# Comprehensive Design Review

TrueBase
SDP 2021
Team 30

TrueBase

University of Massachusetts Amherst BE REVOLUTIONARY™

# Agenda

- Problem Statement
- System Specifications
- Documentation of the Current Prototype
- Integrated System
- Custom PCB
- FPR Plan
- Project Management Plan

# Problem Statement


- Growing number of close-call plays - nearly impossible to officiate by the naked eye
- Replay and review systems waste a lot of time - human error should not be a part of the game
- What if the need for replay and review was eliminated?
- Even better, what if every close call that was made at first base was almost certainly correct?

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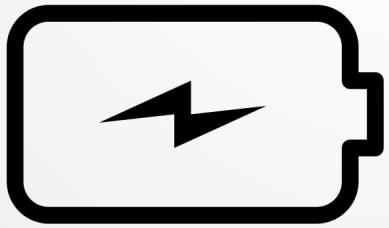
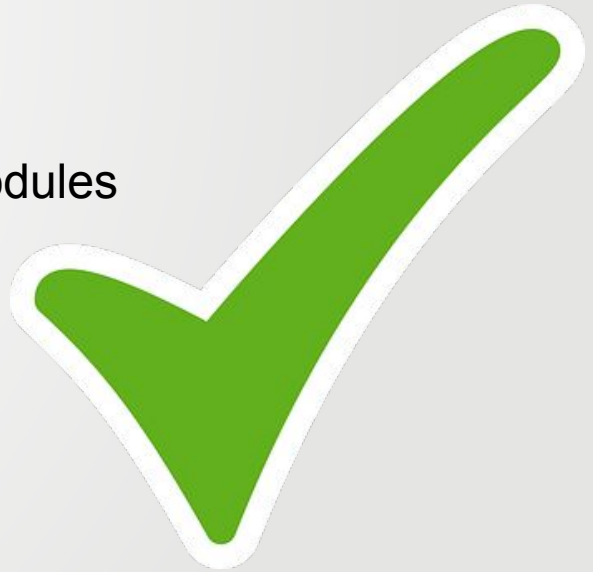
# Updated System Specifications

- **35ms accuracy,** 90% of the time - enough for “bang-bang” plays
- 5+ hour battery life - enough for extra-inning baseball games
- <150g wrist module weight - as much as the average wristwatch
- System will not interfere with gameplay
- Meaningful and easily interpretable output



# Proposed CDR Deliverables

- Fully functioning wrist module that detects the catch of a ball
- Fully functioning base module that detects a runner's foot stepping on the base
- Have the hardware for each development module on breadboards
- On the CC3220SF LauchpadXL:
  - Constantly monitoring for sensor inputs
  - Sends data from over the last x seconds
- On the laptop:
  - Responsible for the time synchronization, sending beacons to the two modules
  - Receives the data from the two modules and plots
- Blank PCB in hand



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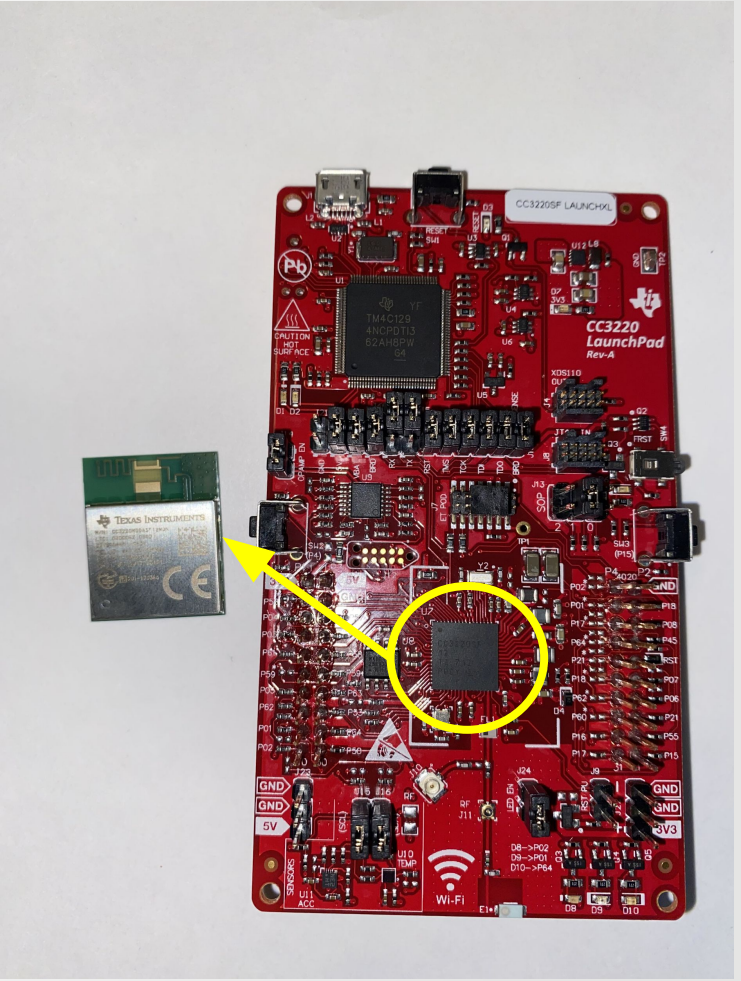
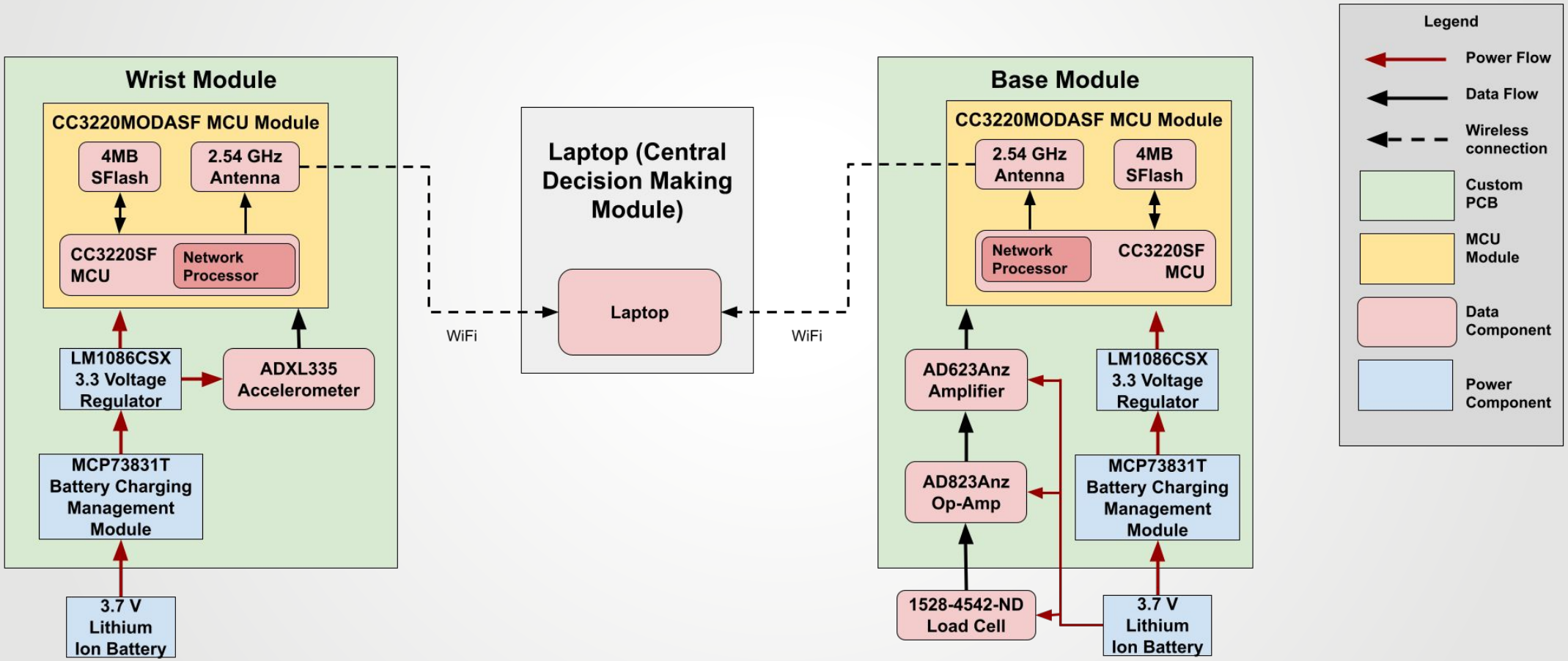
# Hardware List

| Base Module | Wrist Module |
| --- | --- |
| • 1528-4542-ND 20kg load cells<br>• AD623Anz instrumentation amplifiers<br>• AD823Anz op-amps | • ADXL335 Accelerometer |
| • CC3220MODASF MCU<br>• MCP7831T 3.7V lithium-ion battery charging IC<br>• LM1086CSX 3.3 V voltage regulator | |

