responsive environments

Joseph A. Paradiso

David Ramsay

D.D. Haddad

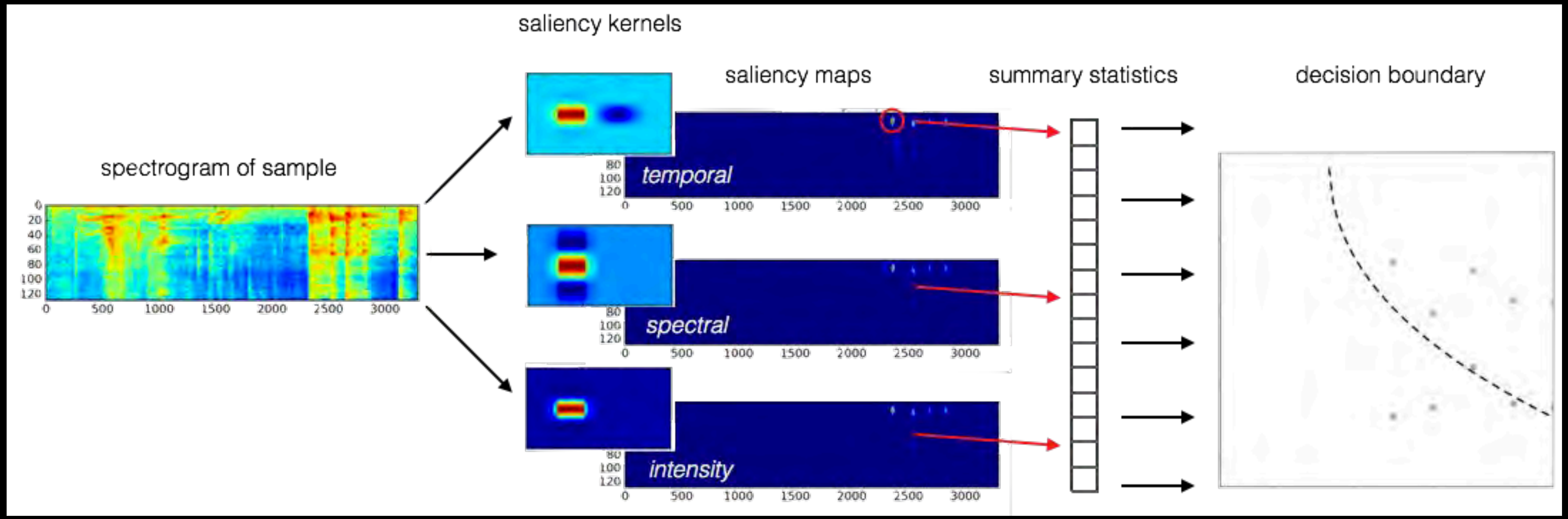
Brian Mayton

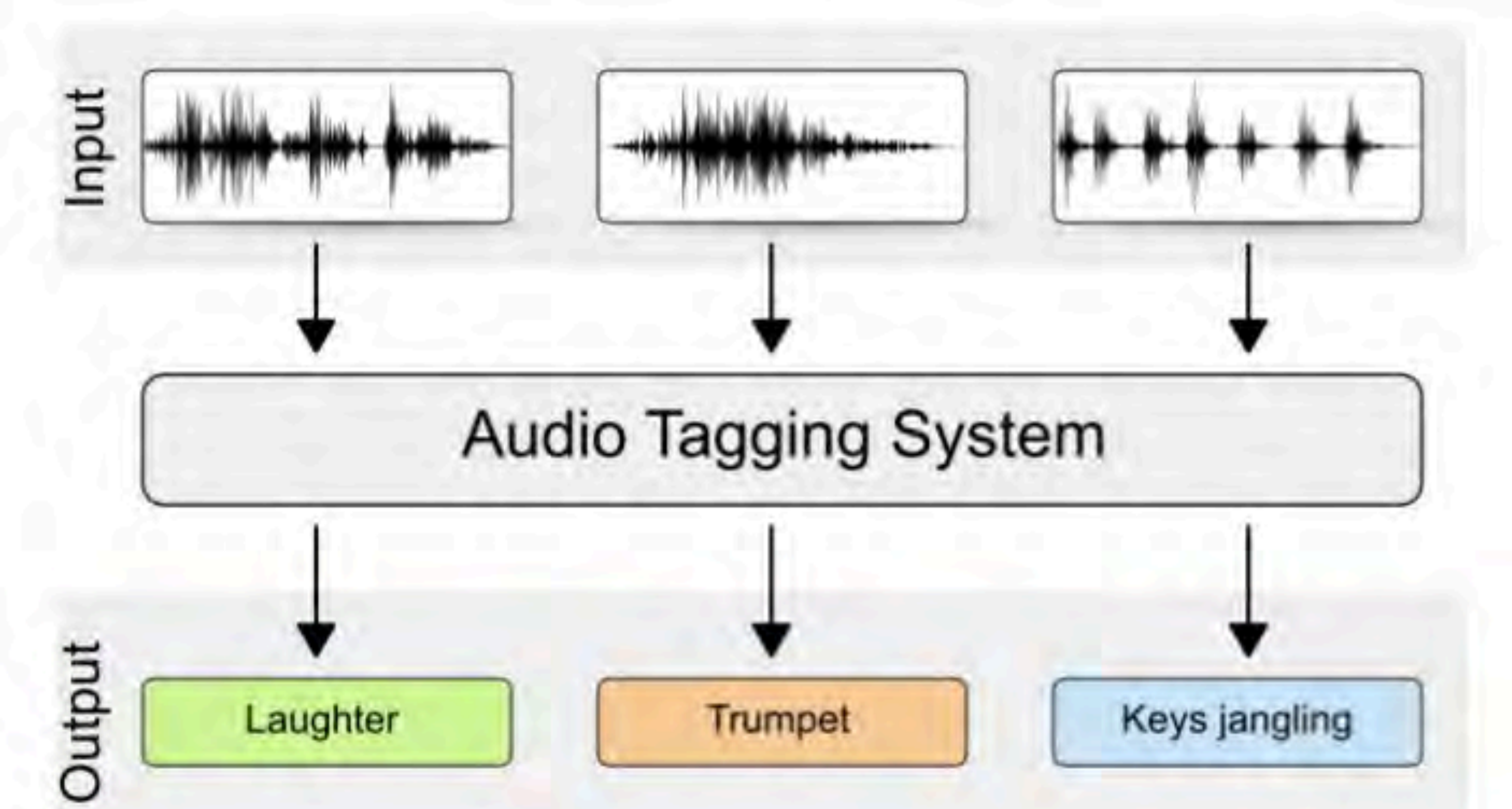

ECG
Respiration
Basic Posture
6FBFA7

Physiological States **+ Models of Attention and Behavior**

Atmospherics **+ Objects and Tools**

Ishwarya Ananthabhotla | David Ramsay





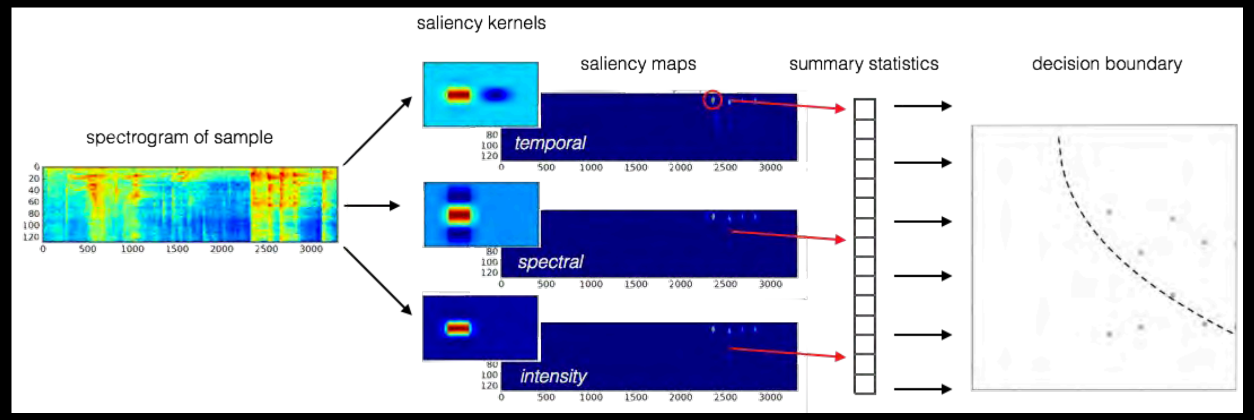
https://arxiv.org/pdf/1807.09902.pdf

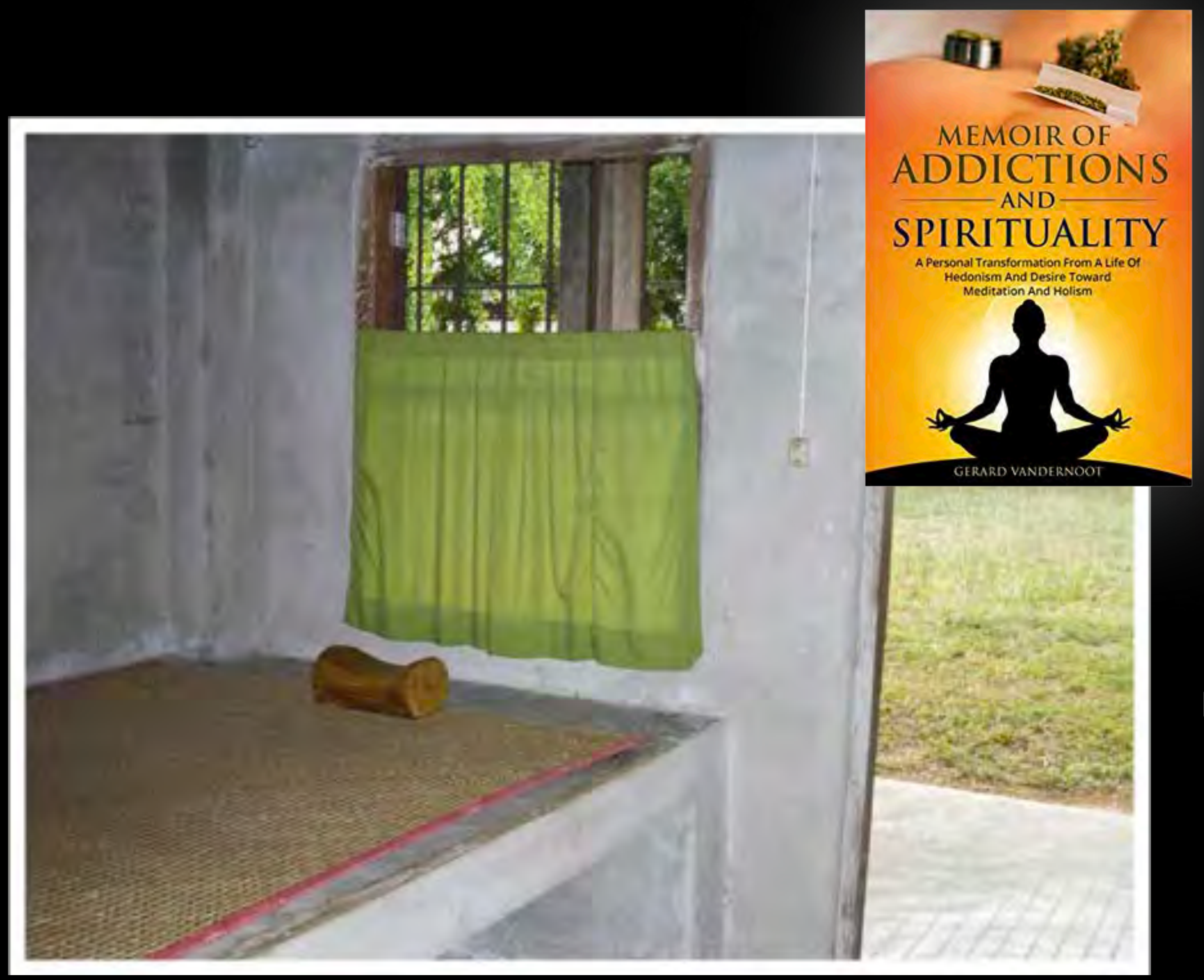
Captivates

Moving the study of deep attention out of the lab –
real moments* across *many contexts and experiences.

