



# Vehicle Intersection Control

McMASTER UNIVERSITY

Hazard Analysis

SE 4G06

GROUP 6

Alex Jackson	-	1302526
Jean Lucas Ferreira	-	1152120
Justin Kapinski	-	1305257
Mathew Hober	-	1228607
Radhika Sharma	-	1150430
Zachary Bazen	-	1200979

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## 1 Revisions

Table 1: VIC Table of Revisions

Date	Revision Number	Authors	Comments
March 11, 2017	Revision 1	Zachary Bazen	<ul style="list-style-type: none"><li>- Included acronym, assumptions and safety consideration section</li><li>- Updated component descriptions</li><li>- Updated/improved information in FMEA worksheet</li><li>- Added additional details to FMEA worksheet</li></ul>
January 9, 2017	Revision 0	Alex Jackson Jean Lucas Ferreira Justin Kapinski Mathew Hober Radhika Sharma Zachary Bazen	N/A

## 2 Introduction

When multiple autonomous cars arrive at an intersection simultaneously, due to the lack of a decision making protocol, the cars have no way of determining in which order to proceed. The purpose of this project will be create a system that allows autonomous cars to navigate through intersections. This will be accomplished by providing an appropriate order for the vehicles to proceed through the intersection.

Vehicle Intersection Control will allow autonomous vehicles to make navigation decisions at intersections. In addition, VIC will be able to dynamically handle changing scenarios at an intersection without running into deadlock or stalemate situations. To ensure safety, VIC will allow cars to navigate through the intersection only after the scheduling algorithm determines the order in which they should proceed.

The following document will outline the hazards that VIC poses to humans, as well hazards to the system. Causes and effect of failures, as well as detection, control and recommended action for failures will also be discussed.

## 3 Acronyms

Table 2: Acronym Definitions and Descriptions

Acronym	Definition	Description
VIC	Vehicle Intersection Control	The name given to the intersection management system
MARC	McMaster Automotive Resource Center	Location of the laboratory used for the project

## 4 Assumptions

<b>HA1</b>	The risks outlined in the document are poised only to the project stakeholders
<b>Rationale</b>	The project is operating in a restricted access laboratory where only stakeholders are able to gain access

<b>HA2</b>	VIC group members are aware of the risks associated with the VIC system
<b>Rationale</b>	Ensures the safety of the group members when operating and developing the VIC system

<b>HA3</b>	The risks to humans are low
<b>Rationale</b>	The VIC system equipment is small and doesn't contain moving parts that could cause significant damage to a human

## 5 Component Descriptions

The components can be divided into three parts: vehicle components, intersection components and communication. The communication component provides means of transferring information between the vehicle components and the intersection components.

### 5.1 Vehicle Components

#### 5.1.1 Image Processing

This component allows the vehicle to follow lanes and detect obstacles. It makes use of a WebCam, Raspberry Pi, and algorithms to allow the vehicle to interpret the track environment.

### 5.1.2 Steering Controller

The steering controller works with the image processing component to steer the vehicle. Further more, the steering controller must make adjustments to ensure the vehicle stays within the track lanes.

### 5.1.3 Speed Controller

The speed controller uses a hall effect sensor to determine the speed of the car. This controller will make adjustments to the vehicle's speed according to the track environment.

## 5.2 Intersection Controller

The intersection camera provides feedback to the intersection controller about approaching vehicles, obstacles in the intersection and departing vehicles. The camera is placed above the intersection and will allow the intersection controller to determine when it is safe for vehicles to proceed through the intersection.

## 5.3 Communication

The communication component uses Bluetooth communication to facilitate interaction between the vehicle and intersection controller. Vehicles send a request to the intersection controller to proceed through the intersection. When it is safe to proceed the intersection sends back a proceed command. In addition to the proceed command the intersection controller also sends out an emergency stop signal when needed.

# 6 Safety Considerations

The safety of group and their respective within the MARC laboratory is paramount. Special consideration was taken to determine the risk and failure modes that would impact the those operating within the MARC laboratory. Risks beyond the MARC laboratory are considered outside the scope of the project. Members of the team agree to the hazards associated with the development and operation of the VIC system. Listed bellow are the hazards of the VIC system.

## 6.1 Moving Parts Hazard

### Problem

- Loose/long hair could be caught in moving parts during testing causing a pinching or tearing injury
- Loose clothing could be caught in moving parts during testing

### Solution

- Enclose moving parts where possible

## 6.2 Collision Hazard

### Problem

- Vehicle may leave track and collide with individuals
- Vehicle may leave track and collide with over vehicles

### Solution

- Ensure individuals stay a safe distance from operating vehicles
- Notify individuals when vehicle operation is about to get underway
- Include object detection to prevent collisions

### 6.3 Burn Hazard

**Problem**

- Vehicle speed controller becomes hot during operation

**Solution**

- Ensure individuals are aware of what the speed controller looks like to prevent accidental contact