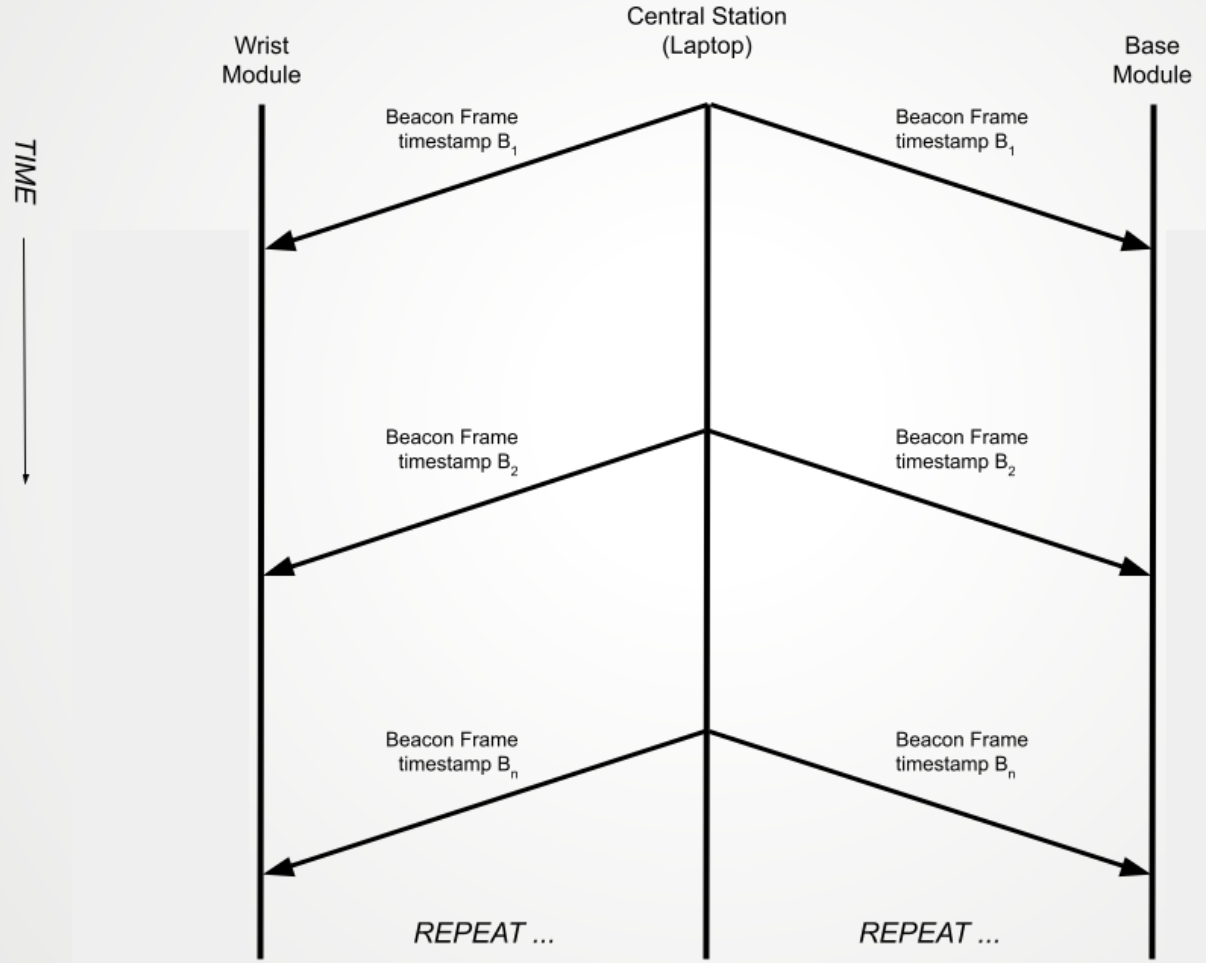


# Current Prototype - Block Diagram

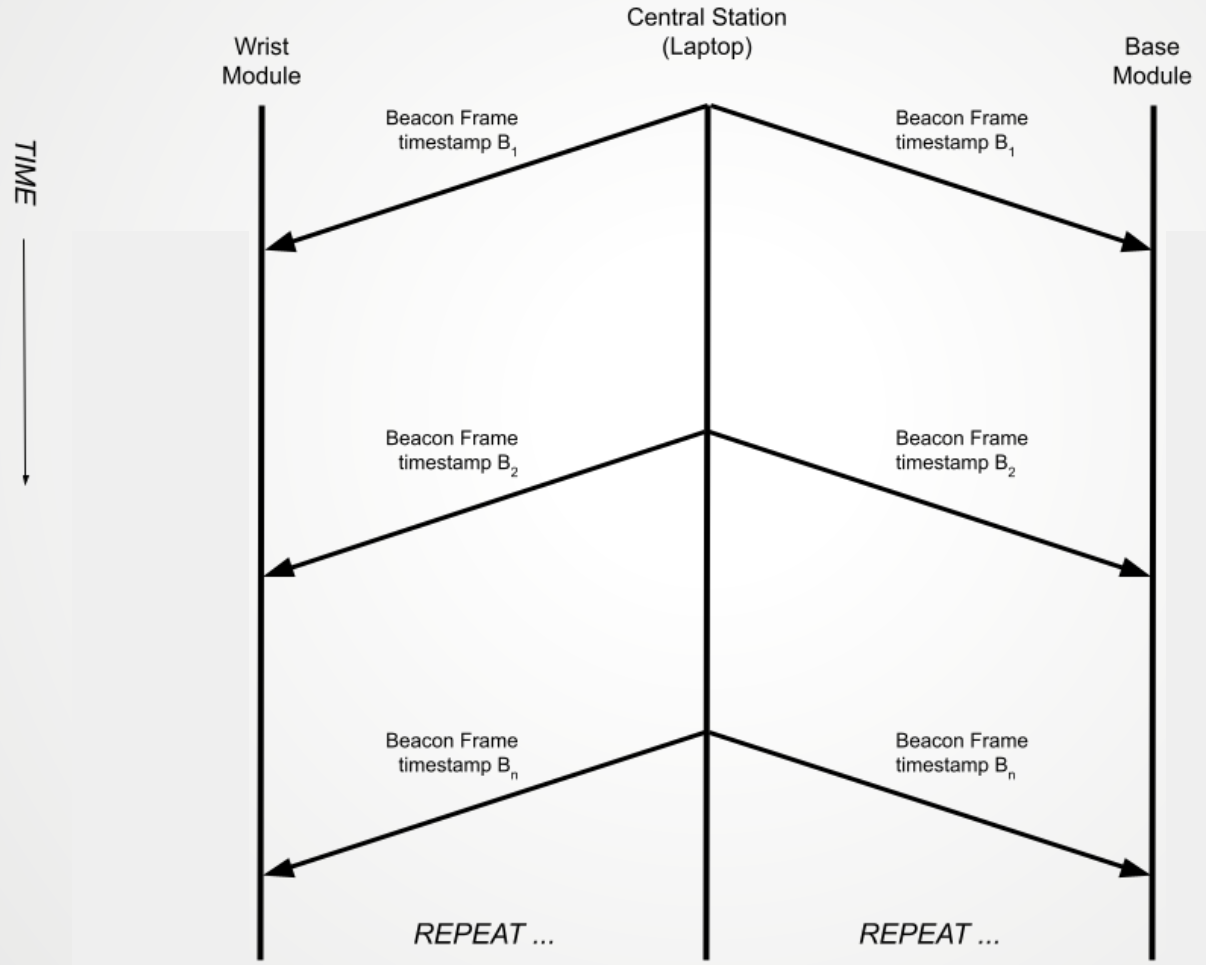


# Hardware on Breadboards

# Time Beaconing Diagram from MDR



# Time Beaconing Diagram from MDR



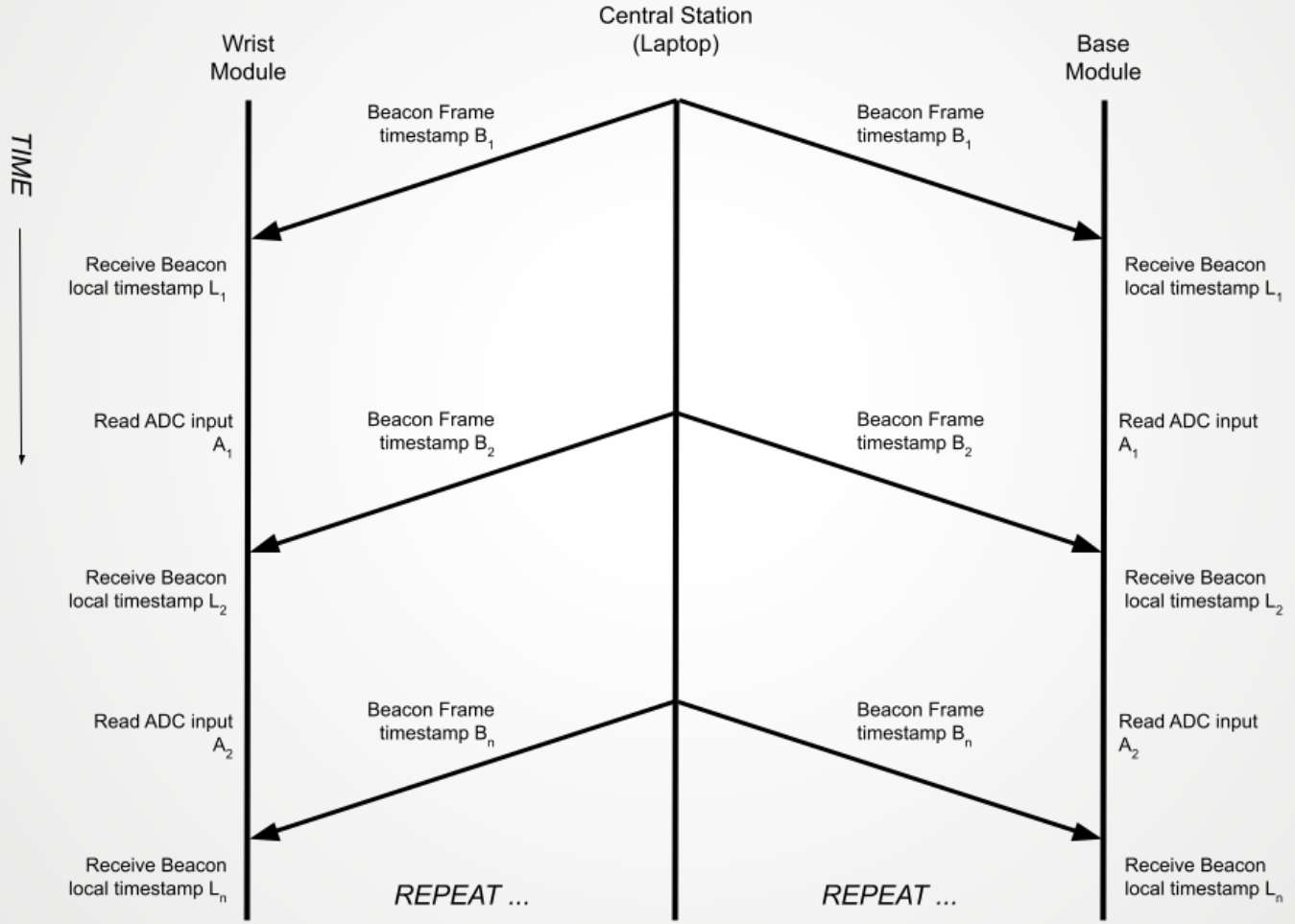
# Updated Time Beaconing Diagram

**Wrist module:**

Beacon_ts = $[B_1, B_2, \ldots B_n]$
Local_ts = $[L_1, L_2, \ldots L_n]$
ADC = $[A_1, A_2, \ldots A_n]$

