SMART CITY 2.0
NEXT-GEN MATERIALS TRANSFORMING TECHNOLOGIES

Avram Alexandru (UNSTPB)

Yesimnaz Cugunlular(ITU)

Elena Somoza (UPM)

Zoltán Havassy (BME)

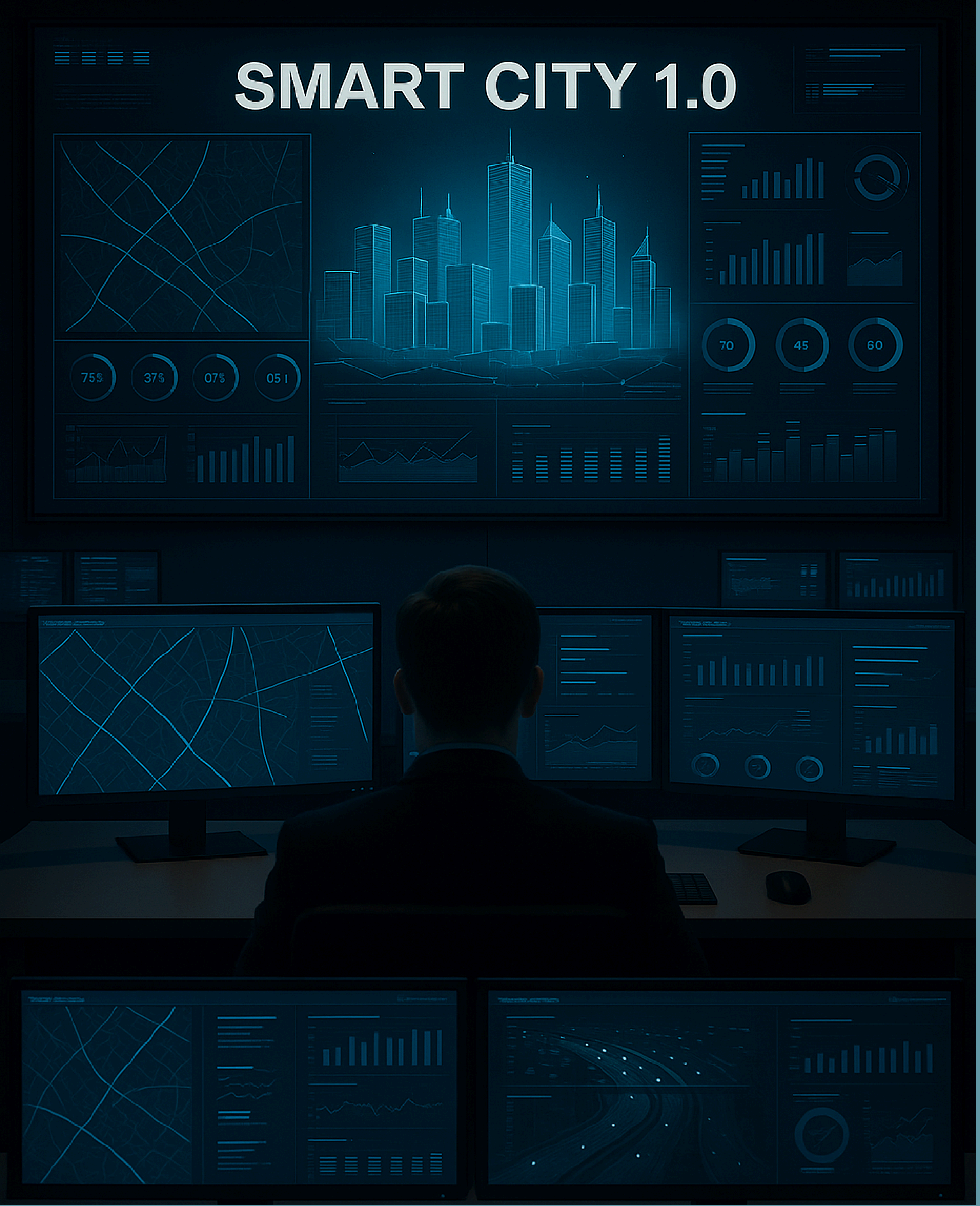
WHAT IS A SMART CITY?

