Twin Transition for The Timber Industry

Deliverable 1.3
Initial KPIs Definition Report

5G-TIMBER | Work Package 1, Task 1.2

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Le Moullec, Yannick

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Responsible Author/Authors	Yannick Le Moullec (TalTech) / Muhammad Mahtab Alam (TalTech); Alar Kuusik (TalTech); Kashif Mahmood (TalTech); Stefania Fortino (VTT); Hradil Petr (VTT); Jari Halme (VTT); Marco Rossoni (POLIMI); Marcello Urgo (POLIMI); Margo Muzakko (Hekotek); Valentina Härma (Hekotek); Mari Emmus (Harmet); Iftikhar Ahmad (Tieto); Oliver Jancke (Innovawood); Tord Kaasa (Jotne); Nicola di Pietro (Athonet); Daniele Munaretto (Athonet); Stephen Parker (Accelleran); Simon Pryor (Accelleran); Kiran Chackravaram (Accelleran)
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Glossary of terms and abbreviations

Abbreviation / Term	Description
5QI	5G QoS Identifier
2D	Two Dimensional
3D	Three Dimensional
5G	5th Generation technology standard for broad-band cellular networks
ACC	Vibration Acceleration
AE	Acoustic Emission
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
CAD	Computer-Aided Design
CAPEX	Capital Expenditure
DB	Database
DBS/SAK	SAK database with access to the necessary UC data (data of downtimes)
DNS	Domain Name System (DNS)
DRP	Deliverable Responsible Person
DT	Digital Twin
DoA	Description of Action
EA	Eclipse Arrowhead
ERP	Enterprise Resource Planning
EU	European Union
GA	Grant Agreement
gNB	Next Generation NodeB
IPSec	Internet Protocol Security

KPI	Key Performance Indicator
NPN	Non Public Network
OEE	Overall Equipment Effectiveness
OPEX	Operational Expenditure
PCI	Physical Cell ID
PI	Performance Indicator
PLC	Programmable Logic Controller
PLC/DEV	Controller of control system
PLC/SAK	Collects necessary/allowed data from PLC/DEV
PT	Project Target
QoS	Quality of Service
QRM	Quality Assurance & Risk Manager
RAN	Radio Access Network
RIC	RAN Intelligent Controller
REST	Representational State Transfer
ROI	Return On Investment
RRC	Radio Resource Control
RUL	Remaining Useful Life
SHM	Structural Health Monitoring
SoA	Service oriented Architecture
SON	Self-Organizing Network
SQL	Structured Query Language
SUCI	Subscription Concealed Identifier
TBD	To Be Determined
TBS	To Be Set
TLS	Transport Layer Security (TLS)

Tx	Transmit
UCs	Use Cases
UE	User Equipment
UPF	User Plane Function
UX	User Experience
VR	Virtual Reality
WVC	Wood Value Chain
xAPP	Software tool used by a RIC to manage network functions in near-real time. Pronounced “zaps”.
XR	Extended Reality
ZSM	Zero touch network & Service Management

1. Executive Summary

This document is the deliverable "D1.3 Initial KPIs Definition Report" of the Horizon Europe Innovation Action project "5G-TIMBER: Secure 5G-Enabled Twin Transition for Europe's TIMBER Industry Sector" (hereinafter also referred to as "5G-TIMBER", project reference: 101058505).

This deliverable presents the status of the work that has been carried out primarily in the task "T1.2 Requirements and KPI definition, considering side stream utilization targets" that runs from M1 to M22, as of M7 (December 2022) of the project.

Building upon D1.1 (Initial Descriptions of Use Cases with Expected Outcomes and Impact Projections to 3 Target Domains), the purpose of D1.3 is to refine and provide the *initial* definitions of the requirements and Key Performance Indicators (KPIs) for the 9 Use Cases (UCs) of the project, which will guide the consortium towards achieving the overall project targets by the end of the project.

The deliverable starts with an outline of the methodological approach used to define the initial requirements and KPIs as well as the conceptualized methods for measuring and visualizing the KPIs. Then, for each of the 3 UC categories (9 UCs in total) of the project, the deliverable explains the clarifications and/or additions that have been made following the initial formulation of the UCs in D1.1. The PIs and KPIs for each UC are introduced and briefly explained. Moreover, a tabulated overview of the Performance Indicators (PIs) and KPIs is provided for each UC category.
Moreover, the network KPIs (5G NPN) which are transversal to the project are presented.

The deliverable concludes with a summary and a list of the next main steps that will be carried out in T1.2. For conciseness and to avoid replication between D1.3 and D1.1, D1.3 mostly includes additional clarifications and details as compared to D1.1. Therefore, the reader should first familiarize with D1.1 before reading D1.3.

The intended audience of D1.3 includes all members of the 5G-TIMBER consortium and the Project Officer.

2. Introduction

This deliverable presents the work that has been carried out primarily in the task "T1.2 Requirements and KPI definition, considering side stream utilization targets" that runs from M1 to M22, in liaison with related other tasks (see Section 2.3 for details).

As a reminder, one of 5G-TIMBER cornerstones is to conduct trials of representative and innovative data-driven material, production, and installation across key elements of the wood value chain (machinery and wood house elements manufacturing, construction and renovation towards green buildings, and wood waste valorisation).

As per 5G-TIMBER's GA, the overall project targets (PT) are to:

1. increase wood-based materials recycling by 50%
2. increase manufacturing productivity by 15%
3. reach 99% of the work done in the factory (vs. 85% today)
4. reduce on-site work by 10%
5. reduce product nonconformities by 10%
6. increase the safety of workers in wooden houses production and on-site assembling

The project is driven by 9 Wood Value Chain (WVC) UCs across 3 categories; the trials will be conducted in 3 representative European regions:

- UC Category 1: data driven sawmill woodworking machines
    1. UC1.1: Data and material models driven lumber production and handling
    2. UC1.2: Digital Twins (DTs) assisted assembly, remote operation and servicing for woodworking machinery
    3. UC1.3: Data and Artificial Intelligence (AI) driven industrial machines' fault prediction and design support

- UC Category 2: modular wood-house factory
    4. UC2.1: Precise localization for production processes optimization and human safety

5. UC2.2: DT, Augmented Reality (AR) and Industry 5.0 User Experience (UX) assisted production supported by Zero touch network & Service Management (ZSM) 5G data exchange
6. UC2.3: Data driven design to production cycle optimization

- UC3 Category 3: construction and renovation with wooden elements, valorisation of composite waste
    7. UC3.1: AR and Industry 5.0 UX assisted assembly and renovation of green buildings
    8. UC3.2: Long term Structural Health Monitoring (SHM) of wooden constructions
    9. UC3.3: Wooden composites waste recycling

The UC owners are:

- VTT: UC1.1, UC1.3, UC3.2, UC3.3
- POLIMI: UC1.2
- TalTech: UC2.1, UC2.2
- Harmet: UC2.3, UC3.1

The pilot site owners are:

- For UC Category 1: Hekotek and Nordwood (Hekotek's partner sawmill – i.e. a stakeholder of the project)
- For UC Category 2: Harmet
- For UC Category 3: pilot sites (to be determined (TBD))

These UCs will be incrementally validated by 2 lab trials followed by 2 field trials in an iterative cycle covering significant portions of the WVC.

Given the above, the objective of T1.2 is to define the requirements and KPIs for the above UCs considering side stream utilization targets while keeping in mind the overall PTs. The whole task T1.2 runs from M1 to M22. This deliverable D1.3 due on M6 documents the work done from M1 to M6, focusing on the *initial* definitions of the requirements and KPIs. The work that will be carried out during the next 16 months of T1.2 in liaison with the other tasks and WPs will be documented in the *final* definitions of the requirements and KPIs D1.4 due on M22.

As a first step, in parallel to the activities carried out in T1.2, the first months of T1.1 (Definition, return and scalability analysis of project UCs of low volume machinery, wooden and construction Industry) have resulted in D1.1 (Initial Descriptions of Use Cases with Expected Outcomes and Impact Projections to 3 Target Domains) which was submitted on M4.
D1.1 has provided an *initial* structured description of the 3 UC categories and the underlying 9 UCs, including general requirements for implementing the UCs and the field trials; D1.1 also covered issues such as the actors involved and their central role in the UCs and field trials, the benefits of 5G technologies, the possible constraints, and the risks.

Taking the above as a starting point, the first part of T1.2 documented in this D1.3 focused on:

1. elaborating, quantifying, or consolidating the requirements where necessary and where possible at this stage of the project;
2. agreeing on a method for defining (and later evaluating) the KPIs;
3. defining the KPIs, including the baseline values (today's situation) where possible and their envisioned target values.

For conciseness and to avoid replication between D1.3 and D1.1, D1.3 mostly includes additional clarifications and details as compared to D1.1. Therefore, the reader should first familiarize with D1.1 before reading D1.3.

2.1. Mapping 5G-TIMBER Outputs

This section maps the components (elements) described in the 5G-TIMBER's Description of Action (DoA)/Grant Agreement (GA), i.e., the description of the deliverable and task description in the DoA/GA, against the chapters included in this deliverable and the justification of the work conducted in the project, see Table 1.

Table 1. Adherence to 5G-TIMBER's GA Deliverable & Tasks Descriptions

5G-TIMBER GA Element	5G-TIMBER GA Element Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D1.3 Initial KPIs definition report	"Initial KPIs definition report"	All chapters	Chapter 2 introduces the D1.3. Chapter 3 outlines the methodology used for defining the initial requirements and KPIs. Chapters 4, 5, 6 presents the details of the initial requirements and KPIs for UC Categories 1, 2, 3, respectively. Chapter 7 concludes D1.3.
TASKS			
T1.2 Requirements and KPI definition, considering side stream utilization targets	In accordance with the requirements of the UCs (T1.1), measurable KPIs will be identified to support the assessment and validation of the results achieved within the project with respect to its pilots.	Chapters 4, 5, 6	Grounding on D1.1 that was produced by T1.1, Chapters 4, 5, 6 presents the details of the initial requirements and KPIs for UC Categories 1, 2, 3, respectively.
	KPIs will match the ambition of the project via a methodological process, be measurable and cover both technical/quantitative and acceptance/qualitative aspects.	Chapters 3 + Chapters 4, 5, 6, 7	Chapter 3 presents the methodology used for defining the initial requirements and KPIs. The requirements, KPIs and their values are documented in chapters 4, 5, 6.