**Base module:**

Beacon_ts = $[B_1, B_2, \ldots B_n]$
Local_ts = $[L_1, L_2, \ldots L_n]$
ADC = $[A_1, A_2, \ldots A_n]$

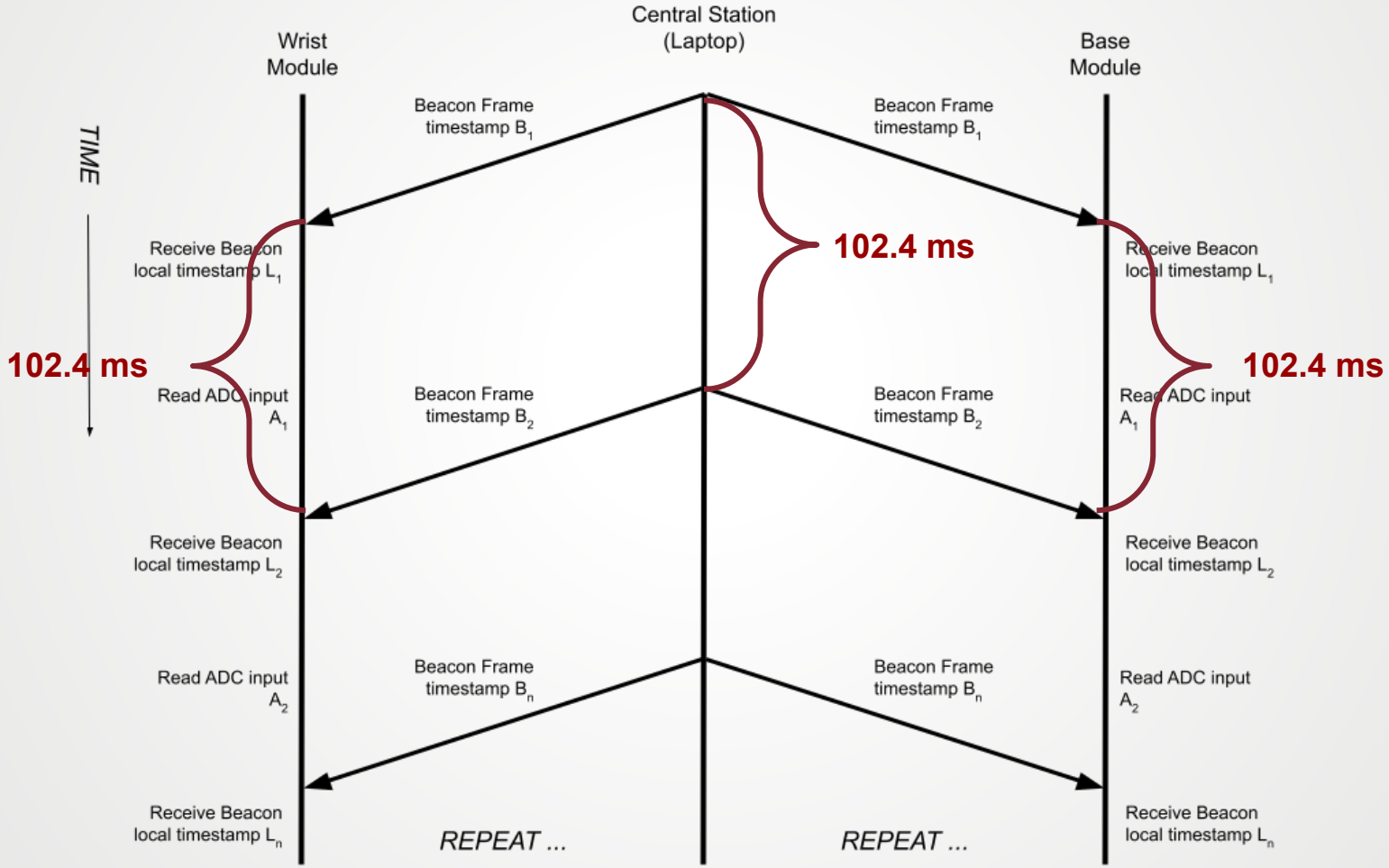



**What percentage of beacons do we capture?**

98.50% average over 1996 trials
95% confidence interval: (96.26%, 100%)

# Time Beacon Testing - Receiving Beacons Consistently

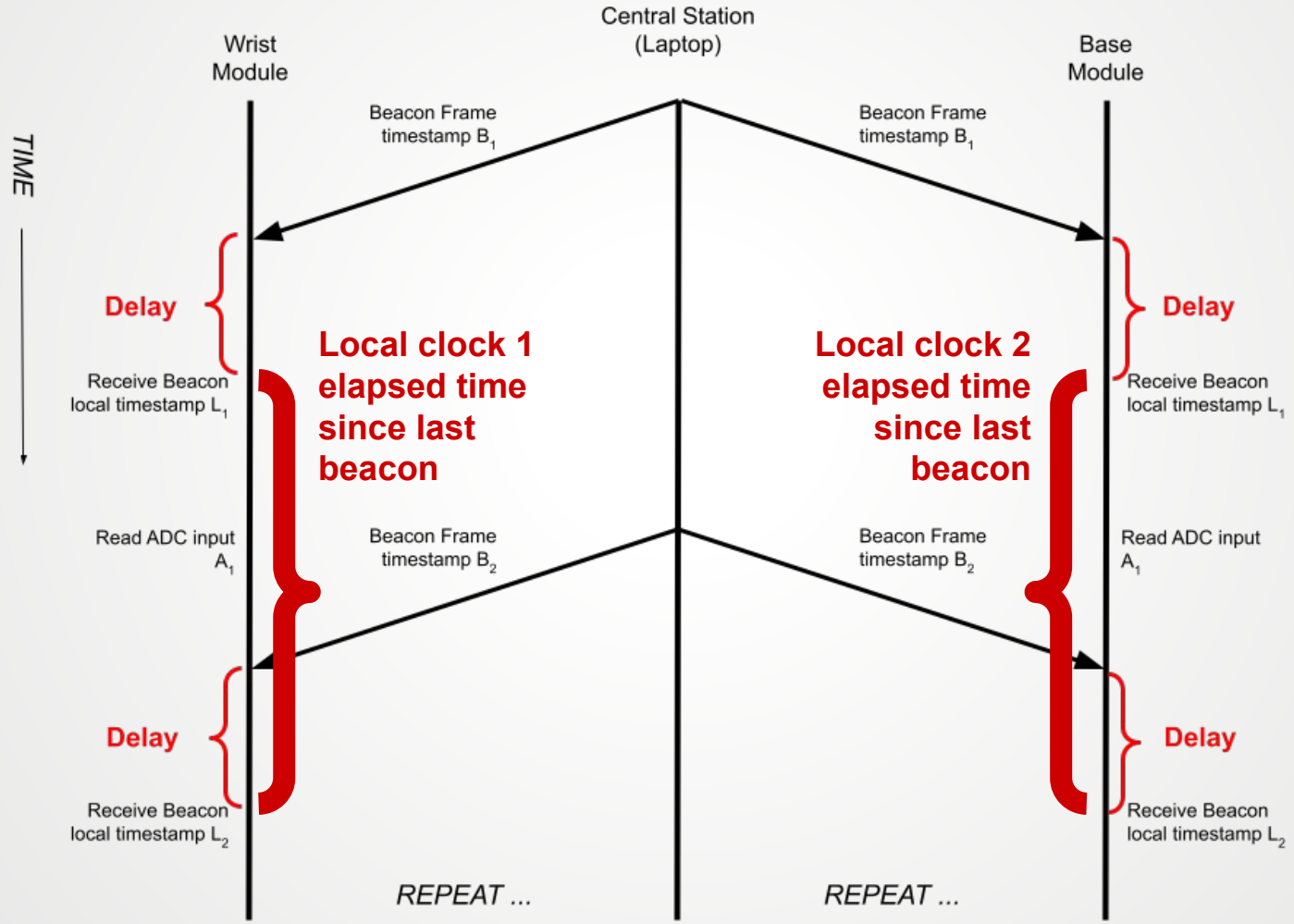
***Beacons are time stamped by the network processor upon receipt**