Key Technology Components:

- **Internet of Things (IoT) Integration:** Sensors and devices collect real-time data on traffic flow, air quality, and urban systems
- **Smart Grids:** Use real-time data to balance electricity supply and demand while reducing waste
- **Advanced Communication Networks:** High-speed internet and 5G networks support vast data generation and enable real-time communication

Infrastructure Elements:

- **Smart Poles:** Connected infrastructure hosting mobile broadband, public Wi-Fi, LED lighting, and multipurpose sensors for monitoring air quality and traffic
- **Fiber-based Networks:** Optical fiber cables provide virtually unlimited capacity as the backbone for smart city communications
- **Sensor-enabled Devices:** Cameras, GPS technology, and other devices capture valuable data across the urban environment



SMART CITY 1.0: TECHNOLOGY DRIVEN APPROACH

Characteristics:

- Led by technology providers (IBM, Cisco) encouraging solution adoption
- Cities contracted out design and implementation to IT providers
- Focus on maximizing advanced technology for viability and control
- Top-down planning with limited citizen understanding
- Command and control centers as centralized management systems

Limitations:

- High taxes for features residents didn't want or use
- Missing key dynamics of city-citizen interaction
- Technology push without proper citizen consultation

SMART CITY 2.0: WHAT WE WANT TO ACHIEVE

Key Characteristics:

- Citizen-Centric Approach: People first, technology as enabler
- Data Democracy: Putting data in citizens' hands for better decision-making

Goals We Want to Achieve:

- Enhanced Quality of Life: Responsive services tailored to community needs
- Sustainable Development: Green infrastructure and resource optimization
- Citizen Empowerment: Active participation in city planning and governance
- Digital Inclusion: Bridging the digital divide and tech literacy
- Environmental Impact: AI-driven solutions for carbon reduction and resource management

SMART CITY WELL-BEING: WEARABLE BIOSIGNALS

PROBLEM:

- Insufficiency of Health Care Systems
- Importance of Early Intervention
- Aging Population's Fear of Being Alone
- Emergency Room Overcrowding / Overuse
- Cost Barriers and Health Inequality
- Unreported or Unnoticed Events
- Data Gaps for Public Health

OUR GOAL:

Provide every citizen with a government-issued wearable device that continuously monitors vital signs (biosignals) and, upon detecting a life-threatening anomaly, automatically alerts emergency services with the user's location.

SMART CITY WELL-BEING: WEARABLE BIOSIGNALS

Wearable Technology in 6 Factors:

- WEARABILITY
- PRIVACY
- DATA ACCURACY
- PERCEIVED VALUE
- DATA RELEVANCY
- EASE OF USE

SOLUTION OVERVIEW

- **Continuous Biosignal Monitoring:** A lightweight wristband measures key vitals 24/7.
- **Secure Data Transmission:** Measurements flow securely and wirelessly to a small-scale private local database.
- **Anomaly Detection:** Advanced machine learning models trained on biosignal data to detect health emergencies in real time.
- **Emergency Dispatch:** If the user is unresponsive or the device deems the event serious, it automatically dials EMS, sending GPS coordinates and medical records.
- **Post-Event Data Sharing:** Real-time vital readings accompany the dispatch, enabling EMS teams to prepare appropriate interventions en route.
- **Data Analytics for Public Health:** Anonymized aggregate data can reveal community health trends: outbreak early warnings, regional stress hotspots, environmental health correlations, etc.

ESSENTIAL BIOSIGNALS TO MONITOR

Electrocardiogram (ECG) & Heart Rate:
Detects arrhythmias and heart attacks early.

Oxygen Level (SpO_2):
Identifies breathing difficulties and drops in blood oxygen.

