



# Vehicle Intersection Control

McMASTER UNIVERSITY

Draft System Requirements

SE 4G06

GROUP 6

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## 1 Revisions

| Date              | Revision Number | Authors   | Comments  |
|-------------------|-----------------|---|---|
| November 29,2016  | Revision 1      | Zachary Bazen   | <ul style="list-style-type: none"><li>- Updated monitored and controlled variables</li><li>- Updated naming conventions</li></ul> |
| November 14, 2016 | Revision 0      | Alex Jackson<br>Jean Lucas Ferreira<br>Justin Kapinski<br>Mathew Hober<br>Radhika Sharma<br>Zachary Bazen | N/A   |
| March 3, 2017     | Revision 1      | Alex Jackson<br>Jean Lucas Ferreira<br>Justin Kapinski<br>Mathew Hober<br>Radhika Sharma<br>Zachary Bazen | Update to system requirements   |

Table 1: VIC Table of Revisions

## 2 Project Drivers

### 2.1 The Purpose of the Project

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 (also known as VIC) 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 functional and nonfunctional requirements of VIC. Other topics that will be covered pertaining to VIC will include: Scope, Project Drivers, Project Constraints, and Project Issues.

### 2.2 The Client, the Customer, and Other Stakeholders

#### 2.2.1 Client and Customer

The client for this project is Shaun Marshall who is the engineering group manager at General Motors.

#### 2.2.2 Stakeholders

The stakeholders consists of:

- The developers and system designers of VIC
- Dr. Alan Wassyng, the project supervisor
- The teaching assistants of the course

### 2.3 Users of the Product

This product is expected to be used by researchers in the field of autonomous vehicles. VIC will act as a prototype to solve the problem of intersection control for autonomous vehicles. It is expected that VIC will be used to create a larger program that will accomplish what VIC does, as well as accounting for a real world environment. VIC is not expected to be used by autonomous cars in a real world environment.

## 3 Project Constraints

### 3.1 Mandated Constraints

Vehicle intersection control has several mandated constraints tabled below.

|             |   |
|-------------|---|
| <b>MC1</b>  | <b>Remote control cars must be 1/10 scale</b>                                   |
| <b>RMC1</b> | The remote control cars must be large enough to mount all the required hardware |

|             |   |
|-------------|---|
| <b>MC2</b>  | <b>Remote control cars must be electric</b>   |
| <b>RMC2</b> | Cars will be operated indoors, gasoline powered remote control cars are a safety hazard indoors |

|             |  |
|-------------|--|
| <b>MC3</b>  | <b>The cost of the project must not exceed \$700 dollars</b>   |
| <b>RMC3</b> | This is to ensure an off-the-shelf solution can not be purchased. It also ensures the project remains economically feasible. |

## 3.2 Naming Conventions and Definitions

### 3.2.1 Naming Conventions

|                          |   |
|--------------------------|---|
| <b>T#</b>                | Track requirement identification and number                         |
| <b>V#</b>                | Remote control vehicle requirement identification and number        |
| <b>IC#</b>               | Intersection control requirement identification and number          |
| <b>MC#</b>               | Mandated project constraints identification and number              |
| <b>RMC#</b>              | Rational for mandated project constraints identification and number |
| <b>A#</b>                | Project assumptions identification and number                       |
| <b>RA#</b>               | Rational for project assumptions identification and number          |
| <b>VIC</b>               | Vehicle intersection control  |
| <b>m_ic_variableName</b> | Monitored variable for intersection controller                      |
| <b>c_ic_variableName</b> | Control variable for intersection controller                        |
| <b>m_vc_variableName</b> | Monitored variable for autonomous vehicle controller                |
| <b>c_vc_variableName</b> | Control variable for autonomous vehicle controller                  |

### 3.2.2 Definitions

1. **VIC** - The name given to the overall intersection control system

## 3.3 Relevant Facts and Assumptions

### 3.3.1 Relevant Facts

- N/A

### 3.3.2 Assumptions

VIC assumptions tabled below.

|            |  |
|------------|--|
| <b>A1</b>  | <b>Ideal driving conditions on the track</b> |
| <b>RA1</b> | Track is situated indoors                    |

|            |  |
|------------|--|
| <b>A2</b>  | <b>Intersection is a four way stop</b>                                   |
| <b>RA2</b> | Different intersection arrangements are beyond the scope of this project |

|            |   |
|------------|---|
| <b>A3</b>  | <b>Only autonomous car will be present on the track</b> |
| <b>RA3</b> | This will help simplify the scope of the project        |

|            |  |
|------------|--|
| <b>A4</b>  | <b>Cars will not have a large variance in size</b>   |
| <b>RA4</b> | The 1/10th model cars will only consists of sedan or coupe styled cars. We will not consider large vehicles such as trucks or buses. |

