VIC

Vehicle Intersection Control

McMaster University

System Requirements

SE 4G06

Group 6

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1 Revisions

Table 1: VIC Table of Revisions

Date	Revision Number	Authors	Comments
March 8, 2017	Revision 1	Alex Jackson Jean Lucas Ferreira Justin Kapinski Mathew Hobers Radhika Sharma Zachary Bazen	- Updated scope of the project - Created new and revised likelihood of change table - Improved privacy requirements - Removed unused system constants section - Updated additional non-functional requirements
March 3, 2017	Revision 1	Alex Jackson Jean Lucas Ferreira Justin Kapinski Mathew Hobers Radhika Sharma Zachary Bazen	- Update system requirements - Added requirement rationale - Updated system assumptions - Removed monitored and controlled variables
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

2 Project Drivers

2.1 The Purpose of the Project

The purpose of this project will be create a system that allows autonomous cars to navigate through intersections. Currently, when multiple autonomous cars arrive at an intersection simultaneously,the vehicles have no way of determining in which order to proceed. This is due to the lack of a decision making protocol. VIC will strive to solve these problems.

Vehicle Intersection Control (also known as VIC) will allow autonomous vehicles to make navigation decisions at intersections. VIC will accomplish this by receiving signals from vehicles, using a scheduling algorithm to determine the proceed order, and then communicating the order back to the corresponding vehicle. To ensure safety, VIC will only signal a vehicle to proceed after it determines that the intersection is clear.

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, Likely Changes and Project Issues.

2.2 Scope

To meet the time and budget constraints, VIC will be implemented in a lab setting. The system will assume ideal weather, track, and lighting conditions. To further constraint the project, various real world conditions will be ignored. Some real world conditions that will be ignored include non-autonomous vehicles and vehicles turning at the intersection.

2.3 The Client, the Customer, and Other Stakeholders

2.3.1 Client and Customer

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

2.3.2 Stakeholders

The stakeholders consists of:

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

2.4 Users of the Product

This product is expected to be used by researchers in the field of autonomous vehicle control. 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 system 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**
Rationale	The remote control cars must be large enough to mount all the required hardware, and fit within the lanes of the given track

MC2	**Remote control cars must be electric**
Rationale	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**
Rationale	This is to ensure an off-the-shelf solution can not be purchased. It also ensures the project remains economically feasible.

MC4	**The cars must not turn at the intersection**
Rationale	To simplify intersection navigation

3.2 Naming Conventions and Definitions

3.2.1 Naming Conventions

Note: The following naming conventions apply to this document specifically.

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
A#	Project assumptions identification and number

3.2.2 Definitions

1. **VIC** - The name given to the overall intersection control system
2. **IC** - Intersection Controller; the portion of the system that will control the intersection and make scheduling decisions.
3. **VC** - Vehicle Controller, The portion of the system that will facilitate navigation of the track by the car.

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
Rationale	Track is situated indoors

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

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

A4	Cars will not have a large variance in size
Rationale	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

