1. PROBLEM STATEMENT

Pet owners do not have many options for being able to monitor the well-being of their pets, particularly in real-time. In situations where a pet's vital signs would have to monitored (e.g. during physical activity, after medical treatment, etc.), having the ability to do so would be of the utmost value.

1.1. Need Statement

Given pet owners' need to monitor their pet's vital signs, this invites an opportunity for a wearable device that can provide access to these figures. The easiest way that this could be achieved on the user end would be via a mobile application or web interface.

1.2. Objective Statement

The objective of this project is to design and prototype a system that enables easy access to their pet's vitals so that their health can be proactively monitored. This should be done via the web-based interface or mobile app to provide a simple user experience.

1.3. Background and Related Work

The Safe Paws project is motivated by the need for a solution to monitor a pet's vital signs and health with constant observations.

2. DESIGN REQUIREMENT SPECIFICATIONS

Safe Paws is a health-monitoring vest designed to ensure the well-being and safety of our dog pets. The vest incorporates multiple sensors that detect/monitor the dog's vital signs. Including their heart rate, body temperature, activity level, and respiratory rate. The user monitors and controls the system wirelessly through the Safe Paws smartphone application. The pet's vitals may be viewed in real-time or as a collection of historical data. This section discusses the specific design requirements, technical constraints, practical constraints, and engineering standards that will drive the development of the Safe Paws pet monitoring vest.

2.1. Requirements

The necessary design requirements as listed in Figure 2-1 and Table 2-1, define the Safe Paws design specifications. These requirements ensure that the product satisfies customer needs and works within the devices technical constraints. This section discusses the marketing and engineering requirements which guides the development of Safe Paws as a health monitoring solution.

2.1.1. Marketing Specifications

This section presents the marketing specifications of Safe Paws.

I. User Experience
    i. Low cost
    ii. Durable
        a. Water/moisture resistance
        b. Outdoor/Indoor temperatures
    iii. Easy to use

iv. Pet-safe

II. Functionality
    i. System connects with a smartphone application and/or web interface
    ii. App provides notifications/alerts to customers
    iii. Long operating time
    iv. Rechargeable battery

III. Performance
    i. Accurate
    ii. Multiple methods to view data wirelessly
        a. Real-time data monitoring
        b. Historical data analysis

Figure 2-1 displays the Safe Paws objectives to satisfy customers' needs.

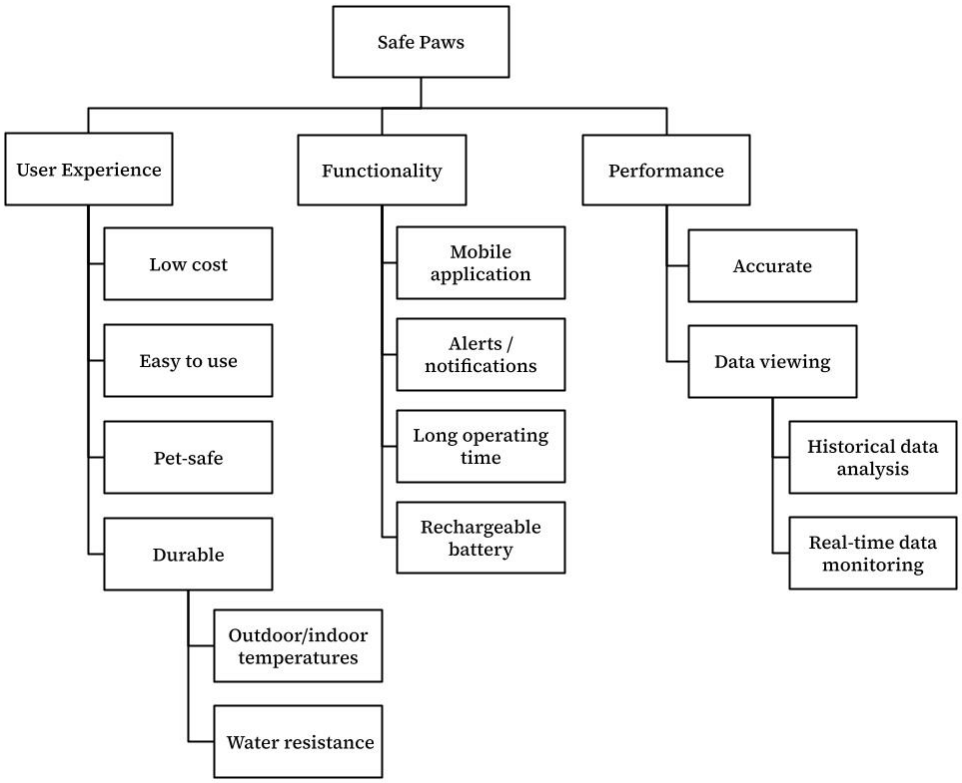

Figure 2-1: Objective Tree for Safe Paws

These marketing requirements are the basis for the engineering requirements.

2.1.2. Engineering Specifications

This section presents the engineering specifications of Safe Paws.

Table 2-1: Engineering Design Requirements

Marketing Requirements	Engineering Requirements	Justicifation

2	The data is accurate and precise.	To produce reliable vital signs data with an error of ≥5% for all sensors.
1-2	The system connects and communicates wirelessly.	To support wireless communication protocols, such as Bluetooth or Wi-Fi, in connectivity with the Safe Paws application.
1-3	The system sends notifications.	To send alerts to user's app when pet is outside of safe health parameters.
2-3	The system sustains a good operating battery life.	To provide a minimum of 12 hours of continuous operation, with a low-battery warning sent to the user's device when the battery level falls below 20%.
3	The vest and the electronics sustains resistances to water and dust.	To be rated at least IP rating of 67 for water and dust resistance to ensure durability and protection in various environments.
Marketing Requirements 1. The system should be easy to use. 2. The system should be accurate. 3. The system should be sustainable.		