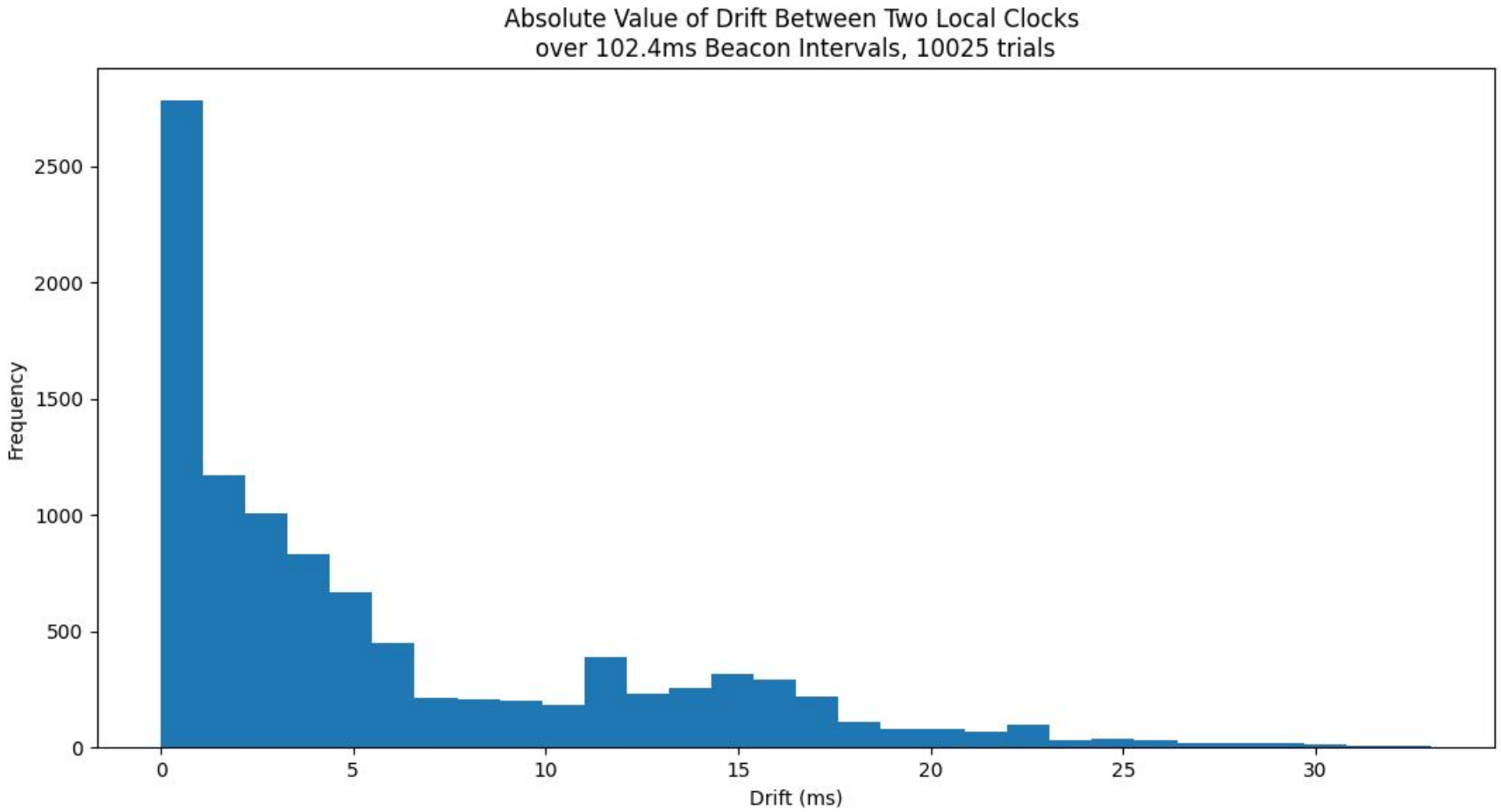

**Out of 991 trials:**
**when beacon time stamps are 102.4 ms apart:**
**989 hardware time stamps were in the range between 102ms and 102.5 ms**

# Time Beacon Testing - Local Clock Drift Between Beacons

***OK if elapsed times are not ~102.4ms, also OK if they vary *as long as they vary similarly***



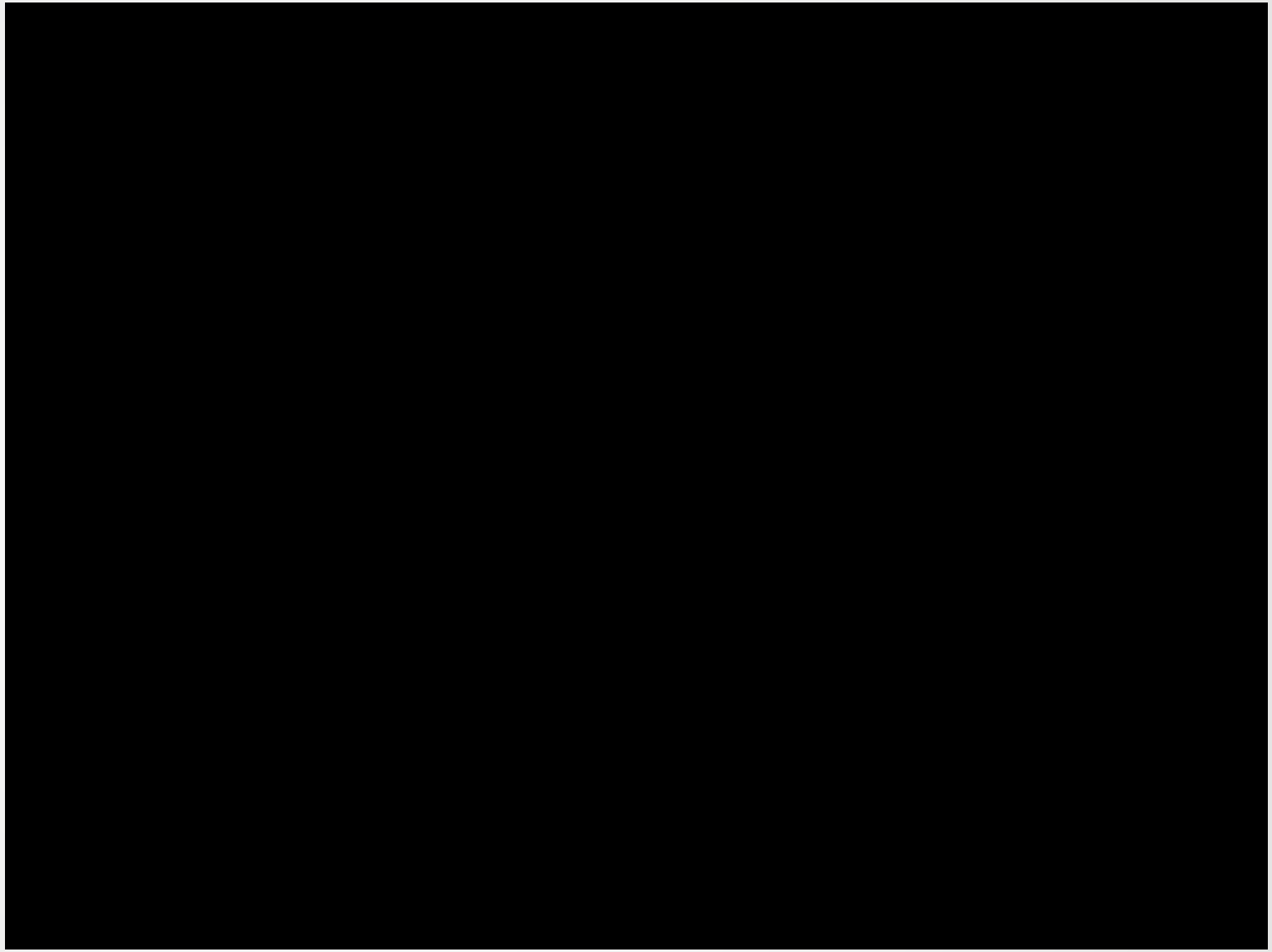
# Time Beacon Testing - Local Clock Drift Between Beacons



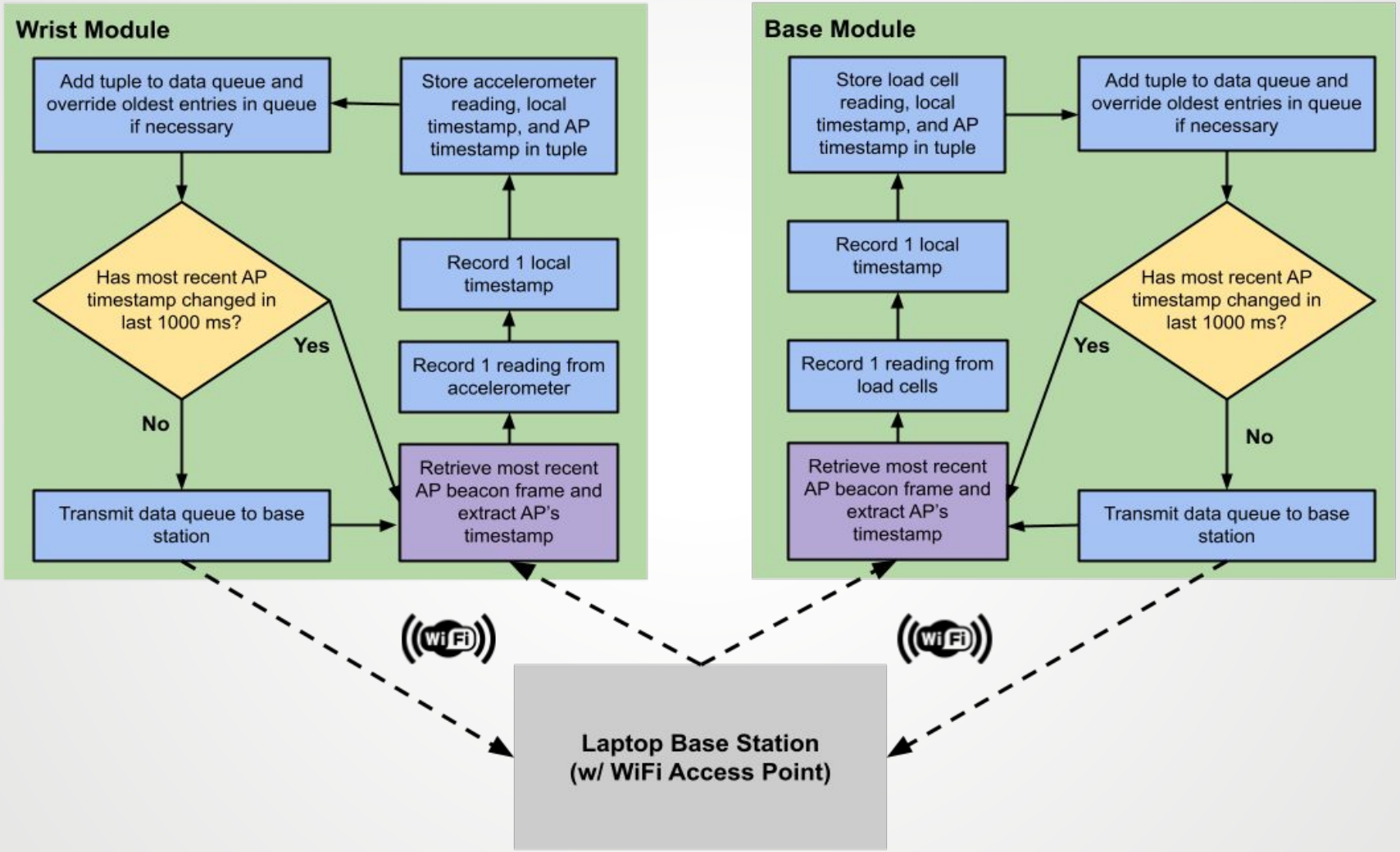

**Drift =**
**abs(clock1_elapsed - clock2_elapsed)**

where elapsed =
(local time at current beacon) -
(local time at last beacon)

