Abstract

During the years 2001 to 2010, the percentage of motor accidents that involved cyclists had gradually increased [Chart 3]. While there are many reasons for this upward trend, the main reasons are the push towards clean and environmentally-friendly means of transportation and the ever-increasing number of cars on the road. In order to mitigate these accidents, a means of clothing illumination needed to be created. Through the use of an Arduino LilyPad connected to multiple light emitting diodes (LEDs), we created a jacket that helps bikers be seen at night. With improved communication between bikers and drivers, a safer environment can be achieved.

The Arduino LilyPad has a multitude of practical uses. The LilyPad is a microcontroller that can be attached to various items and used to power sensors and lights. Our efforts with the LilyPad culminated in a clothing system that enabled both nighttime and daytime bikers to easily use turn signals and brake lights. In addition, we implemented a smartphone application to serve as a Global Positioning System (GPS), security system, and temperature monitor. Any biker wearing this jacket can communicate their intentions, be seen more easily, and access helpful biking information.

The jacket that we created uses sixteen yellow LEDs and eight red LEDs to display a left and right turn signal and brake lights. These are controlled by two on-off switches and one push button connected to the Arduino. The jacket uses two Arduino LilyPads, one for the LEDs and the other for the iPhone connection and the temperature sensor. Our iPhone application, SafeBike, takes the temperature readings, GPS location, and unlocks the LilyPads as a security feature. The two LilyPads are connected so that the LEDs cannot turn on without the iPhone plugged in.

Our jacket significantly increases biker visibility while providing the biker with turn signals, temperature, and GPS information. With this jacket, bikers will have a more interactive and positive experience. However, our smart jacket does not need to be limited to bikers since athletes like runners could also benefit from such a jacket.

I. Introduction

Due to environmental concerns and the rising cost of gasoline, biking is growing in popularity as both a recreational activity and a mode of transportation. However, the rise in popularity corresponds with more injuries and motor accidents. Biking is especially dangerous at night due to low visibility and biker unpredictability. While reflective taping and bright clothing help drivers see bikers, the hand-movement-based turn signals of bikers can easily be
ignored or misread. Experienced riders are more aware of the rules of the road and are therefore more cautious; most accidents were caused by drivers who did not notice an inexperienced and inattentive cyclist and turned into him/her [1]. 29% of all cyclist deaths in 1999 were people aged under sixteen [2]. Furthermore, the majority of these accidents occurred during a specific time period. According to a government study, the majority of deaths occurred between 4:00 PM and midnight [3]. Based on that data, one can claim that the accidents occurred because of the dim lighting during dusk and night [Chart 1].

The purpose of our project is to increase biker safety using the Arduino Lilypad and conductive thread technology. We determined that through the use of conductive thread and custom Arduino sensors, biker visibility could be significantly improved, giving birth to the idea of a high-visibility jacket with multiple rows of LEDs. Some LEDs are used for turn signals while others are connected to a button to signal that the biker is slowing down or braking. The jacket also connects to an iPhone through our custom-made smartphone application SafeBike which gives information on temperature, time, and location. This jacket is perfect for biker safety and there is no other lighted jacket of its kind on the market. Drivers will be able to see the biker and immediately know when the biker is turning, avoiding any and all confusion. Bikers will be able to access many handy features of the jacket, which include being able to determine location using the GPS locator, as well as the ability to record temperatures and be alerted when they are unsafe, mitigating the risk of heat stroke. Even with all of these helpful features, the jacket can still be affordable and sold in the medium price range. If this jacket is successfully marketed to the biking community, it can drastically reduce biker collisions and fatalities.

II. Experiment

In the pursuit of solving a common problem, we developed the idea of our jacket. For this project, we were also required to use smart clothes. We decided that athletics would be a viable area to explore because it has not yet been fully integrated with technology, as smart phones are typically quite cumbersome and impractical in such scenarios. After some research, we determined that biking (more specifically biking safety) showed the most room for improvement. Biking is currently on the rise, but athletic clothing today is not illuminative enough to prevent accidents, especially at night. Therefore, the incorporation of LEDs to serve as turn signals and brake lights for bikers would make a significant impact on biker safety. In addition, the functionality of the smartphone could be used to map biking routes as well, giving the biker better information on speed, distance travelled, and the surroundings.