	Activities will involve all project partners, under the coordination of TalTech. KPIs will guide the activities carried out in development (WP2), integration (WP3), pilots (WP4) work packages as well as the assessment of the business potential of the proposed approaches (WP5).	Chapter 2	Each of the 9 individual UCs (grouped under 3 UC categories) have been assigned a UC owner. Both TalTech and the UC owners have organized meetings/ discussions with the relevant project partners to refine the initial requirements (grounding on D1.1) and to define the initial KPIs. It is planned that these initial requirements and KPIs will be used in WP2 to WP5 as described in Table 2 in Chapter 2.

2.2. Deliverable Overview and Report Structure

This deliverable is organized as follows:

- Chapter 2 introduces the overall purpose and background of D1.3.
- Chapter 3 outlines the methodology used for defining the initial requirements and KPIs.
- Chapters 4, 5, 6 presents the details of the *initial* requirements and technical KPIs for UC Categories 1, 2, 3, respectively.
- Chapter 7 presents the transversal network KPIs (5G NPN).
- Chapter 8 outlines preliminary business KPIs
- Chapter 9 summarizes D1.3 and outlines the next steps.

2.3. Other Project Outputs

This section describes the interdependencies with the other project tasks and activities.

a) Interdependencies between the task(s) of this deliverable and the other WPs (inter-WP dependencies):

- WP2: the federation, integration and orchestration of the technological developments that will be carried out in WP2 will consider the details of the *initial* requirements and KPIs defined in T1.2/D1.3 to drive and tune the technical work. The experience that will be gained in WP2 (mainly via the cycles of lab trials) will feedback to WP1 to elaborate the *final* definitions of the requirements and KPIs in T1.2/D1.4.
- WP3: the details of the *initial* requirements and KPIs defined in T1.1/D1.3 will further propagate to WP3 where they will be considered for carrying out the system level and operational readiness for UC pilots' activities. The experience that will be gained in WP3 (mainly via the cycles of lab trials) will feedback to WP1 to elaborate the *final* definitions of the requirements and KPIs in T1.2/D1.4.
- WP4: the deployment of 5G-TIMBER applications into demonstration sites in WP4 will consist of the cycles of field trials during which the KPIs will be measured and evaluated; the experience that will be gained during the first months of these field trials will feedback to WP1 to freeze the *final* definitions of the requirements and KPIs in T1.2/D1.4.
- WP5: The commercialisation, innovation management and standardisation initiatives that will be carried out in WP5 will focus on the service and business aspects of the project. The experience gained in WP5 will also feedback to WP1 to elaborate the *final* definitions of the requirements and KPIs in T1.2/D1.4.
- WP6: where applicable, the requirements and KPIs will be reflected and/or considered for the dissemination, communication and scale-up activities.
- WP7: the status of T1.2/D1.3 will be reflected in D7.10 (technical report of the first technical review of the project).

b) Interdependencies between the task(s) of this deliverable and the other similar WP Tasks (intra-WP dependencies):

- The *initial* UCs and general requirements defined in T1.1 are the foundation for refining the requirements and defining the *initial* KPIs in T1.2.
- T1.3 will elaborate the *initial* version of the architecture for data sharing and exchange of feedbacked material processing chain

and related UCs; this architecture will have to have the provisions for measuring, storing and exchanging the data needed for collecting and analysing the *initial* KPIs defined in T1.2.

- The *initial* KPIs defined in T1.2 will be considered in T1.4 that will produce a software and hardware inventory list for analysing data interoperability and integration in the diverse UCs.
- Finally, the *initial* KPIs defined in T1.2 will also be considered in T1.5 when defining the functional specifications and long-term strategies for full scale deployment of the 5G NPN infrastructures.

Table 2 provides a list of the other deliverables that produce inputs to this deliverable or consume outputs from this deliverable.

Table 2. List of the other deliverables that produce inputs to this deliverable or consume outputs from this deliverable.

5G-TIMBER GA Element	Contribution and Value of linkage
Input from D1.1 to D1.3	D1.1 provides the initial structured description of the 3 UC categories and the underlying 9 UCs, including general requirements for implementing the UCs and the field trials. D1.3 builds upon D1.1 by elaborating, quantifying, or consolidating these requirements where necessary
Input from D7.1, D7.4, and D7.7 to D1.3	D1.3 strives to follow the guidelines, recommendations, and rules documented in the Project Coordination, Technical & Innovation Management (D7.1), Implementation of quality assurance procedures (D7.4), and Data Management, Ethics and Ethical Compliance (D7.7)
Output from D1.3 to D1.5	D1.5 will elaborate the initial version of the architecture for data sharing and exchange of feedbacked material processing chain and related UCs; this architecture will have to have the provisions for measuring, storing and exchanging the data needed for collecting and analysing the initial KPIs defined in D1.3.
Output from D1.3 to D1.7	D1.7 will consider the relevant details of the initial requirements and KPIs defined in D1.3 to produce a software and hardware inventory list for analysing data interoperability and integration in the diverse UCs.
Output from D1.3 to D1.8	D1.8 will consider the relevant details of the initial requirements and KPIs defined in D1.3 for defining the functional specifications and long-term strategies for full scale deployment of the 5G NPN infrastructures.

Output from D1.3 to D2.1	D2.1 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of digital material (wood) models to predict the performance of selected timber components.
Output from D1.3 to D2.3	D2.3 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the open standard based digital twin for industrial automation.
Output from D1.3 to D2.5	D2.5 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the 5G NPN network monitoring, close-loop automation for optimization of industrial manufacturing.
Output from D1.3 to D2.7	D2.7 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the AI-driven edge computing and precise indoor localization.
Output from D1.3 to D2.9 and D2.11	D2.9 and D2.11 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the security by design and AI-driven digital forensics in manufacturing.
Output from D1.3 to D2.13	D2.13 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the use of IoT live data for predictive machine maintenance and structural health monitoring.
Output from D1.3 to D3.1	D3.1 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of cross-enterprise data exchange software framework implementation.
Output from D1.3 to D3.3	D3.3 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the design, development and configuration of 5G NPN network infrastructure for the use-cases.
Output from D1.3 to D3.5	D3.5 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the augmented reality supported manufacturing and machine servicing system setup.
Output from D1.3 to D3.7	D3.7 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the use-cases for sawmill machinery.
Output from D1.3 to D3.9	D3.9 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of use-cases for wood-based modules manufacturing.

Output from D1.3 to D3.11	D3.11 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of use-cases for construction, renovation and **possibly** waste valorisation (desk UC).
Output from D1.3 to D4.1	D4.1 will consider the relevant details of the initial requirements and KPIs defined in D1.3 required for the development of the infrastructure and IT preparation on pilot sites.
Output from D1.3 to D4.3	D4.3 will consider, **measure and analyse** the relevant details of the initial requirements and KPIs defined in D1.3 when conducting the field trials for sawmill machinery production and operations use-cases.
Output from D1.3 to D4.5	D4.5 will consider, **measure and analyse** the relevant details of the initial requirements and KPIs defined in D1.3 when conducting the field trials for wooden houses use-cases.
Output from D1.3 to D5.1	D5.1 will consider the initial requirements and **especially business** KPIs defined in D1.3 for conducting the EU Landscape market sector assessment, impact and sustainability study.
Output from D1.3 to D5.2	D5.2 will consider the initial requirements and **especially business** KPIs defined in D1.3 for conducting the business models development, commercialisation/business plan and commercial acceleration/sustainability.
Output from D1.3 to D5.4	D5.1 will consider the initial requirements and **especially business** KPIs defined in D1.3 for creating the commercial ecosystem cluster to accelerate commercial revenues and growth.
Output from D1.3 to D5.7	D5.1 will consider the innovations needed to achieve the initial target KPIs defined in D1.3 when preparing the standardisation recommendations.
Output from D1.3 to D6.1 and D6.2	D6.1 and D6.2 will consider the initial requirements and KPIs defined in D1.3 required when conducting the dissemination and communication activities, **especially how the KPIs help achieving and demonstrating the overall project targets (PTs).**
Output from D1.3 to D7.10	D7.10 (technical report for the first project review) will include a summary of the status of the initial requirements and KPIs defined in D1.3 and how these are reflected in the other deliverables and tasks that will be covered in that technical report.

3. Methodological Approach

3.1. Terminology

For the sake of the 5G-TIMBER project, the following definitions are used:

- Project Targets (PT): predefined (and for most of them quantified) improvements or capabilities that the project tries to achieve:
    - Example of PT: increase wood-based materials recycling by 50%

- Requirements (R): capabilities that must be met or possessed by a system or hardware/software component thereof.
    - Example of R: localization accuracy <= 200 cm

- Key Performance indicator (KPI): essential indicator of achievement or improvement toward an intended result. KPIs are composed of one or several Performance Indicators (PI). In the latter case we will consider them jointly; this will allow a multi-risk analysis; the single explicit expression for combining them (e.g. weighted average) will be defined once experimental results have been collected and statistically analysed.
    - Example of KPI: production efficiency; target: increase by +15%

- Performance Indicator (PI): A parameter (metric) that can be measured to obtain information about the performance of a system or hardware/software components thereof.
    - Example of PI: throughput rate; target: increase to between 85 and 100 modules/month

- Business KPI: KPIs that are focused on the efficiency and financial dimensions of the companies
    - Example: Capital Expenditure (CAPEX)

3.2. Method

Collecting the input needed for refining the requirements and defining the KPIs has been conducted as a collaborative work between the UC owners (VTT: UC1.1, UC1.3, UC3.2, UC3.3; POLIMI: UC1.2; TalTech: UC2.1, UC2.2; Harmet:

UC2.3, UC3.1), pilot site owners (For UC Category 1: Hekotek and Nordwood - Hekotek's partner sawmill, i.e. a stakeholder of the project; for UC Category 2: Harmet; for UC Category 3: TBD: pilot sites), and all contributors to T1.2/WP1 as well as additional support from WP5.

