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Tactio

A Modular Tactile Sensor Development Suite

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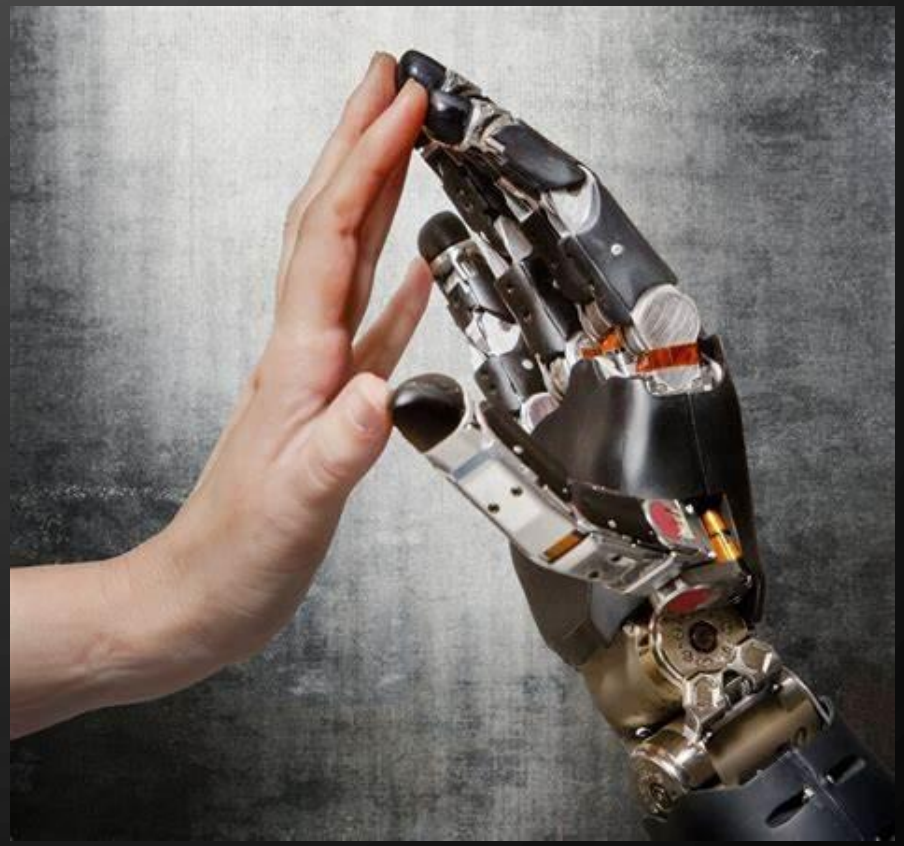
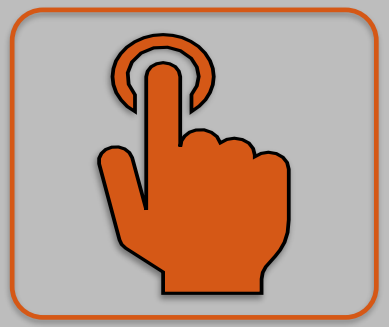
INTRODUCTION

- Humans rely on their tactile senses for robust and informative interaction with objects
- Tactile sensing can enable robots to more effectively grasp and interact with objects in the real world

