TACTIO PROJECT PROPOSAL BY TEAM TOUCHÉ

AUSTIN KEENER

JOSEPH SPALL

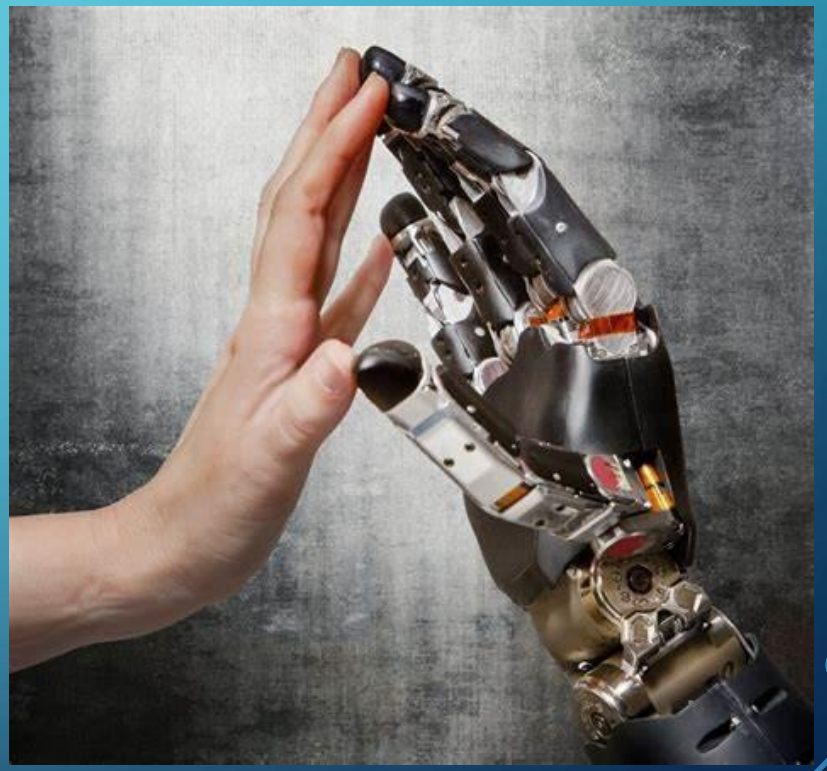
JOSHUA OLDENBURG

JUAN ELIZONDO-VILLASIS

VARUN MADABUSHI

INTRODUCTION

- Humans rely heavily on their tactile senses to understand the weight, shape, and texture of the objects they hold
- Robots require tactile sensors to measure contact forces with objects they interact with
  - Tactile sensing can enable robots to more effectively grasp and interact with objects in the real world

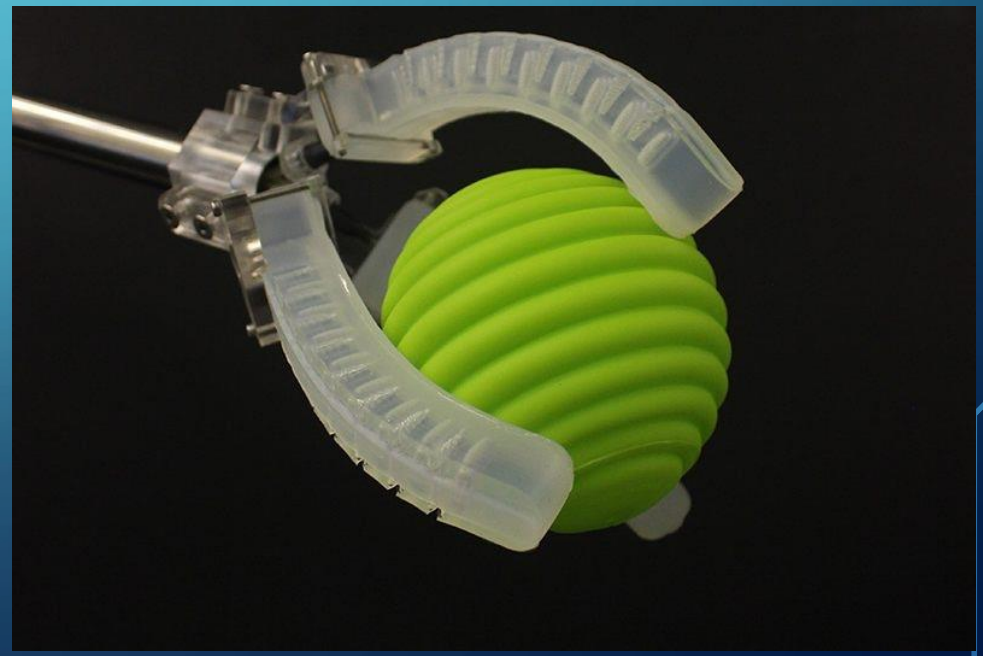


PROBLEMS WITH EXISTING SOLUTIONS

STAG	Optical Sensors (GelSight)	SparkfunX Finger Sensor
• Many Wires • Complex manufacturing method • Market availability	• High Cost • Small sensing area • Market availability	• Small sensing area • Cannot locate contact force

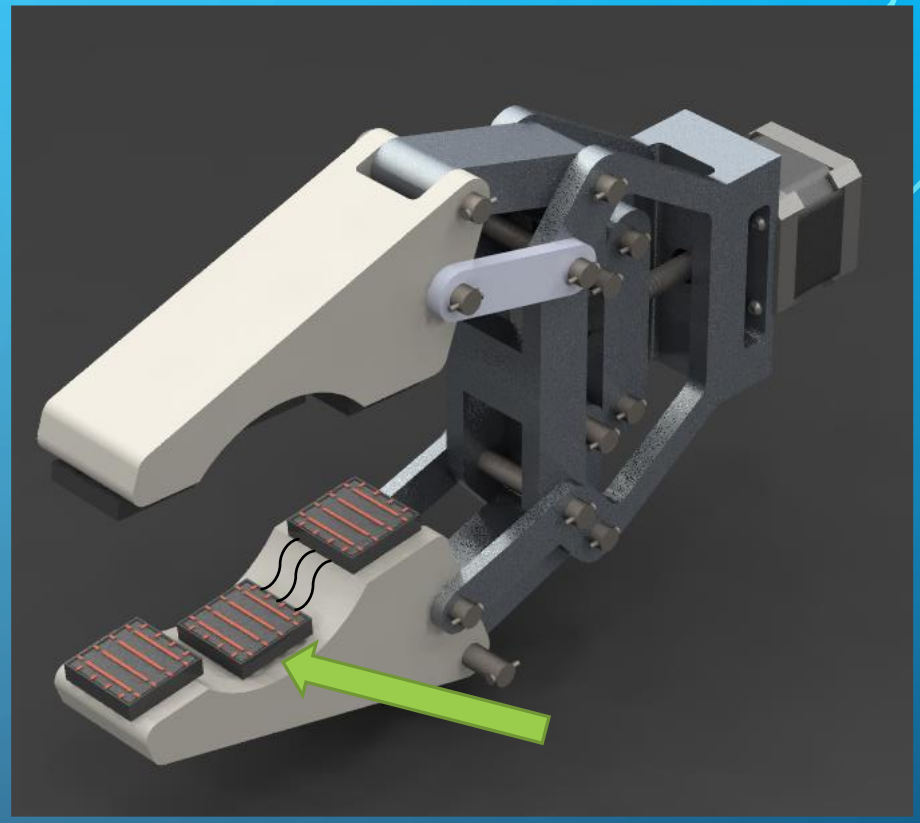
TARGET AUDIENCE

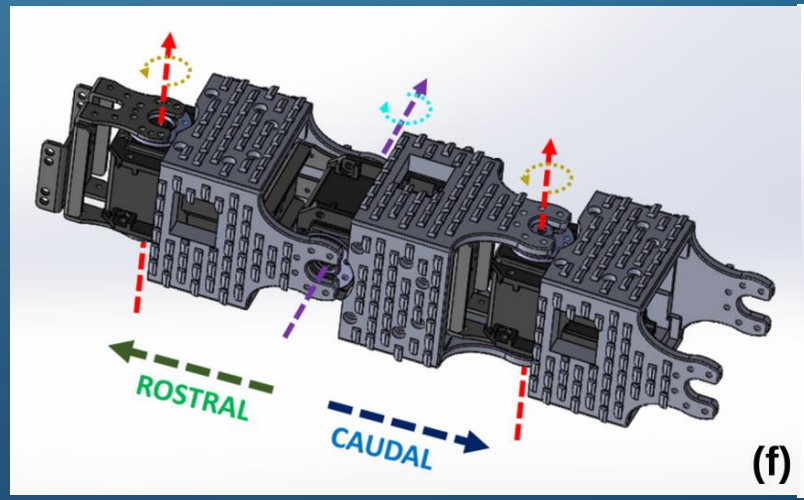
- Our goal is to develop a platform for rapid development and prototyping of tactile sensing solutions
- Three target communities can benefit
  - Researchers
  - Students
  - Hobbyists

