SECOND SIGHT

School of Engineering Science • Burnaby BC • V5A 1S6

http://www.sfu.ca/~asomody • second-sight@sfu.ca

October 15th, 2000

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 340 Wireless Child Tether Functional Specifications

Dear Dr. Rawicz,

The following document, *Wireless Child Tether* F*unctional Specifications*, describes the requirements for our wireless child tether. The goal of this project is to alert parents if their child wanders outside a predetermined area and to then provide means for tracking the child.

This document describes the high-level functions of our system as a whole. This document also describes the more specific functions of both the parent and the child units that make up the overall system.

Second Sight Systems (SSS) consists of four talented and motivated third-year engineering students – Ian Foulds, Shaun Louie, Desmond Lee, and Andy Somody. If you have any questions concerning this project, please contact me by email at ifoulds@sfu.ca or by phone at 926-6921.

Sincerely,

Ian Foulds
President and CEO
Second Sight Systems

Enclosure: Wireless Child Tether Functional Specifications

Wireless Child Tether

Functional Specifications

Submitted By: Ian Foulds
Andy Somody
Shaun Louie
Desmond Lee

Contact: Ian Foulds
ifoulds@sfu.ca

Submitted To: Dr. Andrew Rawicz – ENSC 370
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

Submitted On: October 15th, 2000

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Executive Summary

The Second Sight wireless child tether acts as a child's tireless guardian. It consists of two complementary transceiver units – one for the parent, the other for the child. If the child wanders farther than a predetermined distance from the parent, an alarm on the parent's unit is activated. The parent can then use their unit to determine the direction of the missing child. Alternatively, the parent can remotely activate a distress alarm on the child's unit.

While child-monitoring systems are nothing new, the Second Sight wireless child tether has several key advantages over previous design solutions. There is no physical connection between the parent and child, which allows both parties freedom of movement. Additionally, our wireless child tether gives information about the child's direction, a feature missing from currently available design solutions.

The wireless child tether is a radio frequency system consisting of two devices operating in the 2.4 GHz range. The parent will carry one device, and the child will carry the other device. The parent will track the child in the event that the child ventures beyond a user defined signal-strength threshold. The parent will then have the choice of activating an audible alarm on the child unit. Considerations have also been given to safety, reliability, and testing issues

Introduction

Children don't always understand the need to stay close to their guardians and tend to wander. At Second Sight Systems, our goal is to develop technology that helps guardians protect their children. Physical child tethers have been in existence for quite some time now but they have the disadvantage of being unwieldy and awkward. The physical tether is forever getting tangled around objects and even other people. It becomes a nuisance in large crowds, which ironically is where it is needed most. Fortunately, we at Second Sight have devised an elegant alternative – the wireless child tether.

The wireless child tether will allow both parent and child the freedom of movement but will help the parent to keep their child from wandering. An alarm is activated on the parent's unit when the signal strength of the child's transmitter is below a user-defined threshold at the parent's location. The parent's unit can then be used either to determine the direction in which their child has wandered, or set off an alarm on the child's unit.

In this document we will layout the functional framework that we hope to achieve with our wireless child tether. We begin with an overview of the system functionality as a whole and then go on to discuss other requirements such as electrical, physical and reliability. We will finish off by identifying possible system limitations. The purpose of this document is to focus our goals for the wireless child tether and provide a framework to which we can keep ourselves accountable.

System Overview

Second Sight's Wireless Tether System incorporates two devices, one for the child and one for the parent. The system will give an audio and vibration warning if the child's device is too far away from the parent's device. The parent has the ability to set off an alarm on the child device, and use the direction finding LED's to determine the general direction of the child device.

Figure 1 shows the Wireless Tether System block diagram. The details of each block are discussed in later sections.

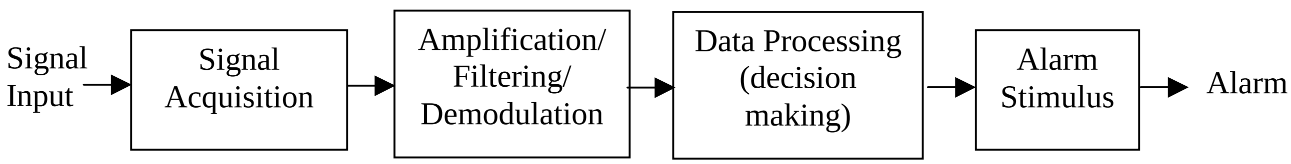

Figure 1: System Block Diagram

The Wireless Tether System will:

- utilize RF signals (~2.4 GHz) to communicate between the two devices.
- have a response time of no more than 1 second; the response time being the time for the parent device to decode the incoming signal and make a determination as to the condition of the child device.
- have a variable signal strength threshold to vary the allowable separation of the child device.
- operate a simple LED display to report the general direction of the child device.
- have an audio/vibration warning system that warns the parent of an event with the child device (i.e. too far away or loss of signal).
- have a separate LED display that reports system status and the type of distress with the child device.
- utilize batteries as power supply.
- have a power switch on the child device. Future designs will employ a locking mechanism that will prevent unauthorized removal and turning off of the child device.

Signal Acquisition

The first stage of the Wireless Tether System will receive a signal from the child device. Figure 2 shows the context diagram for this stage.

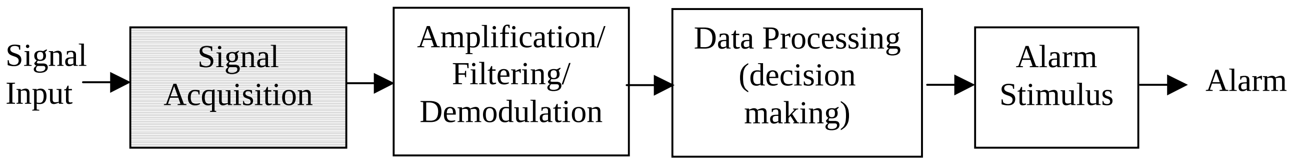

Figure 2: Signal Acquisition Stage Context Diagram

Figure 3 shows the functional block diagram of this stage

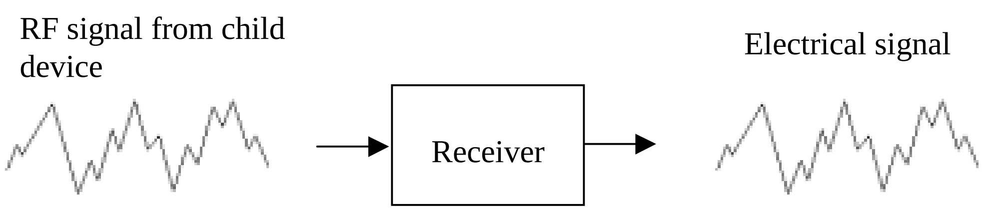

Figure 3: Signal Acquisition Stage Block Diagram

The receivers used to acquire the input for this system will be incorporated in a transceiver device. The type of transceiver to be used will:

- transmit RF signals whose frequency is 2.4 GHz.
- receive RF signals emitted from the other device.
- have a high signal to noise ratio.
- be small enough to fit inside the child device (size constraints on the parent's device are not as critical).
- transmit and receive to distances of 50m in an open area.
- pass the acquired signal to the signal conditioning system.

Signal Amplification / Filtering / Demodulation

The second stage of the Wireless Tether System will condition the signal acquired during the signal acquisition stage. The conditioning process consists of amplifying the signal, filtering the desired frequencies, and demodulating the signal. The output from this stage will be a clean signal that the signal processing stage will be able to interpret. Figure 4 shows the context diagram for this stage.

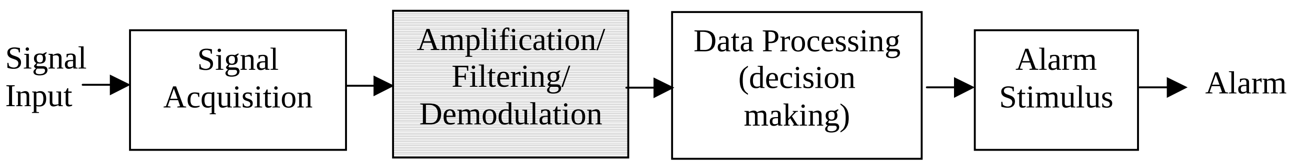

Figure 4: Amplification / Filtering / Demodulation Stage Context Diagram

Figure 5 shows the functional block diagram of this stage.