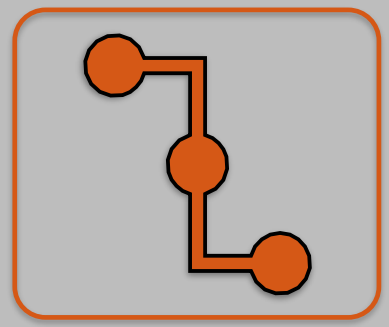


TACTIO Design Goals



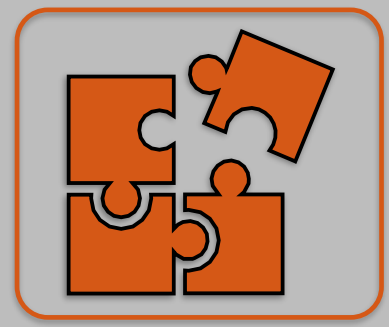
Relative Pressure Sensing

Modular



Chainable

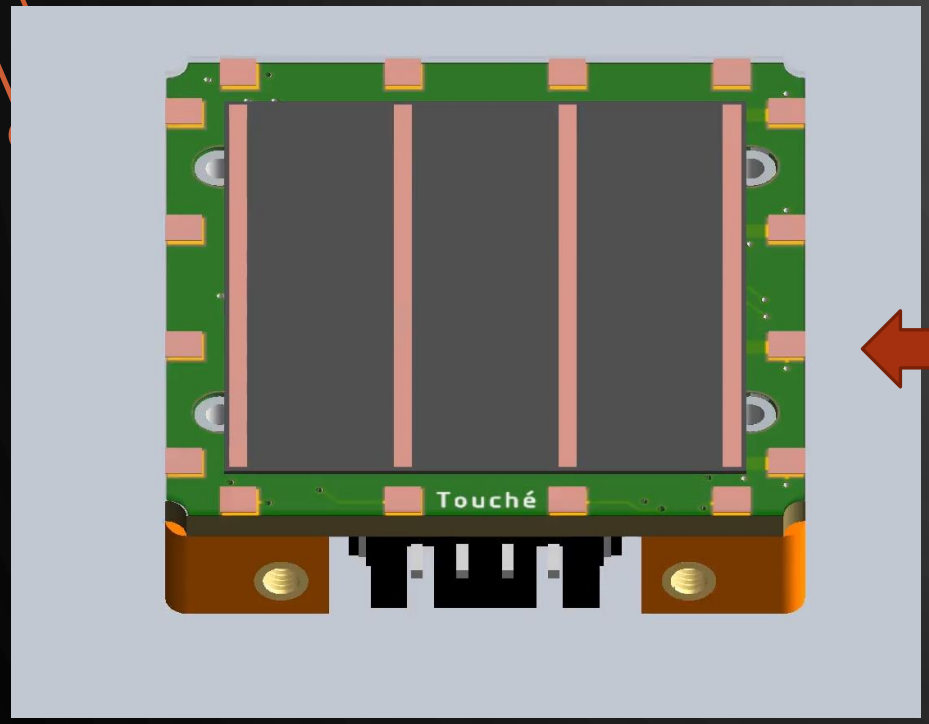
Cost Optimized



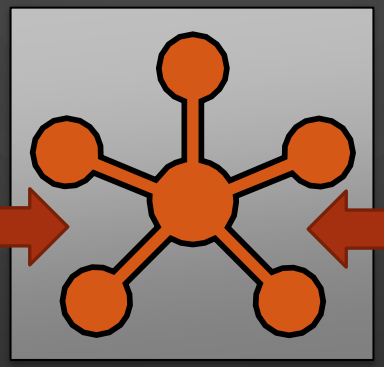
Third Party Integration

Flexible Mounting

Overview



Sensor Nodes

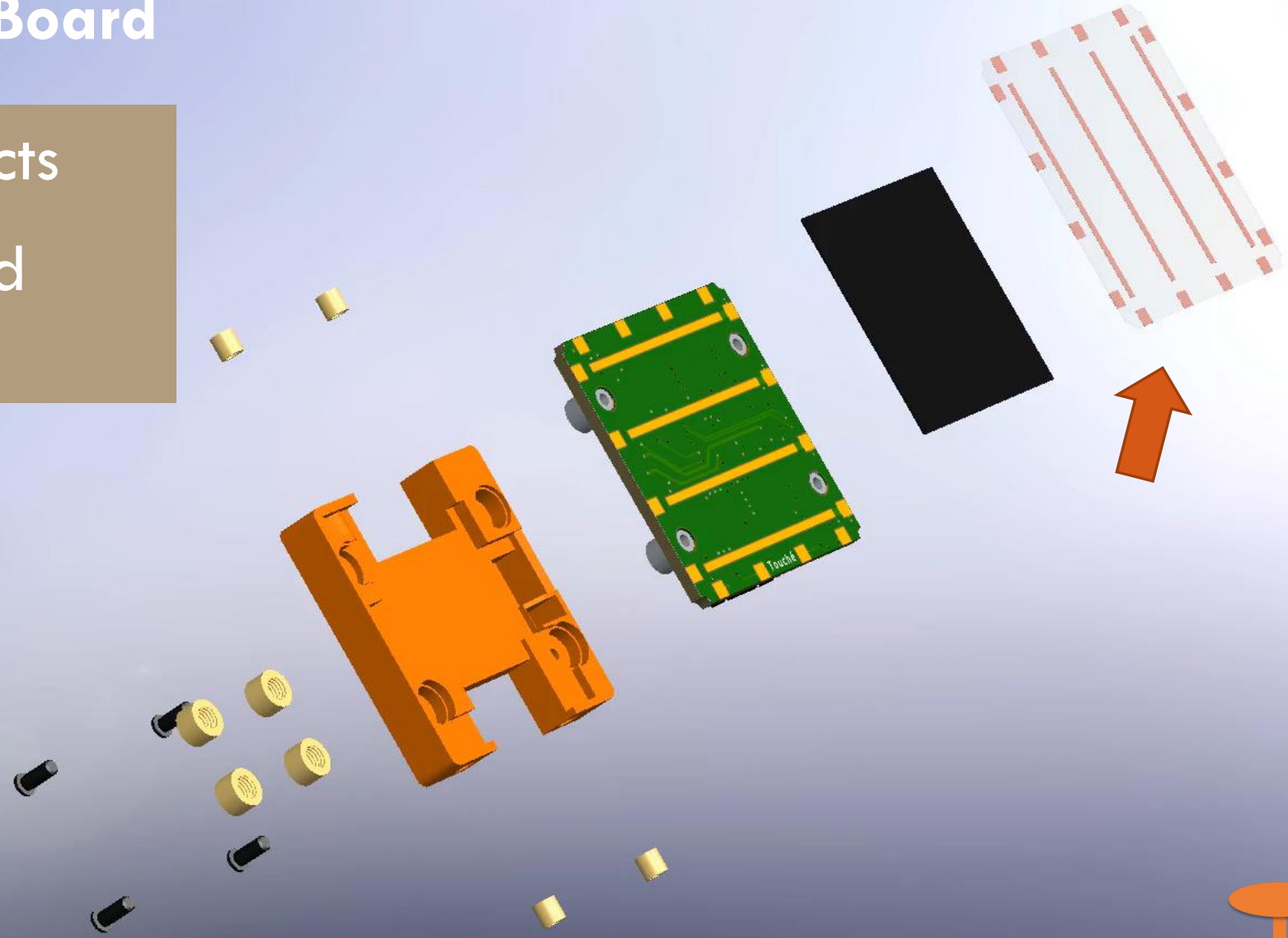


Network Controller

PC Visualization

Flexible Printed Circuit Board

- Upper sensing contacts
- Deforms for localized pressure response



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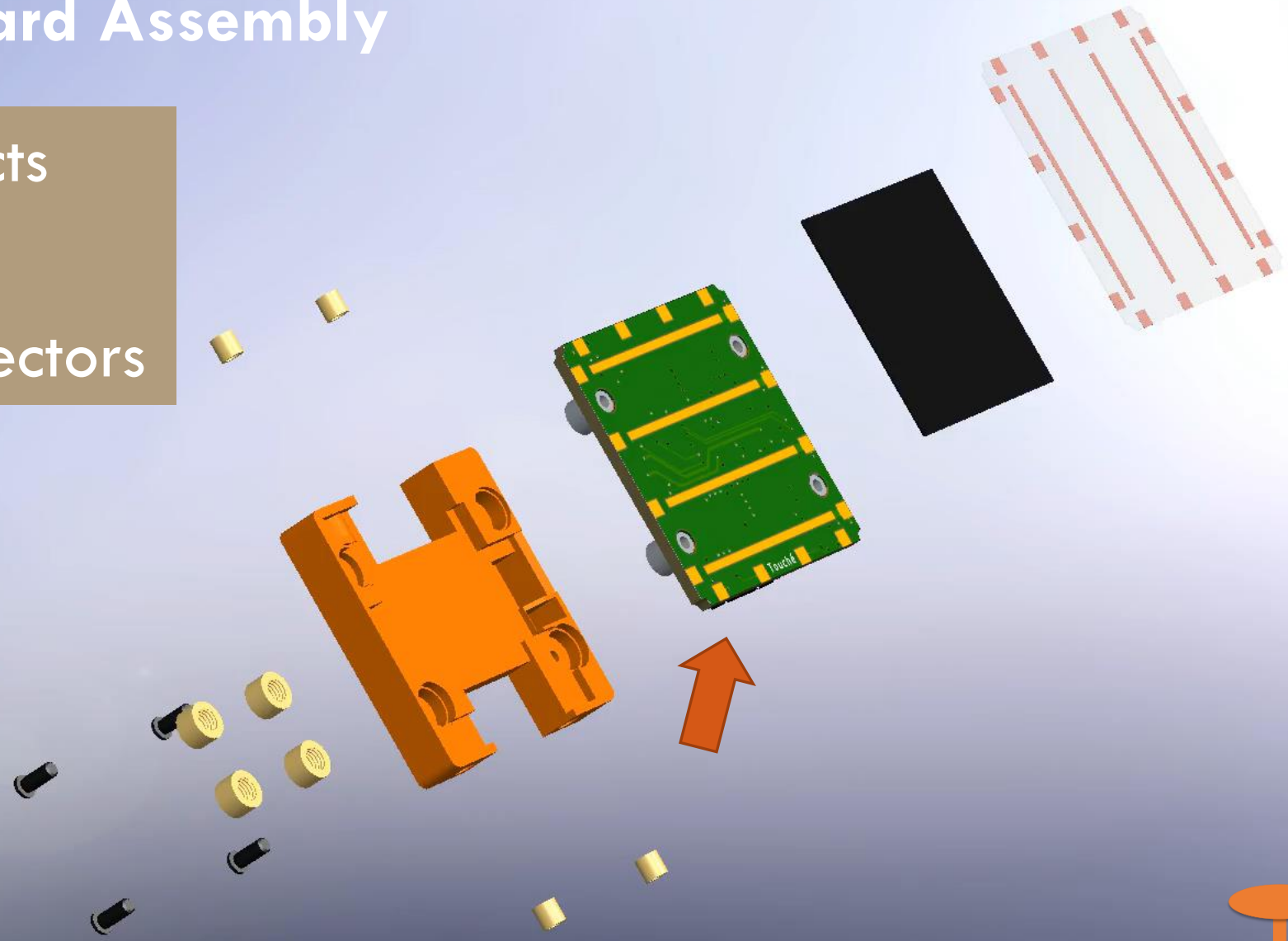
Rigid Printed Circuit Board Assembly

- Lower sensing contacts
- Incorporates all electronics and connectors



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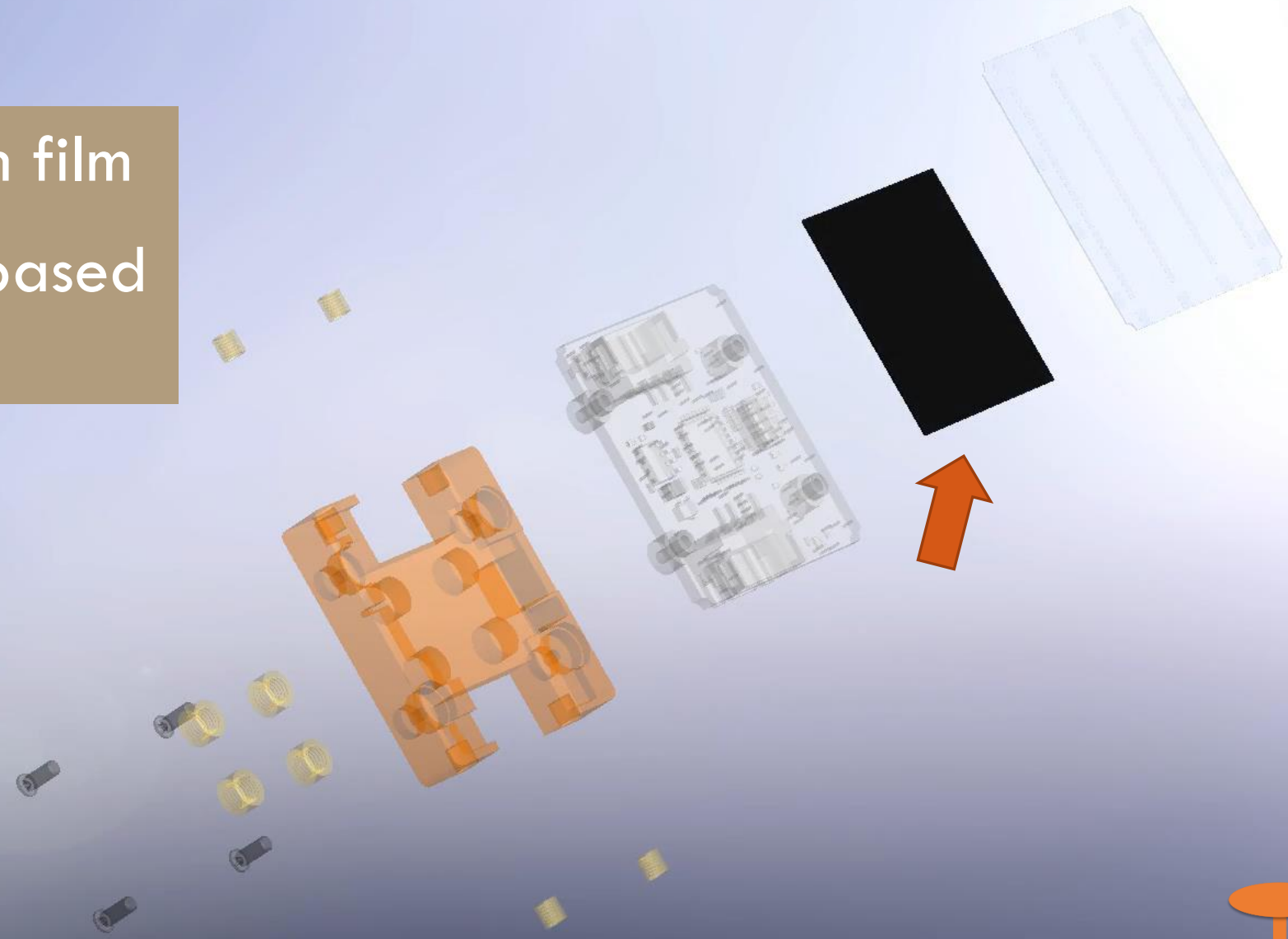
Velostat™

