

# Tempo

## *Bike to Your Beat*



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## I. Abstract [Meghana and Lea]

On Stanford's campus, over 13,000 students bike across 8,180 acres to navigate between activities daily. Students spend a significant amount of time on their bikes and often listen to music to enhance the riding experience. Currently, due to legal constraints, riders must only wear a single headphone or hold an external device to listen to music. Our team aims to design an unobtrusive and practical solution that enhances the biking experience. We propose a new standard, Tempo--a convenient handle-bar accessory composed of a mini bluetooth speaker a conical sound enhancer. The design includes controls for music on the speaker base that allows the rider to customize and control the music. Tempo provides a safe, cost-effective solution for bikers without sacrificing music quality.

## II. Executive Summary [Lea and Meghana]

Every day, thousands of students bike across Stanford's campus, and many opt to listen to music to enhance their commute time. However, California, along with other states, bans riders from wearing more than one headphone due to safety concerns. Therefore, riders must sacrifice sound quality or hold an external device, compromising safety. The team surveyed various Stanford dorms, and results indicated that 70.4% of students seek a solution to listening to music while biking without the aforementioned complications. Inspired by the unmet need on campus, the team aimed to design a practical and unobtrusive solution to provide students with a safe and pleasant music experience while biking.

Our team decided the five main objectives of our solution, ranked from most to least important are: safety, functionality, privacy, cost-effective, and aesthetics. Ultimately, we had to decide between two design alternatives that met all of these objectives, namely the cutout headphones and the handle-bar speakers. In the end, we decided on the handle-bar speaker--Tempo-- composed of a handle-bar attachment containing a mini bluetooth speaker and a plastic conical sound enhancer. The cone also serves to direct the sound towards the biker, which prevents noise pollution and provides sufficient music privacy. Tempo is designed to be easy to remove, attach, and operate without sacrificing music quality. It is a reliable, safe, and affordable solution, perfect for bikers on the go.

While the idea for Tempo was born out of a need among Stanford students, we plan on sharing our innovative music listening experience with bikers across the nation. The team also expects to release improved future generations within the next few years. Future features include:

- A 360-degree pivot that allows the user to customize sound-projection,
- A bike light system integrated with turn signals and brake lights,
- A voice recognition system that allows users to control music verbally,
- A group syncing system that allows users to unite their devices.

### III. Introduction and Overview [Meghana]

#### A. Identifying the Problem and the Need

Every day, over 13,000 bikes navigate across Stanford University. With the campus boasting over 8,180 acres and limited car parking, the majority of students choose to bike as opposed to walk ("Campus Life"). Biking provides a feasible and time efficient method of transportation, and the campus includes many bike-friendly routes and lanes. As a result, Stanford students spend a significant amount of time on their bikes daily, traveling from their dorms to classes and extracurricular activities. To make the commute more enjoyable, many students choose to listen to music. However, physical and legal constraints limit the biker's listening experience.

Currently, the only way to enjoy music while biking is to either wear a single headphone or to hold one's phone and project the music. While wearing a single earphone detracts from the listener's experience, the California Department of Motor Vehicles has deemed it illegal to wear headphones in both ears while operating a bike under Section 27400 ("V C Section 27400"). Students who break this law are subject to ticketing by police on campus. Holding one's phone while biking also diminishes the listener's experience, because phone speakers fail to provide high-quality sound. It also poses a potential danger to both the biker and phone as it detracts from the biker's control of the handlebars. Our team conducted a survey of four Stanford dorms with mixed classes, and out of the 120 responses received, 70.4% of students expressed a desire to listen to music while biking without the aforementioned complications.

The hindrance is not isolated to Stanford University's campus. In fact, states such as New York and Virginia stand alongside California, allowing riders to

operate with a single headphone. Bikers in Florida and Rhode Island are even prohibited by law from wearing headphones. The conflicting legislation amongst states stems from the concern that headphones may close the ear canal and prevent cyclists from hearing approaching cars and the assumption that sound interferes with a rider's ability to operate their bikes (Levin). However, no evidence currently suggests a direct causation between bikers listening to music and their chances of getting into accidents. Bike expert, John Allen, deems a biker's sense of hearing as unreliable in noisy urban conditions and non-essential to safe bicycle operations as it cannot provide an early warning of approaching vehicles. He cites how the majority of traffic laws are based on sight as opposed to hearing to support his argument (Allen). In addition, research done by Katrina Jungnickel at the University of London and Rachel Aldred at the University of Westminster challenges the popular idea that listening to music dampens cyclists' awareness. Their research reveals how bikers deliberately use audio devices and sensory strategies to enhance their awareness and sensations in urban landscapes as opposed to blindly biking through them (Jungnickel). Such opposition and no concrete evidence makes it difficult for clear legislation to be drafted around listening to music while biking with regards to biker safety. Currently, there are limited options for bikers who want to listen to music.

A plausible solution for bikers may include headphones that do not block the ear canal. Currently, three categories of headphones exist: circumaural, supraaural, and intraaural. Circumaural and supraaural headphones both form seals around the ear and play music targeted towards the ear, while intraaural headphones enter the ear and can plug the canal (Allen). Circumaural and supraaural headphones would allow bikers to listen to music without blocking their ear canals. However, legislation currently does not differentiate between types of headphones. Therefore, a new solution that eliminates current roadblocks must be configured.

## B. Final Problem Statement

Stanford students spend a significant amount of time every day commuting to classes and activities on their bikes. Currently, the only way to enjoy music while biking is to either wear a single headphone (it is illegal to wear both), which detracts from the listener's experience, or to hold one's phone, which poses a potential danger for both the biker and the phone. A survey conducted on four Stanford dorms shows that 70.4% of participants wish there were a way of listening to music while biking without the aforementioned complications. This team aims to design a practical and unobtrusive solution to provide students with a safe and pleasant listening experience while biking.