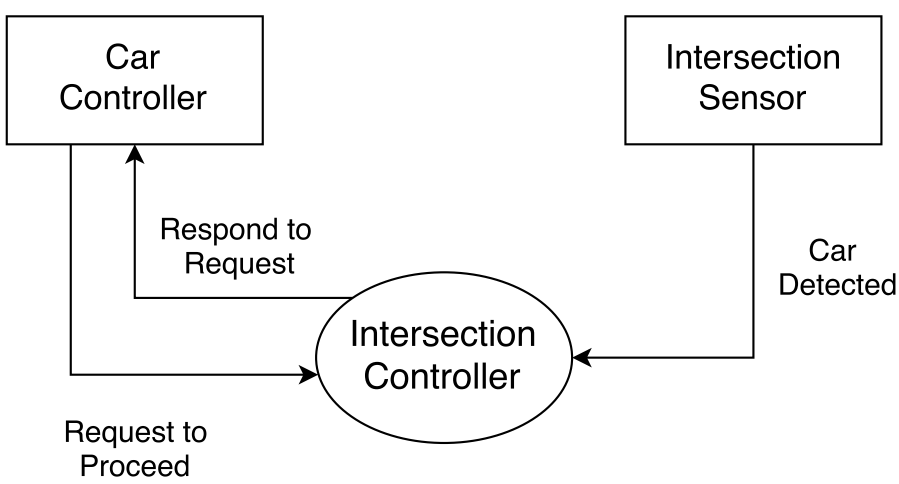


Figure 1: Intersection Controller Context Diagram

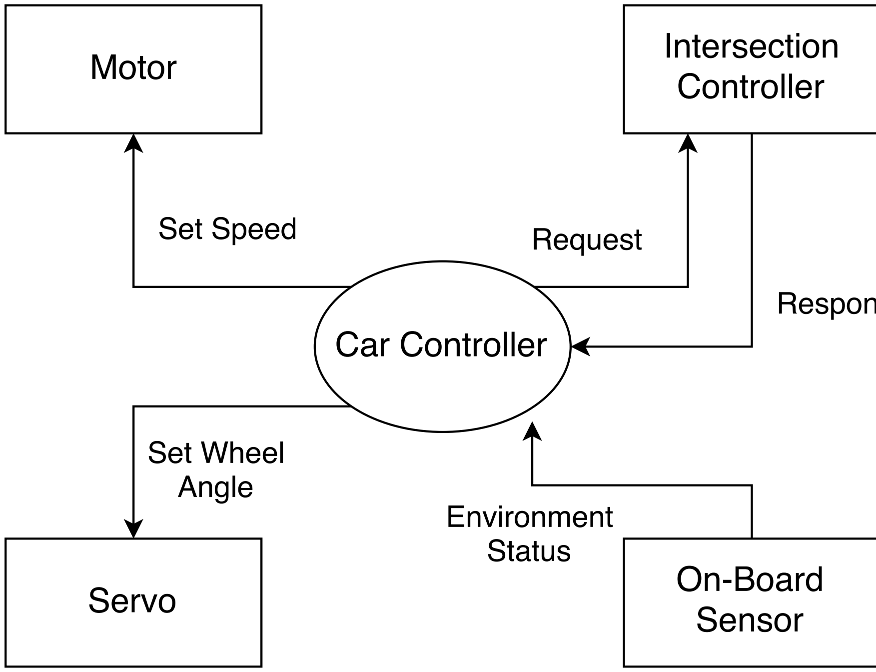


Figure 2: Car Controller Context Diagram

5 Functional Requirements

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

5.1 Track Functional Requirements

T1	The track must have 30 ± 1 cm wide lanes
Rationale	In order to fit $\frac{1}{10}$ scale vehicles

T2	The track must have an intersection
Rationale	Provide a testable environment

T3	The track must have objects to indicate stopping at the intersection
Rationale	To allow the vehicle to identify the intersection

T4	The track must have objects to indicate the direction
Rationale	To allow the vehicle to identify direction it is coming from and going to

5.2 Vehicle Functional Requirements

V1	The vehicle must be able to send and receive signals to and from the intersection controller
Rationale	Provide a means for the vehicles to pass and receive information to and from the intersection controller

V2	The vehicle must be able to detect lanes and follow them
Rationale	To follow an intended path

V3	The vehicle must be able to detect intersections
Rationale	To be able know where to stop at the intersection

V4	The vehicle must be able to stop at intersections
Rationale	To avoid collisions and follow rules of the road

V5	The vehicle must be able to navigate through intersections
Rationale	To continue following the intended path after arriving at the intersection

V6	The vehicle must be able to avoid obstacles
Rationale	To prevent collisions and damage to vehicle and surrounding property

5.3 Intersection Controller Functional Requirements

IC1	The intersection controller must be able to detect if there is a car at the intersection
Rationale	To make safe and informed decisions

IC2	The intersection controller must be able to detect when a car has exited the intersection
Rationale	Confirmation vehicles has left the intersection to allow safe and informed decision