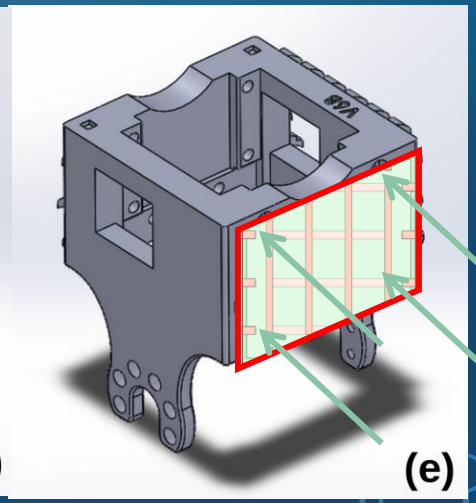


DESIGN GOALS

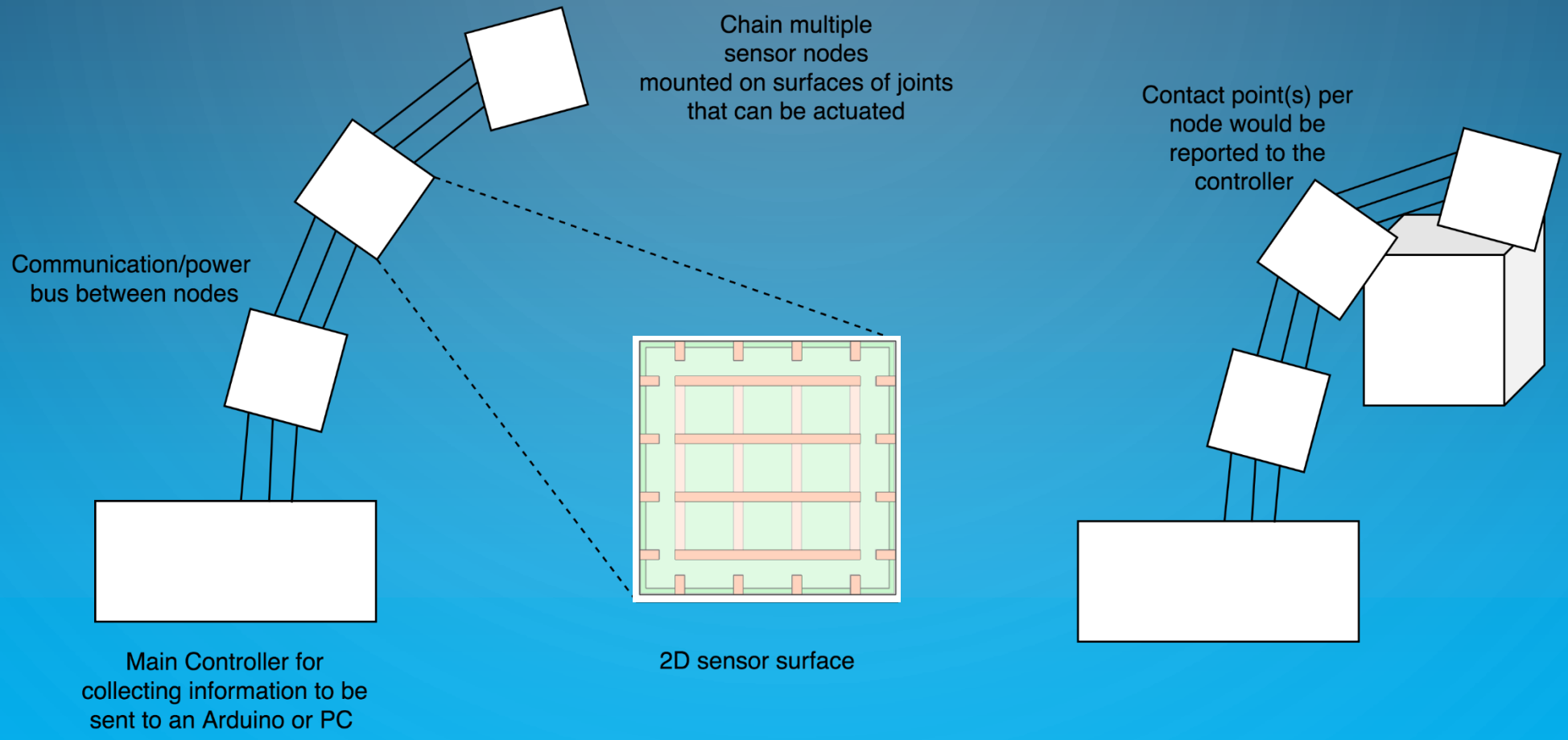
- Chainable modular sensor units
  - Simplifies design and wiring for users
- Flexible mounting configurations
  - Can be easily retrofitted onto existing robots
- Easy third-party integration
  - Compatible with popular ecosystems for electronics prototyping