Initial draft Excel tables were prepared by T1.2 leaders for each UC category and the UCs therein; each table contains requirements with a textual description extracted from D1.1 as well as a tentative and non-exhaustive list of KPIs and PIs. These tables have been shared with the partners and the bulk of the work has then been centred around a series of online meetings (both in large groups and more focused smaller groups), occasional face-to-face visits, discussions at one of the pilot sites (Nordwood), as well as internal discussions within the project partner organizations.

This process has resulted in the *initial* requirements as well as the list of KPIs and PIs presented in Chapter 4 (UC Category 1), Chapter 5 (UC Category 2), and Chapter 6 (UC Category 3) in this D1.3.

The conceptualized overview of the measurement of the PIs and calculations of the KPIs is illustrated in Figure 1. The measurements are performed at the points of measurements on the UC's infrastructure (hardware and/or software elements). The measurement process is typically repeated a number of times (depending on the UC and its operating conditions) and averaged. This average value (and other properties such as min/max/median, standard deviation, etc. if applicable) correspond to the PI value.
Some of the KPIs are obtained by jointly considering several PIs; they will be combined to obtain a single value that makes analysis and interpretation more practical and actionable at a higher level. In such cases, the PIs will be combined by means of e.g. a weighted average to calculate the KPI value. The weights will be determined empirically once the results of the measurements that will be carried out in the trials become available.
It should be noted that, unless already indicated for some cases in curly braces ({}), the way i.e. where and how the data will be collected, measured, analysed, and interpreted will be defined and refined during the next months of T1.2 as the technical work progresses. Non-exhaustive options, depending on the UC and the PIs, include enterprise resource planning (ERP) or other in-house developed reporting software, Excel files, text files, etc. These will be documented in D1.4 (M22).

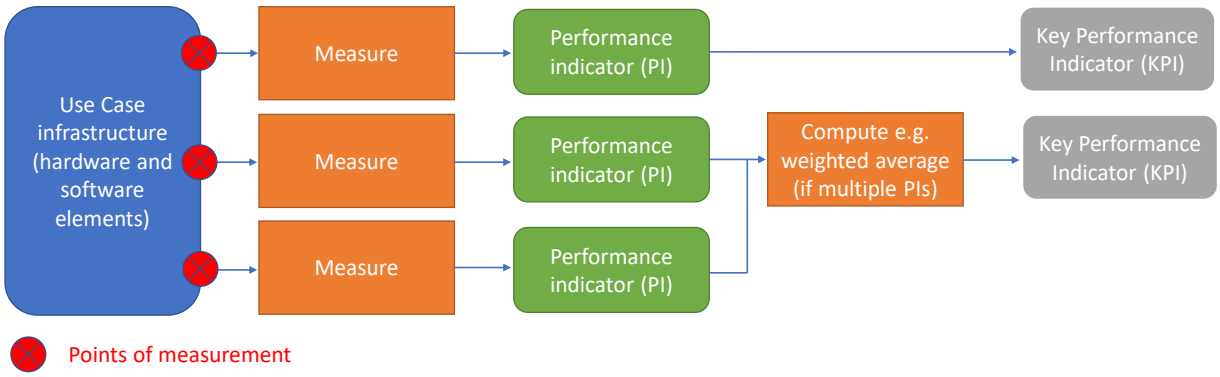

Figure 1. Conceptualized overview of the measurement of the PIs and calculation of the KPIs. The "compute e.g. weighted average" step is needed for KPIs that comprises several PIs. In the other cases, KPI = PI

The process for visualizing, analysing and interpreting the KPIs is conceptualized in **Figure 2**. The selection among the options for the tools for data storage, access, and visualization is ongoing in T1.3.

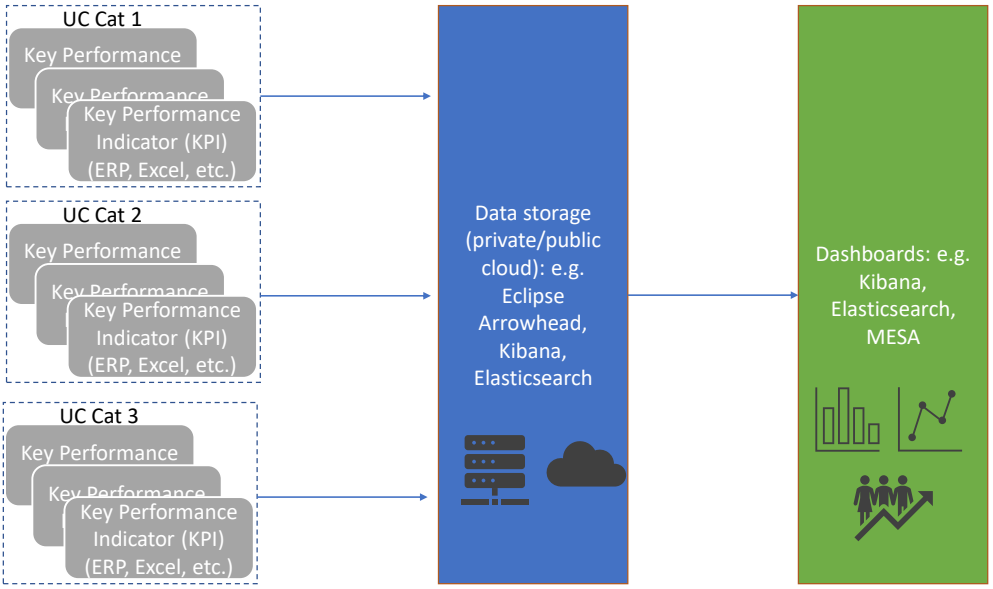

Figure 2. Conceptualized process for storing, visualizing, analysing and interpreting the KPIs

The next 3 chapters present the requirements and initial KPIs that have been elaborated during the first part of T1.2 for the 3 UC categories.
Note that the description of UC1.1 (related to wood modelling) is longer than for the other UCs because it serves as a driver and provides fundamental information to the other UCs.

4. UC Category 1 - Data Driven Sawmill and Woodworking Machine Setup: Requirements and KPIs

UC Category 1 - Data Driven Sawmill and Woodworking Machine Setup (comprising of UC1.1, UC1.2, UC1.3) will leverage 5G network technologies in combination with digital twin models, sensorisation, and edge/cloud computing to validate and assess their benefits in sawmills w.r.t sawmill machinery and resulting wood products.

4.1. UC1.1: Data and material models driven lumber production and handling

UC1.1 - Data and Material Models Driven Lumber Production and Handling makes use of digital models for wood materials, assisted by laboratory work such as scratch tests and tomography investigations carried out at VTT, to support decisions in the sawmill and monitoring of wood products.

4.1.1. Added Value of the scratch tests

An outcome of such tests would be indicators relevant to the wood industry, i.e. whether certain raw material is more suitable for making plywood, mixed wood materials, etc. However, the most important role of scratch tests in 5G-TIMBER project is to support VTT's hygro-thermo-mechanical analyses (based on the numerical tools of VTT ProperTune for wood) in relation to the moisture effects and the evaluation of crack risk in wood components starting from the sawmill until the service life within a modular house (Deliverable D2.2, M24).

Scratch tests and CT tomography of the scratched samples that will be carried out by VTT will give information on the wood performance (scratch resistance to be related to fracture toughness) under:

- cutting-type loads (wet wood samples in sawmill environment)
- loads causing cracks (samples from processed wood products used in service life environment)

Compared to the classical hardness tests, the scratch tests provide more information on dynamic (moving) loads. In particular, the scratch test results are typically given as:

- penetration depth (elastic deformation);

- residual depth (plastic deformation);
- frictional forces and frictional coefficients.

It is expected that the scratch test results (in combination with CT tomography) could show that:

- The resistance of wood to scratch loads increases with the reduction in the cutting tip size (especially relevant in the sawmill environment);
- The resistance of wood to scratch loads increases with the increase in moisture stabilization (especially relevant in modular house environment).

The scratch resistance can be related to the fracture energy in wood in various stages of the wood product life from production to installation and service life conditions. This information is useful especially if the results are also assisted by numerical modelling (VTT hygro-thermo-mechanical models to predict moisture in wood and the related crack risk).

The resulting models will be included in recommendations for the end-users of the wood industry, resulting in added value for them.

4.1.2. UC1.1 KPIs and PIs

- KPI: Production Efficiency
    - PI: Crack risks etc. for the suitability of timber for making beams, other wooden products, etc. Currently, the scratch tests are not performed, and the suitability of timber is not analysed. The target is to enable this by means of VTT experiments.

    - PI: Hardness and other material parameters available for sawmills. Currently, scratch tests are not performed, and the suitability of timber is not analysed for sawmills. The target is to enable this by means of VTT experiments.

    - PI: Hardness and other material parameters available for finished products (modular wood house). Currently, scratch tests are not performed, and the suitability of timber is not analysed for finished products (modular wood house). The target is to enable this by means of VTT experiments.

- PI: Validation of assessment methods (scratch test and CT analysis). Currently, there is no validation of the assessment methods. The target is to validate this assessment during the project by analysing the experimental results.

The values of the PIs for UC1.1 can be found in the corresponding columns of **Table 3** to **Table 5**.

4.2. UC1.2: DTs assisted assembly, remote operation and servicing for woodworking machinery

UC1.2 - DTs Assisted Assembly, Remote Operation and Servicing for Woodworking Machinery deals with monitoring approaches for sawmill machinery, taking advantage of 5G-connected sensors to feed and exploit Digital Twin models and approaches. UC1.2 focuses on the packing machine at the end of the sawn timber handling line.

