Making Rural Roads Safer

With Better Roadway Awareness, Smart Signs, & Intuitive Roads

INTRODUCTION.

In 2019, the fatality rate on rural roads was nearly twice as high as on urban ones, according to the Insurance Institute for Highway Safety. In 2019, over 16,000 people died in a crash on a U.S. rural road even though only about a fifth of the population lives in rural areas according to the National Highway Traffic Safety Administration. Nine out of 10 rural traffic fatalities occur on two-lane roads, according to a May 2020 report by TRIP, a national nonprofit transportation research center. **In 2015, Connecticut had the deadliest rural roads in the United States.**

Transportation experts say a combination of **higher speeds, narrow shoulders, lack of lighting and lots of curves contribute to the problem**. There is plenty of signage to mitigate these problems. The Manual on Uniform Traffic Control Devices (MUTCD) manual identifies over 500 warning and caution signs, object markers for conventional roads, highways, toll booths, intersections, pictographs, and worded signs; there is no paucity of signage. Each sign has exact specifications as to orientation, location, placement, etc. **But is the right sign in the right place**?

The 2021 federal government infrastructure bill pledges between $300 and $750 million to make rural roads safer. In the US House of Representatives, lawmakers filed a bill in April 2021 that would create a **$600 million competitive grant program** that local governments could apply for to make infrastructure safety improvements on rural roads.

Why, then, is the federal government investing so much money? Something very subtle and more pervasive is happening **on rural roads, not highways**. It involves **how humans perceive depth.** While accident data is important (driver age, crash trees, etc.), this study investigates the more subtle, less obvious but extremely important precursors to an accident. This project seeks to identify what is missing on roadways that could prevent roadway departures and accidents by reducing speed.

OVERVIEW

'Making Rural Roads Safer' is an ambitious, **grant request project** that is scheduled for three phases over three years from **Phase One (concept research), Phase Two (prototype development),** and **Phase Three (simulation software development** and driving simulation testing).

The **grant request is estimated at $500,000.00**.

The primary objectives of this project are:

(1) determine ways to reduce speed on rural roads by using simple, novel methods that accentuate depth perception which might include signage, roadway markings and roadway physical features,

(2) develop a conceptual framework, criteria, and algorithms to predict rural roadway departures and accidents through a situational awareness paradigm,

(3) develop sensor-activated electroluminescent traffic sign and smart phone interface,

(4) enhance Connecticut Transportation Safety Research Center (**CTSRC**) driving simulator capabilities based on Phase One results.

All phases and tasks involve the University of Connecticut (UCONN) School of Engineering departments of management and engineering for manufacturing (**MEM**), civil and environmental (**CEE**), electronic and computer engineering (**ECE**). The CTSRC resources are needed to research CT accidents and perform experiments to test the results from Phase One and Phase Two.

Notional Schedule for Three Phases.

The following Excel spreadsheets identify the notional tasks and deadlines suggested by the sponsor. Phase One is primarily submitting a Senior Design proposal and documentation, identifying preliminary unsafe rural road criteria, and submitting a grant request to an appropriate CTDOT agency. Phase Two continues the results from Phase One and begins CTSRC software development and integration based on grant award. Phase Three continues CTSRC software integration, testing, and reporting. Tasks performed in each phase are described in this document. If there is no grant award, then no Phase Two / Three.

Phase One.

Phase One begins on 1 September 2022 and ends 1 June 2023 with the submission of a grant proposal to an appropriate CTDOT agency. This phase involves researching the CTSRC database for accident criteria, as well as developing a **crowd sourcing camp**aign to collect information from volunteers about potentially unsafe rural road locations. Team members need to organize a taxonomy of criteria based on situation awareness paradigm that might predict the antecedent factors of an off-road departure. Teams might use **Unreal Engine computer simulations** to test different configurations of roadway markings, signage, and features.

Another portion of Phase One involves researching and developing the design schematics, hardware, and software for one or more **electroluminescent (EL) traffic signs**. Only a breadboard configuration is expected. The system architecture should include internet connectivity design features and a prototype user interface for a smart phone application that monitors EL sign status.

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The major event is submitting a grant request to a CTDOT or other agency to fund Phases Two and Three. Finding the right agency and writing the grant according to grant guidelines is extremely important as it determines follow on work in CY 2023 through CY2025.

TABLE 1 - PHASE ONE OF MAKING RURAL ROADS SAFER

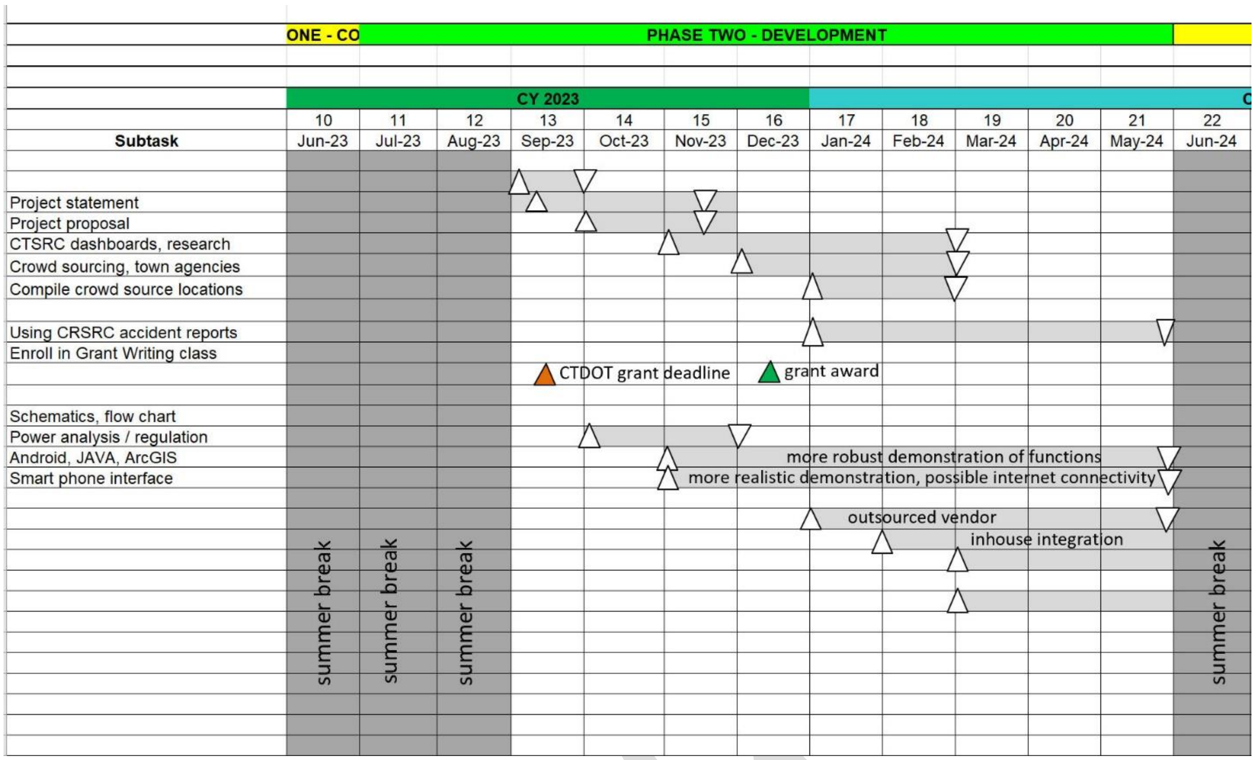
UCONN School Year		PHASE ONE - CONCEPT									
Calendar Year		CY 2022									CY
Running Months		1	2	3	4	5	6	7	8	9	10
MAJOR TASK	Subtask	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23
Read and analyze proposal											
Prepare UCONN SD documents	Project statement										
	Project proposal										
Develop taxonomy of criteria	CTSRC dashboards, research										
Identify candidate unsafe roads	Crowd sourcing, town agencies										
	Compile crowd source locations										
Compare criteria with CTSRC	Using CRSRC accident reports										
Write CTSRC grant	Enroll in Grant Writing class										
CTDOT grant milestones										submit grant	
Develop EL sign architecture	Schematics, flow chart										
Select EL sign hardware	Power analysis / regulation										
Develop EL sign software	Android, JAVA, ArcGIS					beard board only functionality					
Develop user interface	Smart phone interface					basic prototype only limited functionality					
Develop CTSRC software											
Integrate outsourced software											
Test CTSRC software											
Enhance CTSRC capabilities											
Publish final report											summer break

Phase Two.

Phase Two can go a couple of ways. The first way is to continue developing rural road accident profiles and criteria plus developing a more functional EL traffic sign system based on Phase One work. The initial Phase One proposal could be updated and resubmitted for Phase Two. More experiments might be conducted on methods to improve depth perception cues, roadway markings and messaging.

The second way depends on winning the grant proposal. If UCONN School of Engineering wins a CTDOT grant proposal, then work can begin on enhancing CTSRC capabilities through outsourced software development. CTSRC would release a requirements document that specifies exact products needed to test scenarios of multisensory roadway cues. Multisensory cues include roadway messages, new and improved signage, roadway markings and rumble strip simulations.

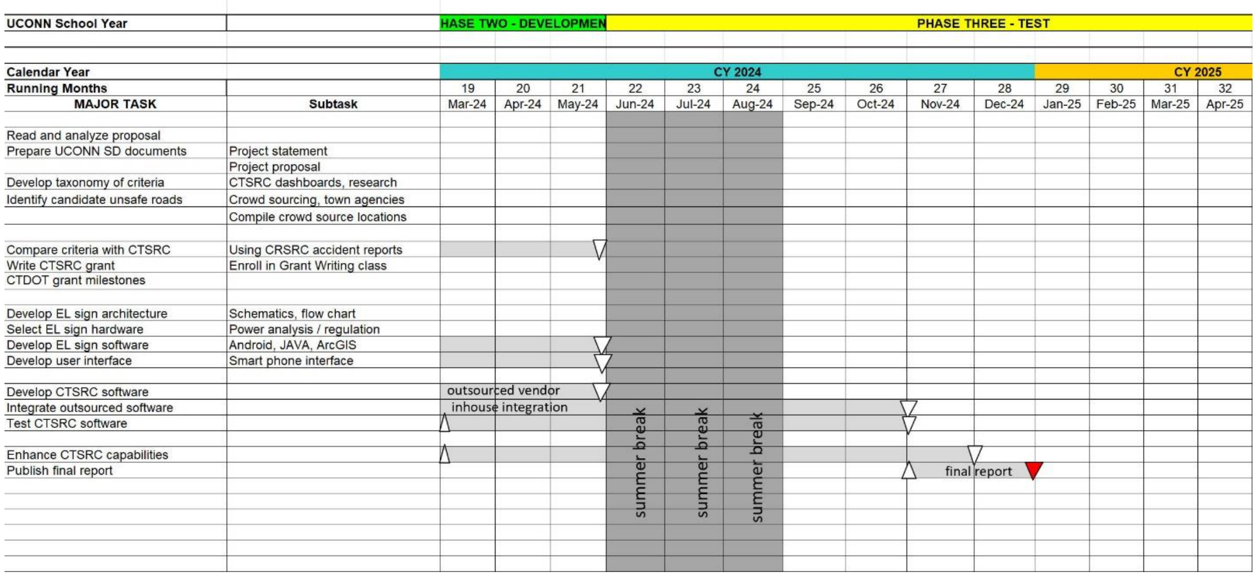
TABLE 2 - PHASE TWO OF MAKING RURAL ROADS SAFER



Phase Three.