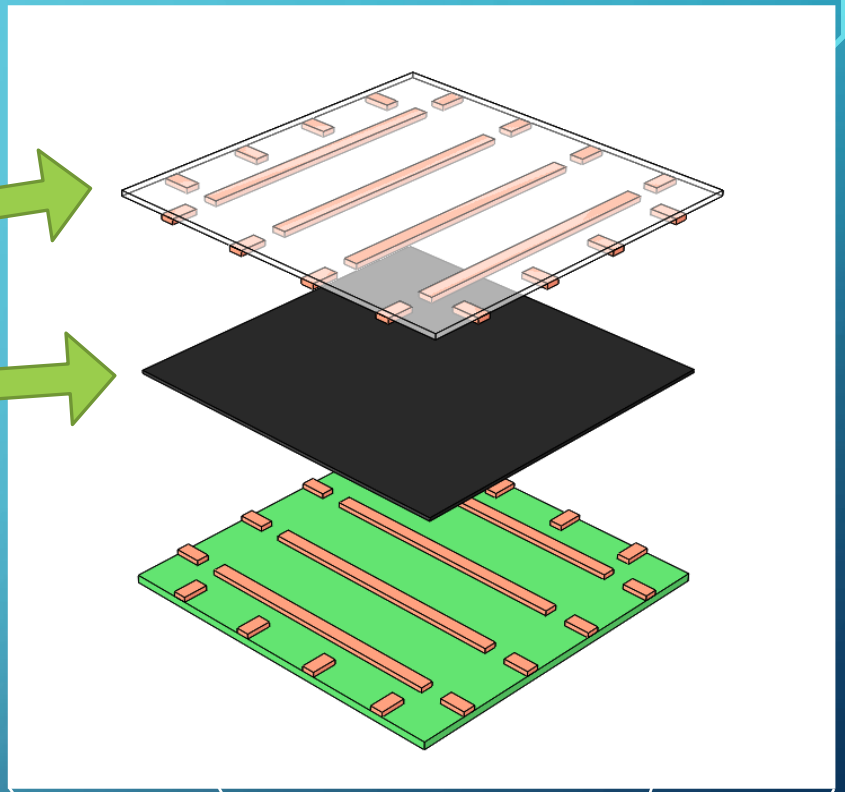


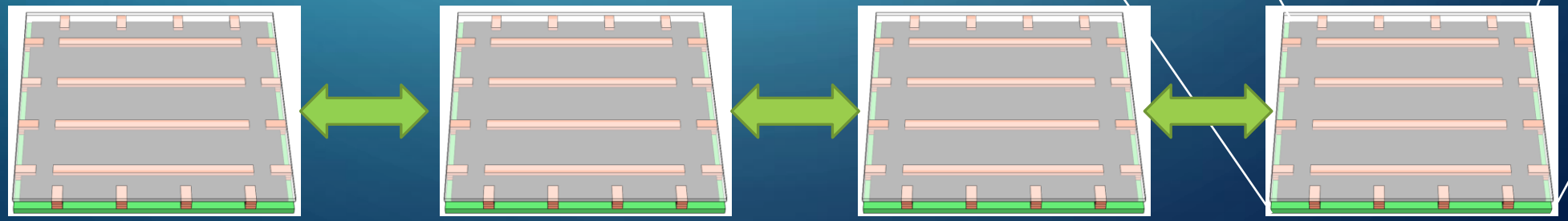
DESIGN CONCEPT



SENSING SOLUTION

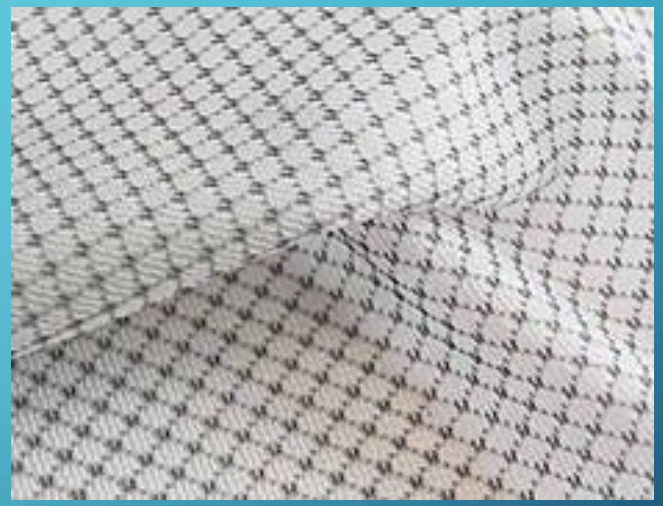
- Flex PCB allows film to deform
- Piezoresistive film (Velostat) changes resistance with strain
- Row-column pattern allows reading in 16 different points



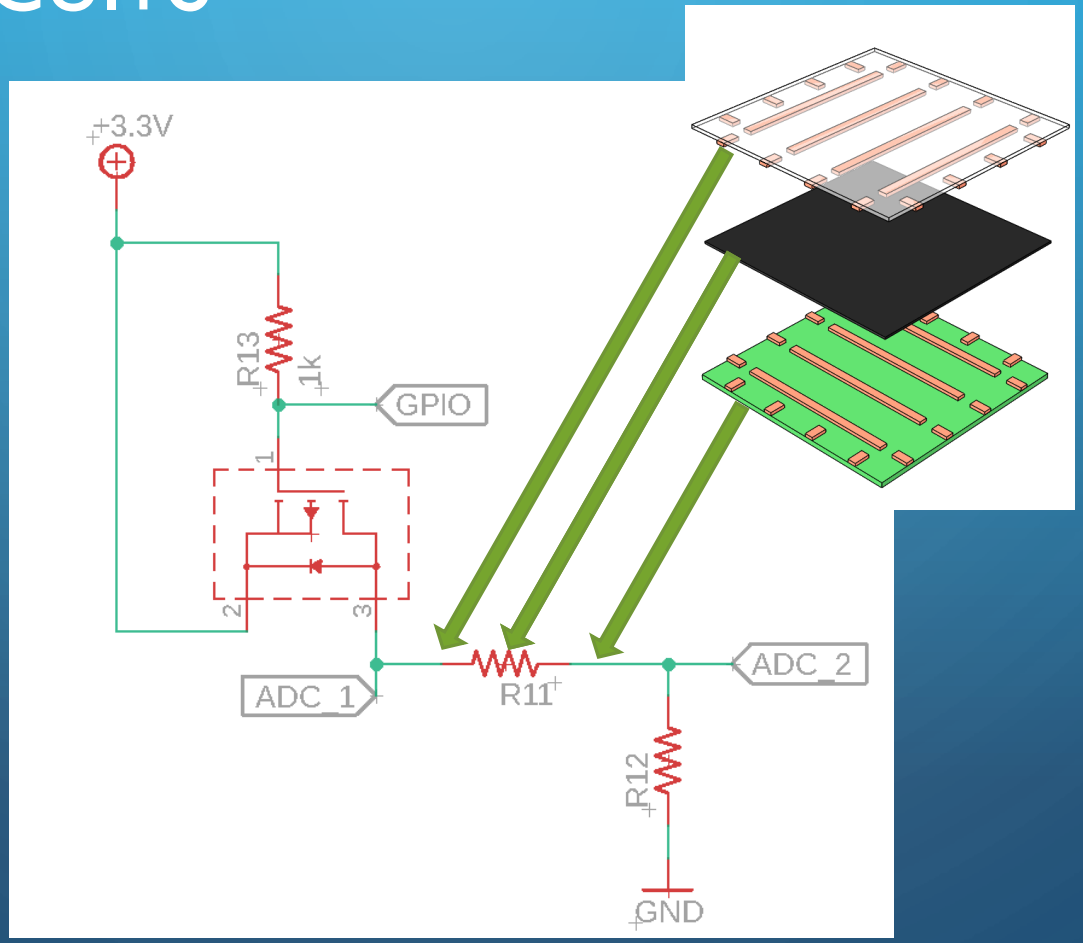


DESIGN ALTERNATIVES - MATERIALS

- EX-STATIC
  - ✚ Thin, inexpensive, and flexible conductive fabric
  - ✚ Good force localization
  - ✖ Poor magnitude response due to high conductivity
  - ✖ Not compatible with stacked design due to very low resistance with no added strain
  - ✖ Easy to short between fabric fibers



