VIC

Vehicle Intersection Control

McMaster University

Draft System Requirements

SE 4G06

Group 6

Alex Jackson
Jean Lucas Ferreira
Justin Kapinski
Mathew Hobers
Radhika Sharma
Zachary Bazen

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1 Revisions

Date	Revision Number	Authors	Comments
November 29,2016	Revision 1	Zachary Bazen	Updated monitored and controlled variables Updated naming conventions
November 14, 2016	Revision 0	Alex Jackson Jean Lucas Ferreira Justin Kapinski Mathew Hobers Radhika Sharma Zachary Bazen	N/A

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.

MC1	**Remote control cars must be 1/10 scale**
RMC1	The remote control cars must be large enough to mount all the required hardware

MC2	**Remote control cars must be electric**
RMC2	Cars will be operated indoors, gasoline powered remote control cars are a safety hazard indoors

MC3	**The cost of the project must not exceed $700 dollars**
RMC3	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

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

A1	**Ideal driving conditions on the track**
RA1	Track is situated indoors

A2	**Intersection is a four way stop**
RA2	Different intersection arrangements are beyond the scope of this project

A3	**Only autonmous car will be present on the track**
RA3	This will help simplify the scope of the project

A4	**Cars will not have a large variance in size**
RA4	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

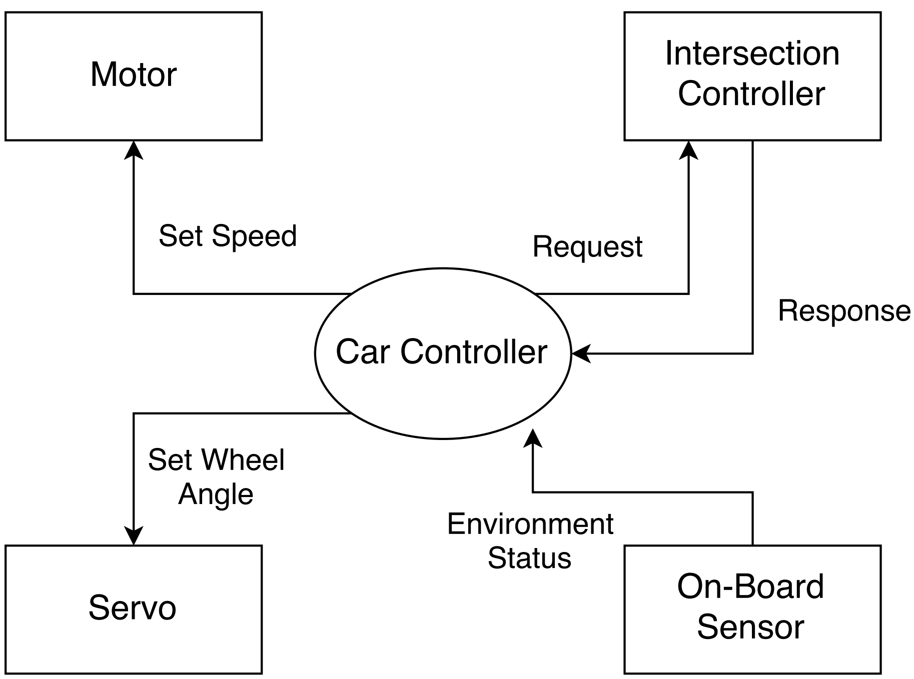

Figure 1: Car Controller Context Diagram

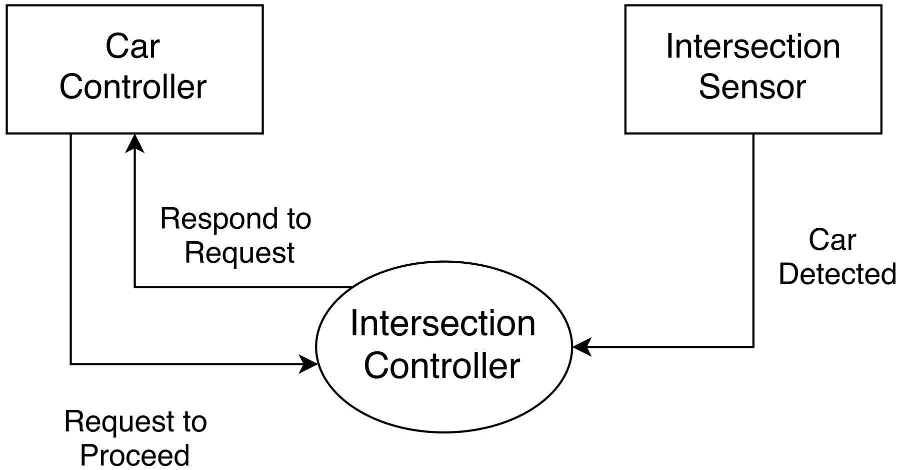

Figure 2: Intersection Controller Context Diagram

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

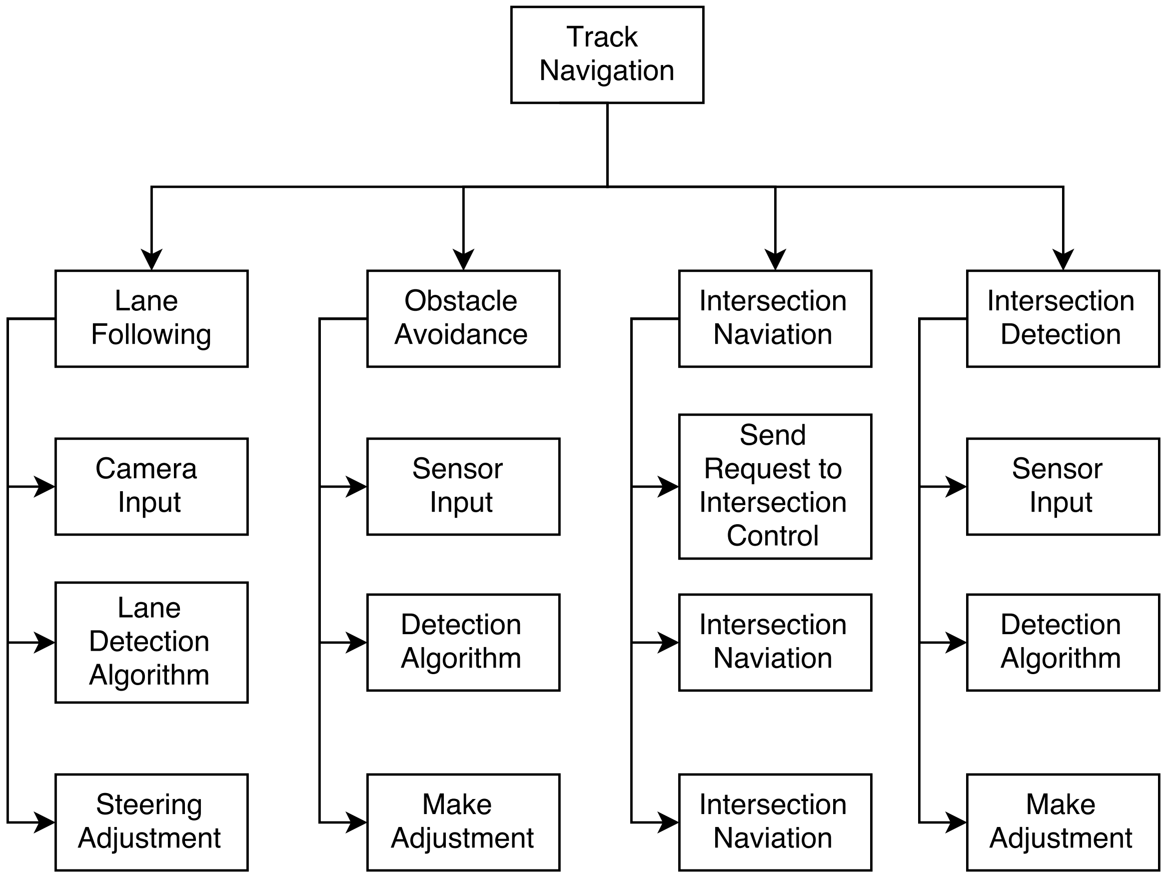

Figure 3: Functional Track Navigation Decomposition

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

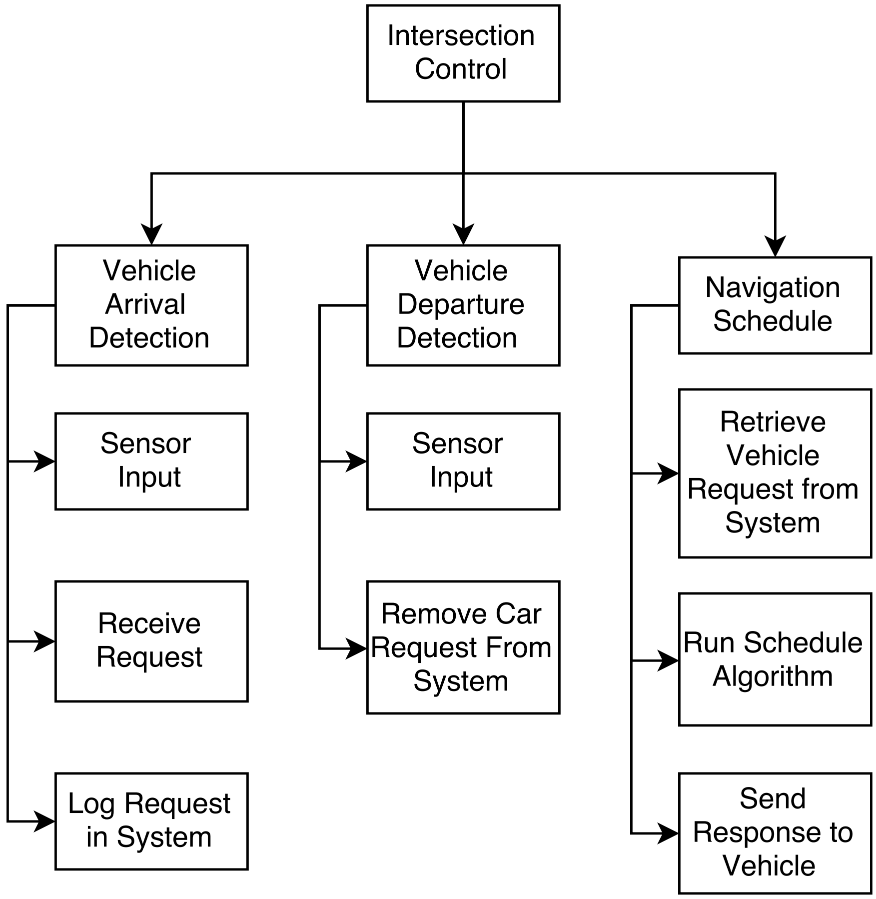

Figure 4: Functional Intersection Controller Decomposition

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