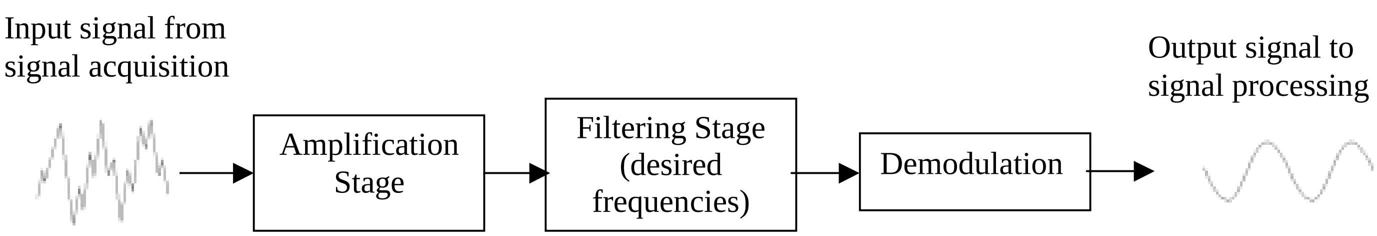

Figure 5: Amplification / Filtering / Demodulation Stage Block Diagram

This stage of the Second Sight system will:

- receive input from the signal acquisition stage.
- amplify the signal that will be required in the signal processing stage.
- filter out all signals that are not in the 2.4 GHz range.
- reduce the amount of noise in the signal.
- provide an input for the signal processing stage.

Data Processing

The third stage of the Wireless Tether System will receive the conditioned signal as input, process the data contained in the signal, and generate an appropriate signal for the actuator. Figure 6 shows the context diagram for this stage.

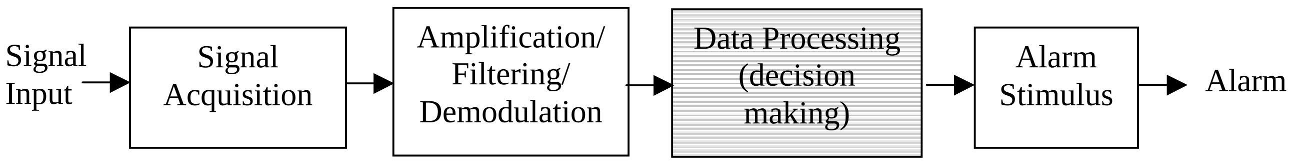

Figure 6: Data Processing Stage Context Diagram

Figure 7 shows the functional block diagram of this stage.

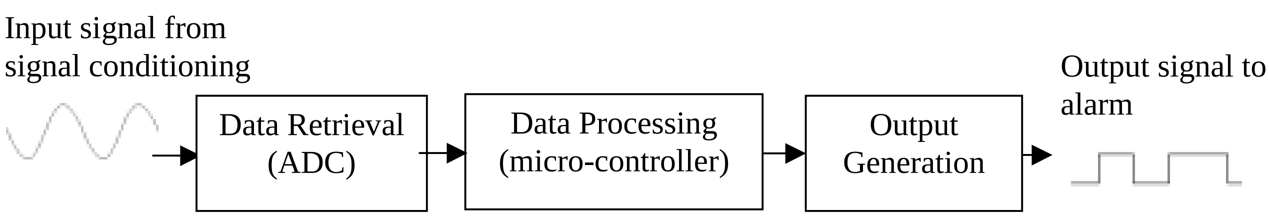

Figure 7: Signal Processing Stage Block Diagram

Data Processing

Before the analog signal is digitized, the signal strength will be required to determine the distance the child device is away from the parent device. The analog signal is then digitized so that it can be analyzed using a micro-controller. At this point, depending on the circumstances of the child device, a specific digital signal is sent to the actuator informing the parent of the recent event. The parent has the option of sending a command back to the child unit to turn on an audible alarm. Figure 8 is a flow chart showing how the signal is analyzed.

