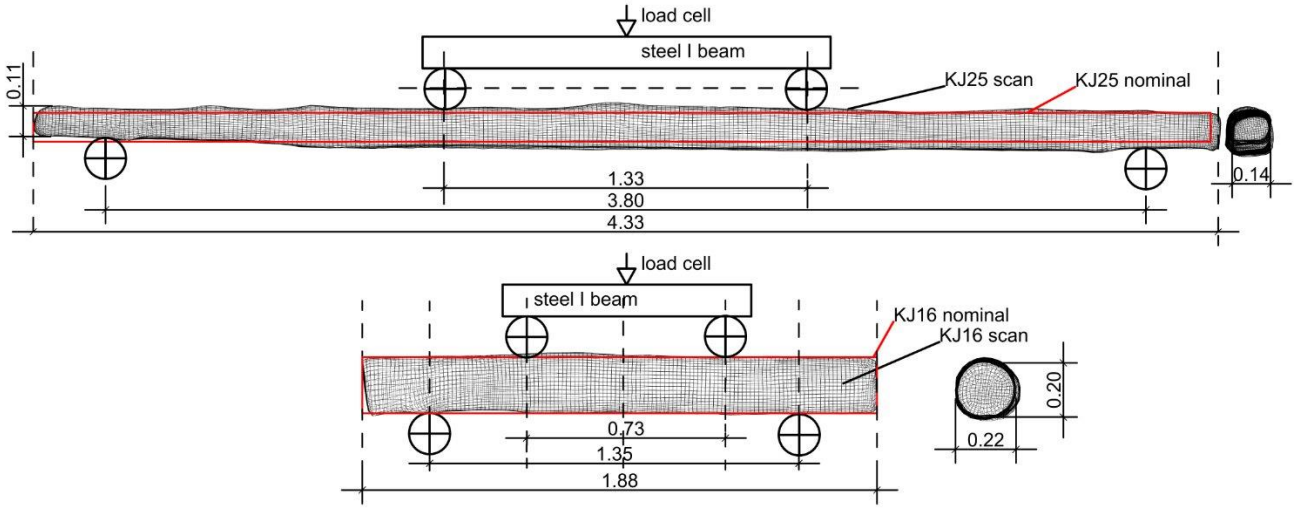


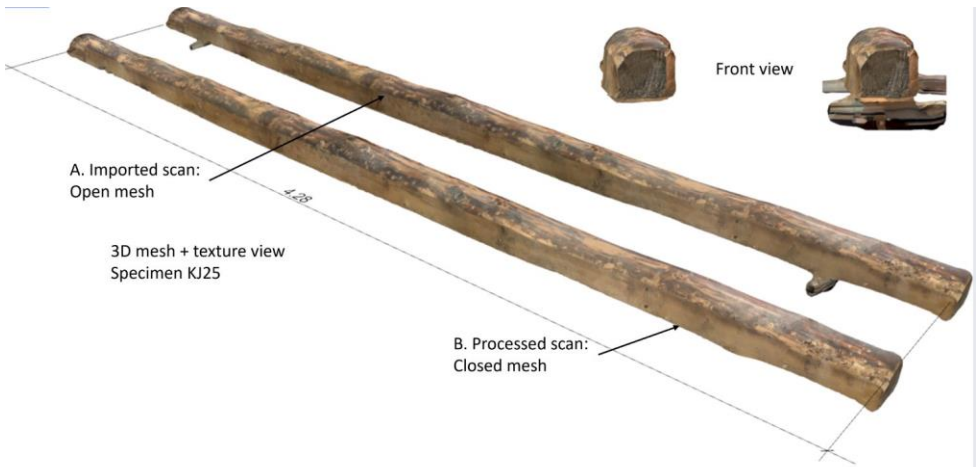


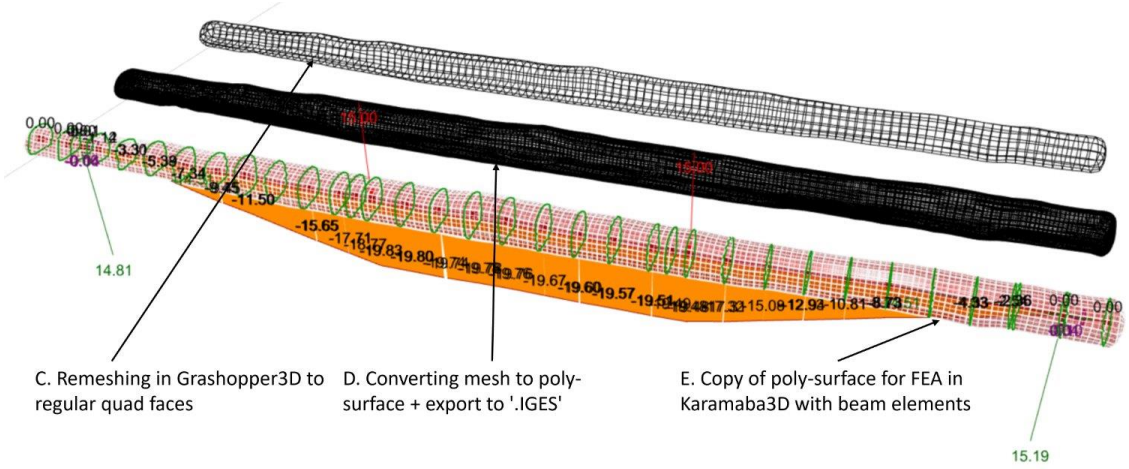
WP2. Advanced data processing *WUT*

T2.3 Analytical and simplified models for NDTs result interpretation and data processing