Patrick Chwalek | David Ramsay

Patrick Chwalek | David Ramsay


saliency kernels
saliency maps
summary statistics
decision boundary
spectrogram of sample
temporal
spectral
intensity



Ascetic Objects
Dispassionate Stoicism

Addictive Objects
Impulsive Hedonism

SensorKnit: Architecting Textile Sensors with Machine Knitting

Jifei Ou,* Daniel Oran,* Don Derek Haddad,* Joseph Paradiso, and Hiroshi Ishii

3D PRINTING AND ADDITIVE MANUFACTURING
Volume 6, Number 1, 2019

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ORIGINAL ARTICLE

SensorKnit: Architecting Textile Sensors with Machine Knitting

Jifei Ou,* Daniel Oran,* Don Derek Haddad,* Joseph Paradiso, and Hiroshi Ishii

Abstract

This article presents three classes of textile sensors exploiting resistive, piezoresistive, and capacitive properties of various textile structures enabled by machine knitting with conductive yarn. Digital machine knitting is a highly programmable manufacturing process that has been utilized to produce apparel, accessories, and footwear. By carefully designing the knit structure with conductive and dielectric yarns, we found that the resistance of knitted fabric can be programmatically controlled. We also present applications that demonstrate how knitted sensor can be used at home and in wearables. While e-textiles have been well explored in the field of interaction design, this work explores the correlation between the local knitted structure and global electrical property of a textile.

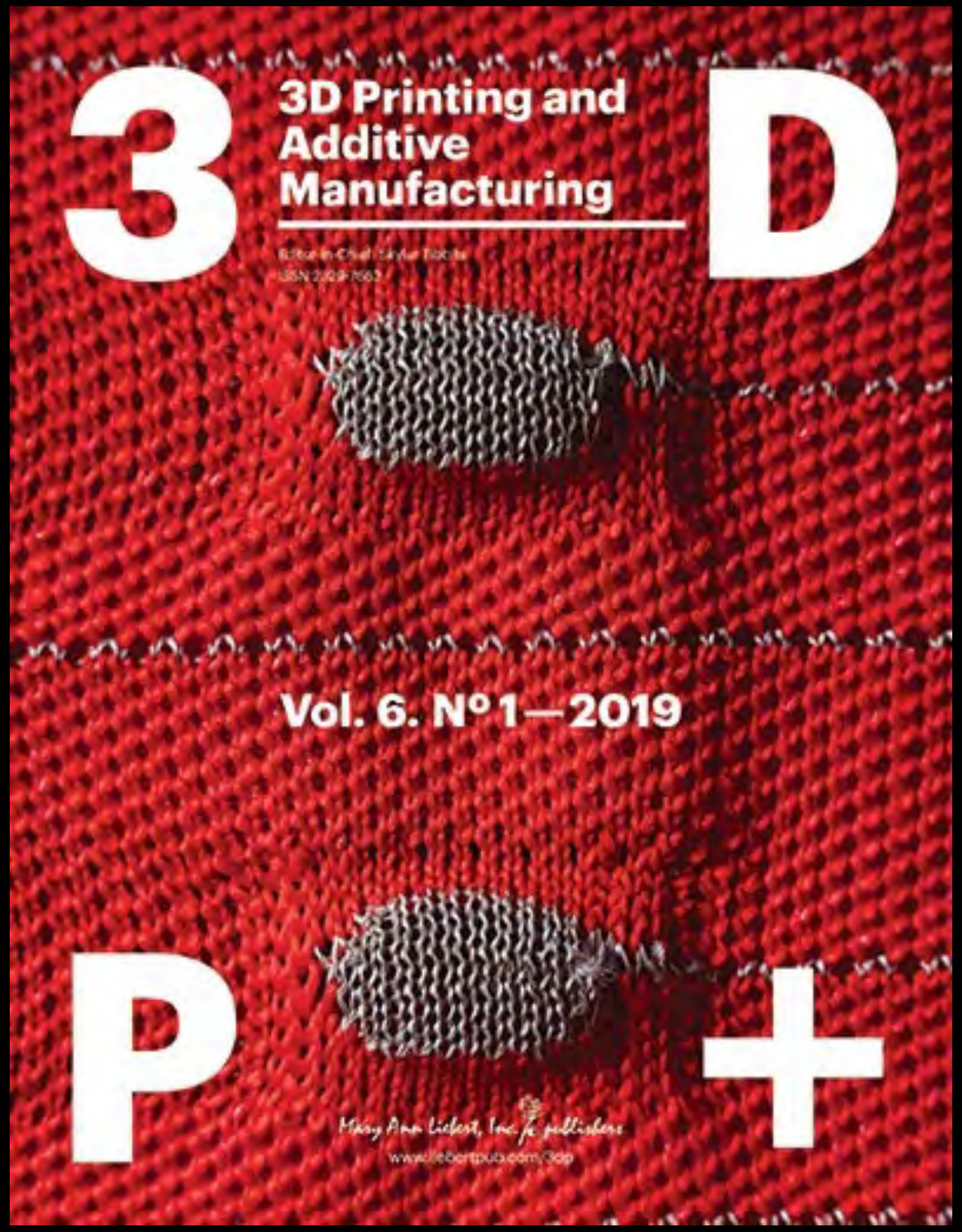
Keywords: digital fabrication, additive manufacturing, textile sensors, machine knitting, material design

Introduction

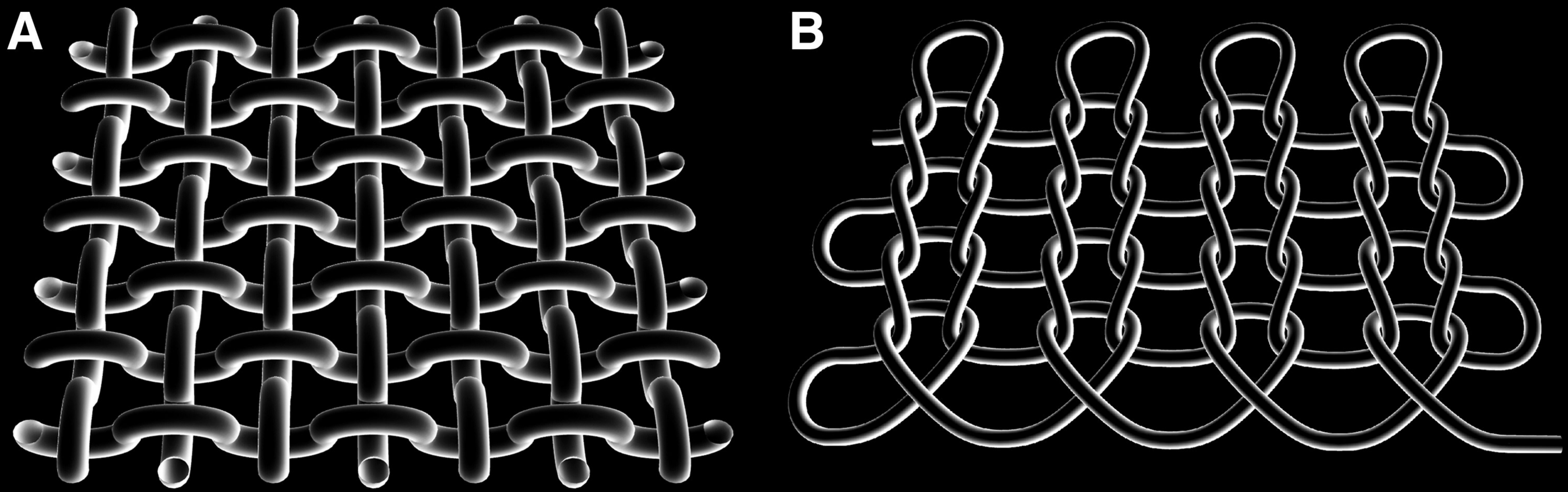
MATERIALS ARE FUNDAMENTAL in how we interact with the world. Recently, there have been growing interests of fabricating multimaterials in the context of digital fabrication and additive manufacturing. In particular, advancements in fab-

sense, weaving, knitting, and embroidery can be considered additive manufacturing methods for textiles.

Twenty years ago, Margaret Orth and her collaborators at the MIT Media Lab developed *Musical Jacket*, an interactive garment with an embedded touch-sensitive keypad connected by conductive yarn.[10] Since then, e-textile has been



Published at the 3D Printing and Additive Manufacturing Journal https://www.liebertpub.com/doi/pdf/10.1089/3dp.2018.0122



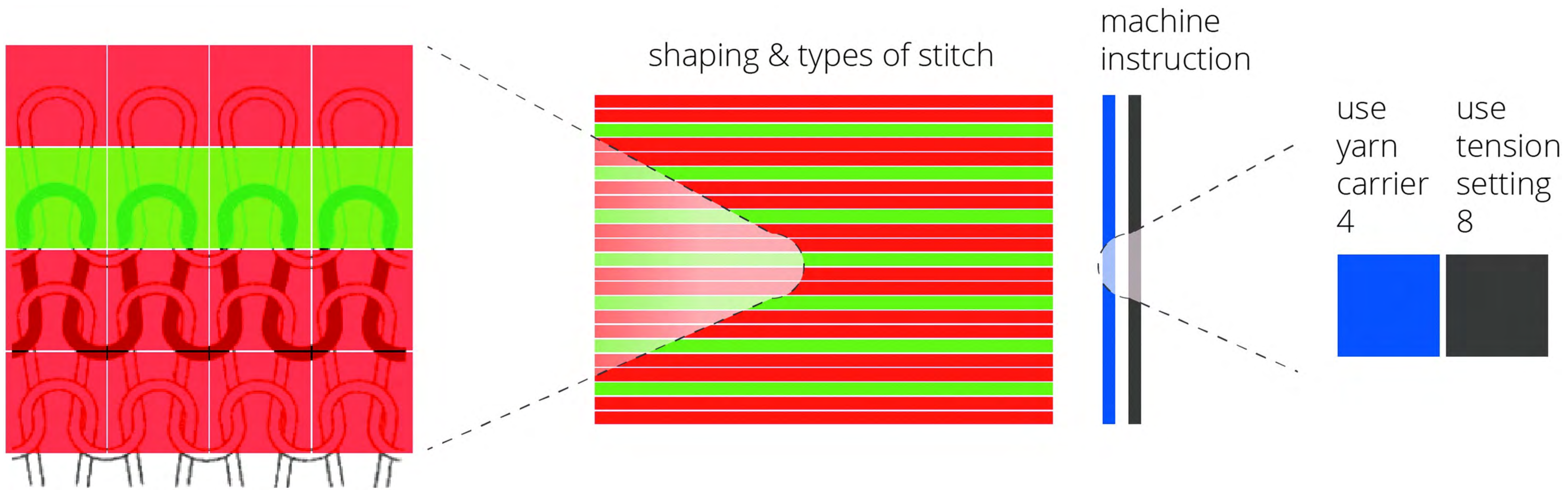
(A) Woven fabric structure, (B) knitted fabric structure.