Phase Three focuses on validating software update in CTSRC and conducting driving simulation testing of techniques to improve depth perception and decrease off road departures s, plus publishing and reporting the results of all phases.

TABLE 3 - PHASE THREE OF MAKING RURAL ROADS SAFER



Project Dependencies.

The project is complex. There are **multiple dependencies**. The first dependency is the **award of a grant to support CTSRC software development** by the Connecticut Department of Transportation (CTDOT). Grants are awarded on 15 September. That deadline means that to receive a grant award for 2023 - 2024, the grant application must be completed by the **end of Phase One - 15 May 2023**. That is a critical dependency for the success of this project. A 3-month evaluation period from grant submission to award is factored into the Phase Two schedule.

One CTDOT agency to solicit is the Highway Safety Improvement Program (HSIP). Total funding for HSIP 2021-2024 is **$118,237,000**.

A second dependency is the **development of CTSRC software** by an outsourced vendor to develop capabilities to integrate depth perception cues plus multi-sensory cues like roadway markings, messages, and rumble strips into the CTSRC driving simulator. From experience at Cisco and Lockheed Martin, software development takes 3X longer than estimated so using the CTSRC to test the outcome of Phase One research and recommendations is pushed out to 2024. Estimated labor cost to develop outsourced software for CTSRC is **$300,000**.

A third dependency is the **integration of the outsourced CTSRC software** into the CTSRC platform. Once the outsourced vendor provides software it must be integrated into the overall software architecture and tested. Labor cost by CTSRC to integrate and test is estimated at **$200,000**. Thus, the minimum grant request is for **$500.000.00.**

PROJECT OBJECTIVES.

The main objective is to reduce speed on rural roads by **developing enhanced depth perception cues, signage, and multi-sensory roadway features**. There are nine secondary detailed objectives that will help achieve the primary objective. These secondary objectives are listed below.

The secondary detailed objectives of the 'Making Rural Roads Safer' Senior Design project are to:

1. Research and formulate several ways how depth perception cues can be integrated into roadway configurations to reduce speeding.
2. Research and determine how human error affects rural road accidents.
3. Develop detailed criteria within a situational awareness taxonomy for identifying an unsafe rural road using traditional and novel methods.
4. Determine the probability of an accident using detailed weighted criteria.
5. Compare and determine effectiveness among a selection of critical traffic signs, i.e. 'icy road', as to clarity, location, severity of consequences and offer improvements.
6. Investigate electroluminescent (EL) technology.

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7. Develop a bread board prototype of an EL 'smart' sign for Phase One.
8. Write and submit a grant to obtain state funding to publish the results of Phase One and augment CTSRC simulation and test capabilities.

Each secondary detailed objective is explained in the section 'Detailed Objectives'.

INCENTIVES.

The $1.2 trillion infrastructure bill requires a study of the rural road safety and launch a new rural road grant program that includes $300 million for high-risk rural road safety programs. The Senate package's rural road safety language was based on a bill filed in May by U.S. Sens. Mark Kelly, an Arizona Democrat, and Richard Burr, a North Carolina Republican, that would have provided $750 million for safety projects on high-risk rural roads.

State transportation departments have made rural road safety a top priority. South Carolina, for example, is investing $124 million over 10 years to make rural roads safer by installing rumble strips, wider pavement markings, brighter signs, high-friction surface treatments, guardrails, and other improvements. Transportation studies suggest driver distraction (texting, cell phone use, complicated dashboards, inadequate lighting) among the causes of rural road accidents. Certainly, unsafe speed is a significant cause of rural road accidents as are slippery surfaces, but **there are other hidden factors that contribute to rural road accidents such as inadequate visual cues for depth perception and timely situational awareness signage.**

Department of Transportation (DOT) corrective action plans recommend engineering changes that local governments can make to prevent crashes, such as flattening slopes, widening shoulders, installing pavement markings and rumble strips, and removing trees that may be too close to the road. **Edge milled rumble strips** are useful to alert the driver that the vehicle is drifting out of lane on high-speed highways. Barriers and guard rails stop or deflect vehicles acutely off the road. Illuminating rural roads might prevent night time accidents but prove expensive and do not solve daytime accidents on rural roads.

The combination of rumble strips and wider shoulders may prevent some of the worst crashes, said Robert Wunderlich, director of the Center for Transportation Safety at the Texas A&M Transportation Institute. "Rumble strips alert you that you've made an error," he said. "The shoulder gives you a place to recover." But by then **it may be too late** because the vehicle is on an unrecoverable path given vehicle speed, human reaction time, and vehicle characteristics. Locating rumble strips in sufficient advance of a hazardous location as identified in this project should prevent severe or near accidents.

PERSONAL MOTIVATION.

As with the previous thirteen senior design engineering projects for Roger Williams University, University of Rhode Island and UCONN, the motivation comes from experience. Julie and I live at the intersection of Dugway Bridge Road and Queens River Drive in West Kingston, Rhode

Island. Both are rural roads. When you drive down Dugway Bridge Road from Rt 138, you have a long stretch of road leading to a sliding left curve. Every six months or so, there is evidence of a roadway departure up the embankment and across to the opposite side of the road despite the presence of horizontal directional signage, tree removal, and high embankments– all typical remedies to mitigate the effects of spin outs. **But these solutions do not address the subtle less obvious causes of roadway departures and spin outs on rural roads.** Why are drivers 'departing' from the roadway in the first place? It is these precursors to an accident that this project will investigate.

Spinouts in Our Neighborhood.

Figure 1 shows the Dugway Bridge Road straightaway leading to a sliding left curve. A horizontal alignment directional sign indicating a change in the direction of the road is present. It is not a warning sign only a directional traffic sign. The sign is about 150 yards before the curve mounted to a utility pole.

The sign indicates a sliding curve to the left but do drivers perceive a sliding curve as less severe than an abrupt curve? Could another directional sign in a better location improve situational awareness? Do drivers recognize, comprehend, and obey directional signage? If accidents occur repeatedly even with existing signage, maybe the sign is the wrong sign or in the wrong location. One of the expected outputs of this project is an assessment of selected signs using paired comparison and rank order methods to assess the effectiveness of critical signs. Team members will down-select from a group of similar signs and evaluate effectiveness.

The Figure 1 shows the straightaway on Dugway Bridge Road leading to a sliding left curve in early winter, 2021. The long straightaway may encourage speeding up or distracting behavior like cell phone use. Also, note there is no strong figure / background distinction; it appears as though you're driving straight ahead into an array of trees. There is no caution or warning sign, either.

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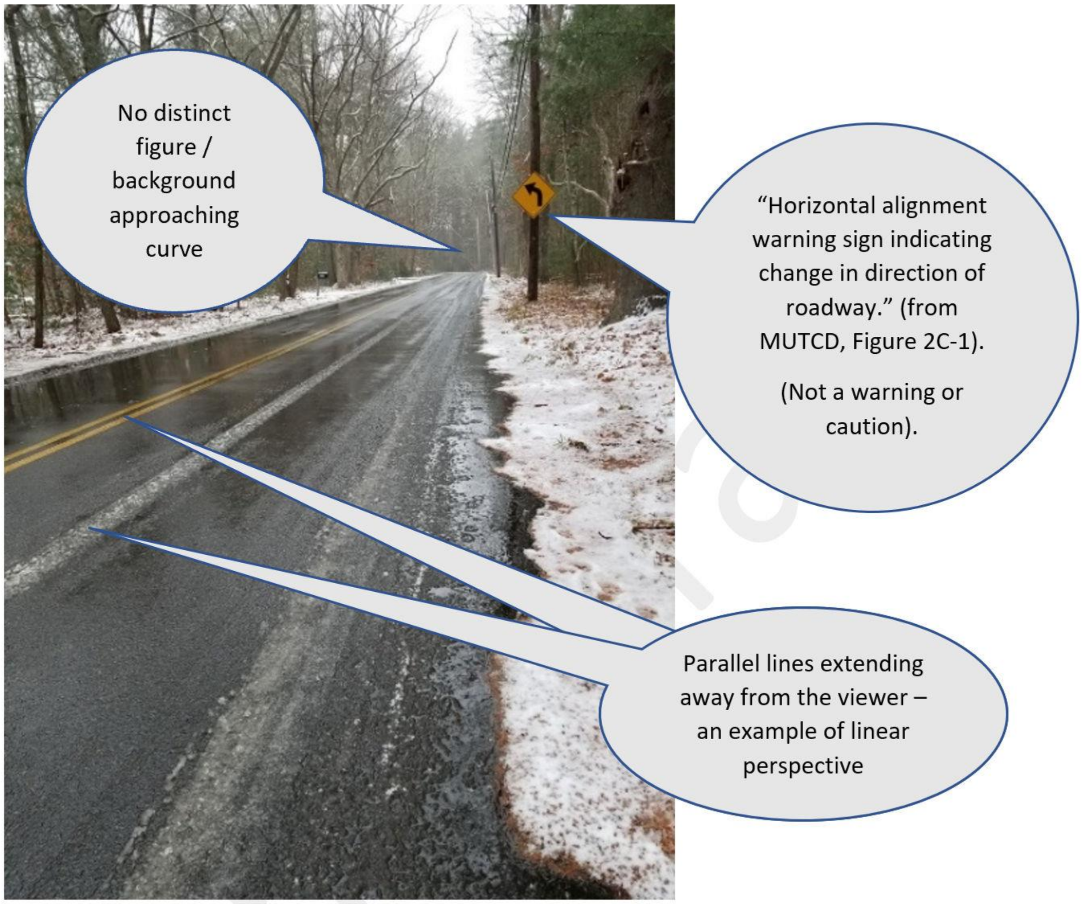

FIGURE 1 - LOOKING DOWN DUGWAY BRIDGE ROAD

Figure 2 shows the 'roadway departure' (spinout) track on Dugway Bridge Road in the leaves along the embankment at the end of the sliding left curve in the road. One might refer to such tracks out of the roadway as an incident. It is not an accident and there is probably no record of it in a Rhode Island DOT database. It is these types of incidents which this project strives to understand and prevent.

FIGURE 2 - SPINOUT ONTO EMBANKMENT

From a human factors' perspective, one of the problems on this local rural road is **the lack of monocular depth perception cues** that indicate how near or far away is the left sliding curve in the road. Speed might have been a factor as was the situational factor of low road coefficient during an early winter freeze. How can you alert the driver that hazardous road condition is present, and that the driver needs to compensate for such conditions?

The driver escaped injury and no property was damaged other than a strip of lawn on the opposite side of the road. The car slides off the embankment, crossed the road and slide off the lawn on the opposite side of the road.

How do you attract attention to a hazard without distracting the driver? This was the subject of a prescient University of Rhode Island Engineering Capstone project in 2016 called 'Highway Safety and Flashing Lights' which I sponsored. It received national and Canadian interest.