## 4 Context Diagrams

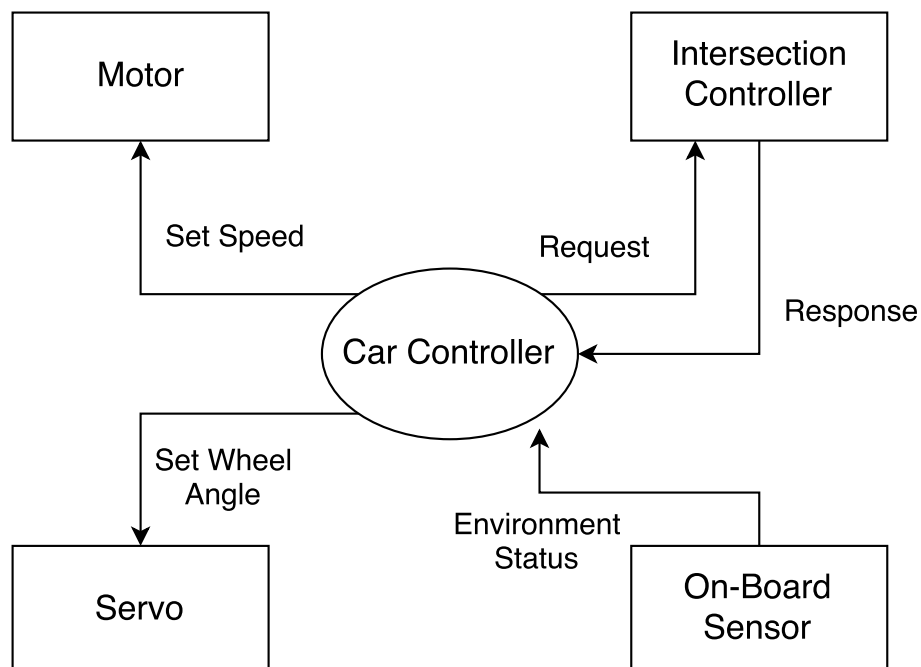


Figure 1: Car Controller Context Diagram

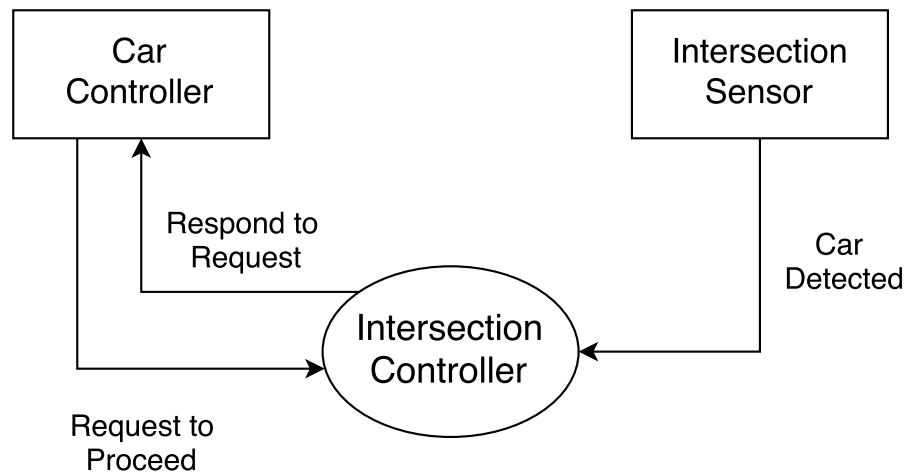


Figure 2: Intersection Controller Context Diagram

## 5 Constants

- TBD

## 6 Monitored and Controlled Variables

### 6.1 Monitored Variables

#### 6.1.1 Intersection Controller

m\_ic\_readSensor[8]

m\_ic\_carSignal[4]

#### 6.1.2 Autonomous Vehicle Controller

m\_vc\_videoCapture[x][y]

m\_vc\_frontDistance

m\_vc\_speedSignal

m\_vc\_hallEffect

m\_vc\_vehicleOrientation

### 6.2 Controlled Variables

#### 6.2.1 Intersection Controller

c\_ic\_carProceedSignal



## 6.2.2 Autonomous Vehicle Controller

|                   |
|-------------------|
| c_vc_wheelAngle   |
| c_vc_carSpeed     |
| c_vc_vehicleBreak |
| c_vc_requestTheIC |

## 7 Functional Requirements

The requirements for this project are separated into the three main components of the system: the track, vehicle, and intersection controller.