## IV. Analysis of Existing Solutions [Zachary]

### A. Headphones

Wearing one earphone or headphone provides a partial solution sounded by drawbacks. It is advantageous in that it is very private, no outsiders will hear the rider's music. However, having only one earbud or headphone negatively affects the listening experience, and wires can get tangled.

### B. Phone Mount

The phone mount solution involves a clip-on mount that can hold a smartphone on the handlebars of bikes, allowing the rider to play music from their smartphone speakers as they ride. An example is shown below:





Figure 1: Source: [blog.bike-park-slovenia.com](http://blog.bike-park-slovenia.com)

The advantages of this design include easy navigability between songs and additional features due to having a smartphone accessible, such as the ability to take calls and navigate maps. The main disadvantage of the smartphone mount is the poor sound quality. First, the mount often blocks the phone's speakers, or else sacrifices some security. Furthermore, the speakers in smartphones do not have good sound quality in the first place, and their volume is not easily audible in louder environments. Lastly, having a smartphone screen available while biking can be a distraction to bikers and pose a threat to safety similar to that of texting while driving (Couch).

### C. Helmet Speakers

The second alternative design is helmet speakers. This solution provides medium sound quality and encourages safety practices. However, for our target audience of Stanford students, wearing a helmet is generally a non-desirable option. Most students prefer to ride with no helmet for reasons like discomfort, image, or hassle. As helmet speakers come with all that might be undesirable about wearing a helmet, they are a poor solution for most Stanford students (Coxworth).

#### D. Bone Conduction Transducers

Bone conduction transducers conduct sound to the inner ear through the bones of the skull, allowing individuals with normal or impaired hearing to listen to music. Headphones that use bone conduction are completely private and deliver good sound quality. Their obvious drawback is the incredibly high cost, which makes them outside the price range of almost all Stanford students, as indicated in our survey, in which very little students said they would be willing to pay over 35 dollars for a solution (Kiger).

#### E. Relevant Technologies

Our group also looked into design solutions such as Obstacle Detection Gadgets for Visually Impaired People and shower speakers for their cheap waterproof quality. Relevant existing technologies such as these provided ideas for us to pull from and influenced our brainstorming sessions.

## V. Design Process [Lea]

### A. Assumption Storming

Prior to determining the objectives and constraints of our design, the group conducted a round of assumption storming. This brainstorming method, invented by Craig Lauchner, serves to get designers to truly think outside of the box by “deconstructing the box” (Lauchner, 2015). This process forces designers to challenge all assumptions they innately and instantaneously make when they are presented with a problem. According to Mr. Lauchner, this should be the very first step in any design process because it is “a tool designed for breaking barriers to innovation wherever innovation wants to be free.” Indeed, in our first round of assumption storming, we challenged many assumptions, of which: music comes out of a phone, music has to be private, music can't come from clothing, and music can't come from a human. By initially pinpointing assumptions like these, we were able to brainstorm actual design ideas, such as: flexible speakers, handle-bar speakers, speaker in mouth, collapsible speaker mount, musical tires, and doughnut headphones speakers. Although certain ideas we initially came up with are not feasible, going through the motion of assumption storming before trying to solve the problem definitely got us to think more freely and creatively.

## B. Brainstorming Sketches

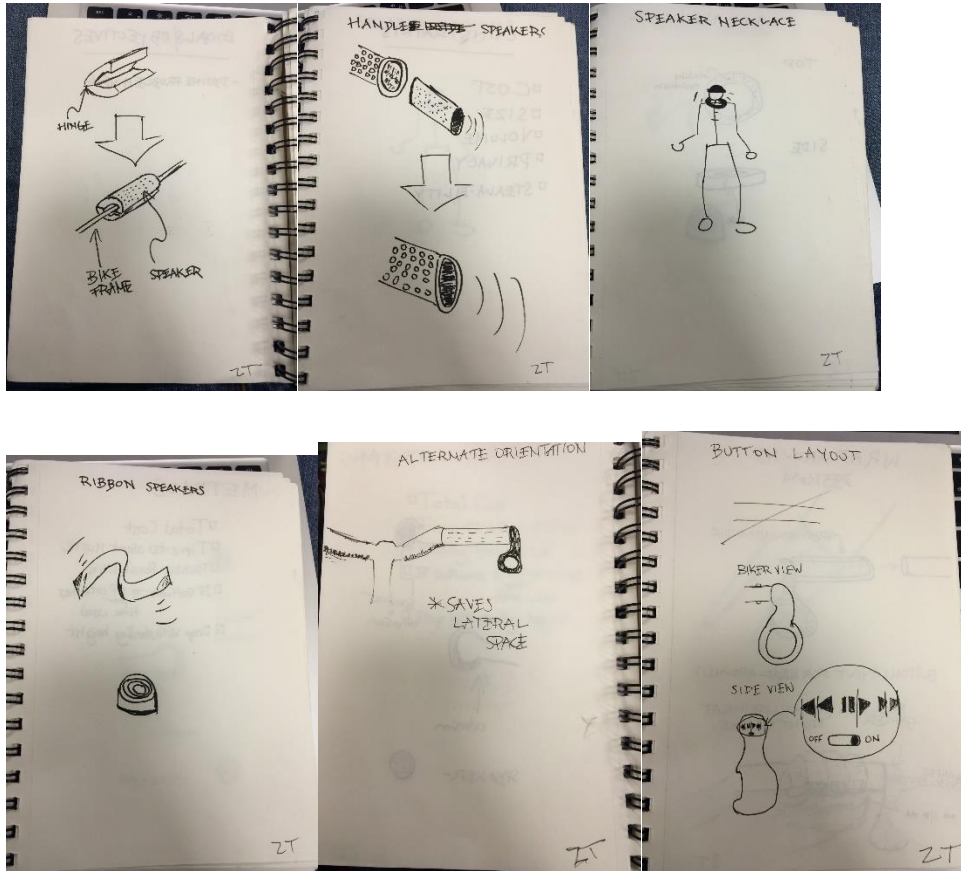


Figure 2: All sketches drawn by Zachary

### C. Objectives/Constraints

The next step in our design thinking process was to determine and prioritize our objectives. Throughout the design process, we gained knowledge that allowed us to modify our preliminary objectives to better fit the problem at hand. For example, after conducting a survey of four Stanford dorms, we learned that students care most about the portability/removability of the speaker, followed by music quality, and finally music privacy and aesthetics. Below is Tempo's final Objective Tree, which represents all of the goals our design should achieve.

