Affordable Heat & Noise Monitoring Sensor Box for Cities, 2026

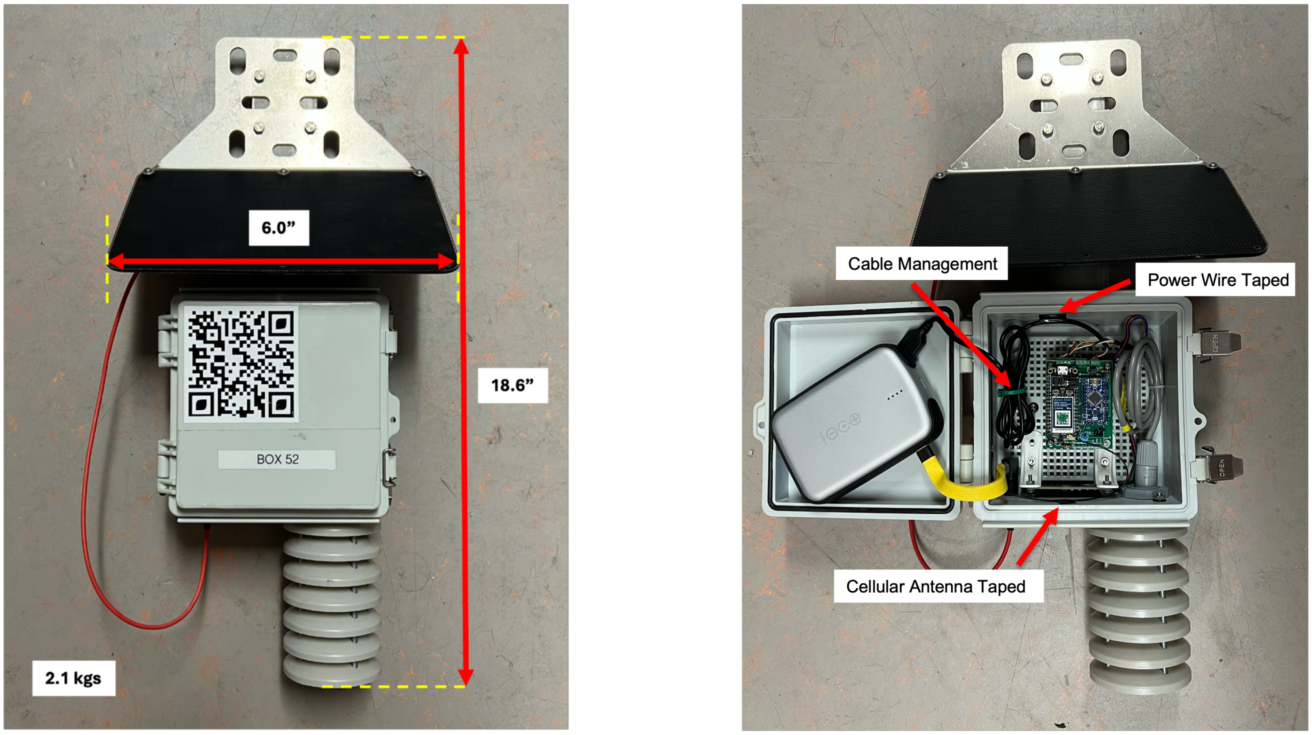

Figure 1. (Left) Final assembled unit: 6.0 in wide × 18.6 in tall, 2.1 kg. QR code enables field traceability. (Right) Internal layout showing LiPo battery, custom PCB with cellular module, organized cable routing, and desiccant for moisture control.

Problem & Constraints:

- Cities rely on sparse monitoring networks, leaving localized urban heat island effects and noise hazards invisible — particularly in underserved neighborhoods
- Commercial solutions cost $1,000s, require Wi-Fi/Bluetooth, and are not designed for continuous long-term outdoor pole deployment
- Must operate autonomously on solar power, survive years outdoors, mount on existing infrastructure without modification, for under $500 in parts

System Design:

- Measures temperature (±0.5 °C), relative humidity (±3% RH), and sound pressure (±1.5 dB) at 1-minute intervals with near-real-time LTE cloud upload
- Three-subsystem architecture: solar panel + LiPo battery; Arduino microcontroller with custom PCB integrating ADC, RTC, microSD, and cellular module; LTE wireless upload
- Custom weatherproof enclosure with water-sealed mounts, acoustic mesh-protected port for sound sensing, and stacked-disk solar radiation shield for accurate temperature readings
- Stainless steel pole-clamp mounting mechanism accommodates variable pole diameters — no infrastructure penetrations required

Challenges:

- Validated that a 1-inch enclosure acoustic port produces statistically equivalent sound readings to an open sensor — enabling fully weatherproof acoustic sensing
- Battery chemistry restricts charging below 0 °C, causing seasonal data gaps in Boston winters; identified as the primary constraint for future iteration
- Scaling 5 prototypes to 55 production units required building an entirely new manufacturing workflow, QA/QC system, and assembly traceability process from scratch on-campus

Manufacturing & Outcome:

- Transitioned from sequential part-by-part fabrication to operation-based batch workflow (PDSA methodology), cutting machine setups from once-per-part to once-per-operation
- Component-level QA/QC with pass/fail logging and unique-ID traceability — **100% pass rate** across all 55 units on all mechanical components
- 55 units deployed to Boston city poles June 2025; **zero mechanical system failures** observed through April 2026

Insights:

- Designing for manufacturability from day one — interchangeable parts, engineering drawings, checklist-driven fabrication — is what makes scaling from prototype to production tractable
- Sensing accuracy is as much a mechanical problem as an electronics one: radiation shielding, enclosure acoustics, and cable strain management all directly affect data quality
- Distributed low-cost sensing gives cities the spatial resolution needed for data-driven environmental justice — the platform's modular, replicable architecture is its most important contribution

Advisor: Dr. Amy Mueller, Northeastern University, April 2026
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Figure 1: Machining enclosure components on the Bridgeport mill using the standardized operation-based batch workflow. 55 units manufactured on-campus.

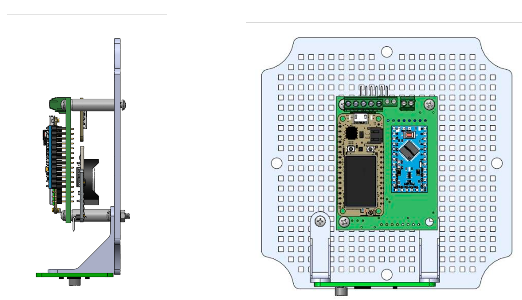

Figure 2: (Left) Side-view CAD of the electronics mounting assembly inside the enclosure. (Right) Custom PCB integrating Arduino Pro Mini, cellular module, ADC, RTC, and microSD storage.

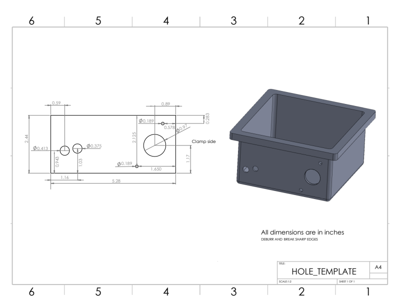

Figure 3: Hole template engineering drawing (Scale 1:2) specifying the acoustic port, clamp-side holes, and cable entry — standardized across all 55 units.