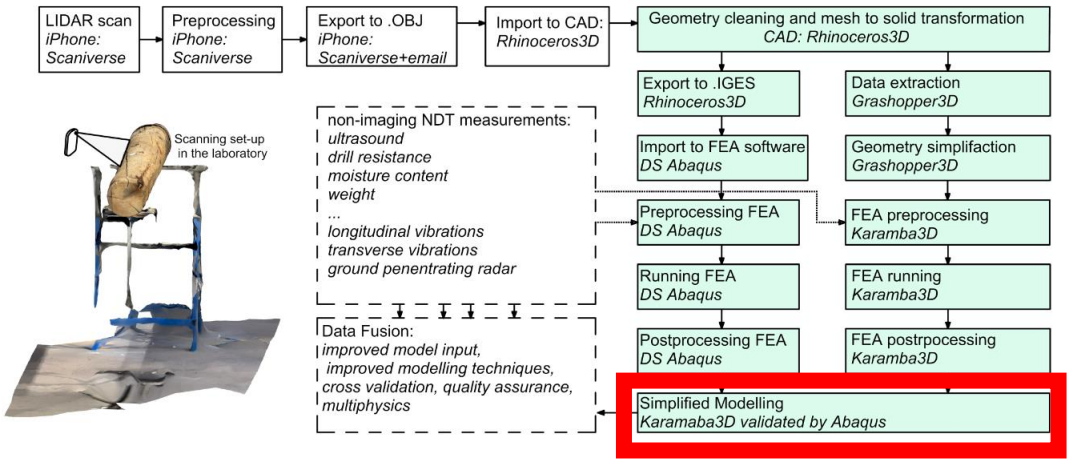


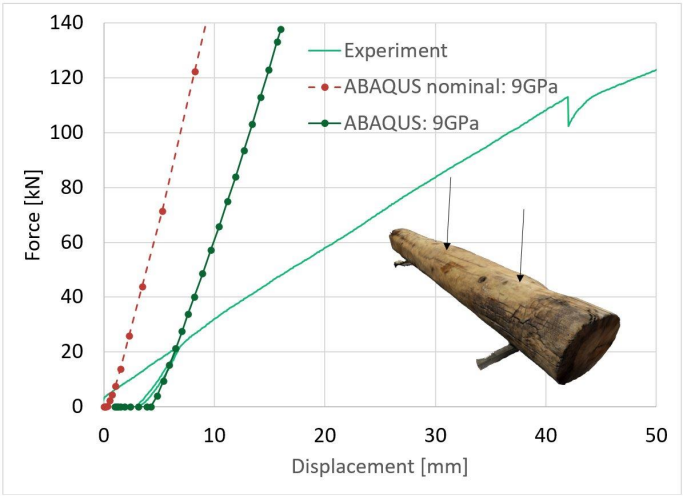


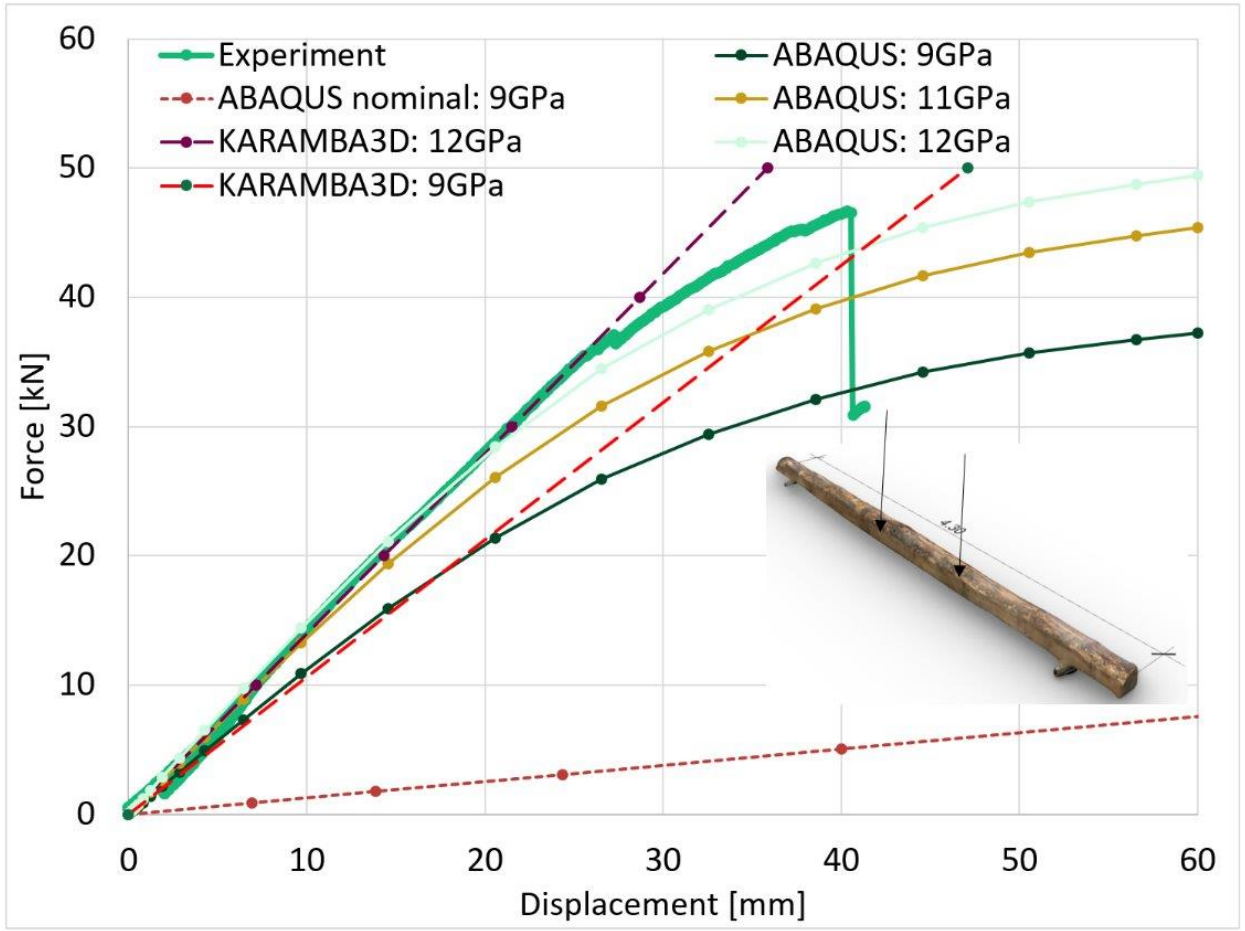


WP2. Advanced data processing *WUT*

T2.3 Analytical and simplified models for NDTs result interpretation and data processing

