SMART CITY CHALLENGE 2025

Solution idea for the city challenges

Max 3 pages

send to smartcity@taltech.ee by Nov 30, 2025

Solution Idea Title (max 5 words, no acronyms) - Accurate Aerial Scanning for Circularity

Planned pilot project duration – 24 months

Main contact/-s – Muhammad Mahtab Alam, muhammad.alam@taltech.ee, +37255939746, TalTech, Thomas Johann Seebecki elektroonikainstituut

1. Which urban challenge or problem are you planning to provide a solution to?

- Lack of accurate enough data about building parts and materials for circular construction

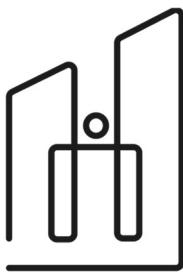## 2. The solution you are proposing

2.1. Background

European cities such as Rotterdam, Tallinn, Tartu, and Vantaa etc., are accelerating their transition toward circular construction, yet they face a persistent barrier related to the lack of accurate and reliable building material data. Without knowing sufficient details about the material types, quantities, and conditions, municipalities struggle to plan renovations, evaluate insulation needs, estimate reuse potential, or comply with emerging circularity policies. Conventional inspections, relying on scaffolding, manual assessments, destructive sampling, and labor-intensive surveys, are slow, costly, and often unsafe. These practices limit the ability of cities to identify reusable elements, plan selective deconstruction, or reduce unnecessary demolition, limiting them to linear construction models. What cities urgently need is a fast, non-invasive, and cost-efficient method to generate accurate material inventories before renovation/demolition enabling transition to circular construction models.

2.2. Proposed Solution: AI-CIRCULARSCAN

To meet this need, we propose the AI-Enabled accurate aerial material monitoring system for circular construction (AI-CircularScan), a closed-loop system that integrates 5G-connected drones, ultra-high-definition multisensory imaging, and AI-based accurate material status and decay detection this in turn will create accurate digital identities of reusable building materials. AI-CIRCULARSCAN deploys autonomous or semi-autonomous 5G drones, operating over public 5G or 5G Non-Public Networks (NPN) to ensure stable control and real-time data transmission in dense urban environments. These drones, equipped with ultra-high-definition cameras, LiDAR, and optional multispectral sensors, perform 360° multi-angle exterior scans of facades, roof structures, joints, and other difficult-to-access elements. Whenever interior access is granted, micro-drones or indoor LiDAR

systems complement exterior mapping. Captured data feeds into the AI-CIRCULARSCAN AI/ML pipeline, which performs detection of material types (timber, concrete, brick, metal, insulation, composites), estimates their quantities and conditions, and assigns circularity indicators. The outcome is a Digital Material Passport, functioning as the digital identity of reusable materials, including component lists, degradation scores, circularity ratings, and recommended reuse pathways. AI-CIRCULARSCAN operates as a closed-loop system: material data is updated after renovation or deconstruction and can be seamlessly integrated into BIM models and municipal circularity platforms. This ensures long-term, city-wide visibility into material flows and building stock.

3. Innovation and piloting of your pilot solution.

AI-CIRCULARSCAN innovate by combining traditionally fragmented processes (drone inspection, sensor-based scanning, and AI analysis) into a unified operational workflow built specifically for circular construction. Its key differentiators include:

- **Unified Aerial Material Intelligence System**, i.e. a single platform integrating 5G drones, ultra-high-definition imaging, LiDAR depth fusion, and AI-supported material detection, classification, and condition/decay estimation.
- **360° Non-Invasive Material Identification**, i.e., a highly precise, contact-free detection of building materials, eliminating the need for scaffolding.
- **Real-Time 5G Operations**, i.e., the use of public 5G or 5G NPN ensures low-latency drone control and immediate data access for city engineers.
- **Closed-Loop Circularity Workflow**, i.e., the system continuously updates material identities to ensure up-to-date inventories throughout renovation and deconstruction cycles.
- **Scalable City-Wide Deployment**, i.e., efficient drone route optimization reduces inspection time and cost, enabling large-scale adoption.
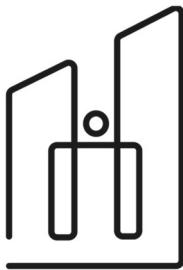
AI-CIRCULARSCAN thus provides municipalities with a scalable and reliable system dedicated to supporting circular renovation decision-making and significantly reduces dependence on slow manual inspections.

3.1. Pilot Plan

The pilot demonstrates end-to-end capability of the AI-CIRCULARSCAN system within real city conditions.

- **Selection of Pilot Buildings:** Cities select up to 3 buildings undergoing renovation, insulation upgrades, or selective deconstruction, prioritizing cases with limited documentation.
- **5G Drone-Based Data Collection:** 5G drones carry out multi-angle (360°) exterior scans of facades, rooftops, wooden and metallic components, and architectural details. Interior scans may be added when permitted to improve material interpretation.
- **AI/ML Material Highly Accurate Detection:** The AI-CIRCULARSCAN pipeline processes the captured data to detect material types, estimate conditions, calculate quantities, and assigned circularity scores along with confidence metrics. During piloting, validation against expert assessment will be included where feasible.
- **Delivery of the Digital Material Passport:** The city receives a comprehensive digital material passport including 3D reconstruction, material identities, degradation indicators, quantities, and reuse

recommendations. Outputs can integrate with BIM systems and city planning tools. Through the pilot, municipalities evaluate the operational benefits of automated material intelligence, reduced inspection costs, and improved accuracy for circular construction planning.

3.2. Competence of the Team

The project is led by TalTech experts with more than a decade of experience in autonomous drone technologies, AI/ML modelling and high-accuracy image and data processing, wood lifecycle modelling and circularity analysis from the 5G-TIMBER project, digital twins and geospatial data processing, and energy-efficient UAV route optimization. Collaboration with the municipalities that proposed the challenge will create interdisciplinary expertise that ensures AI-CIRCULARSCAN is technologically robust, scientifically grounded, and aligned with the practical needs of municipalities transitioning toward circular construction. The key team members are: Tenured Professor Muhammad Mahtab Alam, Head of the Communication Systems Research Group; Tenured Professor Yannick Le Moullec, Head of the Cognitive Electronics Research Group; Alar Kuusik, Head of the Thomas Johann Seebeck Department of Electronics; 5G Solution Expert Margus Rohtla; and Junaid Sajid, Early-stage researcher on AI for drones' detection.

4. Expected impact of your pilot solution.

AI-CIRCULARSCAN will significantly enhance how cities plan and execute circular renovation by providing fast, accurate, non-invasive insights into the material composition of buildings. Through precise digital identities of reusable materials, the system enables:

- Selective deconstruction and can reduce unnecessary demolition by an estimated 10 to 20% in renovation projects.
- Lower inspection costs via decreased on-site inspection time of approximately 40-50%.
- Improved safety by minimizing physical site risks via reduced scaffolding-dependent assessments by up to 70%.

By integrating directly with BIM and city-planning tools, AI-CIRCULARSCAN supports compliance with EU circular economy and renovation directives while giving municipalities a scalable method to monitor material flows. The proposed solution strengthens long-term urban sustainability by enabling data-driven decisions, reducing construction waste, and accelerating the shift from linear to circular construction practices.

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