# SKRY

SEE. HEAR. RIDE.

MHCI+D 2016 Capstone, Final Report

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# TABLE OF CONTENT

# 01

# INTRODUCTION

# EXECUTIVE SUMMARY

Few things compare to the experience of riding. From the feel of the bike beneath your body, to the way the tires grab the road as you round into a curve, nothing compares to the visceral immersion with the environment as the wind blows past your body. Yet, any feelings of exuberance and liberation aside, motorcyclists find themselves in dangerous and even life-threatening situations on a daily basis. Unlike with cars, motorcycles afford little ability to shield the rider from the elements and accidents. The motorcyclists must constantly be aware of their current performance, their surroundings, and other vehicles on the road; all of which can be cognitively taxing in the best of situations. Our goal was to to create a product that would not interfere with the experience of motorcycling but add to it by making the rider smarter by supporting them in their decision making.

Through our research we found that there is no system available to specifically address the needs of the motorcyclist who face a unique set of challenges, such as a pothole, oil spill or high winds, that often will not cause a driver harm, but pose a real threat to the rider's safety if the rider is unaware. Through our process of research, ideation, prototyping and evaluation, we developed a concept called Skry.

Skry is the first advanced awareness and hazard reporting system for motorcyclists.  This system leverages map, weather, and traffic data, as well as crowdsourced feedback from other riders, to alert a rider of what's up ahead on their route with information specific to them.  With the use of a voice user interface and peripheral heads-up display, the rider is able to be forewarned of impending events on their route as well as alert others, without taking their eyes off the road or  their hands off the controls.

**PROBLEM STATEMENT**

Although motorcyclists account for just 3% of the vehicles registered, they make up 14% of all traffic fatalities (NHTSA, 2015).  In fact, if a motorcyclist is in a traffic accident they are 26 times more likely to die than if they were in a car.  Given those statistics, motorcycling is one of the most widely used methods of transportation in the world.

OPPORTUNITIES

To date, no technology exists to specifically support the rider in providing increased situational awareness about what is ahead on their route.

TARGET USERS

Motorcyclists who use navigation while riding.

# MEET THE TEAM

### BONNY CHRISTOPHER

Bonny has a MA in Experimental Psychology from San Jose State University and a BA in Psychology from the University of Cincinnati. Before starting the MHCI+D program, she was a Senior Research Psychologist investigating aviation safety specifically pertaining to workload and attentional tunneling. She is passionate about mitigating workload and increasing situational awareness through better design.

### CHRISTOPHER CHUNG

Chris received his B.S. from Cornell University in Information Science, Systems, and Technology. Before joining the MHCI+D program, he was part of the IT Rotational Program at Baker Hughes. He is passionate about designing novel experiences where users interact with a system under variable conditions, such as while riding a motorcycle, or driving a car.

### RYAN GERBER

Ryan is a Seattle-based UX designer and product manager. He has a passion for early-stage startups and holds a B.S. degree in anthropology and theology from Evangel University.

### RICKI SI XIE

Ricki holds a B.B.A. from the University of Wisconsin. Before joining the MHCI+D program, she worked at Harley-Davidson as an Enterprise Architect who seeks to understand the alignment between business strategies and technology capabilities. Driven by curiosity and empathy, she is passionate about creating delightful experience while developing her skills in interaction design and design process.

# MEET THE SPONSORS

Ustwo is global product studio that builds digital products, services, and businesses. We worked with two members, Harsha Vardhandan and Tim Smith, who specialized in user experience within the automotive space. Through weekly meeting and valuable feedback from various aspect of our design we were able to create Skry.

Tactile translates creative ideas and engineered solutions into compelling products. We collaborated with a team of user experience and industrial designers throughout our research, design prototyping and evaluation process. The guidance from Amy Brumet, Aaron Piazza, and Austin Porter helped us refine and improve our design not only iteratively but immensely.

# PROCESS OVERVIEW

Our process for this journey is rooted in the principles of human-centered design, beginning with deep exploration and research, to dreaming and ideating rich new concepts, through to actually building and testing working prototypes with riders.

| RESEARCH | IDEATION | ITERATION 1 | ITERATION 2 | ITERATION 3 | PRODUCTION |
|---|---|---|---|---|---|
| April 2016 | June 2016 | July 2016 | | | August 2016 |
| **Investigation** | **Ideation and Concept Refinement** | **Prototyping and Evaluation** | | | **Final Production** |

# 02

## INVESTIGATION

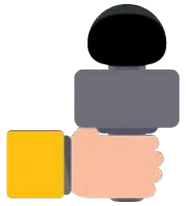
# RESEARCH OVERVIEW

We began our project with a focus on answering the following three research questions in order to gain a deep understanding into our problem space.

1. What types of situations or environments would a rider need an increase in situational awareness?
2. What situations and environments are perceived to be dangerous by the rider?
3. When are riders cognitively taxed?

We answered these question using the following methods.

LITERATURE REVIEW



EXPERT INTERVIEWS

SEMI-STRUCTURED INTERVIEWS

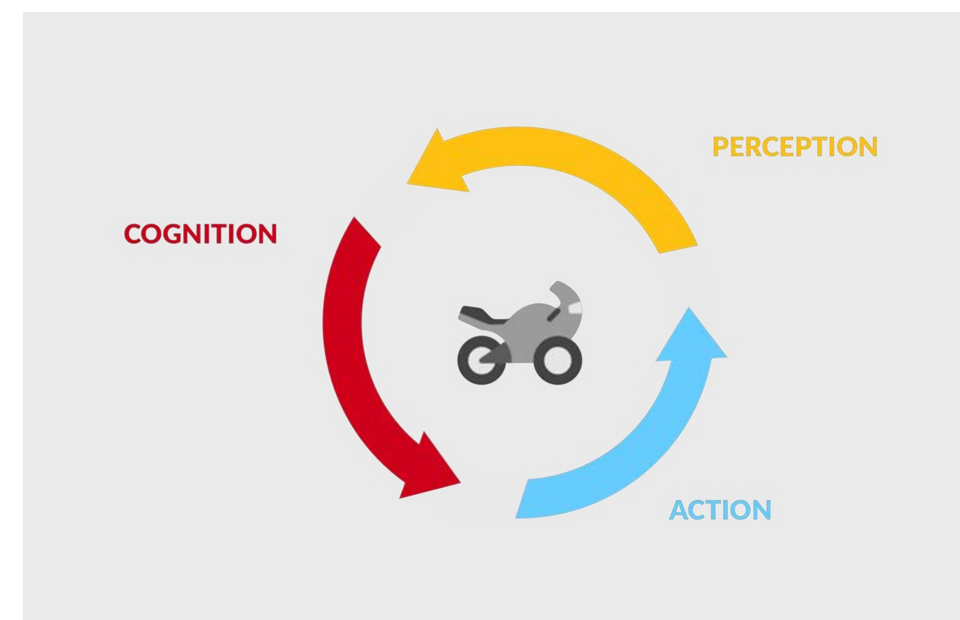
SURVEY

# KEY FINDING #1

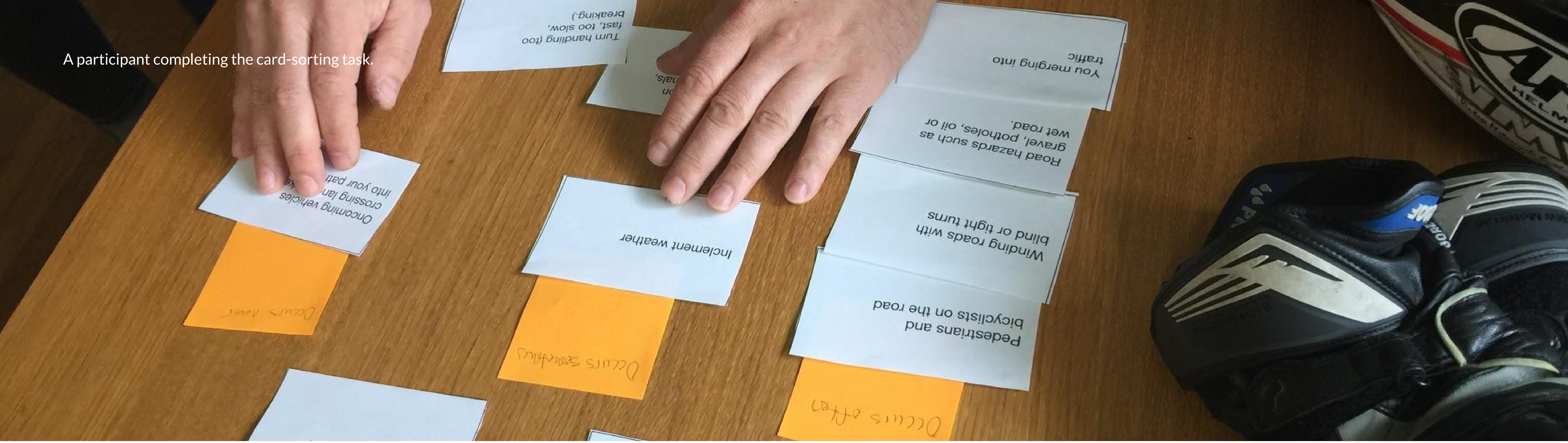
## Riding requires a high level of situational awareness

Due to the nature of the sport, motorcyclist are more exposed than drivers; there is no protective barrier between the rider and their environment. And being on two wheels means the bike is less stable; staying upright is dependent on not only the road but the rider's abilities as well. A pothole, oil spill or high winds will often not cause a driver harm, however these hazards pose a real threat to the rider's safety if they are unaware of them.

Through our investigation of the secondary research, we found that motorcycling requires a high level of situational awareness. While on the bike, the rider is constantly interpreting information about their environment, processing this information and making decisions on how to interact with objects and others on the road, all while managing their own mental and physical workload (Bellet & Banet, 2012). Any unexpected event could severely detriment an overly taxed rider.




Motorcyclists Perception–Cognition–Action mental model.



A participant completing the card-sorting task.

Through our user interviews, we found that situations involving cars were ranked as most dangerous to the rider, however all riders spoke of mitigations strategies to deal the look but fail to see occurrence by drivers.  For example, participant 3 stated they would make sure the driver had looked them in the eye before proceeding through a turn; participant 5 stated they would rev their engine to make others aware of them. These types of mitigation strategies reveal that motorcyclists are well aware of the dangers involving cars, less aware are they of unpredictable events, such as unexpected hazards, such oil or gravel in the road, where making a decision about mitigation strategy may happen too late.

Our card-sorting task revealed that the 6 out of the 7 riders interviewed stated they regularly encountered such unexpected road hazards. Moreover, many of them also stated that they had dropped their bike due to the unexpected, for example, participant 1 stated they ran into gravel where it previously had not been.

We also surveyed over 240 riders and found that these unexpected road hazards were perceived to be among the top three most dangerous situations they encountered, alongside with cars turning left in front of them and cars merging into them.

## IMPLICATION 1

*There is a lot of information that the rider needs to be aware of that is constantly changing, which can lead to cognitive overload. As a result, the proposed solution should allow the rider to manage all of these factors effectively in the temporal moment while having time to plan ahead.*

# KEY FINDING #2

## Technology should be informative and functional

We interviewed five subject matter experts and learned that the design of a system to support the rider should make them smarter on the road. Specifically it should shorten the time between intent and action, and anticipate the needs of the riders to help them make quick and accurate decisions through meaningful and relevant information.

We also learned that over reliance of system could lead to degradation in riding skills. Dr Linda Boyle, spoke with us about the dangers of over reliance on a system and we realized that any sort of adaptive technology that was seen in a car, such as blind spot indicators may lead riders to be less aware of what's coming up behind them. In fact, we did a comparison of advanced car technologies to those of motorcycles and found that the only cross over occurred in antilock brakes.