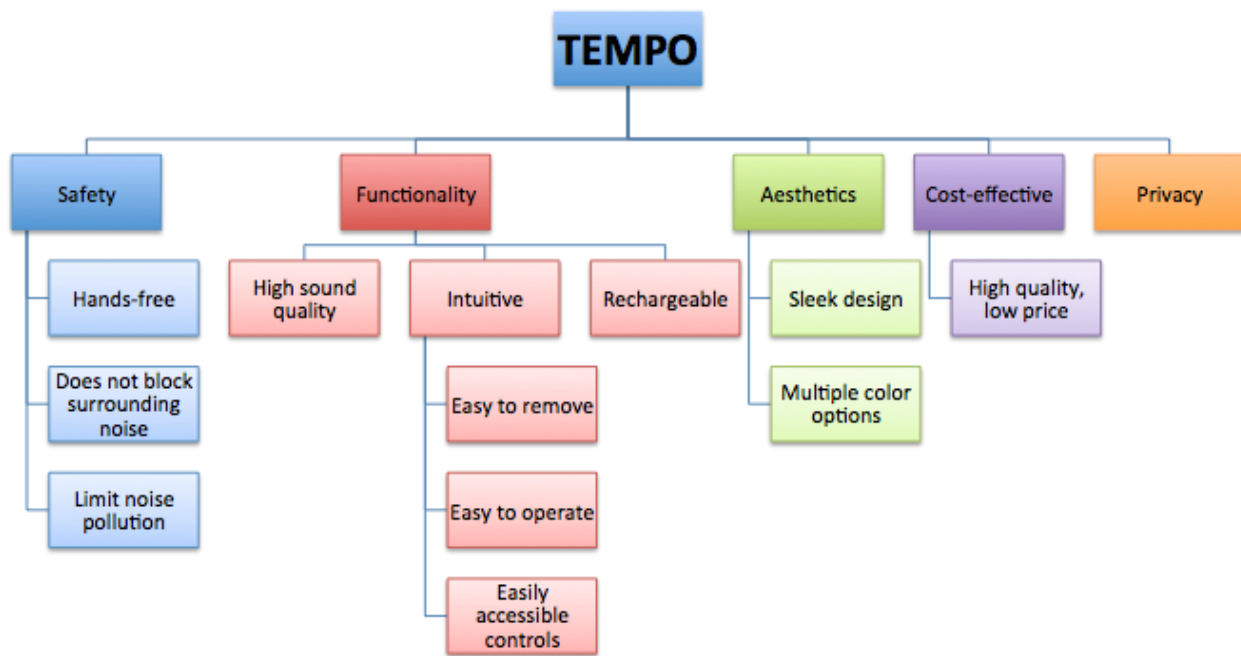


Figure 3: Objective Tree (Lea)

For our design, we decided the five main objectives were safety, functionality, aesthetics, cost-effectiveness, and privacy. After determining these objectives, it was very important to rank them, because it would later help us decide on a final design. For this purpose, we made Pairwise Comparison Charts (PCC) to set a hierarchy of objectives, and the final version is shown below.

## D. Descriptions of Various Alternatives Considered

After doing assumption storming/brainstorming and determining our objectives and constraints, we narrowed down our design alternatives. We decided upon two different solutions, each with its own set of advantages and disadvantages.

### a. Handlebar Speaker

The first design idea is a handle-bar attachment that is composed of a mini bluetooth speaker surrounded by a rubber or plastic cone shape. The cone would serve both to amplify the music and to direct the music towards the biker in order to avoid noise pollution. Additionally, there will be controls for the music at the base of the speaker so that they are easily accessible to the biker yet unobtrusive. In this design, the biker is not wearing any sort of earbuds or headphones, and can therefore still hear outside noise. All in all, this design is wireless, safe, and cost-effective, but does not guarantee music privacy.

### b. Cutout Headphone

The second design idea is a cutout headphone, which resembles typical headphones, but contains a cutout in the earpiece. Therefore, the resulting shape of each earpiece would resemble a doughnut, which would allow the biker to hear outside noises, yet listen to music wirelessly and privately. This design would be less cost-effective, though, and aesthetically appeals to less people.

## E. Evaluation of Design Alternatives

### a. Priority Checkmarks Chart

In order to decide between these two viable alternatives, we used a Priority Checkmarks chart and a Best of Class chart, both shown below.

Design constraints and objectives	Priority (✓)	Open-ear Headphones	Handle-bar Speaker
C: safety			
O: cost-effective	✓✓	1, ✓✓	1, ✓✓
O: sound quality	✓✓	1, ✓✓	1, ✓✓
O: intuitiveness	✓	1, ✓	1, ✓
O: removable/ rechargeable	✓✓✓	1, ✓✓✓	1, ✓✓✓
O: aesthetics	✓✓✓	0	1, ✓
O: privacy	✓	1, ✓✓	0
Total		10	9

Figure 4: Priority Checkmarks Chart (Lea)

In this chart, objectives are ranked as low (1 check), medium (2 checks), or high (3 checks), and we assign each design a 1 if it meets the objective well or a 0 if it does not. To calculate the total amount of checks, we multiply the

number of checks by their score (1 or 0). Any design that does not meet the constraint is eliminated.