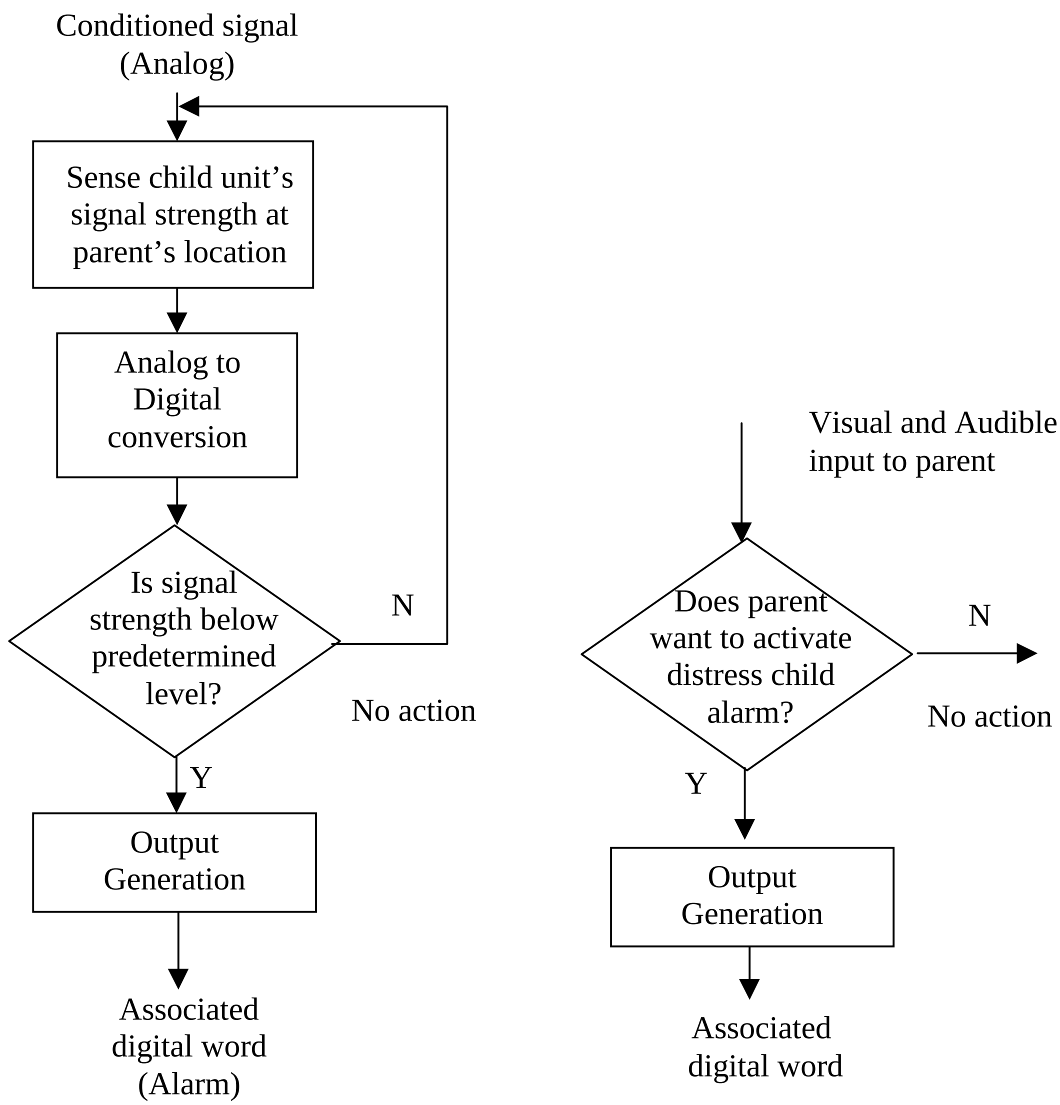

Figure 8: Flow Chart for Signal Analysis

Output Generation

If the processor has triggered a response it will generate an output that will activate the actuator. The parent unit has two actuators, an audible alarm and direction LED's, so the appropriate actuator must recognize the incoming command to turn itself on or off. To accomplish this, different words of digital data will be transmitted depending on the actuator that is to be activated.

Processing Unit

The entire signal processing stage will be implemented using a micro-controller, which must analyze the incoming conditioned data, and generate an appropriate output. The micro-controller to accomplish the above tasks will have the following features:

- analog to digital converter.
- data port
- continuous analysis
- I/O pins
- real-time processing

Alarm Stimulus

The final stage of the Wireless Tether System will decode the signal from the signal processing stage and actuate an audible alarm or direction LED's. Figure 9 shows the context diagram of this stage.

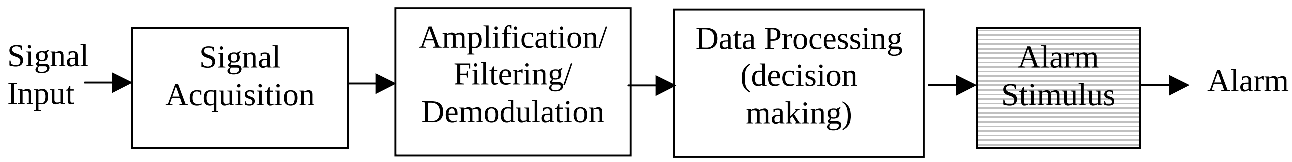

Figure 9: Alarm Stimulus Stage Context Diagram

Figure 10 shows the functional block diagram of this stage.