Conductive thread

A close inspection to the fibers shows a dielectric core coated with a thin film of silver nanoparticles.

Machine

Knitting



Sensing Modalities and Interactions:

Resistive	Capacitive
Stretch	Pressure
Bend	Touch
Slide	Proximity
Touch	

Capacitive

Knits

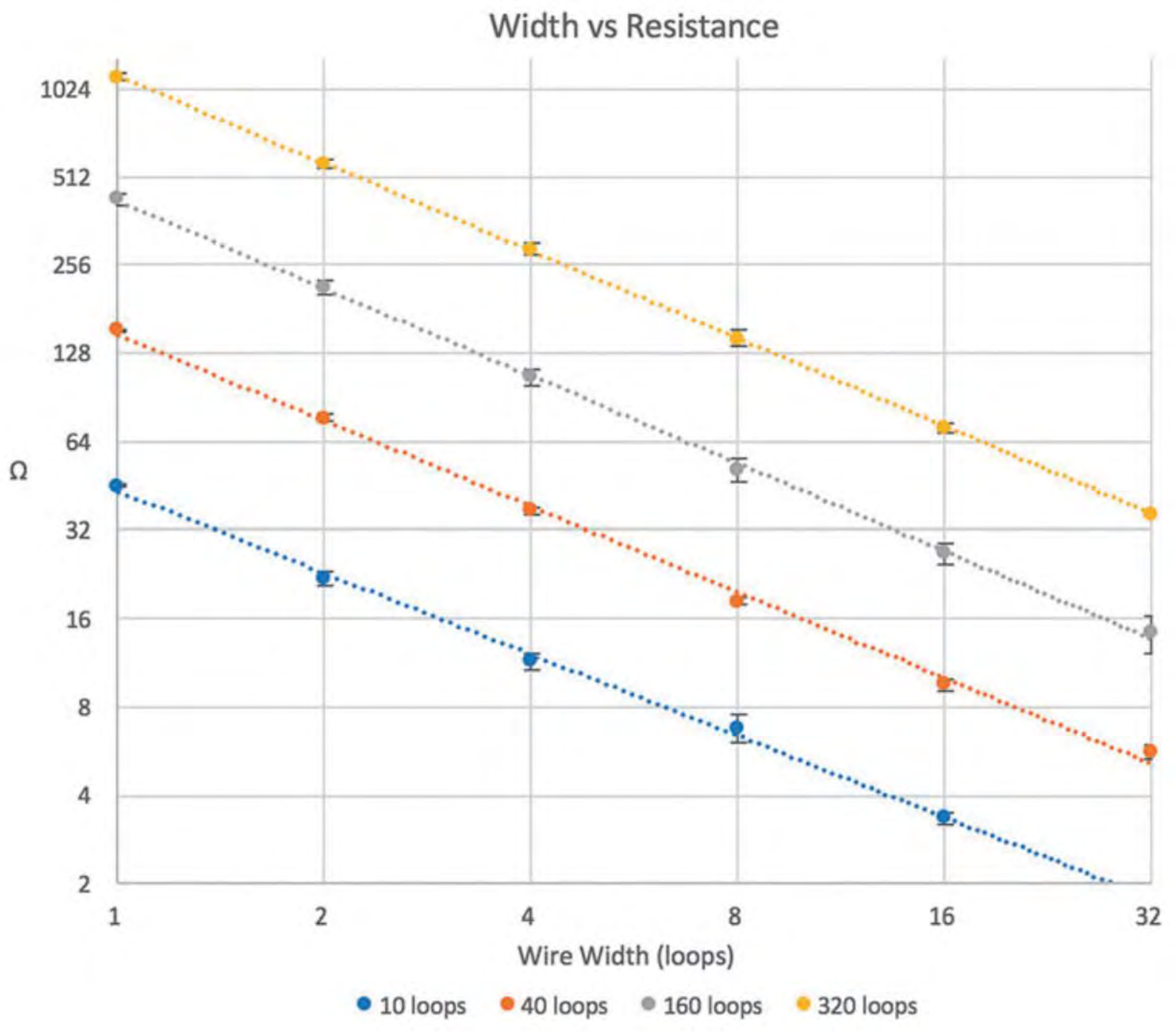
Photo Credit: Daniel Oran


Resistive
Knits
Photo Credit: Daniel Oran

Knit-level conductivity characterization

Photo Credit: Daniel Oran

Knit-level conductivity characterization



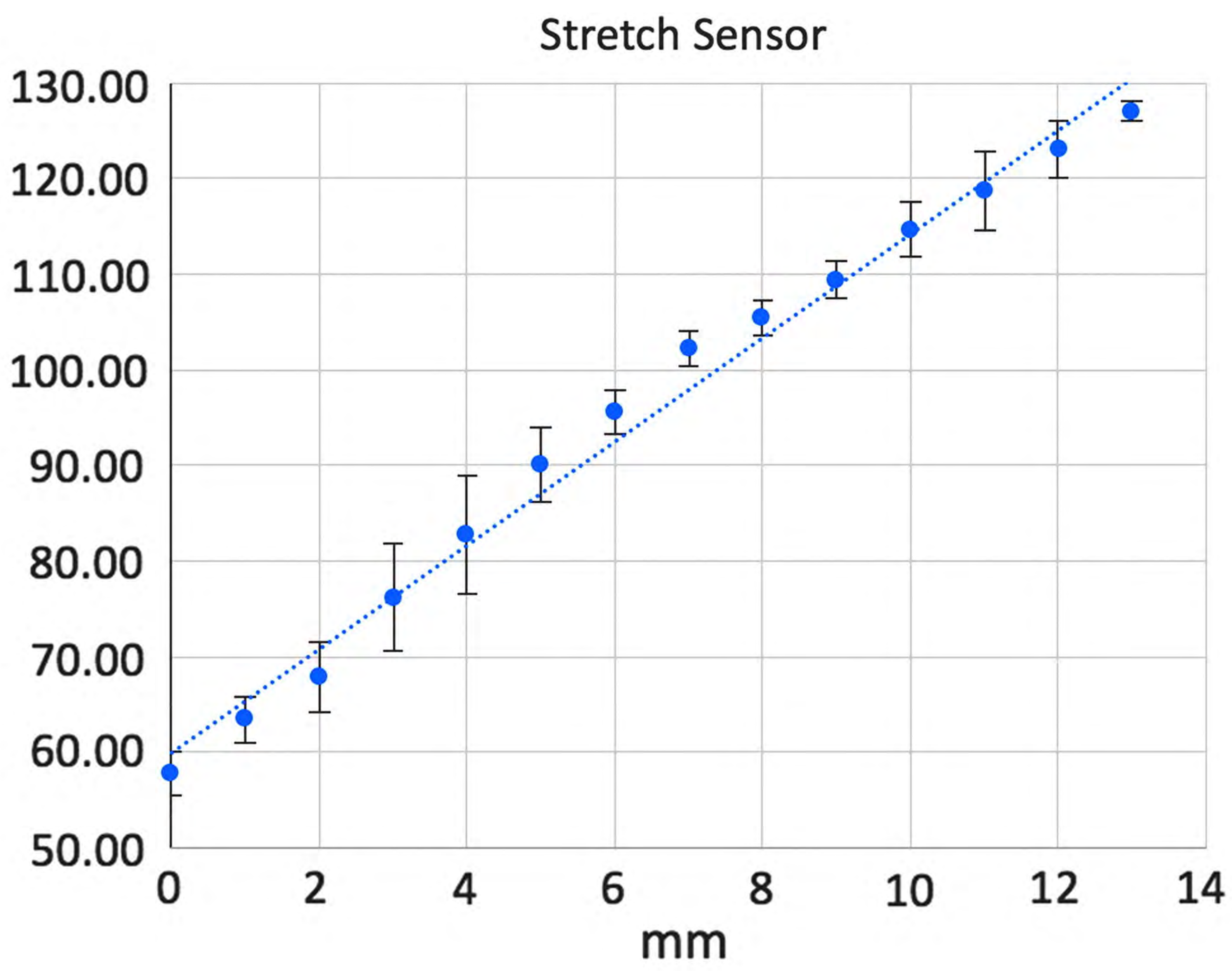
Log base 2 graph describing resistance in relation to loop length and width.

$$\mathbf{R} = L^{*} 2.63^{*} W^{-1}$$

The relation between the loop number in length **L** and width **W** to the total **Resistance** of the structure. The constant **2.63** was calculated based on the characterization test. Given a certain type of conductive yarn, this constant may vary based on the stitch tension.