RIGID PCB CIRCUITS



MOSFET switches each column on to create this circuit with each row

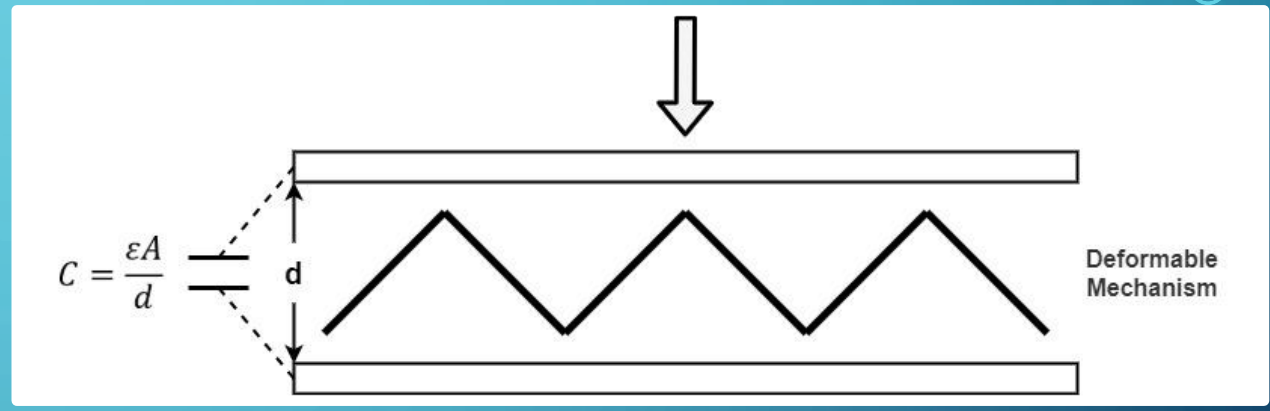
Velostat film

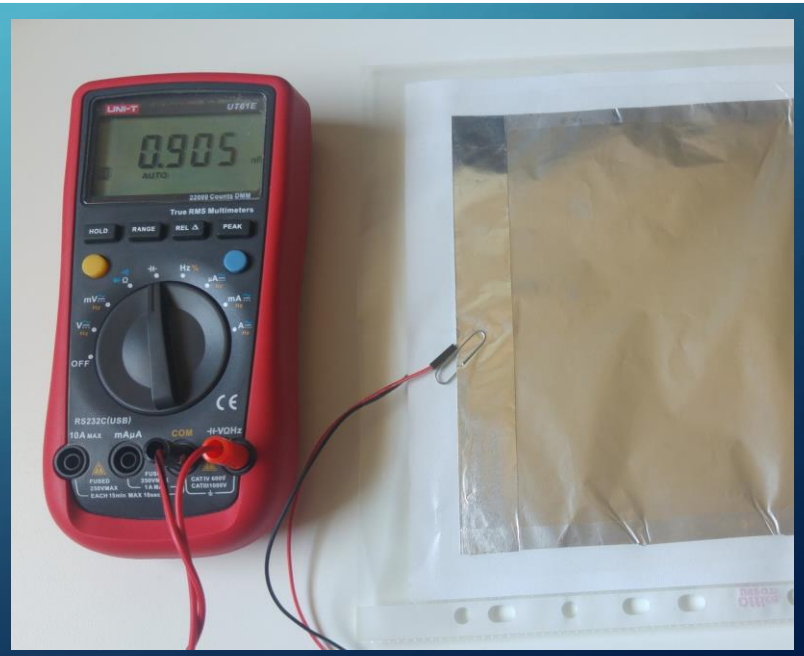
=

R11

DESIGN ALTERNATIVES - SENSING

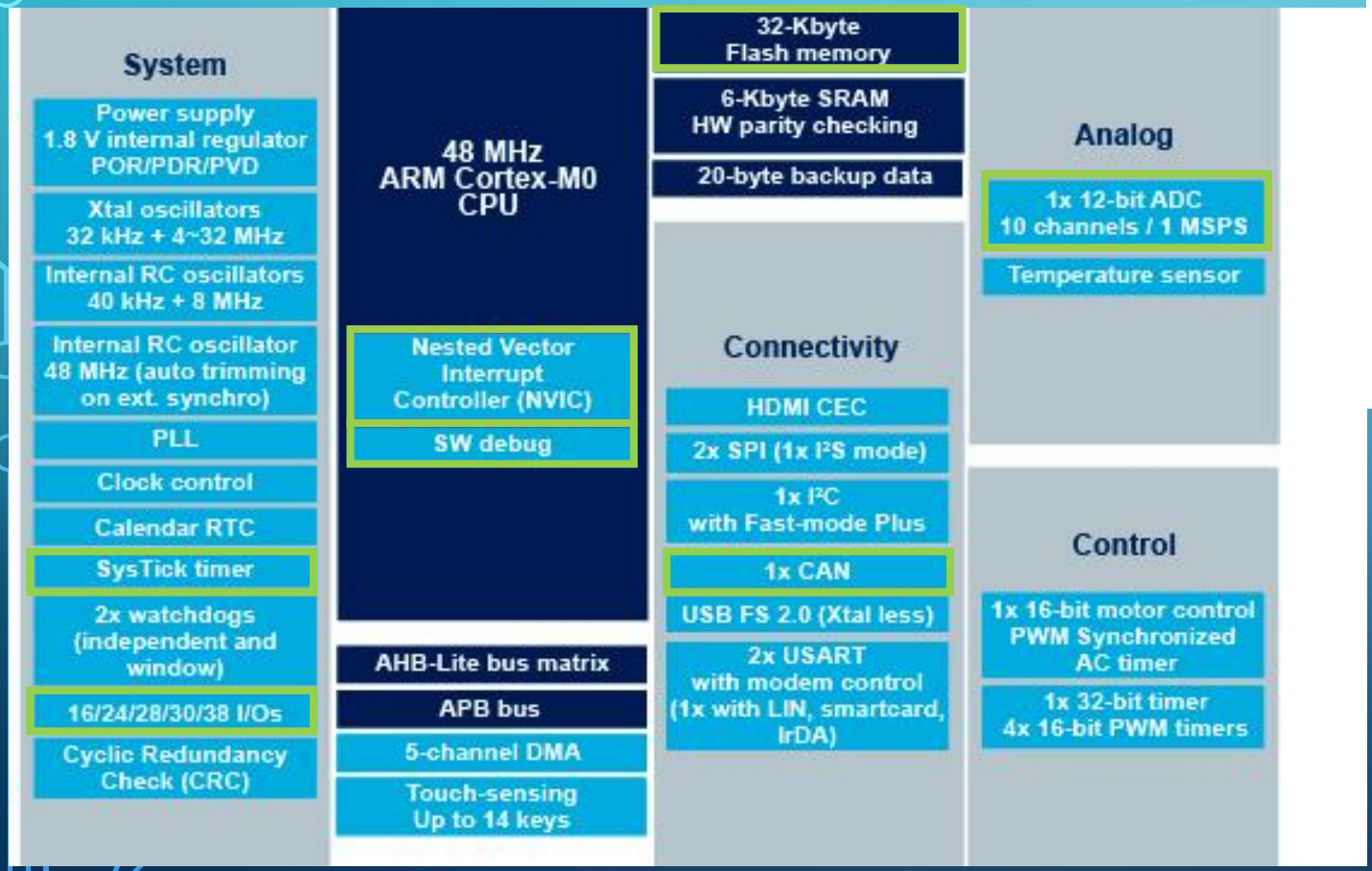
- Capacitive- Based on separation distance of two conductive elements
  - ✚ Good noise immunity
  - ✖ Relatively expensive
  - ✖ Only works with certain materials