- Piezoresistive carbon film
- Resistance changes based on applied pressure



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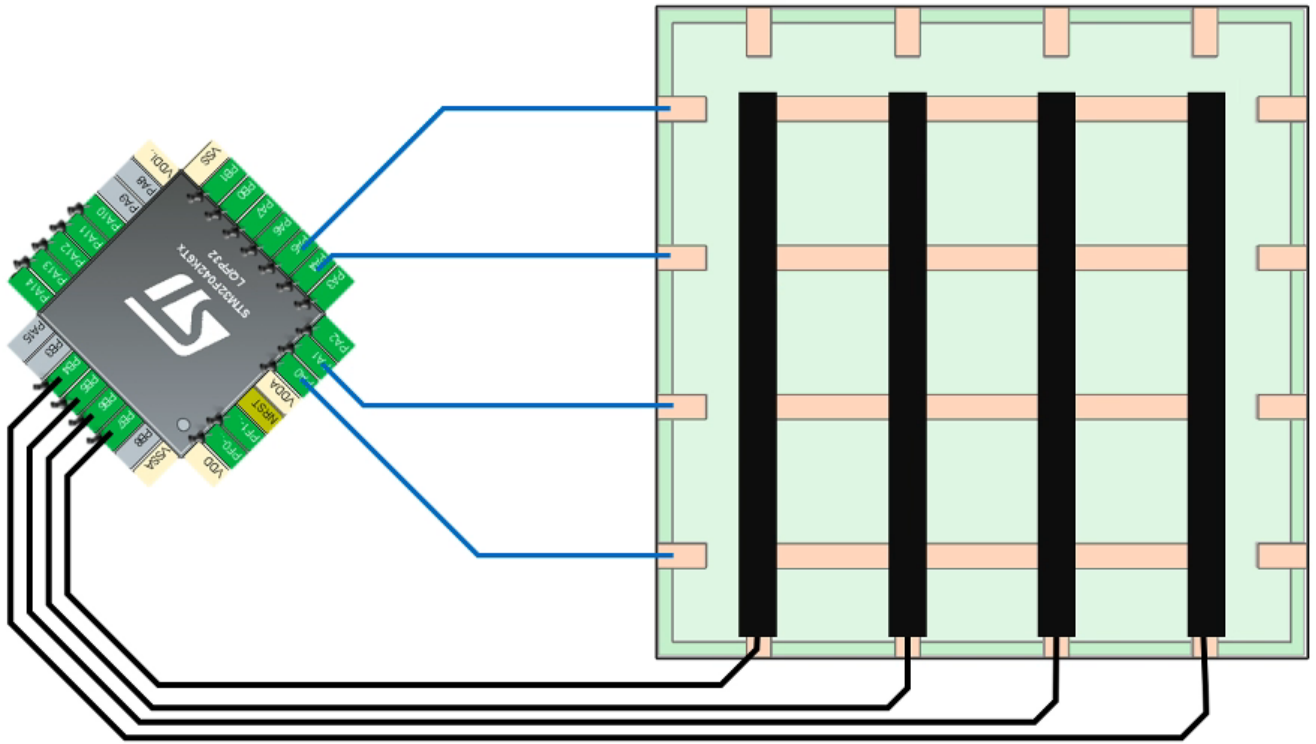
Sensing Grid