Highway Safety and Flashing Lights

How do you attract attention to a hazard without distracting the driver? This was the issue in the **2016 University of Rhode Island Engineering Capstone Project titled 'Highway Safety and**

Flashing Lights - Optimizing Emergency Lighting of Highway Patrol Cars to Prevent Phototaxis and Accidents – Getting Your Attention without Distraction." It unequivocally proved that most state highway patrol cars have the wrong configuration of flashing lights on lightbars to prevent rear ending patrol cars during highway traffic stops for drunk driving**.**

The purpose of the Flashing Lights project was to design, build and evaluate both computer and full-scale simulations of a highway patrol vehicle light bar package that optimizes attention without distraction. Since there are several types of emergency lighting on public safety vehicles, the project was limited to investigate emergency lighting used by stationary highway patrol cars stopped on the right-side highway shoulder during a traffic stop. **An unusually high number of patrol cars are rear ended by drunk drivers at night. Why**?

Team members investigated human eye functions, the effects of dark adaptation, sensitivity of the eye to various wavelengths, and most importantly the phenomenon called phototaxis (also known as Moth-to-Flame Effect). They investigated accidents caused by flashing lights in New England and developed a prototype computer simulation.

They interviewed authorities in law enforcement about diverse types of emergency situations and lighting. They investigated the traditional ways emergency vehicle light bars in **Rhode Island (all red**), **Massachusetts (all blue**) and **Connecticut (red and blue**) in order to compare them against other variations of light configurations during simulations. They looked into variations all over the United States and around the world, particularly Europe.

The primary goal was to determine the degree of distraction caused by emergency vehicle lights. In order to determine distraction quantitatively, the experimenters tracked the eye movements of drivers in the simulation and calculated whether there is a significant delta (difference in) time from when the driver identifies the emergency vehicle lights to when the driver refocuses attention to the road.

Human subjects were evaluated in both a classroom computer simulation of flashing emergency lighting and a simulated driving environment to down select from 10 configurations to 6 configurations. The project manipulated permutations of wave length (blue, red, and white light) as well as frequency, intensity, and flash pattern.

Here is the conclusion.

> "After three different experiments with a diverse set of test subjects and very similar results, we can conclude that low intensity, steady flashing (wig – wag) blue lights are optimal for use when an emergency vehicle is parked on the right side of the road at night or in inclement weather. All three experiments were able to show that this light bar configuration was conspicuous enough to draw attention, but not distracting enough to cause the test subject to look away or be distracted by it."

Remarkably, this low intensity, steady flashing (wigwag) blue light configuration and pattern is the same used in the United Kingdom.

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DEPTH PERCEPTION EXPLAINED.

Depth perception is the ability to see in three dimensions and judge the distance of an object. Depth is perceived with either one eye or both – monocular vision and binocular vision. Depth perception is absolutely essential when driving. The brain relies on different cues. Examples of depth perception cues are occlusion, linear perspective, size perspective, texture gradient, brightness, aerial perspective, depth of focus and shading.

Table 1 from 'Semantic Scholar' describes and illustrates the types of monocular depth perception cues.

TABLE 4 - DESCRIPTION AND ILLUSTRATION OF DEPTH PERCEPTION CUES (FROM 'SEMANTIC SCHOLAR')

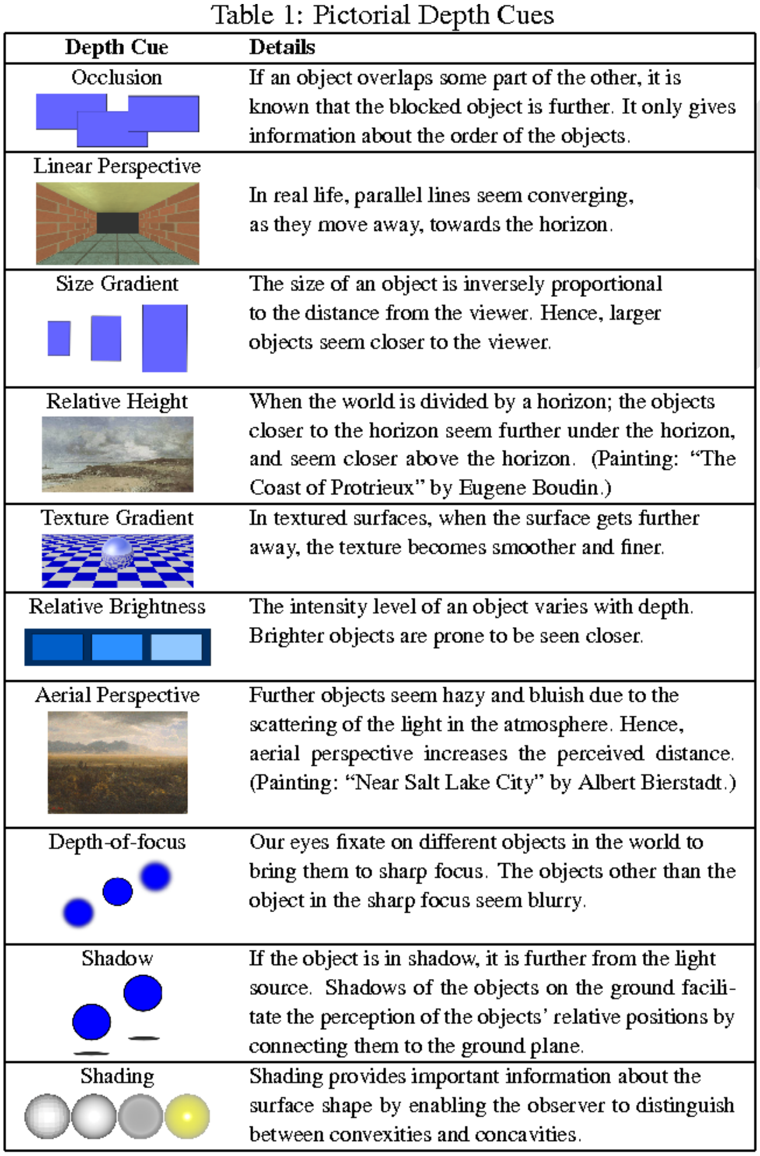

Table 1: Pictorial Depth Cues

Depth Cue	Details
Occlusion	If an object overlaps some part of the other, it is known that the blocked object is further. It only gives information about the order of the objects.
Linear Perspective	In real life, parallel lines seem converging, as they move away, towards the horizon.
Size Gradient	The size of an object is inversely proportional to the distance from the viewer. Hence, larger objects seem closer to the viewer.
Relative Height	When the world is divided by a horizon; the objects closer to the horizon seem further under the horizon, and seem closer above the horizon. (Painting: "The Coast of Protrieux" by Eugene Boudin.)
Texture Gradient	In textured surfaces, when the surface gets further away, the texture becomes smoother and finer.
Relative Brightness	The intensity level of an object varies with depth. Brighter objects are prone to be seen closer.
Aerial Perspective	Further objects seem hazy and bluish due to the scattering of the light in the atmosphere. Hence, aerial perspective increases the perceived distance. (Painting: "Near Salt Lake City" by Albert Bierstadt.)
Depth-of-focus	Our eyes fixate on different objects in the world to bring them to sharp focus. The objects other than the object in the sharp focus seem blurry.
Shadow	If the object is in shadow, it is further from the light source. Shadows of the objects on the ground facilitate the perception of the objects' relative positions by connecting them to the ground plane.
Shading	Shading provides important information about the surface shape by enabling the observer to distinguish between convexities and concavities.

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Linear perspective is a monocular cue because the effects are manifested as actual differences in distance and size that require only a single eye to perceive. Linear perspective is the apparent convergence of parallel lines with distance. Occlusion, the strongest psychological depth cue, occurs when objects overlap one another. The figure callouts in this proposal are examples of occlusion or interposition.

Related in a sense to relative size but also a depth cue is **texture gradient**. Most surfaces, such as walls and **roads, have a texture**. As the surface gets farther away from us this texture gets finer and appears smoother. How can you increase the effectiveness of depth perception cues without distracting the driver from the roadway? Suppose we added more texture gradient to the roadway to enhance linear perspective. What effect do you think that might have on driving? Can you test for modifications in roadway texture that improve driving using a driving simulator or paired comparison photos?

HUMAN ERROR AND ACCIDENTS

What is human error? It's complicated. In the aerospace industry, it is estimated that 80% of accidents are often not true human error but design, training, hardware/software/facility arrangement, work practices, or procedures. **True human error** is the result of circumstances or activities that required the human to remember too many things at once or **exceeded the human perceptual limits** or required the human to do something that exceeded the manual or motor limits. Human error is especially true during lengthy periods of time that require vigilance or constant motor movement like driving a car. Note that this definition mentions 'exceeded the human perceptual limits.' **True human error is caused by issues with memory, decision, perception, cognitive and performance**. These issues are directly related to the driving experience.

Consider **driving a car while distracted** by complex controls and displays on the dashboard or calls on your cellphone. In one second, a car traveling at 35 MPH travels fifty feet. To scan a text message on your cell phone might take 3 - 5 seconds. In that amount of time the car has hurled down the road between 150 – 250 feet. In 2015, the National Traffic Safety Administration found that the **critical reason for 94 percent of crashes is driver (human) error**. Although speeding (a human cognitive error) is usually the number one reason for traffic deaths and injuries, distractions are listed as one of the top three causes of road accidents.

EXPERIMENTING WITH LINEAR PERSPECTIVE.

Teams are encouraged to experiment with ways to create intuitive roadways. What if additional depth perception cues could be integrated into the roadway and driving experience? While there are many different and inconsistent methods to reduce speeding such as speed bumps, humps, and traffic bridges, suppose rural roads had a texture gradient like equally **spaced, painted, or reflective stripes** perpendicular to the center line of the road? The stripes

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would appear in the center of the road leading into the sliding left curve since that is how a vehicle would approach the curve.

This idea uses broken line markers to indicate a hazardous curve. Broken white markers were chosen instead of a solid white line since that stereotype indicates a stop line or a pedestrian walkway. But a **distinct color or pattern might be evaluated** like a chevron or orange. This low-cost enhancement to the road surface is an example of a depth perception cue to alert the driver of distance and depth. Since the driver is watching the road, the eyes would see the texture gradient more easily as shown in the following figure.

Roadway Markings.

The following figure illustrates the effect of a novel roadway linear perspective treatment using broken stripes Dugway Bridge Road.

FIGURE 3 - EXAMPLE OF TEXTURE GRADIENT STRIPES

However, there are questions that must be answered. White is used for crosswalks and edge-of-road marking. But how do drivers perceive these white stripes on one side of the road? How does a driver react to this new visual cue? Do you start to brake? Do you look to see where the strips are going? Is there positive or negative transfer? A driving simulator based on the Unreal 5 Engine with eye tracking might answer these questions.

However, investigations into improving depth perception must consider all road conditions (rain, snow, intermittent shadows, and glare) which are a class of criteria. Identifying various driving and road conditions will require rigorous systems engineering processes like system and detail requirements and ranked risk factors.

Roadway Messages

Teams might experiment with evaluating a sample of DOT signs that use safety words (danger vs. warning vs caution) for effectiveness. **DANGER** indicates a hazardous situation that, if not avoided, **will result** in death or serious injury. **WARNING** indicates a hazardous situation that, if not avoided**, could result** in death or serious injury. **CAUTION** indicates a hazardous situation that, if not avoided, **could result in minor or moderate injury**.

These are key words used in aerospace to indicate a particular condition that might involve injury or equipment damage. Teams are expected to not only test effectiveness of key words but the financial and logistic consequences of painting a roadway including installation and maintenance. Teams are encouraged to examine consistency between signs that use the same key word but different color coding.