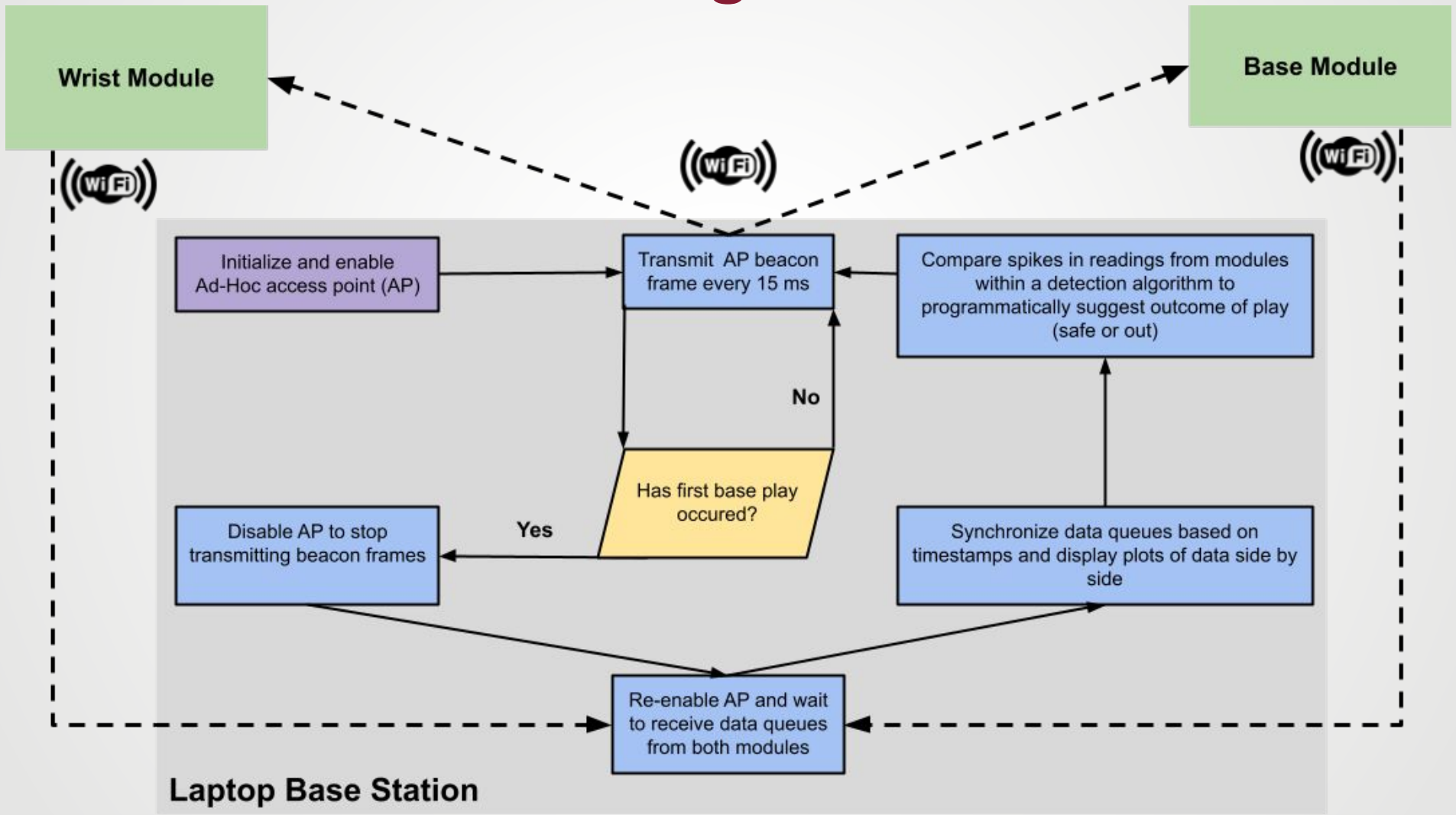
# Local Detection Software - Defunct and Discontinued



# Modules' Software Diagrams



# Base Station's Software Diagram



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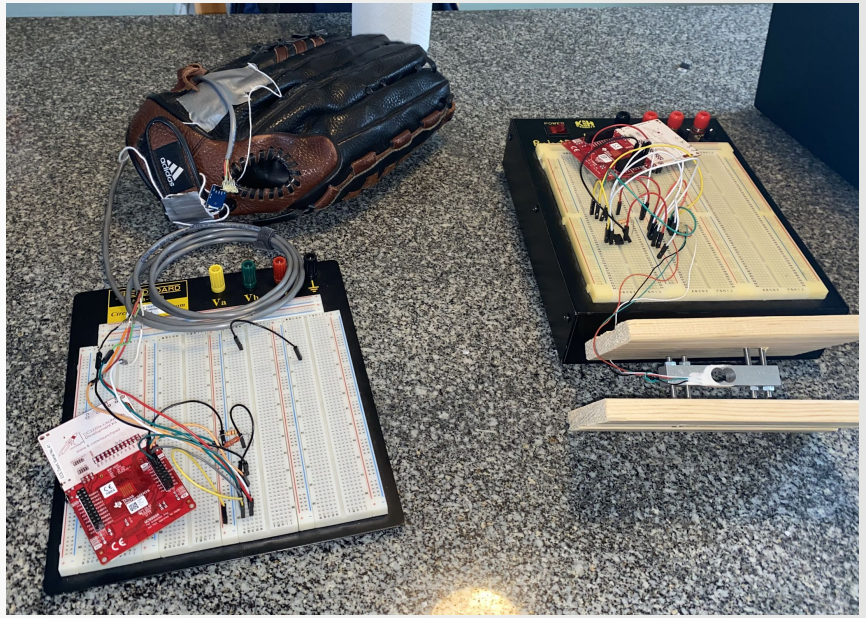

# Integrated System Demo


University of Massachusetts Amherst

# Backup Video Demo

University of Massachusetts Amherst

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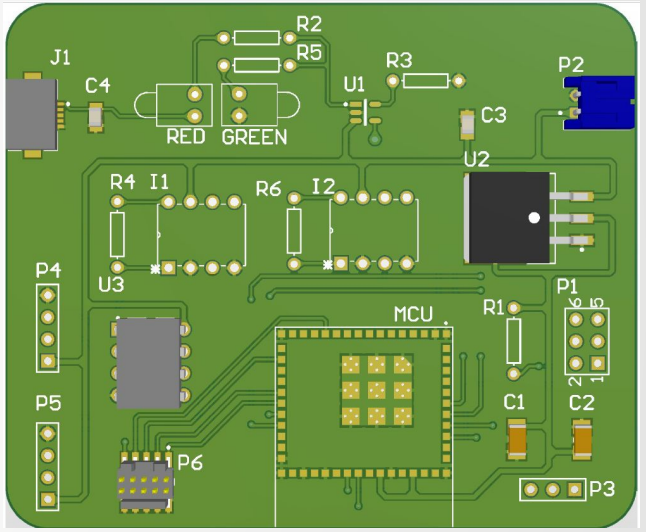
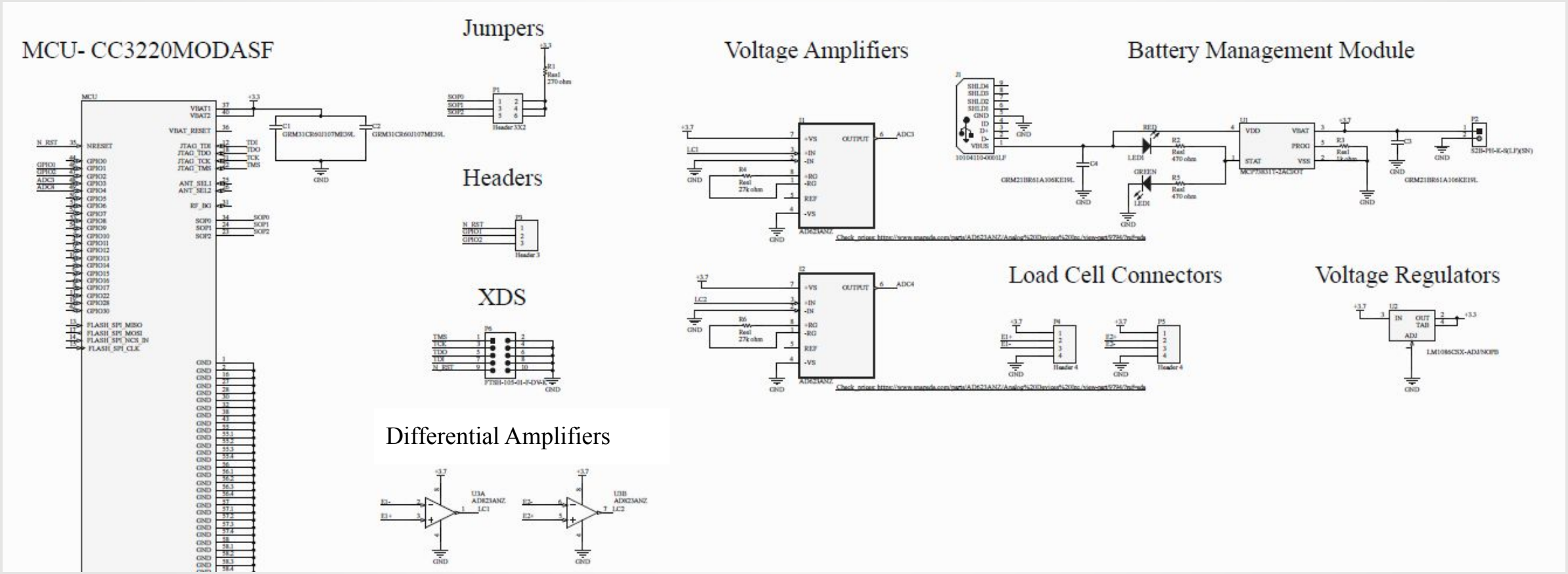
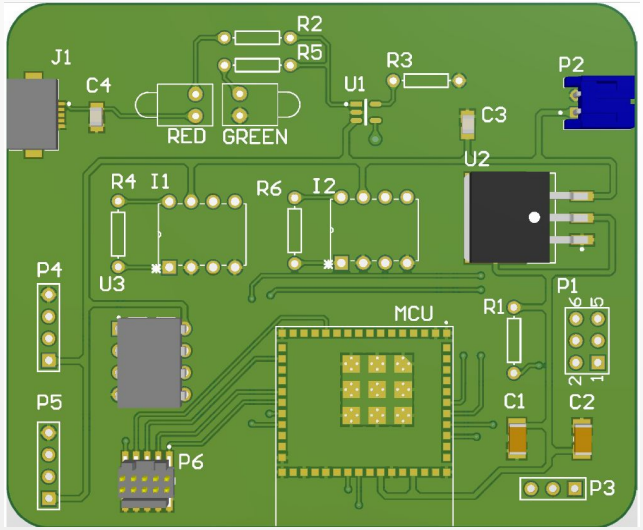