IC3	The intersection controller must be able to determine the order in which the cars should proceed
Rationale	To ensure a fair and safe scheduling policy

IC4	The intersection controller must be able to receive signals from the vehicles
Rationale	Alter the intersection when the vehicle wishes to proceed through the intersection

IC5	The intersection controller must be able to signal to the vehicle when it is allowed to go through the intersection
Rationale	Alert the vehicle when it should proceed

IC6	The system must have two modes of operation, namely: traffic optimization and traditional traffic rules
Rationale	Fulfill projects constraints outlined by the client

6 Functional Decomposition Diagrams

Figure 3: Functional Intersection Controller Decomposition

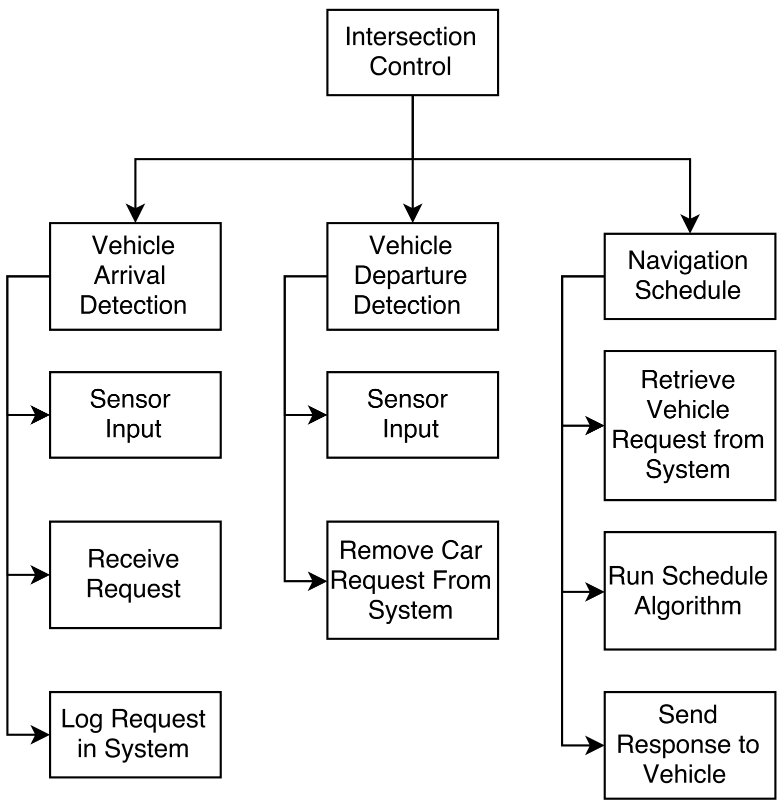
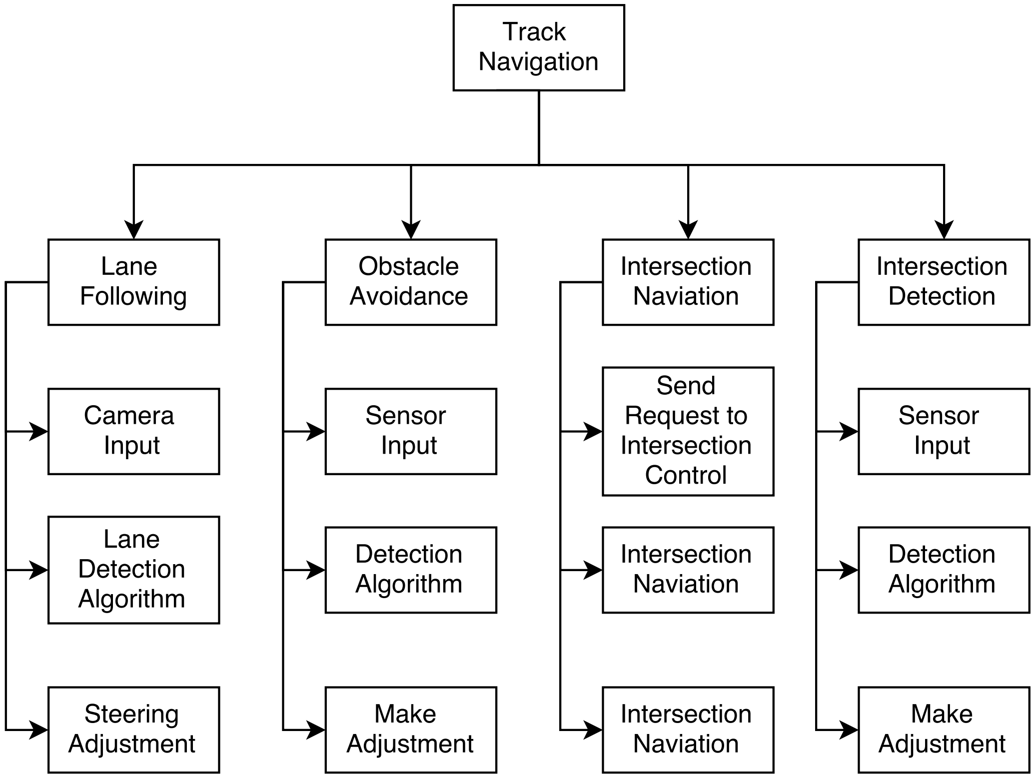


