University of Massachusetts Amherst

Preliminary Design Review

TrueBase
SDP 2021
Team 30

University of Massachusetts Amherst BE REVOLUTIONARY™

Meet the TrueBase Team

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CompE

Vyom Rathod
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Derek Garland
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Nnaji Obinelo
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Professor Arman Pouraghily
Faculty Advisor

University of Massachusetts Amherst

Agenda

- Problem Statement
- Preliminary System Specifications
- Survey of Competing Solutions
- Preliminary Design and Hardware
- Proposed MDR Deliverables
- Cost Estimate
- Project Management

Problem Statement

- Athletes are becoming increasingly stronger, faster, and capable
- 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?

Our Solution

- Accelerometer on the wrist to determine when the ball is caught by the fielder
  - Powered by a small battery system worn on the wrist
- Sensor in the base to determine when the runner steps on first base
  - Powered by a larger battery which can be stored under the base
- Timestamp of both occurrences sent to the base
- Core logic in the base determines the result of the play
- The result of the play is displayed on an LED screen for official use

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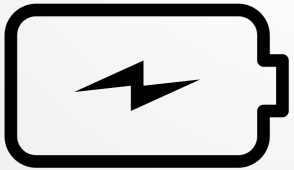
Preliminary System Specifications

- 50ms accuracy - 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

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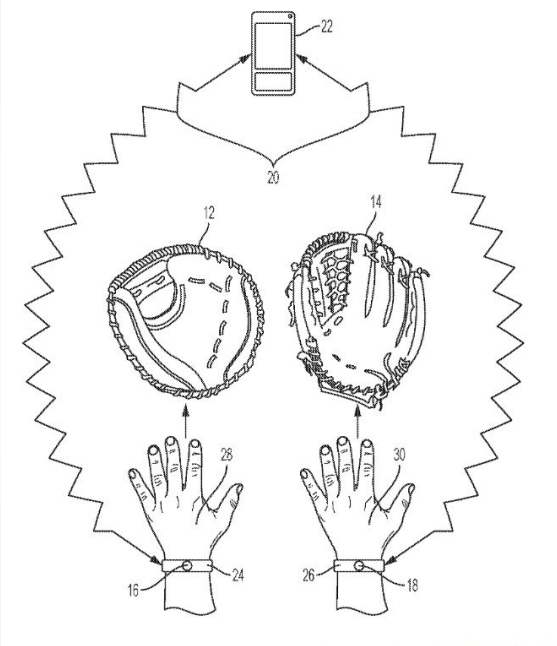


Current MLB Protocol

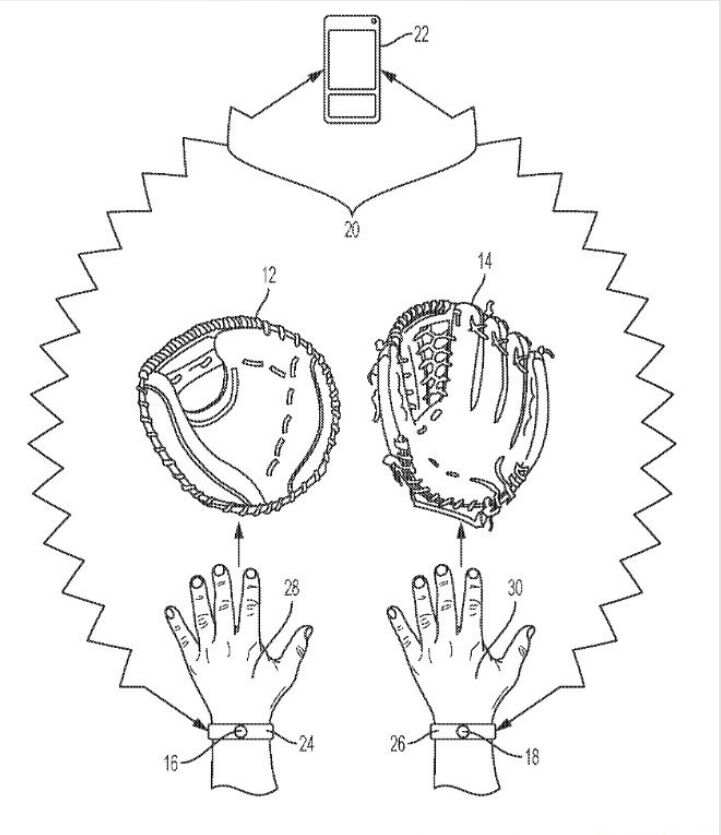
- Replay review system
- Initiated by umpire or manager challenge
- Designed to give “timely” results
- If a call is too close to determine, call on the field is upheld