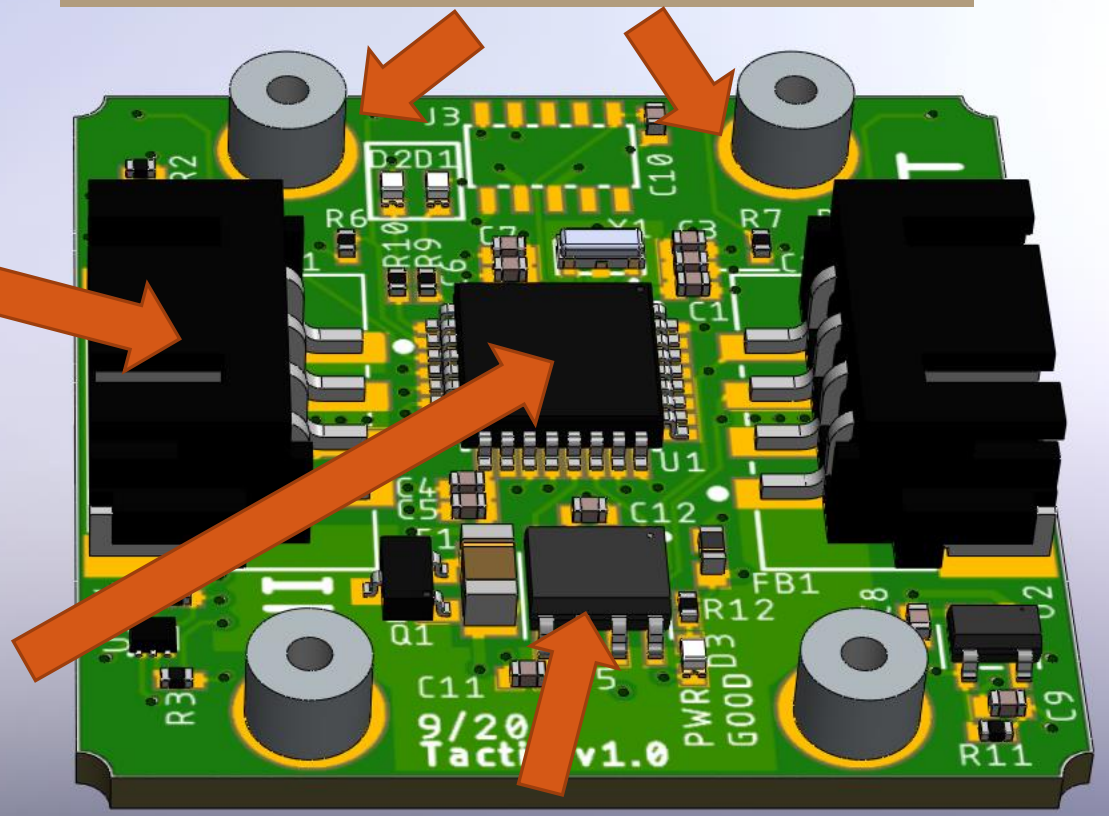
0	0	0	0
0	0	190	0
0	0	240	0
0	0	0	0



Sensor Node PCB Components

Standoffs for Attaching Enclosure

4-Pin JST Connectors for Communications Bus + Power



STM32F04 ARM® Cortex ®-M0 Microcontroller

MCP2562 CAN Transceiver

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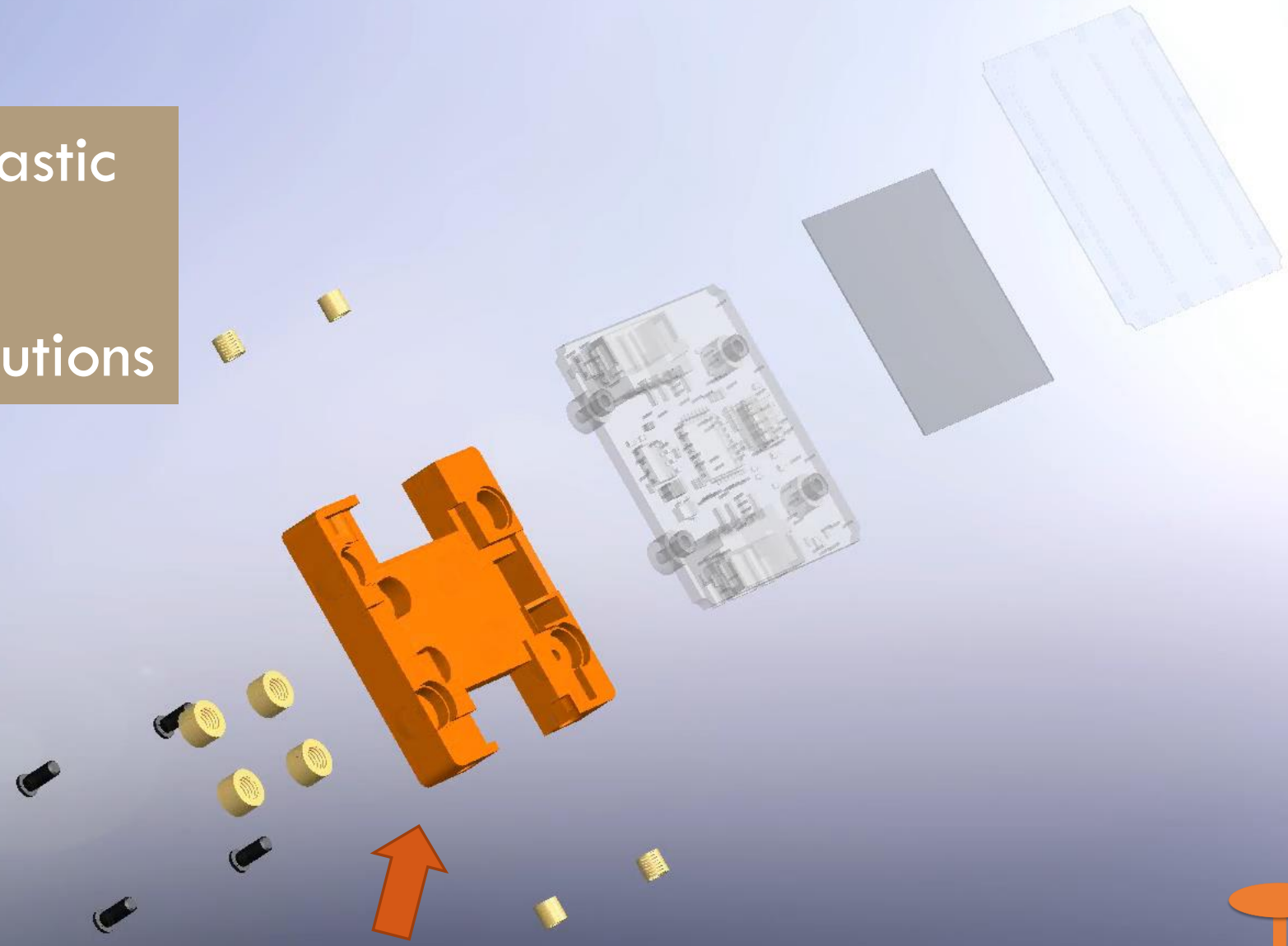
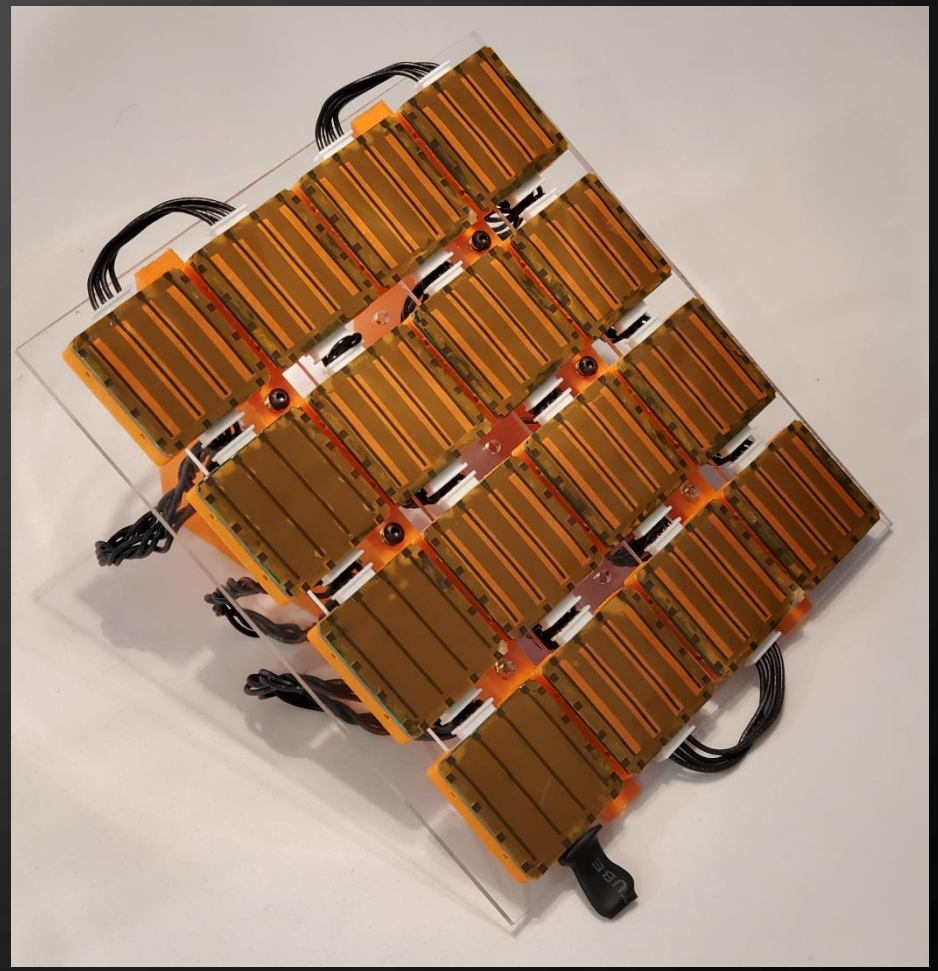
Enclosure

- 3D printed thermoplastic
- Threaded inserts for flexible mounting solutions



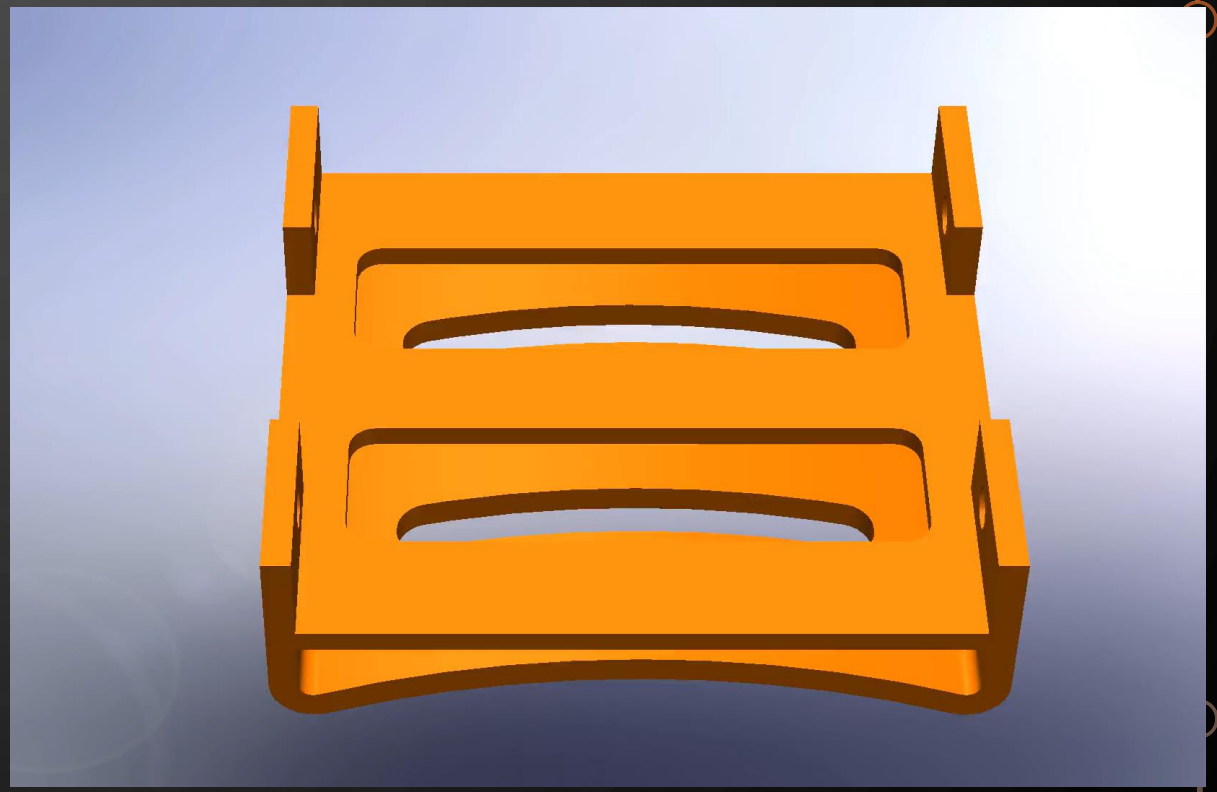
Mounting System

Rear threads can be used to attach sensors directly to planar surfaces



Mounting System

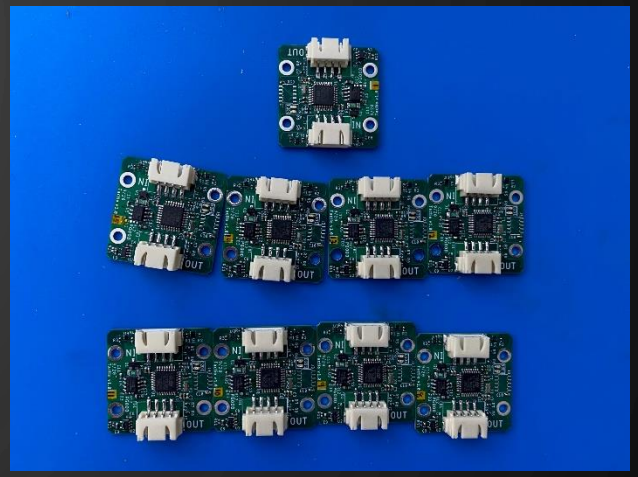
Threaded inserts allow custom mounting brackets to be used for attaching the sensors to non-planar surfaces