**IMPLICATION 2**

*Technologies needs to support the riders without causing them to be too reliant on the system.*

*"How you display the information and where you display it is really important, design for the senses, design for the context, design to make the rider smarter, design to connect, and design to support operations."*

— Geo Felicilda & Dan Darrow, *Harley-Davidson Motor Company*

*"The only survival tool you have is your experience and your attention, you will never survive if you have to rely on technology."*

— Roman Lameshkov, *BMW Ride West*

*"Avoid having the user become reliant on the technological feedback, since this can lead to users becoming complacent if the system becomes routine."*

— Dr. Linda Boyle, *UW Human Factors and Statistical Modeling Lab*

# KEY FINDING #3

## Riding is a way of life

All of the riders we interviewed stated that one of the main reasons for riding was the sense of freedom and oneness with the road. We can also deduce that riding is worth the risk for many; given that a rider is 26 times more likely to die in an accident, the rate of motorcycle registration is still increasing (NHTSA, 2015).

**IMPLICATION 3**

*A successful system should not interfere with the riders experience on the road.*

*"I started riding because it was the ultimate symbol of freedom and the pleasure of being more deeply connected to the road was a great feeling."*

— Semi-Structured Interview, Participant 1

# DESIGN QUESTION

Based on our findings we wondered

## How could we provide information about a motorcyclist environment that could aid in their situational awareness while riding?

# COMPETITIVE ANALYSIS

| | Waze | BMW Navigator V | SKULLY AR-1 |
|---|---|---|---|
| Designed for the rider | | ✓ | ✓ |
| Hands free interaction | | | ✓ |
| Navigation | ✓ | ✓ | |
| Traffic & weather updates | ✓ | ✓ | |
| Hazard alerting & reporting | ✓ | | |

Based on our design question, we looked for a system that would meet the needs of the rider, not only by supporting them on the road in terms of situational awareness of what is ahead, but whether or not the rider could easily and safely interact with the system while on the road.

For example, Waze solves many of these issues for drivers, however it was not designed with a motorcyclist in mind who always needs their hands on the controls and eyes on the road meaning the use of a mobile phone is a particularly unsafe method of reporting. Furthermore, many of the hazards that are dangerous to riders are not included in the hazard categories accepted by Waze.

The BMW Navigator was built with the rider in mind, however their navigation service only supports traffic and weather. The use of a mounted GPS also requires the user to look away from the road and onto the unit.

The Skully AR-1 uses a head up display to present information, however they currently no longer support navigation or weather.

*We found through our competitive analysis that no system currently existed to support the rider in increasing situational awareness by notifying them of specific motorcycle hazards up ahead.*

# 03

IDEATION

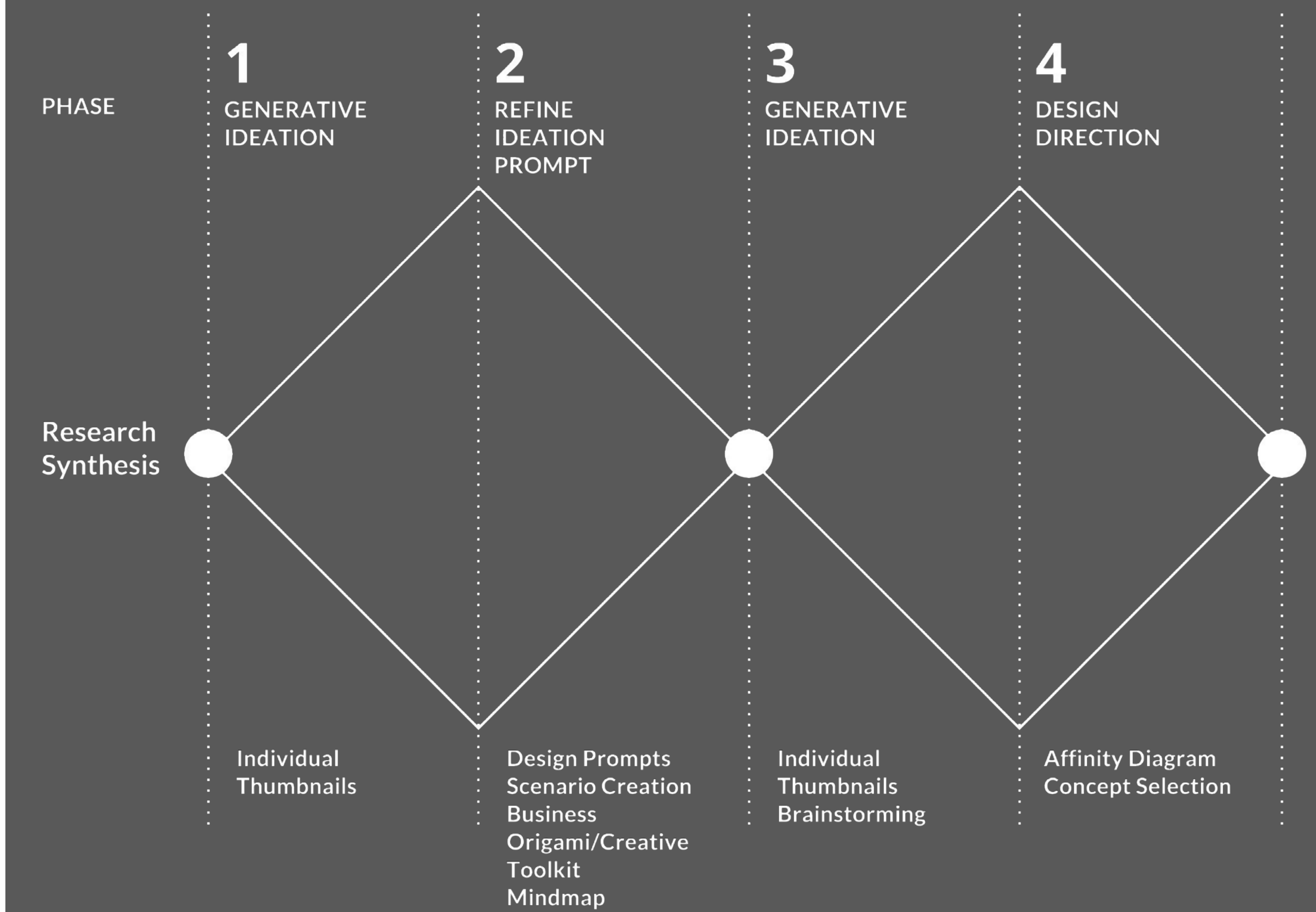
# IDEATION OVERVIEW

We leveraged both unstructured and structured ideation activities to help us generate a broad set of concepts for our design problem. To start, we began diverging from our initial research insights, with each group member generating  ideas by sketching individual thumbnails. Then, to contextualize the problem space, we created tangible representation of three most common scenarios found in our survey.

With the help of our peers from the paired team, we created the following three design prompts to facilitate another round of thumbnails sketchings:

1. How can we reduce the cognitive load of motorcyclists?
2. What information can be provided to others on the road about motorcyclists behavior?
3. What suggestions could be provided to riders on their ability?

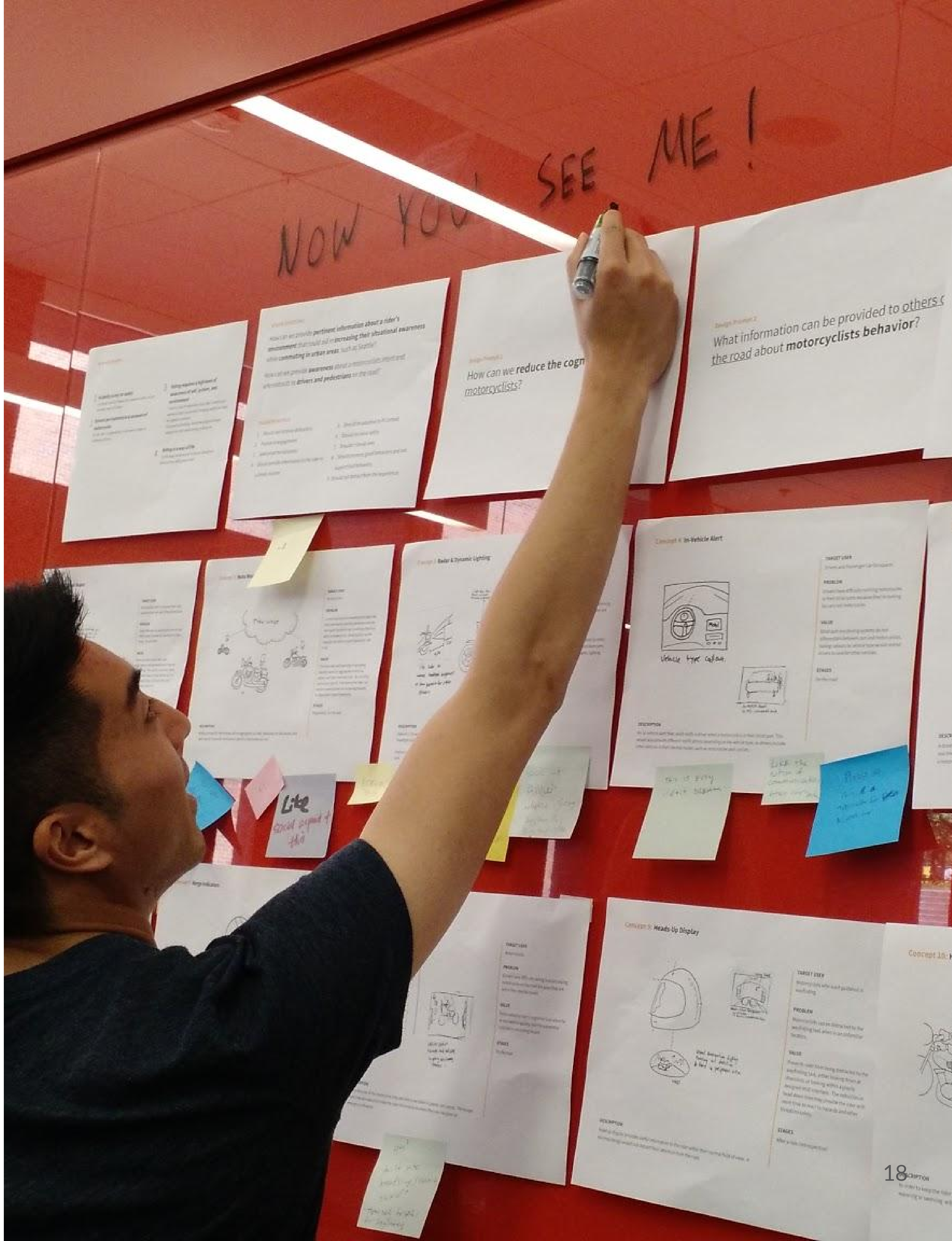
Finally, the team came together as whole to create affinity diagrams which captured  commons themes from all our generated ideas. The top five concepts were selected, and then expanded upon through a  conceptual model and critical incident path for user feedback.



# DEFINING OUR CONCEPT

We narrowed down our concepts from 52 ideas into 2 distinct direction, one was to provide awareness to the rider that allows them to mitigate risk beforehand as well as additional feedback prior to and after a ride.  The second concept dealt with increasing other motorist awareness of the rider's presence. The team worked together and conducted additional rounds of ideation and brainwriting around each concept to come to alignment of the target problem and users it supports, and possible lists of features and affordances that they could provide.