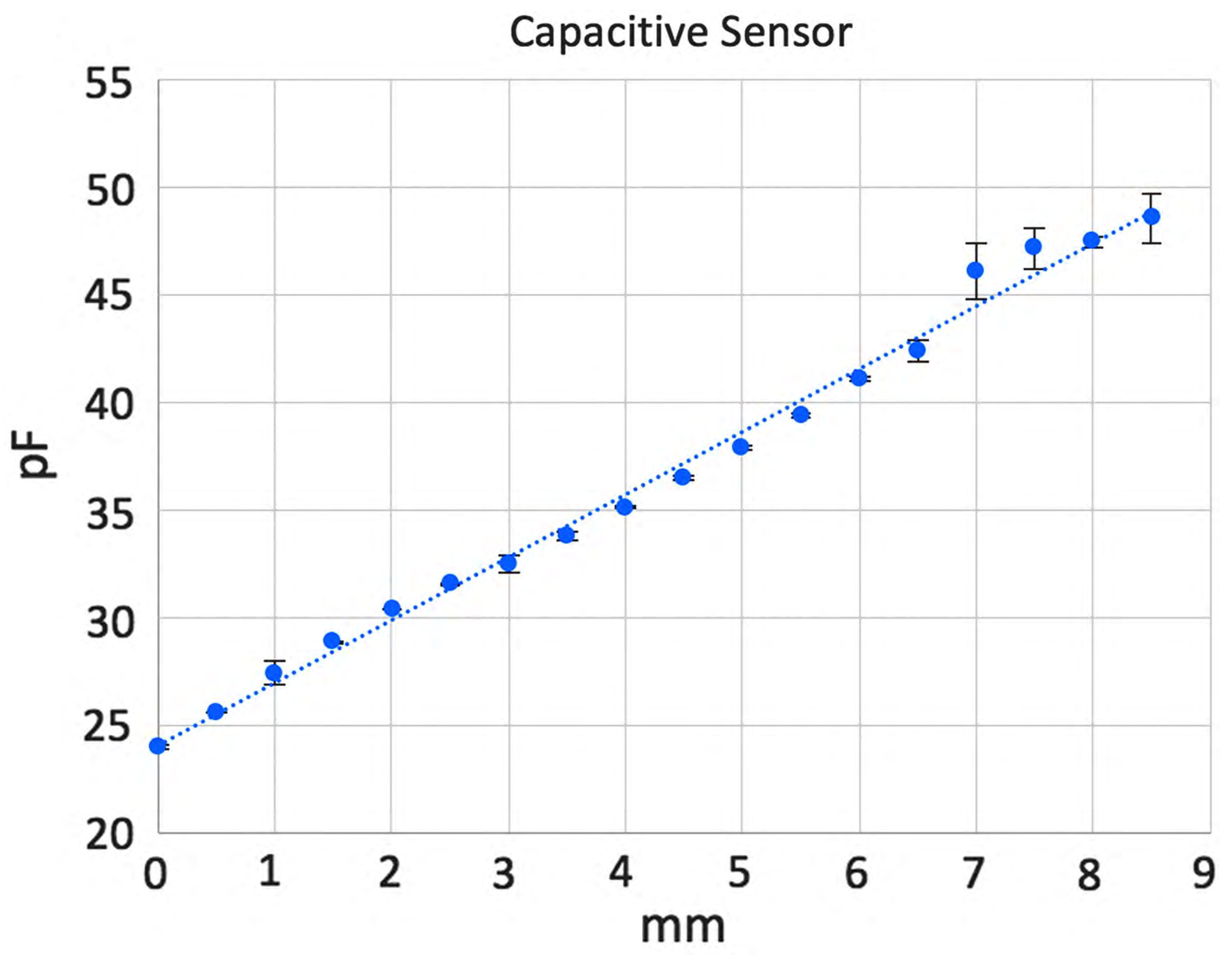
Stretch Sensor
Characterization Test

Resistive sensing characterization



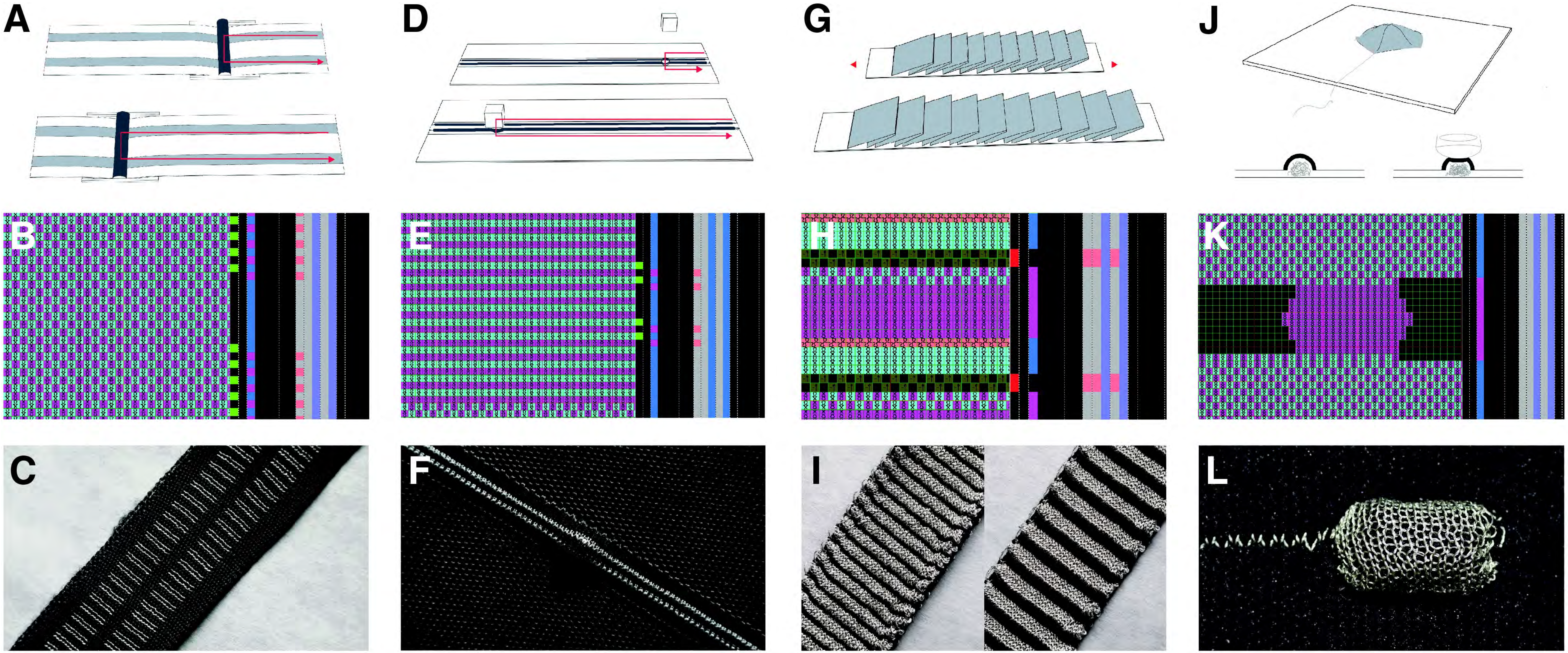
Characterization results of 1 mm increments while noting resistance

Capacitive sensing characterization



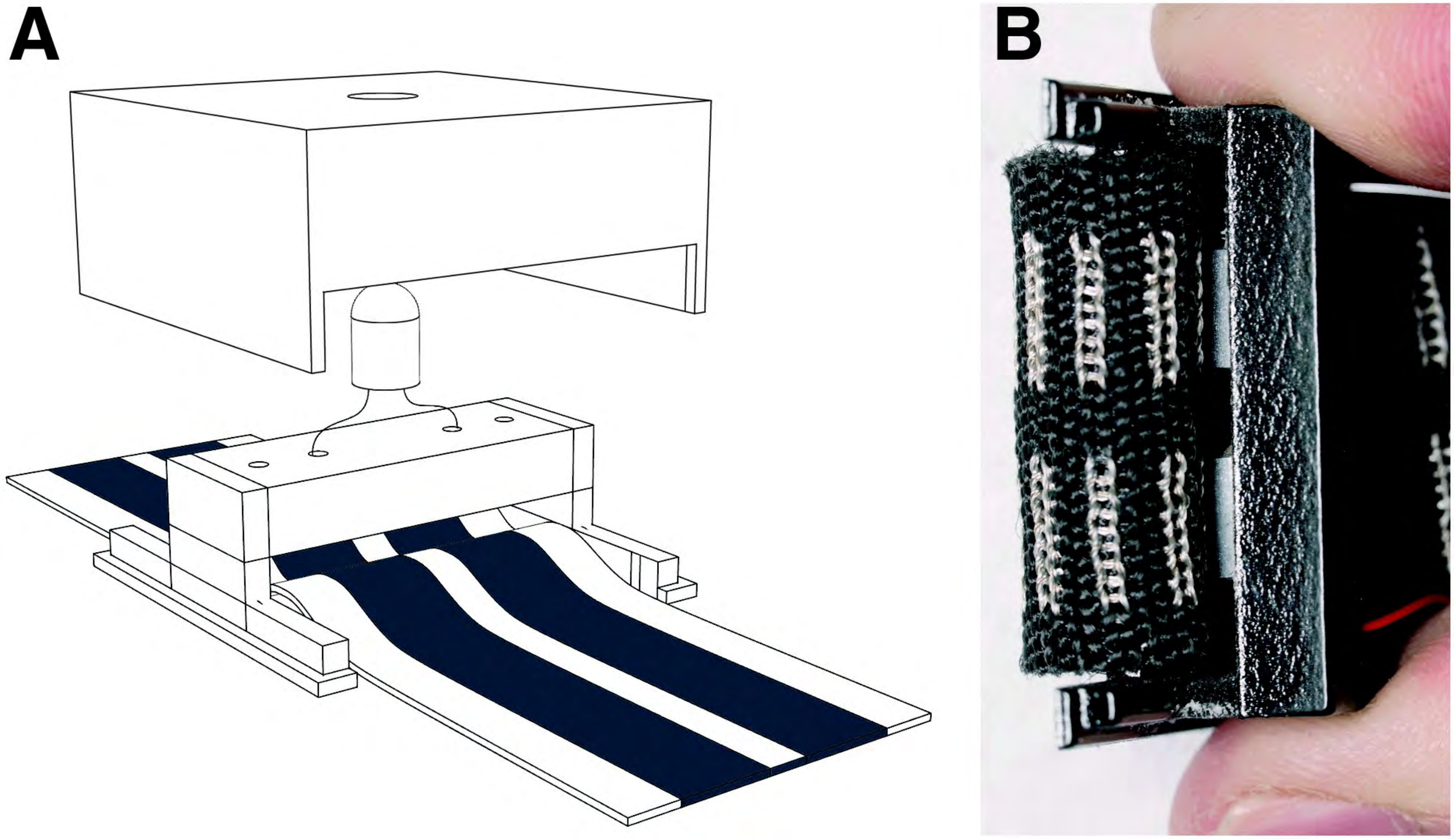
Characterization results of 1 mm increments while noting capacitance.

Design Patterns

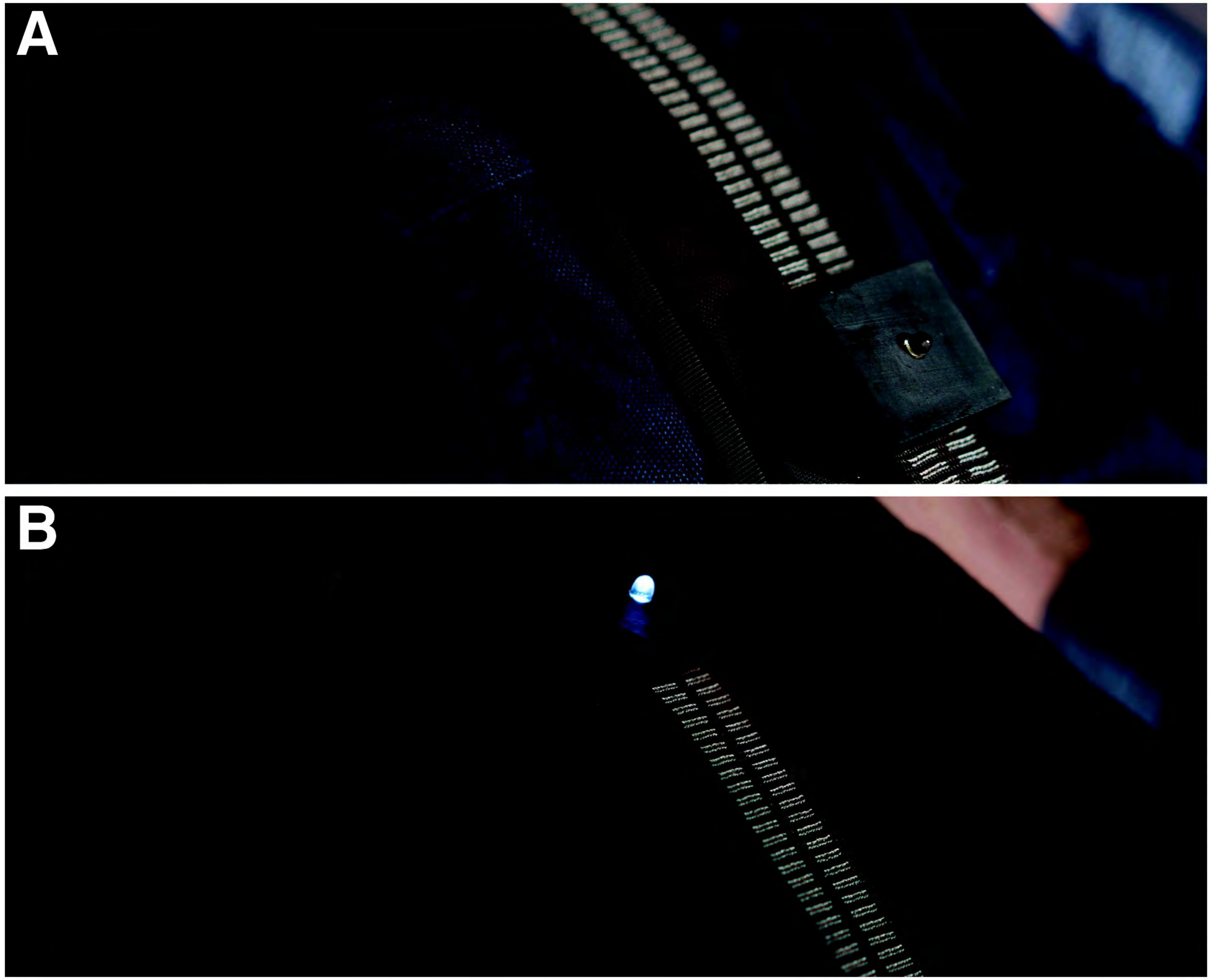


(A–C) Belt rheostat illustration, knit design, and sample photograph. (D–F) Tablecloth rheostat illustration, knit design, and sample photograph. (G–I) Stretch sensor illustration, knit design, and sample photograph. (J–L) Displacement/pressure sensor illustration, knit design, and sample photograph.