![Figure 1](image_url)

While designing the layout of the jacket, we decided to make all signal as clear as possible in order to avoid unnecessary
confusion. Consequently, standard automobile signal colors are used, with the turn signals being illuminated in yellow and the brake lights in red. The turn signals are activated by small switches which are sewn into the sleeves of the jacket. We cut thumb holes in the ends of the sleeves so that the biker can comfortably grip the handles of the bike and use simple thumb movements to turn the signals on and off. The brake lights use a momentary button, right below the right hand switch that turns on the red LEDs. This serves to give trailing motorists an early warning to any braking done by the biker.

![Arduino](image)

**Figure 2**

Arduino is an open-source platform with both hardware and software for programmers and designers. The LilyPad Simple is a microcontroller specifically designed for use in fabrics and clothes [Chart 8]. It has an input voltage ranging from 2.7 to 5.5 volts and can be powered from either a Universal Serial Bus (USB) connection or an external power supply. Because the USB connection is not feasible in a jacket, a Lithium Polymer (LiPo) battery is used instead. It has eleven ports, of which seven are digital and four are analog. A digital port is able to communicate with devices and sensors through a series of ones and zeros; in other words, a digital port is only on or off, communicating via logical highs and low voltages. An analog port is able to communicate through a spectrum of values. Many common signals in our society use analog - television, radio broadcast, and audio signals are some examples. All of the seven digital ports incorporate Pulse-Width Modulation (PWM). PWM constantly modulates the voltage and current by turning the power supply on and off at an extremely rapid pace. This allows a digital port to act similar to an analog port in order to give and receive more information. It also allows LEDs to operate on a lower current so that they do not burn out as quickly.

The circuits in the jacket are all interconnected with conductive thread. The thread is two-ply and made out of intertwined strands of stainless steel. Three-ply would be too stiff and could possibly affect mobility had it been used in the jacket. Also, stainless steel does not oxidize like normal, silver-coated thread, meaning that the wires will work for a longer period of time because they will not rust. Moreover, this means that the wires are more resistant to water, avoiding a potential loss in functionality due to sweat or other moisture. The resistance of the thread is sixteen ohms per foot, which is low enough to power LEDs without any problems.

Since the LilyPad is meant to be integrated into clothing with conductive thread, it was necessary to hone our sewing abilities. The LilyPad, every LED, and the sensors needed to be sewn into the jacket and securely connected with the conductive thread in order to make the jacket work properly. The back stitch and the straight stitch were used because of their speed, ease of replication, and versatility. The back stitch is more flexible and durable but
wastes more conductive thread since it must be looped backwards with every stitch. The straight stitch uses half as much thread and is significantly faster to sew; however, it could easily break due to the tension exerted when the jacket is worn. The circuits made from the conductive thread used both stitches due to the aforementioned different properties.

Once we determined what type of sewing would be used for the circuits, we turned our attention to choosing the specific kind of circuit we would use. While a series circuit would need less thread and therefore be faster to create, the voltage would decrease with each LED and only three could be hooked up efficiently to one port on the LilyPad. Many ports would have to be used in order to get the LEDs to work in a series circuit, and there would not be enough ports for the other functions of the jacket to work properly. Unlike series, parallel circuits can hold ten or more LEDs as the voltage remains the same and only current decreases but would use more thread. Due to this fact, a parallel circuit is a much more effective way connect the LEDs without using too many ports.

For the brake lights, we were planning on using an ADXL193 single-axis accelerometer in order to check the biker’s speed for deceleration. Since the accelerometer would constantly be checking for deceleration, the brake lights would come on automatically. This autonomous feature would let the cyclist pedal without worrying about braking and alert cars to the presence of a slowing bicycle. This accelerometer only measures in one direction and it outputs an analog signal which is can then be read by the LilyPad. The entire device uses only one analog port on the LilyPad and it has the capacity to measure 250 times the magnitude of acceleration due to Earth’s gravity (250 g’s). Unfortunately, 250 g’s is equivalent to 2,450 meters per second squared or 8000 feet per second squared. Because of the large range of measurable values, the accelerometer we had was not sensitive enough to measure bike deceleration. As an alternative, we simply hooked up a button to control braking that resides next to the right hand side turn signal switch. This allows users to have finer control of when the brake light is on or off.