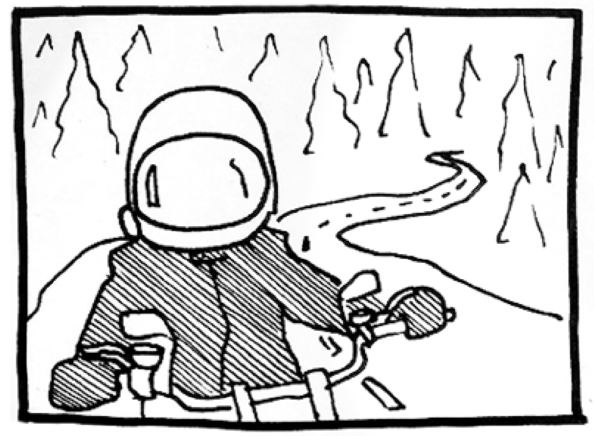
We also created a set of experience flows and storyboards to demonstrate the use of each concept. Context diagram that showed the assumed dependencies of the proposed solution to cover the input and access of the technical implementation were also created.  With the help of our sponsors and instructors, we came to a conclusion  that the former concept address our research findings and the fundamental experience riding the best.



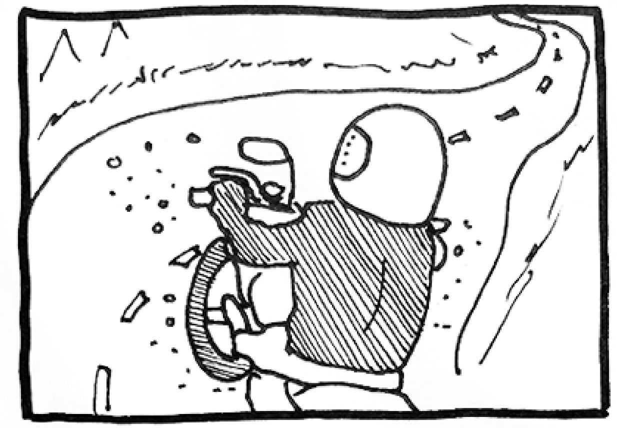
# DEFINING OUR CONCEPT

## Storyboard

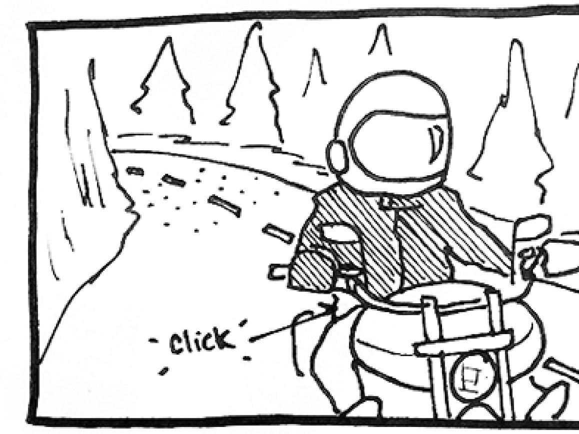
Through auditory and visual channels, the system alerts the rider of upcoming hazards and events. It also provides the ability of riders to alert others to unreported hazards.



*Susan is out for a ride in the country.*



*While going around a sharp curve, she encounters gravel on the road.*



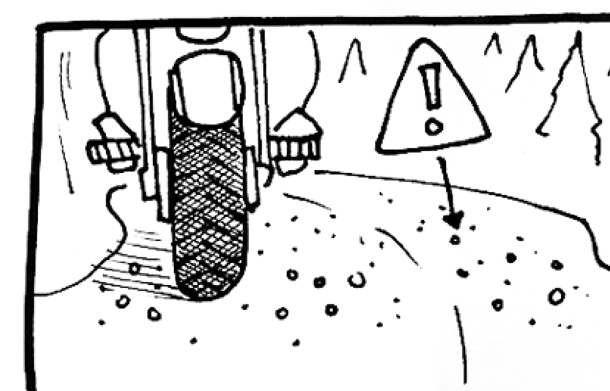

*After narrowly avoiding the hazard, she activates Moto Waze with a tap of button.*

*The system geotags her current time and location and marks the area as containing a “hazard”.*


*Susan is then prompted to record an audio message alerting other riders.*


*Mike is out on the same windy road...*


*When Mike gets within 1 mile of the hazard, he gets an alert from the app and hears Susan’s message.*



*Mike is able to slow down and use caution since he knows there is a hazard ahead.*

# DESIGN PRINCIPLES

Based on our research finding and ideation activities, we refined our design principles to guide our next stage of concept refinement and prototyping.

## PROACTIVE

Providing information within a reasonable timeframe that allows the rider to plan, react and mitigate risk.

## UNOBSTRUSIVE

The system will provide information without overloading or interrupting the primary task of riding.

## FIT FOR THE RIDER

Information provided is specific to the riding experience and the system is designed with their safety in mind.

# 04

## PROTOTYPING + EVALUATION

# PROTOTYPING AND EVALUATION OVERVIEW

In order to validate our concept, we conducted 3 evaluations; 1 of concept and variables that would be used (iconography, tones, and situations) in testing, and 2 prototype evaluations of varying fidelities.

**ITERATION 1**

**Evaluation #1**
Focus Group: Symbology and Hazards
User Interview: Input Method Preference
Wizard of Oz: Scenario Walkthrough
Paper Prototype: Low-fidelity post-ride mobile app v1

**ITERATION 2**

**Evaluation #2**
Wizard of Oz: Scenario Walkthrough with Motorcycling simulation, voice interaction v1 and HUD v1
Paper Prototype: Low-fidelity Post-ride mobile app v2

**ITERATION 3**

**Evaluation #3**
Wizard of Oz: Scenario Walkthrough with Motorcycling simulation, voice interaction v2 and HUD v2
Paper Prototype: High-fidelity mobile app v3

# EVALUATION #1

## Focus group: 3 participants

### WHAT WE DID AND WHY

In the first phase of testing we evaluated symbology, hazards, and button placement.  We evaluated symbology because we wanted to see which icons could be used as global indicators for a hazard and which ones needed to be specific.  For example, could the road sign icon indicating debris be used for all debris on the road; specifically, could it encapsulate the notion of a fallen tree vs. gravel? Hazards were investigated for two reasons, first we wanted to know what types of alerts riders would want to hear and two, to ensure that in future prototype testing we could “force” the user into interacting with the system by presenting hazards everyone deemed to be reportable. Button placement was researched to learn where the best placement was to ensure that riders felt comfortable using the system while on the road.

### HOW WE DID IT

We conducted a small focus group with participatory design to learn about road symbology, hazards, and button placement. When discussing symbology and hazards we presented images to the group and asked opinions.  For button placement, we asked riders to sit on their motorcycle and imagine what it would be like to geo-tag a hazard on the road; we provided stickers and asked them to place it where they believed the button should be placed.

### WHAT WE FOUND

1. Moving beyond the hazard categories, if the action or mitigation is different, a different icon should be used.
2. Our participants stated they would like to know about issues that already have signage (for example construction zones and deer crossing), but would likely not report it to others.
3. Our participants stated they would report hazards that would affect all riders regardless of experience level for example, issues pertaining to cars on the road (for example a car broken down on the side), lengths of bad road, ice, large debris, and speed traps.
4. For button placement, convenience and safety matter the most.

Focus group discussing hazard perception.

# EVALUATION #1

## Concept walkthrough: 2 participants

**WHAT WE DID AND WHY**

To test how users might actually interact with the system while on the road, an experimenter walked them through a scenario using images to represent hazards along the way.

**HOW WE DID IT**

Participants sat on their motorcycles and the experimenter walked them through a scenario in which they are traveling from UW to Bainbridge Island to the Olympic National Park. To simulate a hazard alert, the experimenter pretended to be the system and alerted the user with an audible “beep” and presented an image of an icon. When a crowdsourced message needed to be relayed, the experimenter spoke the message and held up an image of the upcoming event. The user was asked to confirm or deny the existence of the event (some images confirmed and some images denied). For a non-reported event the experimenter held up an image of a hazard. If the participant wanted to report the hazard, they simply pressed the button they previously affixed to their motorcycle. Participants were asked to think-out-loud during their “ride” and were told that they did not need to report or confirm any event if they did not want to.

Following the “ride” the participant was asked to go through the mobile application paper prototype in which they reviewed passed and reported hazards.

**WHAT WE FOUND**

1. Our participants stated they felt good about reporting a serious hazards (e.g., fallen tree) to other motorcyclists because it would help others ride safer.
2. Participants did not report all new hazards during the evaluation test; those reported by both participants were something that would affect all riders regardless of experience (e.g., fallen tree).
3. Participants would want to hear what other people had to say about the hazard and liked the personalization of it, although they did express concerns about the possibility of not being able to understand the speaker's message.
4. Before hearing a report, they would like it to be validated in some way (multiple reports or reported by someone with authority (e.g., police, highly rated power user).
5. They expressed concerns about hearing other people’s messages if they could not understand the speaker (e.g., accent).

   The evaluation of the mobile application revealed the following insights
6. For the mobile application, 2/2 users would be okay with viewing and confirming their own reports, but did not want to view any of those of others.

# EVALUATION #1

## Moving forward

This first pass of testing gave us some really good insights into how our system could be built and tested.  For example, we know that a low number of users will do reporting of events, however to “force” a report and test that interaction, we found several scenarios that our participants felt were significant to report and used those in our second round of evaluation.  We also decided to go with a vocal geotag instead of a physical button, because our participants stated that this would be an easy action, since riders who use headsets are used to using voice activation.  Based on our focus groups and debriefs, we were able to identify some additional supporting information about a reported hazard that users would like to have, specifically, length and severity.

Scenario walkthrough with one of the participants to evaluate the during the ride interaction

Participant interacted with the paper prototype of the mobile app post-ride.

# EVALUATION #2 and #3

## Concept walkthrough: 7 participants

**WHAT WE DID AND WHY**

For the second user test, we focused on constructing a wizard of oz prototype that would best show how the rider would interact with our system, both for reporting a hazard, as well as being warned of an upcoming hazard. This incorporated feedback from our first user test, such as reporting hazards that users found to be the most relevant, moving to a completely voice based interaction with the system, testing out a confirm/deny system to determine if a hazard should be removed from the database, and testing out whether participants would prefer hearing a recorded message from other riders. We also tested the paper prototype from the previous user test, removing features that users found less critical, such as only confirming their own reported hazards, instead of other crowd-reported hazards.

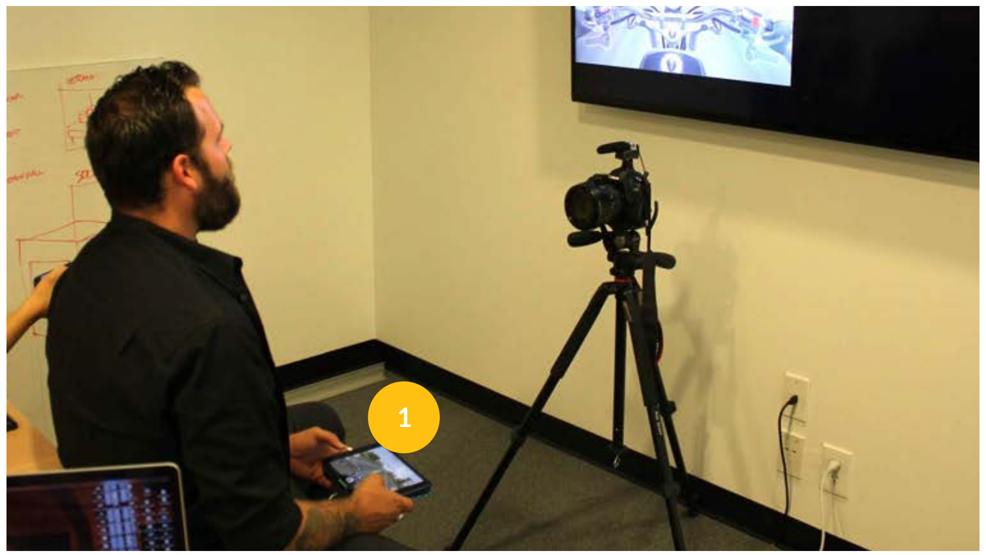
**HOW WE DID IT**

To implement this system, we created a dual-screen task, using a combination of a motorcycle simulation game on an iPad, and a slide deck with the hazards and hud overlayed on top of eachother. The iPad was connected to a MacBook Pro, which was then connected to a TV. This allowed us to display both the game and the hazard/hud slides in a split-screen mode, which allowed us to display both types of information to our user testers simultaneously. The goal of the motorcycle game was to provide a way to simulate the cognitive load a rider experiences when they have to focus on controlling their motorcycle while on the road. While the rider was immersed in the game, a wizard would control the slide deck, which would show reported and unreported hazards. When the slides were changed, the wizard also controlled the different tones that were played.

