

## **1. PROBLEM STATEMENT**

The Workout Buddy, like any innovative solution, was born out of necessity. This necessity forms the backbone of Bravo Builders' design vision and paints a clear picture of the barren market that this product revitalizes.

### **1.1. Need Statement**

A cornerstone concept in the world of fitness, repetition counting is arguably the most important part of any training session [1]. Whether it be to gain muscle, lose weight, or just enjoy the setting, all gym-goers have a goal whose realization is dependent on rep counting of some form. However, an overwhelming majority of free weight workout equipment entirely lacks any system for repetition tracking, often leading users to forget where they are in their sets or even their workout as a whole. Additionally, internal factors resulting from fitness mismanagement, such as gym anxiety or a lack of motivation [2], push many further from their fitness goals rather than closer to them.

### **1.2. Objective**

The Workout Buddy is a sensor-driven solution that connects to a barbell and its respective rack. The Workout Buddy tackles the common conundrums of rep and set miscounting, newcomer gym anxiety, and poor exercise form. The device provides tracking of completed reps and sets as well as feedback on the quality of one's form. Sensors communicate with the core mounted system via Bluetooth connections. Users can connect to the mounted system via Near-Field Communication (NFC). The NFC chip contained within the rack system allows for the exchange of data between the sensor system and the user's smart device. Users can access logged data from their smartphone application. This app consists of workout metrics and feedback. The Workout Buddy displays the number of completed reps to the user and repeats the counting process for each set. Users can set and manage the desired number of reps in each set through the application, as well.

### **1.3. Background and Related Work**

The core theory behind this project is that most free-weight machines in the gym do not have a rep counter. This requires individuals to keep track of their own reps via notepad, manual entry into a fitness tracker, or in their heads [1]. The problem is that people often find it difficult to use any of these methods effectively without either losing track of their progress or diminishing the quality of their workout. Today's commercially available options do not include rep counters on standard free weight equipment. The only real-world example of a rep counter is on select cable machines, and even then, these counters do not provide the user with seamless connectivity and automatic data logging.

## 2. DESIGN REQUIREMENTS AND CONSTRAINTS

The Workout Buddy is a sensor system designed to track rep and set counts as well as form quality. The collected data is visualized on a display module mounted on the rack and later transferred to the user's smart device via wireless communication. The user can monitor workout data using their smartphone app in which rep/set counts and form feedback are stored. The application provides information on how users might also improve their form for a particular exercise.

### 2.1. Requirements

The design requirements for The Workout Buddy can be divided into two categories: broad marketing requirements for general consumer needs and practical engineering requirements to meet those needs.

#### 2.1.1. Marketing Requirements

The marketing requirements for The Workout Buddy consist of the following:

1. The Workout Buddy has a long-lasting battery life.
2. The device collects data from the sensor module and transmits data to the user.
3. The device is portable.
4. The device is durable.
5. The device is user-friendly and accessible.

Figure 2-1 illustrates the marketing requirements above as an objective tree.

