Midterm Report

Team No. 2

Vehicle-to-Vehicle Communications

Members:

Dominic Eaton - *dominic1.eaton*

Robert Etumnu - *roberts1.etumnu*

Kimberly Leandre - *kl12f*

Diandra Prioleau - *diandra1.prioleau*

Faculty Advisor

Dr. Bruce Harvey

Sponsor

Ford Motor Company

Instructor

Dr. Jerris Hooker

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1 Project Overview

1.A Problem | Needs Statement

Vehicle collisions are of main concern to the global society. Approximately 1.3 million people die due to road crashes with an average of 3,287 deaths each day [2]. It is predicted that by 2030 that road traffic crashes will be the fifth leading cause of death [2]. Protecting the livelihood of the individuals in a vehicle has become of high importance to many automotive companies, which has lead to the development of vehicle-to-vehicle communication. The purpose of this project is design an efficient system to alert motorists of possible collision situations. A module will be developed that can be installed in a vehicle where it will be used to collect position and velocity data. The module will share this information with other nearby vehicles and a series of alerts will be generated that will warn the driver of any potential collisions. This project is partnered with the School of Business and Industry at Florida A&M University, who has a team working parallel with the engineering team. Currently, the business team is gathering information to develop customer use cases. This information will be utilized to define technical requirements and specifications for which the engineering team will need to satisfy. This report will highlight the research and steps that have been conducted towards this project: design and analysis, scheduling and resource allocation, and results.

1.B Previous Research

1.B.1 Introduction

Research was conducted by the Department of Transportation in the area of vehicle-to-vehicle communication under the Connected Vehicle Safety Pilot Program [1]. The program demonstrated the effectiveness of the safety applications and devices to reduce vehicle collisions and how motorists respond to these applications within their vehicles. The pilot also tested whether having these devices within vehicles distracted motorists from effectively operating the vehicle or cause unintended consequences. The model deployment was tested in a controlled

environment and on actual highways with other vehicles that do not have these devices integrated into their vehicles.

1.B.2 Research Goals

The following were the goals of the pilot program:

- Support the NHTSA agency decision by obtaining empirical data on user acceptance and system effectiveness;
- Demonstrate real-world connected vehicle applications in a data-rich environment;
- Establish a real-world operating environment for additional safety, mobility, and environmental applications development;
- Archive data for additional research purposes; and
- Identify prototype system characteristics that can be improved or that need to be corrected.

1.B.3 Results

After extensive research and testing, the pilot program proved that vehicle crashes can be lessened and prevented using vehicle-to-vehicle communication. The devices installed into the vehicles were able to transmit and receive messages between one another.

1.B.4 Challenges

While the pilot program was very successful, there are still areas of improvement that are necessary to have a completely effective V2V system. For research purposes, V2V communications transmitted and received messages at a bandwidth of 5.8 to 5.9 GHz frequency; however, as Wi-Fi continues to rapidly increase, the bandwidth will need to be widened, which cause interference from various devices operating on the same frequency. In addition, it is important that the V2V system has a security and communications infrastructure in place to ensure that messages are trustworthy and protected from outside interference. Users must be

ensured that any personal information identifying them or the vehicle will be collected in exchange of messages.

1.C Project Objectives & Goals

The goal of this project is to develop a prototype retrofit system that will be able to collect pertinent data from a vehicle and relay that information to other vehicles outfitted with a similar system to ultimately prevent vehicle collisions. The project will adhere to established Systems Analysis and Design Methodologies and Systems Engineering process discipline. The objectives are as follows:

- System should be able to actively learn and understand its surroundings.
- System should be able to communicate directly with other vehicles to avoid collisions.
- System should be able to recognize nearby vehicle location, in effort to prevent collisions via blindspots.
- System should be designed for voice communication with the user (audible commands from user, audio responses from system).
- System should relay speed and distance information from other vehicles to the operating vehicle and driver.
- System will make use of GPS and other mapping software to collect and maintain location-awareness.
- System will be established for retrofitting to older vehicles via central console.
- System should be easily installable.

1.D Project Constraints

Due to time constraint, the scope of this project will be limited to light vehicles. In addition, the bandwidth for transmitting and receiving messages will be at a frequency of 5.8 to 5.9 GHz, to limit interference as much as possible from other devices. The scope of this project will also be limited to mostly simulation testing.