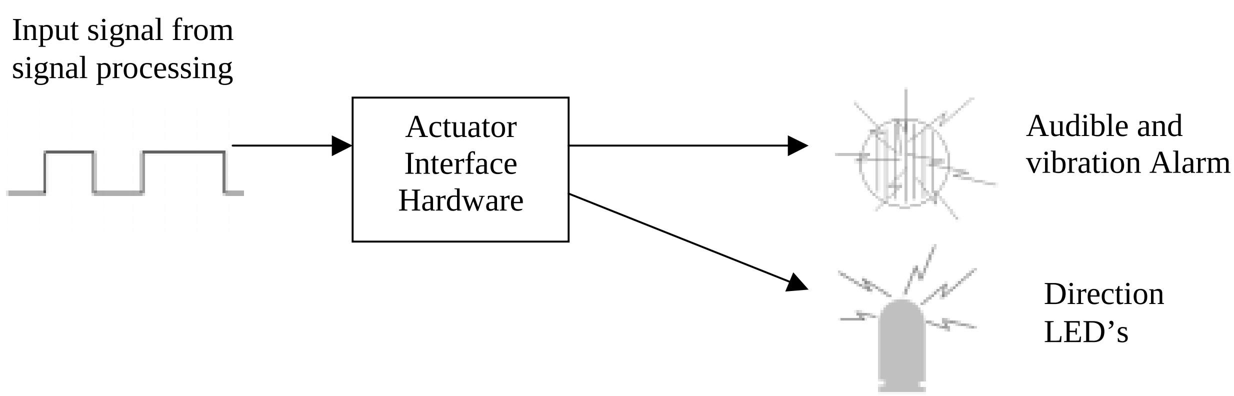

Figure 10: Alarm Stimulus Stage Functional Block Diagram

The Alarm stimulus will:

- receive a logical word from the signal processing stage.
- decode the incoming logic to switch on or off the appropriate actuator.
- be able to attract the attention of the parent, especially in the case of the alarm.
- give useful information to the parent with regard to direction finding.

Physical Requirements

Physically, the wireless child tether will be a non-intrusive, self-contained product. Our system requires both the parent and child to wear a small electronic device similar to that of a modern day pager. We will design the units to be non-cumbersome and non-restrictive to the users movement. The parent and child units will differ from each other, as the child unit will not require all of the functions that the parent's does.

The parent's unit is required to signal the adult user in the event that the child has gone too far and give a sense of the direction in which the child has gone. The unit will be made with a simple user interface. The parent unit illustrated in Figure 11 will be composed of:

- ON/OFF switch,
- Directional indicator,
- Alarm (both audio and vibration),
- Sensitivity control knob,
- Low power indicator.
- Panic button

