CONCUSSION DETECTING HELMET

END OF PHASE 2 REVIEW

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Project Description

Our project aims to create a device to detect concussions during a sporting event. We will do this by not only detecting impacts with an accelerometer, but also recording and comparing previous impacts to better predict when a player receives a concussion. Ultimately, we want our device to be easily incorporated into a helmet without a loss in safety.

Phase 2 Work Completed

- Chose to use a Hockey Helmet, as hockey players have the highest concussion frequency.
- Read through Hockey Helmet regulations in ASTM F1045 [1].
- Began setting up Server Architecture.

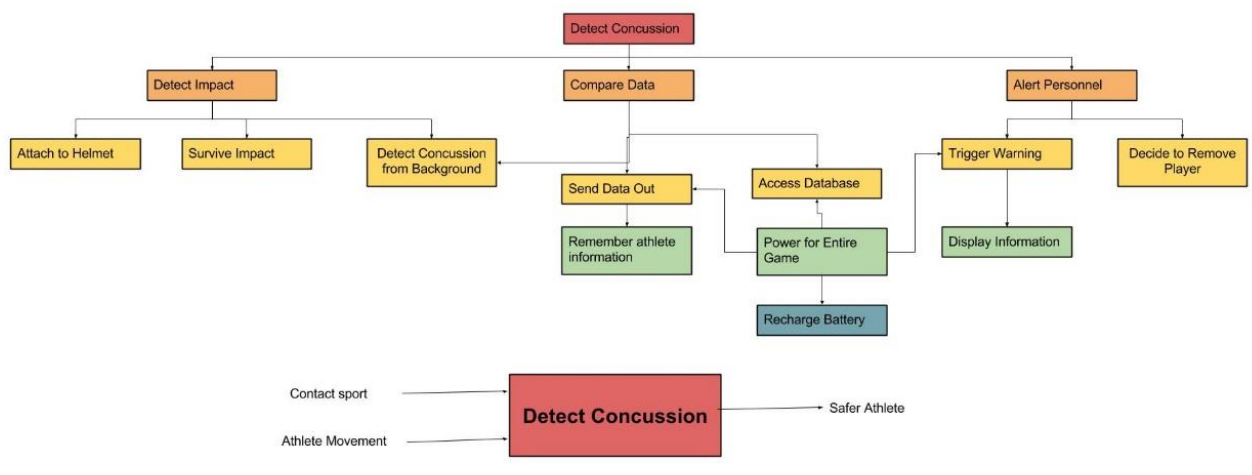


Figure 1: Functional Decomposition

Table 1: Engineering Requirements

RQMT #	Importance	Source	Function	Engr. Requirement (Metric)	Unit of Measure	Marginal Value	Ideal Value
PRP	1	SymOP	System Operation	Battery life	days	10%	30
PRP	1	SymOP	System Operation	RF Range	yards	20%	300
PRP	1	SymOP	System Operation	Max G force capability	G Force	10%	100
PRP	2	SymOP	System Operation	FormFactor	size	50%	Compact case
PRP	2	PUR	Purchasing	Cost	$	50%	20
PRP	2	SymOP	Latency from detection to notification	Latency from detection to notification	ms	30%	200
PRP	1	SymOP	Temperature Requirements	Degrees C	C	0%	-27 - 32 For 4 hours
	3	SymOP	Chin Strap	Force to Separate	N	0%	50-500N
	3	SymOP	Chin Strap	Max displacement @ 109N	mm	0%	25.4mm
	1	TST	Shock Apparatus	max force	G Force	20%	150
	1	SymOP	data storage	Time for data to be stored	years	5%	2
	3	SymOP	Time to pull historical data	Time to pull historical data	seconds	20%	15

Current Design Decisions

For our sensor, we will be replacing the accelerometer on the customer's board with ADXL377, which is made for higher g forces. The current idea for housing the sensor is to cover it in a resin molded into the desired shape. We will directly attach our sensor to the helmet, as we think that this will give better accuracy and survivability compared to attaching to the helmet strap or some other part of the helmet.