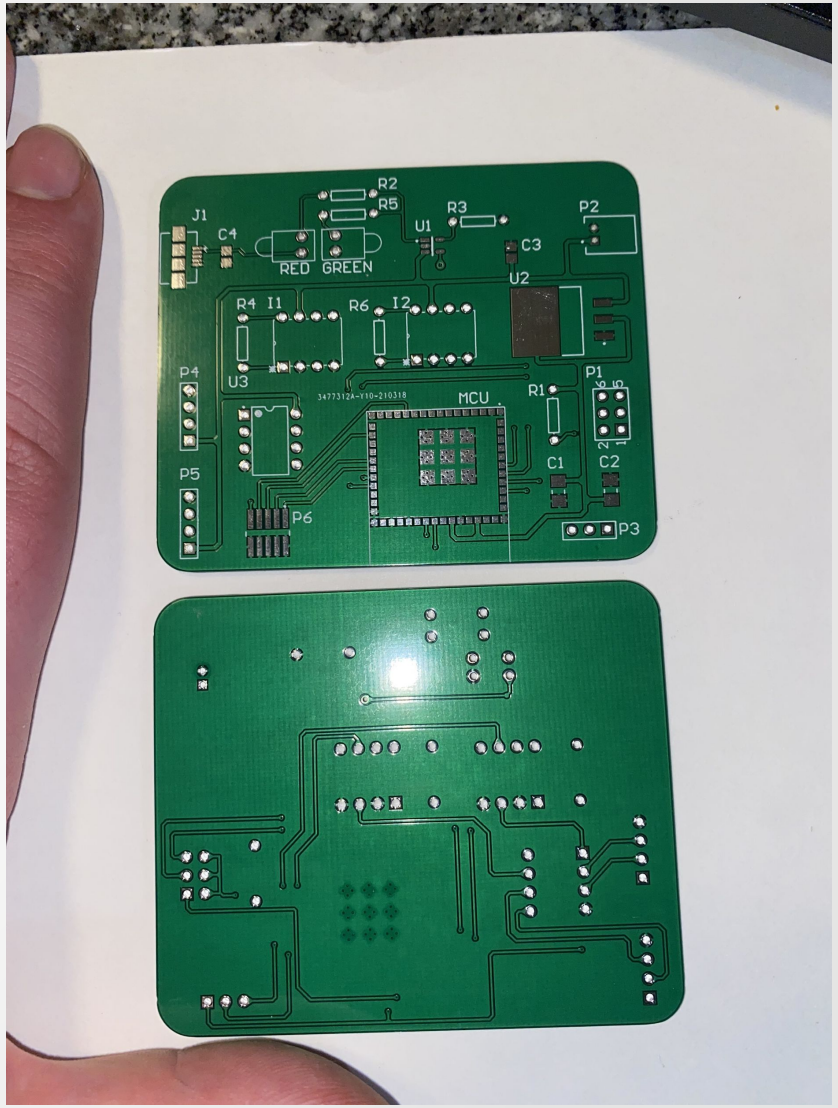
# Custom PCB - Schematic



# Custom PCB - Layout

- Battery management components
- MCU and peripherals
- Load cell connections and op-amps



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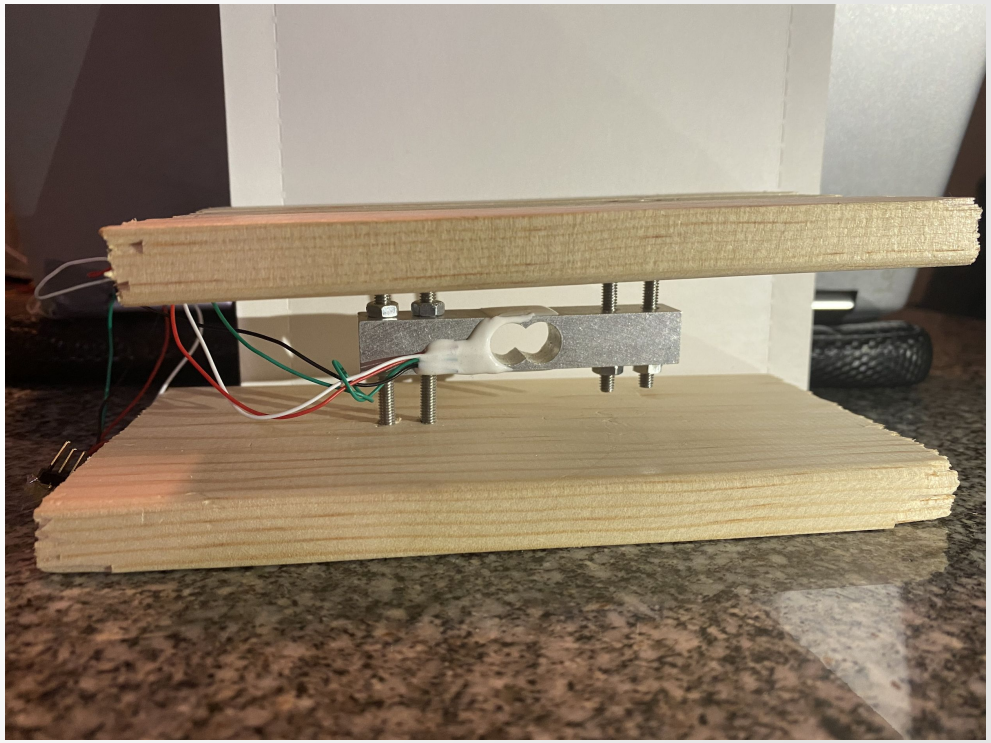
# FPR System

- Move to custom PCBs for both the wrist and the base module
  - CC3220MODASF
  - Battery charging management module
- Working to modify the load cell implementation
  - Dissipate some force on the base so the load cell doesn't overload
- Mounting station for the wrist module
  - Make the system possible to wear during regular play
- Fine-tuning the code
  - Have the trigger mechanism integrated seamlessly with the rest of the code
  - Making minor modifications to improve system performance



# FPR Demo

- Completely working system with 2 PCBs, live demo with baseball equipment
  - Base may be purchased, may be borrowed from local municipality
  - One team member is the first baseman, one is the baserunner
- Output is given based on trigger mechanism
  - Sensor data displayed via graphs, made obvious when an event occurs at each of the stations

# Testing Plan

- Testing the timeliness of our implementation
  - Using slow motion camera on cell phone to compare results
  - Slap the glove against the base to show that the systems fall within specs
  - Show drift over time using a combination of local and beacon times
- Test the battery
  - Run the program for a long period of time on battery

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➢ Project Management Plan

# Gantt Chart Until FPR

| Task | Engineer | 2-April | 9-April | 16-April | 23-April | 30-April | 4-May |
|---|---|---|---|---|---|---|---|
| **CUMULATIVE DESIGN REVIEW** | ALL | | | | | | |
| Design 2nd PCB (Wrist Module) | Derek, Jonah | | | | | | |
| Order 2nd PCB (Wrist Module) | Derek, Jonah | | | | | | |
| Start + Write Final SDP Report | ALL | | | | | | |
| Refine Prototype for FPR | ALL | | | | | | |
| Update Team Website | Vyom | | | | | | |
| Receive 2nd PCB (Wrist Module) | Derek, Jonah | | | | | | |
| Assemble Full TrueBase Prototype w/ PCBs | ALL | | | | | | |
| Test Full TrueBase Prototype | ALL | | | | | | |
| **FINAL PROJECT REVIEW** | ALL | | | | | | |
| **DEMO DAY** | ALL | | | | | | |
| Submit Final SDP Report | ALL | | | | | | |
| **LAST DAY OF CLASSES** | ALL | | | | | | |