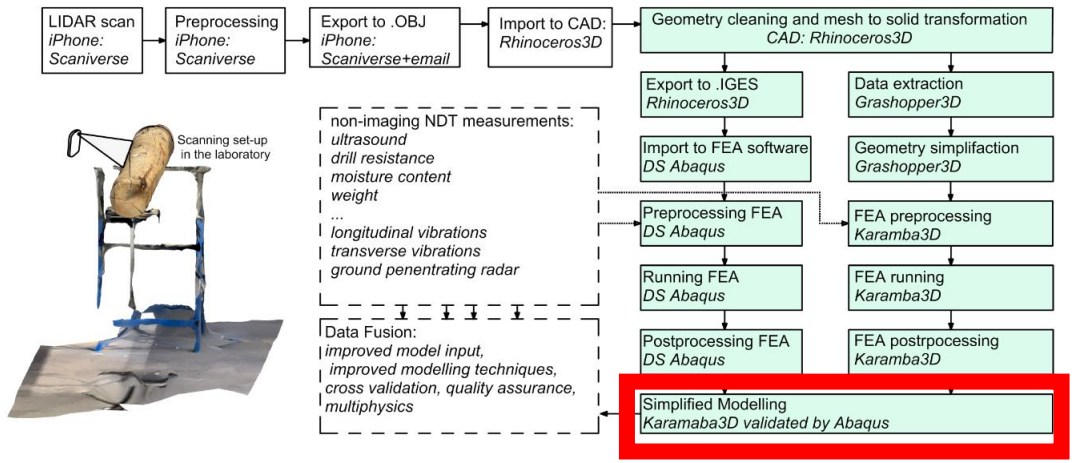


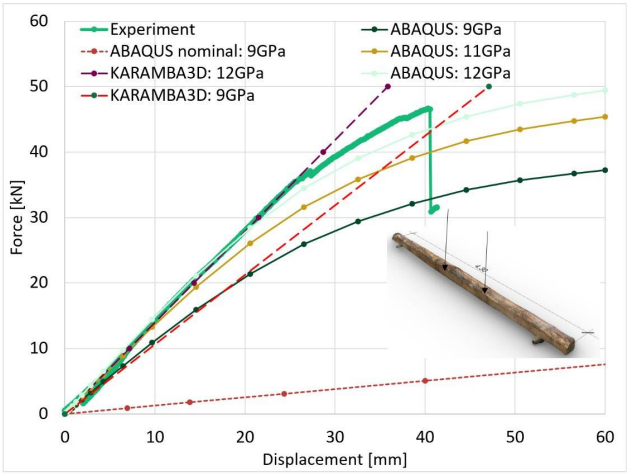


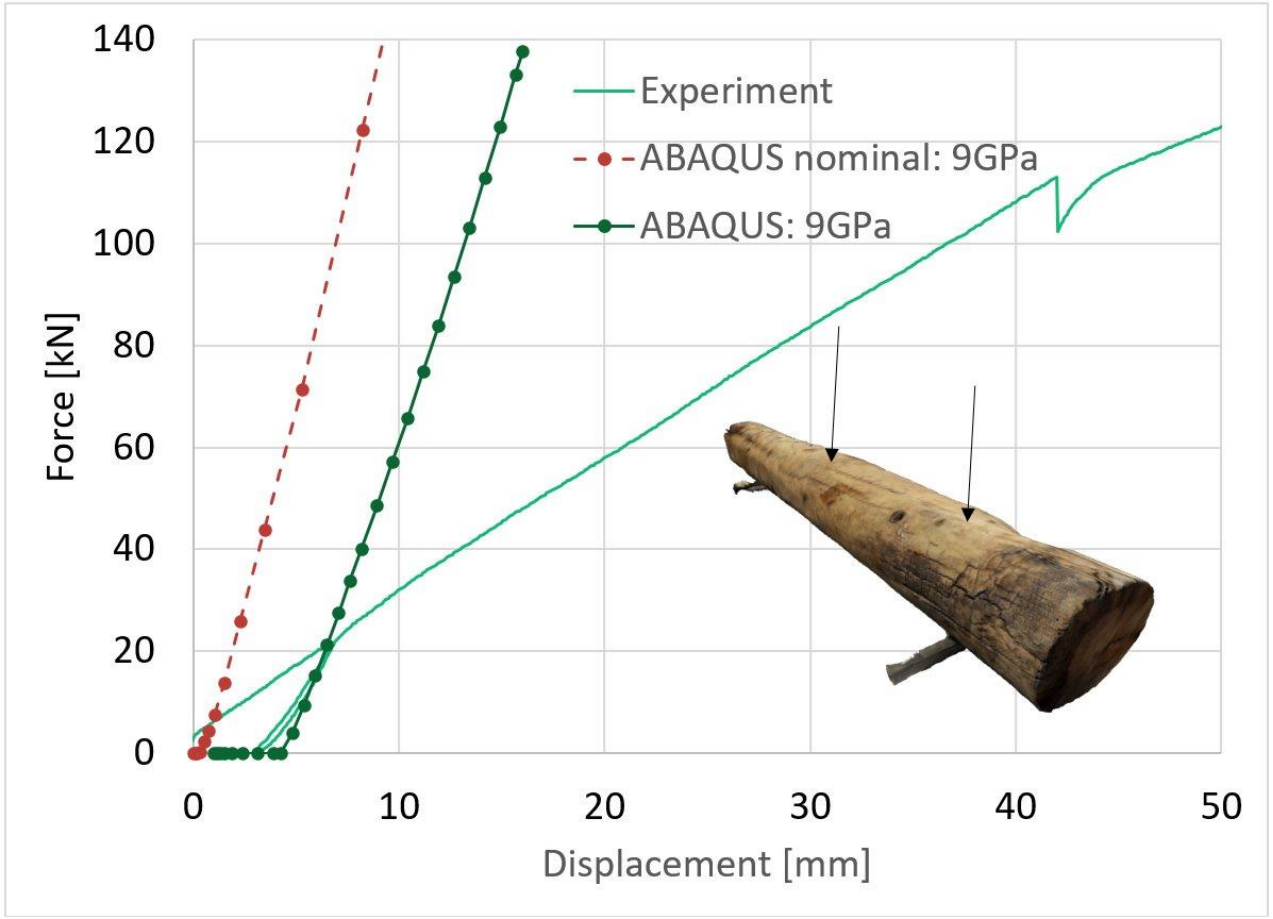


WP2. Advanced data processing *WUT*

T2.3 Analytical and simplified models for NDTs result interpretation and data processing