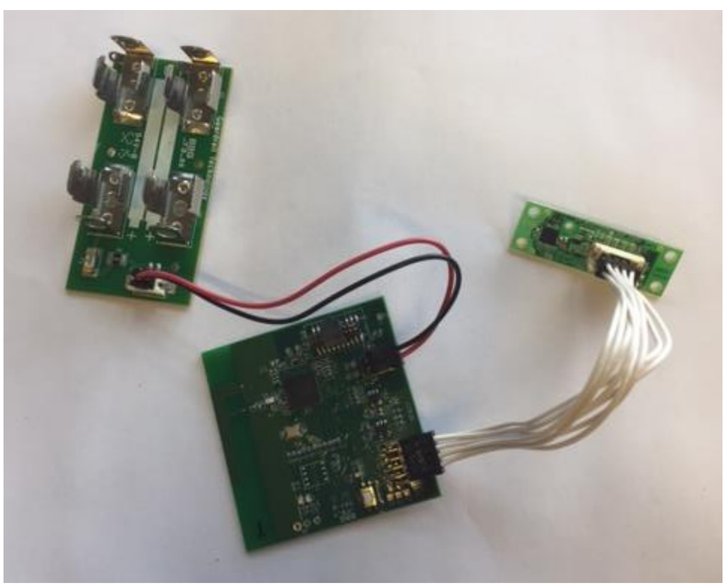


Figure 2: Current Customer Sensor Boards

System Flowcharts

The use of flowcharts provide a "big picture" view of how our systems and subsystems will work. They can help inform and organize our decision making for the future. These charts are likely to change as we refine our ideas over time. Below are several of the key flowcharts that have been designed beginning with the sensor's basic functions. After that it is followed by flowcharts of the usage of the smart phone, how the device will gather data, and finally the testing protocols for the device. The current testing protocols are vague as more specific methods will arise with the creation of a prototype.

