WES Cohort 9 Capstone Project Proposal
V2X Motorcycle HUD

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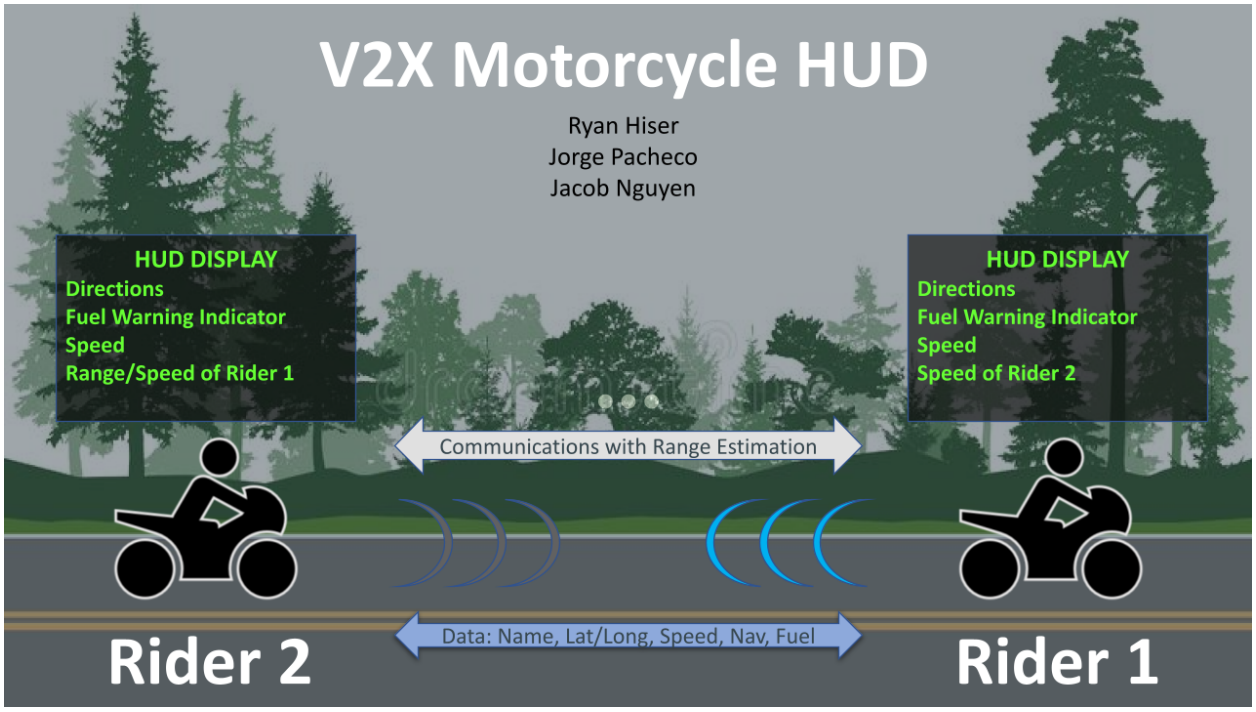


Motivation:
Motorcyclists often ride in groups. To effectively and safely ride it is often necessary to communicate. This takes many forms, such as hand gestures, high speed maneuvers, intercoms, refuel periods. A HUD system would allow for fewer distractions from the driving experience by displaying this information in a digestible format.

