Students:
Arthur Lane, Damon George & Robert Brajcich
Advisor: Tim Ecklund
Liaison: Kamil Agi

Smart Helmet: Connecting Cyclists to Intelligent Vehicles

ENSC 02 Self-Proposed Project

GONZAGA UNIVERSITY
School of Engineering & Applied Science

Problem

Cyclist Safety in the Presence of Smart and Autonomous Vehicles

Solution

A Battery-Powered Helmet, with GPS and wireless Vehicle-to-Everything (V2X) communication, that warns the cyclist of potential collisions via haptic and audible alerts.

Design

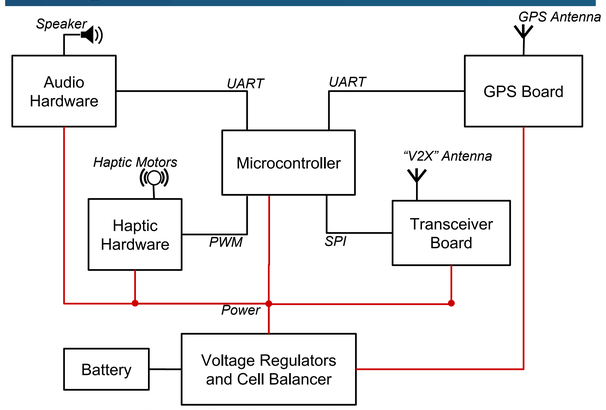

Figure 1: Block Diagram of Full Design

Requirements:
- GPS ✓
- V2X ✓
- Risk Assessment ✓
- Battery Power ✓
- Audio Warnings ✓
- Traffic Simulator ✓

Stretch Goals:
- Haptic Warnings ✓
- Custom PCB ~
- Bluetooth App ✗
- Module Enclosure ✗
- Signal Lights ✗

What is V2X?

Vehicle-To-Everything Communication
- 5G Wireless
- Basic Safety Messages (Cars)
- Personal Safety Messages (People)
- Shared Data: position, size, motion, route data

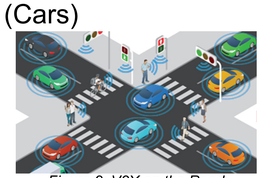

Figure 2: V2X on the Road

Printed Circuit Board (PCB) Design

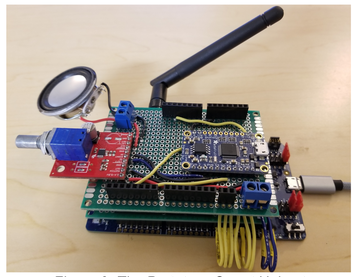

Figure 2: The Prototype Smart Helmet

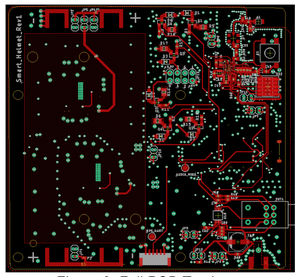

Figure 3: Full PCB Top Layer

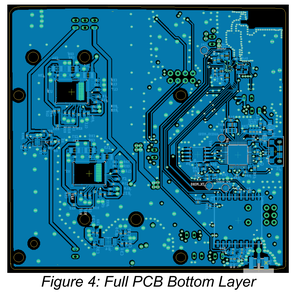

Figure 4: Full PCB Bottom Layer

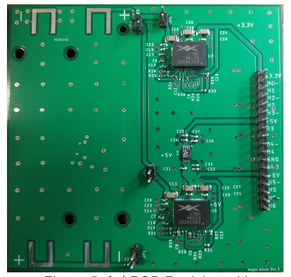

Figure 5: 2nd PCB Revision with Power and Haptics

Full System PCB:
- 4 Layers
- 198 components
- 3rd Iteration

Functionality:
- Power Supply
- Microcontroller
- Haptic Control
- Audio Processing
- V2X Messages
- Bluetooth

Core Software

The core software running on the Smart Helmet's ultra low power **Apollo2 Blue** microcontroller uses the **Free RTOS** Real Time Operating System to handle task scheduling in the embedded and single-threaded environment of the helmet.

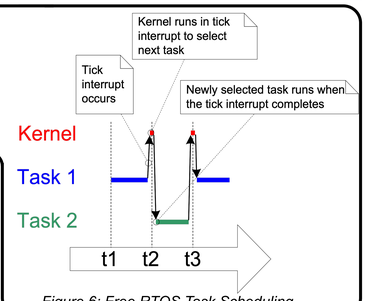

Figure 6: Free RTOS Task Scheduling

Free RTOS Tasks:

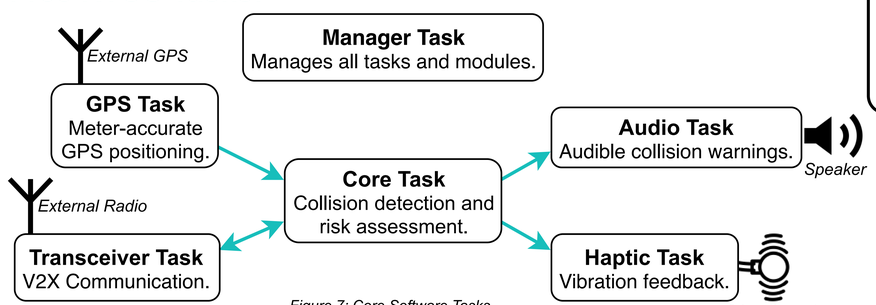

Figure 7: Core Software Tasks

Testing: (with the Ceedling Framework)
- Unit Tests for collision detection algorithms.
- System Tests for custom PCB hardware.

Traffic Simulator

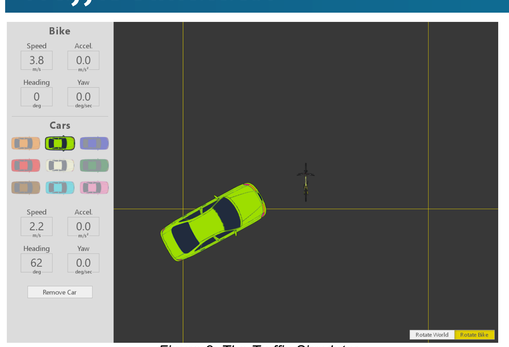

Figure 8: The Traffic Simulator

Java Desktop Traffic Simulator using OpenGL Graphics

Connects via USB to transceiver relay to spoof vehicle data to the Smart Helmet. Allows the user to generate cars in collision scenarios around the cyclist. The bike and currently selected car can be driven using the keyboard, and the motion data for the two are shown as well.

Figure 9: The Traffic Simulator's Transceiver Relay

Results

New Product Material Cost:

Quantity	Cost
1	$292.00
100	$165.00
1000	$122.00

Collision Detection:

Limitations:
- Lack of Processing Power
- No Map Data

Capabilities:
- Linear and Curving Trajectories
- 10 second lookahead

Audio Warnings:

Unknown Threat + Limited Response Time = Simple Directional Messages

Haptic Warnings:
- 6 directional vibration motors.
- Buzzing frequency increases as threat approaches.
- Alternates among top 3 threats.

Project Budget:

Budget	Spent
$5,000.00	$2,600.00

Next Steps

1. Authentic V2X radios.
2. Full printed circuit board with custom helmet.
3. Advanced inertial and proximity sensors for versatile collision warnings.
4. Bluetooth app for personalization and visual threat feedback.

Qualcomm 9150 C-V2X