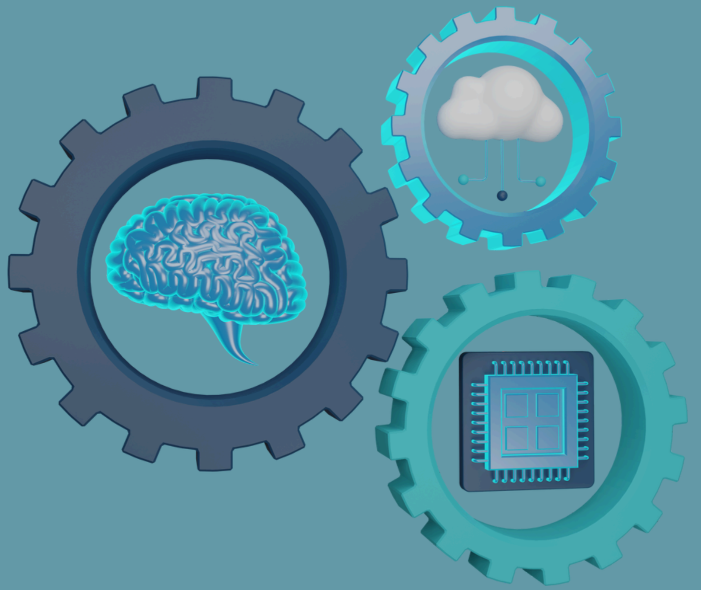
Respiration Rate:
Detects abnormalities in breathing patterns.

Body Temperature:
Alerts for hyperthermia or hypothermia.

Movement & Fall Detection:
Automatically senses falls or accidents.

Electrodermal Activity (EDA/GSR):
Provides supporting data on stress or sudden health changes.

HOW IT WORKS: MACHINE LEARNING FOR ANOMALY DETECTION



WEARABLE → CLOUD (DATA PREP) → ML MODEL → ANOMALY ALERT → EMS NOTIFICATION

1. Data Collection: The wearable continuously streams biosignal data to the database in real time.

2. Data Preprocessing: Incoming data is cleaned, filtered, and segmented to remove noise and unnecessary parts.

3. Model Training & Personalization: ML models are trained on large datasets of biosignals and continuously updated to recognize each user's "normal" patterns.

4. Real-Time Monitoring & Analysis: The trained ML model analyzes the user's incoming data stream for abnormal patterns.

5. Anomaly Detection: If the model identifies a potentially life-threatening event, it triggers an immediate alert.

6. Response & Alert: The system automatically notifies emergency services with the user's location and vital data for fast intervention.

INNOVATIVE NATURE-INSPIRED SOLUTIONS FOR URBAN SUSTAINABILITY

As urban environments continue to grow, the need for **sustainable**, **efficient**, and **nature-integrated** infrastructure has never been greater.

SOLUTION →

The integration of **photoactive materials**, **living walls**, and **bio-inspired filtration systems**, harnessing natural processes.

MATERIALS

PHOTOACTIVE AND MOSS CONCRETE + BIOCHAR AND MYCELIUM COMPOSITES

WE ANALYZE →

- COST
- TIMELINE
- ENVIRONMENTAL IMPACT

AIR QUALITY – SMART SURFACES AND STRUCTURES

PHOTOACTIVE CONCRETE

IMPACT

- Up to 80% reduction in surface air pollutants

TIME

1 year per facade

COST

~$60/m²

HOW IT WORKS

Under UV light, TiO_2 initiates a redox reaction that breaks down NOx and SO_2 into less harmful substances (e.g., nitrates).

WHAT IT IS

A white cement matrix doped with titanium dioxide (TiO_2), a photocatalyst.

MOSS WALLS

IMPACT

- Cools air by 3-5 degrees
- Removes 20-30% of fine particles

TIME

6–12 months

COST

$300–500/m²

HOW IT WORKS

Moss captures CO_2 and traps fine dust (PM2.5), while microbes may metabolize airborne organics. The porous structure increases surface area and passive cooling.

WHAT IT IS

A layered substrate (often concrete or biopolymer-based) with embedded moss and symbiotic microbes.

WATER QUALITY
NATURE-INSPIRED FILTRATION SYSTEMS

BIOCHAR FILTERS

IMPACT

- Captures 70–90% of key water pollutants

TIME

3–6 months

COST

$250–300/m³

WHAT IT IS

A porous, carbon-rich material made by pyrolysis (heating organic biomass like wood chips in low oxygen).

HOW IT WORKS

The large internal surface area and functional groups (e.g., carboxyl, hydroxyl) adsorb heavy metals, nitrate, and microbial contaminants from water.

MYCO-MATERIAL FILTERS

IMPACT

- Reduces chemical pollution in greywater by 60% or more

TIME

$200–350/m³

COST

~1 year across a building network

WHAT IT IS

Composite blocks made of mycelium (fungal root structures), often grown on agricultural waste like straw or sawdust.