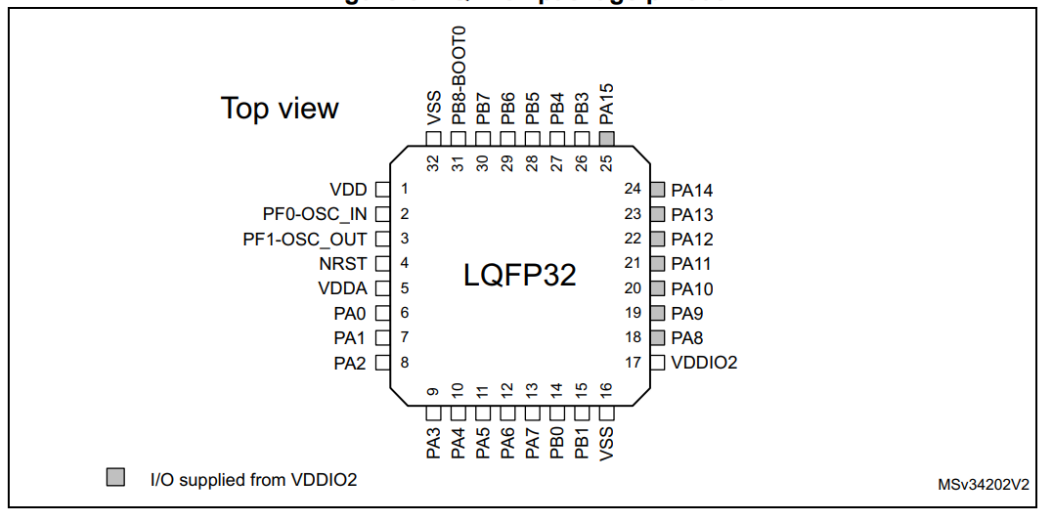




MICROCONTROLLER SELECTION

STM32F042 Features

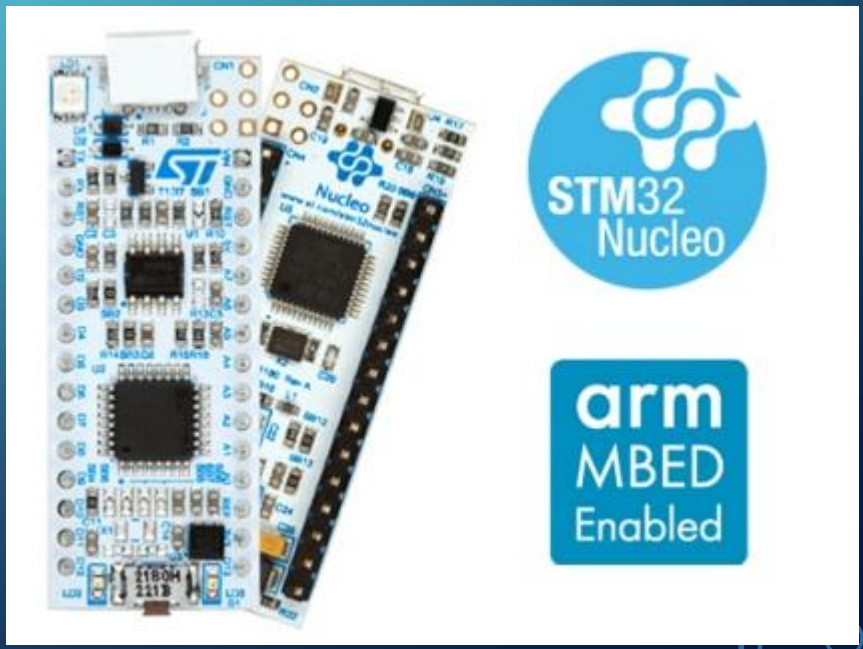




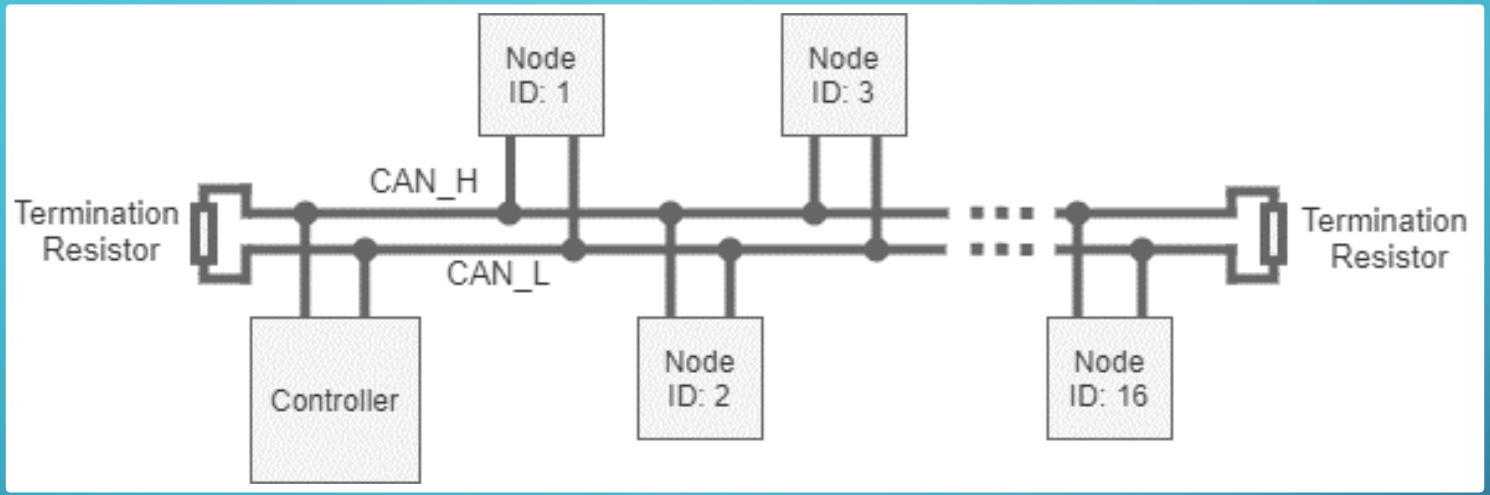
STM32F042 selected based on required peripherals (CAN and ADC), memory, cost, and pin count

FIRMWARE SOLUTION

- Microcontroller running C++ code for measurement and communication
- Planning to use Mbed OS 2, with STM32Cube as a fallback



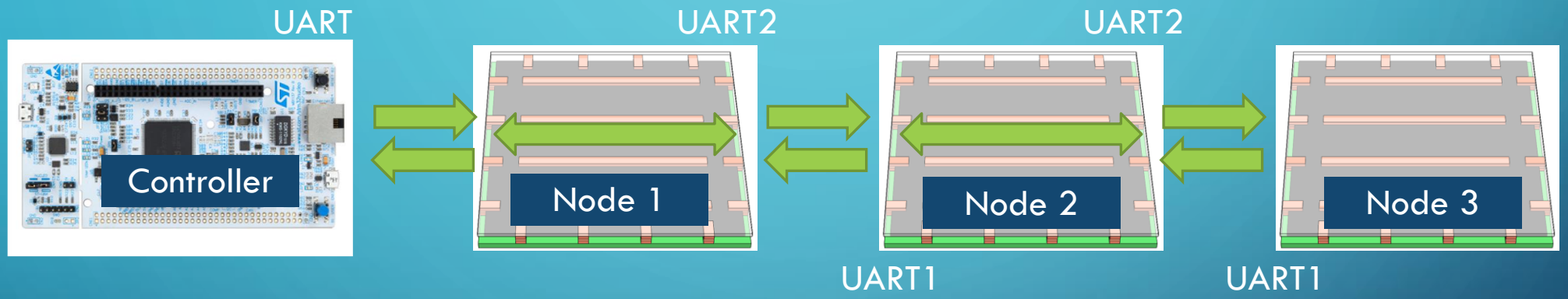
COMMUNICATIONS



- Utilizes CAN 2.0, a multi-master 2-wire serial bus
- Up to 255 individually addressed nodes with automatic or user-controlled addressing
- Network controller manages network and polls sensors

DESIGN ALTERNATIVES - COMMUNICATIONS

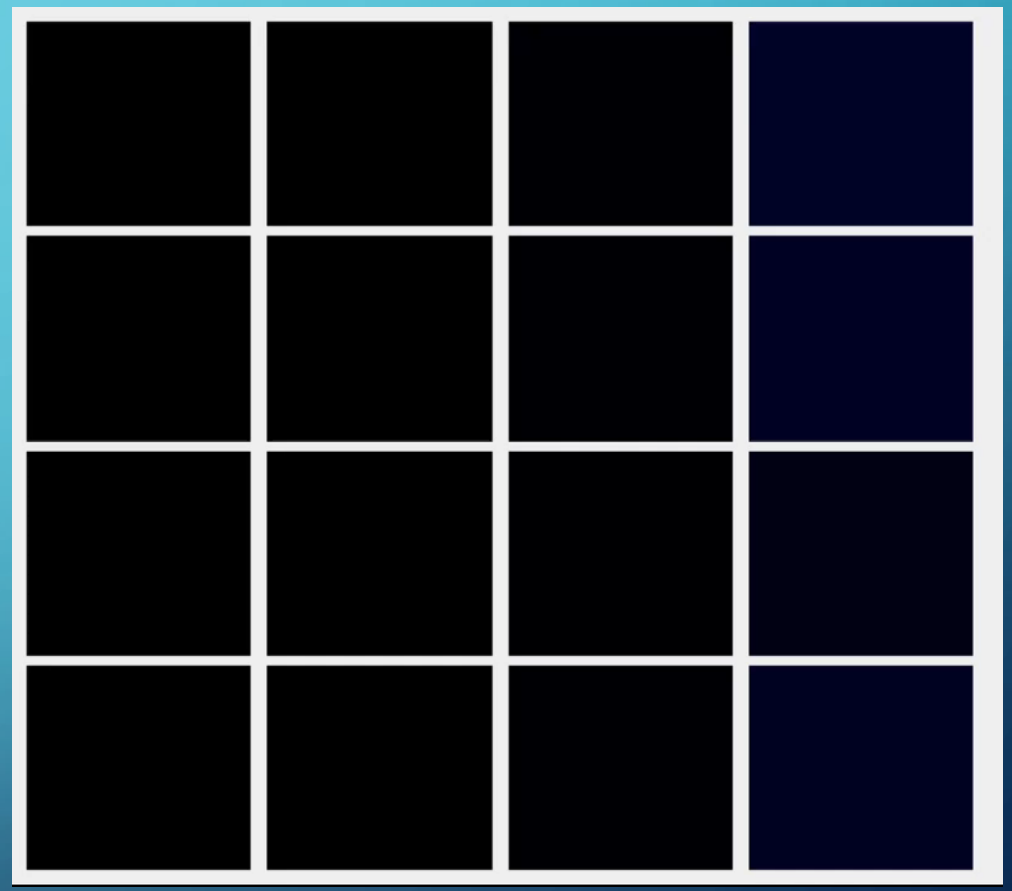
Daisy-Chained UART



Advantages	Concerns
Automatic position-based node addressing	Requires custom peripheral implementation in firmware
No transceiver required	Requires timing coordination

SOFTWARE SOLUTION

- We will provide code to run on an Mbed development board to act as a CAN to USB bridge
- Desktop library to interact with and visualize the sensor