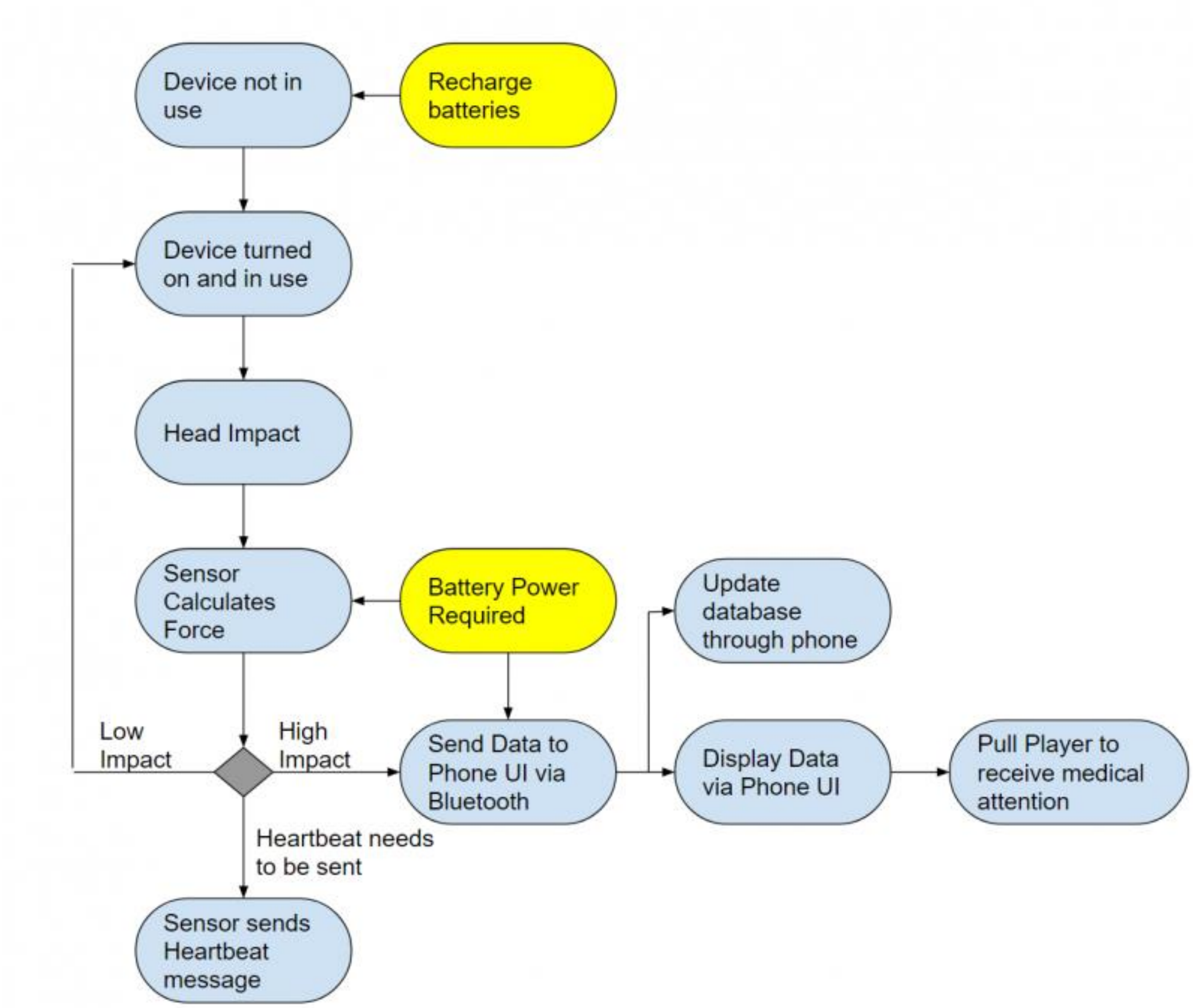


Figure 3: Systems Architecture Flow Chart

Our sensor must be able to continuously data while also limiting the amount of power it uses during transmission. The sensor must remember data to send out every few minutes.

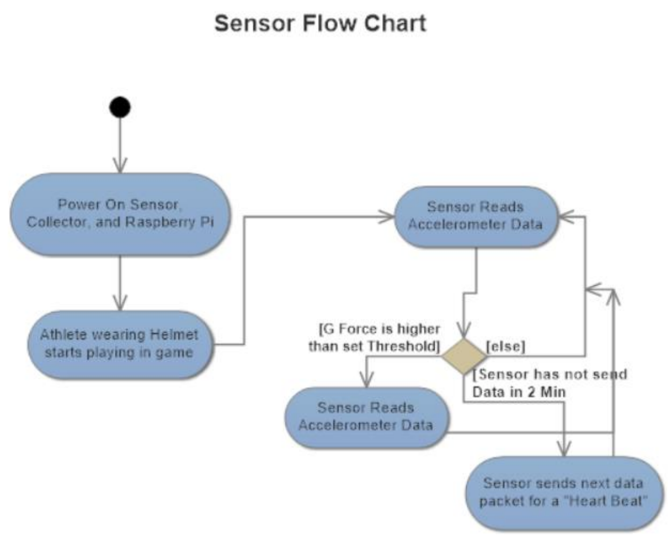


Figure 4: Sensor Flow Chart

Many small impacts can be just as bad or even worse than one large impact when it comes to causing concussions. To improve our predictions, our data must be archived so that it can be accessed to make an informed decision.