The final sensor used in the jacket is a temperature sensor. Our sensor is specifically built to be sewn into the jacket and to be compatible with the LilyPad. It uses changes in voltage to detect temperature, spanning from -40 degrees Celsius all the way up to 125 degrees Celsius. Each degree corresponds to a 10 mV change in voltage. This device uses only one port on the LilyPad, and is completely waterproof and machine washable. It serves as the input for the temperature-monitoring portion of the smartphone application we developed, SafeBike.

The iPhone connects to the LilyPad through a transistor-transistor logic (TTL)
cable that was bought from Redpark, an electronics manufacturing company. All of their products are made for iPhone and they each have a specific Software Development Kit (SDK) that allows information to be sent back and forth between devices. Other less expensive products did not have the “made for iPhone” qualifications so they could not be used in the project because the dock was not unlocked for developers otherwise. TTL is short for transistor to transistor logic which is a type of logic gate that allows two different systems to communicate. TTL uses bipolar transistors which amplify current and can switch signals at high speeds. The TTL cable is one meter in length and uses six analog pins to connect with other devices. The wire that we are using can transfer information at up to 57.6 kilobits per second [7].

The iPhone application was written in XCode. It uses the Redpark Serial SDK to communicate with the Arduino LilyPad, and bases its functions in the standard libraries built into the iPhone such as CoreLocation, MapKit and the ExternalAccessory framework. Its main function is to prompt the user to log in via a four digit code to unlock the suit and prove that their identity is genuine. Once this has been entered, a serial code is sent to the LilyPad, allowing the application to continue with its normal functions. Another large part of the application is a temperature graph. Periodic temperature updates are sent to the phone and displayed at the upper-center of the graph and are then aggregated into a bar graph form of display that shows the past nine temperature values. This was accomplished by reading the temperature sensor and sending it to the iPhone serially with a prefix of the capital letter ‘T’ to denote temperature and allow the phone to react accordingly. It was tough choosing a fitting time interval to send temperature updates but we eventually settled on every five seconds, because even though temperature changes happen relatively gradually, they change quickly enough for twelve readings per minute to be a good update frequency.

We ran into a few problems writing the application. Unfortunately, GPS path-tracking proved to be particularly difficult to accomplish in the amount of time we were allocated to complete the project. We decided to simply have a map view integrated into the application that would display the user’s location and heading. Getting the Redpark Serial Cable to work well with the iPhone was difficult at first but after solving some issues with the cable not being fully connected on both sides, data transfer and cable connection handling came together rather quickly. We coded a special subclass of UILabel, a view for displaying text, that would react to the cable plugging in and unplugging and proceed to display this information to the user. The temperature graph is a custom subclass of UIView, a generic container class for displaying anything to the user. It uses QuartzCore and CoreGraphics functions to display the temperature bars.

We used multiple programming platforms in the creation of the jacket. As
mentioned, XCode was used to develop the iPhone application, and Arduino to program the LilyPads. Arduino created their own system based on the ubiquitous programming language C. Logic and declarations are very similar to C, but there are also many built-in functions that allow the developer to take full control of his/her device. Our Arduino code was relatively straightforward, and took advantage of simple digital, analog, and serial capabilities built into the Arduino programming library.

All of the graphics used in the application were created from either Adobe Fireworks or Xara using either bitmap or vector graphics [Charts 6-7]. Adobe Fireworks is a specialized program for customizing both of these types of images. It was used to embellish the menu of our smartphone application, SafeBike. However, we preferred to use Xara for vector graphics. Xara is vector-graphic-exclusive software that employs surfeit algorithms to perform techniques like embossing, contouring, emboldening, incisioning, and shading on vector images. Because vector images consist of a set of points with defined relationships to one another, enlarging such images does not result in pixelation as the positions of the points are recalculated from their pre-existing associations. Xara was used to create the icon for our smartphone application as well as many designs for the jacket and circuits.

III. Results

The jacket we created has almost all of the functions originally thought of by our group. The turn signal LED arrows light up from the on-off switches located on each hand. There is an extra button on the right hand that corresponds to the jacket’s brake lights.

The second LilyPad, located near the pocket, has the TTL cable and temperature sensor. The cable connects to the iPhone, where our “SafeBike” application processes the temperature data and displays it to the user in the form of a graph. To stop an unauthorized user from using the jacket, the iPhone requests a four digit passcode to unlock the LilyPads. When the second LilyPad receives this code, it begins its processes and sends a signal to the first LilyPad to allow the turn signals and brake lights to function. The application also has GPS capabilities and is able to find the current location and coordinates of the biker.