This chart, although useful, did not really help us determine which design would be better because the two design alternatives are very closely matched. Therefore, we also made the following Best of Class chart.

b. Best of Class Chart

Design constraints and objectives	Open-ear Headphones	Handle-bar Speaker
C: safety		
O: cost-effective	2	1
O: sound quality	1	2
O: intuitiveness	1.5	1.5
O: removable/ rechargeable	1.5	1.5
O: aesthetics	2	1
O: privacy	1	2
Total	9	9

Figure 5: Best of Class Chart (Lea)

In this chart, each design alternative is assigned a score of 1 if it best meets the objective, 2 if it is second-best, etc. If the various alternatives equally meet the objective, they both receive an averaged score (in this case 1.5).



Once again, our alternatives are very evenly matched in this chart. Although both of the charts were very useful in getting a better sense of which designs satisfied which alternatives best, numerically they did not help us decide on a final design. For this reason, our final design decision was truly a matter of group preference.

## VI. Final Design [Annie]

### A. Detailed Description

In the end, our team chose the handle-bar speaker--Tempo--for our final design due to its uniqueness and versatility. The user has the choice to customize his listening experience by either opting for a single Tempo device on one handle-bar or for two devices to create a surround sound system. The overall design has 4 main components outlined below:

1. For ease of attachment, the speaker-holder will have a circular clasp to wrap around the handlebar. The clasp will have multiple levels of ridges so as to adjust to various handlebar sizes. This structure will be similar to the Stanford bike lights as shown below. The purpose of this is to make the attachment easy, intuitive, quick, and versatile. The ridges keep the

speaker-holder secure while at the same time making it adjustable to different handlebars.



Figure 6: Stanford Bike Light

2. Extended from the clasp is an elbow-like tubing structure extruded past the edge of the handlebar and then bent at a 70 degree angle to be pointing towards the rider. After the initial clasp, the tubing is not hollow to provide durability in the design, but can be made so if the materials are not sufficiently lightweight. On the tubing, near the clasp, there will be a control structure for the music including volume controls, pause/play, next, and power. Once the speaker is attached, the controls will be connected for ease of manipulation of the user without the danger of reaching their hand far from the handlebar.
3. Around the bend, the tube morphs into a horn-like structure used to amplify and direct the sound coming from the speakers. The horn will also be made of the same plastic as the rest of the design to ensure durability and lightweight. It is angled at a further 15 degrees out from the connected tube, making it angled 55 degrees total from the parallel of the handlebars. Inside the horn is a hollow cylindrical holder for the speaker. There will be clasps that allow the speaker to click into the holder and eject it with a button at the top of the horn that retracts the clasps.

Having this quick and simple detachment allows for the user to have the speaker for other uses as well as charge it separately from the rest of the design.

4. The last component is the speaker itself, which is not technically part of the design, but included here for a full picture. The speaker is a relative cylinder measuring 1.6" in diameter and 1.6" in height. For the prototype, the speaker will be black but will be available in multiple colors.

## B. Supporting Materials

### a. Technical Drawings [Annie]

For the sake of simplicity, all technical drawings do not include every component of the final design. The attaching clip for the overall structure and control buttons for the speaker are not drawn. The following technical drawings are used to convey the overall look of the design and how it would be utilized in a realistic situation.



Figure 7: Part file (ipt) of overall design (Annie)

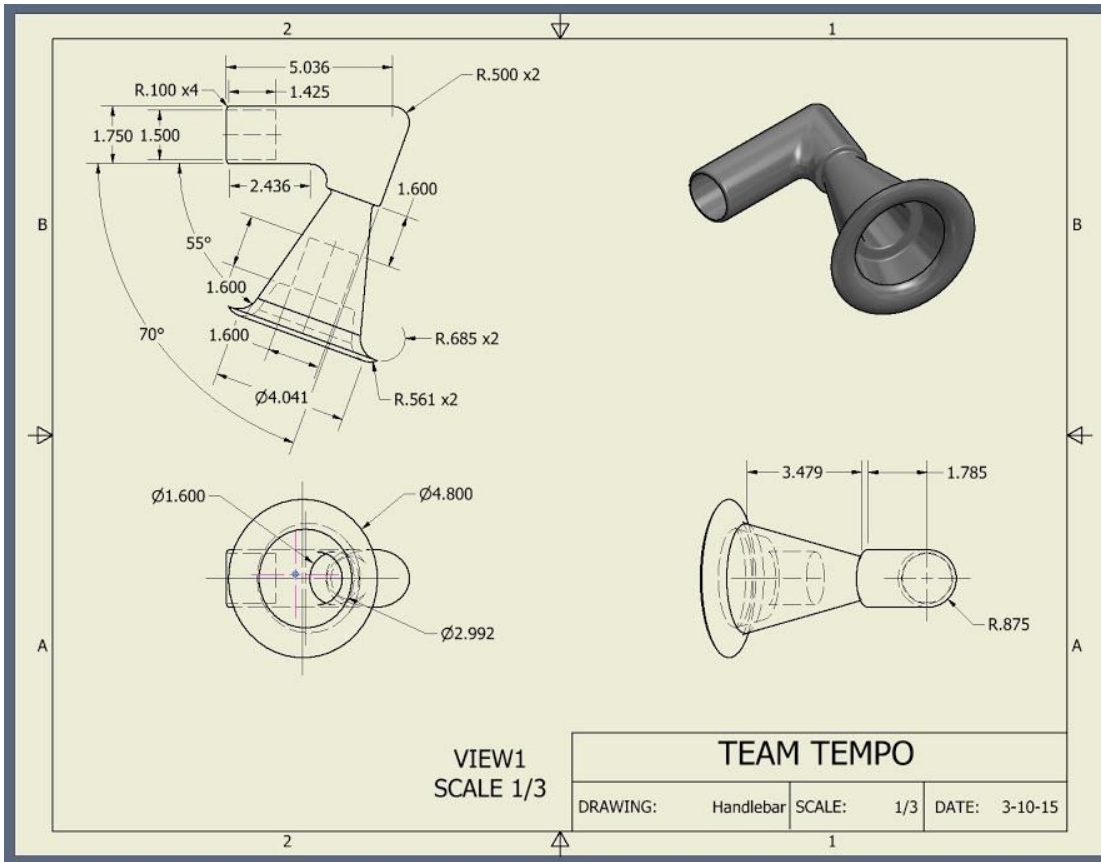


Figure 8: IDW of overall design with dimensions and orthographic views (Annie)



