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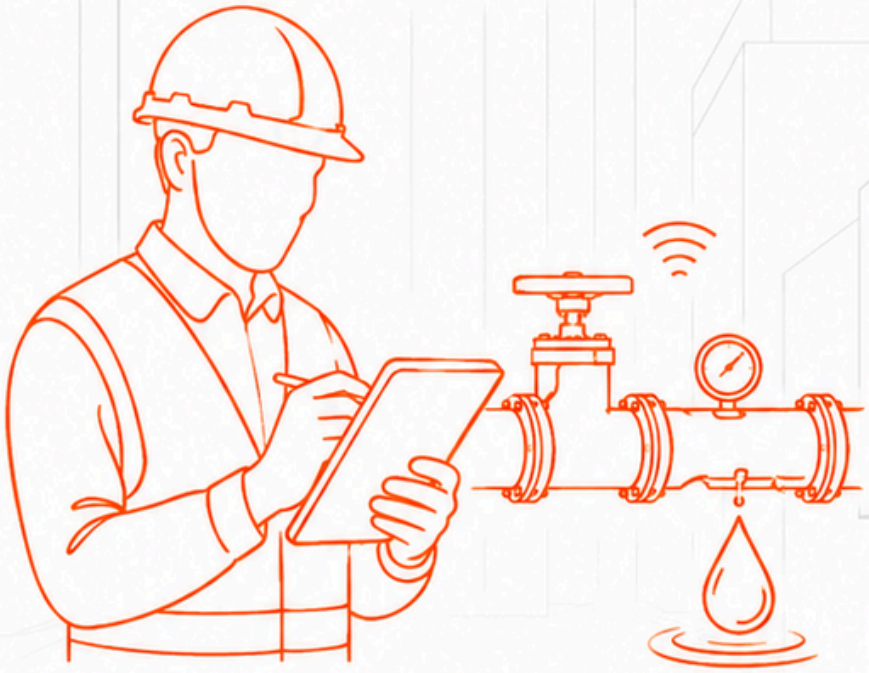
INNOVATION BOOT CAMP IN CIVIL ENGINEERING



Building Bharat Sampaark - National Civil Engineering Civilathon

Problem Statement : Urban water systems - detection of leaks in water lines

Theme : Public Infrastructure

INITIATIVE PARTNERS

AICTE

NIUA राष्ट्रीय नगर कार्य संस्थान National Institute of Urban Affairs

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1. BACKGROUND

Water is one of India's most valuable and increasingly scarce resources. Rapid urbanization, expanding cities, ageing water infrastructure, climate variability, and growing demand have placed enormous pressure on urban water supply systems.

Indian cities collectively lose a significant proportion of treated drinking water before it reaches consumers due to leakages, unauthorized connections, burst pipelines, pressure fluctuations, and ageing distribution networks. These losses, commonly referred to as **Non-Revenue Water (NRW)**, result in:

- Loss of treated potable water
- Increased operational costs
- Higher energy consumption for pumping
- Water shortages
- Reduced pressure at consumer ends
- Frequent road failures due to underground seepage
- Damage to adjacent utility networks
- Increased maintenance costs
- Reduced service reliability

Many urban water utilities still depend on:

- Manual inspections
- Customer complaints
- Periodic pressure testing
- Visual identification of surface leakages

Unfortunately, many underground leaks remain undetected for weeks or months before visible signs appear, by which time substantial quantities of treated water have already been lost.

Most municipal authorities rely on manual cleaning, which is:

- Labour-intensive
- Unsafe
- Time-consuming
- Reactive rather than preventive
- Expensive to maintain
- Difficult during heavy rainfall
- Limited by manpower availability

Blocked drain inlets reduce hydraulic capacity, causing **stormwater to accumulate on roads and public spaces, resulting in flooding** even when the downstream drainage network has sufficient carrying capacity.

With India's Smart Cities Mission, Jal Jeevan Mission, AMRUT, and urban infrastructure modernization programs, there is an urgent requirement for intelligent, affordable, scalable, and real-time leak detection technologies suitable for Indian urban conditions.

The solution should help utilities move from reactive maintenance to predictive asset management, thereby improving water security and operational efficiency.