HOW IT WORKS

The enzymes secreted by fungi (e.g., laccases, peroxidases) degrade complex organic pollutants, including pharmaceuticals and industrial chemicals.

5-STEP IMPLEMENTATION PLAN

SITE ASSESSMENT & FEASIBILITY STUDY

PILOT PROJECT DESIGN & MATERIAL SELECTION

INSTALLATION & DEPLOYMENT

MONITORING & DATA COLLECTION

COMMUNITY INTEGRATION

EXPECTED OUTCOMES

- STRUCTURAL FEASIBILITY REPORTS
- COST FORECASTS
- PERFORMANCE MONITORING
- SYSTEM IMPROVEMENT
- SCALED GREEN INFRASTRUCTURE

SENSORS & AI INTEGRATION

CONCRETE & ROADS

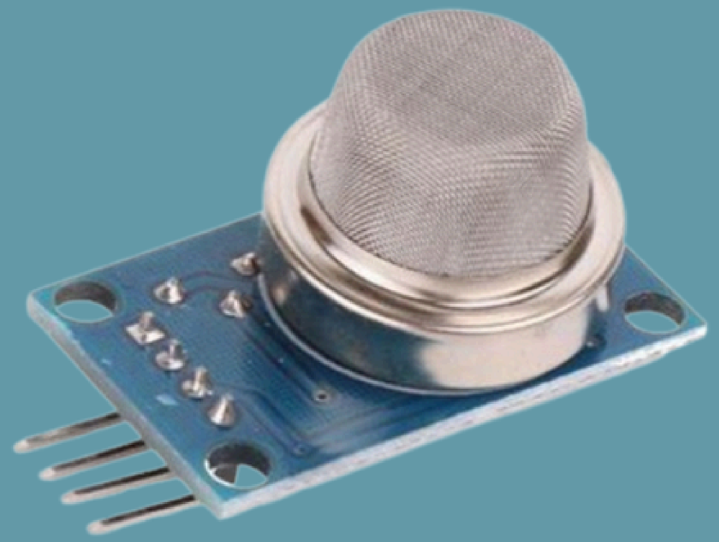
To ensure infrastructure longetivity we could use:

- **Strain gauges:** they measure microdeformations caused by traffic loads, temperature fluctuations or structural stress.
- **Galvanic Corrosion Sensors:** they detect electrochemical changes in reinforced concrete or metal structures.

ML models implementation

- Predict high-risk zones (intersections with heavy breaking.
- Schedule targeted repairs during periods of low traffic.
- Alert city engineers when thresholds exceed safe limits.

Extend lifespan of infrastructure by 15 or 20 years



AIR QUALITY

- **Particular Matter Sensors (PM sensors):** they discern particle concentration sizes ranging from 0.3 to 10 micrometres within the atmosphere.
- **Combination of gas sensors and multigas module:** useful for monitoring combustion-related pollutants and having an enhanced air quality indexing.