Figure 9: Assembly file (iam) of overall design with speaker (Annie)

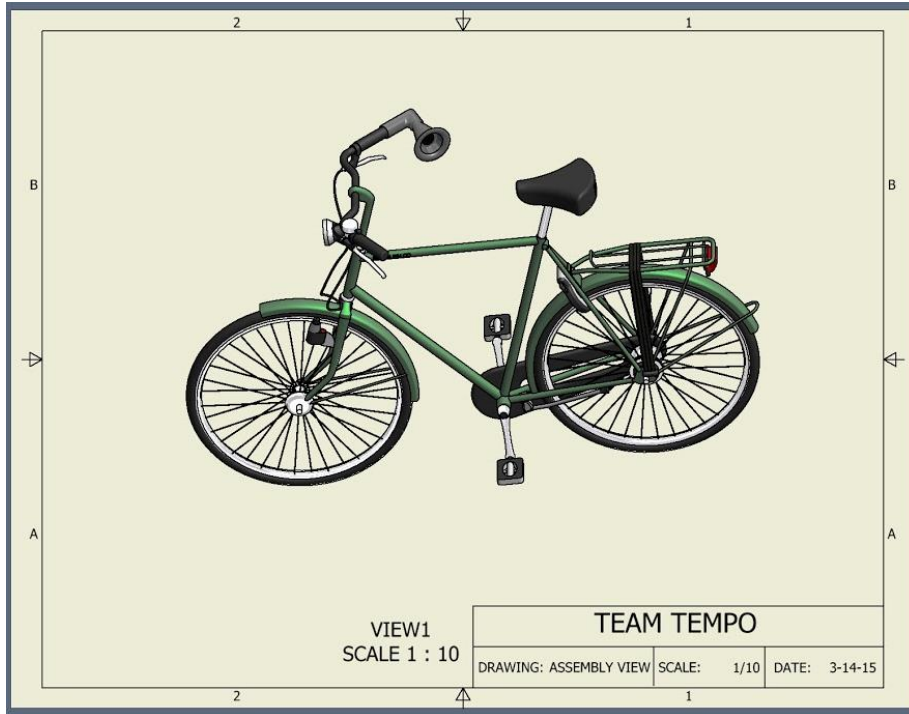


Figure 10: Assembly drawing file of overall design and speaker attached on bike (Annie)

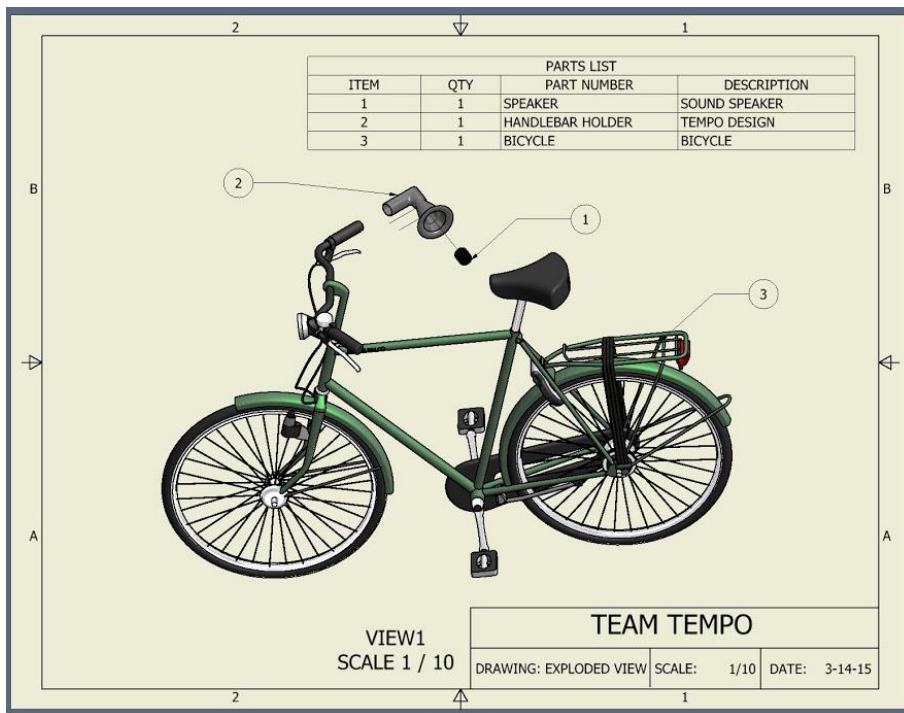
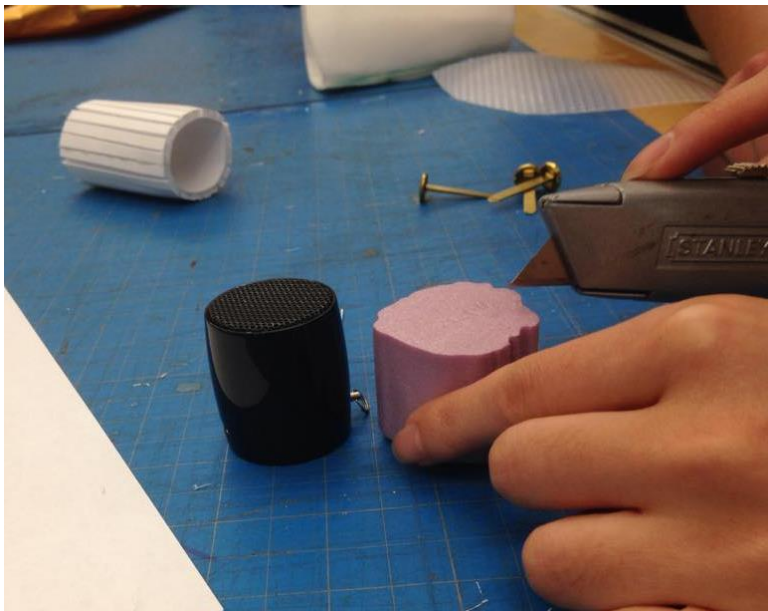