Northwestern SDP Project

- 2 microphones
- Results sent to review booth
- Not tested in professional setting with crowd noise
- Hazard during a potential foul ball

Catcher “Pop Time” Patent

- 2 systems for determining a catch
- Sensors worn on the wrist
- Communication with a central station



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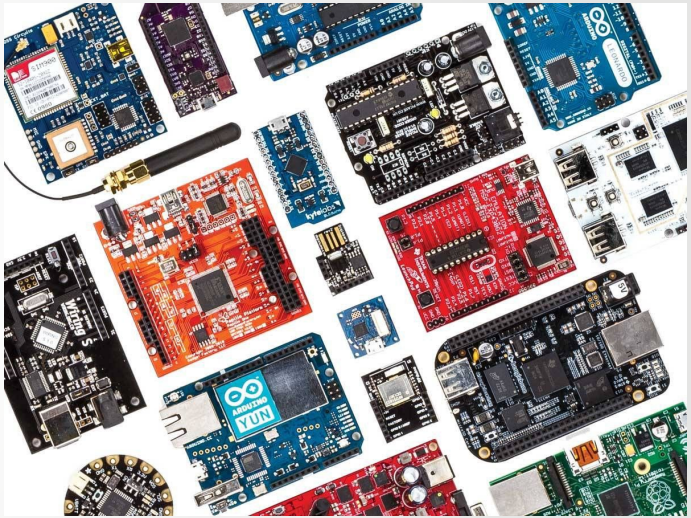
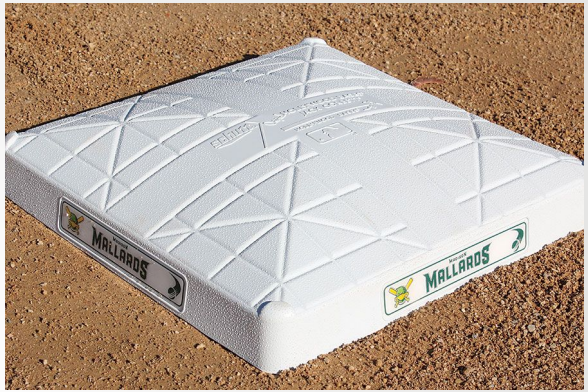