The main problems our group encountered were with the accelerometer and the conductive thread. The accelerometer we used was not sensitive enough while the iPhone’s accelerometer was too sensitive. The lack of insulation on the conductive thread constantly created shorts and the circuits needed to be re-sewn multiple times.
IV. Analysis

The final cost of the jacket excluding tax and shipping was $148.59. The electronics themselves only cost around $128.06, though. In fact, much of the cost came from the TTL cable which contributed $59.00 or 47% to our total cost. This cost, stacked on top of the prices of most official biking jackets, is a problem since such jackets can cost upwards of $200. However, we bought individual parts online and therefore a large portion of the cost could be eliminated if the jacket were manufactured in bulk. Making a hundred jackets at once with components bought from SparkFun would reduce the cost of the electronics to $114.68, a 10% decrease in cost. The cost could be brought down further if each part were bought straight from the manufacturer instead of from an online retailer. The jacket would still be cheaper if we used a single LilyPad instead of two Lilypad Simples, and no major changes would have to be made to the layout of the jacket. While the price of the jacket is high, much more functionality could be added for little extra cost. Both an accelerometer and a barometer could be added for an additional $14.90.

Once the biker safety jacket was completed, we quickly learned that our efforts had not been in vain. All LED lights on the jacket proved to emit light at an intensity high enough to be seen from afar. While testing the jacket, we found that the farthest distance a motorist could discern a bike was from over 150 meters, indicating that a car traveling at a steadfast sixty miles per hour would have an eight-second timeframe to see the biker, be prepared to stop if necessary, and overall be more cautious in the vicinity of the biker so as not to cause an accident.

The turn signals also proved to be more helpful than previously thought to nearby motorists. Conventional hand signals cannot be seen from long distances, especially not at night, and most drivers do not actually know what the hand signals themselves mean. A biker also has to take his/her hands off the handles in order to show a hand signal, and this could cause the bike to swerve off course. Holding out the hand signal for a prolonged period of time as a preemptive sign to drivers becomes even more dangerous. The jacket nullifies these risks and makes it easy and simple to show a signal preemptively. If bikers all wore illuminating turn signals, motorists would become much more aware of bikers on the road and would be given more time to react. Likewise, automatic brake lights serve as an early warning system to drivers, greatly mitigating biker unpredictability. Motorists will quickly acknowledge that a biker is slowing down and will acquire a tendency to be more cautious around them, knowing that the biker may potentially turn or stop.

During the process of sewing parts of the jacket, some problems became apparent. The reflective tape was originally supposed to be sewn onto the jacket, but the process ended up time-consuming and messy. We tried spray adhesive instead because it was thought to be much more effective and quicker than sewing. The spray worked well in some places, but not so well in places that bent frequently, like the bottom of the jacket, so it was used in conjunction with sewing in those places.

At first, we planned to have a multi-layered jacket with the circuits hidden in the inner layer of the jacket. The jacket which we first planned to buy was discontinued, and one similar to it could not be obtained since such jackets were out of season. Ultimately, we resorted to a single-layered jacket. This created a problem with the thread that connects the buttons, because we were planning on using the second layer to hide the thread. Originally, we had thought that normal wires were needed to connect
the buttons, because they were located all the way down near the wearer’s hands. However, a wire could not be run down the sleeve of the jacket without irritating the biker and deteriorating from use. Because of this we decided to use conductive thread. The jacket shorted a few times during testing, creating smoke and possibly permanent damage, but we immediately removed the battery. To make sure the wires did not short again, we insulated the more dangerous areas with nail polish.

Furthermore, the accelerometer that was bought to be used with the Arduino for brake lights was highly insensitive to fluctuations in acceleration. Further research revealed that the accelerometer was actually meant to be used in crash and impact testing, explaining why its readings ranged from negative 250 to 250 g’s of force. However, the iPhone used with the jacket has its own built-in accelerometer. This accelerometer is much more accurate because it is not meant for large readings, but an experimental threshold value had to be determined to reduce noise. The ideal position for the iPhone is in the pocket near to the hip because it is close to the biker’s center of gravity. Therefore, readings do not need to be adjusted if the biker leans over. However, we were unable to get accurate readings from the iPhone in order to be able to have automatic brake lights. The gyroscope and accelerometer in the iPhone do not distinguish between acceleration and deceleration. In order to get the brake lights functioning, we resorted to using a button, which would turn the brake lights on when held and off when not.