Applications



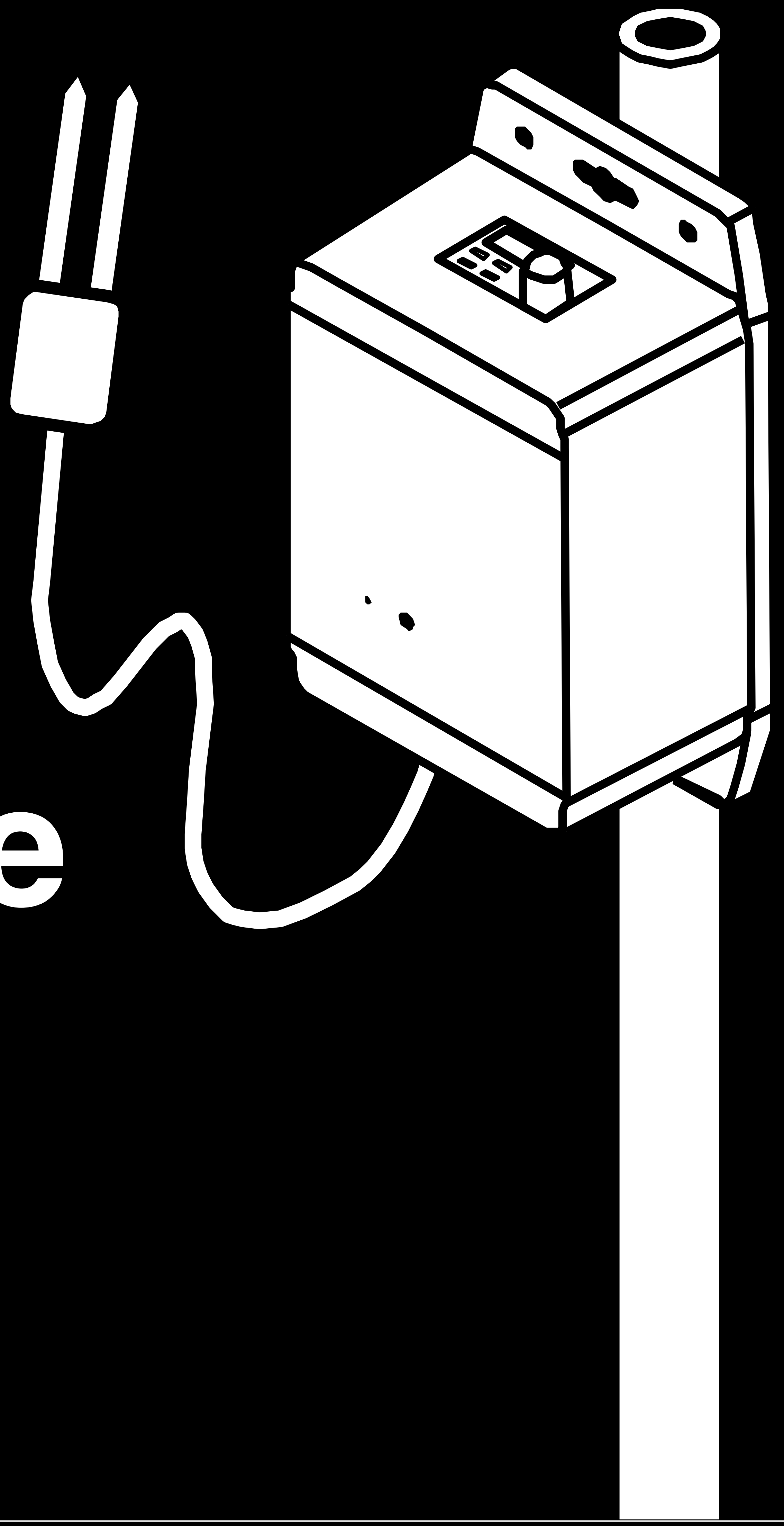
(A) Structural design of the light buckle. (B) Features the connection mechanism to the belt via two metallic cylinders, one connected to ground and the other to 9 V.



Customized belt rheostat sewn onto a backpack with a 3D-printed enclosure that covers the buckle, and a voltage divider circuit that changes the brightness of an LED; (A) low brightness, (B) high brightness.

Photo Credit: Daniel Oran

Building and Deploying the Networked Sensory Landscape




Haverhill
Nashua
Lawrence
95
Rockport
Gloucester
Lowell
Westford
3
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Salem
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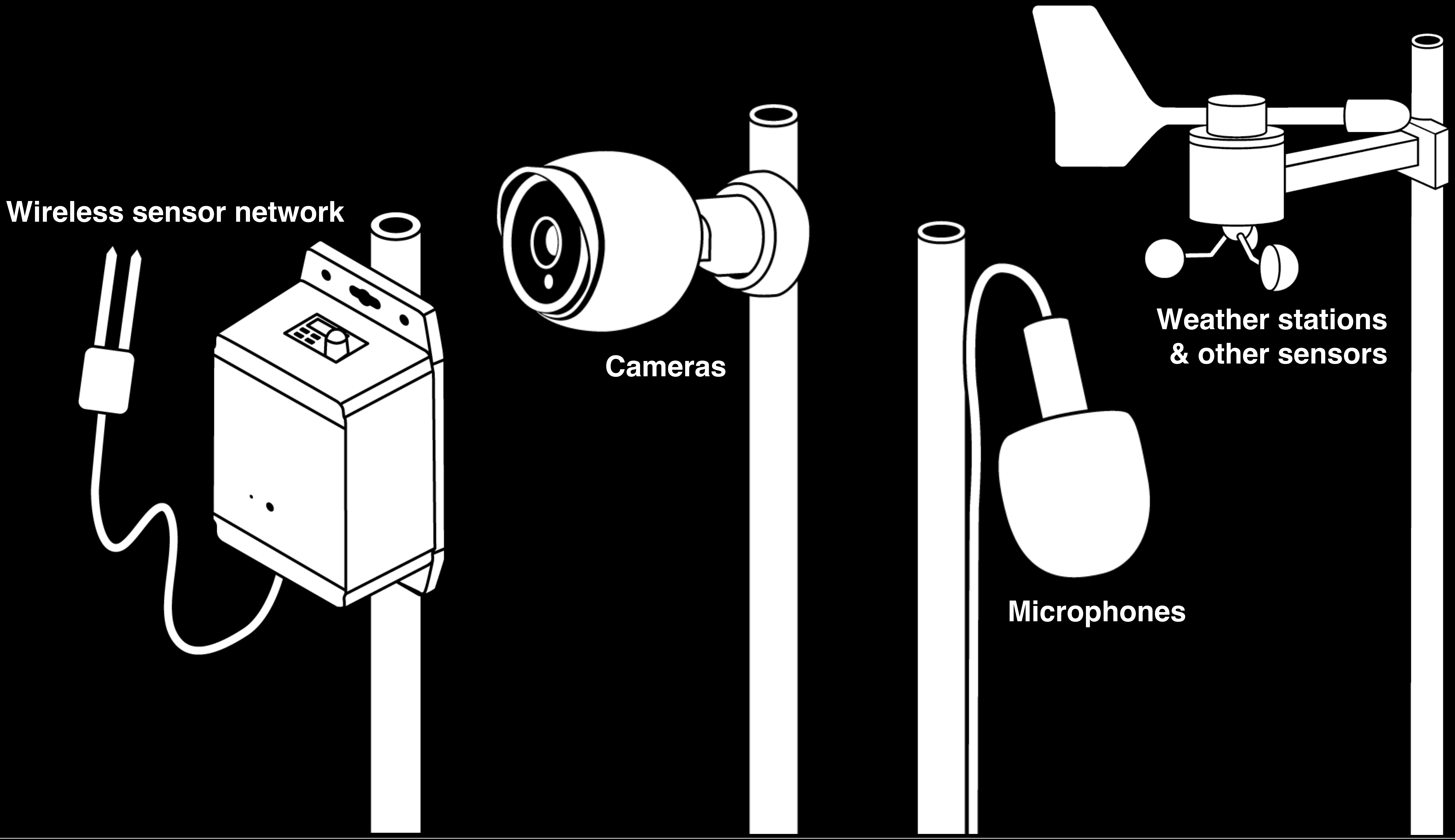
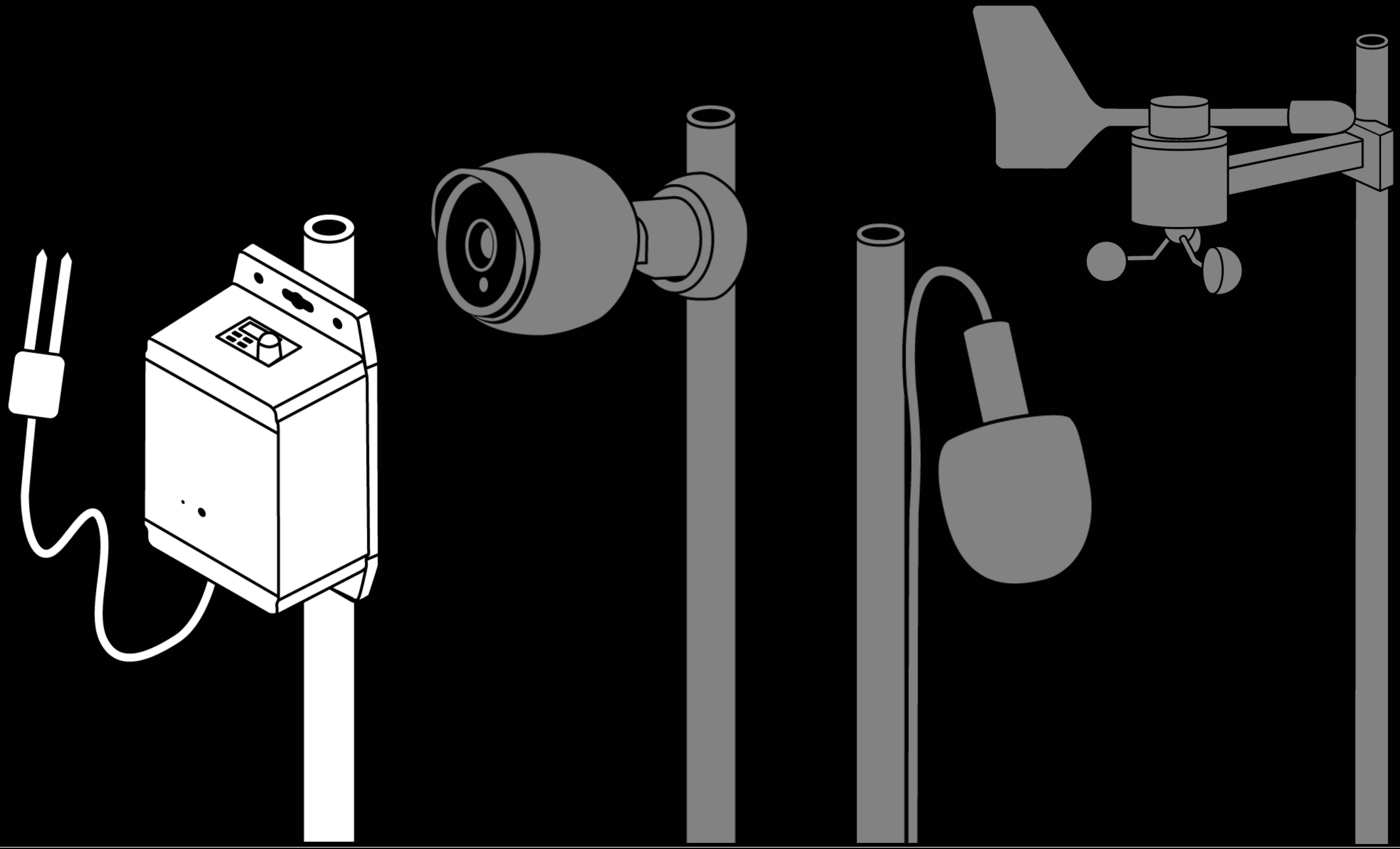
Waltham
Boston
Framingham
228
3A
93
123
3
495
Marshfield
Brockton
Provincetown
95
6
Woonsocket
495
Cape Cod Bay
Plymouth
Cape Cod
National
Seashore
146
Attleboro
24
44
295
Taunton
Pawtucket
Providence
495
Cranston
195
140
25
Orleans
Wareham
Sandwich
6A
Dennis
Warwick
Fall River
195
Barnstable
6
Chatham
28
95
New Bedford
28
1
Falmouth
Middletown
Newport
Buzzards Bay