2 Project Deliverables

Outlined below are the required tasks to be completed for the V2V communications project. Figure (1) gives a generalized overview of the project is structured and the relationship between tasks. Table (I) gives a more detailed analysis of the chart from figure (1) and further explains each tasks, which team member is responsible for the tasks completion and a rough time frame to complete these tasks. Finally, figure (2) shows the Gantt chart which delineates a more solidified timing structure, in graphical form, for necessary tasks to needed to be completed for the project.

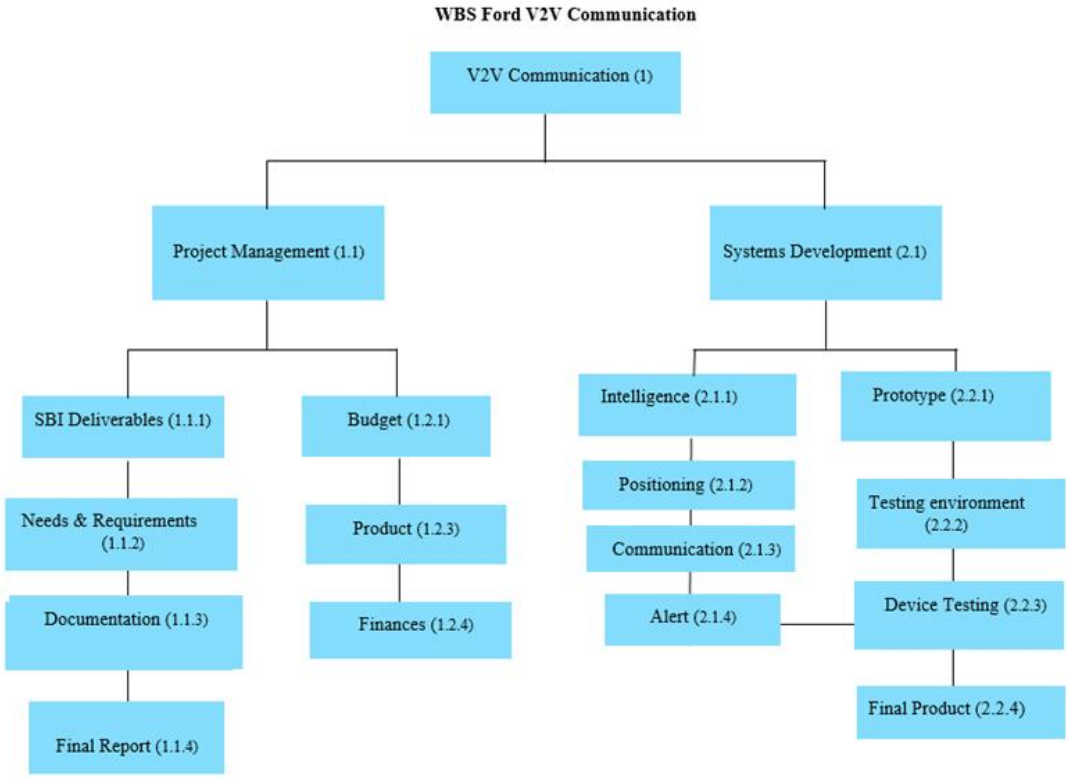

***Figure (1)*:** V2V Project work breakdown structure with corresponding table reference values

Table I: V2V Communication Project in-depth work structure Analysis with Task Assignments

ID	Activity	Description	Deliverables/ Checkpoints	Duration(Days)	Assigned Persons	Resources
1	**Project Management**	Methodology		200	Kim	
1.1.1	SBI Deliverables	School of business requirements		Completed	N/A	
1.1.2	Needs & Requirements	Components needed	-Receive Deliverables	Completed	All	
1.1.3	Documentation	Documents		15	All	
1.1.4	Final Report	Summary of documentation		90	All	
1.2	Budget	Allocation of funds	-Amount of funds	N/A	Diandra	
1.2.1	Product	Devices required	- devices for the system	50	All	
1.2.2	Finance	Spending of funds for the devices	-Device needed -Order device - Acquire device	N/A	Diandra	
2	**Systems Development**	Systems required for product to function		100	All	
2.1	Intelligence	Brains of the system	- Algorithms	100	Dominic	Arduino
2.1.1	Positioning	Navigation system, INS, velocity, and position	- Data for velocity, speed, acceleration, direction	100	Robert	Devices - GNSS, INS, GPS