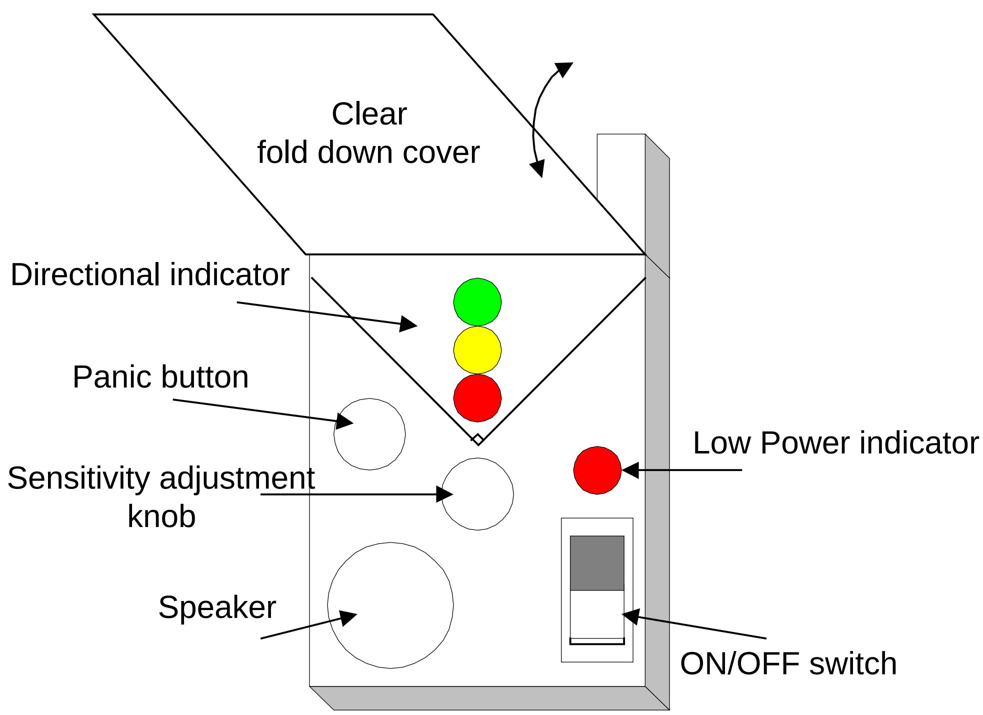

Figure 11: Parent unit

The directional indicator consists of three LEDs, which will light up depending on signal strength detected in the 90-degree cone. Red, yellow and green will represent weak, medium and strong levels of received signal strength respectively.

The sensitivity control knob will allow the user to adjust how far the child can travel before the alarm will sound. The panic button will send a signal to the child unit to emit an audible signal. This feature is intended to assist the parent in determining the location of their child. These additional controls and indicator will result in the parent unit being slightly larger then the child unit. However, the major contributing factor to the size of the parent's unit is the directional antenna, which will be between 6 – 8 inches in length. Therefore, the increase in the size of the parent's unit due to these additional indicators is not a showstopper.

The child unit's only function is to transmit a signal to the parent unit. It will be made as small and simple as possible to reduce any tampering from inquisitive minds. The child unit illustrated in Figure 12 will consist only of:

- ON/OFF switch,
- Speaker

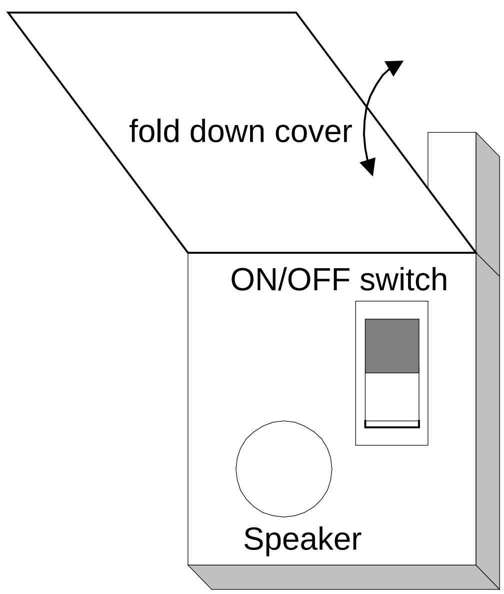

Figure 12: Child unit

The switch will be placed in a manner such that it will not be easily turned off by incidental contact. A fold down cover is a possible solution. The speaker will emit an audible signal in the event that the parent unit has activated its panic button. The simplified child unit will allow it to be made small and easily concealable.

Preliminary dimensions for each unit are listed below in Table 1.

Table 1 : parent and child unit dimensions

	Parent unit	Child unit
Length	6.5 cm	4 cm
Width	4 cm	4 cm
Depth	2.5 cm	2.5 cm

Both units will be made as rugged as possible to survive the wear and tear of daily use. They should be shock resistant and be able to withstand being dropped or impacted with varying amounts of force. They will also be made lightweight. The defining factors of the weight will be the casing, batteries and the antenna.

The packaging will be made of, or lined with, a conductive material to shield the unit from outside interference and noise.

Electrical Requirements

Due to the portable nature of the device both the parent and child units must operate on batteries. The battery operation will require each device to draw as little power as possible. This will be accomplished by having the child's unit transmit in pulses, rather than as a continuous stream. Both devices should be able to operate continuously for 8 hours without battery recharging. In general use of a couple hours per session, the units should be able to go months before batteries need replacing. This is comparable to the operating time of commercial pagers. Since the parent unit performs a receive function similar to that performed by pagers, this is a reasonable guideline to set. There will also be an audio low battery warning that alerts the parent if either of the units has under an hour of battery power remaining. A summary of our electrical specifications is listed below in Table 2.

Table 2: electrical requirements

Operating frequency	2.4 GHz
Voltage	3.3 / 5 V
Max Transmit (TX) power	mW range
Continuous operating duration	8 hours
Heat Dissipation	Low

Normal Operating Conditions

The wireless child unit will be able to operate in varying temperature and humidity environments. General operating conditions are listed in Table 3.