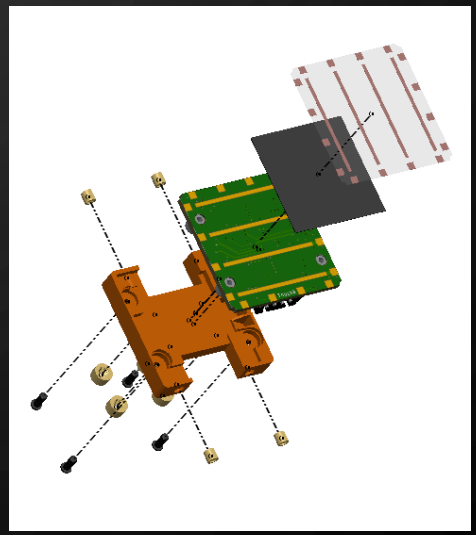


Manufacturing

Process per sensor:

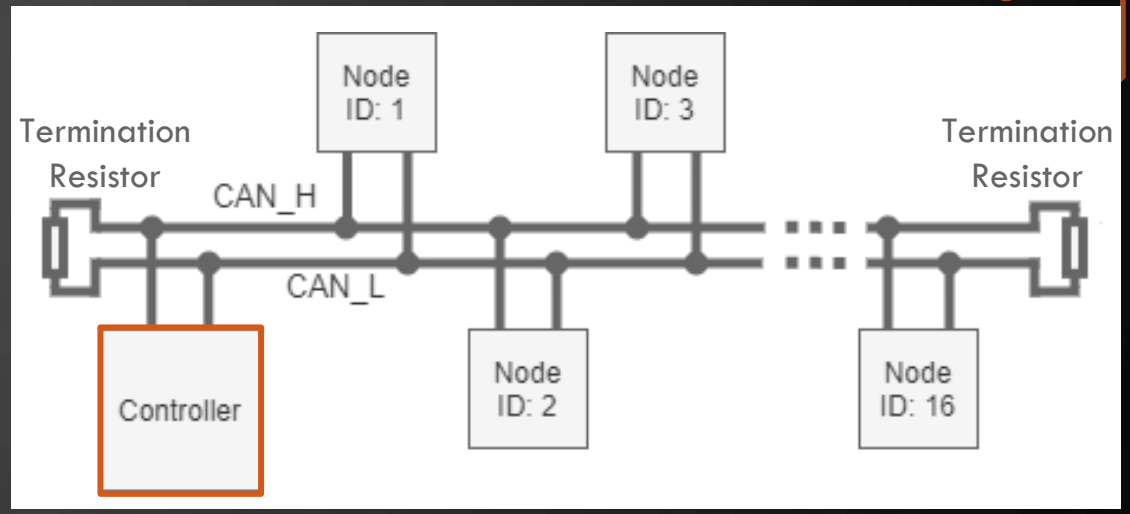
1. Assemble microcontroller components
   - Verified functionality of micro + power
2. Solder in standoffs
3. Add 1/8in copper tape to both rows and columns
4. Solder one side of flex PCB tabs
5. Place in Velostat
6. Use adhesive on remaining sides
   - Used glue, tape for comparison

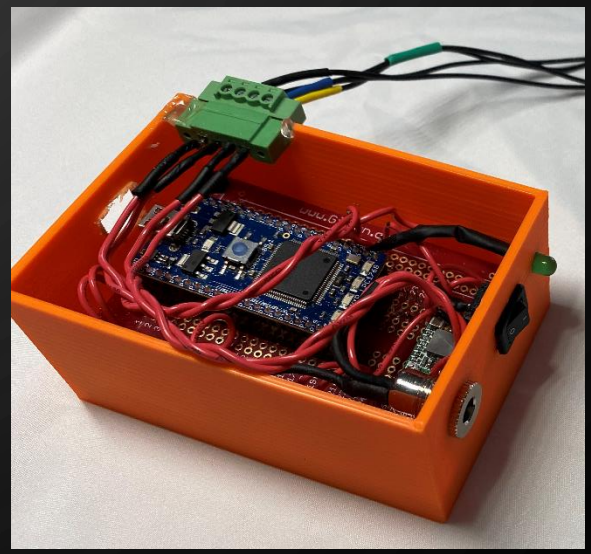




Network Controller

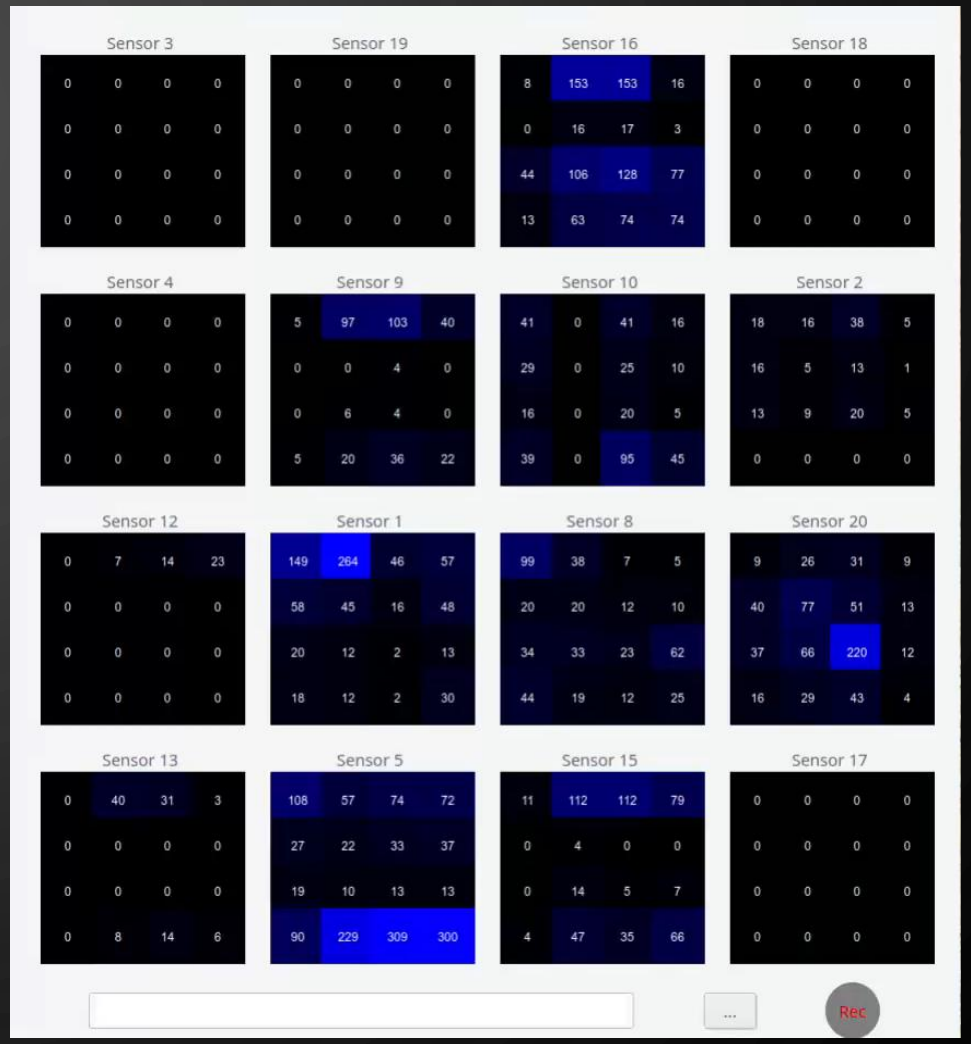
- Commissions sensor nodes onto the CAN network
- Polls sensors for measurement data
- Interfaces between CAN network and external devices
- Portable C++ code targeting the MBED ecosystem





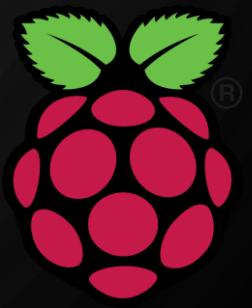
PC Software

- Convenient UI for reading and controlling sensor data
  - Parses and visualizes sensor data from the network controller
- Flexible layout definition using XML