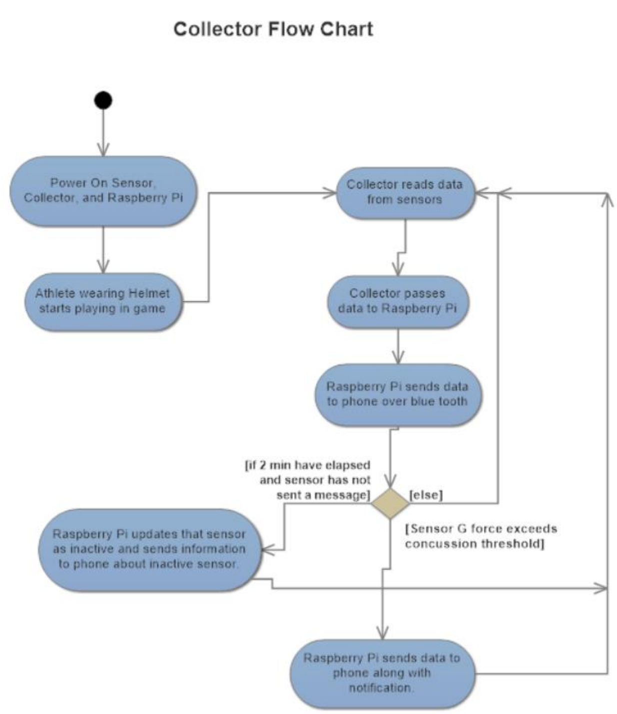


Figure 5: Collector Flow Chart

Concussion detection is useless if the humans using our device don't know if an event has occurred. We want to create an app that will accompany our system to simply display the data our sensor has gathered.

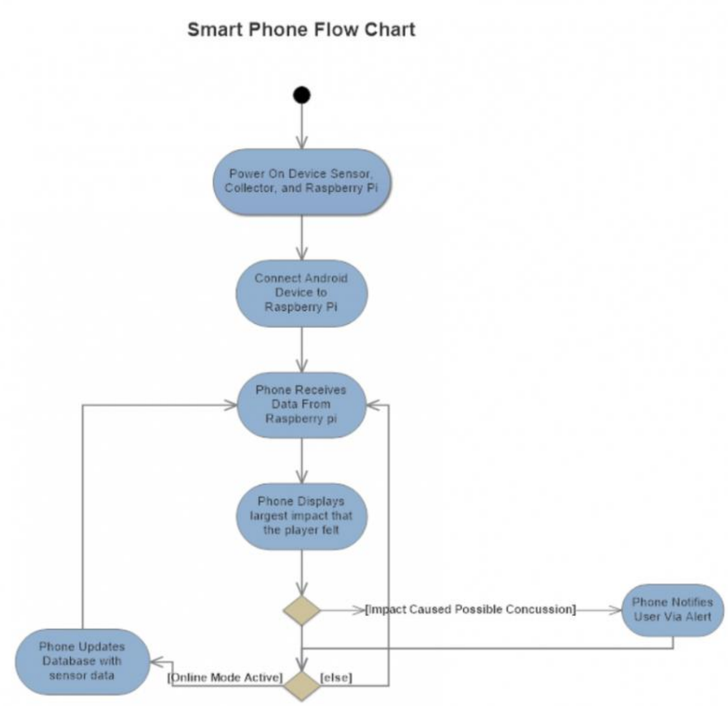


Figure 6: Phone App Flowchart

Our customer wants the device to be able to run off of its battery for as long as possible with the goal of a full season of play between recharges. Because of this, power management will be a major focus of our design. We have decided to use a Lithium Ion Battery, like those used in phones.

