# **Final Project Review**

TrueBase SDP 2021 Team 30



University of Massachusetts Amherst BEREVOLUTIONARY

# Agenda

- Problem Statement
- System Specifications
- Documentation
- Custom PCB
- Final System Performance







# **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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# **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</li>
- System will not interfere with gameplay
- Meaningful and easily interpretable output







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## **Hardware List**

Base Module	Wrist Module
<ul> <li>1528-4542-ND 20kg load cells</li> <li>AD623Anz instrumentation amplifiers</li> <li>AD823Anz op-amps</li> </ul>	ADXL335 Accelerometer
<ul> <li>CC3220MODASF M</li> <li>MCP7831T 3.7V lithi</li> </ul>	CU um-ion battery charging IC

• LM1086CSX 3.3 V voltage regulator







## **Block Diagram**







# **Block Diagram**







# **Modules' Software Diagrams**







#### **Base Station's Software Diagram**







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#### **Base PCB Altium Files**







## **Base PCB**

- Ability to connect via Launchpad board
- Able to run code on base PCB
- Successful output of data over network
- Added proto-board with pull-down resistor for N\_RST
- No micro-USB port







#### **Wrist PCB Altium Files**







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#### Wrist PCB

- Able to connect to the MCU
- Unable to program the flash memory







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# Final Prototype Demo



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#### "On-Field" Demo







#### Wrist Module Weight System Spec - Less than 150g









## **Battery Life System Spec - 5 hours**

- Using an 1200 mAh lithium ion battery
- TrueBase base module uses:
  - ~45 mA when gathering ADC readings
  - ~88 mA when transmitting data over TCP
- Highest current draw observed 97 mA
- Lowest current draw observed 45 mA
- Worst case scenario more than 12 hours of battery life





# **Same Time Trigger Results**

- 51/57 trials triggered in both within 35 ms of each other
- 6 millisecond sleep
   function within the code
- 89% of trials within 35 ms specification
- 95 percent confidence interval 63%, 100%





#### **Same Time Trigger Results**







#### **Outlier Case 1**







# **Outlier Data 1**







#### **Outlier Case 2**







# **Outlier Data 2**







#### **Outlier Case 3**







## **Outlier Data 3**







# **Slow Motion Testing - 50 Trials**



- Parameters measured:
  - Correct order of events
  - TrueBase estimated time between events
  - Slo-mo video estimated time between events (480 FPS)





# **Slow Motion Testing - 50 Trials**

- Correctness 46/50 (92%)
- When slo-mo time between events is over 35ms:
  - 25/25 trials correct (95% confidence interval of 60%, 100%)
- When slo-mo time between events is under 35ms:
   21/25 trials correct (95% confidence interval of 44%, 100%)
- Of the 4 incorrect:
  - 1 wrong
  - 2 where TrueBase predicted the event at the same time
  - 1 where load cell was not pushed hard enough





## **Slow Motion Testing - Wrong Incorrect Trial**









# **Slow Motion Testing - Load Cell Pushed Softly**









# **Slow Motion Testing - TrueBase Same Time Prediction**



- 2 instances
- Slo-mo estimated times of 6.5 ms and 12.5 ms





# Difference between Slo-mo Predicted Time and TrueBase Predicted Time







# **Slo-mo Testing - Base Module Triggered Wrist Module**







#### **Future Directions**

- More testing with the wrist module PCB
  - Possible Re-order
- More testing with the voltage regulator on the base module PCB
- New base module PCB with incorporated pull down setup for N\_RST
- Make the base module completely unintrusive
- 15 ms beaconing
- More readings from the analog to digital converter
- Seamless zoom on graphed data





# SDP'21 - FPR Wrap Up

- Project Cost: \$450
- Product Cost: \$80
- Team Website: <u>www.ecs.umass.edu/sdp/sdp21/team30</u>
- Thank you!















# Questions?

Frick Approximation program in the second state and the second



#### **Slow-Mo Trials: Video**







#### **PCB Powered on Battery**







#### **Difference between Slo-mo Predicted Time and TrueBase Predicted Time - Trials under 40ms**