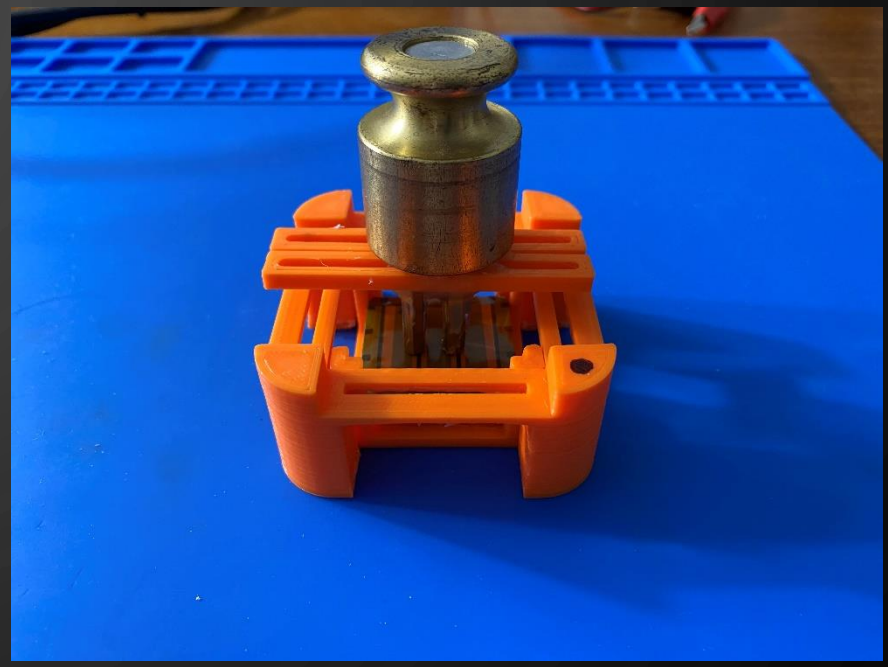
PC Software

- Visualization built in Python with PyQT
- Underlying USB communications library is open-sourced for end-user application development
  - Compatible with Arduino, Mbed, Raspberry Pi, etc



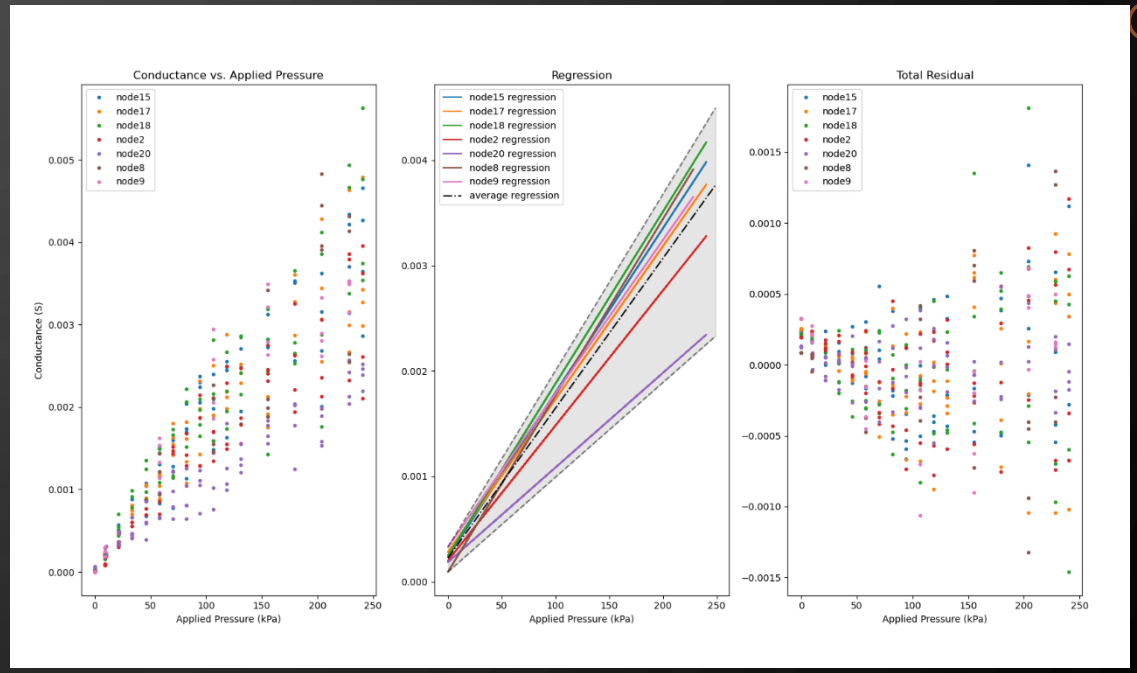
Testing Methods

- Picked multiple sensors for sampling
  - Noticed variance in offset and force curve varied between sensors and regions
- Used jig (on right) with adjustable pegs for pressure placement
- Initial sampling was 4 center points of grid and rotate for asymmetry
- Used various weights and recorded using the software suite



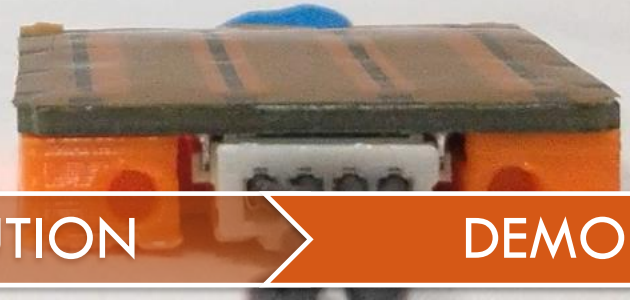
Modeling

- Assumed linear data for models
- Increasing variance with pressure
- Residuals increase with pressure
- Predictive model left for next steps



Object Sensing

9	0	3	3
0	0	0	0
0	0	0	0
0	0	0	0



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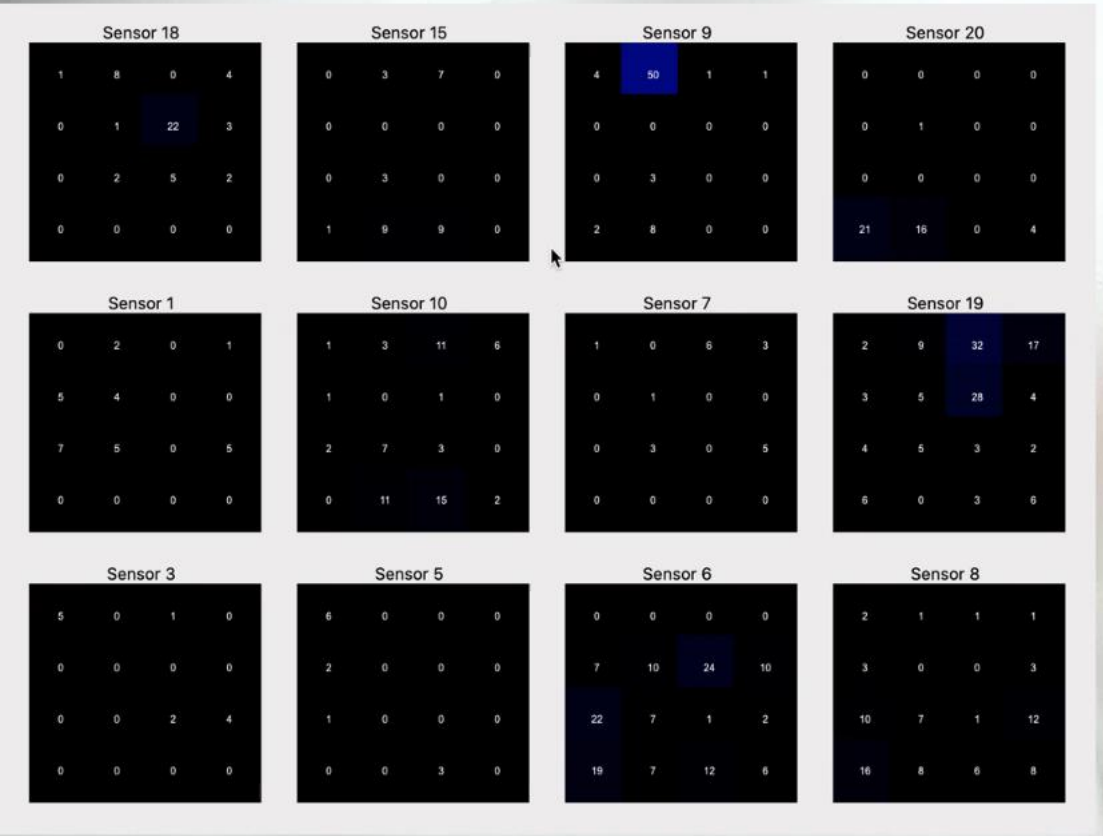
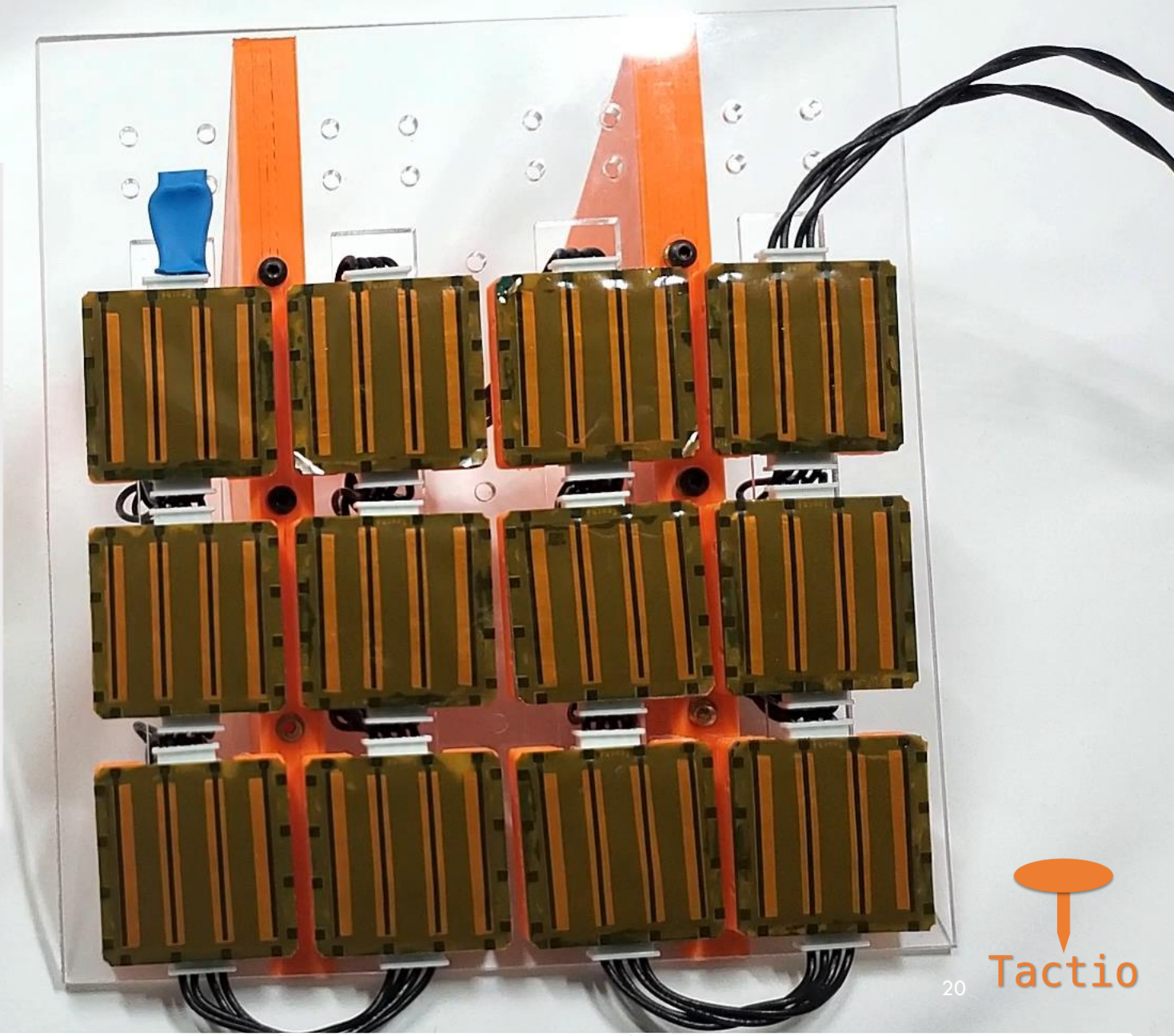
3x4 Grid Panel