2. INDUSTRY PROBLEM STATEMENT

Design an innovative digital solution (hardware, software, or hybrid) capable of **detecting, locating, monitoring, predicting, and reporting** leaks in urban water distribution systems in real time.

The proposed solution should:

- Detect hidden underground leaks
- Minimize water losses
- Reduce leak detection time
- Improve maintenance planning
- Support utility decision-making
- Reduce operational expenditure
- Improve reliability of urban water supply

- Scalable for Indian municipalities
- Adaptable to both new and existing water distribution networks

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3. CHALLENGE OBJECTIVE

Students are expected to design a solution capable of:

- Early leak detection
- Leak localization
- Continuous pipeline monitoring
- Predictive maintenance
- Water loss estimation
- Real-time alerts
- Digital asset management
- Decision support for utilities
- Reduction in Non-Revenue Water (NRW)
- Improvement in network reliability

4. REAL-TIME INDUSTRY NEED

Indian urban water supply agencies currently face several operational challenges.

INFRASTRUCTURE CHALLENGES

- Ageing pipelines
- Corroded water mains
- Joint failures
- Pipe bursts
- Illegal connections
- Valve leakages
- Poor pipeline documentation

OPERATIONAL CHALLENGES

- Delayed leak identification
- High manual inspection costs
- Difficulty locating underground leaks
- Lack of continuous monitoring
- Limited manpower
- Reactive maintenance

ECONOMIC CHALLENGES

- High Non-Revenue Water (NRW)
- Increased pumping costs
- Water treatment losses
- Road restoration expenses
- Emergency repair costs

PUBLIC SERVICE CHALLENGES

- Water shortages
- Low consumer pressure
- Interrupted water supply
- Traffic disruption during emergency excavation
- Public complaints
- Loss of consumer confidence

ENVIRONMENTAL AND SOCIAL IMPACT

- Wastage of treated potable water
- Increased energy consumption
- Environmental stress on water sources
- Impact on sustainable development

5. SCOPE OF THE CHALLENGE

Students may develop solutions for:

- Urban water distribution pipelines
- Transmission mains
- Service connections
- Elevated service reservoirs
- Distribution chambers
- Smart water districts
- Institutional campuses
- Industrial water networks
- Housing societies
- Smart cities

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6. EXPECTED SOLUTION AREAS

Students may choose one or more engineering approaches.

A. SMART LEAK DETECTION SYSTEM

Develop a hardware or software solution capable of detecting:

- Small leaks
- Hidden underground leaks
- Pipe bursts
- Joint failures
- Valve leakage
- Service connection leakage

Possible technologies include:

- Acoustic sensors
- Pressure sensors
- Flow meters
- Ultrasonic sensors
- Vibration sensors
- Fibre optic sensing
- MEMS sensors
- Distributed sensing networks

B. AI-BASED LEAK PREDICTION

Develop Artificial Intelligence models capable of predicting:

- Probability of future leakage
- Pipe failure risk
- Remaining useful life
- Burst likelihood
- High-risk pipeline segments

Possible inputs:

- Pipe age
- Material type
- Soil conditions
- Pressure history
- Historical failures
- Water demand patterns

C. IOT WATER MONITORING PLATFORM

Develop a real-time monitoring platform capable of:

- Pressure monitoring
- Flow monitoring
- Water level monitoring
- Leak alerts
- GIS visualization
- Sensor health monitoring
- Dashboard analytics

D. DIGITAL TWIN OF WATER NETWORK

Develop a Digital Twin capable of:

- Real-time network visualization
- Leak localization
- Hydraulic simulations
- Pressure optimization
- Maintenance planning
- Scenario analysis

E. COMPUTER VISION-BASED LEAK DETECTION

Develop AI models capable of identifying:

- Surface water seepage
- Wet pavement
- Water accumulation
- Soil erosion
- Road distress caused by underground leakage

Using:

- Cameras
- Drones
- Satellite imagery (optional)
- Mobile devices

F. MOBILE LEAK INSPECTION APPLICATION

Develop an application enabling engineers to:

- Report leaks
- Upload photographs
- Geo-tag defects
- Schedule repairs
- Record inspection history
- Generate work orders
- Track repair progress