### 7.1 Track Functional Requirements

- T1:** The track must have lanes
- T2:** The track must have an intersection
- T3:** The track must have an object to indicate stopping at an intersection

### 7.2 Vehicle Functional Requirements

- V1:** The vehicle must be able to send and receive signals to and from the system infrastructure
- V2:** The vehicle must be able to detect lanes and follow them
- V3:** The vehicle must be able to detect intersections
- V4:** The vehicle must be able to stop at intersections
- V5:** The vehicle must be able to navigate through intersections
- V6:** The vehicle must be able to avoid obstacles
- V7:** The vehicle must follow the laws of the Highway Traffic act

### 7.3 Intersection Controller Functional Requirements

- IC1:** The system infrastructure must be able to detect if there is a car at the intersection
- IC2:** The system infrastructure must be able to differentiate between autonomous and non autonomous cars
- IC3:** The system infrastructure must be able to detect when a car has navigated through the intersection
- IC4:** The system infrastructure must be able to determine the order in which the cars should proceed
- IC5:** The system infrastructure must be able to signal to the vehicle when it is allowed to go through the intersection

## 8 Functional Decomposition Diagrams

Figure 3: Functional Track Navigation Decomposition

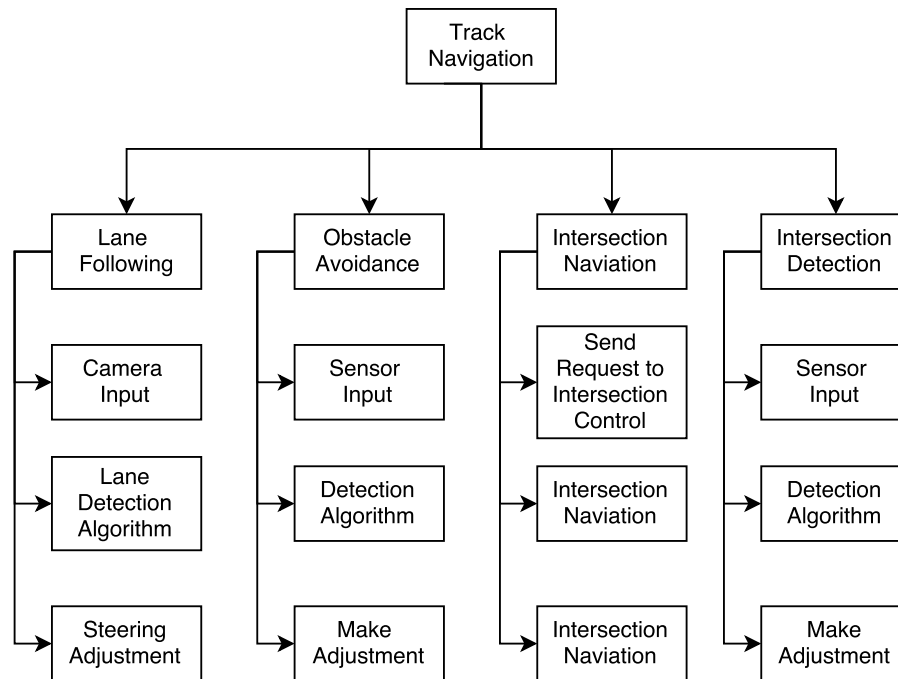
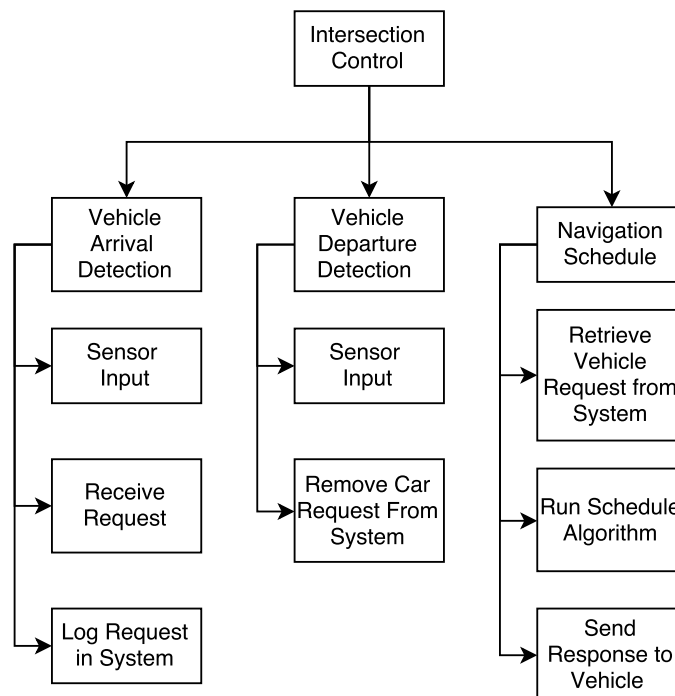