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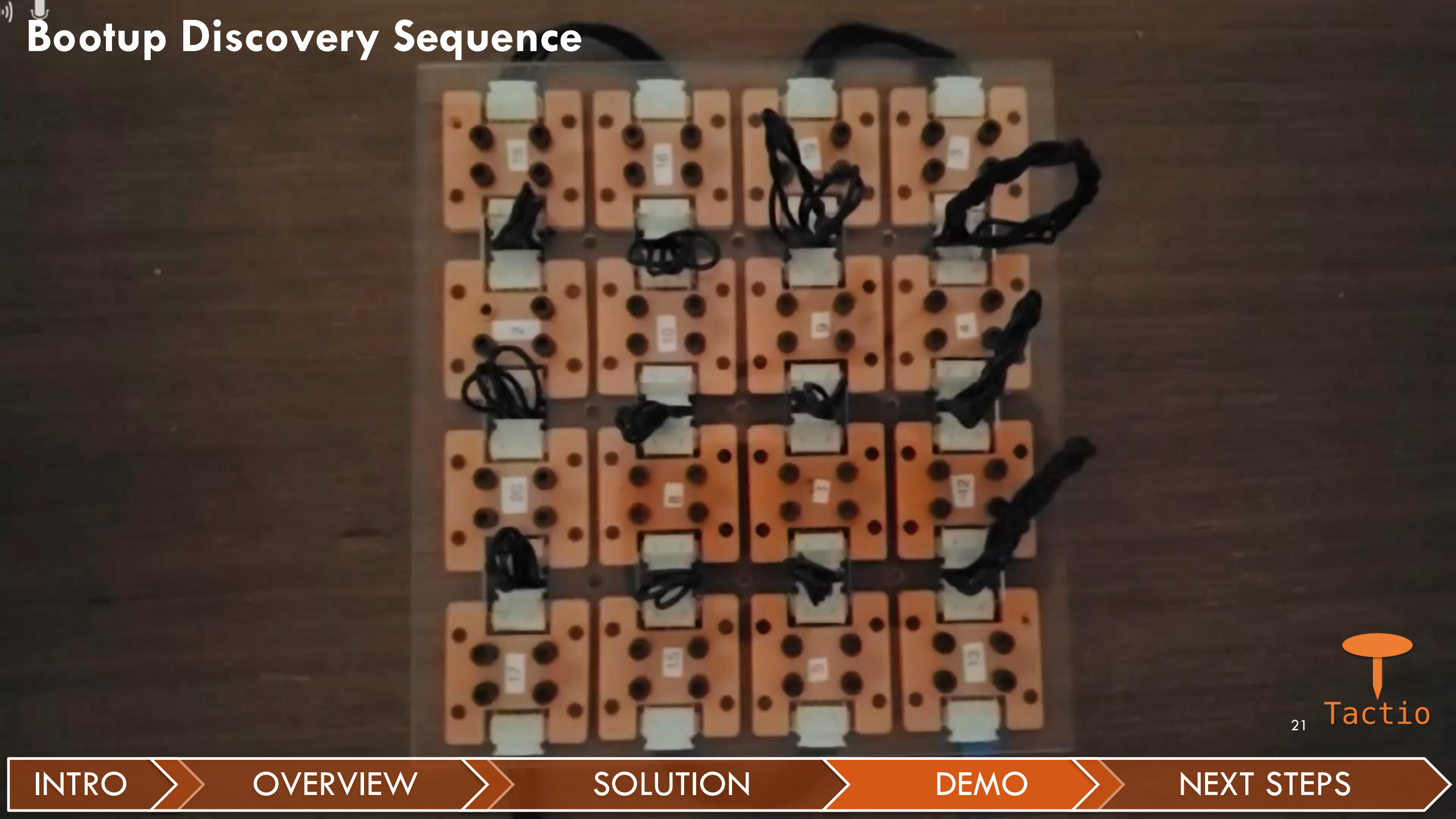
Bootup Discovery Sequence