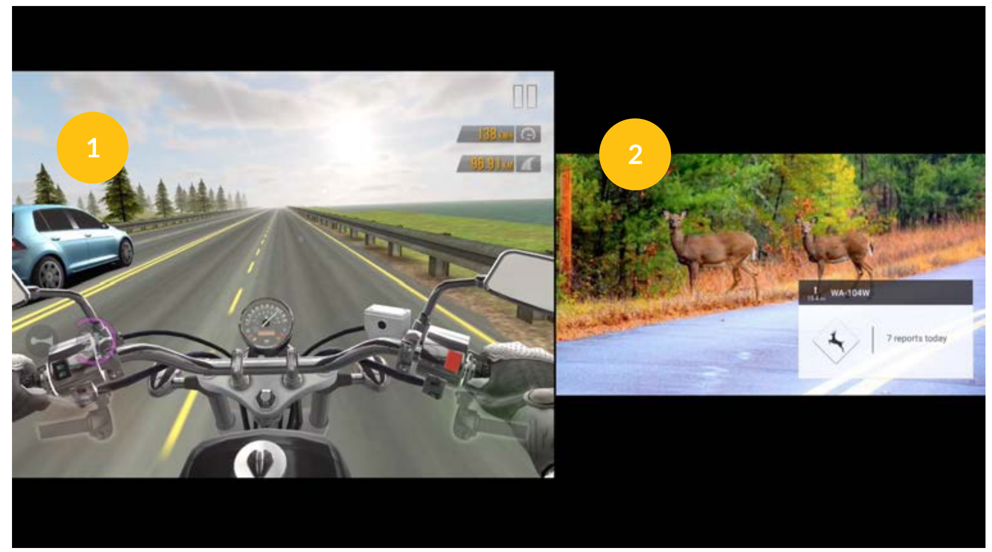
# EVALUATION #2 and #3

## Prototype Design

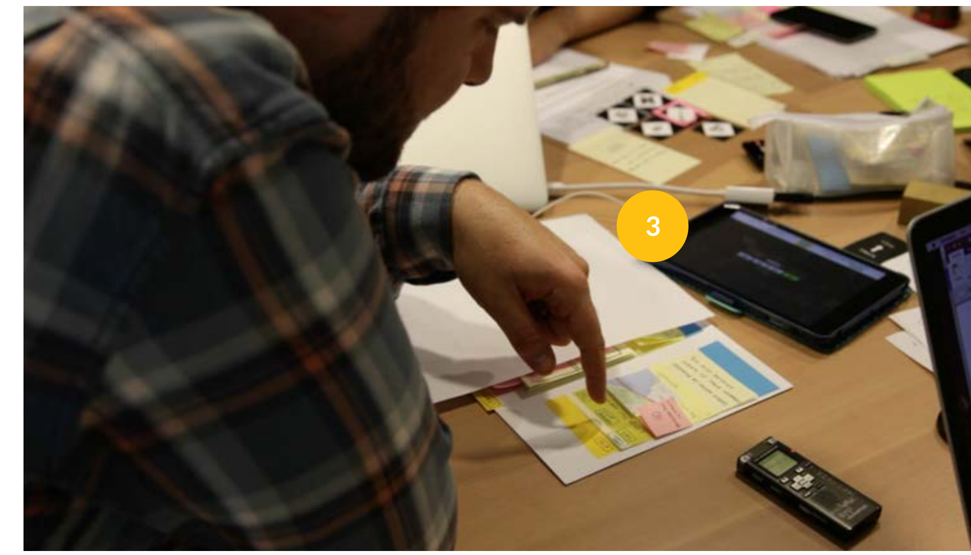
### Prototype #2 for Evaluation #2




1. Motorcycle simulation game on iPad

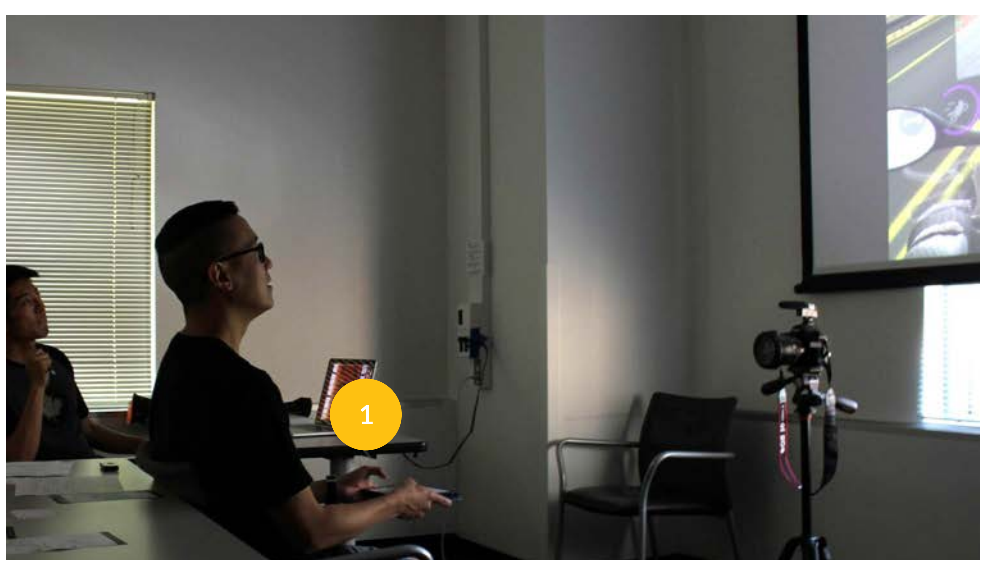



2. Split screen set up of the simulation and hazard presentation

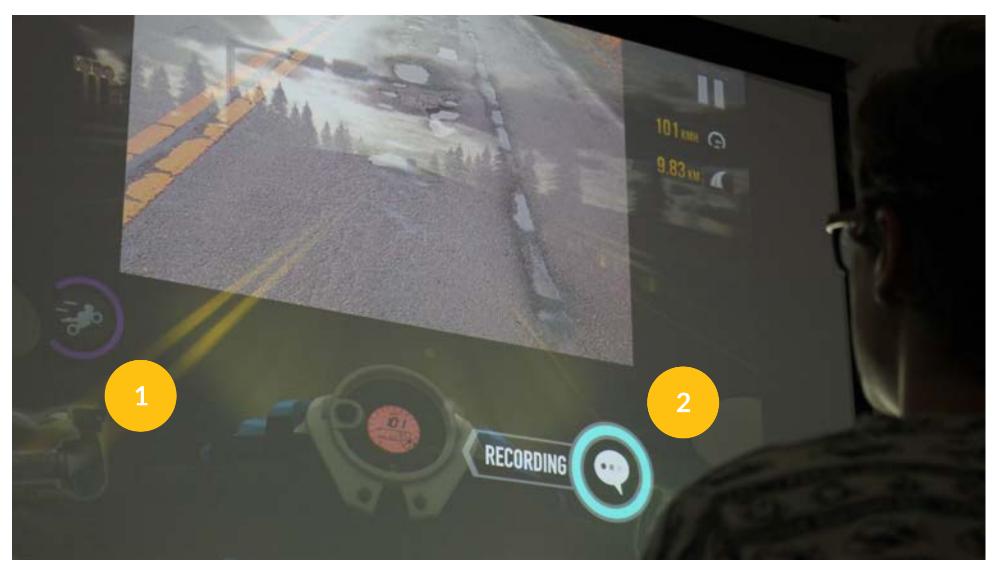



3. Low-fidelity paper prototype for post-ride hazard review

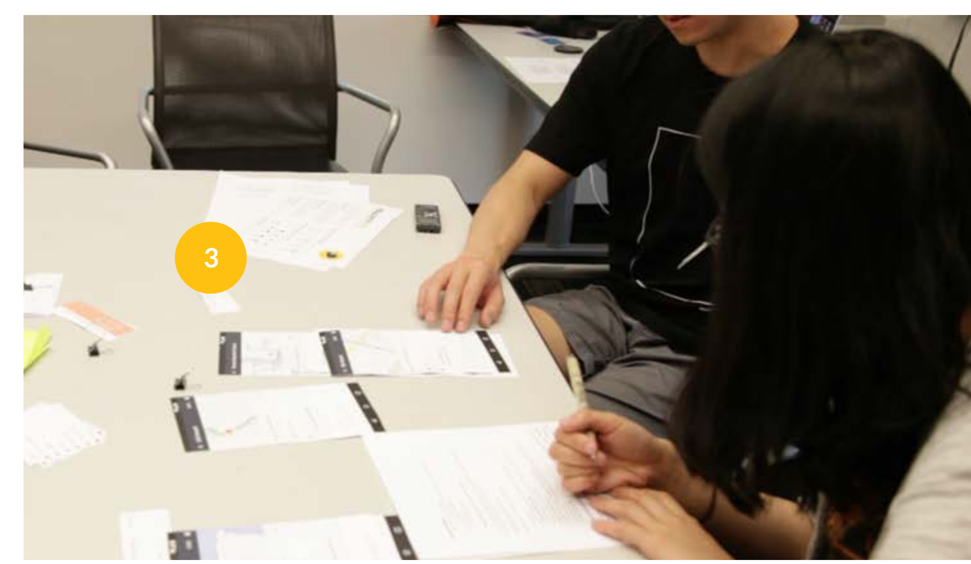
### Prototype #3 for Evaluation #3




1. Motorcycle simulation game on iPad




2. Dual projections of the overlayed hazard presentation




3. High-fidelity paper prototype for pre- and post-ride mobile app

# EVALUATION #2

## Task and Findings

**THE TASK**

The script was that users would be going on a ride from Seattle to Olympic National Park, and would be using our system to report hazards they encountered, as well as receive warnings of upcoming hazards, which they would then confirm/deny for later riders. Users were given a brief demo of the system to help onboard them as to how it worked. They were expected to initiate the system we created (Skry) when reporting a hazard, by saying the clutch “Skry report.” This was then followed by a confirmation tone, where the user could then record a message of the hazard they saw. Once the message was complete, the user would then say “Skry end”, which was followed by an end tone.

For the warning aspect of our system, the system would first provide a hazard alert tone as the user entered the hazard zone, which was coupled with the hud display. The hud provided additional supplementary information, such as an icon of the hazard up ahead, and more specific information if available, such as 7 reports today if it was an animal related hazard. After the user exited the hazard zone, they would hear an end tone, and then be prompted after 5 seconds to confirm or deny that the hazard was there through a confirmation tone.