Testing might be done with superimposed markings and messages on computer simulated rural roads using a simple driving simulator developed on the **Unreal 5 Engine**. An eye tracking device like **Eye Tribe** eye tracker might be used to record where drivers are looking and for analysis.

The following figure represents a roadway text message receding down the road. It's an advisory message and does not use a key word like caution, warning, or hazard.

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FIGURE 4 - ROADWAY TEXT WARNING

Example of Pedestrian Crosswalk Using Linear Perspective.

The University of Rhode Island (URI) marked Upper College Road with differentially spaced white stripes that direct the driver's eye to the pedestrian crossing. This is a real-life example of linear perspective attracting attention to a pedestrian walkway.

These roadway markings are very similar to the examples for Dugway Bridge Road. But there are hundreds of different configurations of markings with little consistency. Which configurations are most effective? How can you test effectiveness? Much like the URI Capstone Project 'Highway Safety and Flashing Lights', in Phase One this Senior Design Project might perform computer-based experiments to test different configurations and solicit feedback from users as to effectiveness. More controlled studies might be performed in Phase Two and Three using the CTSRC.

The following figure shows the configuration of stripes on the URI campus.

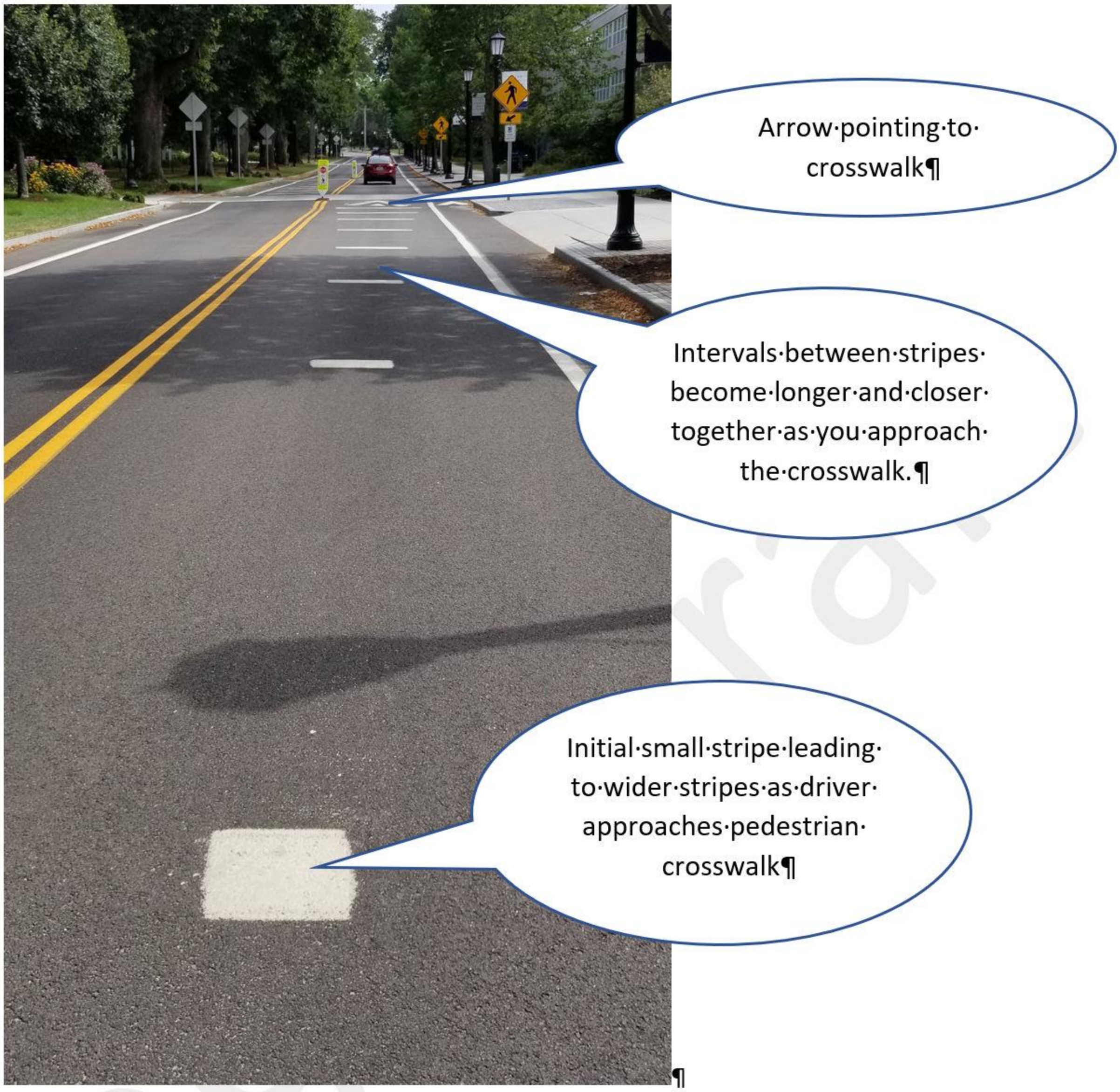

FIGURE 5 - URI PEDESTRIAN WALKWAY LEAD-IN STRIPES USING LINEAR PERSPECTIVE

Departments of Transportation worldwide attempt to design ways of reducing speed in different circumstances like pedestrian walkways, parking lots, and urban streets. Each location has different requirements. One method is to build a 'traffic bridge' or bump vs. a 'hump'. There are many different types of traffic bridges to slow drivers for certain traffic environments like urban, rural, and parking lots. Teams are encouraged to compare and contrast a selection of different designs and design an optimal configuration for only one environment.

The following figure shows a selection from the alamy web site. What do you think each of these signs or roadway markings imply or mean?

FIGURE 6 - ROADWAY SIGNS, BUMPS, HUMPS AND MARKINGS.

Example of Multiple Roadway Alerts.

What if you develop a multi-sensory alert? What if you combined a roadway warning message ('slow down'), a linear perspective cue (broken bars), and an off-center rumble strip? A milled rumble strip provides more noise and vibration than rolled strips and is much cheaper, more durable, and easier to construct. **Sweden reported reducing head-on accidents by 30% using center rumble strips** (as compared to edge strips that warn the driver that the vehicle is drifting off the pavement).

Could multi-sensory devices reduce speeding on rural roads? How effective is a combined multi-sensory experience compared to just a roadway text message or roadway horizontal alignment sign? Is an interrupted or **unsynchronized stretch of milled rumble strips** more effective than a continuous stretch? Unsynchronized stretch of rumble strips means a random set of milled strips in succession. Teams are encouraged to develop and test their own ideas.

Simple Way to Improve Figure / Ground Relationship.

Perhaps a simple way to accentuate the figure / ground relationship in this situation is to place a sign at the end of the straight away that indicates an abrupt turn or change in the horizontal alignment. While it is less expensive than milled rumbles stripes and roadway markings, is it more effective in reducing roadway departures? How can you test?

The following figure shows a single chevron sign pointing in the direction of the turn. The chevron sign graphic was placed on the image of the Dugway Bridge Road. It clearly indicates a left horizontal turn much better than the curve sign placed too far from the point of roadway departure. What other ways can you think of to enhance the figure / ground in this situation?

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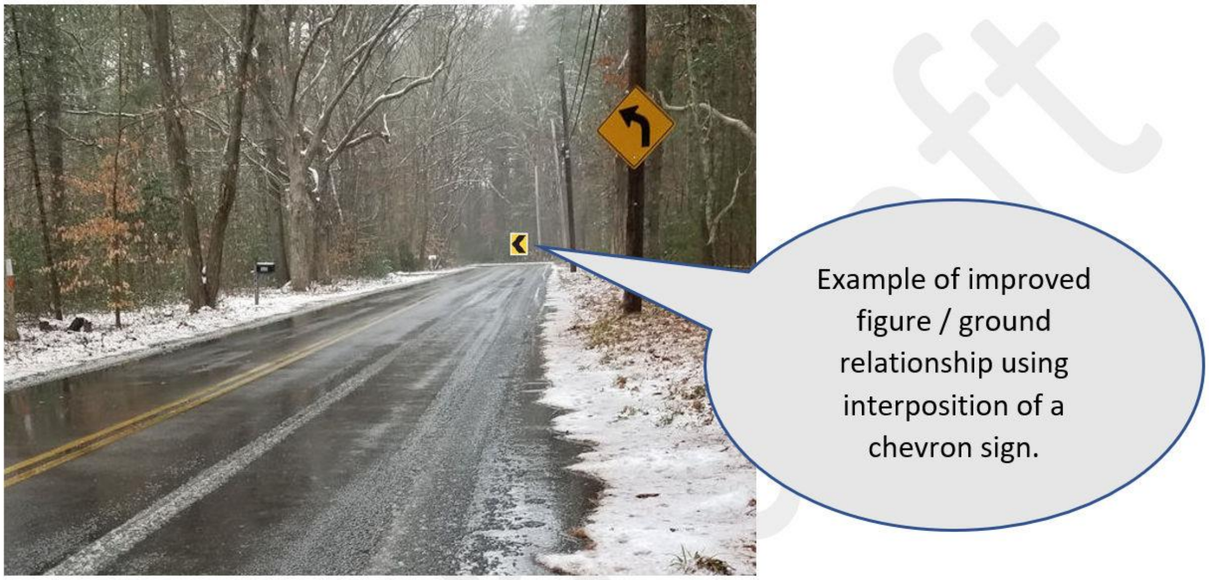

FIGURE 7 - EXAMPLE OF INTERPOSITION AND IMPROVED FIGURE / GROUND

DEVELOPING A 'SMART SIGN'.

Another method of alerting drivers in a timely manner of road conditions is to **design, develop, and test 'smart signs' called electroluminescent or adaptive signs**. A smart sign uses current to activate a traffic message or text message using electroluminescent paint. The paint changes color when a current is passed over it. The paint is used on high-end automobiles like Lamborghini's. This project proposes to use electroluminescent technology to display a text or symbol message given input from a variety of sensors.

Electroluminescent Technology.

For instance, imagine a **solar powered sign with electroluminescent paint that responds to environmental weather conditions**. This type of paint treatment lights up when an alternating electric current is applied across a metal surface to warn drivers of hazardous road conditions. Smart signs would use simple set of temperature and moisture sensors.

The following figure shows the layers of electroluminescent coating provided by Lumilor.