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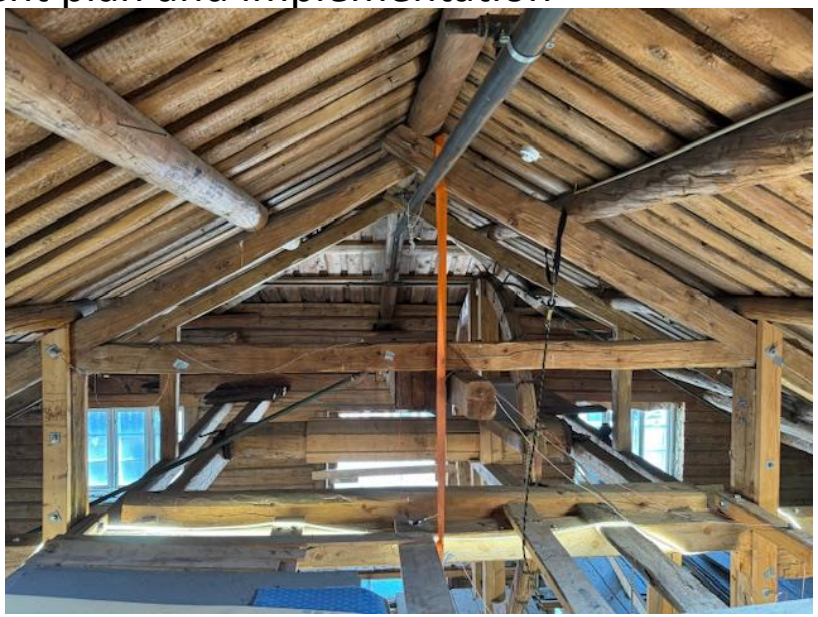
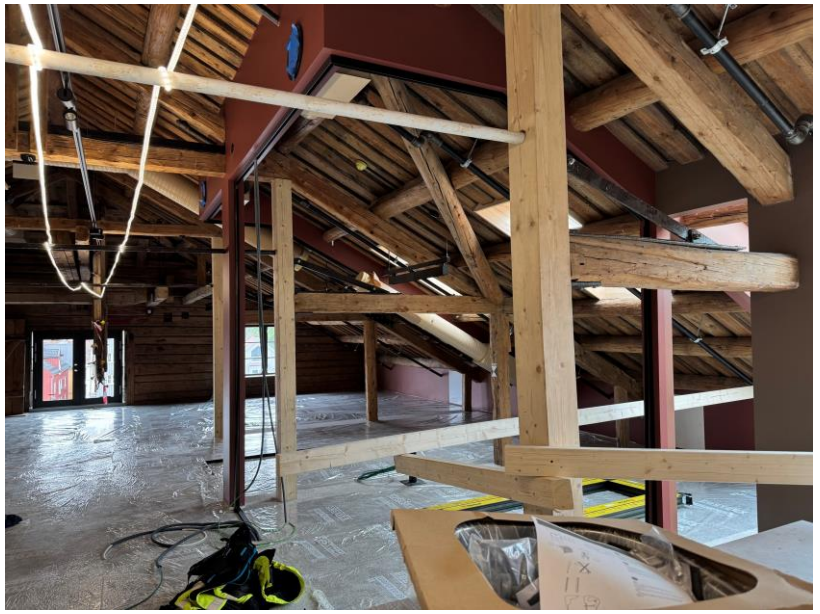
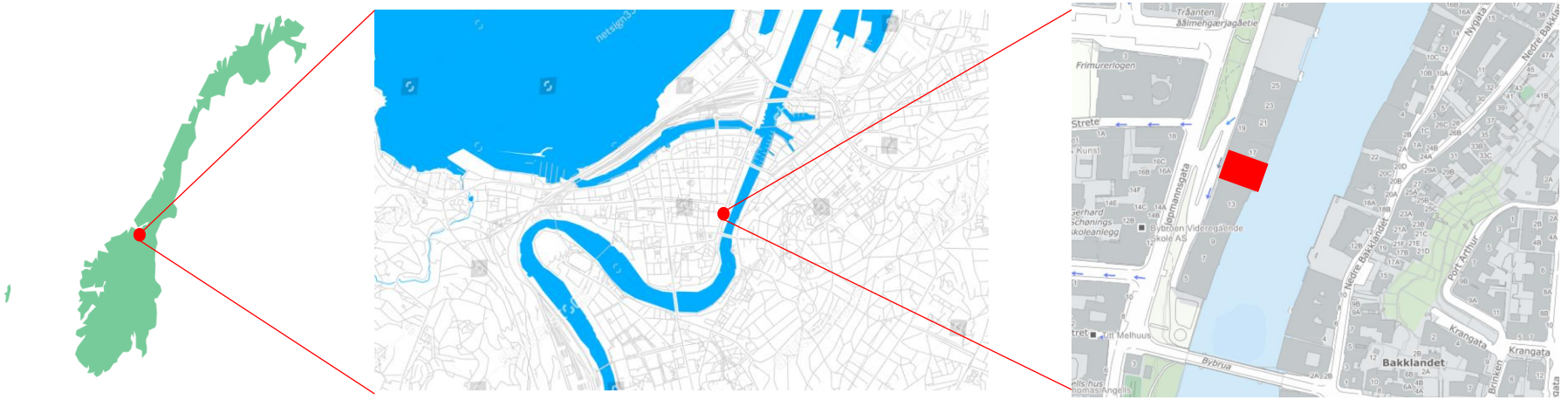
WP3. Pilot project: adaptive reuse