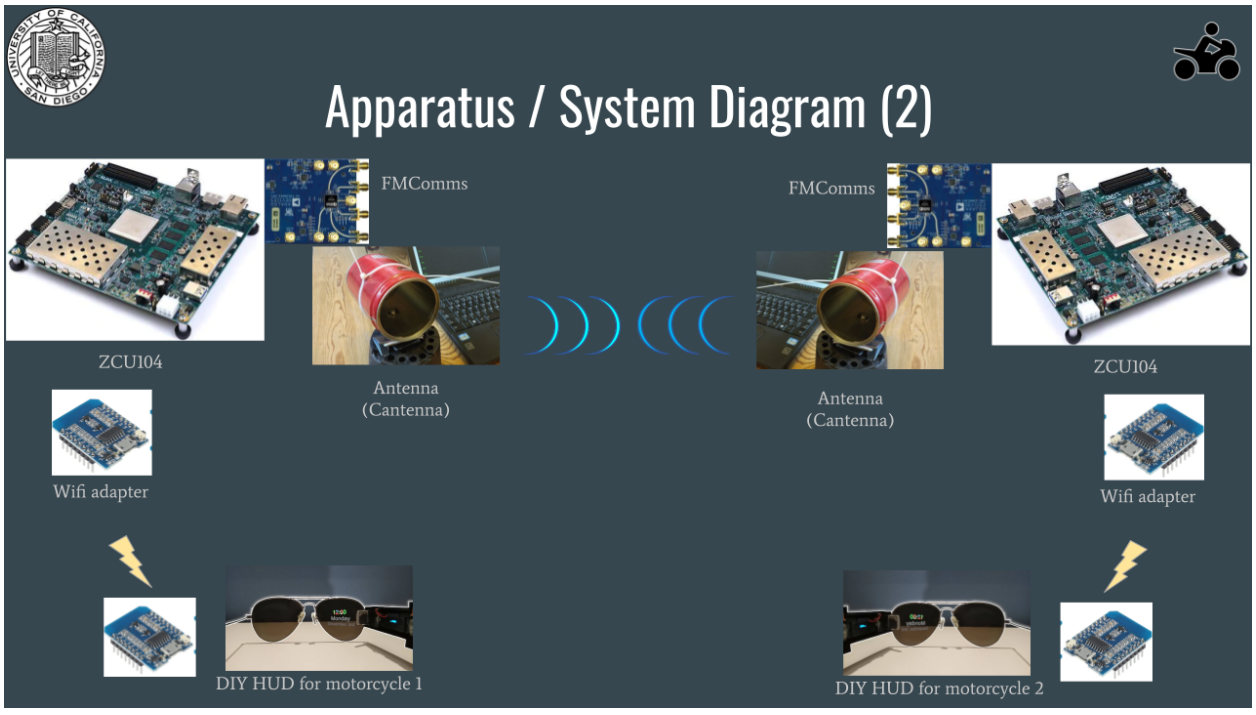
Abstract:
Our team seeks to create a V2X (vehicle-to-everything) system using two motorcycles, in which each vehicle shares its driving status with the other. Each driver shall see this shared information through their worn HUD.This information includes the other vehicle's name, navigation directions, speed, and geographic location.

The scenario above shows two riders communicating information with each other. Both riders will mount a transceiver (XCVR), and they will communicate using a TDMA protocol. In order to sync the devices and assign time slots, the Riders will need to synchronize their clocks at the start of operations. Distance calculations will be determined using the time delay between a message being transmitted and received. Each transceiver is responsible for capturing and

recording both its local status information and the received status information. This information will be displayed on each Rider's HUD.

Project Statement:
Our project will require 3 essential systems to be designed: software on the microprocessor board(s), hardware for the HUD(s), and hardware for the transceivers (XCVR):

System	Responsibilities
Software (Microprocessor)	• Track local status • Track received status • Display HUD info • Prepare transmit data • Decode received data
Hardware (HUD)	• Display data in a digestible format • Display info without hindering view •
Hardware (XCVR)	• Determine distance between systems • Process transmit data and receive data



Design Goals	Description
Objectives	• Be effective in the presence of noise • Be robust and work when data is never received or lost

	● Be designed with simulation, testing, and prototyping in mind
Constraints	● Max HUD refresh rate: 2Hz ● Max detection distance: 0.25mi (0.4km) ● Max vehicle speed: 125MPH (200km/h) ● Min navigation distance resolution: 0.5mi