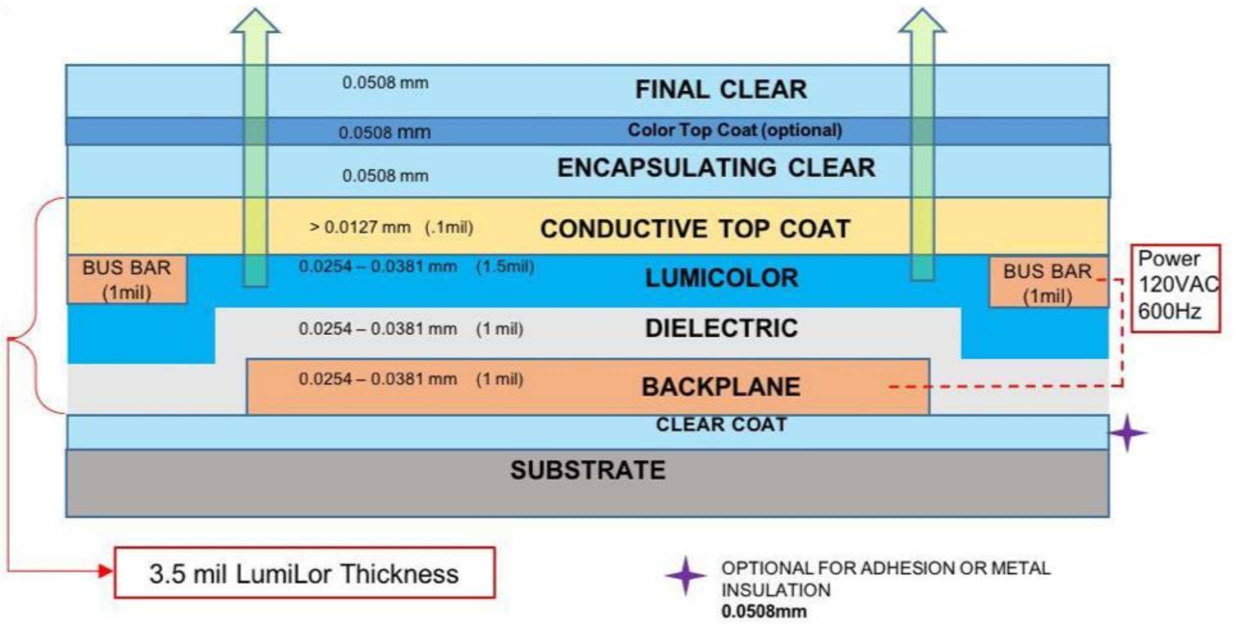

FIGURE 8 - ELECTROLUMINESCENT PAINT LAYERS

The following figure shows electroluminescent text on the side of an airplane.

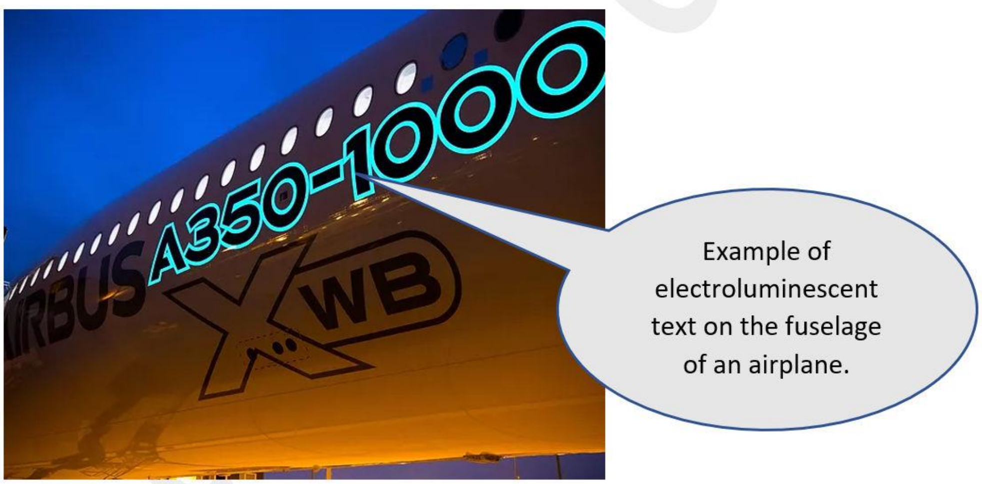

FIGURE 9 - ELECTROLUMINESCENT TEXT ON AN AIRPLANE

Smart Sign Systems Engineering.

Designing a smart sign requires a systems engineering approach. Developing an 'Icy Road' sign is more complex that it appears. A smart sign is just one piece of the system. It is a combination of electronics, sensors, materials, circuitry, and connectivity. Connectivity refers to how the sign electronics communicates with a server, perhaps the **ArcGIS server**, concerning its status. Phase One should only design and develop a 'breadboard' of an EL sign.

An ArcGIS capability is extremely complicated (and expensive). Fortunately, **CTSRC** has comprehensive dashboards (twenty-three) that allow examining and sorting different circumstances (criteria) of driving incidents, such as distracted drivers, aggressive driving, and speed related crashes. These categories appear to be criteria within the taxonomy of situational awareness.

Teams can develop a 'smart phone' application that tracks sign status and reports it to an ArcGIS server or equivalent. The smartphone application can be a prototype (non-functional) for Phase One, but it reveals the realm of possibilities to make sign status and weather available via an intuitive user interface. It would show the intended functionality and user interface only.

For the **URI Capstone Project 'Hack That Flood'**, the Computer Engineering and Electrical Engineering teams developed a smart phone interface that demonstrated the notional interactivity of NOAA data, RIDOT, live sensor, and plain flood data. The prototype demonstrated the functionality and user interface. It was only a prototype and not 'up and running' on a hosted server.

The following figure shows their prototype.

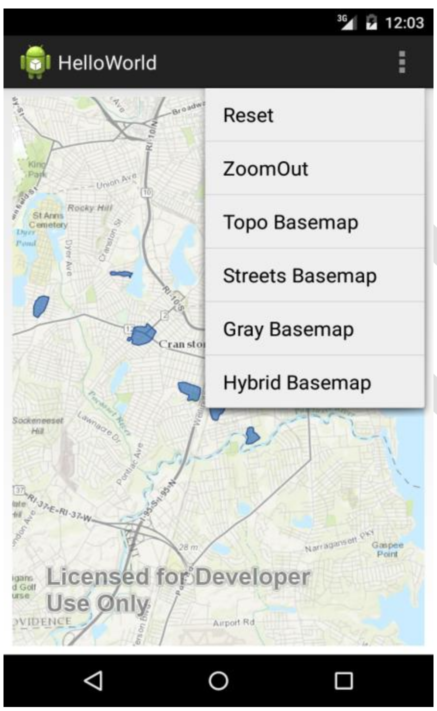

FIGURE 10 - PROTOTYPE GIS SMARTPHONE INTERFACE

Icy Road Signs

For instance, consider the 'icy road' signs. There are dozens of variations. The following figure shows a sample of icy road signs. How easy or difficult is it to recognize, interpret, and respond to one vs. another? Does your selection of icy road signs follow color coding conventions for key words like danger, warning, and hazard? Is one sign easier to read and recognize than others? Is simpler better? Can you evaluate which sign is the best given a set of criteria? What would be those criteria? One sign presents the word 'icy'. Another sign shows a car skidding plus a thermometer and a value in centigrade. Which one do you think is the best?

Teams are encouraged to perform comparison studies of existing icy road signs to collect evidence. Comparisons might be total rank order of signs or paired comparisons. Both methods require some statistical analysis. Paired comparisons can be conducted using printouts of signs or a computer-based experiment.

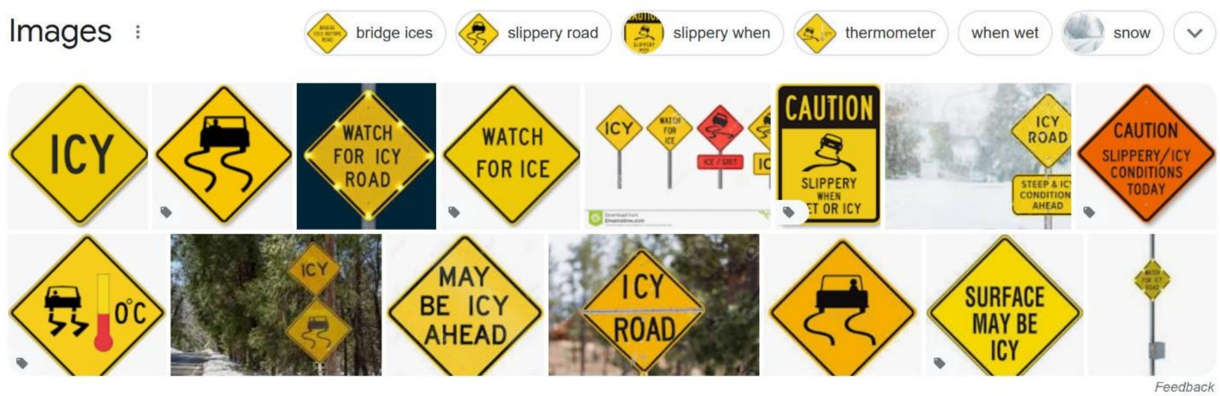

FIGURE 11 - SAMPLE 'ICY ROAD' SIGNS.

Although the DOT installs 'icy' road signs, this message makes less sense in warm spring, summer or fall. Drivers can experience **habituation. Habituation is growing accustomed to a situation or stimulus, thereby diminishing its effectiveness** and results in drivers ignoring such warnings. Why are there so many types of 'icy' signage? **Imagine a smart adaptive sensor sign that displays a warning only when it is needed.**

Icy Road Smart Sign

The following figure represents an electroluminescent sign without current. Without current applied, the sign is blank and does not distract the driver. When weather conditions change as detected by simple and inexpensive moisture or temperature sensors, a current is applied to the sign that displays the warning. The sign could be solar powered with standby battery power.

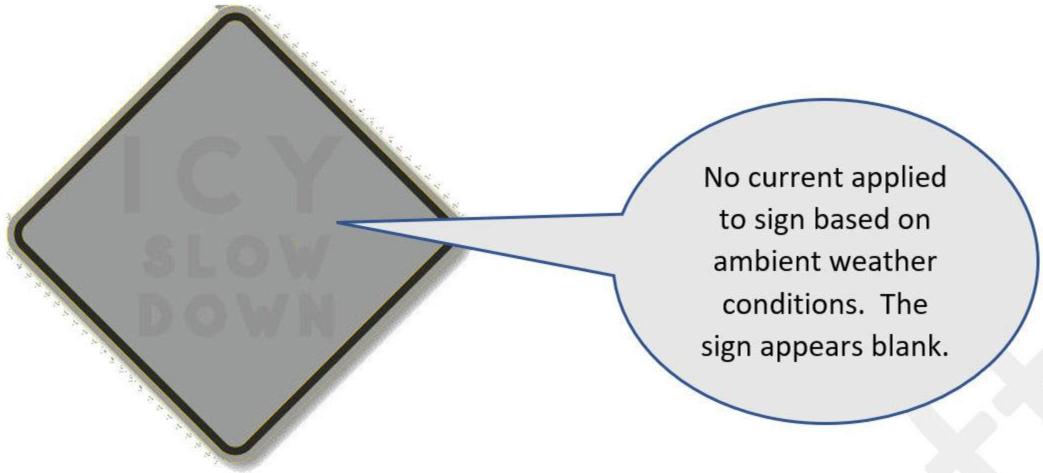

FIGURE 12 - ELECTROLUMINESCENT SIGN WITHOUT CURRENT APPLIED

The following figure shows an activated electroluminescent sign that displays the road condition depending upon preset sensor readings. In this case, the sign displays the warning condition '**icy'** and the corrective action '**slow down'**. **These two messages are the essential ingredients for an instructive action sign.**