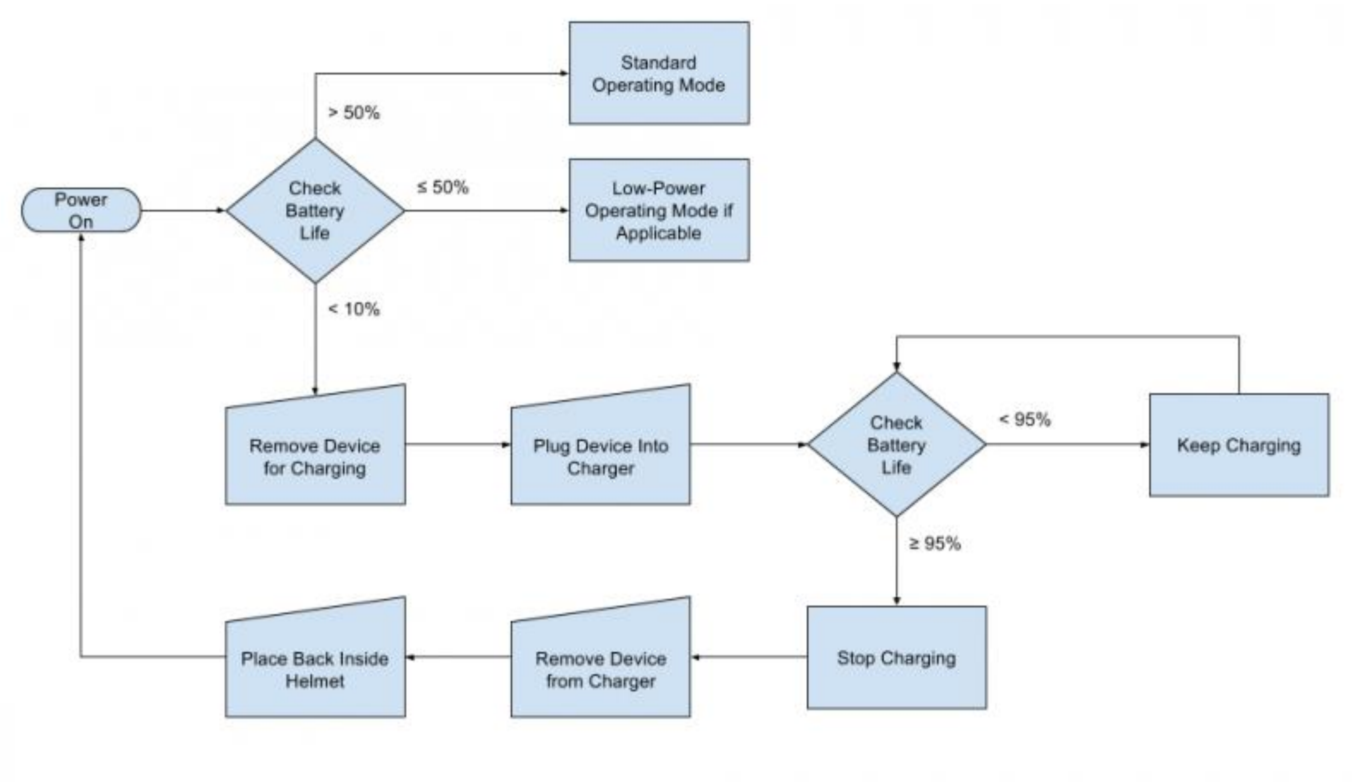


Figure 7: Power Management Flowchart

Our helmet must conform to HECC helmet regulations as detailed in ASTM F1045 [1]. Our required testing is detailed in these standards. The relevant tests include impact and extreme temperature. Other tests do not need to be completed by us, as we will not be modifying most parts of the helmet.