System Overview



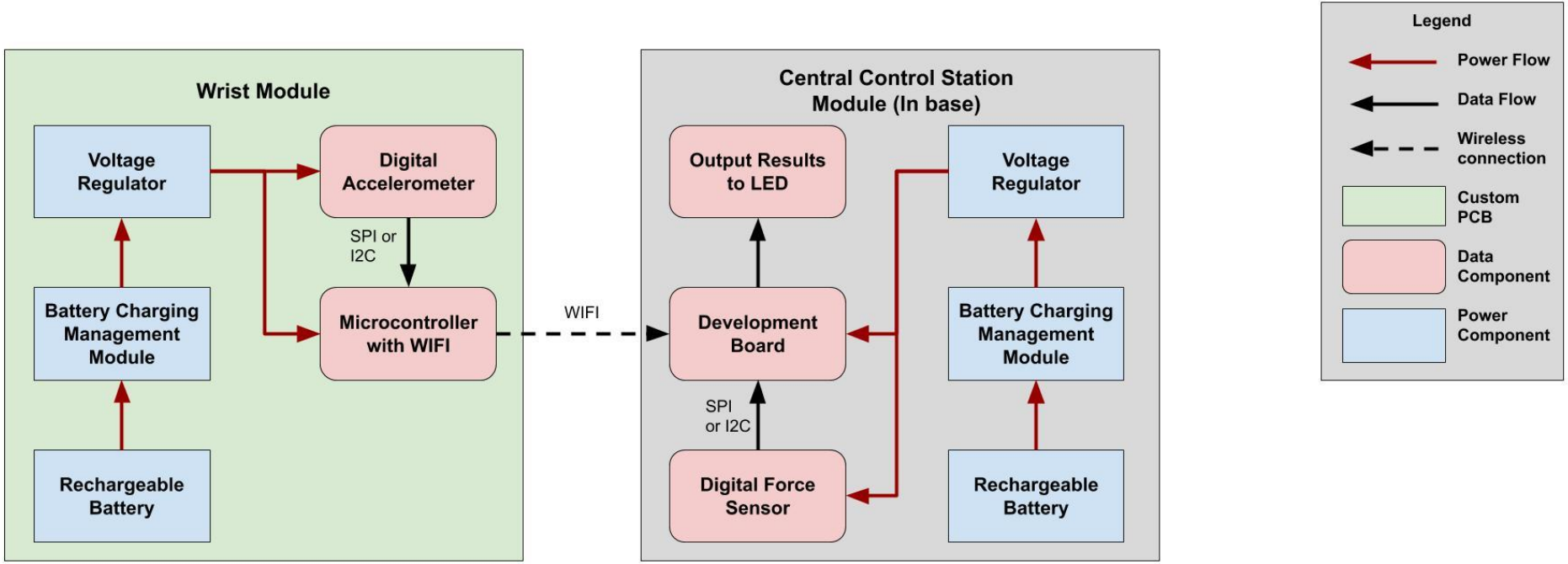
Wrist Module

- Answers the question “Has the ball been caught?”
- Sends this timestamp to the base module