4.2.1. UC1.2 Requirements, KPIs, and PIs

In addition to the initial requirements already listed in D1.1, the following aspects have been discussed and clarified, as described in what follows.

- KPI: Production efficiency. Regarding the production efficiency, Hekotek considers two types of downtimes:
  - PI: Short downtimes are stoppages with a duration of less than 2 minutes which require between 5 to 30 seconds for the operator to fix the issue. As of today, these short downtimes are not recorded. These short stoppages are mainly caused by material issues and Hekotek has a target to detect them earlier by means of an AI-based early image detection and alarm mechanism. The target is to reduce these short stoppages by using the DT for improving the way adjustments are made and avoiding adjustment mistakes from 21% to 16%.

  - PI: Long downtimes are stoppages based only on Hekotek equipment failures due to e.g., proper adjustments that have not been done; this means that such adjustments have to be done earlier in the process. Hekotek has a target to detect these issues earlier by means of the digital twin (DT) for preventive maintenance.

The target is to reduce the frequency of these long stoppages from 8% to 7%.

  - PI: Mean Time Between Failure (MTBF) is also valuable for Hekotek as it provides valuable information about the quality of the design and manufacturing of the equipment. As of today, this is not explicitly monitored by Hekotek, and the target is that this shall be implemented in the project.

  - PI: Machine efficiency assessment. Hekotek also plans to perform a machine efficiency assessment based on the average running time considering failures and other stoppages. This is not implemented as of today, and the target is that this shall be done as part of the project.

  - PI: New recipe making. This refers to making all necessary adjustments on the machine prior to launching a production run. The target is to reduce the time needed for maintenance and setup operations from 1 working day to 1 hour by means of the DT.

- KPI: Training time reduction. Regarding the training time, Hekotek focus is on the following point:
  - PI: training time of "Adjustment personnel". This refers to the operators and personnel who perform the adjustments of the machine. It is not straightforward to conclude when the training of such personnel ends and when their productive work starts. The empirical rule of thumb is that it takes 6 months for most operators to acquire the skills needed to work at the nominal speed of the production line. Hekotek's target is to lower this training time from 6 months to 3 months by means of the DT.

- KPI: 5G Non-Public Network (NPN) for remote operation (adjusting parameters). Regarding the remote operation, Hekotek's plan is to make use of remote operation (specifically, adjustment of the machine's parameters) considering the following:
  - PI: Remote operation (adjustment of parameters) with high reliability (%). This is not implemented today, and the goal is to enable remote operations by means of the 5G NPN with high reliability (99.99%).

- PI: Remote operation (adjustment of parameters) with low end-to-end latency (ms). This is not implemented today, and the goal is to enable remote operations by means of the 5G NPN with low latency (100 ms).

The values for the PIs for UC1.2 can be found in the corresponding columns of **Table 3** to **Table 5**.

4.3. UC1.3: Data and AI driven industrial machines' fault prediction and design support

UC1.3 - Data and AI driven industrial machines' fault prediction and design support deals with AI-driven maintenance policy, with a focus on the packing machine at the end of the sawn timber handling line.

4.3.1. UC1.3 Requirements, KPIs and PIs

In addition to the initial requirements listed in D1.1, the following aspects of UC1.3 have been further discussed and clarified:

- R: Sensors. Regarding the sensor for the machine that shall embed 5G boards and SIM cards and/or provide the appropriate hardware/software interface to realise the connection with 5G radio equipment, the following was clarified:
  - Programmable logic controller (PLC) of UC control system (PLC/DEV): sensor data & frequency converter data: speed, current, torque, temperature.
  - PLC that collects from the PLC/DEV necessary/allowed UC data (PLC/SAK): material data
  - Database (DSB/SAK) with access to the necessary UC data: equipment down time & reason of down time (unless micro stoppage).
  - Not all measured data should be pushed through all the time, especially in dynamic measurement cases. Services are needed

to filter/pre-parameterize data at the edge connected to 5G communication boards.

- R: Battery. Regarding the battery powered sensors for the machine, 5 Wh will be initially considered. However, battery consumption and maintenance/replacement management are needed, and wired solutions should be possible as well.

- R: Data storage and access. Regarding the data collected (raw data, history data, pre-processed streams) storage and access, options at Nordwood sawmill include PLC/DEV for sensor and frequency converter data (that data is not yet saved), PLC/SAK (SQL) for material data, DBS/SAK for equipment down time data and reasons. In addition, Octavic PLC/GW and Octavic database (DB) are under construction for the integrated Nordwood packing machine (UC1.3) process and sensor data collection and storage. This will be used as a data window towards 5G-TIMBER project. The sampling frequency baseline is estimated at 100 ms, to be adjusted with the possibilities/needs. Special attention must be given to data synchronization (time stamping). Also, services discovery/authorization (in liaison with WP3) must be considered. Options include the open source Eclipse Arrowhead (EA) for service discovery, authorization and connection online (fulfils Service-oriented Architecture (SoA)) requirements: vendor independent, late binding, lightweight, etc.). Service consuming and provision would be carried out over Representational State Transfer (REST) RESTful API (e.g. json files). One possible option for maintenance data and asset management is the open-source MIMOSA data model (MIMOSA-Open Standards for Physical Asset Management), and one possible option for database option at the edge level is open-source Maria DB.

- R: Security. Regarding security: not only the 5G architecture should be secured by design, but it should be noted that the developed services' security is important too so that each and every application service running either at the edge or in the cloud could be dynamically authorized, identified and orchestrated in a secure and unified way, and to operate e.g. with IoT device based on certificates and tokens issued in the service clouds.

- KPI: Production efficiency. Regarding the production efficiency, Hekotek's focus is on the following:

    - PI: Failure rate avoidance (based only on Hekotek equipment failures). At the moment, based on data from Hekotek's sawmill partner, this failure rate is 2.30%. The objective is to reduce the failure rate for a give set of failures; the target is to decrease this to 2.10%, considering predictive maintenance and wear-off.

The values for the PIs for UC1.3 can be found in the corresponding columns Table 3, Table 4, and Table 5.

4.4. Overview of KPIs for UC Category 1: Data Driven Sawmill and Woodworking Machine Setup

This section provides a tabulated overview of the previous sections by means of **Table 3**, **Table 4**, and **Table 5** corresponding to the 3 KPIs (and underlying PIs) for UC Category 1.

Table 3. Production efficiency KPIs for UC Category 1: Data Driven Sawmill and Woodworking Machine Setup

KPI: Production efficiency	UC Category 1 – Data Driven Sawmill and Woodworking Machine Setup					
	UC1.1: Data and material models driven lumber production and handling		UC1.2: DTs assisted assembly, remote operation and servicing for woodworking machinery		UC1.3: Data and AI driven industrial machines' fault prediction and design support	
	Baseline	Target	Baseline	Target	Baseline	Target
PI: Crack risks etc. -> suitability of timber for beams etc.	Scratch tests not performed, and suitability of timber not analysed	Scratch tests performed and suitability of timber analysed	Not applicable	Not applicable	Not applicable	Not applicable
PI: Hardness and other material parameters available for sawmill	Scratch tests not performed, and suitability of timber not analysed for sawmill	Scratch tests performed and suitability of timber analysed for sawmill	Not applicable	Not applicable	Not applicable	Not applicable
PI: Hardness and other material parameters available for	Scratch tests not performed, and suitability of timber not analysed	Scratch tests performed and suitability of timber	Not applicable	Not applicable	Not applicable	Not applicable

finished product (modular wood house)	for finished product (modular wood house)	analysed for finished product (modular wood house)				
PI: Validation of assessment methods (scratch test and CT analysis)	Validation of assessment methods not performed	Validation of assessment method performed				
PI: Short downtimes (less than 2 minutes, 5 seconds to 30 seconds to fix the problem)	Not applicable	Not applicable	21%	Reduce these short stoppages by using the DT for improving the way adjustments are made and avoiding adjustment mistakes from 21% to 16%	Not applicable	Not applicable
PI: Long downtimes (based only on Hekotek equipment e.g. adjustments have not been done, adjustments have to be done earlier)	Not applicable	Not applicable	8%	7%	Not applicable	Not applicable
PI: Mean time between failure (MTBF) (Available	Not applicable	Not applicable	Monitor and determine / To be set	Monitor and determine / To be set	Monitor and determine / To be set	Monitor and determine / To be set

Production Time / Total Number of Failures)						
PI: Machine efficiency assessment based on average running time based on failures and other stoppages	Not applicable	Not applicable	Machine efficiency assessment based on average running time based exclusively on failures without other stoppages is not implemented	Machine efficiency assessment based on average running time based exclusively on failures without other stoppages is implemented	Not applicable	Not applicable
PI: New recipe making	Not applicable	Not applicable	1 working day	1 hour, based on digital twin	Not applicable	Not applicable
PI: Failure rate avoidance (based only on Hekotek equipment failures)	Not applicable	Not applicable	Not applicable	Not applicable	2.30%	2.10%

Table 4. Training Time Reduction KPIs for UC Category 1: Data Driven Sawmill and Woodworking Machine Setup

KPI: Training Time Reduction	UC Category 1 – Data Driven Sawmill and Woodworking Machine Setup					
	UC1.1: Data and material models driven lumber production and handling		UC1.2: DTs assisted assembly, remote operation and servicing for woodworking machinery		UC1.3: Data and AI driven industrial machines' fault prediction and design support	
	Baseline	Target	Baseline	Target	Baseline	Target
PI: Adjustment personnel training time	Not applicable	Not applicable	6 months	3 months	Not applicable	Not applicable

Table 5. Development time reduction of new product derivates KPIs for UC Category 1: Data Driven Sawmill and Woodworking Machine Setup

KPI: 5G NPN for remote operation (adjusting parameters)	UC Category 1 – Data Driven Sawmill and Woodworking Machine Setup					
	UC1.1: Data and material models driven lumber production and handling		UC1.2: DTs assisted assembly, remote operation and servicing for woodworking machinery		UC1.3: Data and AI driven industrial machines' fault prediction and design support	
	Baseline	Target	Baseline	Target	Baseline	Target
PI: Remote operation (adjustment of parameters) with high reliability (%)	Not applicable	Not applicable	Not implemented	99.99% with 5G	Not applicable	Not applicable
PI: Remote operation (adjustment of parameters) with low end-to-end latency (ms)	Not applicable	Not applicable	Not implemented	100 ms with 5G	Not applicable	Not applicable

As mentioned earlier in Section 3.2, it should be noted that, unless already indicated for some cases in curly braces ({}), the way (where and how) the data will be collected, measured, analysed, and interpreted will be defined and refined during the next months of T1.2 as the technical work progresses. This will then be updated and reported in D1.4 (M22).