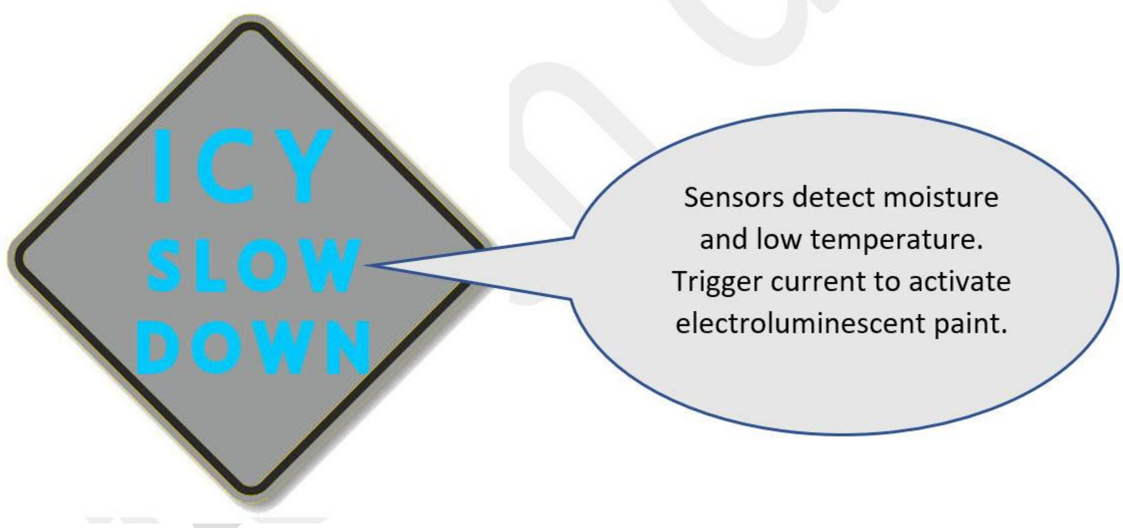

FIGURE 13 - ELECTROLUMINESCENT SIGN AFTER CURRENT APPLIED

Figure 15 shows a notional block diagram for an icy solar powered adaptive sign including electronics. A small solar panel with built-in charge controller powers a rechargeable 12-volt battery. This power source provides power to an Arduino MEGA or Seeedino MEGA board and peripherals. The Arduino processes inputs from the humidity and temperature sensors that detect dropping temperature and increasing humidity. Once a predetermined threshold is reached, a signal is sent to a switch inverter that converts DC to A to flip the EL paint circuit. The ethernet shield and GPS antenna send the activation alarm to a central office to notify the authorities that icy conditions were detected.

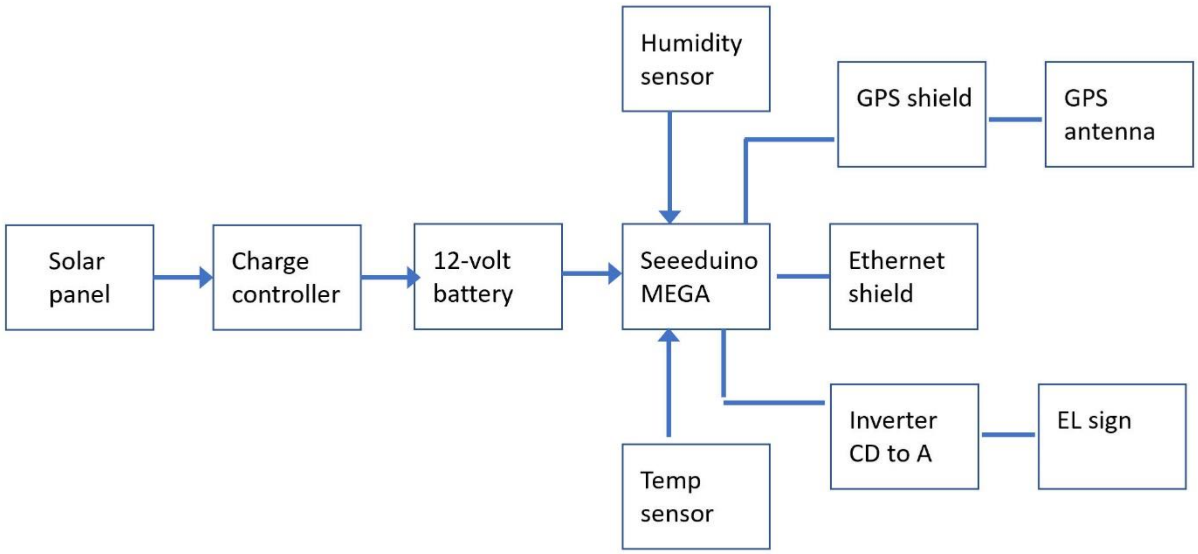

FIGURE 14 - 'ICY ROAD' SIGN BLOCK DIAGRAM

Electro-Optic Smart Sign

An ‘icy road’ sign is not the only condition that might benefit from a smart sign. Most cars manufactured after 2000 have running lights. What if a smart, **headlight sensitive** electro-optic (EO) sign is designed to detect either an oncoming single or dual headlight and ‘turns on’ to display a message like ‘bad curve’, ‘slow down!’. Perhaps it could blink or flash to attract attention. School zone flashing beacons attract drivers’ attention to the school zone. These are solar powered and sell at retail for $3,500.00.

The following figure shows the block diagram for an electro-optic sign which is very similar to the ‘icy road’ block diagram.

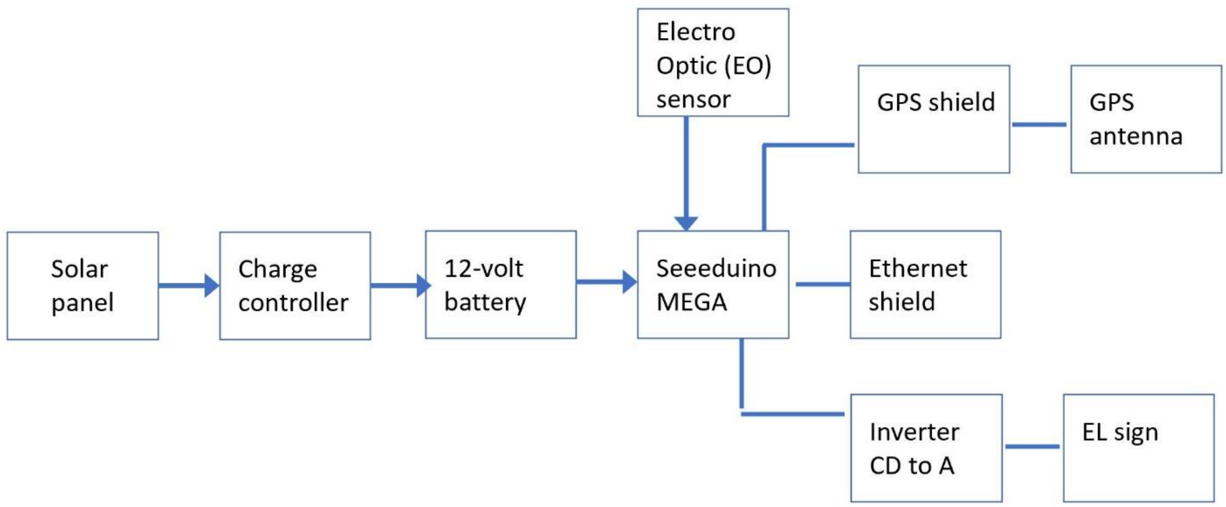

FIGURE 15 - FLASHING EO SMART SIGN BLOCK DIAGRAM

The smart EL chevron sign might look like the following figure.

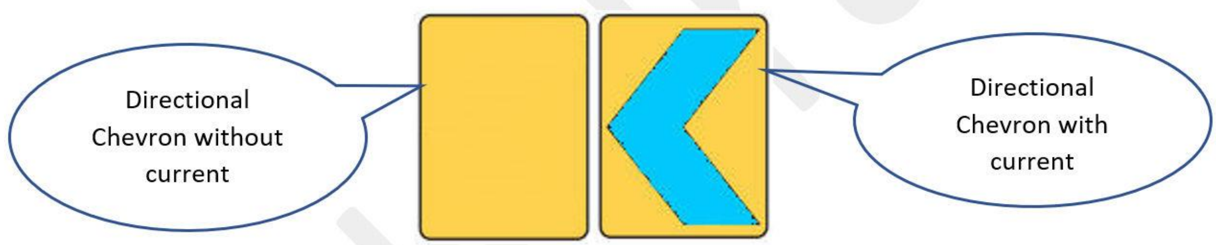

FIGURE 16 - ELECTRO-OPTIC ACTIVATED CHEVRON SIGN

Smart Sign Phase One Expected Deliverables.

Phase One development of the EL sign system is considered only a breadboard or basic demonstration of functionality. Phase Two should be considered more realistic in terms of housing, packaging, functions, durability.

Phase One deliverables expected are:

1. Circuit schematic / diagram
2. Block diagram
3. Power analysis / regulation
4. Sensor selection
5. Processor selection
6. Software architecture
7. User interface
8. GSM communication

9. Breadboard

SITUATIONAL AWARENESS TAXONOMY

Situational awareness is critical for making rural roads safer. Wikipedia defines situational awareness as the **perception of environmental elements and events with respect to time or space, the comprehension of their meaning, and the projection of their future status**.

Creating a taxonomy of situational awareness provides a coherent structure for criteria as we shall see. It is part of the systems engineering approach to problem solving. The following figure offers a framework or taxonomy of situational awareness classes and criteria within the context of driving an automobile. The main classes within the situational awareness taxonomy for this project are **events, environment, and roadway.**

Notional Taxonomy of Classes and Criteria

The following figure shows a suggested taxonomy or framework for organizing criteria in a coherent structure.

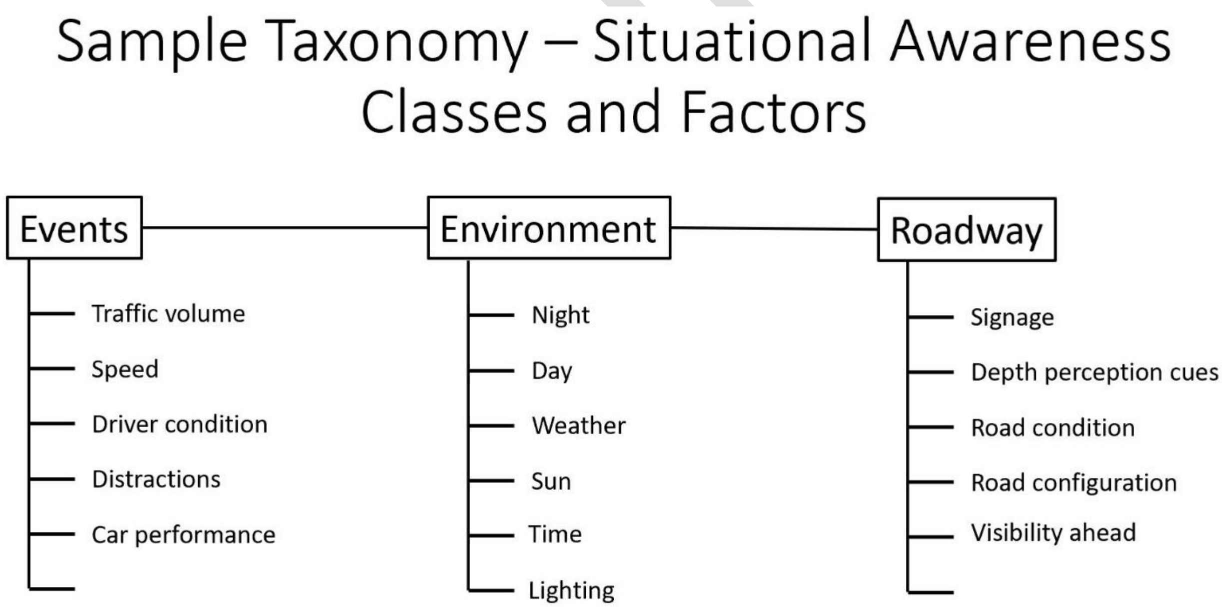

FIGURE 17 - TAXONOMY FOR SITUATIONAL AWARENESS AND VEHICULAR DRIVING

The ultimate goal is to develop a formula or algorithm that can predict to some degree of certainty, the probability of an accident. By investigating these various criteria and weighting them based on accident outcomes and other data, it may be possible to develop one or more formulas or algorithms that predict an accident given factors in the taxonomy. Once a notional set of algorithms is constructed, then apply that formula to a random sample of one or two rural roads and cross reference with accident reports found in the CTSRC. Then revise your criteria and your algorithm and try again. This process demonstrates the iterative systems engineering approach.