Figure 11: Exploded IDW (taken from ipn file) of all design parts and bike (Annie)

## b. Prototyping

### i. Mock Up

The first step Tempo took in prototyping was to make a mock-up of the initial design. This mock-up was made purely to get a sense of the design as a whole without incorporating functionality or detailed aesthetics. The mock-up consisted of pink foam that was shaped into a rough cylinder to represent the speaker, soft foam used to shape a cone to hold the speaker, and foam core scored to create a cylinder to wrap around the bike handlebar. Although the team took no efforts to assemble all of the pieces, the mock-up greatly helped in keeping all the members on the same page in terms of design and allowed for slight redesigns in order to improve the overall shape and functionality.



*Figure 12: The pink foam speaker model in comparison with the real speaker*



*Figure 13: First mock up cone made of soft foam*

## *ii. Preliminary Prototype*

After the team got a better idea of the design through the first mock-up, Tempo decided to create a preliminary prototype. Initially, the team hoped to 3D print the design, but limited time and resources prevented that. Instead, the group explored what alternative options to create a sturdier and more accurate preliminary prototype of our design.

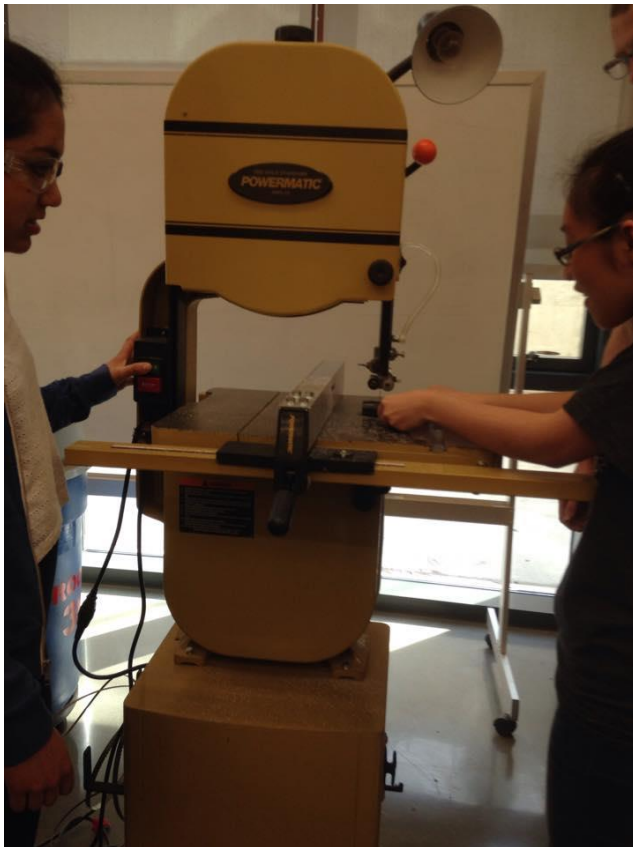
Using foam core, the team recreated the cylindrical attachment to the bike handlebar and the cone-shaped horn to amplify the speaker. This was done by scoring the foam core such that it would bend and wrap around itself to create a rounded edge.





*Figure 14: Foam core scored into a cylindrical shape*

We adapted a 3-ended plastic pipe into the elbow-pipe-like structure in our design. By using the band saw to cut off one of the ends, the team was able to produce a closer resemblance to our design.



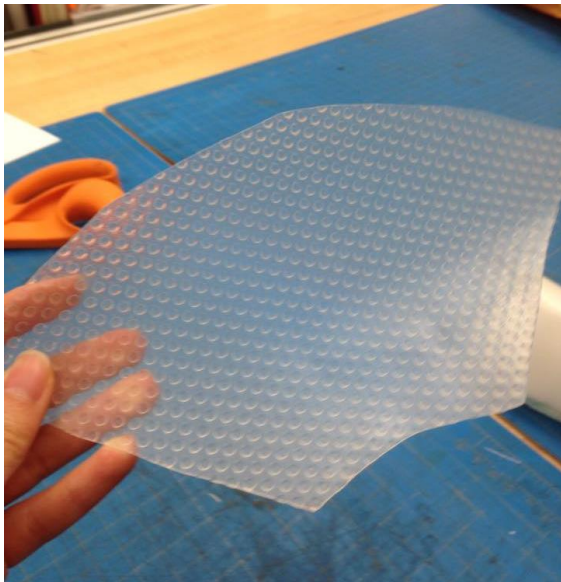
*Figure 15: Annie cutting off the third edge of the pipe using a band saw*





*Figure 16: The resulting elbow pipe after cutting off the third edge*

For waterproofing, the team also shaped a rubber-like material to wrap around the foam-core horn.



*Figure 17: Plastic material used to wrap around the horn for waterproofing*

When put together, the preliminary prototype is able to roughly resemble the overall design enough to convey the idea of the design to others. For aesthetic appeal, our design was finally spray painted a metallic black color. We tested this design out on a bike and found that music privacy is not an issue; in fact above a 5 ft. radius, only the biker and hear the song. We also found that the design is sleek and unobtrusive.