5. UC Category 2 – Modular Wood-House Factory

UC Category 2 - Modular Wood-House Factory focuses on the manufacturing process of the wooden house module, from when the lumbers arrive at the woodhouse factory to when the modules leave the factory for the construction site. UC2 category addresses deploying a 5G private network within a production environment and how it can support integrating different applications and tools.

5.1. UC2.1: Precise localization for production processes optimization and human safety

UC2.1 - Precise Localization for Production Processes Optimization and Human Safety deals with the deployment of a tracking system in a particular portion of Harmet's Kumna facility. Besides demonstrating the feasibility of a 5G-based positioning system, it will also be integrated and reused by UC2.2 and UC2.3.

5.1.1. UC2.1 Requirements and KPIs

- R: Generic vs. safety oriented localizations. One important clarification that emerged after refining the initial requirements for UC2.1 listed in D1.1 is about the localization accuracy. It is decided to consider two separate situations:
    - Generic localization of goods, machines, humans, for which the requirements is more relaxed (see PI below);
    - Safety oriented localization of humans, for which the accuracy requirements is more stringent (see PI below).

- KPI: Production efficiency. Regarding production efficiency, Harmet's focus in on:
    - PI: Throughput rate (number of units produced / time), for which their target is to increase the number of produced XA modules from 80 modules/month to between 85 and 100 modules/month.

- KPI: Positioning accuracy (Generic localisation accuracy of goods, machines, humans)

- PI: Position accuracy (cm). As of today, generic localization is not implemented; the target is to reach between 100 cm and 500 cm accuracy.

- KPI: Detection and later reduction of potential hazard events (human safety) related to overhead crane hoists and forklifts. When it comes to the reduction of potential hazard events (human safety), Harmet's focus is on the following:
  - PI: Potential Serious Injuries or Fatalities (PSIFs) and near misses related to overhead crane hoists and forklifts. As of today, PSIFs and near misses are registered manually. Meaning that somebody has to report them and then the cases will be registered. Harmet has a reason to believe that as there is no automated system currently being used, some potentially hazardous events go unreported. Overhead crane hoists and forklifts related PSIFs and near misses shall be monitored, and the baseline determined; the target is to decrease PSIFs and near misses by between -5% and -15%.

  - PI: Safety oriented localisation accuracy. As of today, the safety-oriented localization accuracy is limited to information of the type "In or out the building/area of interest"; the target is to reach an accuracy of between 20 cm and 50 cm.

The values for the PIs for UC2.1 can be found in the corresponding columns of Table 6 to Table 10.

5.2. UC2.2: DT, AR and Industry 5.0 UX assisted production supported by ZSM 5G data exchange

UC2.2 - DT, AR and Industry 5.0 UX Assisted Production Supported by ZSM 5G Data Exchange focuses on making available 3D data to the operators while assembling the woodhouse module through the XR interface supported by the product digital twin. Moreover, the optimisation of the production cycle will also be addressed with the implementation of a digital twin of the process, taking the operator's safety aspects into consideration.

5.2.1. UC2.2 Requirements, KPIs, and PIs

In addition to the initial requirements listed in D1.1, the following points have been clarified:

- R: Data and information formats
    - For the product: 3D models files: .step, .ifc., dwg, .fbx, .obj, CAD drawings;
    - For the floor plan: step export, .dwg;
    - For the process: assembly task description: .csv, .json, cdf.
- R: AR devices (smart glasses and/or tablets): for lab testing, both tablets and smart glasses are acceptable (contrary to UC3.1 where only tablets are suitable for safety reason (in-field testing)): 5 devices (1 smart glass and 4 tablets). Tablets should support Android. The system should make use of QR codes. They have to be sticked on elements at Harmet.
- R: Safety compliance: Protective gloves should be touch ready.
- R: Connectivity: Most of the commercially available tablets support Wi-Fi and mobile data connection. HoloLens 2 supports Wi-Fi too; in case this device will be used, it is also possible to use a 5G router to provide connectivity.
- R: UI of the XR: this should be also defined based on the company requirements and can be developed after preliminary users assessment of the interface.
- R: Networking aspects:
    - Network end-to-end latency for VR: < 20 ms, which can be achieved under local network coverage
    - Network end-to-end latency for AR: < 10 ms, which can be achieved under local network coverage

- Network peak data rate >= 100 Mbps, which can be achieved under local network coverage

- R: Availability of task definition and assembly process description: parts of the assembly process that must be enhanced using XR. Assembly tasks descriptions and allocation have to be provided.

- R: Software compatibility requirements: should also include availability of pre-made Application Programming Interface (API) or snippets for integration with the Unity environment used at TalTech. It will be required to develop an application in Unity to fetch the models and render/display them. Note that this application is not only managing the model loading and updates but is also based on the company and user requirements. The application will provide the interface structure (visual and backend) that would allow the operator to: select and navigate the models (e.g., zoom, rotation), touch the input, feedback and re-port on the elements or assembly procedures, visualise or listen to audio alerts.

- KPI: Production efficiency. Regarding the production efficiency, Harmet's focus is on:

  - PI: Lead Time (Production End Time - Production Start Time) [Measured in different in-house developed reporting software]. The lead time consists of the total time which one module spends in the saw centre, 2D and 3D production. The target is to reduce the lead time of produced XA module from 11018 minutes by between -10% and -15%.

- KPI: Training time reduction. Regarding training time reduction, Harmet's focus is on:
  - PI: Time that Level 1 workers need to achieve 50%/75%/100% of standard productivity using the digital help compared to the test group without digital help [Measured in different in-house developed reporting software]. This is currently not implemented and will be monitored and determined in the project. The target is to reduce the training time by between -10% and -20%.

- KPI: Nonconformities reduction. Regarding nonconformities reduction, Harmet's focus in on:
    - PI: Production mistakes per module [Measured in different in-house developed reporting software]. This is currently possible, but the baseline has to be set. The target is to reduce these errors by between -5% and -15%.

The values for the PIs for UC2.2 can be found in the corresponding columns of Table 6 to Table 10.

5.3. UC2.3: Data driven design to production cycle optimization

UC2.3 - Data Driven Design to Production Cycle Optimization closes the loop between the production and the design phase by implementing a feedback mechanism from the production floor to the design department, grounding on the same DTs previously developed.

5.3.1. UC2.3 Requirements and KPIs

The following clarifications were made as compared to the initial requirements listed in D1.1:

- R: Networking aspects
    - Motion-To-Photon latency for VR: < 20 ms, which can be achieved under local network coverage
    - Motion-To-Photon latency for AR: < 10 ms, which can be achieved under local network coverage
    - Network peak data rate >= 100 Mbps, which can be achieved under local network coverage

- KPI: Nonconformities reduction. Regarding the nonconformities reduction, Harmet's focus in on the following:
    - PI: Drawing-related errors found in the factory per module (on average) [Measured by different in-house developed reporting software]. This is currently possible, but the baseline has to be set. The target is to decrease this by between -5% and -15%.

- PI: Time for solving a drawing error (on average) [Measured by different in-house developed reporting software]. This is not yet possible and will be implemented in the project. This will have to be monitored and determined and the baseline has to be set. The target is to reduce this by between -5% and -15%.

The values for the PIs for UC2.3 can be found in the corresponding columns of Table 6 to Table 10.

5.4. Overview of KPIs for UC Category 2: Modular Wood-House Factory

This section provides a tabulated overview of the previous sections by means of **Table 6**, **Table 7**, **Table 8**, **Table 9**, and **Table 10** corresponding to the 5 KPIs (and underlying PIs) for UC Category 2.