Figure 4: Functional Intersection Controller Decomposition



## 9 Functional Requirements Likelihood of Change

| Requirement Group    | Requirement | Likelihood of Change |
|----------------------|-------------|----------------------|
| Track                | T1          | Unlikely             |
|                      | T2          | Unlikely             |
|                      | T3          | Unlikely             |
| Vehicle              | V1          | Likely               |
|                      | V2          | Unlikely             |
|                      | V3          | Unlikely             |
|                      | V4          | Unlikely             |
|                      | V5          | Unlikely             |
|                      | V6          | Unlikely             |
|                      | V7          | Unlikely             |
| Intersection Control | IC1         | Likely               |
|                      | IC2         | Likely               |
|                      | IC3         | Likely               |
|                      | IC4         | Likely               |
|                      | IC5         | Likely               |

## 10 Nonfunctional Requirements

### 10.1 Look and Feel Requirements

#### 10.1.1 Appearance Requirements

- N/A

#### 10.1.2 Style Requirements

- N/A

### 10.2 Usability and Humanity Requirements

#### 10.2.1 Ease of Use Requirements

- N/A

#### 10.2.2 Personalization and Internationalization Requirements

A: The system must be able to function according to North American road standards

### 10.2.3 Learning Requirements

- N/A

### 10.2.4 Understandability and Politeness Requirements

- N/A

### 10.2.5 Accessibility Requirements

- N/A

## 10.3 Performance Requirements

Please note that the following non functional requirements will be updated as the system is created and data is acquired.

### 10.3.1 Speed Requirements

- A: The system must be able to determine an order and convey it to the vehicle before a soft deadline

### 10.3.2 Safety-Critical Requirements

- A: The system must only signal a car to proceed when the intersection is clear  
B: The vehicle must stop within a safe distance of an obstacle

### 10.3.3 Precision Requirements

- A: The vehicle must not deviate from the lanes more than 1%

### 10.3.4 Reliability or Availability Requirements

- A: The system must operate without failure 99% of the time  
B: The vehicle system must operate as long as car's internal power supply is charged

### 10.3.5 Robustness or Fault-Tolerance Requirements

- A: In the event of a complete vehicle system failure, the vehicle must come to a stop

### 10.3.6 Capacity Requirements

- A: The intersection controller shall be able to manage one intersection at a time  
B: The intersection controller shall be able to communicate with a maximum of four cars at a time

### 10.3.7 Scalability or Extensibility Requirements

- N/A

### 10.3.8 Longevity Requirements

A: Components should be functional for up to one year

## 10.4 Operational and Environmental Requirements

### 10.4.1 Expected Physical Environment

A: The track must be 1/10 scale of a real world intersection

### 10.4.2 Requirements for Interacting with Adjacent Systems

A: The components must be able to use the API of existing and partner components

## 10.5 Maintainability and Support Requirements

### 10.5.1 Maintenance Requirements

A: Issues must be resolved within one week of discovering an error in the system

### 10.5.2 Supportability Requirements

- N/A

### 10.5.3 Adaptability Requirements

- N/A

## 10.6 Security Requirements

### 10.6.1 Access Requirements

A: All stated stakeholders have full access to the product

### 10.6.2 Integrity Requirements

A: The system will not be altered by external signals

### 10.6.3 Privacy Requirements

- N/A

### 10.6.4 Audit Requirements

- N/A

### 10.6.5 Immunity Requirements

- N/A

## 10.7 Cultural and Political Requirements

### 10.7.1 Cultural Requirements

- N/A

### 10.7.2 Political Requirements

- N/A

## 10.8 Legal Requirements

### 10.8.1 Compliance Requirements

- N/A

### 10.8.2 Standards Requirements

- N/A

## 11 Project Issues

### 11.1 Open Issues

A: The track design is not finalized.

### 11.2 Off-the-Shelf Solutions

#### 11.2.1 Ready-Made Products

A: Autonomous Intersection Management, an existing product that partially solves the problem of autonomous intersection navigation.

### 11.3 Risks

A: Component failure - Failure of components can result in damage to the remote control cars.

B: Damaged parts - Damaged parts will result in delay of the project and will require more parts to be bought.

C: Potential of minor injuries to humans - Humans can be injured if parts malfunction.

### 11.4 Costs

The general budget for the major components are as follow:

A: 1/10th model car \$200.00 each

B: Cameras and sensors \$100.00

C: Micro-controllers \$200.00

## **11.5 Waiting Room**

**A:** Having the system work with other autonomous car models

**B:** Having the system work with non-autonomous cars