Initially, we planned on using three Arduino LilyPads, one on the back, one on the front, and one on the shoulder. These were needed to hook up the accelerometer, the temperature sensor and the LEDs, as we previously wanted to put them in a series circuit. Originally, we planned to use a heart rate monitor and create another graph section within the application. However, heart rate monitors for the LilyPad were very expensive and we did not have one available for the project. Because the heart monitor was unavailable, only two LilyPads were used in the jacket.

In the final stages of the project, it became apparent that we would need a more immediate power source to test the LilyPads and all of the programs since we had yet to order the CR2032 batteries and their

Figure 7

The temperature sensor worked considerably well and is accurate up to the hundredth place. The only problem we encountered with the temperature sensor is that it required a negative five degree offset to be accurate. This offset was found from experimenting and testing the sensor several times. This difference between the real temperature and the experimental one is because the sensor itself heats up slightly when current passes through it, thereby changing the number it reads. We also insulated the temperature sensor using a piece of Styrofoam so that it would not detect radiant body heat.
respective breakout boards. Just as we had realized this, we were supplied with three Arduino Developer Kits which came with better sew-in buttons than the ones we ordered, a buzzer, an actuator, a sew-in temperature sensor provided in our kit, a light sensor, six white LEDs, and an on-off switch. The kits also came with Arduino LilyPad Simples, which were very similar to the original LilyPads, but were much easier to use, having only 11 ports and a port for the battery which was also supplied with it. The battery is a GSP 061225 lithium polymer battery that outputs 3.7 volts and is rechargeable via a breakout board that receives a mini USB connector input and outputs to a computer via a full-size USB connector. This breakout board was also provided to us and was very handy for uploading programs, testing, and charging. These new sensors, buttons, and LilyPads were all very helpful and made the final steps of the project significantly easier. We ended up only needing two LilyPad Simples which both were placed on the back of the jacket.

Although we had originally planned to use buttons for the turn signals, on-off switches were found to be easier to implement and more reliable. The original buttons were momentary push buttons, with a constant current flowing through them. Upon being pressed the button completed the circuit and the LilyPad counted the number of presses. This would have been used to turn the signal on with one press and off with a successive press. However, the button had very little tactile feedback and this made it hard to tell if it was actually pressed. Because of this, we used the on-off switches included in the Arduino Development Kit. On-off switches have a forward position to turn the signal on and, intuitively, a backwards position to turn the switch off. Doing this gives more feedback to the biker and allows the biker to always know whether his/her signal is on or off. Therefore, the on-off switches ultimately ended up being the better choice for equipping the jacket.

While the jacket shows much promise, there is more that can be done to increase its productivity. As it is a piece of “smart clothing”, it has the ability to do plenty of functions in addition to the ones it currently does. One of our ideas was to use the temperature sensor to not only create a temperature graph of the region the user was in, but also to have a possible feature where it would be able to upload information to a server that stores temperature data around the world to create a community-based weather application. If people worldwide began to use the jacket, it would allow for a real-time, continuously updated system. Some other possible uses for the jacket were also found during our research. The Arduino accelerometer, because of its high range, could be used to determine if a biker got into an accident. Upon impact, the accelerometer will read an incredibly high value and could possibly have the iPhone call 911 and relay that an accident occurred at the coordinates specified by the GPS. This assures that if a biker did get into an accident with the jacket, however unlikely it might be, help would be on the way.

Arduino also sells actuators that are compatible with the LilyPad. These could be sewn onto to both arms of the user and vibrate in the direction that a biker needs to turn if they are using the GPS for directions. Since a biker would not be able to listen to the iPhone for directions when it is in a pocket, it will instead send gradually increasing vibrations, based on the proximity of the turn, in the direction of the turn. This allows bikers to visit places they have not visited before without being worried about getting lost. Furthermore, drivers could use this so that they do not
have to detract their attention from the road to look at the GPS and instead simply rely on the vibrations for directions.