Table 3: general operating conditions

Requirement	Range
Temperature	-20 –> 80 degrees Celsius
Humidity	0 –> 100%
Interference/Noise rejection	Dependent on implementation

There will be the ability to operate in low interference areas. However, interference differs on what frequency band the device will be chosen to operate.

Safety Requirements

Enclosure

In order to ensure that the child is wearing his transceiver at all times, the child's unit must be difficult to remove. However, this must be accomplished without impairing movement or restricting blood flow. The method of keeping the transceiver affixed to the child should not be dependent on the child's size, thus allows our device to be used for a wider variety of applications. Additionally, both units (in particular, the child's) should have no sharp edges or jagged points. The antenna is a potentially dangerous object in this respect. However, since only the child's unit only requires an omni-directional antenna, this problem will be minimized. The omni-directional antenna on the child' unit will be under 4 inches in length, in contrast to the 6 – 8 inch directional antenna on the parent's unit. We could also add a durable domed casing that is permeable to radio frequencies to eliminate any direct contact between the child and the antenna.

Electrical Isolation

We must ensure that the casing is electrically isolated from the power supplies on both units. The principal limitation on this isolation is the size of our components and the amount that our casing can be deformed. In order for the casing to be durable, it must be able to bend when a force is applied. However, if the casing material is too bendable, it can potentially come into contact with components on the board, causing a short. We ideally want to minimize the space between the two sides of the casing, but reducing the amount of space between the components and the case also reduces the amount that the case can deform without causing a short. Creating a short between the power supply and the case is not only a safety hazard, but would also force a large amount of current to be diverted from the transceiver to the case, which could stop the unit from operating.

Emission Limitations

In addition to the governmental limitations on transmit power, biological limitations must also be considered. At present, there is no concrete health risk associated with cellular radiation. However, a recent report published by the Wireless Technology Research Group stated that "neither the government nor the phone industry can guarantee that wireless technology is safe, nor guarantee your safety if you use it. Only you can decide what is acceptable for you and your family." (http://www.protector.co.il/cellsafe.htm)

In a survey of 15 parents, we found that over 50% of them were concerned about the potentially harmful effects of exposing their child to cellular radiation. This concern is amplified by the fact that our transceiver will be in close proximity to the child’s body. Therefore, we must minimize the child tether’s transmit power. This drawback to this is that it limits the maximum range of the device. However, our survey also indicated that the majority of parents would want to be alerted if their child was more than 10 feet away. Therefore, the operating range of the child’s transmitter does not need to be very large, and consequently, the child unit’s transmit power can be minimized.

Reliability Requirements

Response Time

Maximizing the response time of the wireless child tether is one of our most important design requirements. We must alert the parent as soon as the distance between themselves and their child is greater than the predetermined limit, and ensure that this alarm is noticeable, regardless of the situation the parents may find themselves. In order to minimize the error between the time the child leaves the predetermined area and the time the parent’s alarm is raised, more pulses could be transmitted to the parent’s unit each second. However, this causes the batteries to be drained more quickly. In order to balance these two factors, we have specified our device to have a 1-second response time. This was based on the assumption that 1 second will be negligibly small in comparison to the time it takes for the parent to react to the alarm. This assumption will be tested at a later stage of product development, and the rate of pulse transmissions can be increased at that time if a more accurate response time is desired. Through an averaging algorithm we will limit the amount of false alarms.

The parent's alarm will have both an audio and vibration output, guaranteeing that it will be noticed regardless of what the parent is doing when it goes off. As well, the parent will be able to manually deactivate the audio output, allowing the wireless child tether to be used in the situations where loud noise would be unappreciated. However, parents will be advised in our documentation that keeping both the audio and vibration outputs active increases their chances of quickly responding to an alarm and gives them a backup alarm system in case one fails.

The directional indicator on the parent's unit should also have a very fast response time, since even a slight delay could cause the device to output erroneous information about the child's direction. Since the child's unit will be transmitting pulses at the one-second intervals specified above, this may not provide a fast enough refresh rate to the directional indicator. Therefore, when the child leaves the specified area, the parent's unit may have to send a message to the child, which boosts the child unit's pulse transmission rate. A flow chart indicating this process is shown in Figure 2.