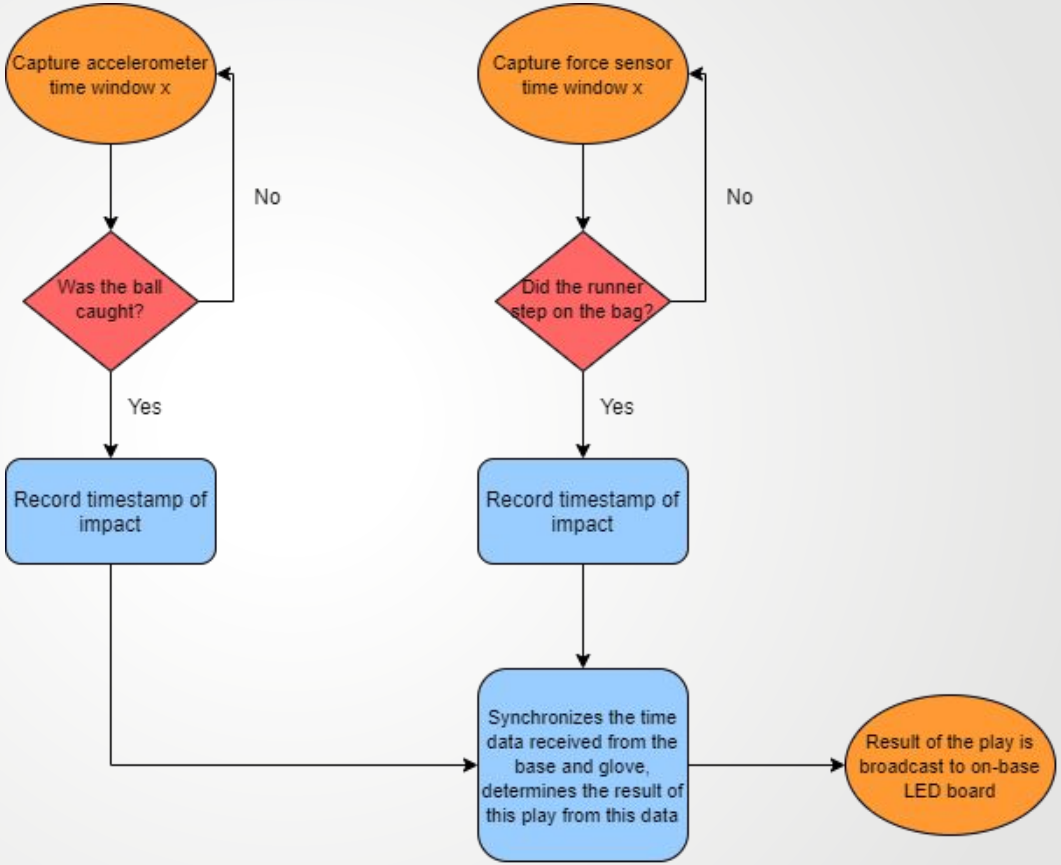
Base Module

- Answers the question “Has the runner stepped on the base?”
- Receives timestamp from the wrist module and compares with its own timestamp
- Outputs result to LED screen

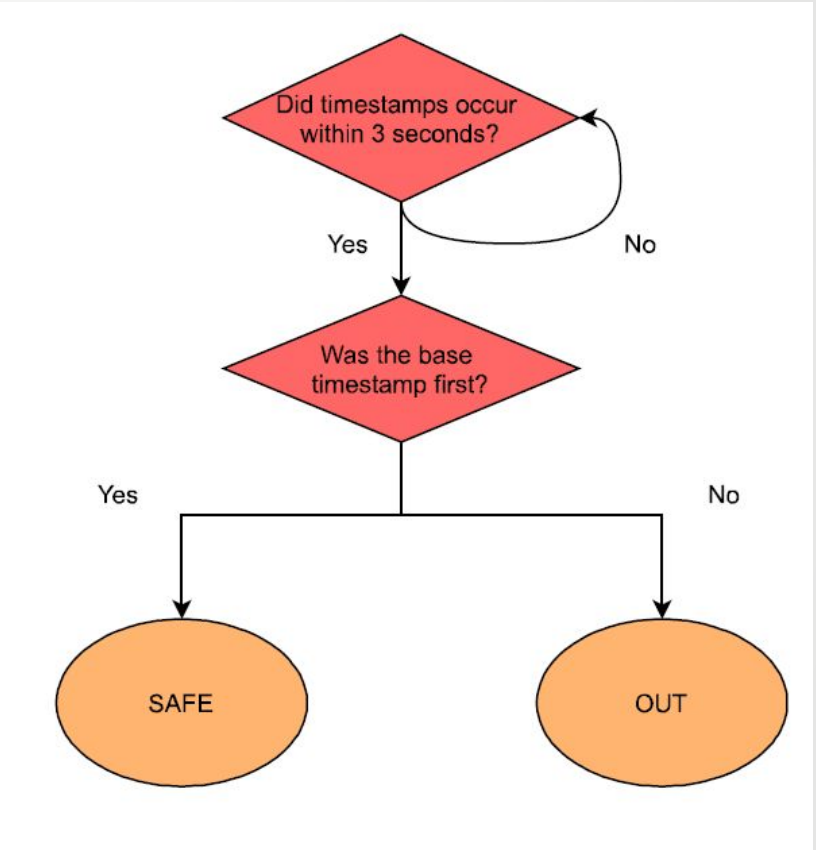
Block Diagram



Software Diagram



Central Control Decision



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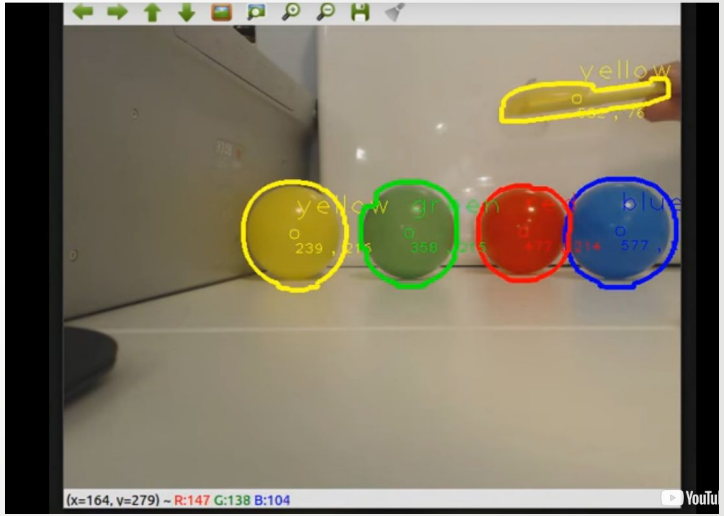
Proposed MDR Deliverables