The final phase of this user test was the updated paper prototype for the mobile app. Users were asked to confirm or deny hazards after they finished the riding portion of our user test. We had them confirm their own hazards that we had scripted out in the first portion of the user test. We also wanted to confirm  what we had heard from the previous test, which was whether users would be willing to confirm other hazards that were reported.

**FINDINGS**

1. Initially we tested 5 different tones for different stages of the ride, however we quickly learned that some of the tones were redundant or were difficult for a rider to differentiate, so we reduced them down to 3 tones.
2. We also learned that our riders wanted more information through the auditory channel and less through visual because it required more effort to look away from the road.
3. Participants liked the idea of a crowdsourced message but revealed they would find the voice of Skry relaying the message to be more trustworthy.
4. Lastly, all participants stated they did not feel comfortable denying certain hazards that can often be unseen, for example the presence of deer.
5. Participants would want this paired with navigation planning, riders would want to see upcoming and newly reported hazards on the route when stopped.
6. Participants would be willing to confirm their own reports, but it would need to be easy.

# EVALUATION #3

## Task and Findings

**THE TASK**

The final prototype evaluation followed the flow of the previous with a few key differences. First, we moved from a tonal system to that of a conversational UI, for example, instead of hearing a tone to alert the rider of the upcoming hazard zone, the system tells the user what is coming up on their route. Instead of providing crowdsourced messages, we moved to a system that would use NLP, so all crowdsourced messages were parsed for keywords and those keywords were presented to the rider in lieu of the real messenger. Finally, we asked our riders to use the mobile app paper prototype to input their destination and choose a route. Our testing method also moved from side to side to an overlay of the HUD onto the game using dual projectors.

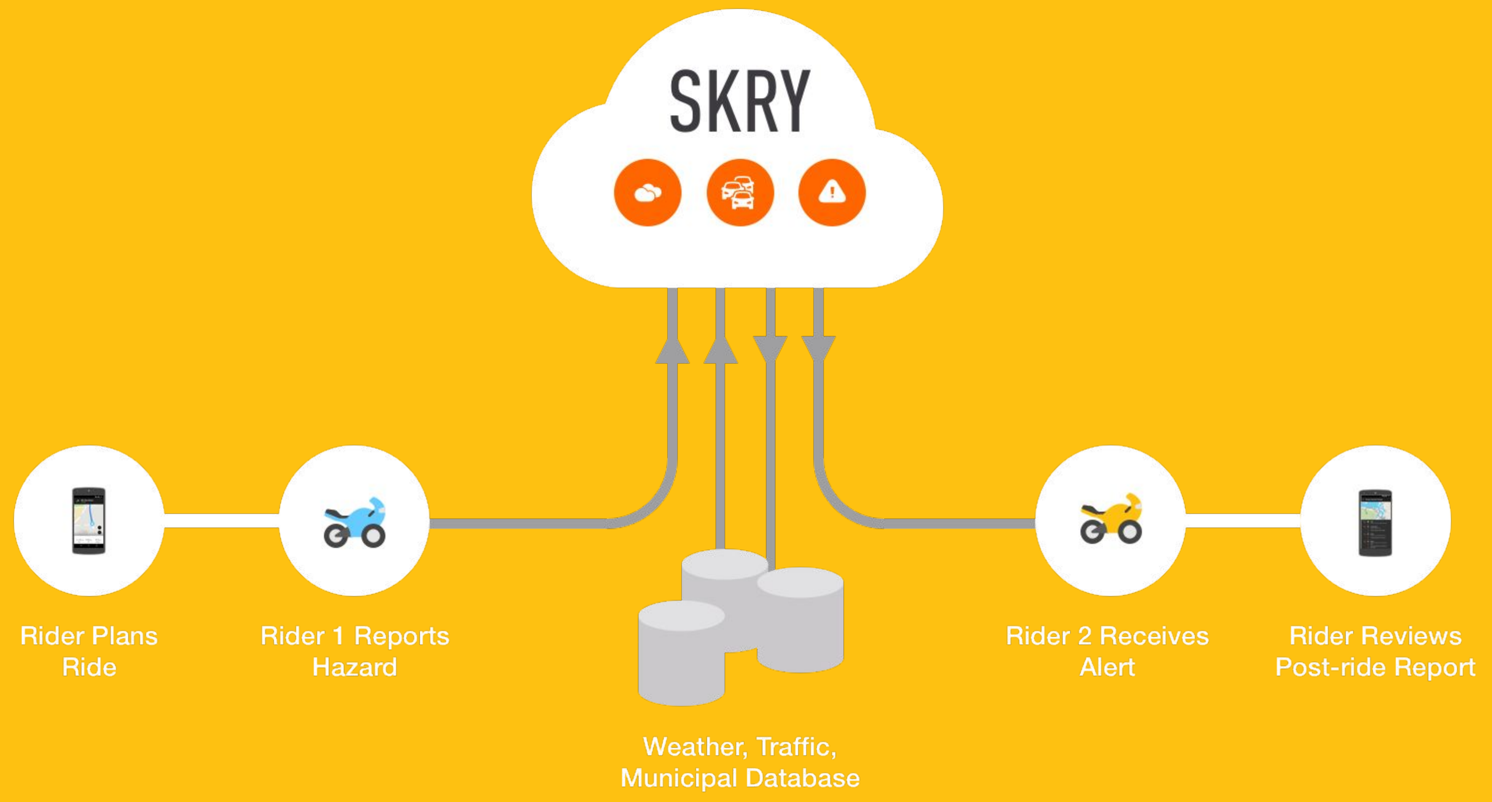
**FINDINGS**

1. When participants stated “skry hazard” skry would respond back, “state hazard and location,” the reasoning behind adding location was to see if our users could easily state what side of the road it was on, however we learned that those tested did not know how to answer this question without additional instruction.
2. We also learned that users wanted to be able to report points of interest and learn more about good routes nearby.

# 05

## INTRODUCING SKRY

Skry is an advanced awareness and hazard reporting system for motorcyclists that leverages map, weather, and traffic data, as well as crowdsourced feedback from other riders, to alert a rider of what's up ahead on their route.



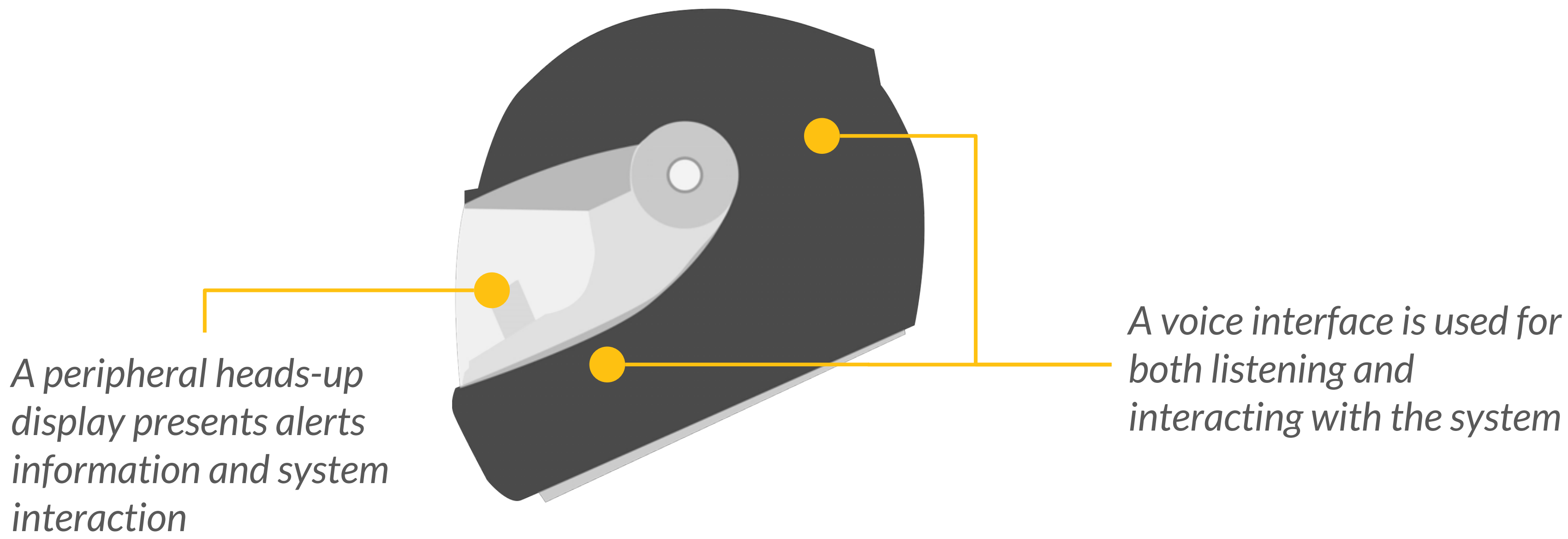

Fueled through the Skry mobile app, Skry first allows a rider to choose the best route for them based on data that has been collected. They will be able to plan out their route, searching for destinations or points of interest in a map interface similar to Google Maps. Here, they will be able to view real-time hazards along the route, and plan accordingly. The mobile app will provide users with the ability to sort routes based on distance or ETA, which will also display the number of hazards on that route.Traffic and accident data will also be integrated with the system, using the Connected Citizens Program to get information from weather, traffic, and municipal providers such as Waze, INRIX.

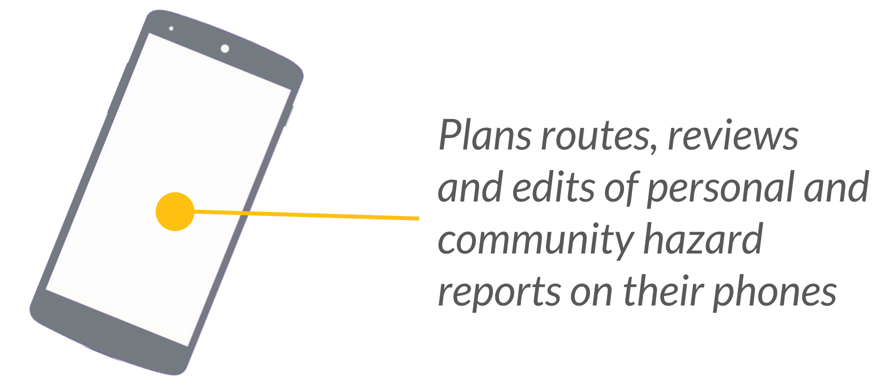
While on the road, the rider will have the ability to report and alert other riders of hazards or events they have encountered. The Skry system tags the hazards time and location and immediately makes this information available to others on the road. This information is uploaded to a centralized server, which will allow the Skry agent to process all the reports, and avoid duplicate entries in the system. As mentioned previously, data from external databases will be  integrated into this system, which will allow car-related hazards, traffic, and municipal work such as construction to be reported by the system. This will help provide riders the most accurate and up to date information possible across a wider breadth,  than simply user reported data. It also gives more credibility to the reports, which can be validated with the existing data to establish a reliability score.

After a motorcyclist is done with their trip, or if they want to take a break, they will be able to view information about their ride, such as relevant statistics or behaviors. This will be gathered using the onboard sensors of the smartphone, which have a plethora of sensors such as GPS, gyroscope, accelerometer, barometer, etc. The aggregated data will also be available for view using data visualizations, such as average speed over time for the past week, to better understand a user's riding behavior across time. Riders will also have the ability to review or amend any of the hazards they reported. This will consist of a preview of the route traveled, with the hazards reported along the route. A timeline view will also be available. Here, rider's will be able to listen to the recording that they made of the encountered hazard, and re-record it or tag it with the appropriate hazard category.