*Figure 18: The resulting preliminary prototype all assembled*

### C. Existing Engineering Incorporated into Tempo's Design [Zachary]

Several elements in the design and in the production process of Tempo's handlebar speakers have already been thoroughly engineered by existing firms, and we can use this knowledge in our designs through reverse-engineering. The

first element is the speakers. The team chose to use iTreasure mini bluetooth speakers, mainly for their impressively small size and low price. Our production process may also take advantage of 3-D printing or injection molding. The following paragraphs give a brief overview of some of the design challenges and manufacturing choices that we will have to face going forward.



Figure 19: Source:

[http://i00.i.aliimg.com/photo/v3/1873000946/iTreasure\\_portable\\_multifunction\\_wireless\\_bluetooth\\_speaker\\_bluetooth.jpg\\_350x350.jpg](http://i00.i.aliimg.com/photo/v3/1873000946/iTreasure_portable_multifunction_wireless_bluetooth_speaker_bluetooth.jpg_350x350.jpg)

One challenge we will face is getting maximum sound output from a small speaker. The output is limited by temperature; small speakers typically cannot handle large amounts of electrical power, and when the current is increased to increase sound output, excess heat in the voice coil can tear apart the glue holding the voice coil together (Scarlett). The trick to solving this problem is maximizing power efficiency and limiting excess heat. To do this, we will have to develop models of the complex and often unpredictable relationships between power, electrical input, and heat (Scarlett).

Another design challenge in creating mini speakers is avoiding over-excursion. Over-excursion occurs when the diaphragm of the speaker moves past its maximum allowable displacement, typically around .4mm for small speakers (Scarlett). Over-excursion occurs when the diaphragm starts operating at resonant frequency, which increases amplitude. Micro-speakers often have a limit that excludes the resonant frequency, but this sacrifices most of the bass and significantly degrades sound quality (Scarlett). To solve this problem, we will have to accurately map the resonant frequency in response to changing conditions and find an innovative way to avoid this frequency and prevent over-excursion.

Shaun Scarlett also mentions more general ways to enhance sound output in his article. One way is by compressing the signal's dynamic range, which amplifies volume without changing peak voltage levels (Scarlett). In addition, feedback systems can improve safety and allow for higher sound quality by updating internal models that predict speaker behavior and adjusting accordingly (Scarlett).

Our design manufacturing process will incorporate either 3-D printing or injection molding. The advantage of 3-D printers is that they are additive, meaning they do not waste any materials, and can be cheaper when creating quantities or parts up to 10,000 units. However, for quantities higher than 10,000, injection molding becomes more cost-efficient, as shown in the chart below, where the blue line represents high-efficiency 3-D printing and purple represents injection molding.

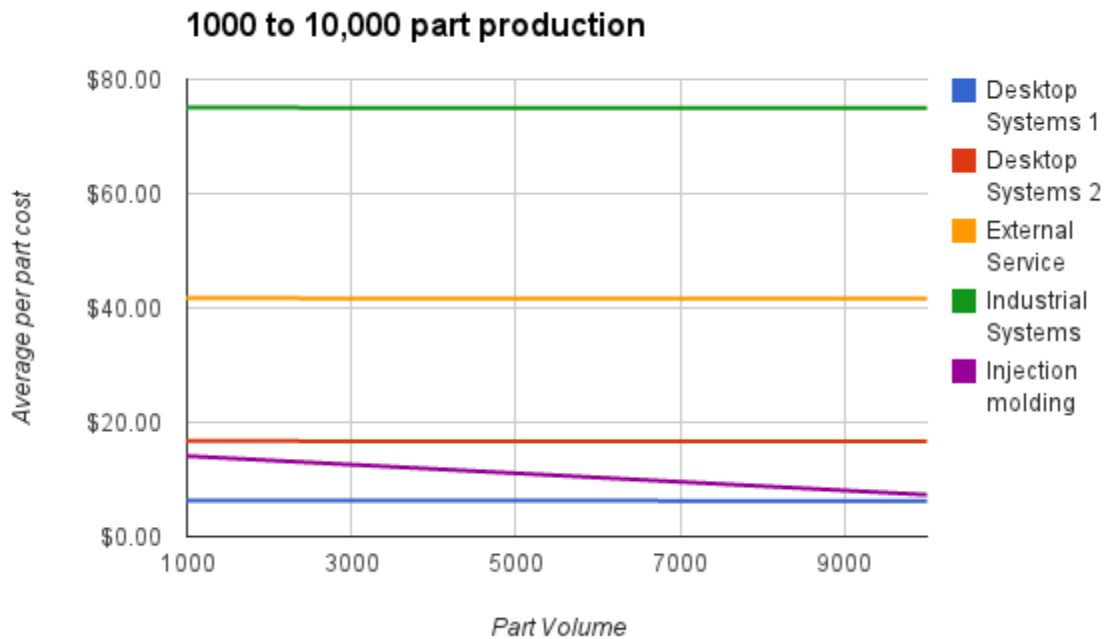


Figure 20: Source: <http://www.3ders.org/articles/20141106-is-3d-printing-technology-a-viable-and-affordable-alternative-to-injection-molding-production.html>

#### D. Cost

The cost estimation below is for one product which includes one holder and one speaker. Therefore, clients who choose to buy two products for a better “surround sound” experience, would have to purchase 2 separate products.

The holder consists of the design the team created, while the speaker, for now, is a small cylindrical iTreasure bluetooth speaker from Alibaba wholesale. The costs detailed are raw estimations based on the possibility of mass producing the product to cover material cost only.

Quantity	Description	Source	Price
1	Speaker	Alibaba wholesale (for an order of 100)	\$1.47
1	Handlebar Clip	Alibaba wholesale (for an order of 100)	\$0.50
1	Holding Structure	Plastic from EurekaZone (\$0.10 per square inch)	\$0.35
<b>Total:</b>	<b>1 Holder + Speaker</b>		<b>\$2.37</b>

Figure 21: Cost estimation for 1 unit (Annie)

With an added manufacturing cost of about \$1.00 per unit, the total price of manufacturing the product still rounds to less than \$4.00. Based on the group's initial survey of student peers, the majority of the responses opted for a price range of \$15-25, which is well within the team's budget. If the team priced the product at a reasonably affordable \$20.00, the total profit per unit would be about \$16.00.