ML models implementation

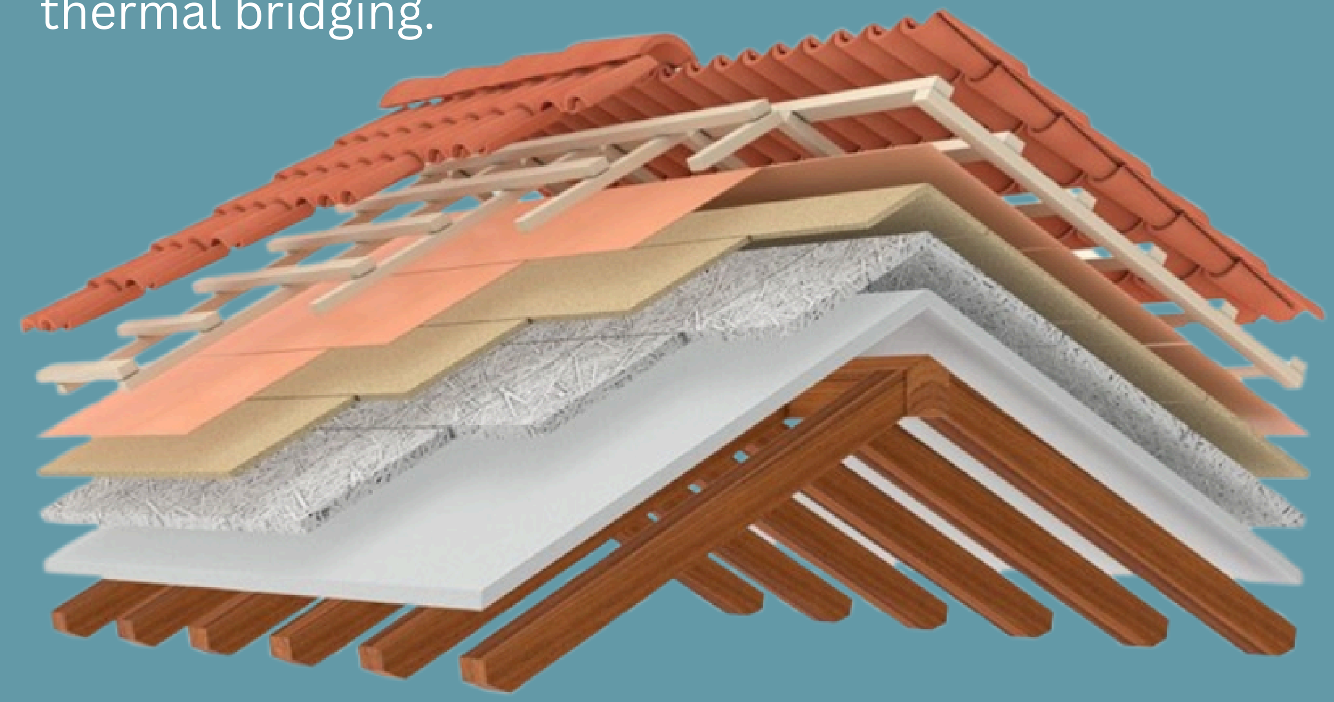
- AI powered real-time adjustments for a dynamic traffic management.
- Public health alerts to vulnerable groups in case of poor air quality.
- Prediction of pollution spikes and identification of chronic pollution sources

- Reduction in respiratory hospital admissions
- Emission reduction via AI-optimised traffic.

SENSORS & AI INTEGRATION

BUILDING MATERIALS

- **Embedded fibre-optic sensors:** assessing thermal conductivity and moisture absorption within hemp or flax panels.
- **Capacitive humidity sensors:** identifying risks of interstitial condensation, preventing the growth of mould in wall assemblies.
- **Silica aerogel roofs equpped with micro-thermocouples:** tracking of surface and subsurface temperature gradients.
- **Hygroscopic sensors:** prevention of thermal bridging.

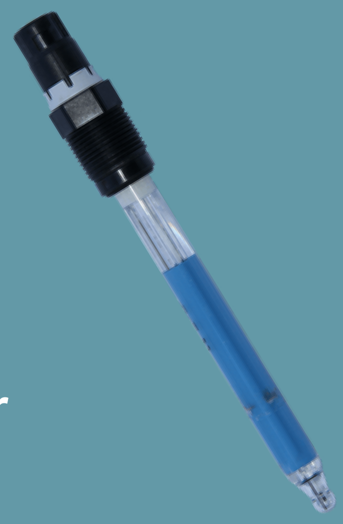


ML models implementation

AI-Driven energy optimization with a dynamic HVAC control system.

- Enhanced building resilience.
- Potential energy savings.

WATER SYSTEMS



Myco Biochar Filter sensor network:
Biochar filtration nodes with pH/turbidity sensor arrays:

- Optical turbidity sensor with a 0-1000 NTU range.
- Solid-state pH sensors with graphene electrodes to detect acid/base shifts from heavy metal leaching.

Myco -filtration modules with **electrochemical biosensors** (detection of pharmaceutical residues) and **conductivity probes**.

ML models implementation

- Real-time adaptive control system.
- Predictive maintenance programme.

- Facilitation of capture of almost 90% of heavy metal present in water.
- Reduction in pharmaceutical residues by 60%.