# SYSTEM COMPONENTS

## Heads-up Display, Voice Interface



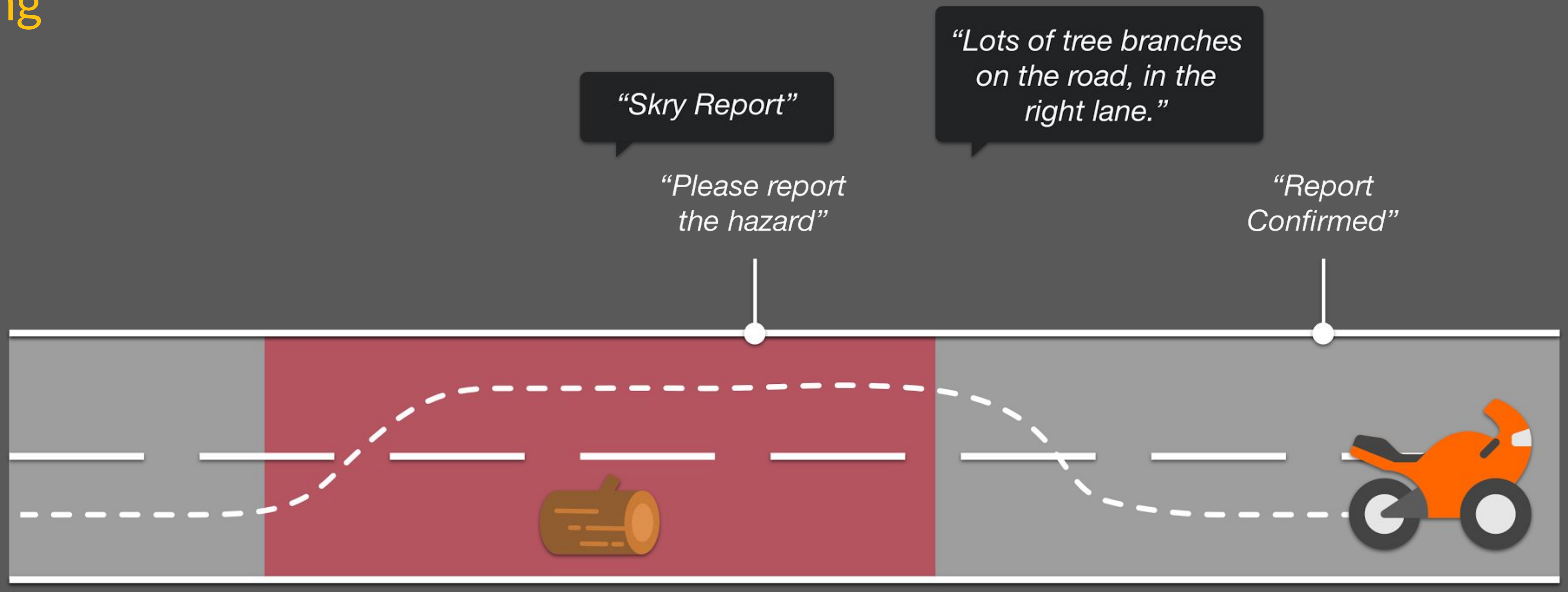

Designing for riders meant creating a clean, minimal experience to assist both in environmental and situational awareness as well as wayfinding. While the primary mode of interaction between Skry and the rider comes through a voice interface, a secondary peripheral heads up display allows the rider to interact and get real-time feedback from the system through multiple senses. The voice interface serves as the main mechanism of communication between the system and the rider, while the HUD provides supporting information to the rider that will be easily recognizable via color and movement. This means that the rider doesn't need to take their eyes off the road in order to understand the nature of the event.

Unlike most systems currently available in this domain, Skry utilizes an entirely hands-free interaction model, allowing the rider to simply speak and the system listens. This is a focal aspect of our system, as pre-existing systems focused on a combination of touch and voice interaction, which leads to cognitive overload. One example is the Sena bluetooth control system, which can be mounted on the side of the helmet, and allows the rider to make calls, play music, and more from the touch of a button. Although they have a very simplified interface, with very little button control required, the combination of physical buttons and voice commands can be taxing on a rider. This is especially true in dangerous situations, where a rider needs to keep their hand on the bike to mitigate the hazard. If they had to take their hands off the wheel to warn others around them, or had to spend time thinking about the right control or command, that could lead to a potential accident.

The final component of the system is the mobile app, which is used to connect the rider to the Skry system.. It will sync with the HUD and speakers in the helmet through bluetooth to deliver hazard warnings and system messages. During the ride, the smartphone will play a passive role, as it is very dangerous for riders to be looking at a mobile screen while riding. Its main purpose will be for the pre-ride and post-ride, where riders will be able to plan trips and view their trip summary. It also serves as the node for collecting and sending GPS and hazard data, which can then be aggregated across all riders.

# INTERACTION TIMELINE

## Hazard Reporting

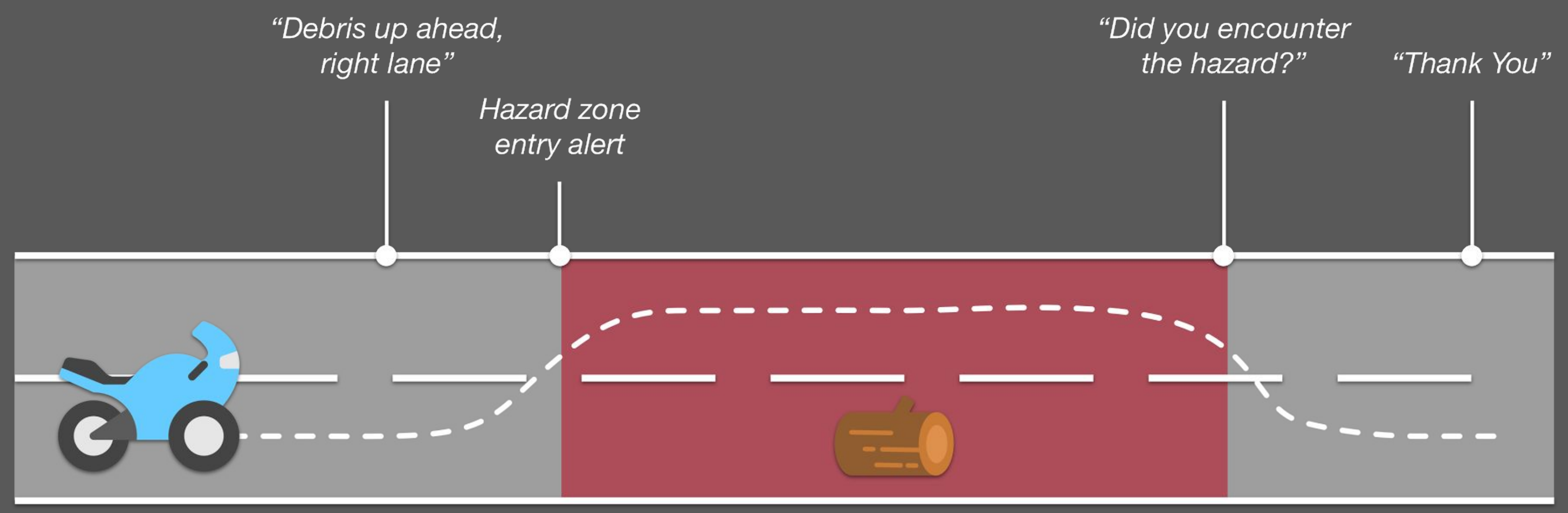



When the rider is able to report, they will say "Skry Report," which places a geotag at the location within a 1/2 mile radius around each end to indicate a hazard zone. The system will prompt the rider to record a message, stating "Please report the hazard." This will be accompanied by a visual cue in the hud, which will consist of a microphone icon to indicate the system is listening and recording. The rider will then record a message regarding what they encountered, which will be parsed for key terms using natural language processing to form a concise message for the next rider. For example, if the rider says, "Lots of tree branches on the road, in the right lane", the system would know to classify tree branches as debris. Once the message has been recorded, and 2 seconds have elapsed, Skry will acknowledge it has received the message by replying to the user with "Report Confirmed."

A feature we looked into due to user feedback was the ability to re-record a message or cancel a report. This was due to the potential need to prematurely end a report if the rider encountered another hazard as they were making the report. They would then have to re-record the message, or delay it till they have safely avoided the hazard. Ultimately, we decided not to test this feature because it would increase the complexity of our system. The users would have to remember additional commands, and may not be able to recall it in the heat of the moment. On the other hand, immediately after avoiding a hazard, riders are still on high alert, so they should be able to at least respond to the hazard.

# INTERACTION TIMELINE

## Hazard Alerting




Following the previous scenario, when another rider comes along, they will receive the message "Debris up ahead, right lane" a half mile before entering the hazard zone. They will then receive another warning that the hazard is up ahead when they enter the hazard zone. This will consist of an auditory alert and visual cue through the hud. We chose to provide the message first, and then the tonal alert second, since users need time to process and prepare their mitigation strategy. The tonal alert serves as a reminder that the hazard is coming up, and is much less distracting compared to a message, since much less information is contained in the alert.

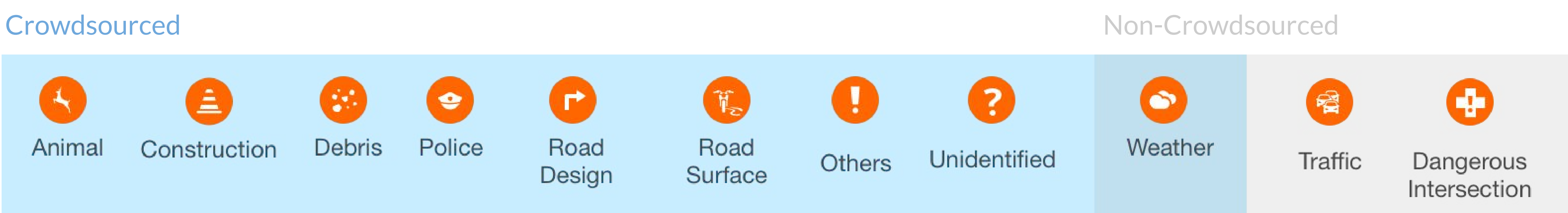
As they exit the hazard zone, the visual cue will disappear and they will be asked "did you encounter the hazard?" This is to confirm whether the hazard is still there, as many hazards are time-dependent such as weather related hazards or debris in the road. Other hazards may be present for extended periods of time, such as ongoing construction. This information will allow the system to know when the hazard no longer needs to be relayed to others, through an escalation and decay system that will be discussed in the following section. If the user chooses not to confirm or deny that they encountered the hazard, the system will assume that the hazard is still there. This is to account for users who only listen to reported hazards, and never report or confirm. Once the confirmation has been received, the system will provide feedback that it has been received by saying "thank you."

# HAZARD CATEGORIZATION MODEL

## Hazard taxonomy

We created a taxonomy to categorize crowdsourced hazards into 7 categories based on research done by Jenkins and Young (2016). A set of predefined hazards within each category will be inputted to the system to help the rider identify hazard quickly. For instance, gravel, rock, or sandy roads are all categorized as debris because the mitigation strategy for each is the same.

We also included categories that can be relayed to the riders but aren't necessary crowdsourced. For instance, alerts about dangerous intersection could come from historical information of accident records or city planning database, information about traffic and general weather condition are based on external data providers.