Table 6. Production efficiency KPIs for UC Category 2: Modular Wood-House Factory

KPI: Production efficiency	UC Category 2: Modular Wood-House Factory					
	UC2.1: Precise localization for production processes optimization and human safety		UC2.2: DT, AR and Industry 5.0 UX assisted production supported by ZSM 5G data exchange		UC2.3: Data driven design to production cycle optimization	
	Baseline	Target	Baseline	Target	Baseline	Target
Indicator: Throughput Rate (Number of Units Produced / Time)	80 modules "XA"/month	Between 85 and 100 modules "XA"/month	Not applicable	Not applicable	Not applicable	Not applicable
Indicator: Lead Time (Production End Time: Production Start Time) [Measured in different in-house developed reporting software]	Not applicable	Not applicable	11018 minutes	Between -10% and -15%	Not applicable	Not applicable

Table 7. Training Time Reduction KPIs for UC Category 2: Modular Wood-House Factory

KPI: Training Time Reduction	UC Category 2: Modular Wood-House Factory					
	UC2.1: Precise localization for production processes optimization and human safety		UC2.2: DT, AR and Industry 5.0 UX assisted production supported by ZSM 5G data exchange		UC2.3: Data driven design to production cycle optimization	
	Baseline	Target	Baseline	Target	Baseline	Target
Time that Level 1 workers need to achieve 50%/75%/100% of standard productivity using the digital help compared to the test group without digital help [Measured in different in-house developed reporting software]	Not applicable	Not applicable	Monitor and determine	Between -10% and -20% training time decrease	Not applicable	Not applicable

Table 8. Positioning accuracy (Generic localisation accuracy of goods, machines, humans)) KPIs for UC Category 2: Modular Wood-House Factory

KPI: Positioning accuracy (Generic localisation accuracy of goods, machines, humans)	UC Category 2: Modular Wood-House Factory					
	UC2.1: Precise localization for production processes optimization and human safety		UC2.2: DT, AR and Industry 5.0 UX assisted production supported by ZSM 5G data exchange		UC2.3: Data driven design to production cycle optimization	
	Baseline	Target	Baseline	Target	Baseline	Target

Position accuracy (cm)	Positioning is not implemented	Between 100 cm and 500 cm	Positioning is not implemented	Between 100 cm and 500 cm	Not applicable	Not applicable

Table 9. Reduction of potential hazard events (human safety) KPIs for UC Category 2: Modular Wood-House Factory

KPI: Reduction of potential hazard events (human safety)	UC Category 2: Modular Wood-House Factory					
	UC2.1: Precise localization for production processes optimization and human safety		UC2.2: DT, AR and Industry 5.0 UX assisted production supported by ZSM 5G data exchange		UC2.3: Data driven design to production cycle optimization	
	Baseline	Target	Baseline	Target	Baseline	Target
Potential Serious Injuries or Fatalities (PSIFs) and near misses related to overhead crane hoists and forklifts	Monitor and determine / To be set	Between -5% and -15%	Not applicable	Not applicable	Not applicable	Not applicable
Safety oriented localisation accuracy	In or out the building / area of interest	Between 20 cm and 50 cm	Not applicable	Not applicable	Not applicable	Not applicable

Table 10. Nonconformities reduction KPIs for UC Category 2: Modular Wood-House Factory

KPI: Nonconformities reduction	UC Category 2: Modular Wood-House Factory					
	UC2.1: Precise localization for production processes optimization and human safety		UC2.2: DT, AR and Industry 5.0 UX assisted production supported by ZSM 5G data exchange		UC2.3: Data driven design to production cycle optimization	
	Baseline	Target	Baseline	Target	Baseline	Target
Production mistakes per module	Not applicable	Not applicable	To be set	Between -5% and -15%	Not applicable	Not applicable
Drawing-related errors found in the factory per module	Not applicable	Not applicable	Not applicable	Not applicable	To be set	Between -5% and -15%
Time of solving a drawing error (on average)	Not applicable	Not applicable	Not applicable	Not applicable	Monitor and determine / To be set	Between -5% and -15%

As mentioned earlier in Section 3.2, it should be noted that, unless already indicated for some cases in curly braces ({}), the way (where and how) the data will be collected, measured, analysed, and interpreted will be defined and refined during the next months of T1.2 as the technical work progresses. This will then be updated and reported in D1.4 (M22).

6. UC Category 3 – Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

UC Category 3 - Construction and Renovation with Wooden Elements, Valorisation of Composite Waste addresses selected steps in the lifecycle of wooden elements: wooden houses' lifecycle and analysis of alternative wooden composite materials.

6.1. UC3.1: AR and Industry 5.0 UX assisted assembly and renovation of green buildings

UC3.1 - AR and Industry 5.0 UX Assisted Assembly and Renovation of Green Buildings addresses the wooden houses' construction phase, ranging from when they leave the factory to when the building modules are assembled at the on-site location.

6.1.1. UC3.1 Requirements and KPIs

The following clarifications and additions have been made as compared to the initial requirements listed in D1.1:

- R: Regarding the DT/BIM model of the wood house: 3D models of wooden modules and instructions how to construct the wooden house are required. The following tools shall be used: Autodesk AutoCAD, Autodesk REVIT, Cadmatic.

- R: Regarding AR devices, only a tablet should be employed in the use case (smart glasses pose a safety issue for in-field trials). The tablets should support Android. The system should make use of QR codes. They have to be sticked on elements at Harmet. The QR codes have to be placed in the correct positions on each element to trigger some AR guidance.

- R: Regarding the networking aspects:

    - Motion-To-Photon latency for VR: no stringent real-time requirements, up to 1-5 s is acceptable for the UC.

    - Motion-To-Photon latency for AR: no stringent real-time requirements, up to 1-5 s is acceptable for the UC.

  - Network peak data rate >= 100 Mbps is sufficient because the 3D model is fetched once at the beginning and then only small updates (e.g. upload errors) are done at the end.

- R: Safety compliance: For AR devices: protective gloves should be touch ready.

- R: Connectivity: Most of the commercially available tablets support Wi-Fi and mobile data connection.

- R: Software compatibility: availability of pre-made API or snippets for integration with the Unity environment used at TalTech. As compared to UC2.2, here this is only for fetching the model. It will be required to develop an application in Unity to fetch the models and render/display them. Note, that as in UC2.2, the application is not only managing the model loading and updates. Based on the company and user requirements the application will provide the interface structure (visual and backend) that would allow the operator to: select and navigate the models (e.g., zoom, rotation), touch input, feedback and report on the elements or assembly procedures, visualise or listen to audio alerts.

- KPI: Production efficiency. Regarding the production efficiency, Harmet's focus in on the following:

  - PI: Construction assembly time per module [Other production reporting tools (Excel or e-mail)]. This can already be measured, but the baseline must be set. The target is to reduce this time by -5%.

  - PI: Possible work done in the factory (%), defined as the hours spent on a project in the factory / (Hours spent on a project in the factory + hours spent on site to finish work not completed in the factory) [Other production reporting tools (Excel)]. This is not possible as of today and will be implemented in the project. To be monitored and determined to set the baseline. The target is to reduce this by between -5% and -10%.

- KPI: Construction site situation awareness about safety during lifting the modules (human safety). When it comes to rising awareness of safety on site, Harmet's focus is on:
    - PI: Construction site situation awareness about safety during lifting the modules [Other production reporting tools (Excel)]. Currently, there is no data collection about the construction site safety while lifting the modules. The target is to enable GDPR-compliant safety-related data collection.

- PI: Nonconformities reduction. Regarding nonconformities reduction, the focus is on:
    - PI: Errors reported during assembly per module Software. As of today, errors are not reported at all, or they are reported late because there is no network connection at the assemble site. The baseline has to be set and the target is to reduce this by between -5% and -10%.

The values for the PIs for UC3.1 can be found in the corresponding columns of **Table 11** to Table 16.

6.2. UC3.2: Long term SHM of wooden constructions

UC3.2 - Long Term SHM of Wooden Constructions covers the use-phase[1] of the house, thus addressing 5G IoT devices, tools and methodologies supporting the monitoring and maintenance in relation to structural health monitoring (SHM).

6.2.1. UC3.2 Requirements and KPIs

In addition to the initial requirements listed in D1.1, the following points were clarified:

- R: Overall, for UC3.2, decision support for further renovation and reuse support for new houses should reflect the overall state, short term validity, long term estimation (Remaining Useful Life (RUL)) for selected reuse cases and environments.

[1] The use phase is the period during which the building is in use, i.e. the time between the pre-use phase and the end-use phase.

- R: Concerning the availability of 5G IoT sensors to be embedded in selected structural wooden parts, 3 phases will be considered for SHM (time depended): A) Transportation (short term activity); B) Assembly (short term activity); C) State over time (long term activity).

- R: Concerning sensors for monitoring different variables: A) Moisture, temperature; B) Moisture, temperature, loading, alignment; C) Moisture, temperature, loading, alignment, bending, displacement, cracks (acoustics emission (AE)), impacts (vibration acceleration (ACC)), and in addition: virtual, model based sensors.

- R: Concerning 5G -enabled sensors: it is also required a test environment selections/specifications and build-up, a test plan and execution for possible above A), B) and C). For in-field trials: sensors from TalTech et al., edges (5G) from TalTech and THA DIS&AIS, Services (EA) from VTT et al. For lab trials: sensors from each lab, data to info from each lab.

- R: Comment about the edge/cloud computing architecture: the actual transferred info might be small but requires local edge processing.

- R: Clarification about number of measurements per day vs. sampling frequency: the number of measurements will be in the order of 10 measurements per day, which might be sufficient; however, the actual sampling frequency of the measurements at the edge can be much higher for possible dynamic measurements. This should be implemented either using a constant interval and/or on a trigger-based.

- R: Note that the selected wooden components (Kerto LVL, massive wood and cladding board) used for the modular house produced by Harmet can be found in D1.1.

- KPI: Product Lifecycle Traceability. Regarding the product lifecycle traceability, the focus is on:
    - PI: Generating suggestions and requirements for wood and wood-based products of wood houses, which need to be gathered for the wood digital passport. Such suggestions and requirements for the wood digital passport are not existing at the

moment and the target is to propose some of them during the project.

- PI: Product traceability (Material assigned to traceability system / Total material). Today this is 0%, and the target is to make proposals for reaching 50%.
- PI: Improved documental Management (number of materials (or components) with machine-readable information / total number of materials (or components)). Today this is 0%, and the target is to make proposals for reaching 50%.
- PI: Get live update of building indoor and construction's health via sensors etc. over IoT and 5G. This is currently not implemented, and the target is to implement it.

The values for the PIs for UC3.1 can be found in the corresponding columns of **Table 11** to Table 16.
See also D1.1 for a list of selected wooden components for modular house.

6.3. UC3.3: Wooden Composites Waste Recycling

UC3.3: - Wooden Composites Waste Recycling addresses the analysis of alternative wooden composite materials for the wooden house, aiming to improve waste recycling in the production process.

6.3.1. UC3.3 Requirements and KPIs

UC3.3 is conducted as desk research; therefore, the targets are marked as Theoretical Target.
The following clarifications have been made in addition to the initial requirements listed in D1.1:

- R: Availability of appropriate models to predict deterioration of the quality of the material in response to the external loads is required.
- R: Availability of material data (laboratory test results, chemical composition, …) of the base material, adhesives and coating is required.
- R: Bill of materials / components from the pilots is required.