2.1.2	Communication	Communication between vehicles	-Transmits and receives message within a specified range	100	Diandra	ARADA DSRC
2.1.3	Alert	Warns driver of eminent collision	Audio device, LED	100	Kim	LED Arduino USB-SD MP3 shield Battery
2.2	Prototype	Initial product		150	All	
2.2.1	Testing environment	Area designated for testing device		N/A	Robert	Roadway
2.2.2	Device testing	Final testing of device	All systems (see 2).	200+	All	Car, simulated software
2.2.3	Final Product	Functioning System	All systems (see 2).	200+	All	All systems (see 2).

The Gantt chart below gives a preliminary timeline for which the pertinent tasks of the overall project are to be completed. This Gantt chart ranges over the estimated lifetime of project, all the way until the final project presentation.

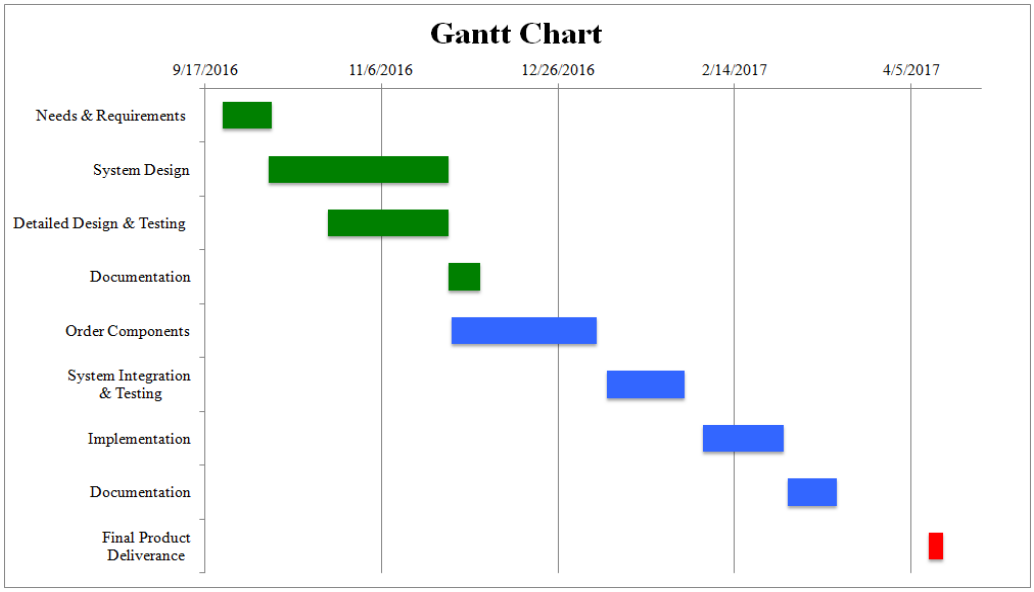

***Figure (2)*:** Gantt chart of the V2V Project outlining the work timeline for completing various project tasks.

2-A Assignment of Resources

Team Member 1: Kimberly Leandre – Team Leader

· Responsible for developing the best alert system that effectively warns the driver without deviating their focus from the road.

Team Member 2: Diandra Prioleau – Financial Advisor

- Responsible for communication system.
- Communication should not suffer from interference.
- Must be viable in harsh conditions.

Team Member 3: Roberts Etumnu – ECE Lead

- Responsible for researching and obtaining the best Positioning and data control system
- Must be capable of GPS/INS and possible GNSS.
- Must track velocity and position.
- Must find usable solution for obtaining necessary input data to be utilized by the overall system

Team Member 4: Dominic Eaton – ECE Lead

- Responsible for Intelligence system.
- Algorithm for collision response.

3 Product Specifications

3.A Design specifications

Specification of features of the system of the project are presented below as well as proposed preliminary expectations of the performance capabilities of the V2V device and overall system.