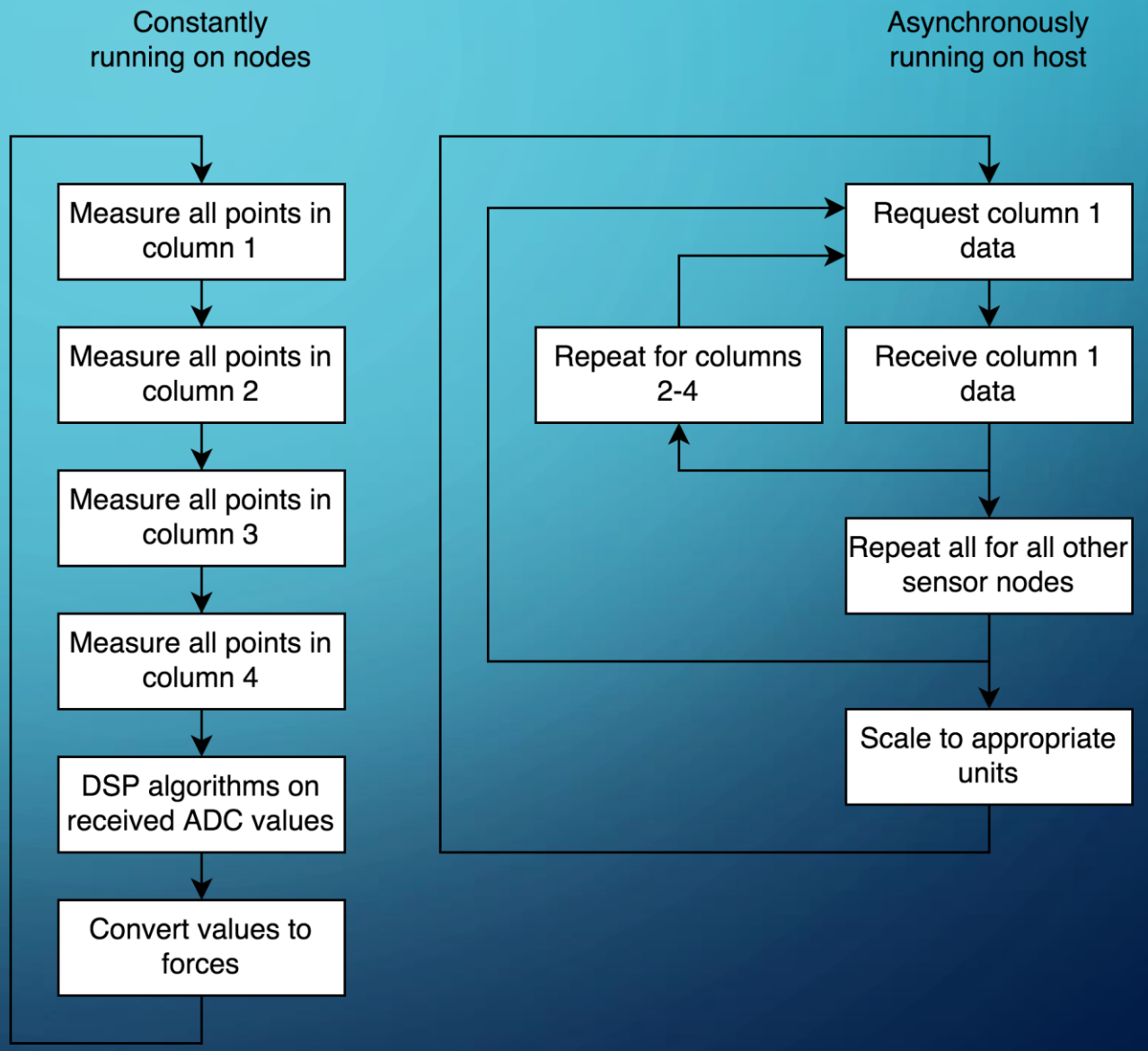


ANALYSIS FLOW

Due to packet size, single sensor readings are split into multiple frames

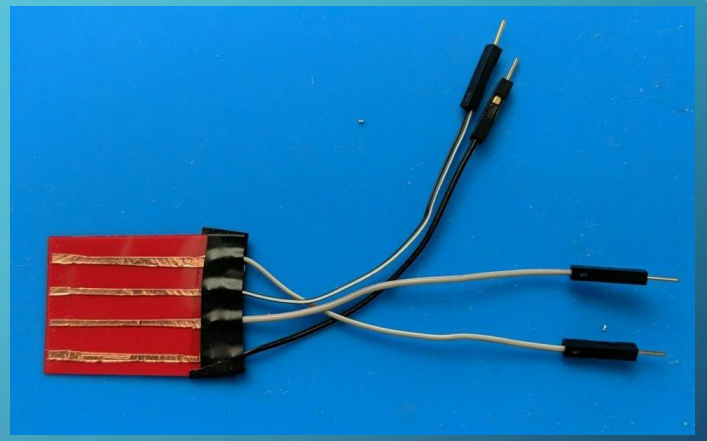
Polling

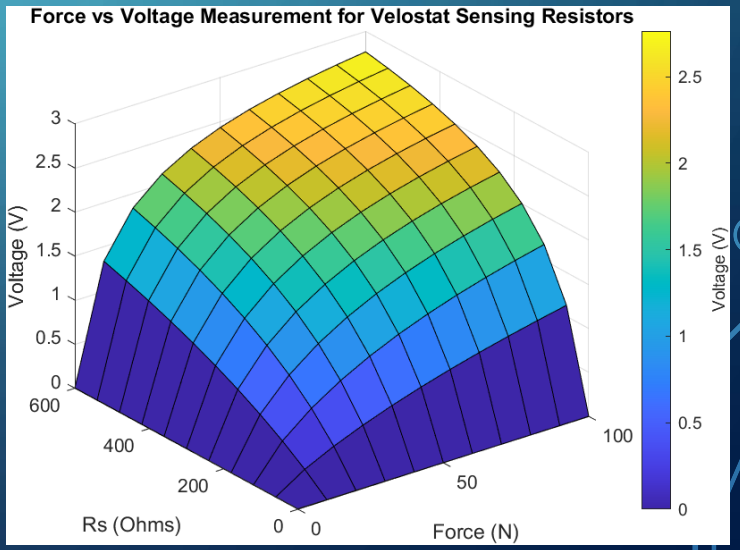
- Allow sensors to stabilize
- Lower RAM requirements of host for reconstruction



CURRENT STATUS - ELECTRICAL / MATERIALS

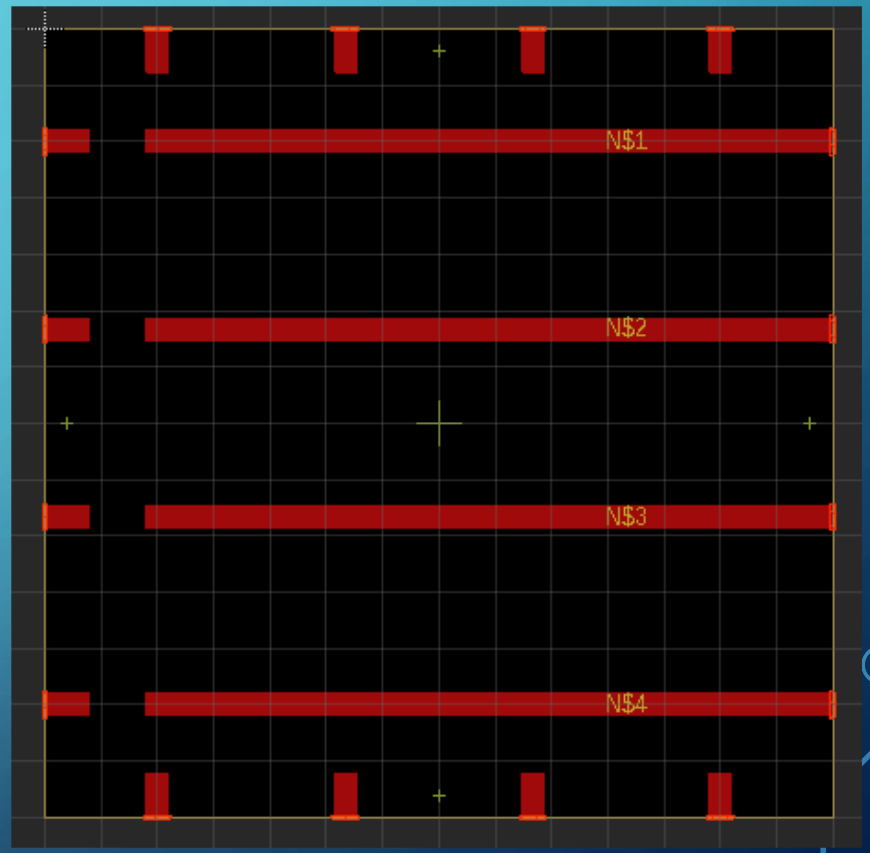
- Prototyped sensor
  - 2x flexible plastic sheet with 4 copper tape rows
  - Velostat in the middle
  - Stack taped together at 90 deg angle
  - Modeling of Velostat for ADC range