- R: Production waste breakdown (reused, incinerated, sent outside, …) is required.

- R: Production energy breakdown (internal from incinerated wood and external) is required.

- R: Access to monitoring data is required, e.g. moisture in wood elements. This can be based on VTT's work in UC1.1 or on information provided by Harmet to its clients (if measured).

- KPI: Internal wood waste reduction. Regarding the internal wood waste reduction, the following points will be focused on:
    - PI: Internal Waste (Internally generated waste/ Total Material). At the moment, no approach has been identified. The theoretical target is to propose solutions on the long term. For example, using custom panels as input material. This is expensive today, but perhaps this will be much cheaper in the future thanks to new machinery.

    - PI: Internal Waste sent for Recovery (Internally Recovered Material / Waste Material). At the moment, this is 0%. The theoretical target is to propose solutions and ideas. For example, usefulness for Harmet to sort the wood waste for its external partners.

    - PI: Internal Waste Incineration (Incinerated material / Recovered Waste Material). Today, approximately 1/3 of the wood waste is burned for heating and hot water production at Harmet Kumna factory. The theoretical target is to propose solutions for increasing this value to e.g. 2/3.

- KPI: Lifecycle Wood Waste Reduction. Regarding the lifecycle wood waste reduction, the focus will be on:
        - PI: Waste Prevention 1 - (Waste material / Total material). Currently, this is 0%. The theoretical target is to propose solutions to reach 20%.

        - PI: Waste Reuse (Reused Material / Waste Material). Today this is also 0%. The theoretical target is to propose solutions to

reach 20% (e.g. replace nails with other softer elements to avoid damaging wood).

- PI: Waste Recycling (Recycled Material / (Waste material - Re-used material)). The baseline will be found in the literature depending on the UC3.1 pending locations. The theoretical target is to propose solutions to reach 50% waste recycling.

For the above three targets, other solutions could be investigated in terms of architectural design (exposition of facades to rain etc.) so that the wood houses are better structurally protected. Such solution could make use of tools from the ClickDesign project[2] (ERA-NET Cofund ForestValue).

The values for the PIs for UC3.3 can be found in the corresponding columns of **Table 11** to **Table 16**.

[2] https://innorenew.eu/project/click-design-delivering-fingertip-knowledge-enable-service-life-performance-specification-wood/

6.4. Overview of KPIs for UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

This section provides a tabulated overview of the previous sections by means of **Table 11**, Table 12, Table 13, Table 14, Table 15, and Table 16 corresponding to the 6 KPIs (and underlying PIs) for UC Category 3.

Table 11. Production efficiency KPIs for UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

KPI: Production efficiency	UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste					
	UC3.1 AR and Industry 5.0 UX assisted assembly and renovation of green buildings		UC3.2: Long term SHM of wooden constructions using IoT and embedded AI		UC3.3: Wooden composites waste recycling	
	Baseline	Target	Baseline	Target	Baseline	Theoretical Target
Construction assembly time per module [Other production reporting tools (Excel or e-mail)]	To be set	-5%	Not applicable	Not applicable	Not applicable	Not applicable
Possible work done in the factory (%) = Hours spent on a project in the factory / (Hours spent on a project in the factory + hours spent on site to finish work not completed in the factory) [Other production reporting tools (Excel)]	Monitor and determine	Between -5% and -10%	Not applicable	Not applicable	Not applicable	Not applicable

Table 12. Reduction of potential hazard events (human safety) KPIs for UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

KPI: Reduction of potential hazard events (human safety)	UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste					
	UC3.1: AR and Industry 5.0 UX assisted assembly and renovation of green buildings		UC3.2: Long term SHM of wooden constructions using IoT and embedded AI		UC3.3: Wooden composites waste recycling	
	Baseline	Target	Baseline	Target	Baseline	Theoretical Target
PI: Construction site situation awareness about safety during lifting the modules [Other production reporting tools (Excel)]	No data collection	GDPR compliant safety related data collection enabled	Not applicable	Not applicable	Not applicable	Not applicable

Table 13. Nonconformities reduction KPIs for UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

KPI: Nonconformities reduction	UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste					
	UC3.1: AR and Industry 5.0 UX assisted assembly and renovation of green buildings		UC3.2: Long term SHM of wooden constructions using IoT and embedded AI		UC3.3: Wooden composites waste recycling	
	Baseline	Target	Baseline	Target	Baseline	Theoretical Target
PI: Errors reported during assembly per module [Software]	To be set	Between -5% and -10%	Not applicable	Not applicable	Not applicable	Not applicable

Table 14. Product lifecycle traceability KPIs for UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

KPI: Product lifecycle traceability	UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste					
	UC3.1: AR and Industry 5.0 UX assisted assembly and renovation of green buildings		UC3.2: Long term SHM of wooden constructions using IoT and embedded AI		UC3.3: Wooden composites waste recycling	
	Baseline	Target	Baseline	Target	Baseline	Theoretical Target
PI: Suggestions and requirements for wood and wood-based products of wood houses, which need to be gathered for the digital passport	Not applicable	Not applicable	Suggestions and requirements not available	Suggestions and requirements are available	Not applicable	Not applicable
PI: Product traceability (Material assigned to traceability system / Total material)	Not applicable	Not applicable	0%	Proposals to reach 50% are made	Not applicable	Not applicable
PI: Improved documental Management (number of materials (or components) with machine-readable information / total number of materials (or components))	Not applicable	Not applicable	0%	Proposals to reach 50% are made	Not applicable	Not applicable
PI: Get live update of building indoor and construction's health via sensors etc. over IoT and 5G	Not applicable	Not applicable	Not implemented	Implemented	Not applicable	Not applicable

Table 15. Internal Wood Waste Reduction KPIs for UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

KPI: Internal Wood Waste Reduction	UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste					
	UC3.1: AR and Industry 5.0 UX assisted assembly and renovation of green buildings		UC3.2: Long term SHM of wooden constructions using IoT and embedded AI		UC3.3: Wooden composites waste recycling	
	Baseline	Target	Baseline	Target	Baseline	Theoretical Target
PI: Internal Waste (Internally generated waste/ Total Material)	Not applicable	Not applicable	Not applicable	Not applicable	No approach has been identified.	Propose solutions on the long term. For example, using custom panels as input material. This is expensive today, but perhaps this will be much cheaper in the future thanks to new machinery.
PI: Internal Waste sent for Recovery (Internally Recovered Material / Waste Material)	Not applicable	Not applicable	Not applicable	Not applicable	0%	Propose solutions and ideas. For example, usefulness for Harmet to sort the wood waste for

						its external partners.
PI: Internal Waste Incineration (Incinerated material / Recovered Waste Material)	Not applicable	Not applicable	Not applicable	Not applicable	1/3	Propose solutions for increasing this value to e.g. 2/3.

Table 16. Lifecycle Wood Waste Reduction KPIs for UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste

KPI: Lifecycle Wood Waste Reduction	UC Category 3: Construction and Renovation with Wooden Elements, Valorisation of Composite Waste					
	UC3.1: AR and Industry 5.0 UX assisted assembly and renovation of green buildings		UC3.2: Long term SHM of wooden constructions using IoT and embedded AI		UC3.3: Wooden composites waste recycling	
	Baseline	Target	Baseline	Target	Baseline	Theoretical Target
PI: Waste Prevention: 1 - (Waste material / Total material)	Not applicable	Not applicable	Not applicable	Not applicable	0%	Propose solutions to reach 20%.
PI: Waste Reuse (Reused Material / Waste Material)	Not applicable	Not applicable	Not applicable	Not applicable	0%	Propose solutions to reach 20%
PI: Waste Recycling (Recycled Material / (Waste material - Reused material))	Not applicable	Not applicable	Not applicable	Not applicable	The baseline will be found in the literature.	Propose solutions to reach 50%

As mentioned earlier in Section 3.2, it should be noted that, unless already indicated for some cases in curly braces ({}), the way (where and how) the data will be collected, measured, analysed, and interpreted will be defined and refined during the next months of T1.2 as the technical work progresses. This will then be updated and reported in D1.4 (M22).

7. Network KPIs (5G NPN)

This chapter presents the KPIs related to the 5G NPN aspects of the project, which are transversal to the project. These KPIs are organized as per:

- 5G core and access network general KPIs
- 5G core and access network security conformance
- Network Zero-Touch Install Features in the Radio Access Network (RAN) KPIs
- Other RAN KPIs

The process for guiding the definition of the network KPIs is based on the partners' experience in the industry and other EU project. Moreover, specifically regarding the NPN aspects, our approach also considers the requirements and performance indicators provided in the recent (November 2022) 5G PPP Technology Board Non-Public-Networks –State of the art and way forward document[3] (including Figure 3), of which some central points are outlined below.

Table 3-2: Mapping of network capabilities to use case requirement levels

	Level 1	Level 2	Level 3
Guaranteed QoS	No E2E QoS guarantees	Support for different classes of Service but no guarantees	Guaranteed QoS
Customization	Limited add on features even if fully customisable	Good amount of add-on features available but only few can be provisioned	All available add-on features are possible
Network control	Connection service	Controllable connection service	Owned infrastructure
End User Data protection	Weak protection within the whole system even with full control over the data	Strong protection within the whole system but limited control over the data	Strong protection within the whole system including full control over the data
Capability Exposure	Limited capabilities to expose even if fully customisable	Good amount of capabilities are available to be exposed but only few can be exposed	Rich set of capabilities to expose available and possible
Target area coverage	Best effort	Can be covered but without exclusivity	Exclusive coverage of any given area possible
Traffic engineering	No TE means available	Some TE can be chosen	Support for any typical TE method

Figure 3. Mapping of network capabilities to use case requirements levels (extracted from [3])

[3] 5G PPP Technology Board Non-Public-Networks –State of the art and way forward. Version 1.0. Date: 2022-11-17. Version: 1.0. DOI: http://doi.org/10.5281/zenodo.7230191

1. Guaranteed Quality of Service (QoS): performance parameters (e.g. Latency, Jitter and Throughput (Uplink and Downlink) or combination thereof). In 5G-TIMBER, the focus is primarily on throughput and latency, while jitter is less critical.