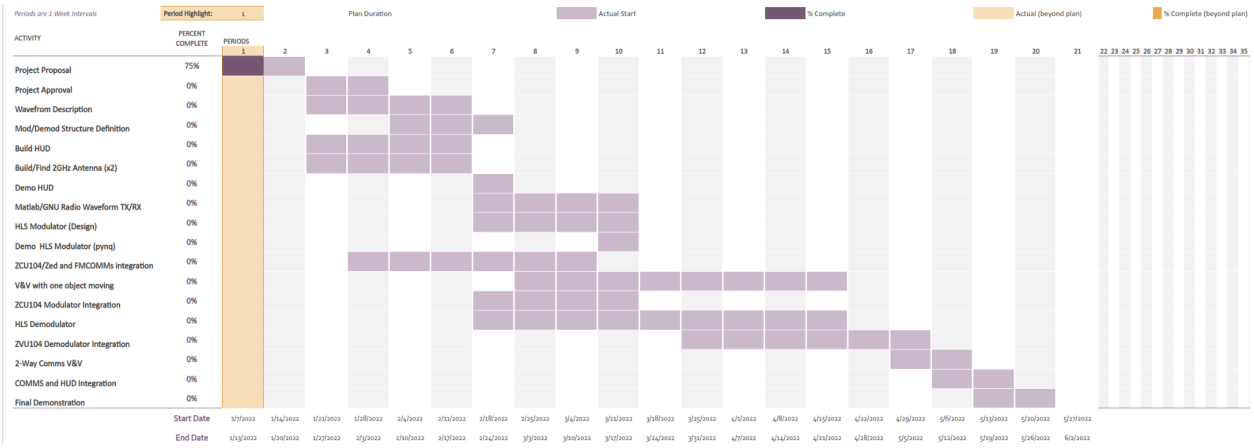
Waveform Description	**Description**
Data Packet	Data: 144 bits ● Identifier (name): 32 bits (4 ASCII Characters) ● Position (lat/long): 64 bits (float, float) ● Speed (mph): 8 bits (255 max) mph ● Navigation: ○ Directions: 8 bits (left, right, straight, u-turn, arrived) ○ Distance to next step: 32 bits (float)
Encoding	Viterbi
Modulation	QPSK
Synchronization	● Preamble (Barker or MLS) ● PLL
Frequency Details	● Carrier: 2.4GHz (WiFi band) ● Data rate: TBD ● Narrow band

Schedule:

Milestones:

Milestones	**Description**
Winter Quarter	● Fully running TX and RX on 2 PlutoSDRs ● Running HUD Prototype with dummy data
Spring Quarter	● Functioning distance detection with XCVRs ● Real world simulation and testing performed on system ● Real time HUD updates with accurate status

Gantt chart:



Bill of Materials:

Hardware:

Item	Qty	Price	Notes
ZCU104/ZedBoard	2	$0	Borrow
FMComms Board	2	$0	Borrow
PlutoSDR	2	$0	Borrow
HUD	2	$0	DIY: https://www.instructables.com/DIY-Smart-Glasses-ArduinoESP/
OLED	1	$0	Already Have (x3)
Battery (LIPO)	1	$0	Already Have (x3)
Batter Charger	1	$20-30	Need to identify (based on battery)
Google Cardboard	1	$0	Already Have (x3)
Wifi/Microprocessor	1	$0	Already Have (x5)
2GHz Antenna	1	$0-100	Find/build: https://www.askaprepper.com/make-tin-can-wifi-antenna-extend-communication-emp/
GPS Unit	2	$?	Need to Identify (or will use a preloaded LUT to simulate)

Software:

- Matlab
- GNU Radio
- Xilinx Vivado and Vitis
- Python/C/C++

Antenna:

The antenna costs can be reduced by fabricating a custom antenna from a can. This is referred to as a cantenna. The antenna frequency is dependent on the area of the opening. The cantenna will act as a horn antenna and will provide better gain than an omnidirectional antenna.

The gain (G) of the antenna is related to the Area of the opening of the can.

$$A_e = \frac{\lambda^2}{4\pi} G$$

Where $\lambda = C/f$ and G is the desired gain. The height of the can is dependent on the desired frequency f. We intend to aim for $f = 2GHz$ so we need approximately 15mm (minimum) of

height for a quarter wavelength. In order to get the correct impedance we have two options. The connector can be inserted along the side of the can and the placement will affect the impedance. Another approach if we have difficulties getting the correct impedance is to use foil inside the can and attach the connector to the bottom. The foil would then be shaped such as to funnel the opening down to the connector. This part of the antenna design will require measurement and testing.

Verification and Test:
The final demonstration will be simplified to avoid any safety issues with using motorcycles. This test has Rider 2 held stationary, while the Rider 1 will move at a rate capable by a scooter or cart. This setup also allows for simpler and cheaper methods of powering the devices.

In this test, Rider 2 sends data packets to Rider 1 and is simultaneously estimating Rider 1's distance and speed. Rider 1 will receive the message and then proceed to send a return data packet. The results of this test will be saved to a data file for post-experiment verification and is displayed on the HUD devices.

References and Links:
- Github page: https://github.com/jtn017/capstone