## 7 FMEA Worksheet

Design Component	Failure Modes	Causes of Failure	Effects of Failure	Detection	Controls	Recommended Action
Intersection Camera	Failure to detect vehicles	<ul style="list-style-type: none"> <li>- Damaged/ disconnected webcam</li> <li>- Error in software processing image</li> <li>- Images contain too much noise</li> </ul>	<ul style="list-style-type: none"> <li>- Vehicle stalled at intersection</li> <li>- System deadlock if intersection controller does not detect vehicle leaving</li> <li>- Vehicle collision</li> </ul>	<ul style="list-style-type: none"> <li>- Visual inspection of webcam</li> <li>- Vehicles waiting longer than requirement targets</li> </ul>	<ul style="list-style-type: none"> <li>- Bluetooth communication between vehicle and IC</li> </ul>	<ul style="list-style-type: none"> <li>- Reconfigure/Replace camera</li> </ul>
Communication	Failure to transmit signal	<ul style="list-style-type: none"> <li>- Software controlling bluetooth transmitter incorrect</li> <li>- Damaged transmitter or receiver</li> <li>- Loss of power</li> </ul>	<ul style="list-style-type: none"> <li>- Vehicle waits too long at intersection</li> <li>- Vehicle goes through intersection at the wrong time</li> </ul>	<ul style="list-style-type: none"> <li>- Intersection camera will detect car at intersection</li> </ul>		<ul style="list-style-type: none"> <li>- Refresh/Restart communication software</li> <li>- Vehicle shut down and repair/replace device</li> </ul>
	Failure to maintain signal	<ul style="list-style-type: none"> <li>- Low signal due to reduced battery power</li> <li>- Car distance out of range</li> <li>- Loss of power</li> </ul>	<ul style="list-style-type: none"> <li>- Vehicle waits too long at intersection</li> <li>- Vehicle goes through intersection at the wrong time</li> </ul>	<ul style="list-style-type: none"> <li>- Intersection Sensors will detect car at intersection</li> </ul>		<ul style="list-style-type: none"> <li>- Refresh/Reconnect</li> <li>- Vehicle Shut down and repair/replace device</li> </ul>
Image Processing	Incorrect Obstacle Detection	<ul style="list-style-type: none"> <li>- Webcam physically damage</li> <li>- Error in software processing image</li> <li>- Slow feedback due to processing time targets being missed</li> <li>- Low power or loss of power</li> <li>- Images contain too much noise</li> </ul>	<ul style="list-style-type: none"> <li>- Collision with humans resulting in injury</li> <li>- Collision with cars and other objects resulting in property damage</li> </ul>	<ul style="list-style-type: none"> <li>- Visual inspection of webcam</li> <li>- Low battery alert</li> </ul>	<ul style="list-style-type: none"> <li>- Image processing algorithm must respond within a required time</li> <li>- Ensure track is clear and no undesired objects are present</li> </ul>	<ul style="list-style-type: none"> <li>- If too many consecutive deadlines are missed, controller will adjust speed</li> <li>- If RaspberryPi battery dies alert the car controller to go in emergency shutdown mode</li> </ul>
	Incorrect Lane Following	<ul style="list-style-type: none"> <li>- Webcam physically damage</li> <li>- Images contain too much noise</li> <li>- Slow feedback due to processing time targets being missed</li> <li>- Dead battery degrades RaspberryPi performance</li> </ul>	<ul style="list-style-type: none"> <li>- Collision with humans resulting in injury</li> <li>- Collision with cars and other objects resulting in property damage</li> <li>- Vehicle exits intended lane</li> <li>- Image processing degrades or fails to operate</li> </ul>	<ul style="list-style-type: none"> <li>- Visual inspection of webcam</li> <li>- Low battery alert</li> </ul>	<ul style="list-style-type: none"> <li>- Image processing algorithm must respond within a required time</li> <li>- Ensure track and surrounding area is clear and no undesired objects are present</li> </ul>	<ul style="list-style-type: none"> <li>- If too many consecutive deadlines are missed, controller will adjust speed</li> <li>- If RaspberryPi battery becomes low alert the car controller to go in emergency shutdown mode</li> </ul>

Speed Controller	Incorrect Speed	<ul style="list-style-type: none"> <li>- Overheated speed controller degrades performance</li> <li>- Incorrect speed calculation</li> <li>- Hall Effect sensor not working/inaccurate</li> <li>- Motor failure</li> <li>- Disconnect wires</li> <li>- Low power or loss of power</li> </ul>	<ul style="list-style-type: none"> <li>- Failure to stop at intersection</li> <li>- Overshooting lanes when turning</li> <li>- Vehicle instability</li> <li>- Collision with vehicle or cars</li> </ul>	<ul style="list-style-type: none"> <li>- Hall Effect sensor</li> <li>- Visual check</li> </ul>	<ul style="list-style-type: none"> <li>- Feedback loop between speed sensor and speed controller</li> </ul>	<ul style="list-style-type: none"> <li>- Speed corrected with software</li> <li>- Vehicle shutdown</li> <li>- Recalibrate/Repair/Replace Speed sensors and/or speed controller</li> </ul>
Steering Controller	Incorrect Steering	<ul style="list-style-type: none"> <li>- Error is software processing speed</li> <li>- Damaged servo operates in unintended fashion</li> <li>- Disconnected Wires</li> <li>- Loose steering assembly</li> <li>- Low power or loss of power</li> </ul>	<ul style="list-style-type: none"> <li>- Collision with humans resulting in injury</li> <li>- Collision with cars and other objects resulting in property damage</li> <li>- Vehicle Exits Track</li> <li>- Vehicle fails to make turn</li> </ul>	<ul style="list-style-type: none"> <li>- Visual inspection of vehicle</li> </ul>	<ul style="list-style-type: none"> <li>- Software processing track images</li> </ul>	<ul style="list-style-type: none"> <li>- Direction corrected with software</li> <li>- Shutdown vehicle if servo performance degrades</li> <li>- Recalibrate/Repair/Replace Servo</li> </ul>