The sample of criteria for '**events'** are traffic volume, speed, driver condition, distractions, and car performance. These are arbitrary high-level categories. Teams are encouraged to edit and identify detailed criteria extant in tools like the **CTSRC.** Each criteria might be broken down into a lower level which is then applied to determine a 'safety index' for that particular rural road location.

For instance, the '**roadway'** class is a situational factor that is not temporal. Both the 'Events' and 'Environment' class are more temporal in that they are more likely to change. 'Roadway' criteria like signage, depth perception cues, and road condition are less likely to change. However, the 'Environment' factor 'Weather' is extremely important. Thus, teams might consider developing a seasonal weighted criteria item called 'weather'. Teams are encouraged to breakdown each class into lower-level criteria which can be used to evaluate the safety coefficient for a rural road, perhaps on a seasonal basis.

HOW TO FIND UNSAFE RURAL ROADS.

Crowd Sourcing Campaign.

Collecting data and information to identify locations and compile accident criteria involves many potential sources. Crowd sourcing by team members offers the Connecticut community an opportunity to contribute to identifying hazardous 'scary' rural roads and locations and roadway departure criteria. This effort will be coordinated by **MEM** to solicit candidate locations of 'scary' roads in Connecticut. An alumni magazine article might be published as well as an article in a local newspaper or mailing list from team members. Using Google Earth features, volunteers will be asked to nominate 'scary' locations in Connecticut where spinouts, departures, or just plain 'scary' roads and corners have occurred.

Connecticut Transportation Safety Research Center

The CTSRC 'dashboards' contain an extensive collection of accident data to be explored and cross checked with other sources. Keep in mind that one objective of this project is to predict where an accident will occur. Where volunteers think an accident might occur can be cross referenced with the CTSRC dashboard accident data to confirm the suggested location. Essentially, teams would reverse engineer the CTSRC database with their findings on other sources of accidents and criteria. The main objective is to identify precursors of

Other Sources of Information.

How many minor incidents occur on rural roads that did not result in damage or injury? It is anyone's guess, but it might be fairly significant given the high number of rural road accidents. One source of data might be

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1. Tow truck records (national AAA and local independent) of towed vehicles on rural roads. You can obtain time, date, location data from such records. Usually, accident reports record time and place information.
2. Local Public Services, Town Manager. The town manager is responsible for road repairs requested by residents and businesses as well as their own surveillance. The road repair and cleaning services might record evidence and location of roadway departures.
3. Waste management drivers making weekly pickups might be solicited to record any roadway departures.
4. UCONN Cycle Team might be solicited to participate.
5. Local DOT and police personnel might be helpful, knowing that **UCONN is working on a comprehensive approach** to identifying hazardous rural roads. Interviews might be done remotely via Zoom or similar software with local safety personnel.
6. United States Postal Service might participate. Team members might **invite USPS executive leadership** at the district level to authorize USPS drivers to record any evidence of a spinout.

Google Earth Pro

The Google Earth Pro tools are available for download on any computer. Google Earth Pro altitude and street views and tools are very useful to identify potentially hazardous rural road configurations in a sample of rural roads in Connecticut. Tools include distance, path, placement, record a tour (for record keeping), and ruler. Team members would look for criteria, i.e., long straight aways with abrupt turn, obscured turns, lack of lighting, narrow road, no signage indicating turn, etc. Team members can 'pin' the location and then cross check with the CTSRC database for accident data.

A solicitation for 'scary' corners and roads from volunteers might be done using an online form to collect information to a database for sorting, research, and comparisons. This application could be provided by the UCONN School of Engineering. Users would use either an iPad or tablet or PC and Google Earth to 'pin' a spot. On a PC you 'save place as…' a kmz file. Then send that attachment to the web site.

Imagine developing an **ArcGIS program** that could scan Google Earth rural roads based on the detail criteria and predict the probability of an accident?

ENGINEERING TEAMS.

'Making Rural Roads Safer' Engineering Senior Design project could be a combination Civil and Environmental Engineering (CEE), Electronic and Computer Engineering (ECE), Computer Science and Engineering (CSE), and Management and Engineering for Manufacturing (MEM). **CEE** could be responsible for researching rural road safety, rural road accident profiling, and surveying (using Google Earth Pro) and conducting experiments using the UCONN Driving Simulator. **ECE** might investigate solar powered EL signage that responds to changes in temperature, light, moisture, and current to display current road conditions. **CSE** could analyze, design, and evaluate system software, utility programs and software-hardware architecture of the EL sign. **MEM** will manage and coordinate the entire project and its results to the Connecticut state agencies involved. **MEM** will write a grant to obtain funding for a more extensive study.

VERIFICATION OPTIONS.

Mockups – Phase One

For Phase One, teams might develop mockups of notional signage on the UCONN campus to assess effectiveness. These new locations may not be consistent with the MUTCD; however, they might yield some insight into why location, color coding, and depth perception are important. Verifying these new locations might be accomplished using interviews and paired comparisons. Verification might be conducted using scenes developed and presented via computer.

Teams are encouraged to develop subjective methods for gathering data including questionnaires, surveys, paired comparisons, and relative ranking methods. These verification methods can be applied to evaluating the effectiveness of selected signage, hazard rankings of rural roads, and criteria.

CTSRC Testing – Phase Two / Three

Due to software requirements to test the outcomes of Phase One regarding depth perception cues, multi-sensory roadway features, and roadway markings, CTSRC testing is scheduled for Phases Two / Three. Once team members investigate and analyze rural road characteristics, conditions, and accidents, team members could use the CTSRC to create scenarios and test depth perception concepts and configurations.

Teams should review the collection of reports and research accumulated since 2017 by the CTSRC. The CTSRC is a comprehensive facility dedicated to collecting, analyzing, and reporting on accidents, crash analysis, and injury prevention. A couple of studies investigated rural road accidents in California. The CTSRC has published thirty-nine articles in transportation magazines about multi-lane merging, advanced traffic management, crash rates during COVID, intersection accidents, crash count models, and more safety related issues.

An eye tracker might be used to examine exactly where and how long drivers are looking at signs, road, shoulder, near and far objects. Teams should consider a **secondary masking task** to assess driver attention. Team members would **establish timelines** that include latency, human reaction times, and vehicle response times. Team members would learn about human perception, reaction times, and task analyses related to driving.

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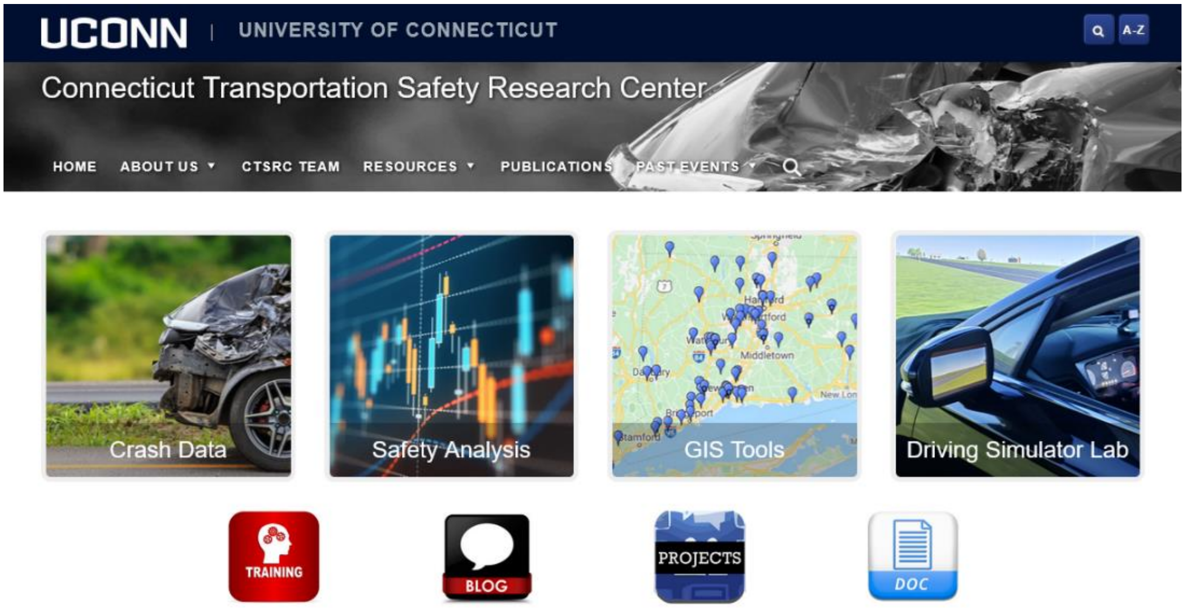

FIGURE 18 - UCONN DRIVING SIMULATOR FLYER

WHAT'S INTERESTING ABOUT THIS PROJECT?

Since this project requires a multidiscipline approach engineering teams will learn to work together to solve pervasive complex problems in Connecticut rural roads.

Civil and Environmental Engineering (**CEE**) students will learn about how visual perception affects behavior and human response times. They will learn firsthand about rural road configurations and what makes them dangerous. They will interview public safety and DOT personnel and analyze recording and data. They will do comparative studies of signage effectiveness, develop innovative methods of warning drivers of hazardous road conditions, and survey rural roads. CEE teams will learn how to apply statistical methods to determine sign effectiveness.

Electronic and Computer Engineering (**ECE**) and Computer Science and Engineering (**CSE**) members interested in electronics, solar power and conversion, materials and processes will work together to design, develop and prototype one EL sign and associated software and connectivity. How do you select a COTS solar panel? Do you need to convert voltage to power the EL sign? What is the best inverter to use in this application? What are the electroluminescent properties of this paint that reacts to current? How do you protect the electronics and paint from environmental elements? What prototyping tools will you use to develop the user interface (UI) for the smartphone application?

Management and Engineering for Manufacturing (**MEM**) members interested in managing the project will learn how to coordinate all aspects of the study. That includes contacting and working with outside agencies like DOT and USPS, coordinating with other teams and faculty, conducting design reviews and all meetings, and recording minutes / action items. MEM is expected to determine the costs for rolling out selected electroluminescent signage based on their down selection process at a state level. MEM members will work with the **Office of Grants** and **sign up for Course 2001 - Introduction to Grant Proposal Writing**.

EXPECTED DELIVERABLES.

