**2. DESIGN REQUIREMENTS/CONSTRAINTS**

The Horse Health Monitoring (HHM) team aims to create a device that will measure a horse’s temperature and heart rate in order to provide an early warning system that reports declining horse health to horse owners. The HHM device must allow users to configure the reporting settings for the device as well as receive immediate notifications if a horse’s health is in jeopardy. The intent in developing this system is to allow horse owners to catch abnormal horse health as soon as possible so that they may treat a horse’s illness before severe or fatal conditions arise. Precision is key regarding the measurement of a horse’s health as the ranges for nominal and abnormal temperature and heart rate leave little room for error. Following this paragraph are the constraints used to design the HHM device, divided into two subsections: technical design constraints and practical design constraints.

**2.1 Technical Design Constraints**

The five technical constraints listed in Table 2.1 outline the necessary metrics the Horse Health Monitoring team must meet to establish an operational prototype.

Table 2.1 Technical Design Constraints

|  |  |
| --- | --- |
| **Constraint** | **Description** |
| Temperature Sensor Accuracy | The temperature sensor must measure the horse’s temperature within a degree Fahrenheit of the rectal thermometer measurement between the range of 90˚F and 110˚F. |
| Pulse Sensor Accuracy | The pulse sensor must be able to give an accurate heart rate between the range of 25 and 200 beats per minute (bpm). |
| Ingress Protection | The device must adhere to Ingress Protection Rating IP56. |
| Battery Life | The device battery must maintain device operation for a minimum of 12 hours. |
| User Notifications | The device must update the user via text message at certain intervals based upon the user’s discretion as well as alert the user to unusual horse health activity. |

**2.1.1. Temperature Sensor Accuracy**

The HHM device will utilize a temperature sensor probe that must accurately retrieve the core temperature of a horse via placement in the horse’s ear. Nominal horse core temperature during rest ranges from 99.5˚F to 101.5˚F [1]. Acquiring a horse’s temperature to the tenth of a degree is of the utmost importance as slight changes in temperature during rest must be identified to increase the chance of detecting an illness. The temperature sensor probe must also be able to acquire a core temperature range of 90˚F to 110˚F to allow the user to continue to monitor the horse’s core temperature outside nominal ranges in the event of an illness or if the horse is experiencing symptoms of shock. Being able to retrieve a horse’s core temperature in these ranges with the accuracy described will allow a user to effectively monitor a horse’s health as well as quickly detect changes in nominal core temperature, increasing a horse’s chance of recovery from illness.

**2.1.2. Pulse Sensor Accuracy**

A pulse sensor probe will be utilized by the HHM device to accurately retrieve the heart rate of a horse. An adult horse’s nominal heart rate ranges between 28 and 40 bpm; however, illness, excitement or strenuous exercise can raise a horse’s heart rate to as high as 200 bpm [1]. The HHM pulse sensor probe must be able to measure a horse’s heart rate between the ranges of 25 and 200 bpm, allowing users to acquire an accurate representation of their horse’s health and fitness.

**2.1.3. Ingress Protection**

The HHM device must be able to operate in the elements of an outdoor barn and range. The device, including probes and wired connections, must meet Ingress Protection Rating IP56 to protect the device from “limited dust and high pressure water jets from any direction” [2]. This standard of protection is needed because outdoor barns are notoriously dusty, and if a horse is cleaned with hoses or jets, the device will be able to withstand the ingress of water. These standards protect the device from barn conditions as well as when the horse is free to roam.

**2.1.4. Battery Life**

The battery of the HHM device must sustain operations at a minimum of 12 hours with any device reporting settings the user configures. The target audience consistently monitors the horses during working hours but needs a device to monitor a horse’s health and fitness during hours when owners are away from the barn and/or range. This objective will be achieved through practicing low-power system design and the utilization of low-power probes and peripherals. A 12-hour battery life would be able to cover evening and early morning times when the horses are placed in the barn, resting and unmonitored.

**2.1.5. User Notifications**

The HHM device must update a user via text message. The user must be able to configure how often notifications are received as well as receive notifications when a horse’s health is outside nominal resting ranges. These notifications must include core temperature, resting heart rate, name and date. The ability to communicate to the user with consistent notifications allows the user access to a historical log of the horse’s vitality and helpful on-the-spot information.

**2.2 Practical Design Constraints**

The five practical constraints listed in Table 2.2 outline the needs the Horse Health Monitoring team must meet to establish an operational prototype.

Table 2.2 Practical Design Constraints

|  |  |  |
| --- | --- | --- |
| **Type** | **Name** | **Description** |
| Health | Safety | The Horse Health Monitoring system must not be hazardous or dangerous to horses. |
| Economical | Cost | The system must stay at a low cost for consumers because horses are already costly. |
| Durability | Damage | The system must be installed somewhere on the horse, where it will not get damaged by the horse. |
| Ethical | Reliability | The system must satisfy the goal of saving horse’s lives. |
| Manufacturability | Size | The system must be able to fit on varies sizes of horses. |

**2.2.1 Health**

The objective is to make this product as safe as possible while tending to a horse’s needs. Safety is one of the main priorities of the HHM design because of how much some horses show discomfort to internal invasion. The Horse Health Monitoring system must not be hazardous or dangerous to all horses when measuring its temperature and pulse. This system comes with an adjustable strap around the horse’s jowl for comfort and is low powered so it will not overheat while it is attached.

**2.2.2. Economical**

The goal of this product is to ensure cost efficiency for the consumers. The product must remain at a lower price than its competition because it is understood by most owners that horses are costly. Each competitor’s health systems cost over $350 with additional fees that notify the user of the horse’s health. The estimated cost of the HHM system will be $200 to compete with the other products that average $400.

**2.2.3. Durability**

Most of the time, horses like to lay on their side so it is impossible to place a system on its belly or its side. The HHM system must be placed somewhere the horse will not damage the product. Therefore, resulting in using an adjustable strap around their jowl so they cannot harm the system when they are ill or tired. The strap allows the owner to place the device anywhere on the horse that will feel comfortable to the horse, although the jowl is preferred and recommended. The goal is to make sure the device works at all times no matter what the horse may do on its daily basis.

**2.2.4. Ethical**

The overall target is to ensure and uphold the purpose of saving as many horse’s lives by notifying the owner of its health. Due to the purpose being held by this device, the system must operate accurately at all desired times.

**2.2.5. Manufacturability**

The Horse Health Monitoring System must fit on all sizes of a horse from newborn to adult. The device must accommodate all different body types of horses in one design. It is important that the horse will be monitored without having the consumer buy another system strictly because it a size that does not fit.

**References**

[1] Brett D. Scott, Ph.D. and Mike Martin, DVM, *Understanding Vital Life Signs in Horses* [Online]. Available: http://texashelp.tamu.edu/005-agriculture/pdf/understanding-vital-life-signs-in-horses.pdf [Accessed: February 1, 2017]

[2] DSMT.com, “IP Rating Chart | DSMT.com”, 2017. [Online]. Available: http://www.dsmt.com/resources/ip-rating-chart/ [Accessed: February 1, 2017]

[3] searchmobilecomputing.com, “GSM (Global System for Mobile communication)”, 2007. [Online]. Available: http://searchmobilecomputing.techtarget.com/definition/GSM [Accessed: February 1, 2017]