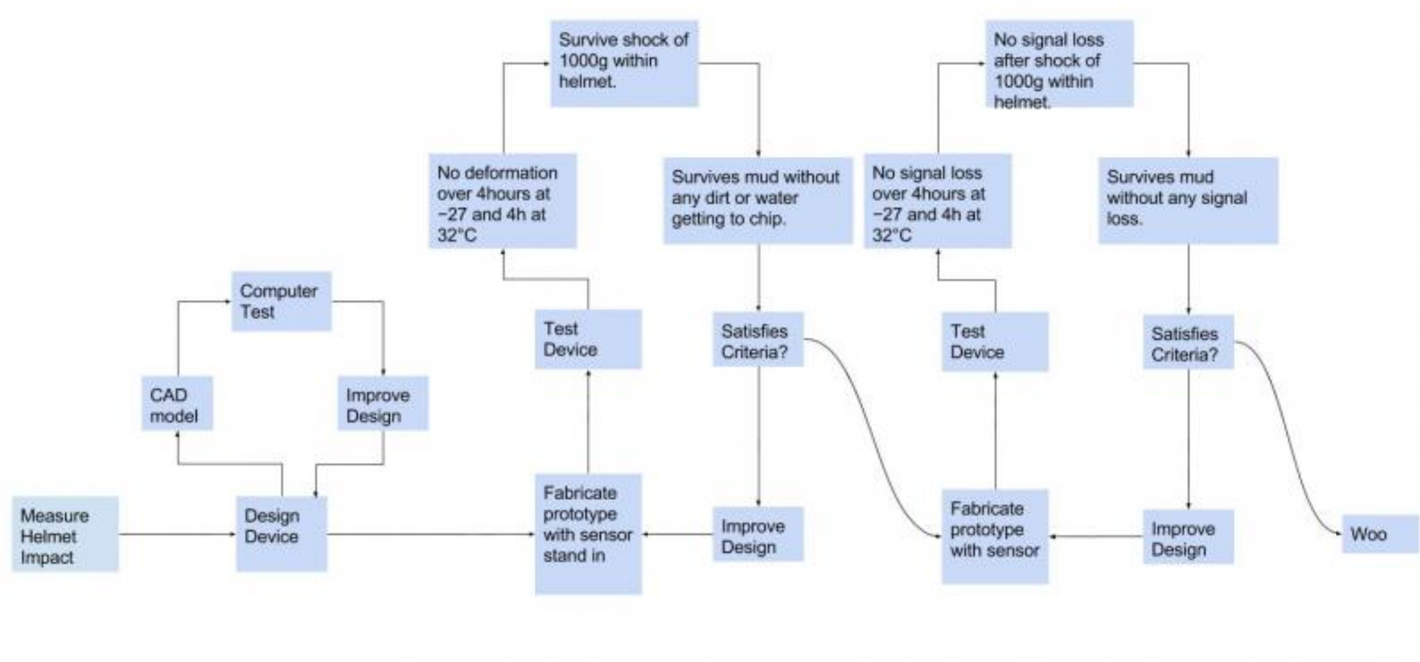


Figure 8: General Testing Flowchart

Phase 3 Work to do

Sensor Form

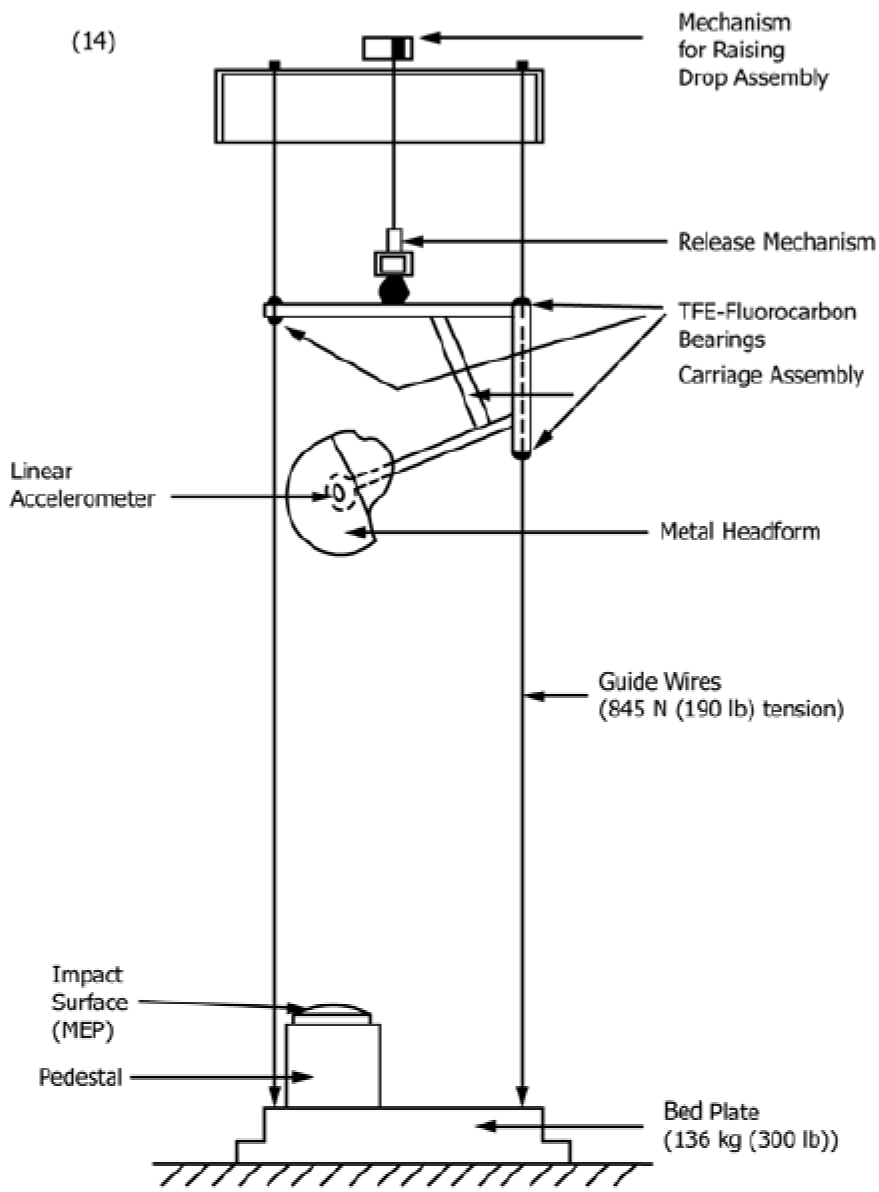
Although we want to directly attach our sensor to the helmet, we do not yet know where exactly to attach it. In order to decide between the 3 sensor locations shown in Figure 9, we will require impact testing to determine what location provides the best mix of accuracy and survivability.

Figure 9: Possible Sensor Placements. 1 - outside, 2 - inside padding, 3 - around head, 4 - large battery placement

We have a general design for our sensor casing which will be modified to fit within the helmet. It is simply a thin puck surrounding the sensor with outlets for the wires traveling to the battery case.

Systems Testing

Impact testing is detailed in ASTM F1045 [1]. The testing rig has been used by previous teams, and assembly instructions should be easy to find. We will run the impact test for each of our proposed sensor locations and compare their data to find the location with the best accuracy. We also must make sure that our device doesn't cause the helmet to fall below safety standards.



NOTE 1—Rail-guided drop assemblies are also permissible.

Figure 10: Testing Rig from ASTM F1045 [1]

Software Testing

In order for the system to work, multiple software systems must work independently and with each other.