Device Requirements:

- Total capacity of the V2V device to be contained within a rectangular prism of 6.5 x 6.5 x 6.5 [in]
- Total power needed for the V2V device is specified as such as to not overload or overheat the vehicle, but still allows the device to perform at optimal levels
- Device is able to draw its power from its host vehicular environment and utilize resources only from this environment

Overall System Requirements:

- Each module within the system is able to communication via a communication bus for which the V2V device is the centralized intelligence coordinator of these modules and entire system

3.B Performance Specifications

Expectations of performance in the field or when used by consumer including: instrumentations output requirements (operation range, accuracy, resolution), display features, detection capability, energy efficiency, and data transmission.

Overall System specifications:

- Able to perform normal operations at a specified temperature value

- Able to perform normal operations in specified environmental conditions

V2V Device specifications:

- Able to operate at a specified DC voltage value

Data transmission specifications:

- Able to transmit BSM signals to other devices within a 10 [m] radius
- Able to detect possible collision situation within a given distance of meters
- Able to send messages within a given time range

4 Conceptual Design

Two conceptual system prototypes have been developed in order to provide a solution to the presented problem of the V2V communications project. The two design options are presented below.

4.A Proposed Designs

CONCEPTUAL DESIGN I

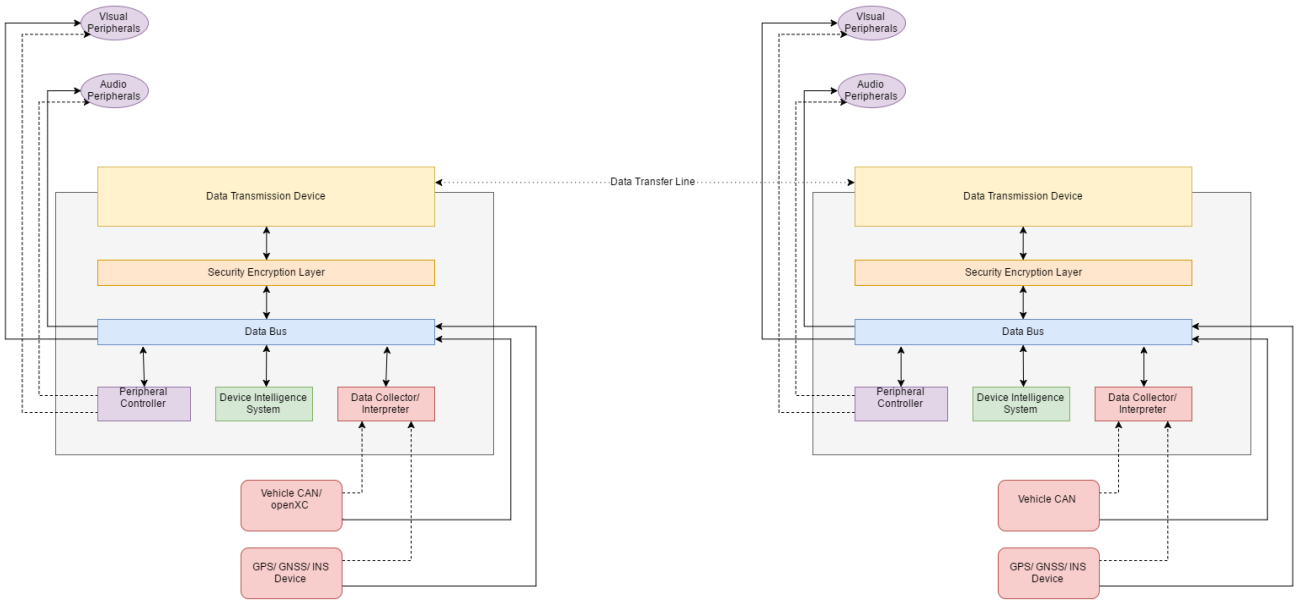

Figure (3): Device outline with principal components outlined and data transmission connection between devices shown.