G. PREDICTIVE MAINTENANCE DASHBOARD

Develop an analytics platform displaying:

- High-risk pipeline segments
- Leak trends
- Pressure anomalies
- Water loss estimates
- Maintenance priority ranking
- Asset health score

H. SMART VALVE AND DISTRICT METERING INTEGRATION

Develop solutions capable of integrating:

- District Metered Areas (DMAs)
- Smart valves
- Automatic isolation
- Pressure management
- Flow balancing
- Remote monitoring

7. INNOVATION EXPECTATIONS

Students are encouraged to integrate:

Artificial Intelligence	Internet of Things (IoT)	Machine Learning	Digital Twins	GIS	SCADA	Edge Computing	Cloud Computing
Computer Vision	Acoustic Analytics	Fibre Optic Sensing	Predictive Analytics	Low-Power Wide-Area Networks (LPWAN)	Autonomous Inspection Robots	Drone-assisted Inspections (where applicable)	

The emphasis should be on creating practical, affordable, and scalable technologies suitable for Indian water utilities.

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8. TECHNICAL EXPECTATIONS

The proposed solution should demonstrate sound engineering design.

HARDWARE

- Arduino
- ESP32
- Raspberry Pi
- PLC Controllers
- Pressure Sensors
- Flow Meters
- Acoustic Sensors
- Accelerometers
- Ultrasonic Sensors
- MEMS Sensors
- Water Level Sensors
- GPS Modules
- LoRaWAN Communication Devices

SOFTWARE

Frontend

- Flutter
- React Native
- Angular

Backend

- Node.js
- Django
- Spring Boot

Database

- PostgreSQL
- MongoDB
- Firebase

ARTIFICIAL INTELLIGENCE

- TensorFlow
- PyTorch
- OpenCV
- Time Series Analysis
- Predictive Analytics
- Anomaly Detection
- Deep Learning

CLOUD

- AWS
- Azure
- Google Cloud

INTEGRATION

Teams are encouraged to integrate with:

- SCADA Systems
- Smart Water Platforms
- GIS Platforms
- Municipal Asset Management Systems
- Digital Twin Platforms
- Smart City Integrated Command and Control Centres (ICCC)
- Enterprise Resource Planning (ERP) Systems

9. PERFORMANCE EXPECTATIONS

The proposed solution should demonstrate measurable improvements in one or more Key Performance Indicators (KPIs), such as:

- Leak detection accuracy (%)
- Leak localization accuracy (m)
- Detection response time
- Reduction in Non-Revenue Water (NRW)
- Reduction in maintenance response time
- Reduction in emergency repairs
- Improvement in network reliability
- Water savings (MLD or %)
- Energy savings
- Reduction in operational costs
- Reduction in consumer complaints

Teams should support performance claims through laboratory experiments, simulations, hydraulic modelling, or prototype testing.

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10. DESIGN CONSTRAINTS

The proposed solution should consider:

- Buried pipelines
- Mixed pipe materials (DI, CI, PVC, HDPE, Steel, AC where applicable)
- Variable water pressure
- High urban traffic
- Limited accessibility
- Low power consumption
- Affordable deployment
- Ease of retrofitting into existing infrastructure
- Scalability across large urban networks
- Cybersecurity and secure data transmission

Solutions should be designed with the realities of Indian urban water utilities in mind, including **intermittent water supply systems, budget constraints, and ageing infrastructure.**

11. USER EXPERIENCE EXPECTATIONS

The solution should:

- Operate on Android, iOS, and web platforms
- Support multilingual interfaces
- Provide intuitive dashboards
- Enable offline data collection with cloud synchronization
- Generate automated alerts and reports
- Offer role-based access for utility engineers, operators, contractors, and municipal administrators
- Present actionable insights rather than raw sensor data

12. EXPECTED DELIVERABLES

Each participating team should submit:

A. INDUSTRY PROBLEM ANALYSIS

- Existing leak detection methods
- Current industry challenges
- Stakeholder analysis
- Benchmarking with global best practices

B. PROPOSED SOLUTION

- Engineering concept
- Working principle
- Innovation
- Technology stack
- Expected benefits

C. PROTOTYPE

A working prototype demonstrating:

- Sensor integration
- Leak detection system
- AI models
- Dashboard
- Mobile application
- Analytics platform

D. TECHNICAL DOCUMENTATION

Include:

- Hydraulic concept
- System architecture
- Hardware design
- Software architecture
- AI model description
- Database design
- APIs
- Cybersecurity measures
- Scalability strategy

E. VALIDATION STRATEGY

Teams should provide one or more of the following:

- Laboratory testing
- Hydraulic simulations
- Pilot-scale demonstrations
- Comparative performance with conventional leak detection methods
- Cost-benefit analysis

F. BUSINESS MODEL

Describe:

- Target customers
- Commercialization strategy
- Deployment model
- Cost analysis
- Return on Investment (ROI)
- Scalability across Indian cities

G. DEMONSTRATION VIDEO

A 5–7 minute video including:

- Industry challenge
- Proposed solution
- Prototype demonstration
- Performance evaluation
- Expected impact

H. PITCH PRESENTATION

Maximum 10 slides covering:

- Industry Challenge
- Existing Problems
- Proposed Innovation
- Engineering Design
- Technical Architecture
- Prototype Demonstration
- Validation Results
- Business Model
- Industry Impact
- Future Roadmap

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13. EVALUATION PARAMETER

Solutions will be evaluated based on the following parameters:

1. Understanding of Industry Problem

Depth of problem understanding, clarity of root causes, and relevance of proposed solution.

2. Innovation and Originality

Uniqueness of idea, creativity, novel use of technology, and differentiation from existing solutions.

3. Engineering and Technical Feasibility

Soundness of engineering design, technology selection, system integration, and feasibility of implementation.

4. Quality Improvement and Structural Safety Impact

Impact on water loss reduction, network reliability, asset health, and infrastructure safety.

5. Scalability and Industry Readiness

Potential to scale across cities, readiness for real-world deployment, and interoperability.

6. Business Viability

Strength of business model, cost-effectiveness, ROI potential, and commercialization strategy.

7. Presentation and Demonstration

Clarity of communication, quality of prototype demonstration, and overall presentation.

14. EXPECTED INDUSTRY IMPACT

A successful solution should:

- Significantly reduce Non-Revenue Water (NRW) in urban distribution networks.
- Enable early detection of hidden leaks before they become major failures.
- Improve the efficiency and reliability of urban water supply systems.
- Reduce water losses, energy consumption, and operational costs for utilities.
- Minimize road excavation and disruption through accurate leak localization.
- Improve asset management through real-time monitoring and predictive maintenance.
- Enhance resilience of water infrastructure against ageing and climate-related stresses.
- Support Smart Cities, Jal Jeevan Mission, AMRUT, and other urban water initiatives through data-driven decision-making.
- Improve customer satisfaction by ensuring more reliable water supply and faster response to failures.
- Contribute to sustainable water resource management and the national vision of Viksit Bharat 2047.

15. STRETCH GOALS (BONUS)

Teams seeking advanced recognition may incorporate:

AI-driven leak localization

Using hydraulic models, pressure transients, and sensor fusion.

Digital Twin integration

For real-time simulation and optimization of water distribution networks.

Satellite, drone, or thermal imaging

Integration for large-area leak screening.

Autonomous robotic inspection devices

For internal pipeline surveys.

Smart pressure management

Algorithms to reduce leak occurrence and extend pipeline life.

Carbon and energy savings dashboard

Quantifying environmental benefits of reduced water losses.

Integration with SCADA, GIS, ERP

And municipal asset management systems through open APIs.

Generative AI-assisted maintenance

Recommendations, repair prioritization, and automatic work-order generation.

Interoperability with existing infrastructure

Ensuring seamless integration with current utility systems.

High performance and scalability

Delivering measurable reductions in water losses and maintenance costs.

Solutions that demonstrate high leak detection accuracy, rapid localization, affordability, scalability, interoperability with existing urban water infrastructure, and measurable reductions in water losses and maintenance costs will receive the highest consideration.

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Thank You!

TO ALL PARTICIPANTS, MENTORS & PARTNERS

"Desh को बनाना है। कुछ कर के दिखाना है।"

JOURNEY TO *BUILDING BHARAT*

has begun...

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