## VII. Outlook [Emily]

### A. Target Populations

Tempo seeks to provide a quality music experience catered to the needs of frequent bike riders. The number of college and young adult bikers has steadily increased over the past decade (Edmondson, 2011). According to the National Sporting Goods Association Sports Participation Study in 2010, 15% of US bicycle riders are age 18-24 (Edmondson, 2011). This growing population of young adult bicyclists is largely due to the popularization of bike riding on college campuses. The movement to “go green” has gained traction among environmentally savvy college students, making bikes one of the most popular methods of transportation on college campuses across the nation.

Campus biking is exemplified by the students of Stanford University, named the number one bicycle-friendly college campus in the US by the League of American Bicyclists (“10 Most Bike-Friendly Campuses Across America”). Stanford excelled in all five categories evaluating how conducive the campus is to biking. The categories include: what the school has designed and built to create a biking-accessible environment, the amount of instruction on safe bike-riding habits provided by the school, the extent to which the school actively promotes bicycling, the involvement of local law enforcement in creating a safe environment for biking, and the school’s plans and programs in place for the future of biking (Top Bike-Friendly College Campuses in the US, 2011). Stanford received top marks due to its extensive bike programs and resources, including bike safety classes, bike repair stands and route maps, making it the only school to receive the Platinum level in the “most bicycle-friendly college campus” competition (Schools For Cyclists, 2011).

As previously mentioned, the majority of Stanford students we surveyed showed interest in having a safer, simpler and overall more enjoyable music listening experience while biking. Team Tempo sees our current target population as students attending bike friendly campuses, such as Stanford. Our team focused the features of our design on meeting the needs of an average Stanford student. Tempo is aimed at making a product easy to remove, attach and operate, knowing that students are busy and constantly on the go. It is important to our team to give students a product that is reliable, safe and affordable. Throughout the design process we emphasized these qualities and our final hands-free design is a safe, cost-effective product that exemplifies high sound quality.

While the idea for Tempo was born out of a need among Stanford students, our innovative music listening experience is certainly not designed as a uniquely Stanford product. We see the market for our product expanding among other college campuses that support bike culture. The League of American Bicyclists recognize the following colleges as the most bike-friendly campuses in America:



<b>College/University:</b>	<b>Award:</b>	<b>Location:</b>
Stanford University	Platinum	Stanford, CA
University of California, Davis	Gold	Davis, CA
University of California, Santa Barbara	Gold	Santa Barbara, CA
California State Long Beach	Silver	Long Beach, CA
Colorado State University	Silver	Fort Collins, CO
Portland State University	Silver	Portland, OR
University of Arizona	Silver	Tucson, AZ
University of California, Irvine	Silver	Irvine, CA
University of Minnesota, Twin Cities	Silver	Twin Cities, MN
University of Oregon	Silver	Eugene, OR
University of Washington	Silver	Seattle, WA
University of Wisconsin, Madison	Silver	Madison, WI

Figure 22: Source: (Schools For Cyclists, 2011)

While the current target audience is college and young adult age bike riders, Tempo is a product that all bike riders of any age can appreciate. The median age for adult bike riders in the US is 41.5 and many adults use bikes for transportation to and from work or for recreational purposes (Edmondson, 2011). Tempo will also target cities with the largest bike-riding populations, such as Minneapolis, Portland, Boulder, Seattle, Eugene and San Francisco (Bicycling's Top 50, 2014).

## B. Implementation

In terms of production, our team plans to bring our design for Tempo to life and test out our product among the Stanford student body. Tempo would be available for individual sale in a variety of colors and print designs. Eventually Tempo hopes to mass produce the product depending on the demand. As a West Coast based company, serving mainly cities and schools on the West Coast, Team Tempo plans to start local and sell our products mostly online and in bike stores along the West Coast. We see this product gradually expanding to other states that limit bikers' experiences.

## C. Possibilities for Future Generation

Our team's vision for the future of Tempo is to continue to improve the product and to expand our target population. Currently, this product is useful for bike riders who want a quality music experience while riding. However, in a second generation we hope to add new features, making the product appealing to a larger audience. One of our preliminary ideas for a second generation is to make it possible for Tempo to pivot 360 degrees, which would allow the user to customize sound-projection. We have looked into adding a light feature that could take the place of a bike light. Users would only have to attach Tempo to their bike to create a combined music and light experience. The bike light system could also be integrated with turn signals and brake lights, displaying separate lights to signal when the biker is stopping or turning. We also have considered adding voice recognition and allowing users to pause, play, skip or change the volume of a song through simply speaking aloud.

Team Tempo foresees future generation products that utilize group syncing speakers. The technology currently exists that allows users to sync their music to multiple devices and play music to a new level of quality. Companies such as,

Sonos, a smart system of HiFi wireless speakers and audio components, can unite digital music collections in one app that can be controlled from any device. Tempo would integrate this technology into the design, creating a more complete and revolutionary music experience. Tempo users would be able to sync music to multiple speakers and listen to songs together while riding, adding a new dimension to the entire bike-riding experience.

## VIII. Conclusion [Zachary and Emily]

Throughout the design process, our team became familiar with many possible solutions and each one's advantages and disadvantages. Ultimately, Tempo's handlebar speaker design is the most effective and elegant way to listen to music while biking. The design features sleek, unobtrusive sound amplifiers that clasp to the handlebars and contain small bluetooth speakers, ideal for enhancing the daily biking experience of our target audience. Tempo incorporates existing engineering knowledge combined with an artfully original design to bring a never-before-seen product to our customers. As we progress with the development of Tempo, our team hopes to expand our design to include additional innovative features and further, more advanced generations.

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