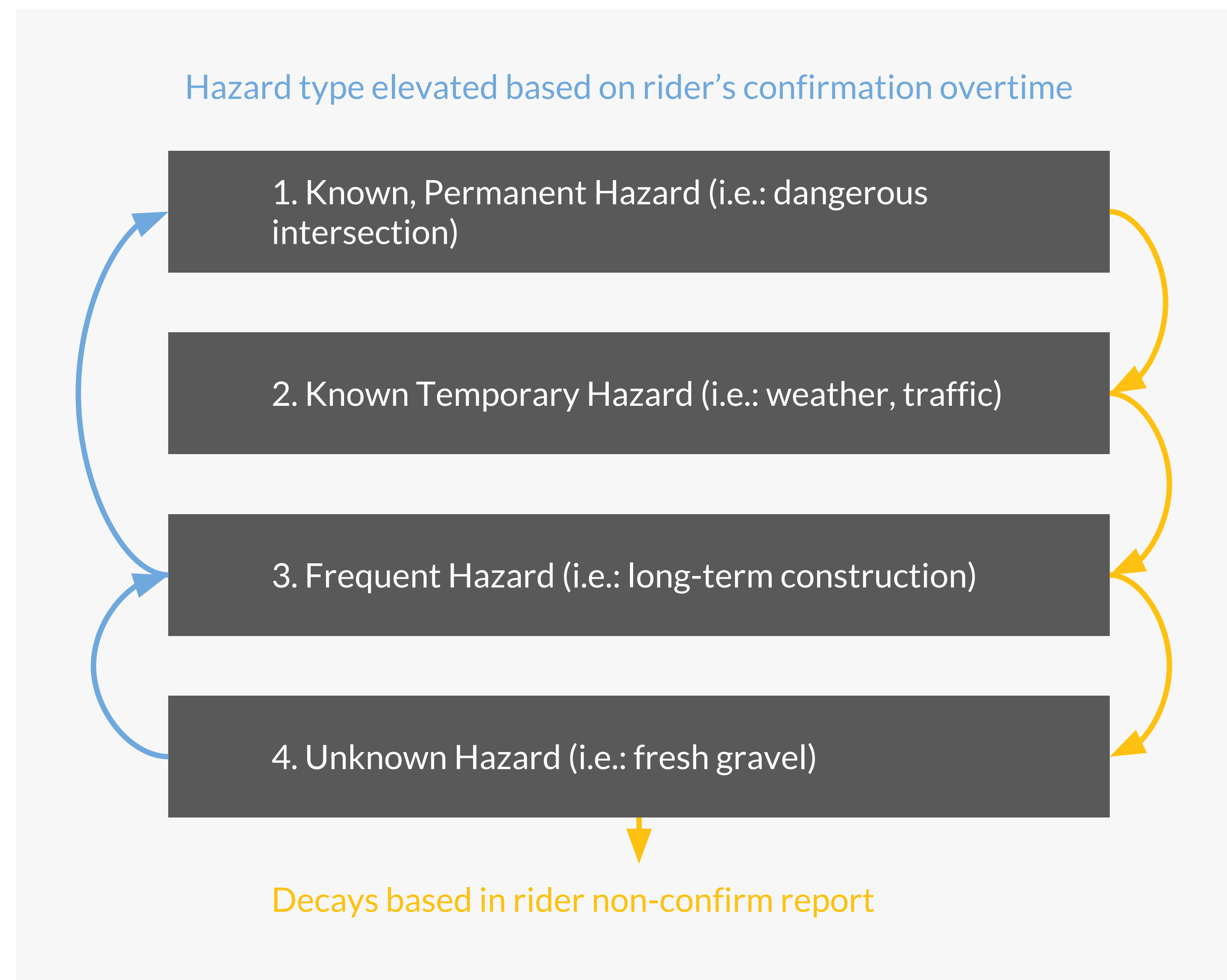
# HAZARD CATEGORIZATION MODEL

## Decay model

We also considered the data quality in terms of time. One of the challenges that our design encountered is the issues of duplicated records. For instance, when multiple rides go through this sequence and report the same hazard, but geotag it in different locations. Then riders would have multiple alerts for the same hazard, which would not only be annoying, but dangerous. This was why we generated a half-mile radius when a rider geotags a hazard. This helps avoid duplicate reports that occur when a rider's report hazards at different times, either before, during or after encountering the hazard. The simple solution was to expand the hazard zone radius to include all the reports with the same hazard. If the same hazard is reported within an established hazard zone, the hazard zone radius will be increased, and the reports will be merged.

As a result, we came up with a system categorization model, which would rank hazards based on frequency and duration. Certain hazards such as dangerous intersections, are known permanent hazards, based on historical accident data. Other hazards such as weather or traffic, are known temporary hazards, that will only be present for short periods of time. As a result, it was important that we have a framework for keeping and removing hazards, based on their hazard category. We took a lot of inspiration from Waze for our model, which uses thumbs up/thumbs down from users to determine if a hazard is still present. Hence, we have hazards being removed after 3 users have confirmed that the hazard is no longer there.

However, because there are a lot less riders on the road compared to vehicles, we needed another mechanism for keeping and removing hazards. Ultimately we decided on an elevation/decay system, where hazards were first classified as unknown or known temporary hazards. Unknown hazards came from user-reported hazards, while known temporary hazards came from external databases with weather, traffic, and accident-related info. As more and more users reported and confirmed unknown hazards, they became frequent hazards, and eventually known permanent hazards. Then dependent on the hazard category, hazards would gradually decay and be removed with time, unless enough users confirmed the hazard was no longer there.



# DESIGN SPECIFICATION

## Voice interface and Natural Language Processing Model


In order to process the recorded message provided by riders into a coherent format, we mapped out the natural language processing algorithm that would have to be developed for this system to work. It would consist of three different phases: speech recognition, natural language understanding and management, and system feedback.

The first phase, is speech recognition, which is commonly seen nowadays in major conversational voice platforms such as Siri or Alexa. This requires the system to have a clutch word such as “Siri”, or in our case, “Skry” that will activate the system so that it will start listening for voice commands. Once the system is active, an icon will appear in the hud to provide the user instantaneous feedback that the system is ready for their commands.

The next step is the actual processing of a user’s speech. This requires an agent that will be able to recognize the intent of the user. For instance, if the user wants to report a hazard, or cancel a command, the agent will have to be able to discern the context of the command and take the appropriate action. This is then followed by content management. The system will have a model that will classify different keywords it hears in a message into the different hazard categories we have delineated. The accuracy of such a classifier will depend on the dataset it has been trained on. As such, a user-reported system like Skry will have to use an existing dataset to train on first. The best one in our case is the Waze dataset, which already has an existing hierarchy for voice commands that it listens for, as well as a large database of reported hazards. The main difference between our system and Waze is the conversational management aspect. Waze, chose to have the system say all the possible commands or choices first, before the user can respond. This ensures that the user says a word or a phrase that the system can interpret, since it's from a controlled word pool.

# DESIGN SPECIFICATION

## Voice interface and Natural Language Processing Model (CONT'D)

However, our system would be taking recorded messages, that only have the constraint of including the hazard observed.This means that our classification will not be as accurate as Waze's.

To mitigate this, we have the post ride app, which will allow riders to re-classify hazards that were misinterpreted by our system. This is actually the final step of the system, which is fulfilling the user's command. In our case, it will be classifying the reported hazard into the correct category. There are two ways the system can provide feedback. It can playback to the user the hazard category they binned the recorded message into. This would allow the user to instantly know if the system correctly identified the hazard reported. The other way is through post-ride component of the mobile application, which allows users to view the hazards that were classified along their route, and correct them if necessary. Although the system may perform poorly at the start, as it receives more and more validation from the rider, it will be able to improve.

# DESIGN SPECIFICATION

## Heads-up Display


Early on, after exhaustive research and evaluation of existing HUD systems, both for pilots and motorcyclists, we had arrived at several conclusions that would influence our visual aesthetic, mainly; keeping the interface extremely clean, simple and able to get out of the way easily. Most piloting HUDs had complicated interactions and interfaces that required a high degree of training to use, and unfortunately we found that most motorcycle HUDs resembled more science fiction concepts than well-honed systems designed for the rider. In the end we arrived at a minimal HUD UI able to effectively display multiple levels of context quickly, without requiring the rider's full attention.

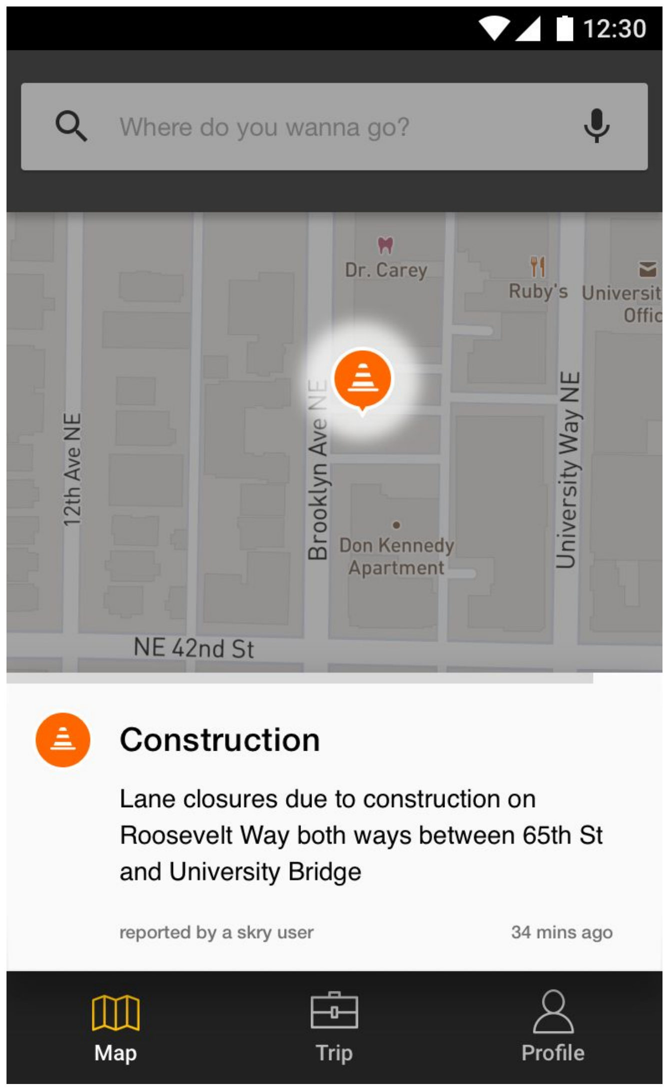
The strengths of this visual system are many. Capable of "getting out of the way" when there is no pertinent information to display, the UI can crouch into a simple gray circle just in the rider's periphery until an alert is being presented. This goes back to one of our main design principles of considering the riding experience. Rider's don't want a distracting interface in front of their face unless they need it to be there.

Next, was the simple pairing of vivid color circle and wings allows us to show multiple levels of context quickly. Primarily, the color of the circle can indicate severity of the alert (yellow = mild hazard, red = severe hazard, green = success, blue = system message, etc). Even without looking at the circle the rider is able to discern the importance of the alert, retaining the ability to keep their eyes on the road if need be.

