# CAD-BASED MODELLING OF A SMART WASTE BIN FOR UNIVERSITY CAMPUSES

## Executive Summary

The rising emphasis on sustainability and digital infrastructure in educational institutions calls for efficient waste management solutions. This case study presents the conceptualization, design, and simulation of a smart waste bin tailored for university campuses. Equipped with a proximity-based automatic lid, ultrasonic fill-level sensors, and real-time alert systems, the bin is modelled using Fusion 360. The design integrates ergonomics, modular electronics placement, and environmental durability. The objective is to improve hygiene, optimize waste collection, and reduce overflow incidents through IoT-enabled monitoring.

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## 1. Introduction

Smart waste management has become a key component in smart campus initiatives. Overflowing bins, delayed collection, and manual monitoring are persistent issues in universities with large student populations. This project aims to model a smart bin that automates lid operation and provides real-time fill-level alerts to campus facility managers. The model is developed in CAD, integrating IoT sensor space and optimizing for ease of manufacture and maintenance.

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## 2. Problem Identification

Universities face:

- **Hygiene Concerns**: Manual lid contact in shared bins raises contamination risk.
- **Overflow Issues**: Fixed collection schedules ignore bin capacity variation.
- **Monitoring Gaps**: Staff cannot easily identify which bins need immediate attention.

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## 3. Literature Review

Prior research and prototypes show:

- Smart bins using **ultrasonic sensors** and GSM/Wi-Fi modules improve collection efficiency by up to 30%.
- Designs with **touchless lids** increase compliance and usage.
- Maintenance-friendly modular bin designs reduce hardware downtimes.

Key Sources:

- Abhilash, M., & Azeez, R. (2021). *Smart Bin System for Smart Cities*
- IEEE Sensors Journal, Vol. 21(8), *IoT-based Real-Time Waste Management*

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## 4. Design Objectives

- **Sensor Housing**: Compartment for ultrasonic sensor and microcontroller.
- **Hygienic Lid**: Servo-motor-powered automatic lid with motion sensor.
- **Connectivity**: Wi-Fi module for real-time data transfer to collection staff.
- **Power**: Battery-operated with solar top-up panel for outdoor bins.
- **Modular Design**: Easy separation of hardware for servicing.

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## 5. Design Process

**Tools Used**:

- **Fusion 360** for 3D modelling
- **TinkerCAD** for circuit prototyping
- **FEM Simulation** for load and wear

**Workflow**:

1. Benchmarked sizes: 60L, 100L, and 150L bin capacity.
2. Defined compartments for hardware (upper-back) and waste (lower-body).
3. Incorporated a sloped base to guide waste toward the sensor.
4. Added vent holes and heat dissipation channels for electronics.

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# 6. Modelling and Simulation

Key dimensions for the 100L model:

- Height: 85 cm
- Width: 38 cm
- Depth: 42 cm
- Sensor zone: 8×6×4 cm compartment at rear top
- Lid opening angle: 120° with damped servo motor

**Simulation Results**:

- Ultrasonic fill reading range: 2–60 cm, accuracy ±0.5 cm
- Lid open/close time: 1.2 seconds
- Internal airflow prevents overheating, verified with thermal simulation

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# 7. User Interaction Flow

1. **Approach Detected**: Infrared sensor triggers servo to lift lid.
2. **Fill-Level Monitoring**: Ultrasonic sensor tracks waste level.
3. **Data Transmission**: ESP8266 sends fill data via Wi-Fi every hour.
4. **Alert System**: Dashboard displays bins >80% full with location ID.

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# 8. Evaluation and Improvements

**User Feedback (Simulation Group)**:

- Preferred hands-free operation.
- Liked visible LED indicators showing fill level.
- Requested manual override button in case of malfunction.

**Proposed Enhancements**:

- App integration for live monitoring.

- QR-based bin scanning for servicing logs.
- Use of recycled ABS for casing to align with campus sustainability.

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## 9. Conclusion

The smart waste bin model addresses critical gaps in waste management on university campuses. It combines usability, hygiene, and operational efficiency through a structured design approach and IoT features. Future work may involve prototyping and testing in real-world campus settings.

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## 10. References


- Abhilash, M., & Azeez, R. (2021). *Smart Bin System for Smart Cities*, IJRET.
- IEEE Sensors Journal (2021). *IoT Waste Monitoring in Urban Spaces*.
- Autodesk Fusion 360 Documentation
- Arduino.cc Sensor Libraries
- TinkerCAD Circuits, Autodesk Education