- PI: Throughput: [core network] the baseline will be monitored and determine; the target is to support 80% of the nominal throughput of network interfaces (e.g. 1 Gbps -> 0.8Gbps) at the network interface cards of the servers (hardware specific).
- PI: Latency [core network]: the baseline will be monitored and determined; the target is to achieve < 100 microseconds for the core only (or User Plane Function (UPF) only)

2. Customisation: features needed by the enterprise to meet its business needs. In 5G-TIMBER the focus is on time synchronization, localization accuracy, 5G-LAN support, and integration with remote cloud; support for high density of User Equipment (UE) is less critical.

- PI: Location [core network]: the target is that location services will be supported
- PI: KPI Positioning Accuracy Confidence %/Resilience/Robustness/ - (Localisation xApp) [access network]: the baseline accuracy is ± 150 m (Cell ID); the target[4] is to achieve a generic localization accuracy of between 100 cm and 500 cm (robust) and between 20 cm and 50 cm for the safety oriented localisation accuracy. It should be noted that the more input sources the higher confidence percentage and robustness. It is foreseen to fuse and exploit positioning information from heterogeneous sources (e.g. 5G, Ultra Wide Band (UWB), camera) by means of the RAN Intelligent Controller (RIC) and xApp features of the network.
- PI: Mobility [core and access network]: the target is that handover will be supported (inter-Next Generation NodeB (gNB)).

3. Network Control: reflects the enterprise desire for end-to-end control of the network management, its resources and its services. In 5G-TIMBER the focus is on data, information, and operations technologies, while communication technology itself is considered as the necessary backbone. A key

[4] By means of e.g. predictive handover

feature to make 5G NPN networks manageable by SMEs is Network Zero-Touch Install Features.

- PI: Neighbour Recognition (xApp) [access network]: The baseline is that this is currently not available, or the planning is done offline. The target is to enable dynamic planning.
- PI: Physical Cell ID (PCI) Allocation Optimization (xApp) [access network]. As above, the baseline is that this is currently not available, or the planning is done offline. The target is to enable dynamic planning.
- PI: Self-Organizing Network (SON) Tx Power (xApp) based on RIC [access network]. This is currently not available. The target is to enable dynamic configuration and management.

4. End User Data protection: level of data protection for the subscriber/user. In 5G-TIMBER the focus in on security by design (encryption and storage location) while redundancy is less critical.

- PI: Level of 5G security features implemented. The target is to ensure that these will be implemented at a given level.
- PI [Core and access network]: Measured: Subscription Concealed Identifier (SUCI), Transport Layer Security (TLS) 256 on N2/N3 interfaces, Trusted Domain Name System (DNS): via Internet Protocol Security (IPSec). The target is to ensure these will be measured.

5. Capability exposure: mechanisms for exporting relevant network information and features to the verticals.
In 5G-TIMBER, this includes the network KPIs presented in this section.

6. Target area coverage: radio coverage in a specific geographical area. In 5G-TIMBER, the coverage shall be guaranteed at the pilot sites (Harmet production hall, Nordwood sawmill). Both pilot sites do not have difficult environments/layouts.

- PI: Coverage and capacity optimisation (interference Management transmit (Tx) Power xApp) [access network]: this is currently not available, or the planning is done offline. The target is to enable dynamic planning.

7. Traffic Engineering: mechanisms to steer and isolate the traffic as per the technical and business needs. In 5G-TIMBER, QoS prioritization and slicing will be supported.

- PI: QoS support [core and access network]: the target is that QoS will be supported for 5QI[5]
- Slicing supported [core and access network]: the target is that Slicing will be supported end-to-end

In addition to the above, 5G-TIMBER will also investigate energy-saving mechanisms

- PI: Radio Resource Control (RRC)-Inactivity (UE Energy Saving) [access network]. The baseline is that such feature in currently not available. The target is to enable such energy saving.

A tabulated overview of the above network KPIs, organized as Core Network KPIs, network security conformance KPIs, ZSM Install Features in the RAN KPIs, and other RAN KPIs is provided in Table 17 to Table 20.

Table 17. Core and Access Network KPIs

KPI: Core and access network general		
	Baseline	Target
PI: Throughput	Monitor and determine	80% of nominal throughput of network interfaces (e.g. 1 Gbps -> 0.8Gbps)
PI: Latency	Monitor and determine	<100 microseconds for the core only (or UPF only
PI: Location services		Location services supported
PI: Slicing		Slicing supported
PI: Mobility		Handover supported (inter-gNB)
PI: QoS support		QoS supported for 5QI[5]

Table 18. Core and Access Network Security Conformance KPIs

KPI: Core and access network security conformance		
	Baseline	Target
PI: Level of 5G security features implemented	Not implemented	Implemented and corresponding level
PI: Measured (SUCI, TLS 256 on N2/N3 interfaces, Trusted DNS: via IPSec)	Not measured	Measured

[5] https://www.5gworldpro.com/uncategorized/what-is-5qi-in-5g.html

Table 19. Network Zero-Touch Install Features in the RAN KPIs

KPI: Network Zero-Touch Install Features in the RAN		
	Baseline	Target
PI: Neighbour Recognition (xApp)	None/offline planning	Dynamic planning
PI: PCI Allocation Optimization (xApp)	None/offline planning	Dynamic planning
PI: SON Tx Power (xApp)[6]	None	Dynamic

Table 20. Other Features in the RAN KPIs

KPI: Other Features in the RAN		
	Baseline	Target
PI: Coverage and capacity optimisation (interference Management Tx Power xApp)	None/offline planning	Dynamic planning
PI: RRC-Inactivity (UE Energy Saving)	RRC-Inactivity (UE Energy Saving) not implemented	RRC-Inactivity (UE Energy Saving) implemented
PI: KPI Positioning Accuracy Confidence %/Resilience/Robustness/ - (Localisation xApp)	±150 m (Cell ID)	Generic localization accuracy of between 100 cm and 500 cm (robust) and between 20 cm and 50 cm for the safety oriented localisation accuracy.

[6] E.g. to power down a BS. Based on RIC.

8. Preliminary Business KPIs

In addition to the technical KPIs presented in the previous chapters, the technological interventions that will be deployed at the pilot sites during the field trials will also be assessed from a business perspective. What follows is a preliminary list of measures and indicators that will be considered later during the project once all the technical aspects for executing the field trials are settled and the proposed solutions are deemed successful from a technical perspective while executing the field trials.

1. Overall Equipment Effectiveness (OEE). OEE actual expression depends on the type of system/machine being analysed[7]. These will be defined and calculated for the specific cases, and a e.g. weighted average function will be defined in order to obtain an overall OEE.

2. Capital expenditures (CAPEX) are defined as the funds spent by a company for acquiring, upgrading, and maintaining physical assets. A detailed analysis of such costs will be carried out post field-trials so that enough data and experience will be collected to provide meaningful results.

3. Operating expenditures (OPEX) are defined as short-term expenses used for running a business or system. A detailed analysis of such costs will be carried out post field-trials. As for CAPEX, a detailed analysis of such costs will be carried out post field-trials so that enough data and experience will be collected to provide meaningful results.

4. Return on investment (ROI) is calculated as the ratio between the benefit resulting from an investment and the cost of that investment. Similar to the above, a detailed analysis of ROI will be carried out post-trials.

5. Balance time (or break-even period) is the time needed to generate enough profit to cover the initial costs of the investment. This will be analysed together with the ROI.

[7] Example, among others: (units produced × max cycle time) / available production time.

6. Medium term worth creation. Due to the relatively short duration of the 5G-TIMBER project, the focus will be on the analysis of the worth (added value) generated by the interventions on the medium term and not long term.

7. Value boost due to information sharing. Data sharing, and thus information sharing, is a central aspect of 5G-TIMBER. A detailed analysis of the expected improvements in the 9 UCs will be carried out, with a focus on how and to what extent data sharing contributed to the overall value boost along the WVC.

9. Conclusions

Building upon the UCs description provided in D1.1, this deliverable D1.3 has clarified and elaborated the initial definition of the requirements and KPIs of the 9 UCs of the 5G-TIMBER project.

Workshops and meetings held with the project partners, in particular the UC owners and pilot site owners, have contributed to making the requirements more explicit and quantified where needed and where possible at this stage of the project.

Correspondingly, the needs and opportunities for relevant initial KPIs and PIs have been analysed by the project partners and are listed in the deliverable. These requirements and KPIs will be used to assess the UCs and will help moving toward achieving the overall project objectives across the 5G-TIMBER WVC.

9.1. Next steps

Deliverable D1.3 reflects the current understanding of the UCs definitions and the plan for executing them as of M6/November 2022. T1.2 will continue until M22/March 2024. This is a significant period of time (16 months) during which additional work will be carried out.

Indeed, as was described in detail in **Table 2** (Chapter 2), the other tasks in WP1, as well as several tasks in WP1 to WP7 will consider the *initial* set of requirements and KPIs defined in D1.3.
As the work in these tasks (related to the design, implementation and lab/field trials) will progress, experience will be gained and feedback to T1.2 on a continuous basis. This will allow to iteratively clarify and/or revise the requirements and KPIs towards achieving the main objectives of the project while confronting and adapting to the industrial reality in the field.

The status of T1.2 will also be reported in D7.10 (technical report due on M9 for the first technical review of the project), and updates to the KPIs will be documented later on in D1.4 (Final KPIs definition report due on M22). They will also be reflected (more or less directly) in the deliverables generated by WP1 to WP6 that takes those requirements and KPIs into account.