- Gather Data: The Accelerometer must function and record data at all times. The gathered data must be stored on the device itself until it can be uploaded to the database. Testing this can be done in conjunction with impact testing, since data gathering will occur during impact once the device is in commercial use.
- Amazon Database: Test data upload and download reliability. The stored data must be able to be accessed quickly in order to make a decision.

- Decision Making: The final software system will use all of our data to determine if the player has received a concussion.
- Display Data: Once our device is reliably using data, the information needs to be displayed in an understandable format. Different methods of sending our data to and displaying it on a mobile device will most likely be our final test of our system.

The final test will be a full systems check, recording an impact, uploading the data, checking previous data, and making a decision for multiple impacts.

Electrical

The primary concern with our electrical systems are providing the correct amount of power to our sensor for the entirety of its operation. We already have a test running to find how long the sensor can measure and transmit data at our proposed cycle (see Figure 4). As of writing, the sensor has been running continuously for 2 weeks.

References

1. ASTM Standard F1045, 2016, “Standard Performance Specification for Ice Hockey Helmets,” ASTM International, West Conshohocken, PA, 2016, DOI: 10.1520/F1045-15, www.astm.org.
2. “The Quest for a Better Football Helmet.” *SI.com*, www.si.com/mmqb/2017/05/31/nfl-quest-better-football-helmet.