- Core logic design will be completed
- Be able to power force sensor with rechargeable battery and read its output using dev board
- Be able to power an accelerometer with a rechargeable battery and read its output using a dev board
- Real Time Clocks (RTC) will sync properly and have negligible drift
- Be able to send timestamp data over WIFI to development board

Possible Future Project Enhancement

Machine Learning video camera detection system

- Use to detect when player collides with base through image processing
  - Utilize object detection software to draw outlines around players and base and identify outline overlaps
- Redundancy check
- Help determine outcome of non-first base plays
- Help detect edge cases (non-force outs)



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Cost Estimate

Wrist Module

2x Accelerometer	~$12
Breakout Board Accelerometer	~$15
Rechargeable Battery	~$5
Battery Charging Management Module	~$2
Voltage Regulator	~$1
3x Microcontrollers w/ WiFi	~$18
WiFi Antenna	~$3
2x Half-Size Breadboard	~$10
Raspberry Pi	~$35

Base Module

Force Sensor	~$32
Rechargeable Battery	~$13
Battery Charging Management Module	~$2
Voltage Regulator	~$1
2x Raspberry Pi	~$70
2x Breadboard	~$10
LED Screen	~$25
Baseball Base	~$50

Total: ~$305

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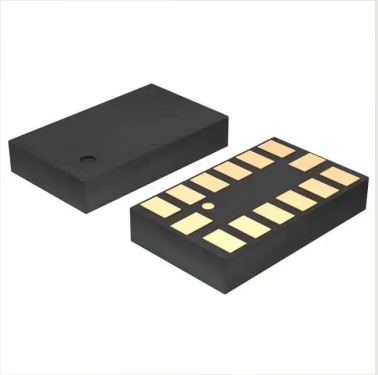
Part Candidates

- Accelerometer: ADXL345
  - Digital output with I2C
  - Wide voltage range
  - About 3 g
- Force Sensor: FX1901-0001-0200-L
  - Push button force sensor
  - Requires 5V power supply
  - 250lb max overload
- MCU: CC3220SF (TI)
  - Trusted manufacturer
  - Not very expensive
  - Built in WiFi
- Battery Lithium Ion Battery
  - Small model for wrist module
  - Larger batteries for base module
  - Nominal voltage 3.7



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Project Responsibilities

Jonah	Team Coordinator, responsible for implementation of the PCB on the wrist module, specifically implementing the microcontroller in coordination with the accelerometer including the necessary software
Vyom	Altium Lead, responsible for testing and proving the timeliness of the data from the glove module to the base module, thus ensuring that system specs on response time are met
Derek	Budget Management Lead, responsible for developing the battery system used for the wrist module as well as configuring the force sensor in the base module including the necessary software
Nnaji	Software Lead, responsible for developing the wireless communication between the two modules through a LAN configuration

Task	Engineer	21-September	28-September	5-October	12-October	19-October	26-October	2-November	9-November	16-November	23-November
PRELIMINARY DESIGN REVIEW	ALL										
Determine appropriate Real Time Clock(s) to use	Vyom										
Determine appropriate accelerometer to use	Jonah										
Determine appropriate force sensor to use	Derek										
Determine appropriate microcontroller to use	ALL										
Determine appropriate battery to use	Vyom										
Order and recieve parts	ALL										
Research RTC drift patterns and implementations	Vyom										
Research accelerometer curve patterns	Jonah										
Research optimal data transfer mechanism	Nnaji										
Begin core logic implementation	ALL										
Begin PCB design	ALL										
CHECK-IN 3	ALL										
Begin putting together prototype	ALL										
Run RTC trials	Vyom										
Run accelerometer tests	Jonah										
Run force sensor tests	Derek										
Run data transfer tests	Nnaji										
Run core logic tests with dummy data	Nnaji										
Combine hardware + software and test	ALL										
Finaize working prototype v1.0	ALL										
MIDWAY DESIGN REVIEW	ALL										

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Questions?
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