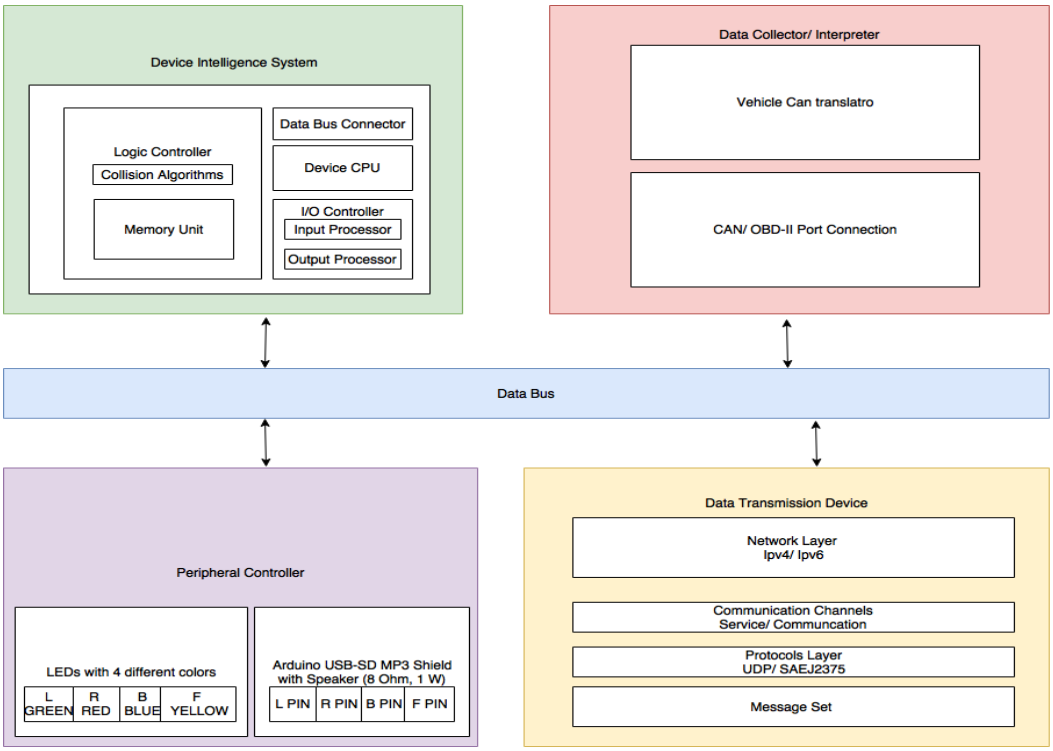

Figure (4): Systems Break down by components

As seen in Figure (3), a prototype device has been conceptualized and consists of several layers. On the most transparent layer affixed to the device, a communication system exists which will have the ability to transmit and receive BSM signals. Deep to the communication system exists a proposed security layer which may perform data encryption services to incoming and outgoing data to the internal components of the device and the communication system. Central to the entire system lies the intelligence system of the project. This system has the task of providing all necessary logic functions and necessary calculations of data passing throughout the system. The collision avoidance algorithm will also be implemented here. External to the V2V device exists an input and output system. The input system will consist of a data information gatherer of the

host vehicle, and the output system will be the alert system which shall serve as a warning to possible collision situations.