Beaver Dam Rd
Beaver Dam Rd
Beaver Dam Rd
Beaver Dam Pond
The Arm
Island Pond

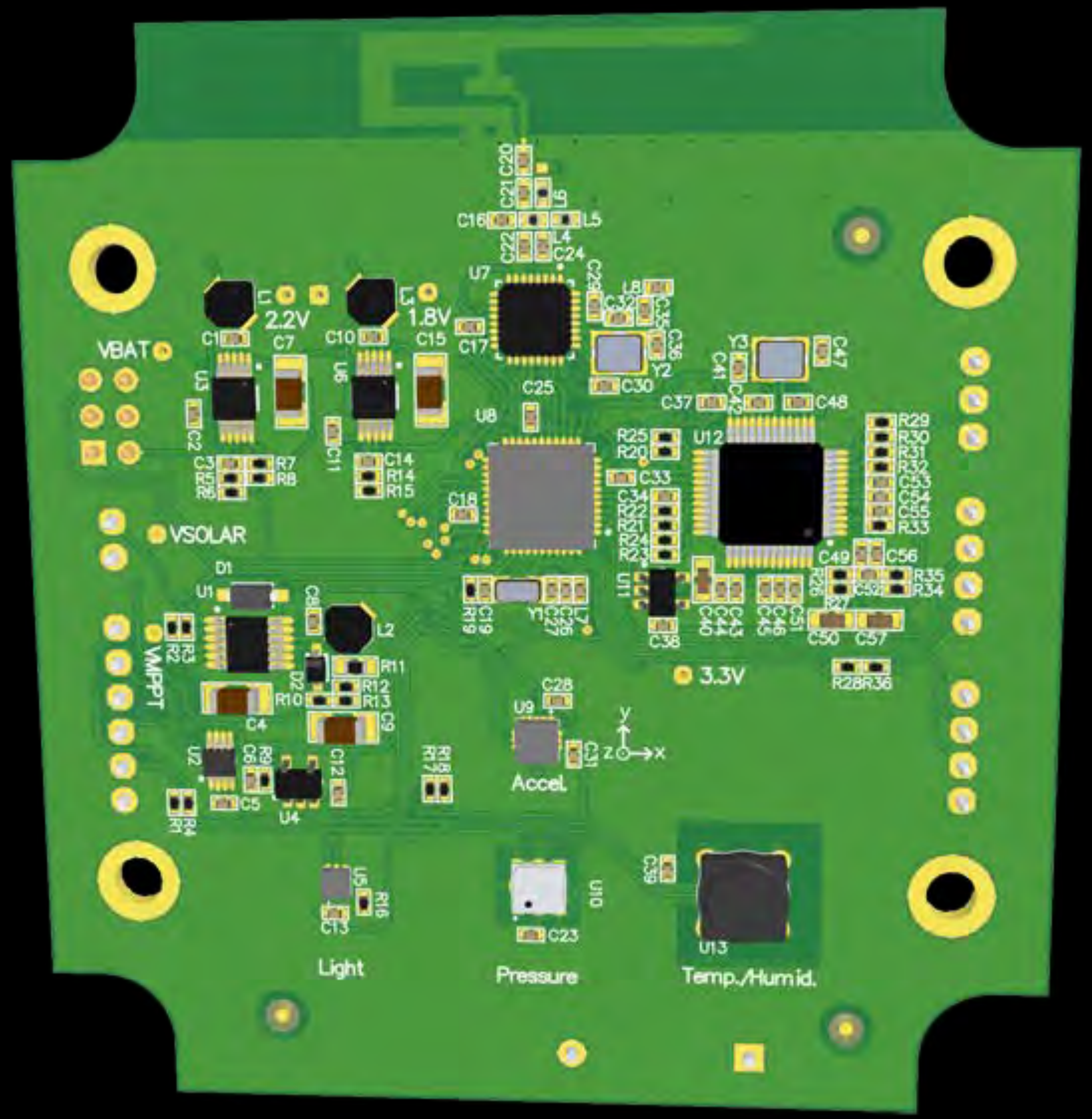

Wireless sensor network
Cameras
Weather stations
& other sensors
Microphones



The Sensing Platform, mark I

- Temperature
- Humidity
- Atmos. Pressure
- Visible Light
- Accelerometer

- ~2 year battery life



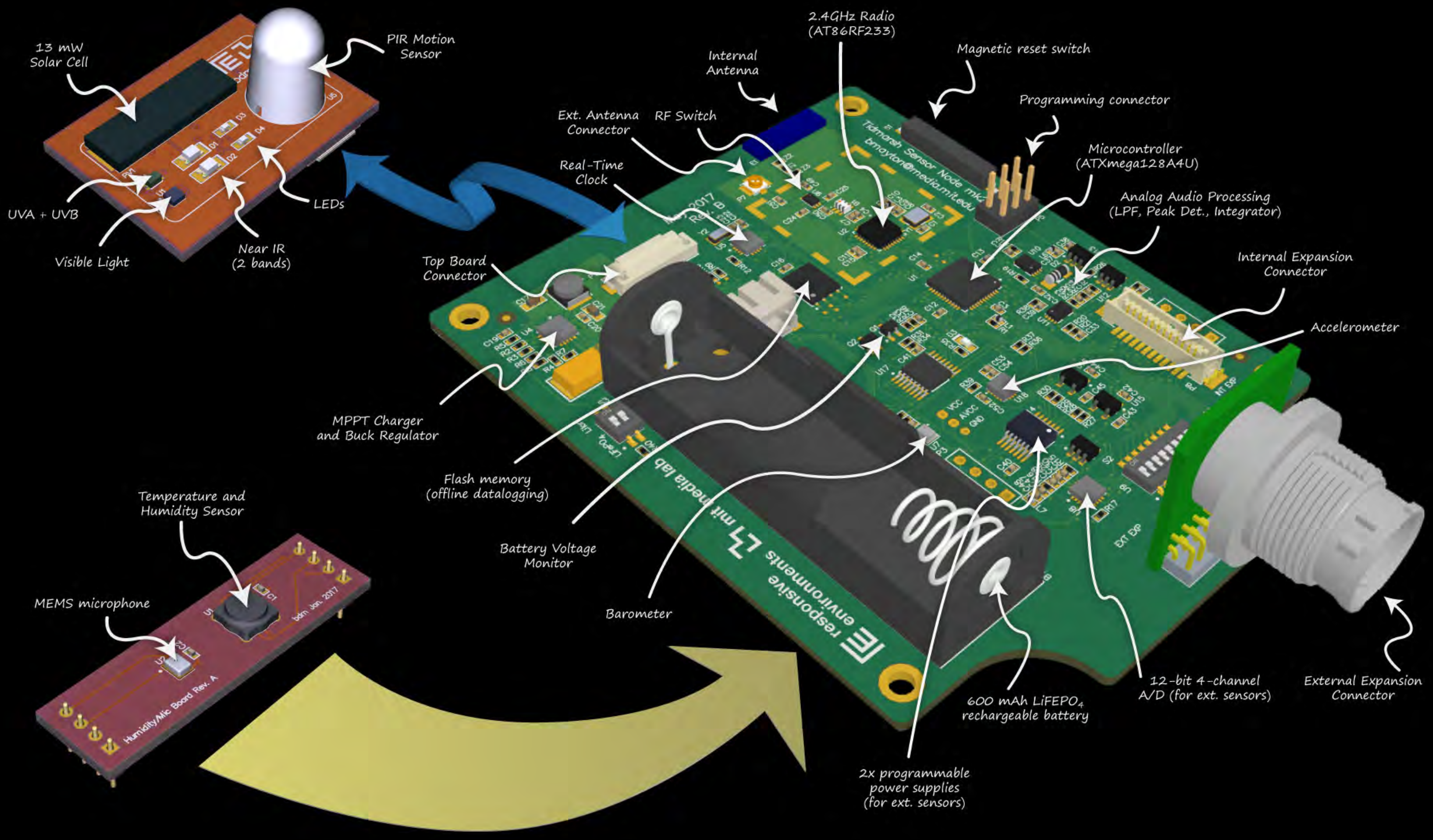
The Sensing Platform, mark II

- Temperature
- Humidity
- Atmos. Pressure
- Visible Light
- Ultraviolet (UVA + UVB)
- Infrared
- PIR motion
- Audio levels/FFT
- Accelerometer

- Indefinite lifetime (with sun)
- ~ 1 year battery life (no sunlight)

- Up to 4 analog channels, 0-3V range with signal conditioning
- 2 programmable voltage outputs
- Onewire, I2C, UART