1. **Implementation plan** for the 'Making Rural Roads Safer' senior design project.
2. Discussion of human error and the limitations and capabilities of the human cognitive, visual, and motor systems pertaining to vehicle driving.
3. **Research** into effects of depth perception on driving performance.
4. Assessment of the effectiveness of a sample of critical signs, i.e., 'icy road' and suggested improvements.
5. **Interviews** with safety and transportation personnel, if possible.
6. Taxonomy of **unsafe rural road ranked characteristics** (criteria).
7. List of 7 or more candidate CT rural roads for further study.
8. List of creative methods to **increase effectiveness** of signs (placement, size, position).
9. Tradeoff study of icy road signs and the best 'icy road' sign design.
10. Tradeoff study of the best 'traffic table' or 'bump' design.
11. A breadboard for a smart sign (Phase One).
12. Full up working prototype of an EL traffic sign (Phase Two / Three).
13. Output from the UCONN Driving Simulator scenarios (Phase Three).
14. Bimonthly progress or weekly activity reports.
15. Conceptual and Final Design Reviews.
16. End of semester and final reports.
17. A **grant request** to Connecticut DOT or federal agency to procure funding for Phases Two and Three.

DETAIL PROJECT OBJECTIVES.

The following list of detail objectives comes with some questions you should ask yourself and answer in your reports.

Research depth perception cues.

How do we perceive depth? Clue – think binocular and monocular vision. Which are important for driving? What do we mean by 'figure / ground' relationship? What happens when you do not perceive a figure / ground relationship while driving? Consider figure / ground relationship when assessing road configurations that are considered unsafe. If an unsafe road has poor figure / ground relationship, how would you improve that in a **cost-**

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effective manner? The answers to these questions should be covered in the project reporting.

Determine how human error affects rural road accidents

What is real human error? Are there any examples of poor equipment design in automobile dashboards and visual displays? Think of any example of a bad design in your automobile or computer interface. How does real human error relate to driving an automobile? Using your experience, have you ever encountered a situation where your human error might have caused an accident, i. e., misjudged speed of oncoming vehicle at an intersection when you are turning against traffic?

Identify the characteristics of unsafe rural roads.

Some rural roads are unsafe for one or more reasons. Some reasons might be a blind turn (unable to see xxx yards ahead), long straight away leading to a blind turn or obscured turn, very narrow roadway, no signage, ambiguous signage, none, or incorrect roadway lighting.

Use traditional methods of identifying unsafe roads through the CTSRC, tow truck company reports, newspaper reports, local news articles, if available. Novel methods involve using Google Earth Pro tools to identify candidate rural roads that may be hazardous based on your list of criteria in your situational awareness analysis.

If possible, take one incident and drive to the location and see the location for yourself. Once you have listed some characteristics of unsafe roads, use novel methods by using Google Earth Pro street views and aerial views to identify candidate roads that exhibit sharp turns, no signage, inadequate or confusing signage. Think of how you would improve the signage or view of the roadway and document your findings.

Determine the probability of an accident on a rural road.

Once you have criteria for the physical characteristics that make a rural road unsafe, then weight those characteristics. Teams are encouraged to examine several actual accident reports or CTSRC dashboards to see if environmental and situational variables are recorded. This approach might allow you to compile a list of criteria, weight them, and construct a formula.

Teams are encouraged to weight different criteria within a class of factors like environmental, situational, and roadway. Which is the most important? Build a list of five (5) to seven (7) criteria in each class. One example of detailed criteria might be xxx feet of obscured visual access to sliding turns or intersections. The greater the xxx feet of visibility to lower the probability of an accident, presumably. Other detailed 3rd level criteria might be presence of xxx feet of clear shoulder, proximity (or absence) of horizontal direction sign at curve, presence (or absence) of interposition of visual cues at curve (objects, guard rail, etc.)

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Develop 'situational awareness' scenarios.

Situational awareness is perceiving **the environmental circumstances, events, and conditions** and being able to anticipate outcomes. **Situational awareness is critical** for driving a vehicle on rural icy roads, narrow roads, roads with abrupt turns, roads with reduced visibility during rain or snowstorm.

One possibility is to develop CTSRC **'what if' scenarios** as a submittal for the DOT grant. Scenarios will be developed using Phase Two software development. Scenarios could be used as training tools for drivers. Scenarios might be recorded as video **'stop action' episodes** with 3 possible outcomes. For instance, one scenario might show a bicyclist on a narrow rural road. Options might be 'slow down and wait for straightaway', 'pass bicyclist now', 'pull over and wait'. Users would be given a one-second to decide, and then the correct or most correct option displayed and explained. Scenarios would be part of the grant offering.

Scenarios might be constructed that involved potentially hazardous situations like combine reduced visibility, lack of depth perception cues, specular glare on windshield, bicyclists riding along rural roads, dog running into road, dog / owner walking on a narrow rural road, passing turning vehicle, no shoulder / shoulder overgrown with shrubs and tall grass, overtaking farm vehicle, etc., on a rural road.

Multisensory roadway alerts might be simulated in the CTSRC using video of milled rumble strips synchronized with the sound and vibration of tires passing over the rumble strips. One way to simulate the vibration and sound effects is by using an **X Rocker Typhoon dual pedestal gaming chair with vibration**. The vibration is generated by bass reflex speakers in the chair. The driving simulator would record the driver's response as the vehicle passes over the strips, possibly tracking eye movement. Hypothetically, drivers in the simulation should slow down since rumble strips are used by DOT at toll booth stations and on highway edges strips.

Calculate effectiveness of certain traffic signs.

Teams are encouraged to compare the effectiveness of a similar set of signs concerning their effectiveness. For instance, there are several 'icy road' signs. How effective is the sign that says, 'May Be Icy'? Or 'Watch for Ice'. Do these make sense when you are driving 60 miles an hour? Do such signs improve 'situational awareness? Are the key words **caution, warning, and danger** applied consistently according to accepted industrial system safety standards? Teams might use compared comparison questionnaire or a ranking questionnaire based on all available signs on that topic.

One way to conduct an analysis of the effectiveness of signs, location, size, etc., is to construct your improved version of a selected sign using FOMCOR.

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Investigate electroluminescent (EL) technology.

This proposal includes an idea for developing an adaptive sign for 'Icy Road'. Other situations like 'Poor Visibility' or 'Flooded Road' are possible. However, teams are encouraged to investigate EL technology and apply it to a pilot study using one environmental condition. Several suppliers offer do-it-yourself kits and supplies. Building an EL display involves a layering process of paint and other materials plus electronics for internet connectivity, sensor interfaces, etc.

Develop a 'smart' sign.

Once El technology is understood, teams are expected to develop a breadboard smart sign for Phase One and a working model of a smart sign in Phase Two and Three. The working model shall be a standalone item with its power supply, sensors, connectivity, substrates, and paint.

Write and submit a grant.

Teams must write a grant that incorporates the research, information, data, and technologies for improving rural road safety. Expected content includes how to improve depth perception, how to predict rural road safety (using the weighted criteria), how to develop selected smart signage, plus costs for implementation of a pilot study in CT.

SUMMARY.

'Making Rural Roads Safer' can be either a small or large project depending on interest and resources. At the small end, it might involve just developing and prototyping a smart EL sign. At the large end, it could be a full-blown extensive investigation into developing criteria, predicting the probability of an accident on a rural road, and profiling several potentially hazardous rural roads in CT, plus a working prototype of a smart sign, plus enhancements to the CTSRC driving simulator lab, plus writing a DOT grant to further investigate and apply how to prevent rural road incidents on a national basis. The possibilities are endless.

BUDGET.

This project is offered with no upfront or final design budget for either materials or labor. Sponsor is still paying down the $2,000 2020 'LooLoo' UCONN senior engineering design project and cannot assume additional debt. The reward will be procuring a DOT grant for $500.00.00 to apply the results of this project to CTSRC capabilities and a larger sample of CT rural roads.

SPONSOR RESPONSIBILITY.

1. Interpret objectives, requirements, and responsibilities written in the proposal.
2. Familiarize team members with human factors principles, data, and information.
3. Encourage creative solutions to integrate depth perception cues into road features.
4. Instruct students about human error, definitions, causes related to accidents.
5. Offer advice on systems engineering design requirements.
6. Assist in organizing conceptual and final design reviews using aerospace best practices.

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7. Offer instruction on accepted practice for cautions, warnings, and hazards used in aerospace industry.
8. Assist with developing interview forms and analyses.
9. Assist with statistical treatments of data, parametric and non-parametric.
10. Instruct teams on good design review methods and procedures.
11. Provide ideas for secondary masking tasks in driving simulations.
12. Attend meetings and assist in conducting design reviews.

SPONSOR BIO.

Richard C. Davids. Mr. Davids is a cancer survivor and retired senior staff human factors engineer with Lockheed Martin Missiles and Space Systems, Sunnyvale, California, 1974 – 2007. He applied human factors engineering principles and design standards to mobile command shelters, large communication facilities, missiles, ships, planes, spacecraft, Office of the Secretary of Defense Crisis Coordination Center, the ISS, transportation systems, railcars, missile and submarine support equipment, electronic equipment, and computer human interfaces.

Mr. Davids worked with mechanical and electrical engineering, systems engineering, specialty engineering, manufacturing, training, support equipment, logistics, parts, materials and processes, facility and field engineering, DOD, and some very special customers.

Mr. Davids taught Specialty Engineering, Concept of Operations, and human factors engineering classes at Lockheed Martin and is a Certified Human Factors Engineer #529.

He was graduated from the University of Rhode Island with a Bachelor of Arts in Psychology in 1971 and from New Mexico State University in 1974 with a Master of Arts in Engineering Psychology.

Since 2011, he has sponsored and privately funded 13 Engineering Capstone, Honors, and Senior Design projects at the University of Rhode Island, University of Connecticut, and Roger Williams University. His projects won regional and international awards. Projects study and propose solutions to issues in homelessness, refugee and IDP shelter, vertical agriculture, modular furniture, tree disease detection, human waste recycling, highway safety and flashing lights, elderly in-home fall detection, urban and rural flood control, walking assistance and Internet of Things physical therapy, and inflatable snow plowing. Two projects won **NMSU International WERC Environmental Design awards.**

Having worked with three outstanding New England Universities, Mr. Davids prepared **a Saturday Senior Design Symposium Proposal** in 2017 to increase cooperation and effectiveness of Capstone, Senior Design and Honors projects among New England universities. The proposal was distributed to interested faculty at New England universities.

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Contact Information:

Richard C. Davids
10 Queens River Drive
West Kingston, Rhode Island, 02892
Cell Phone: 831-359-6851
Email: rcdavids1@verizon.net

PROPOSAL REFERENCES AND ACKNOWLEDGMENTS.

"Deadly crashes on rural roads prompt new safety efforts", USA Today August 17, 2021.

"Report: Connecticut Has Nation's Deadliest Rural Roads", Hartford Currant, May 19, 2015.

"Transportation Group Says Connecticut's Rural Roads Are Deficient", CT NewsJunkie, 2017.

"State's rural roads are unsafe, report says". CT Bulletin, May 23, 2015.

Connecticut Crash Facts Book, 2019.

"Evaluating Driver Performance on Rural Two-Lane Horizontal Curved Roadways Using a Driving Simulator", Department of Transportation, December 2012.

"Manual for Traffic Control Devices", 2019.

Lumilor website - https://www.lumilor.com/

"Rumble strips save lives on Swedish roads", Science Nordic, 2013.

https://www.alamy.com/street-speed-bump-in-the-road-for-safety-painted-with-yellow-color-image332100097.html

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X-Rocker Gaming Chairs - https://xrockergaming.com

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