CONCEPTUAL DESIGN II

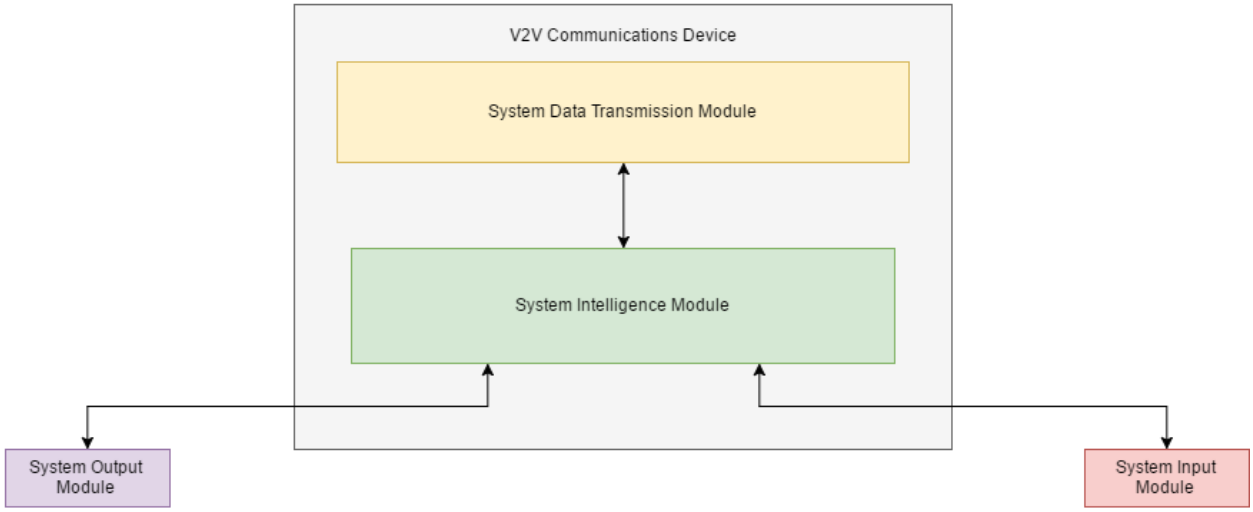

Figure (5): Systems Break down by components

This design is similar to that of conceptual design I. The main difference between this design and its predecessor is that intelligence system is proposed to be housed within the same enclosure as the communication system, rather than having two different devices handling these two systems. Though this will shrink the overall size and possibly simplify the programming of the entire system, the hardware aspect of combining these two systems may prove to be the greatest challenge this design faces.

4.B Proposed Devices

By system, the proposed devices are the following:

Table II: Proposed devices to be utilized by each system in the project

	Communication	**Intelligence**	**Alert**		**Data Management**
Device Name	LocoMate classic OBU	Arduino Mega	Arduino Uno with USB-SD MP3 Shield	Multicolored LEDs	OpenXC
Company	Arada Technologies	Arduino Company	Arduino Company	General Electronics Company	Ford Motor Company
Capabilities	Supports DSRC technology	Ability to be programmed to perform a set task.	ability to provide a sound interface	Able to display colors based upon given input signal	Able to interpret data via the OBD-II Port
	Consists of radio antennas which allow for the transmission and receiving of BSM signals to and from device to other devices	Able to perform necessary logic functions and calculations.			Interpreted data comes from the CAN bus of the host vehicle, which is where information about the vehicle is passed.
	Supports ASN library, which will be used to create BSM message sets.	Has self-contained memory cells for data storage.			

5 Conclusion

The plethora of injuries and fatalities due to collisions necessitates the need for a device which has the ability to increase drive range of visibility and alertness of motorists on the road. The Ford Vehicle to Vehicle Communication System Senior Design Team is responsible for developing an electronic device that allows a vehicle to transfer information about its location speed, direction etc.. in order to warn drive of possible collisions. The project has four main components: Communication, Data Collection, Intelligence and Alert System. The Communication System, lead by Diandra Prioleau, will consist of a low latency network with wireless capabilities. The Data Collection System, lead by Robert Etumnu, will include a Global Positioning System (GPS) and Inertial Navigation System (INS). The Alert System lead by Kimberly Leandre will retrieve information about possible collisions and alert the driver via sound and LEDs. The final system, Lead by Dominic Eaton, includes the Intelligence System and will require a microcontroller and an algorithm that handles the various possible situations that may result in a vehicle-to-vehicle collision. The controller will collect the data provided by the Data Collection and Communication System to make proper calculation based on the algorithm. The goal of this project is to maintain reliable communication between vehicles, provide accurate vehicular data, calculate condition for possible collusion, and alert the driver early enough in order to produce an effective reactive response.

7 References

[1] Harding, J., Powell, G., R., Yoon, R., Fikentscher, J., Doyle, C., Sade, D., Lukuc, M., Simons, J., & Wang, J. (2014, August). *Vehicle-to-vehicle communications: Readiness of V2V technology for application.* (Report No. DOT HS 812 014). Washington, DC: National Highway Traffic Safety Administration.

[2] Association of Safe International Road Travel. (2016, August 1). *Annual Global Road Crash Statistics.* Available:https://asirt.org/initiatives/informing-road-users/road-safety-facts/road-crash-statistics

Appendix A

Acronyms and Terms

BSM - Basic safety message

OBD - On board diagnostic (system)

GPS - Global positioning system

GNSS - global navigation satellite system

INS - inertial positioning system

UDP - user datagram protocol

TCP - transmission control protocol

DSRC - distance and short range communication

OBU - On board Unit

RF - Radio Frequency

ASN - abstract syntax notation

Arduino Shield - Installable hardware available for arduino devices which provides enhancements to the base arduino device.

SAE J2735 - SAE standard which specifies the nature of the message sets to be used within the V2V communications project.