The Sensing Platform, mark II




CLASS WORKSPACE
KEEP CLEAN
MAS836 WOR

Respo
resenv

Base Map

Dataset

USDA NAIP

Image Type

Visible

Year

2018

Overlay Maps

- [ ] Inter-Fluve Drone Imagery
- [ ] 2019 Stream Thermal Imagery
- [ ] March 2018 Stream Channel Visible Imagery

Sensor Network

- [x] Sensors

Temperature

Humidity

Soil Moisture

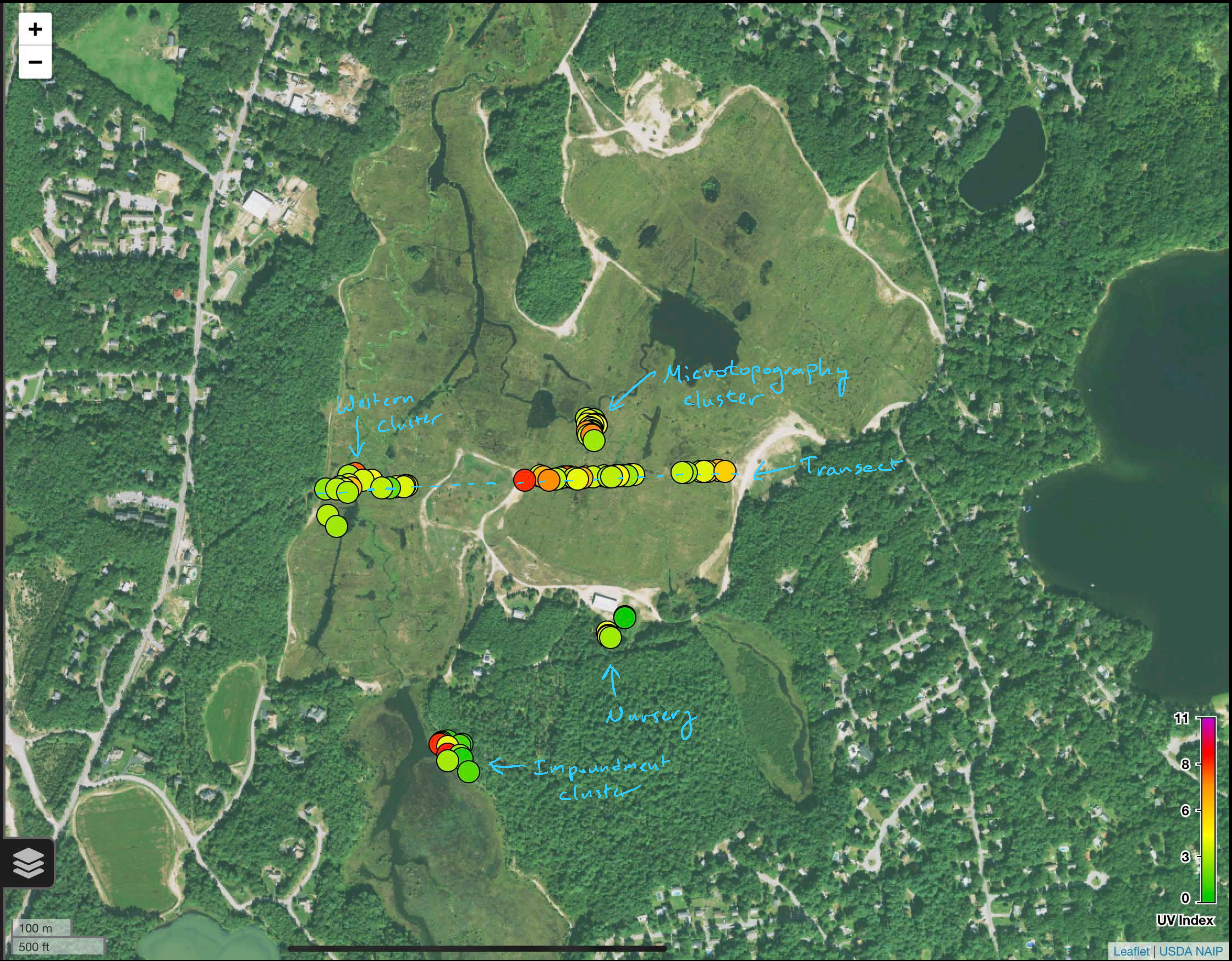
Soil Temperature

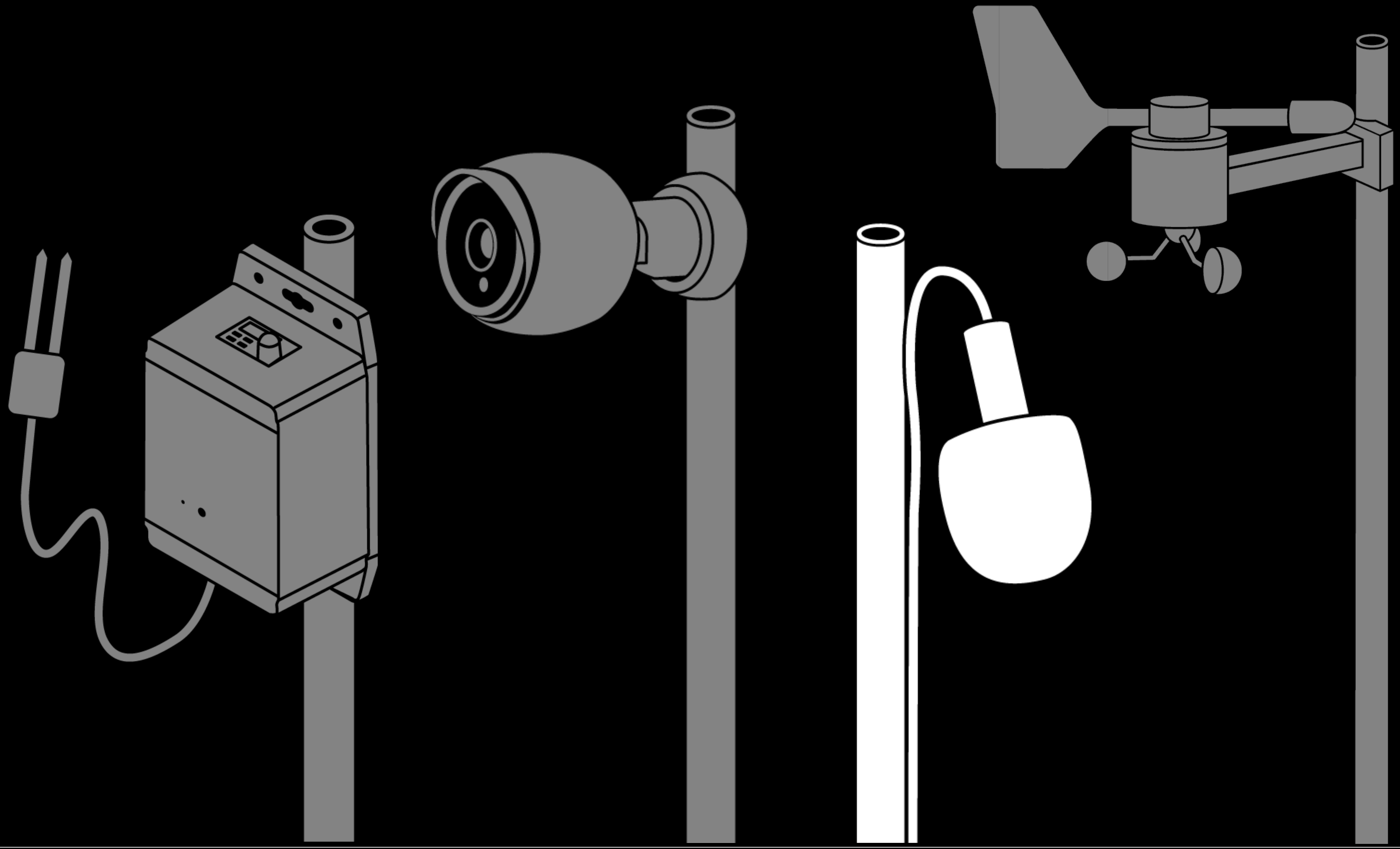
UV Index

→ Composite

UV A

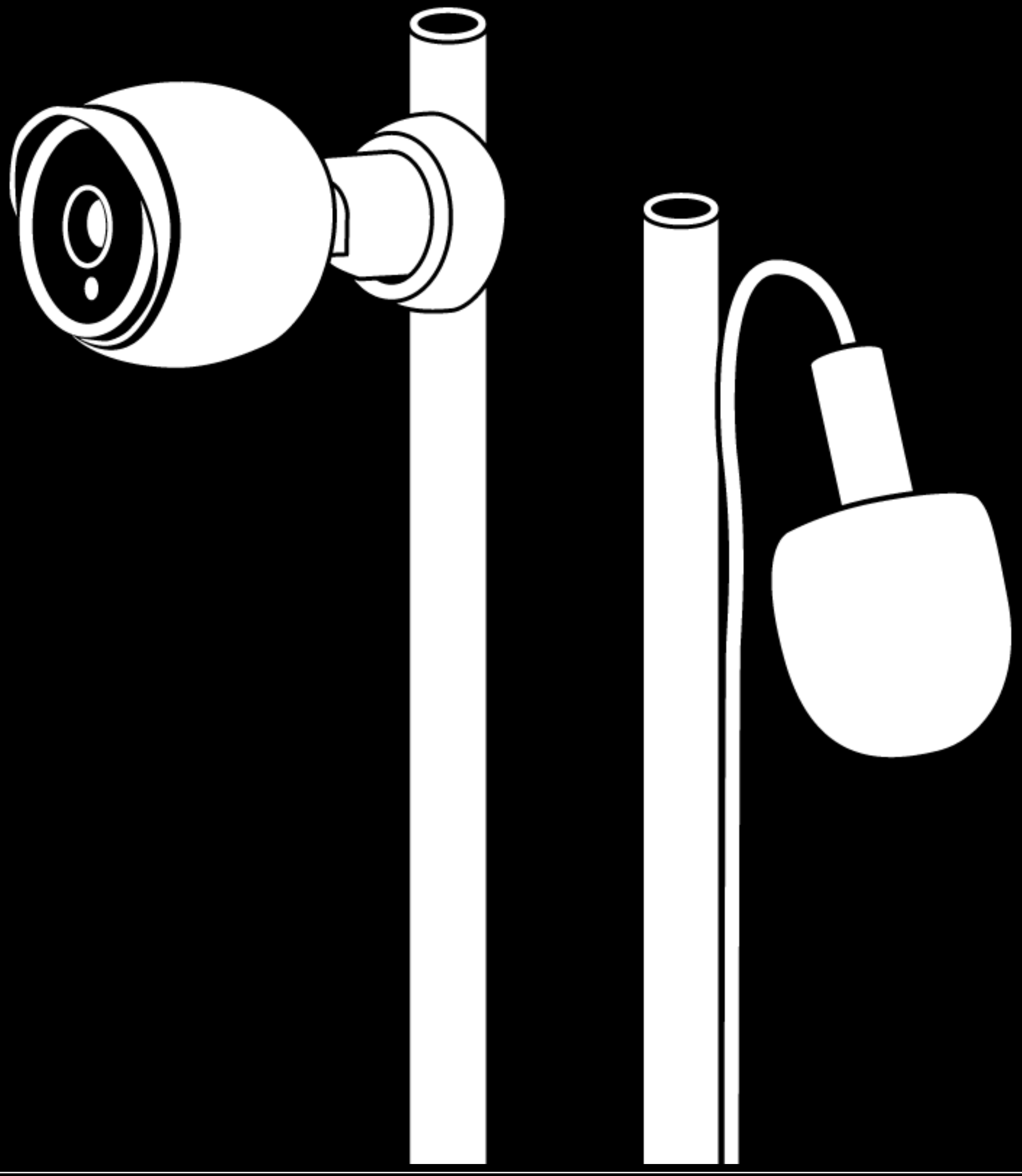
UV B

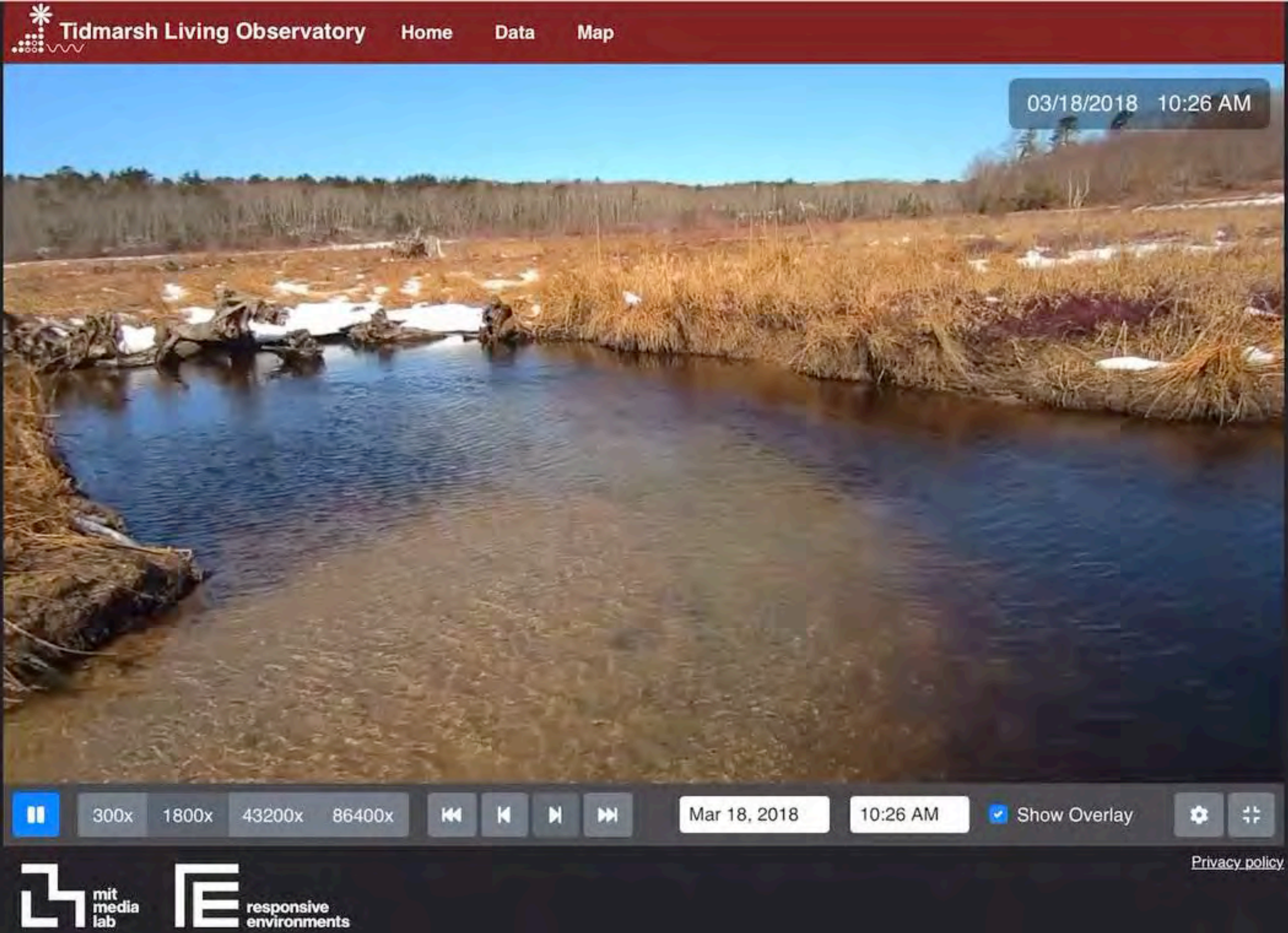





NETGEAR

Cameras & Microphones




Tidmarsh Living Observatory