The Safe Paws meets the engineering specifications set upon by technical needs.

2.2. Constraints

This section defines the product's technical and practical constraints, as listed in Table 2-2. The constraints in the Safe Paws system include the developmental cost and time limitations, durability to the typical behavior and environments of dogs, pet safety, battery life, and size and weight limitations for the dogs wearing the vest.

Table 2-2: Constraints

Type	Name	Description
Economic	Development Limitations	The project does not exceed the budget of $1000 and the project timeline of two semesters.
Environmental	Durability	The vest does withstand the typical dog indoor and outdoor environments and normal wear and tear.
Health and Safety	Pet Safety	The product design must not harm the dog.
Power and Performance	Battery Life	The battery does operate for a minimum of 12 hours on a single charge.

Usability	Size and Weight	The vest must be designed for dogs weighing 50-90 pounds. The vest weighs 5-9 pounds.
Manufacturability	Operating Temperature	The overall system including its sensors and devices does not exceed 100 °F. This keeps the device well under its recommended operating temperature [4] and will cause overheating/discomfort for the pet.

The constraints guide the development of the Safe Paws product.

2.2.1. Economic Constraints

The design project operates within a budget of $1000 and is constrained by the timeline of two semesters, with functioning subsystems due at the completion of the first semester. This means that design decisions, material choices, and development processes align with the available financial resources and adhere to the project schedule.

2.2.2. Environmental Constraints

The Safe Paws vest is designed to withstand the typical dog environments along with the wear and tear it may encounter during a dog's daily activities. These environments include exposure to a degree of weather conditions, outdoor activities, and the potential for rough handling.

2.2.3. Health and Safety Constraints

The product must prioritize the safety and well-being of the pet wearing the vest. It should not cause any harm, discomfort, or stress to the dog. The design utilizes electric and electronic devices that do not generate high temperatures. The design is pet-friendly, ensuring that the dog can wear the vest comfortably for the daypart [1].

2.2.4. Power and Performance Constraints

The vest's performance is constrained by the requirement to operate continuously for a minimum of 12 hours on a single battery charge. This constraint is critical to ensure that pet owners can rely on the device for extended monitoring periods without frequent recharging.

2.2.5. Usability Constraints

The vest’s design centers on accommodating the dog’s weight and strength. The vest, in its current state, weighs 5-9 pounds. Since research shows that a dog can comfortably carry up to 10 percent of its body weight throughout the day [Citation], then the vest is designed to target dogs between 50 and 90 lbs. It holds a balance between size and weight to avoid hindering the dog's mobility and to ensure the vest is wearable without causing discomfort.

2.2.6. Manufacturing Constraints

Safe Paws design focuses on ease of manufacturing by not requiring any special parts or machining for assembly, and by being made from an easily worked material.

2.3. Standards

Table 2-3 outlines the engineering standards that Safe Paws satisfies. These standards are set and/or enforced by government law and regulations and organizations like The International Electrotechnical Commission (IEC), Institution of Electrical and Electronics Engineers (IEEE), and American National Standards Institute (ANSI) guarantee industrially acceptable aspects of the design.

Table 2-3: Engineering Standards

Specific Standard	Standard Document	Specification / Application
Public Law 89-544	The product follows the Animal Welfare Act [2].	Relates to animal testing and welfare.
IEC 62368-1	This product meets the Safety of Audio, Video, and Similar Electronic Apparatus [3].	Relates to the necessary safeguards to prevent electrical hazards like wire covering and insulation work.
IP-67	The product meets Ingress Protection Standard 60529 set by the International Electrotechnical Commission [4].	Dust-tight, immersion up to 1 m depth.
IEEE 802.11	Bluetooth connectivity allows for remote data transmission.	Relates to Bluetooth connectivity for data transmission between vest and user’s application
ANSI/AAMI EC13-1992	Safe Paws follows the requirements of Cardiac Monitors, Heart Rate Meters, and Alarms in electronic devices [5].	Relates to heart rate monitoring accuracy and safety.

The Safe Paws meets the engineering standards set upon by technical needs.

2.3.1. Animal Welfare and Ethical Testing Standards

In alignment with ethical considerations and legal requirements, the testing standard includes protocols for conducting animal testing, if necessary. It ensures that any animal testing conducted adheres to the Animal Welfare Act, prioritizing the welfare and ethical treatment of animals involved in testing.

2.3.2. Connectivity and Communications Standards

To ensure seamless data transmission between the vest and the user's application, the testing standard includes procedures based on IEEE 802.11. The standard evaluates the reliability, security, and compatibility of the vest's Bluetooth connectivity, verifying that it meets industry best practices.

2.3.3. Safety Standards

To achieve electrical and operating temperature safety, certain measures and tests from IEC 62368-1 and IEC 60950 standards are being used. The testing evaluates the vest's electronic components for full compliance with safety requirements, effectively mitigating electrical risks. This measure ensures the vest is reliable and safe for both pets and their owners.

2.4. References

[1] “Animal Welfare Act,” USDA APHIS | Animal Welfare Act, https://www.aphis.usda.gov/aphis/ourfocus/animalwelfare/sa_awa (accaessed Sep. 29, 2023).

[2] “IEC,” IEC 62368-1:2018 | IEC Webstore, https://webstore.iec.ch/publication/27412 (accessed Sep. 29, 2023).

[3] Arduino Support Team, “What is the operating temperature range for Arduino boards?,” Arduino Support, https://support.arduino.cc/hc/en-us/articles/360016076980-What-is-the-operating-temperature-range-for-Arduino-boards- (accessed Sep. 30, 2023).