PREDICTIVE URBAN MAINTENANCE: AI-DRIVEN PROBLEM SOLVING WITH HUMAN OVERSIGHT

1. DATA LAYER

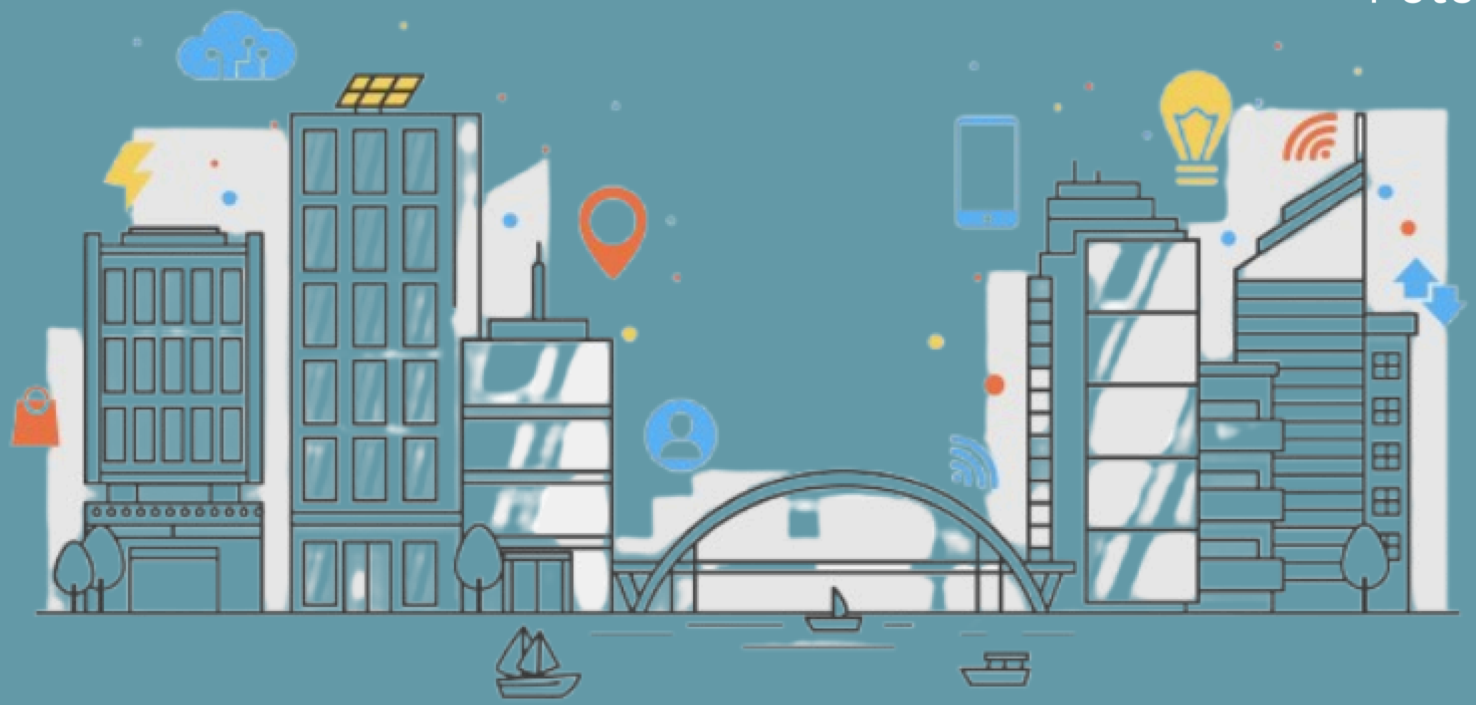
- Data collected from the sensors.
- Citizen reports via mobile applications.

2. ML PREDICTION LAYER

- **Time-series forecasting**, such as ARIMA and LSTM for prediction of road degradation.
- **Machine Vision** to detect cracks in pavement.
- **Anomaly detection**, such as targeting abnormal water pressure.
- **Priorization** of the issues predicted.

3. AI SOLUTION ENGINE LAYER

- Generation of **repair** and **mitigation strategies.**



REVIEW INTERFACE DASHBOARD

- Predicted problem and solution.
- Assessment of the associated costs.
- Temporal implications.
- Environmental consequences.
- Potential alternative solutions.

BEFORE SOLUTION'S IMPLEMENTATION

The solution will undergo:

- Safety verification process.
- Budget approval procedure.
- Public disruption assessment.

MOBILE APPLICATION

Allowing citizens to provide feedback on the solutions proposed.

QUESTIONS?

THANK YOU FOR YOUR ATTENTION!