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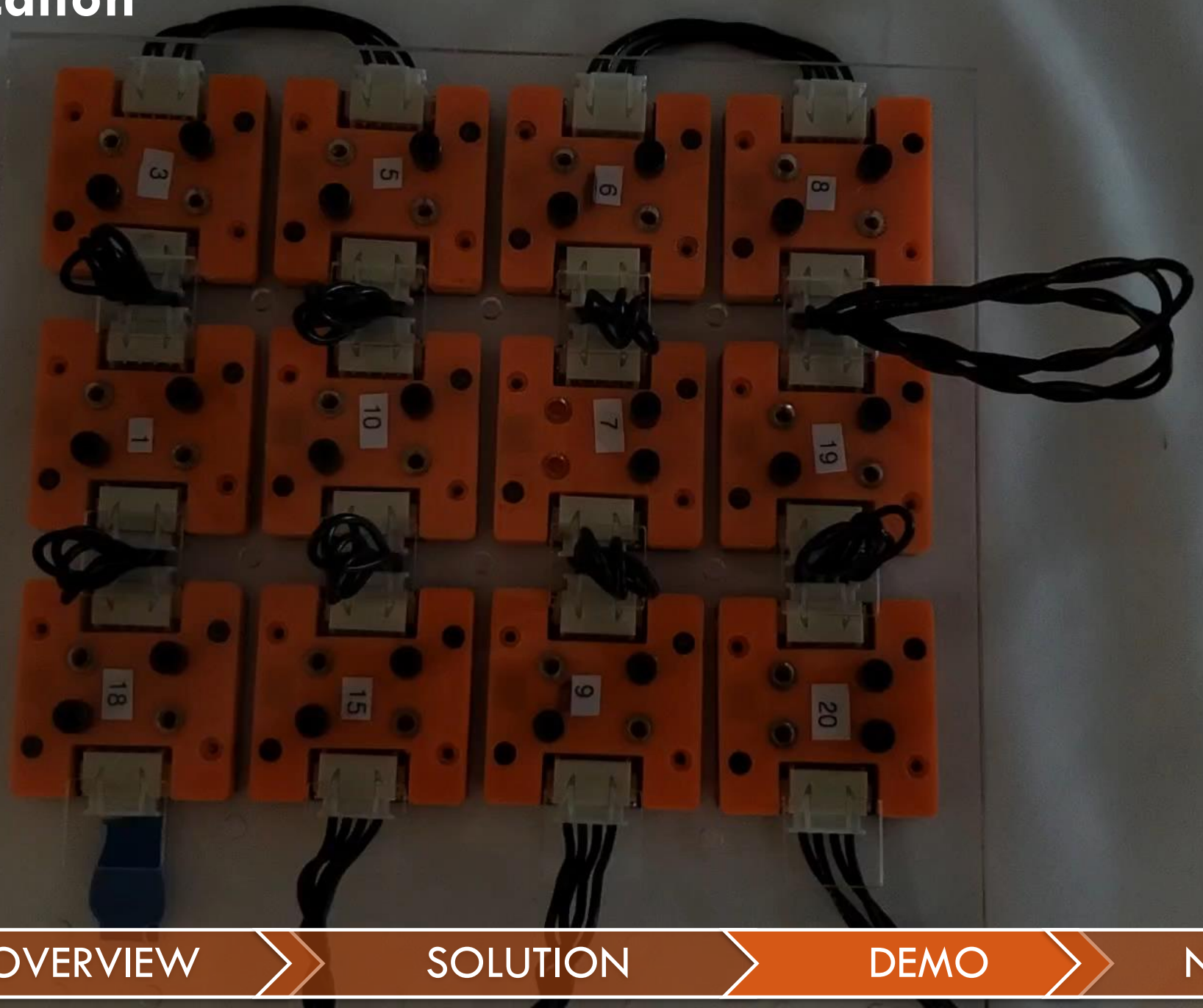
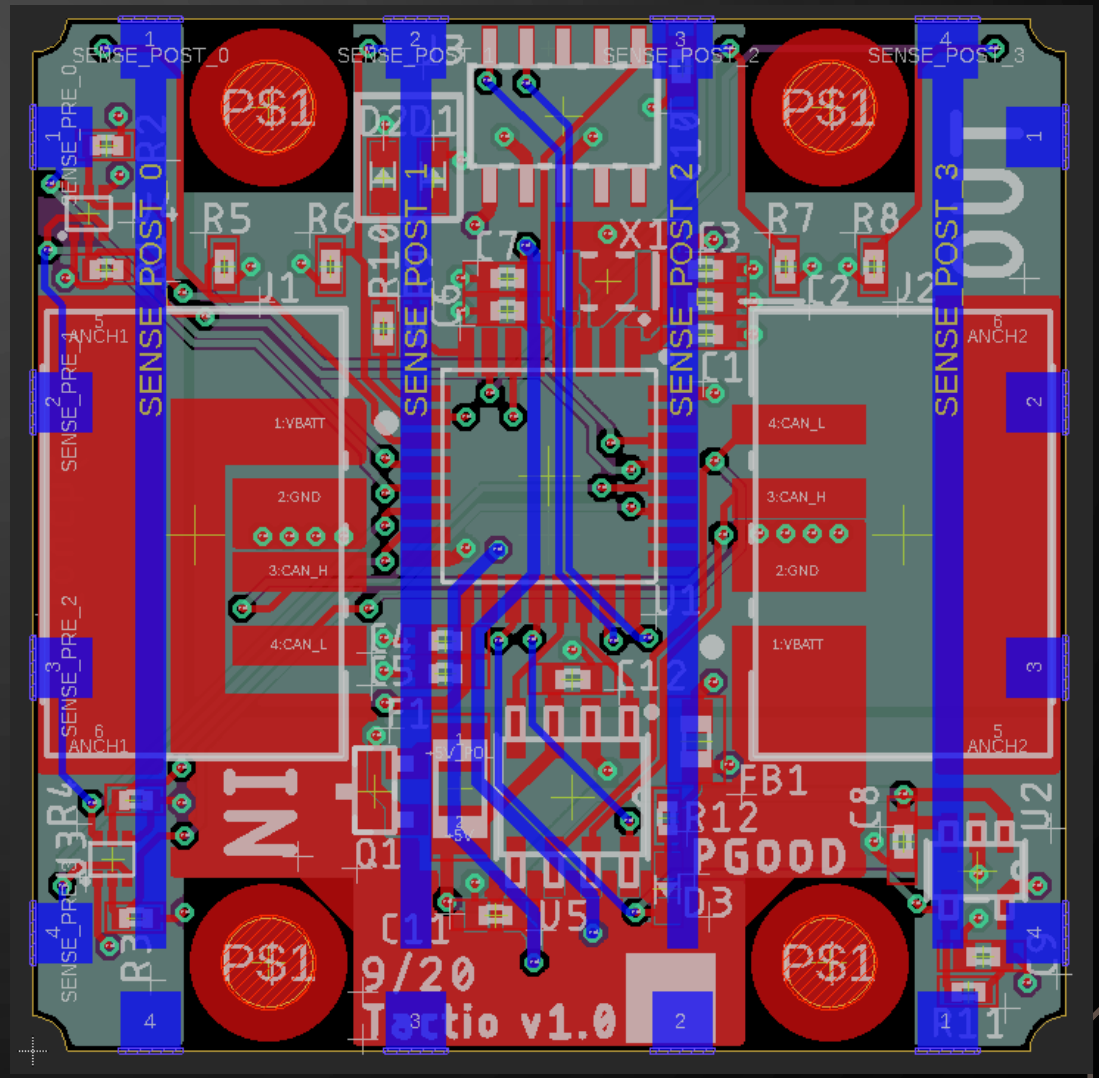
Self Identification



Next Steps - Electrical

- Fixing power LED issue
- Adding debugging UART line
- No more copper tape
  - Redesign with buried vias
- External clock
  - Hardware or firmware?



Next Steps - Mechanical

- Modify node design and assembly process to reduce manufacturing difficulty and cost
- Extensive testing to inform design improvements
  - Durability
  - Reliability
  - Environmental

Next Steps - Software

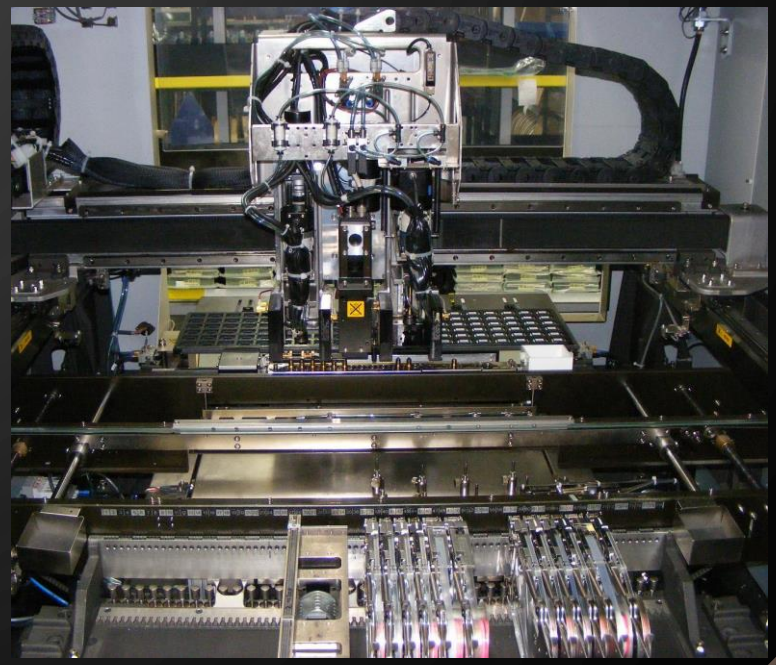
- Better support for multiple OS and screen resolutions
- End User Quality of Life improvements
- New Features:
  - ROS Integration
  - Theming

Next Steps - Firmware

- Incorporate models
- Some nodes intermittently discover slowly
- Measurement loop can be optimized
- Controller needs to be more reliable

Next Steps - Manufacturing

- For the project to be viable, improved yield rates and reduced sensor variance performance necessary
- Add discrete components with automated methods
  - Would require much larger order volume of sensors
- Redesign mounting of flexible PCB to rigid
  - Could fix…
    - Velostat heating issues
    - Reduce delamination
    - Improve alignment of grid
    - Remove need for adhesive



Next Steps - Team

- Possible avenues for the team / project
  - Paper publication
  - License hardware
  - Crowdfunded hardware
- Methods to those avenues
  - Work with Georgia Tech Research Lab
  - Startup Launch
  - Inventure Prize
  - Self-funded

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