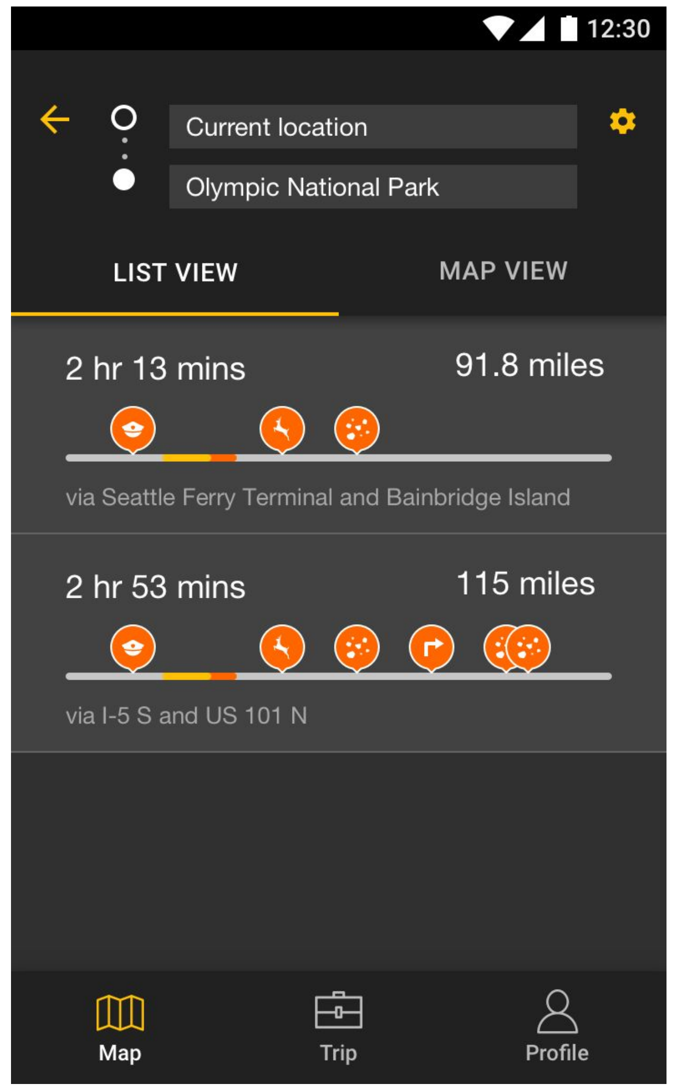
Finally, in the center of the circle we were able to show the specific type of hazard or alert the rider is encountering. This was complemented by 'wings', that can slide out to show tertiary context to better inform the rider of duration or other messaging/voice prompts important at that moment.

# DESIGN SPECIFICATION

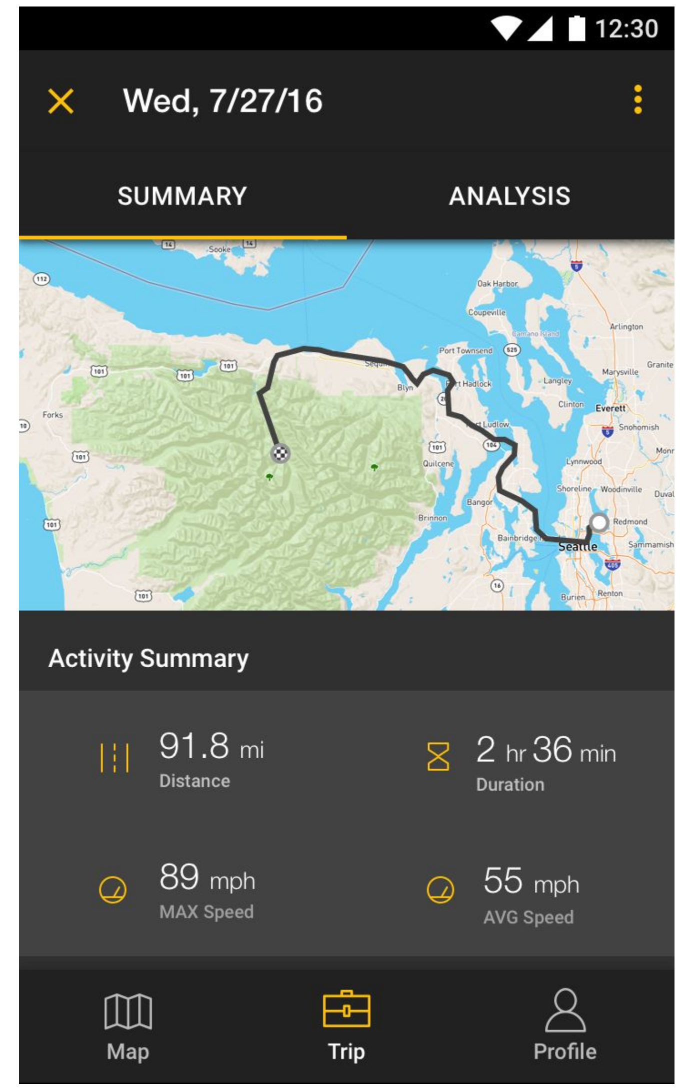
## Mobile Interface



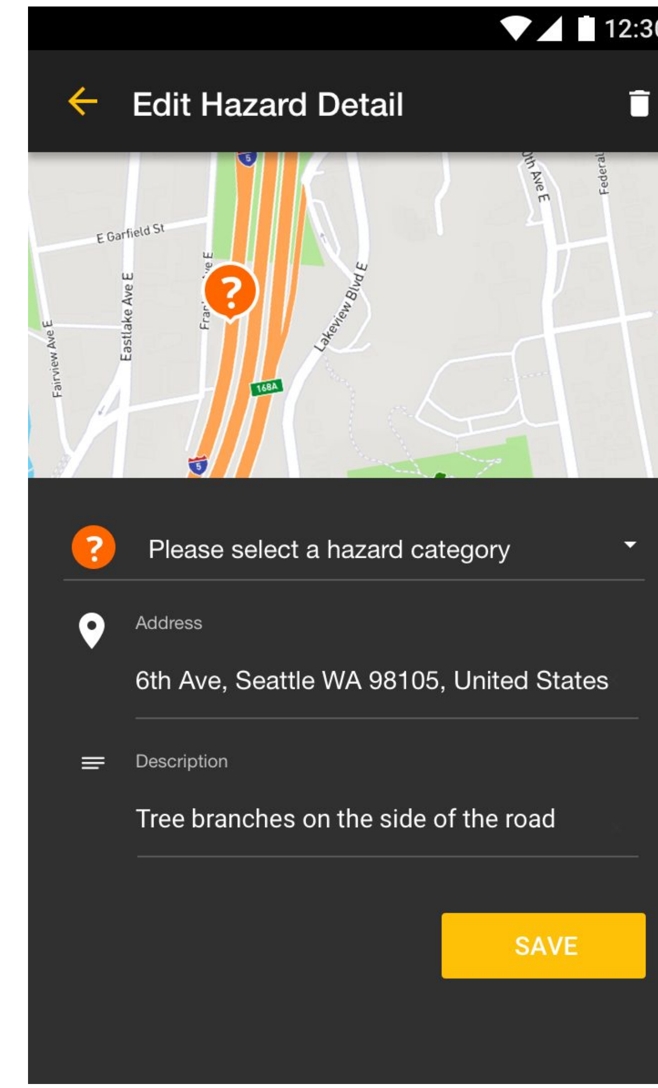

1. Map view of real time hazards nearby




2. Displays route options with current hazards




3. Provides trip recap with collected data




4. Ability to view and update reported hazards

The rider interacts with the mobile application before and after the ride. It has three main sections: Map, Trip, and Profile. The Map section is where the rider inputs the destination, and views current hazards on the road. They are able to select potential routes they might take, with the current hazards along each route shown. After they've selected a route, they will begin the navigation. Once the ride has been completed, they will be provided with a recap of their trip, based on the data collected from the app. If they have any reports that they wish to fix or update, they will be able to make those change here. The trip will then be saved in the Trip section, so that it can be viewed at a later date if necessary. If the rider has any settings they wish to customize, such as the frequency of alerts, or switching to only tone-based alerts instead of system messages, they will be able to make those changes in the Profile section.

# 06

# CONCLUSION

# MOVING FORWARD

## Future Evaluation

The next steps for our Skry concept would be to build out the natural language processing algorithm discussed in the previous section, which would allow us to more accurately test the feasibility of implementing the system on a larger scale. The most important aspect would be the ability for the system to learn and improve itself, so that it would be able to correctly classify reported hazards into the correct bins. This along with infrastructure concerns would be the most essential components of the system that would need to be evaluated, to see if such a system would be able to scale. Before all of this though, would be testing the Skry concept for safety using a motorcycle simulator. Once it has sufficiently been tested in a simulator setting, the testing could then be moved onto the road, obviously after the liability concerns have been addressed, and consent has been received.

# MOVING FORWARD

## Building out the System

The construction of the Skry system would be built in phases, with different sets of features being included in each iteration. This would consist of three overarching phases, beginning with the integration with existing systems, and ending with technology that would come from connected vehicles.


### SYSTEM INTEGRATION

The first phase would be integrating Skry with existing traffic, navigation, and hazard providers such as Waze, INRIX, and Google Maps, as well as bluetooth headset provider Sena to provide a central hub for rider while riding. Waze, INRIX, and Google Maps would provide the external database input into Skry that would greatly increase the amount of relevant information Skry can provide to the rider such as traffic, weather, and accident-related data. This would then be used in conjunction with the user-reported data, to provide more detailed information to the rider, such as hazards dangerous to both riders and drivers. It would also allow riders to use only one app for everything, which allows for a much more seamless experience.

### ADDITIONAL SENSORS

Next, would be the addition of sensors to the bike to provide more detailed information to Skry about rider status. The current system only utilizes the sensors available on the smartphone. However, the sensors on a smartphone are not consistent across all smartphones, and are highly dependent on the age and model of the phone. By providing an aftermarket kit with sensors, the system can be programmed with maximum sensitivity and efficiency in mind, since all bikes using the system would be receiving the same amount of data. This would allow for more thorough trip statistics, as well as better analysis from the aggregated data. It would also allow the bike to potentially track other safety related events, such as sending an SOS signal if the bike has been involved in an accident and the rider is unable to call 911.

### CONNECTED VEHICLES

The last and final phase would be the inclusion of Vehicle-to-Vehicle communication in the future to provide warnings of oncoming vehicles to riders. When the technology is available for vehicles to communicate their presence and position to each other, riders would then be able to receive alerts using our system, either visual or auditory, that a car is approaching them. This could be a driver not aware of the rider, or vice versa. This would ultimately help avoid collisions between the two vehicles, which are always more dangerous to riders due to the lack of a cage for protection.

# REFLECTION

## Understanding users is the key

We learned that getting close to our users was key to our project's success. We engaged with motorcyclists in every stage of the process, from research to prototyping and approached the problem with user-centered design methodology to understand what their current behaviors and pain points were, what the resources we could leverage, and what is unknown but still needed for the riders . As a result, we arrived at a solution that generated positive feedback and excitement from all those asked.

## Constraints make design better

The immutable truth to every project is the limitation of time and resources. It was important for us to understand how to scope the project, and divide and conquer in a way that allowed us to produce quality work within the time constraint. As a team we learned to set aside individual preference and opinions for the good of the project. We also learned to think outside of the box to validate our concept with a combination of prototyping techniques with the constraints of safety liabilities.

## Be flexible and be comfortable with surprises

Although we had a straightforward solution, we had adapted our concept and modified on our design iteratively based on user input, expert feedbacks and our assumptions. The project started with the hope of making motorcycling safer and providing situational awareness to the riders without sacrificing their reasons to ride. While the process was nonlinear -- we rescoped, reinvented, and redefined our project which allowed us to create an innovative solution that address the culture and experience of our core users by leveraging the power of the community.

# APPENDIX

## CAPSTONE DELIVERABLES

Research Summary Report
Concept Refinement Presentation
Concept Evaluation Presentation
Final Presentation

## FINAL PRODUCTION

Mobile Interface Prototype
Tone Set
Heads-up Display Interface
Concept Video

# REFERENCES AND CREDITS

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Slide 36: A Speech Interface in 3 steps. https://api.ai/blog/2015/06/03/SpeechInterface/