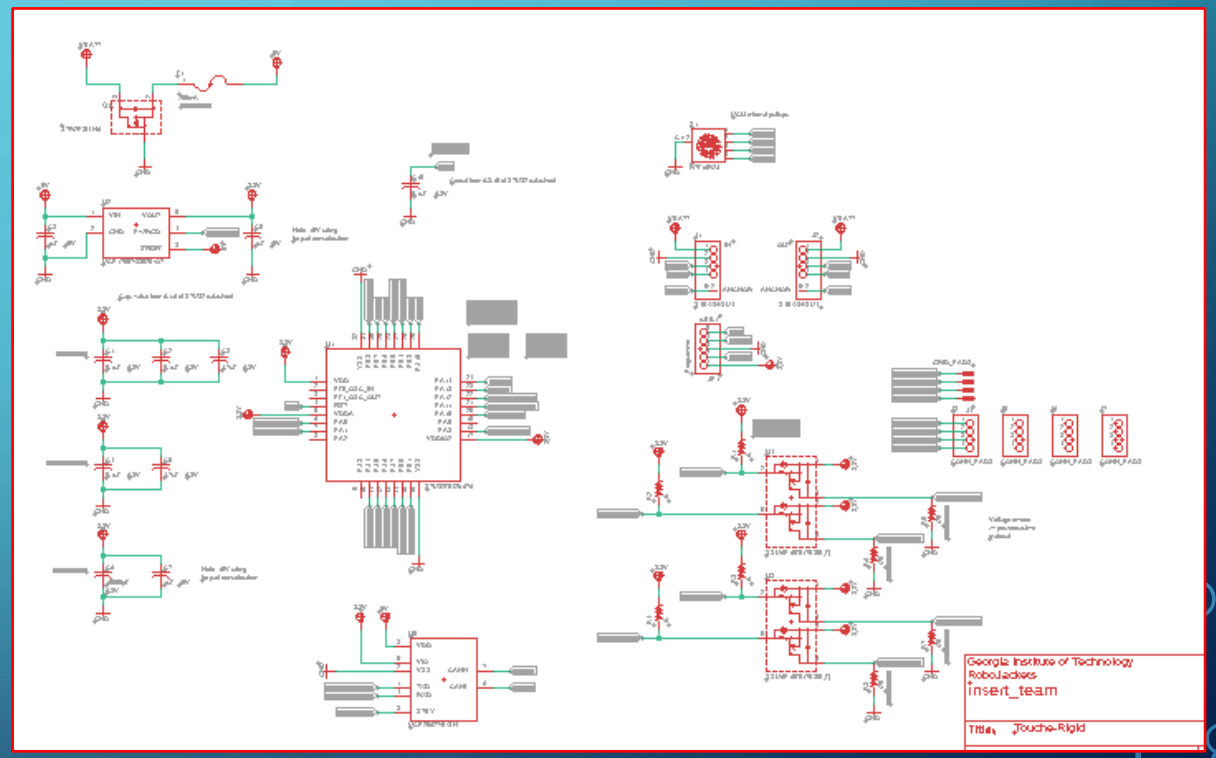
CURRENT STATUS - ELECTRICAL

- Flex PCB
  - Designed in Autodesk EAGLE
  - Perimeter tabs for soldered mounting
  - Rows for connection to rigid PCB
  - Will be ordered when rigid is finished



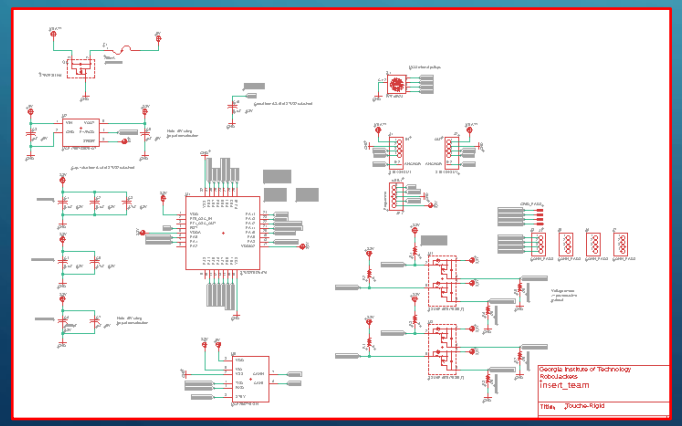
CURRENT STATUS - ELECTRICAL

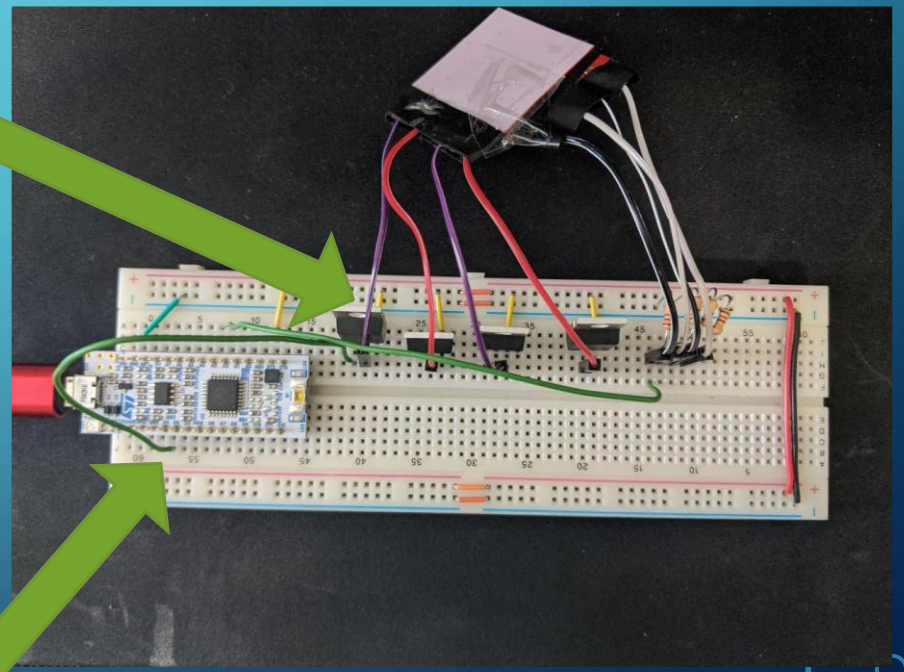
- Rigid PCB
  - Designed in Autodesk EAGLE
  - Schematic nearing completion
  - Major components
    - STM32F0 MCU
    - Communication
    - Power
    - Safety
    - Driving Circuits



CURRENT STATUS - ELECTRICAL / FIRMWARE

- Bread-boarded circuit mimicking rigid PCB + flex PCB design
  - Wrote firmware to test...
    - Reading Velostat with ADCs
    - Driving rows with PFETs
    - Printing to screen