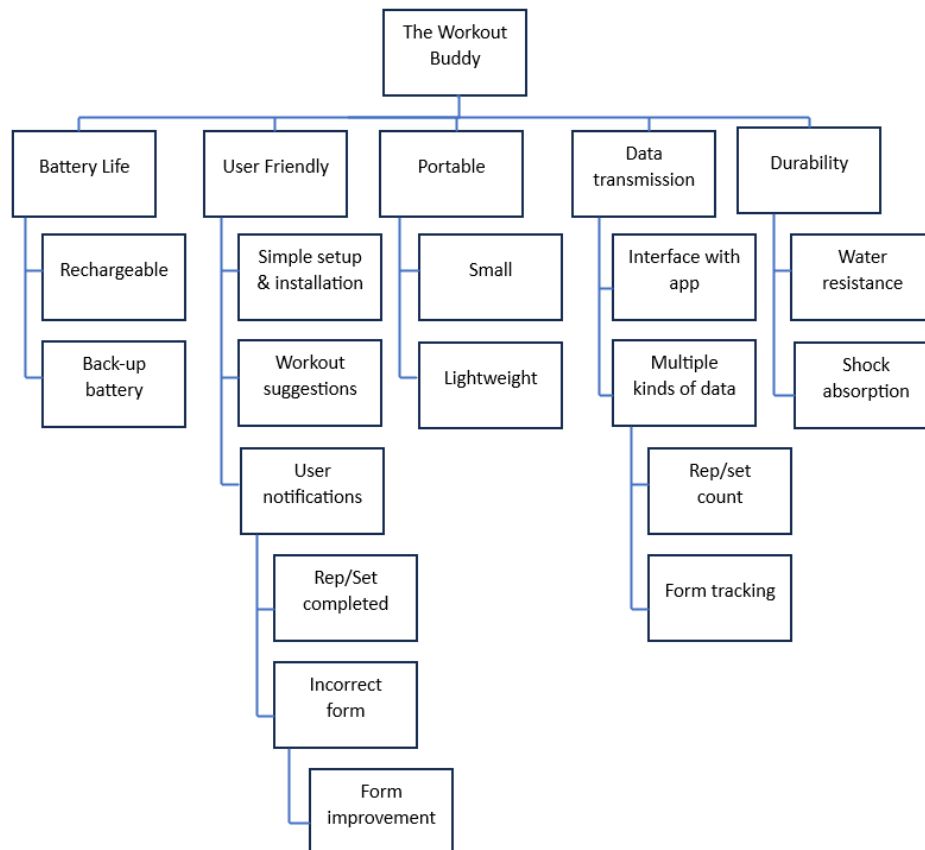


Figure 2-1. Objective Tree for The Workout Buddy

### 2.1.2. Engineering Requirements

The Workout Buddy's engineering requirements are tailored to ensure that the product meets all marketing requirements previously listed.

**Table 2-1: Engineering Design Requirements**

<b>Marketing Requirements</b>	<b>Engineering Requirements</b>	<b>Justification</b>
2, 5	The product meets or exceeds $X\%$ accuracy in rep detection and logging.	This accuracy ensures that the user receives an accurate number of reps and sets.
1	The average battery life of the product is at least $X$ hours in active use and $X$ hours in standby mode.	The Workout Buddy has a long battery life so that the user is not required to charge the battery frequently.
2, 5	The product includes a visual display of the current number of reps completed and number of sets completed/remaining.	The user can see the number of reps and sets they have done on a digital screen.
3, 5	Product does not exceed safe levels of electromagnetic (EM) radiation at proximity.	This limit ensures that the user can safely use The Workout Buddy without adverse effects.
5	The Workout Buddy includes a short-range communications system to receive user data from and transmit metric data to the user's smart device.	The user can easily connect to The Workout Buddy system and seamlessly receive workout metrics.
2, 5	The product includes an audio output for feedback to the user as each rep/set is completed.	The device outputs a notification sound letting the user know that the set or workout is done.
3	The sensors are housed in a protective casing for environmental resilience.	The sensor system is in a case that protects it and any wires from user sweat or other liquids, such as water.

## 2.2. Constraints

Table 2-2 contains a categorized list of design constraints along with a brief description of each element.

**Table 2-2: Constraints**

Type	Name	Description
Economic	Cost	The Workout Buddy has a \$1,000 development budget provided by Mississippi State University.
Economic	Time	The design team has two semesters in which to complete a working prototype.
Manufacturability	Size	The equipment dimensions do not interfere with the use of a standard 1-inch barbell.
Manufacturability	Weight	The total weight of equipment on a barbell does not exceed 2.5 pounds.
Health and Safety	Safety	Wires and equipment are isolated and protected from the user/environment.
Technical	Communication	The NFC transmitter has a maximum range of 4 cm.

The above constraints are elaborated upon further in the following subsections.

### 2.2.1. Economic Constraint

Bravo Builders have two economic constraints: a time constraint and a financial constraint. Bravo Builders are given two semesters to design, research, and develop a working prototype. In addition to this timeline, a total project budget of \$1,000 is provided for both design phases. The costliest part of this project is the gym equipment required for testing. The circuit components are inexpensive, providing the opportunity for extensive testing prior to prototyping. The project is required to stay under approximately \$700 in costs for the first semester design phase, leaving \$300 dollars for the second semester design phase.