The final use for the jacket that we aimed to achieve could have been implemented given surfeit resources to further development. A heart rate monitor could prove to be useful to athletes and trainers. It could be used to graph and study changes in heart rate over time for various sports. It could also be used to study athletes of varying heights and weights and how their heart rate increases when compared to others. To an ordinary athlete, not someone performing studies, it could also be helpful for them to know if and when their heart rate is high, how quickly it increases, and what their resting and active rates are. Since it would be integrated into the jacket, it would be very easy to activate and could be used at any time.

![Figure 8](image)

V. Conclusion

The jacket that we created successfully increased biker safety and visibility. It integrated Arduino cloth circuits with the iPhone platform to create working turn signals and data collection. The jacket successfully stored temperatures and GPS locations in our iPhone application, SafeBike. The iPhone also activated the jacket with a built-in passcode so the jacket would not work without it. This security system was particularly effective as we found it to be both efficient and aesthetically pleasing. It prevented jacket theft and helped communication between the two machines. The switches were sewn right into the arms in as ergonomic a manner as possible. The buttons and thumb holes were then placed in the jacket so that a biker could light up the turn signals and brake without taking their hands off of the bike handle. This provided the safest and most comfortable experience we could think of. The resulting cost of our jacket totaled $148.59 excluding shipping.

Though our jacket is mainly intended for use with cyclists, runners could also find the jacket helpful. Many runners have trouble on crowded streets that have no sidewalks; our jacket could help runners, which are inherently less visible than bikers, be seen better by drivers as well. As not all mopeds have turn signals or brake lights, moped drivers could also find a use for the jacket.

In the future, this jacket could help substantially mitigate bicycling casualties across the nation. Bicycling is on the rise as a recreational activity and all night cyclers need to be seen more easily. Also, the temperature data could be collected and used as a worldwide, community-based weather system. SafeBike application and jacket users would provide real-time temperature data, which could be displayed on a map for all to see. The possibility for incorporating other weather sensors also exists. Focusing more on the biking aspect of SafeBike, the application could be further expanded to track cycling routes and times. The jacket could also be integrated with other fitness-oriented devices, such as a heart rate monitor, and even used by many other athletes, such as runners.
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References


Source Code

Arduino Code:

// Temperature + iPhone LilyPad
char serialInput[4];
boolean authorized = false;

int otherLilypadPin = 11;
int tempPin = 4;

void setup(){
    pinMode(otherLilypadPin, OUTPUT);
    pinMode(6, OUTPUT);
    digitalWrite(6, HIGH);
    pinMode(tempPin, INPUT);
    Serial.begin(9600);
}

void loop(){
    if(!authorized){
        if(Serial.available() == 4){
            for(int x = 0; x < 4; x++){
                serialInput[x] = Serial.read();
            }
                authorized = true;
                digitalWrite(otherLilypadPin, HIGH);
            }
        }
    }else{
        int reading = analogRead(tempPin);
        float voltage = (reading * 3.3) / 1024.0;
        float temperatureC = (voltage - 0.5) * 100.0;
        float temperatureF = (temperatureC * 1.8) + 27.0; // 27 instead of 33 due to skew
        Serial.print("T");
        Serial.print(temperatureF);
        Serial.print("\n");
        delay(1000);
    }
}
// Brake light + Turn signal LilyPad
int leftLed = 10;
int rightLed = 6;
int otherLilypadPin = 11;

void setup()
{
pinMode(otherLilypadPin, INPUT);
pinMode(leftLed, OUTPUT);
pinMode(rightLed, OUTPUT);
}

void loop()
{
if(digitalRead(otherLilypadPin) == HIGH)
{
digitalWrite(leftLed, HIGH);
digitalWrite(rightLed, HIGH);
delay(200);
digitalWrite(leftLed, LOW);
digitalWrite(rightLed, LOW);
delay(200);
}
}

iPhone Code:
https://github.com/ibly31/SCSP
(the iPhone code is too long to be included without extensively lengthening this paper)
Appendix

[Chart 1]

Bicycling Fatality Times

[Chart 2]

Pedalcyclist Fatalities
[Chart 3] - Percent of Total Fatalities

[Chart 4] - Jacket Design

46 cm (Armspan)

- Turn Signals
- Brake Light

75 cm

Reflective Tape

LilyPad

Temperature Sensor
[Chart 5] - Jacket Circuitry

[Chart 6] - SafeBike Icon
[Chart 7] - SafeBike Application

[Chart 8] - LilyPad Arduino Simple