# Project Expenditures

**Start Budget: $500**
**Current Total Expenditures: $307.02**
**Remaining Budget: $192.98**

**Projected Future Expenditures: $60**

- **2nd PCB & Stencil + Shipping**
- **Associated hardware + Shipping**

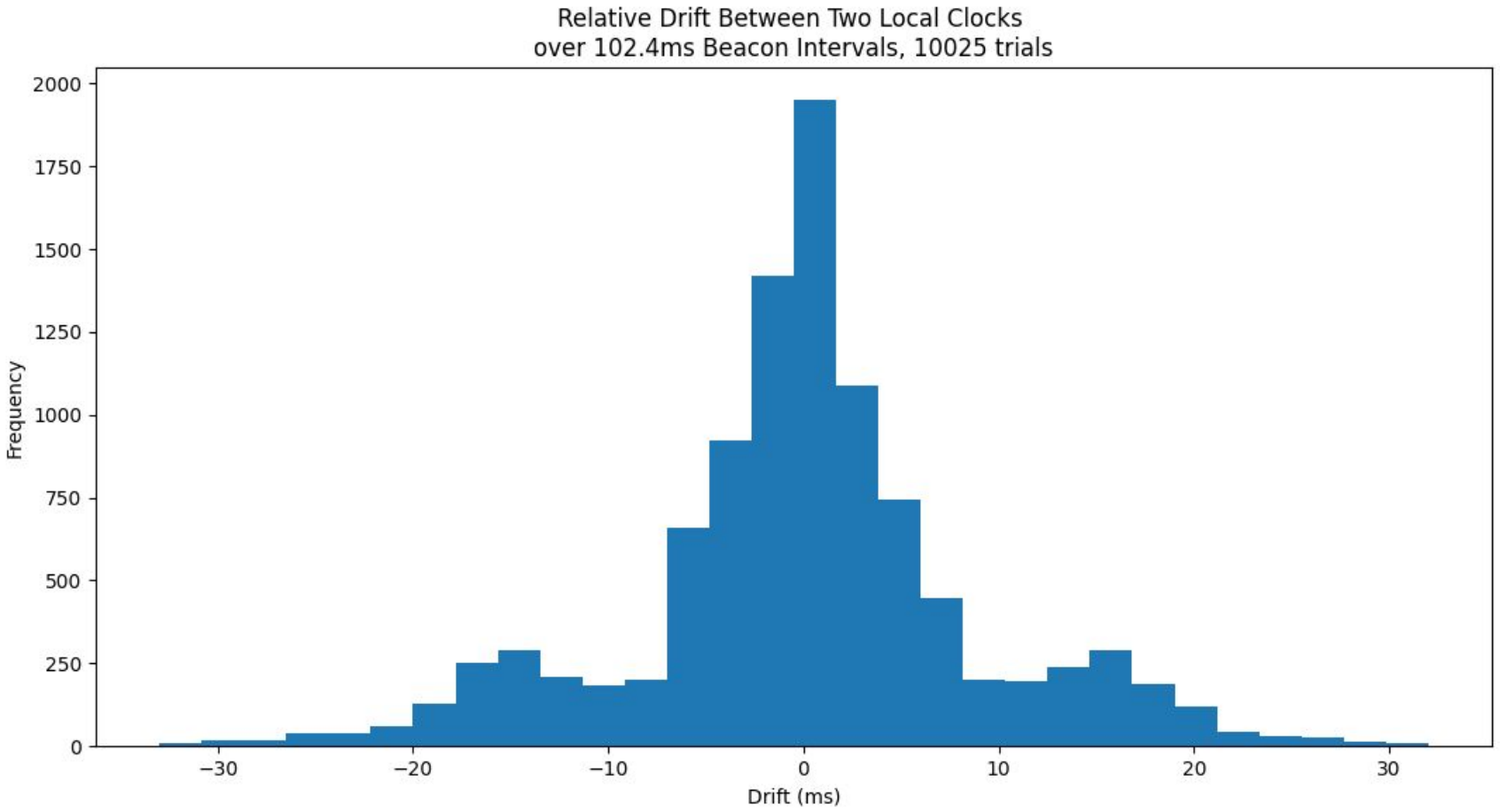
**PROJECT COST: ~$380**

**PRODUCT COST: ~$80**

| Product Cost Breakdown | | |
|---|---|---|
| Item | Quantity | Total Cost |
| MODAS Board | 2 | $14 |
| PCB | 2 | $4 |
| Accelerometer | 1 | $10 |
| Force Sensor | 2 | $10 |
| Digikey Hardware | Multiple | $30 |
| Batteries | 2 | $12 |

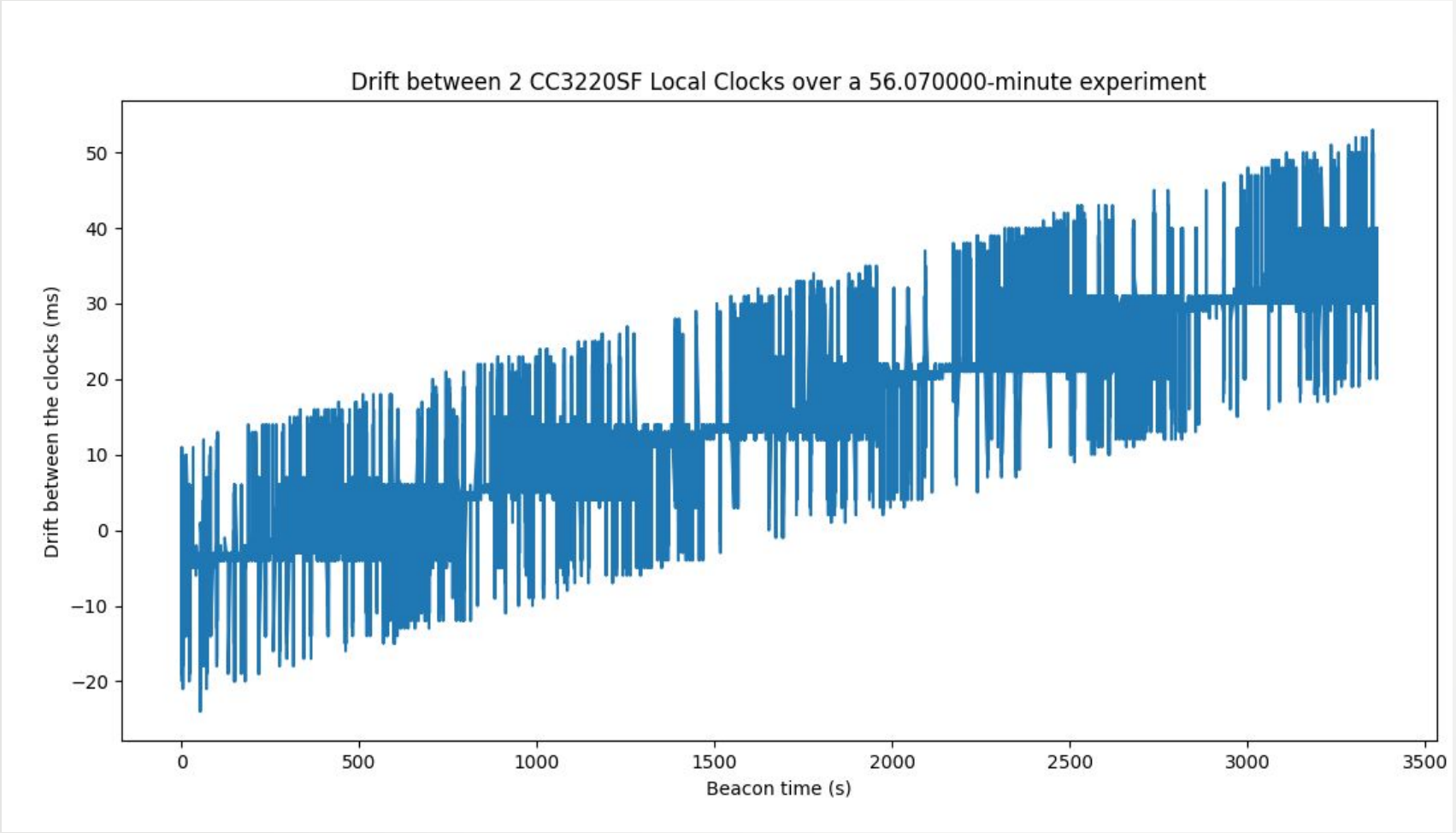

Questions?
TrueBase

# Time Beacon Testing - Local Clock Drift Between Beacons




**Drift =**
**clock1_elapsed - clock2_elapsed**

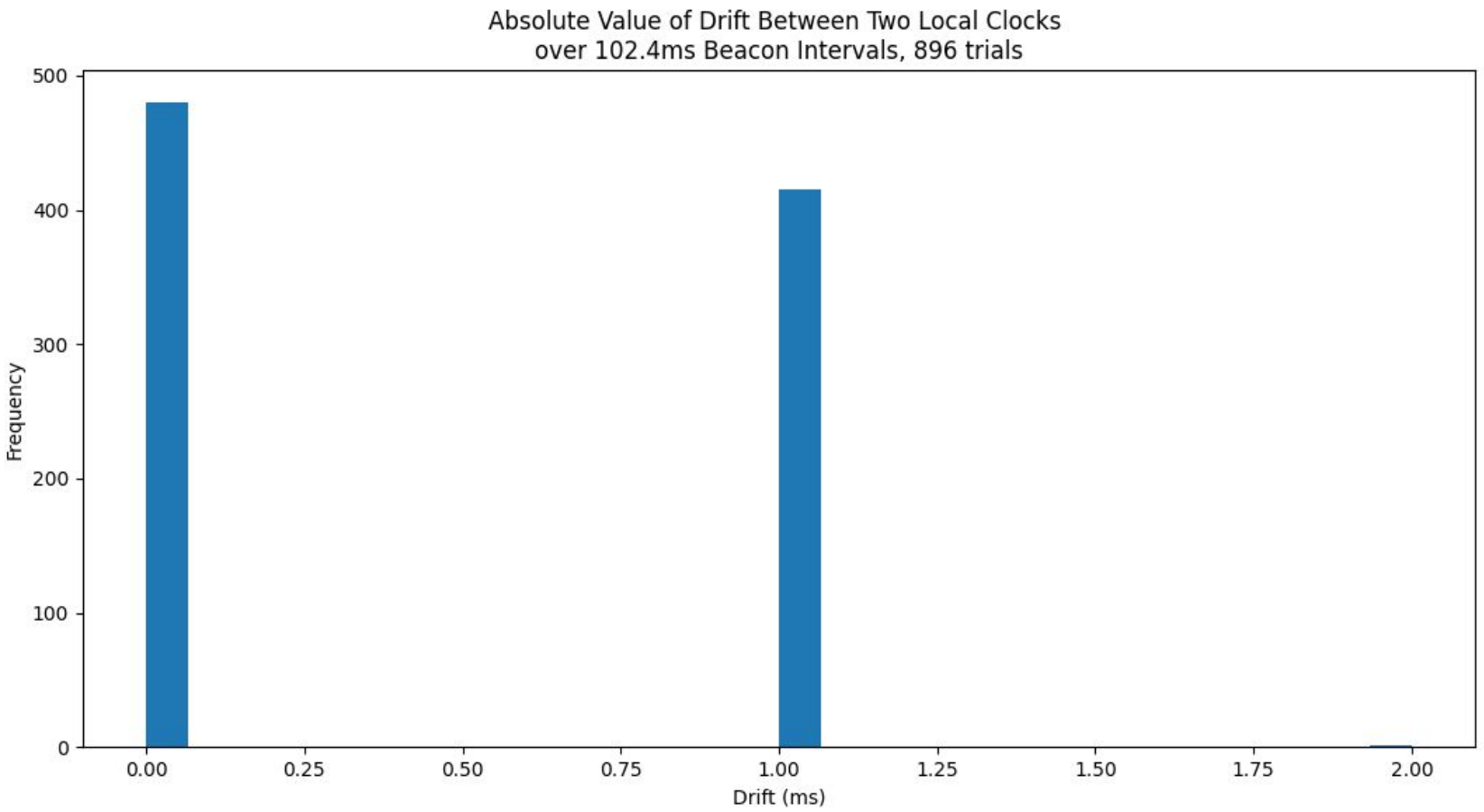
# Time Beacon Testing - Local Clock Over 56 Minutes