### 2.2.2. Manufacturability Constraint

The Workout Buddy does not interfere with typical use of a standard 1-inch barbell, and it does not have a weight greater than 2.5 pounds. The weight requirement prevents a non-negligible amount of weight from being added to the barbell without user knowledge.

### 2.2.3. Health and Safety Constraint

The health and safety concerns of this project revolve around the fitting of the circuit components. All sensors and wires are closed off from the outside environment to prevent harm to the user or equipment. The sensors on the barbell do not interfere with user hand placement at any time during the use of this product.

### 2.2.4. Technical Constraint

The NFC transmitter cannot exceed a range of 4 cm according to NFC standards [3].

## 2.3. Standards

Bravo Builders abide by the engineering standards listed in Table 2-3 as The Workout Buddy continues to be developed and tested. These standards ensure the safety of the user, the stability of the product, and the reliability of the design and product testing. If Bravo Builders are required to alter the standards, then the proper amount of testing is performed to ensure the product meets the newly established standards.

**Table 2-3: Engineering Standards**

Specific Standard	Standard Document	Specification/Application
IP-67 [7]	IEC (International Electrotechnical Commission) Standard 60529	The Workout Buddy is water and sweat proof. This ensures the safety of the equipment and user.
ISO/IEC 18092:2013(E) [3]	NFCIP-1	The data is transmitted from the base station to the user's smartphone.
IEC 61960-3:2017 [4]	IEC standards for battery power electronics	This standard ensures that the battery is safe for consumers to use.
IEEE 829-2008 [5]	IEEE (Institute of Electrical and Electronics Engineers) standard for software and system test documentation	This standard is for software testing when using a software-based system.
Bluetooth Core Specification Version 5.4 [6]	Bluetooth Core Specification Version 5.4	This standard is used to communicate between the sensor and the home base.

These standards are explained in more detail in the following subsections.

### 2.3.1. Electrical Standards

The Workout Buddy requires a compact, long-lasting battery to power the sensors required to collect relevant data. IEC 61960-3:2017 [4] enumerates the requirements for safe battery operation in consumer electronics.

### 2.3.2. Communication Standards

The Workout Buddy utilizes NFC connections to transmit workout data from the core system to the user's smartphone.

### 2.3.3. Testing Standards

The Workout Buddy follows the testing standards outlined in IEC Standard 60529 for water resistance. The same standard is applied for testing dust resistance. To test The Workout Buddy's engineering requirements, the testing standards from IEEE 829-2008 [5] are followed. This standard describes the process of testing software-based systems to ensure the system satisfies the needs of the user.

## 2.4. REFERENCES

- [1] B. Skwarecki, “How to count reps and sets of an exercise when your brain just won’t pay attention,” Lifehacker, <https://lifehacker.com/how-to-count-reps-and-sets-of-an-exercise-when-your-brain-1847239060> (accessed Sep. 18, 2023).
- [2] Psychreg, “Why people stop going to the gym,” Psychreg, <https://www.psychreg.org/why-people-stop-going-gym/> (accessed Sep. 18, 2023).
- [3] *Information technology — Telecommunications and information exchange between systems — Near Field Communication — Interface and Protocol (NFCIP-1)*, International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 18092:2013, March 2013. [Online]. Available: <https://www.iso.org/standard/56692.html> (accessed Sep. 18, 2023).
- [4] N. Internationale, “IEC 61960-2003 - evva-tech.com,” IEC 61960 standard document, <http://evva-tech.com/uploads/IEC%2061960-2003.pdf> (accessed Sep. 29, 2023).
- [5] IEEE standard for software and System Test Documentation - GitHub Pages, <https://malenezi.github.io/malenezi/SE401/Lectures/5-Test%20Management/IEEE%20Standard%20829-2008.pdf> (accessed Sep. 29, 2023).
- [6] M. Woolley, Bluetooth® Core Specification version 5, [https://www.bluetooth.com/wp-content/uploads/2023/02/2301\\_5.4\\_Tech\\_Overview\\_FINAL.pdf](https://www.bluetooth.com/wp-content/uploads/2023/02/2301_5.4_Tech_Overview_FINAL.pdf) (accessed Sep. 29, 2023).
- [7] “IP ratings,” IEC, <https://www.iec.ch/ip-ratings> (accessed Sep. 29, 2023).