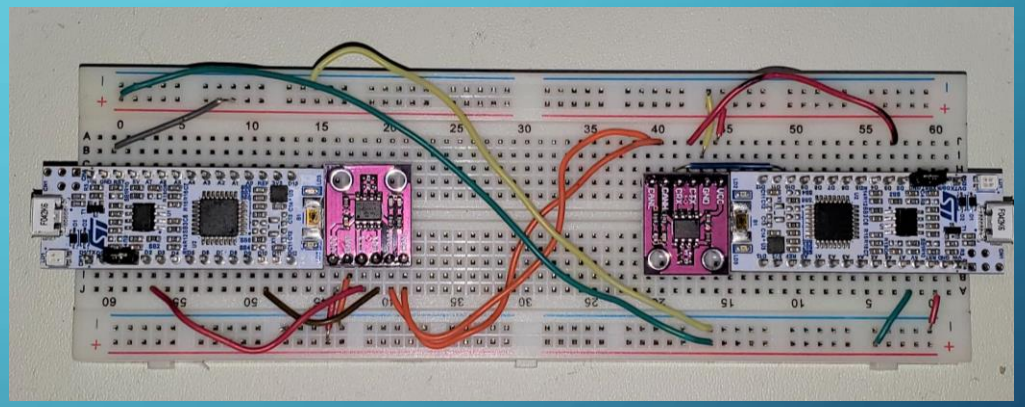




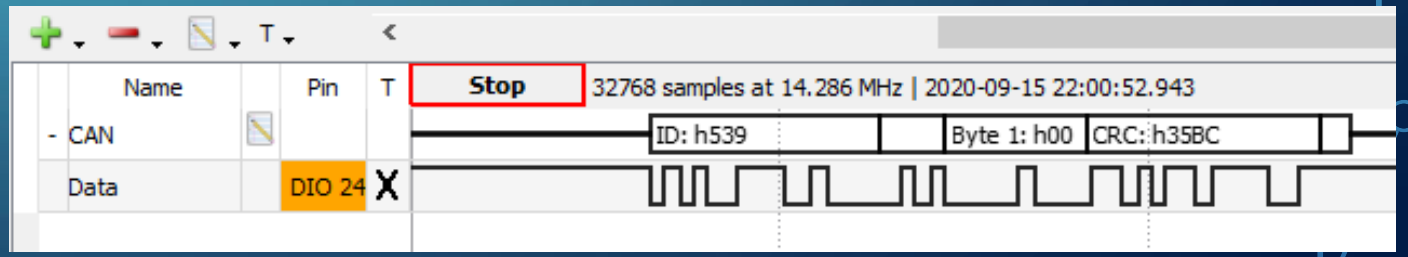
CURRENT STATUS - COMMUNICATIONS

CAN bus testing with breadboard prototype using

MCP2562 transceiver



Logic analyzer capture of CAN packet



Workspace Settings Window Help

Welcome Help Logic 1 Protocol Supplies

File Control View Window

UART SPI I2C CAN AVR

Settings

TX: None RX: DIO 24 Polarity: Low

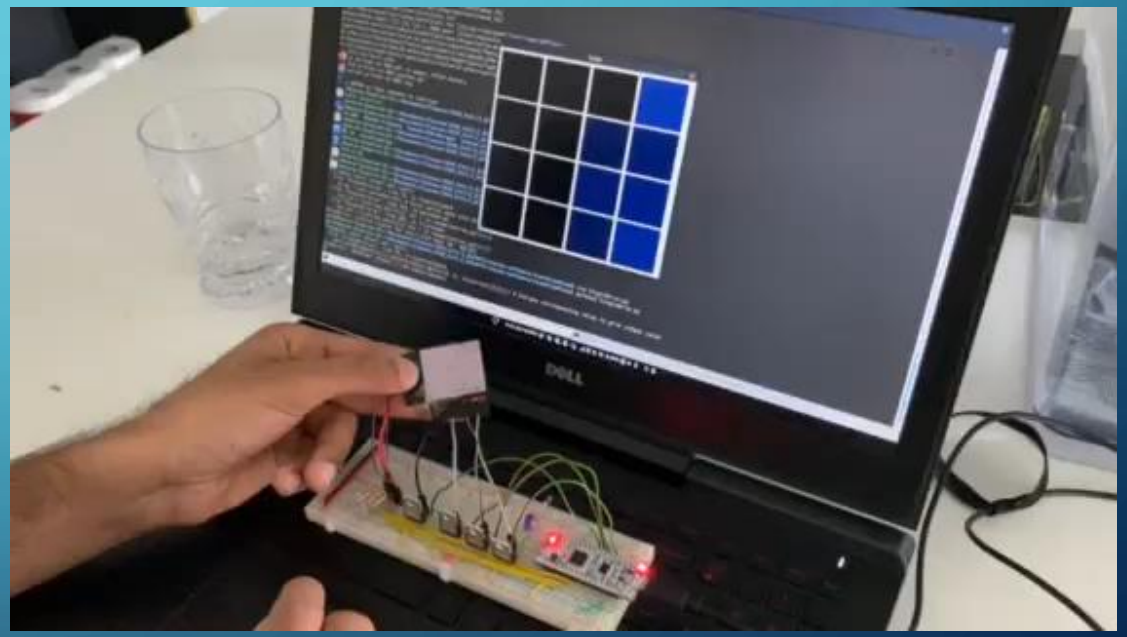
RX

Stop Filter by ID

```
ID: 0000075 Extended DLC: 01 Data: 01 CRC: 317E NAK
ID: 0000075 Extended DLC: 01 Data: 02 CRC: 3A4C NAK
ID: 0000075 Extended DLC: 01 Data: 03 CRC: 7FD5 NAK
ID: 0000075 Extended DLC: 01 Data: 04 CRC: 2C28 NAK
ID: 0000075 Extended DLC: 01 Data: 05 CRC: 69B1 NAK
ID: 0000075 Extended DLC: 01 Data: 06 CRC: 6283 NAK
ID: 0000075 Extended DLC: 01 Data: 07 CRC: 271A NAK
ID: 0000075 Extended DLC: 01 Data: 08 CRC: 00E0 NAK
```

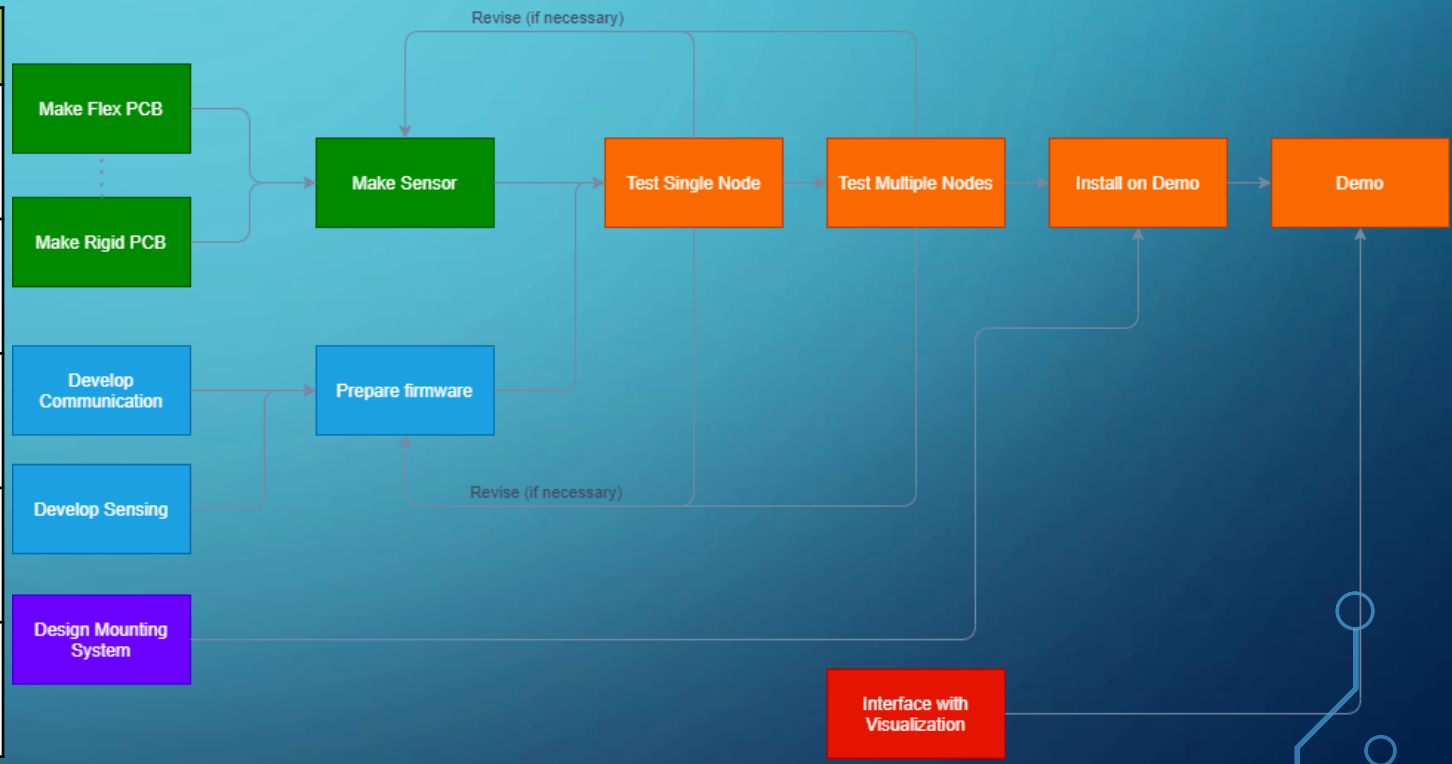
CURRENT STATUS – SOFTWARE

- Visualization using PyQT
- Parses messages from network controller
- Shows sensor force location and relative magnitude



POSSIBLE PROBLEMS / ISSUES

Issues	Severity
Flex PCB manufacturing	!!!
General PCB turnaround	!!!
Modeling Velostat force-resistance	!!
Tight time-line	!!
Mbed OS compatibility issue	!



QUESTIONS?