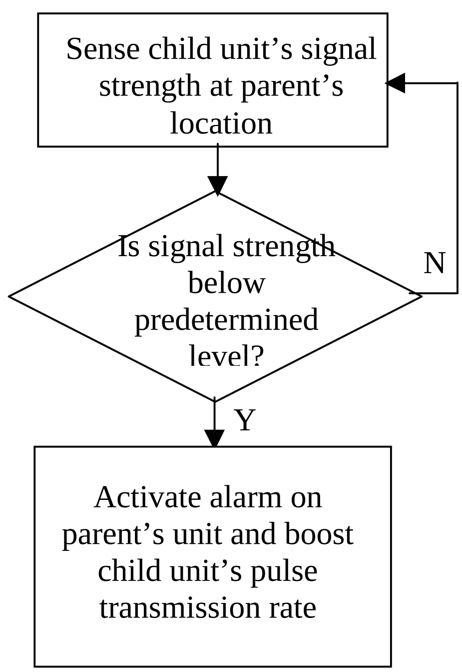

Figure 13: Method for increasing directional indicator response time

Again, the need for this modification will only be established once the device has been thoroughly tested.

Failure Warnings

There must also be a means of alerting the parent about a failure on either device. It is particularly important to create a reliable low battery warning. These failure warnings will be transmitted through the existing outputs on either of the two units. A visual symbol corresponding to the source of the error will light up on the parent's unit. This will distinguish an alarm indicating that the child is wandering from a battery failure.

Durability

The two units (particularly the child's) must be quite durable so that they can withstand a large amount of abuse from the user. In particular, they must be very shock resistant and unresponsive to vibration and deformation. The antenna is a particularly vulnerable section because of its length and relative thinness. We will select an antenna designed to be flexed repeatedly. Additionally, we will test the maximum shocks that the units can receive by conducting drop tests. The maximum vibrations the device will be able to withstand will be mainly due to the jarring up-down motion of walking or running, so we can test this in vibration chamber that is oriented to vibrate on its vertical axis.

Testing

We will develop a feature test plan to adequately test the performance of the wireless child tether. This test plan will include:

1. Circuit debugging.
2. Field tests

    Typical environments: open area, crowded areas, inside/outside buildings

    Testing in each area requires verification of:

    - Operation range and sensitivity variation
    - Alarm triggering
    - Panic button

Standards

The major standards organizations which regulate the use of cellular bands are the FCC and CTRC, the former being an American institution and the latter being its Canadian counterpart. These organizations have allocated various frequency bands for specific purposes, and most of these bands can only be used with the permission of the FCC/CRTC. However, there are a number of Industrial Scientific and Medical (ISM) bands, which can be transmitted over freely, as long as the specified maximum power requirements are adhered to. These specified power limitations will only be an issue if they are too low to give the wireless child tether its desired operating range. Fortunately, for the reasons described in the emission limitations section above, the operating ranges for our device will normally be very small, so the maximum power guidelines should be higher than our maximum required transmit power.

User Training

Much of the user interface for our device will be intuitive, since it mimics the user interface of a cell phone. For example, an audio or vibration alarm will tell the parent to check the visual indicator, and the parent can then take steps to locate their child. The only unintuitive portion of the interface is the interpretation of the visual indicator. The parent is required to sweep a full 360° in order to determine the direction of the maximum received signal strength, and therefore the direction of their child. Since the parent will probably be frightened and desperate to find their child once their alarm goes off, they may not take the time to perform a full 360° sweep and may then end up misinterpreting the child's direction. In order to avoid this from happening, the procedure for interpreting the visual indicator will be clearly laid out in the documentation. Additionally, there will be an online tutorial to help the user to become familiar with the visual interface, so that they may coolly and efficiently track their child when the need arises.

System Limitations

The wireless child tether is an assistive device and is not intended to replace the role of a parent/guardian watching over the welfare of your children. The following are known physical and functional limitations of the system.

- Units will not tolerate excessive physical damage
- Continuous operating time is limited to battery life
- Precise position of child unit can not be determined
- Maximum operating range is limited

Radio Signal Strength will vary depending on objects between units and environmental conditions. Objects may include walls, doors, corners, people, etc.

Conclusions

In this document we laid down the functional framework for our wireless child tether. The functions described in this document are the deliverables that we hope to provide. We began with an overview of the system functionality as a whole. We also discussed other issues such as electrical, physical and reliability requirements. We also identified possible system limitations. We at Second Sight feel this document will help to guide us in our further development and help to keep us accountable.