**Drift =**
**clock1_elapsed - clock2_elapsed**

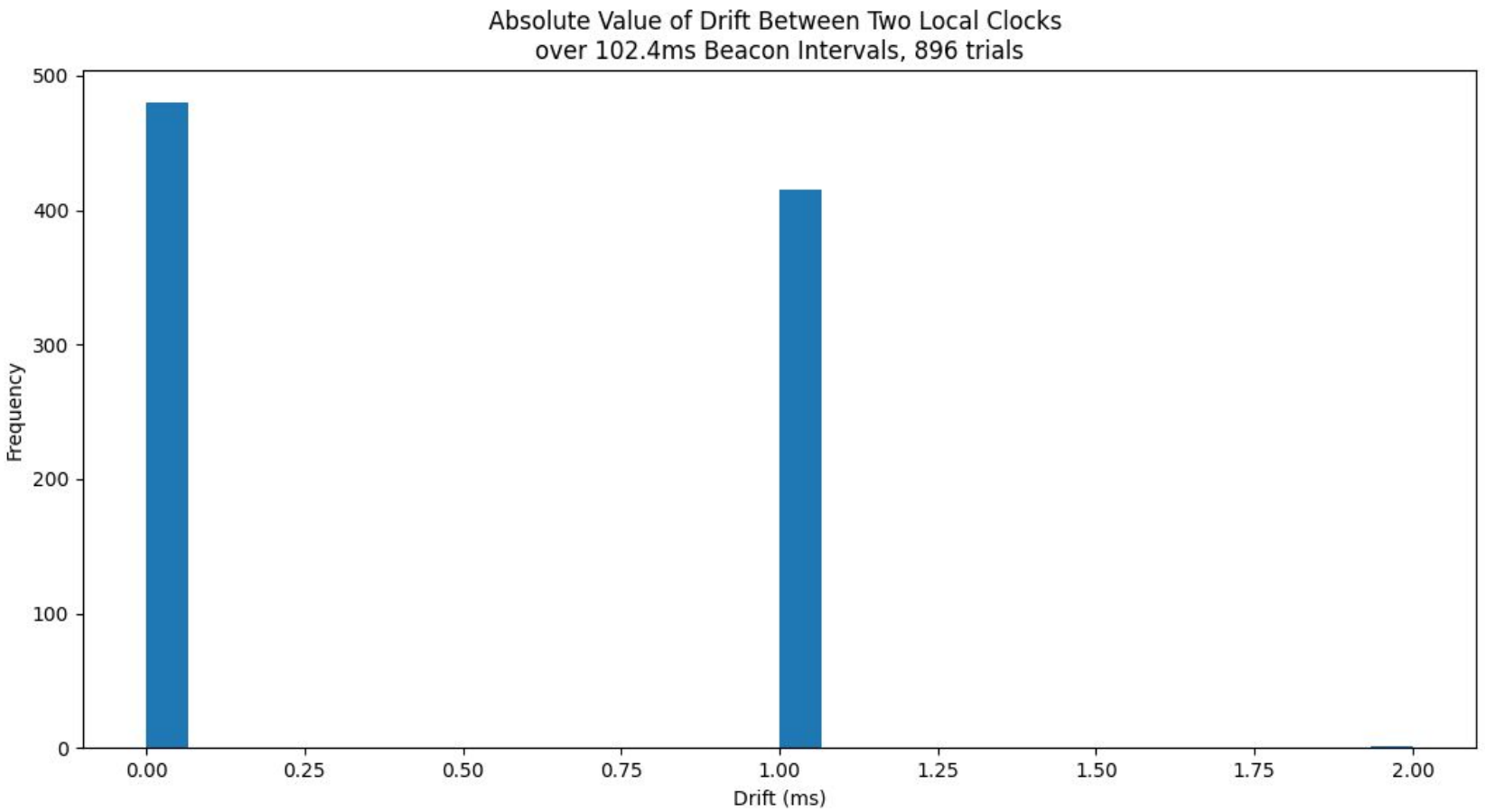
**where elapsed means**
**(current time) - (start time)**

# Time Beacon Testing - Local Clock Drift (Blocking)

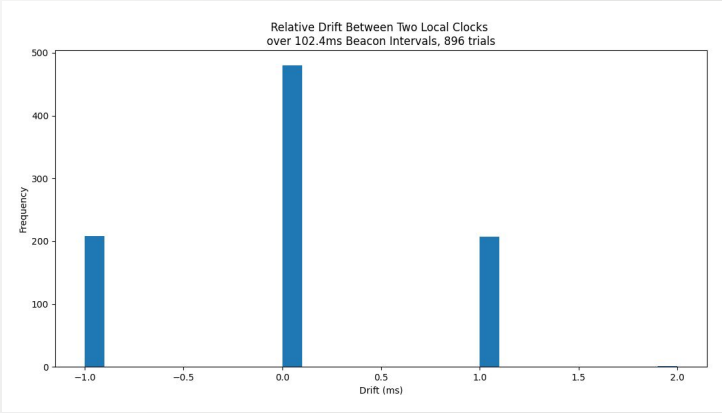



**Drift = abs(clock1_elapsed - clock2_elapsed)**

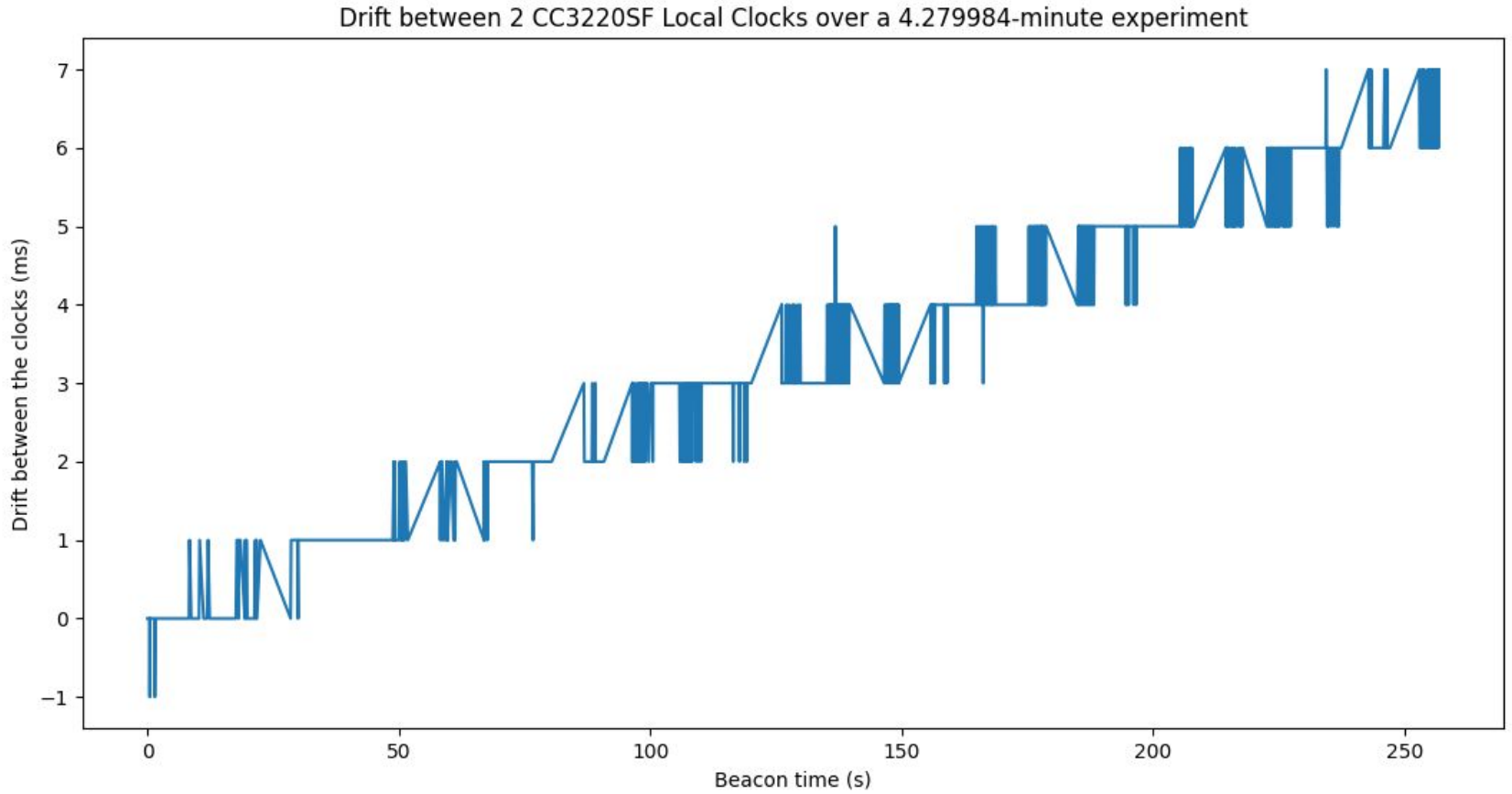
# Time Beacon Testing - Local Clock Drift (Blocking)




**Drift = abs(clock1_elapsed - clock2_elapsed)**



# Time Beacon Testing - Local Clock Over 4 Min - Blocking




**Drift =**
**clock1_elapsed - clock2_elapsed**

**where elapsed means**
**(current time) - (start time)**

# Example Output of System