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Data
Map
03/18/2018 10:26 AM
300x
1800x
43200x
86400x
Mar 18, 2018
10:26 AM
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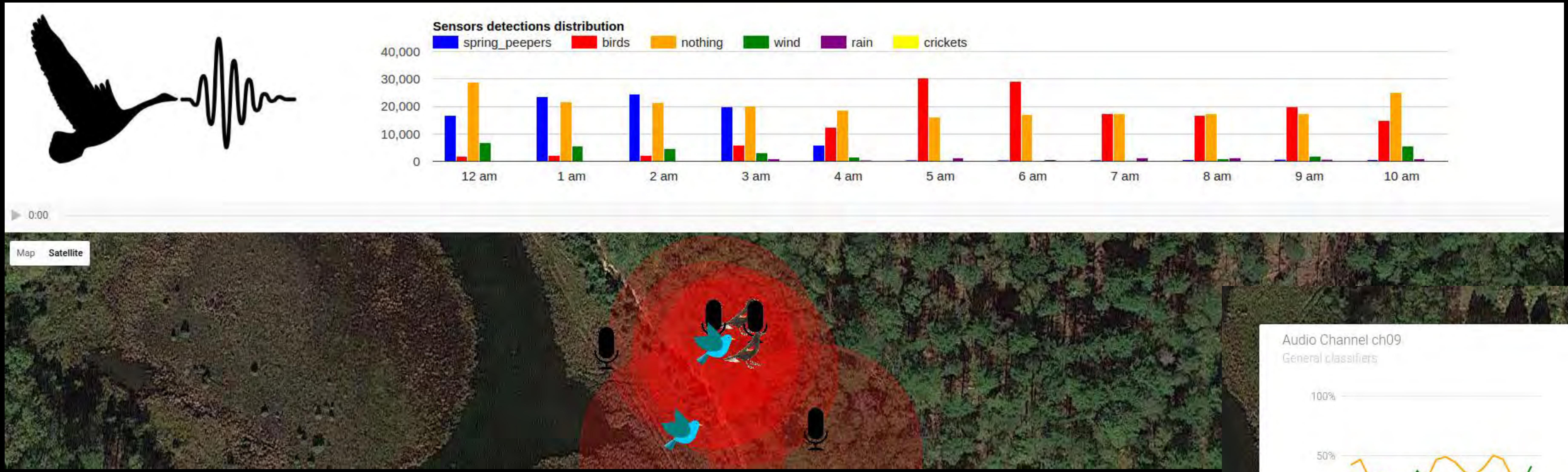
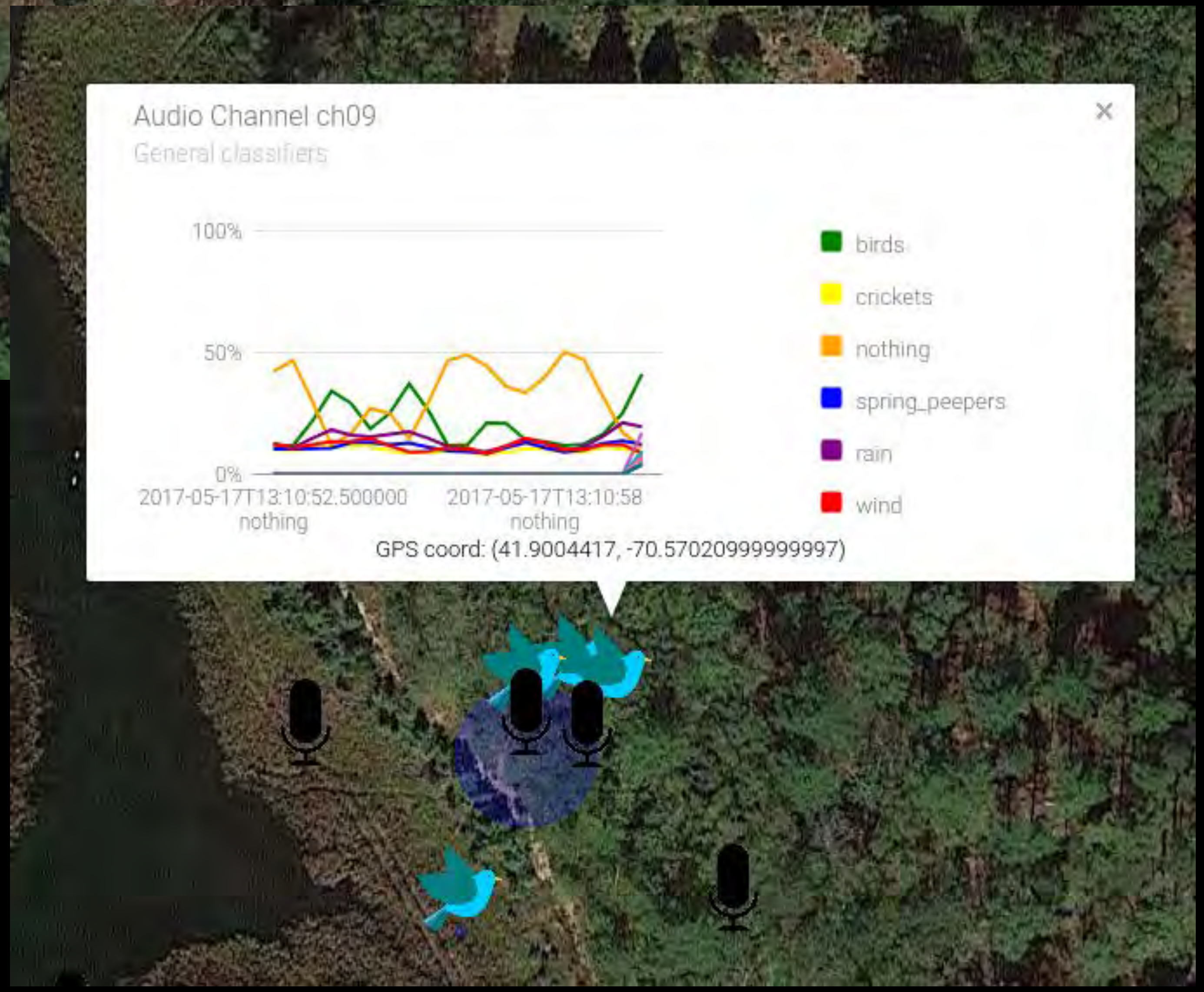
Privacy policy
mit media lab
responsive environments

Doppelmarsh


17.76°C
12.15°C

Tidzam





http://tidzam.media.mit.edu


hear there
Auditory HMD
IMU
Touch L/R
UWB
BLE
Attention
EEG
Stillness
Eye Tracker
Mobile Device
BLE
GPS
Orientation
Touch L/R
Location
Audio Rendering
Bone conduction
Head tracking, touch, EEG
Network, AI
Interface, rendering
mit media lab
responsive environments
Gershon Dublon
gershon@media.mit.edu