T 3.1 Field NDT measurement plan and implementation

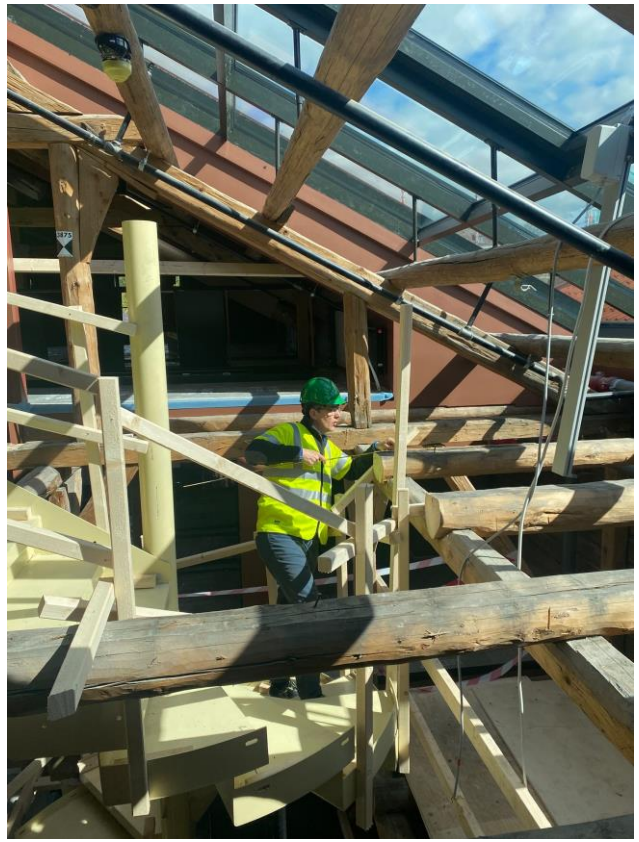


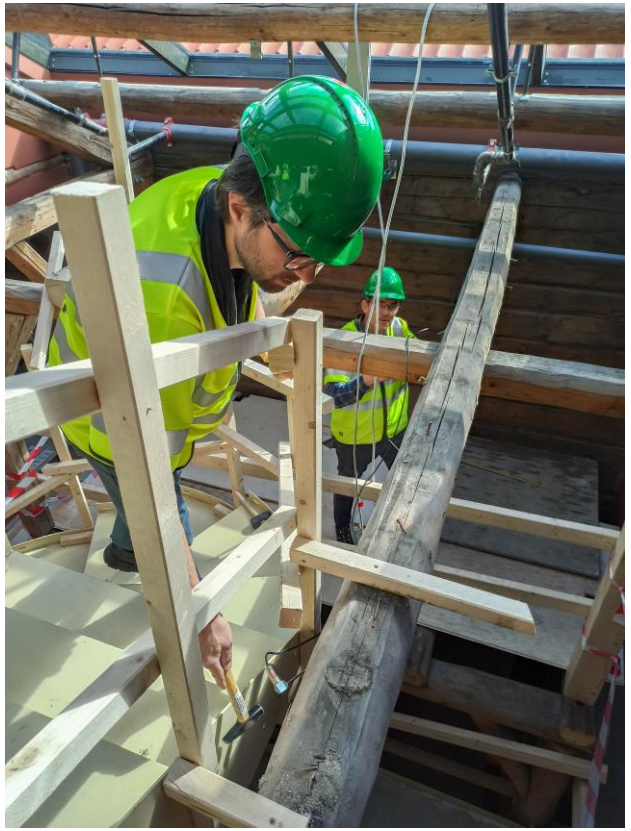




WP3. Pilot project: adaptive reuse

T 3.1 Field NDT measurement plan and implementation





$$v = \frac{L}{t_f} \qquad \rightarrow MOE\_dyn = \rho \cdot v^2$$

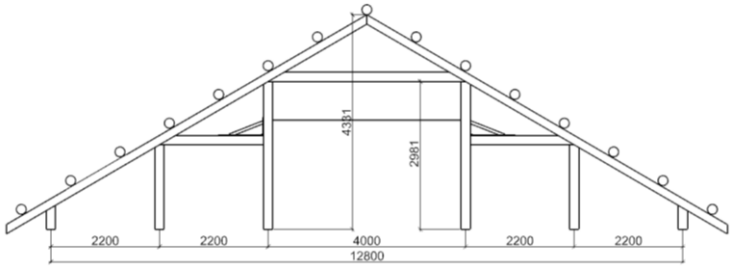
WP3. Pilot project: adaptive reuse

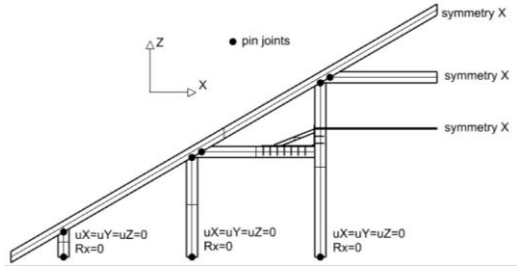
T3.3 Performance evaluation based on test data

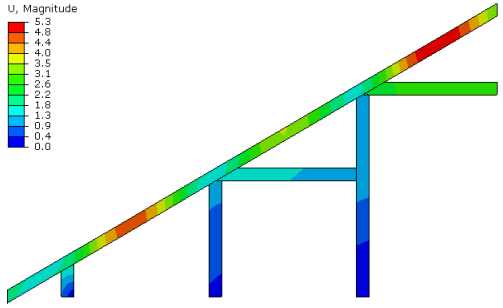
ID	L x b x h [mm]	MC [%]	MOE_dyn (UPV) [MPa]	MOE_dyn (MST) [MPa]	Max diameter knot [mm]	MOE_dyn (resonance) [MPa]	MOE_dyn mean [MPA]
S1	2,115 x 215 x 180	15	13,292	12,083	50	11,022	12,132
S2	4,160 x 170 x 170	13	12,869	13,797	20	13,820	13,495
S3	2,130 x145 x 180	14	13,292	12,207	30	11,487	13,329
	Mean	14	13,151	12,696	33	12,110	12,958
	Std. dev.	±0.8	±199	±780	±12	±1224	±607

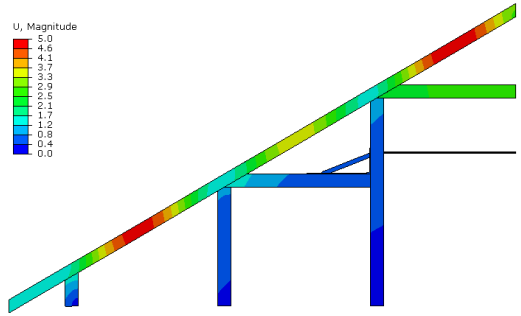
Engineering constants for the orthotropic material model of wood.

E_L	E_R	E_T	G_{LR}	G_{LT}	G_{RT}	ν_{LR}	ν_{LT}	ν_{RT}
7000	200	200	450	450	30	0.5	0.8	0.8









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WP4. Environmental analysis: life cycle assessment (LCA), *Aalto*

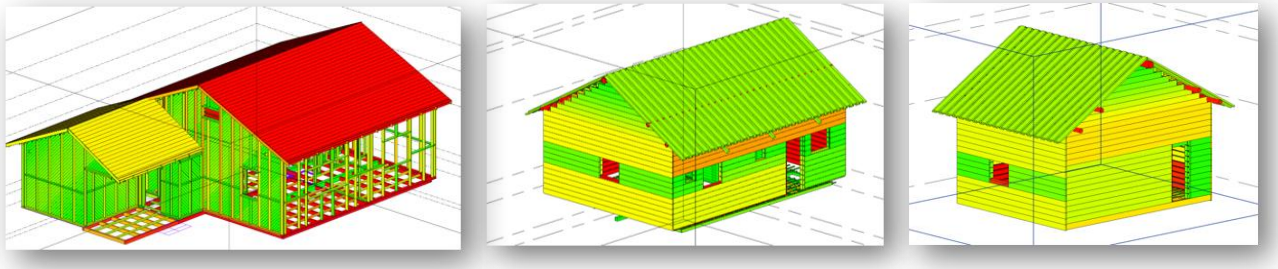
The focus is on quantifying:

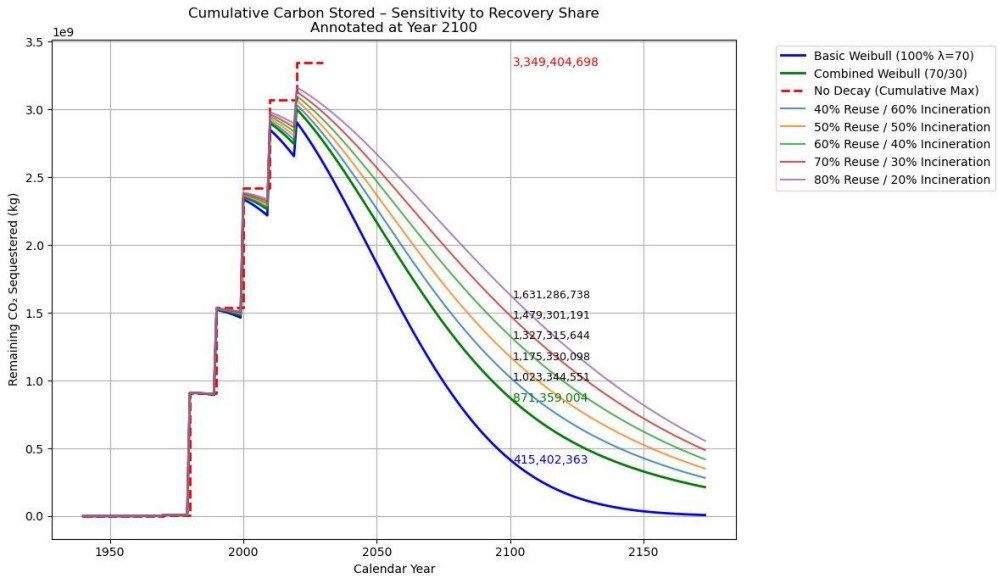
- **Biogenic carbon content** stored in the original material.
- **Emissions associated with creating new elements** from virgin timber.

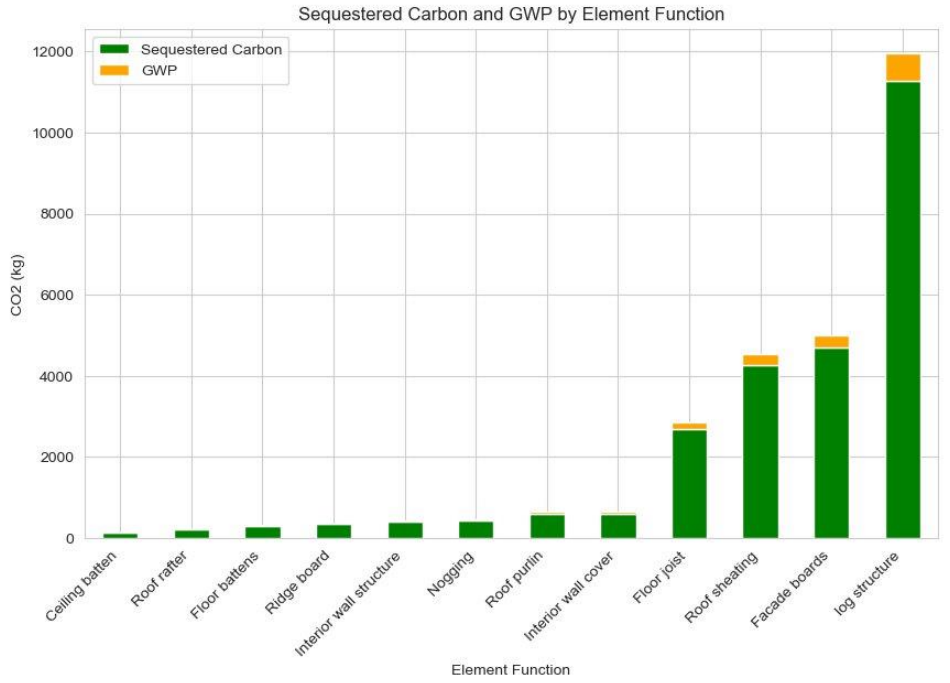
Objective:

Understand the environmental value of timber reuse in terms of carbon savings.

Balloon-frame house (1950s), Single-story log house (1943), Two-story log house (1943)







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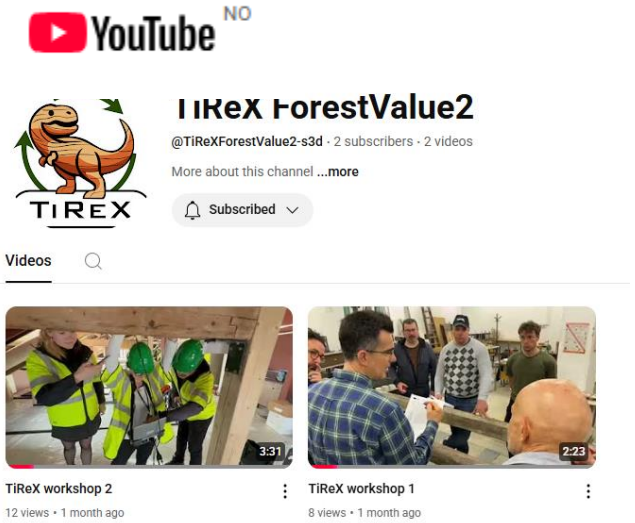
WP5. Dissemination and communication *VUAS*

WEBSITE: www.tirex.info



Seminar in Recovered Timber for High School students

4°ESO +empresa

Lecture on testing of reclaimed timber

Norwegian University of Life Sciences

SHATIS 2025

WORLD CONFERENCE ON TIMBER ENGINEERING 2025
BRISBANE, AUSTRALIA

cisbat 2025
3-5 September, 2025
Hybrid International Scientific Conference
THE BUILT ENVIRONMENT IN TRANSITION

Presentation on forum

FRISSBE
fire-safe sustainable built environment

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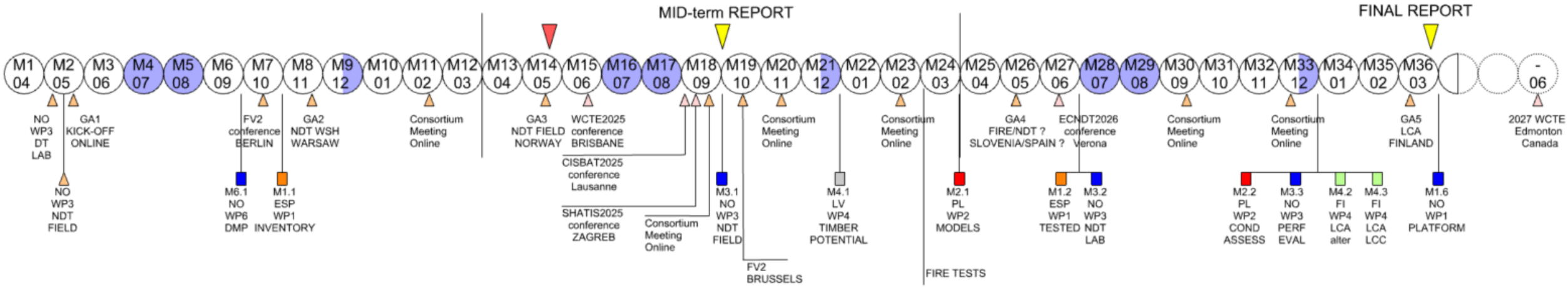
WP6. Project monitoring and management. *SINTEF*



Added **long-term IMPACTS** of the improved techniques for condition assessment of salvaged/waste/reclaimed timber:

- Higher **forestation rate** through stabilizing demand and lowering pressure on forests
- Better **quality of forests** (utilized for more durable products)
- More **reliable forest products** (better utilization of their value)
- Prolonged **CO_2 storage** in wood products: long-lived products (lower emissions)
- **Stable** wood product **prices** (within the circular economy)

Thank you!

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+4740580813

www.tirex.info

Funded by the European Union

Grant agreement ID: 101094340 https://forestvalue.org/