Figure 4: Functional Track Navigation Decomposition



7 Functional Requirements Likelihood of Change

7.1 Track

Requirement	Change Likelihood	Rationale	Ways to Change
T1	Very Unlikely	Mandated constraint	N/A
T2	Very Unlikely	Mandated constraint	N/A
T3	Very Unlikely	Mandated constraint	N/A
T4	Likely	Subject to consent of other groups	Means of direction identification could change

7.2 Vehicle

Requirement	Change Likelihood	Rationale	Ways to Change
V1	Very Unlikely	Key implementation aspect	N/A
V2	Very Unlikely	Key implementation aspect	N/A
V3	Very Unlikely	Key implementation aspect	N/A

V4	Very Unlikely	Key implementation aspect	N/A
V5	Very Unlikely	Key implementation aspect	N/A
V6	Likely	This requirement has a lower priority compared to other requirements, and it is subject to time constraints	Requirement may be removed

7.3 Intersection Controller

Requirement	Change Likelihood	Rationale	Ways to Change
IC1	Very Unlikely	Key implementation aspect	N/A
IC2	Likely	IC may not be able to accurately detect when the vehicle has left the intersection	System can be configured such that the vehicle directly informs the IC when it has left the intersection
IC3	Very Unlikely	Key implementation aspect	N/A
IC4	Very Unlikely	Key implementation aspect	N/A
IC5	Very Unlikely	Key implementation aspect	N/A
IC6	Likely	This requirement has a lower priority compared to other requirements, and it is subject to time constraints	Requirement may be removed

8 Nonfunctional Requirements

8.1 Look and Feel Requirements

8.1.1 Appearance Requirements

- N/A

8.1.2 Style Requirements

- N/A

8.2 Usability and Humanity Requirements

8.2.1 Ease of Use Requirements

- N/A

8.2.2 Personalization and Internationalization Requirements

A: The vehicle must drive on the right side of the lanes

8.2.3 Learning Requirements

- N/A

8.2.4 Understandability and Politeness Requirements

- N/A

8.2.5 Accessibility Requirements

- N/A

8.3 Performance Requirements

8.3.1 Speed Requirements

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

B: The system must capture and process intersection information within 0.3 seconds

C: The vehicle must process the state of the track in less than 0.3 seconds

8.3.2 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

C: The system must have an emergency shutdown mode

8.3.3 Precision Requirements

A: The vehicle must not deviate from the lanes more than 10%

8.3.4 Reliability or Availability Requirements

A: The system must operate without failure 95% of the time

B: The vehicle system must operate as long as the car's internal power supply is charged

8.3.5 Robustness or Fault-Tolerance Requirements

A: In the event of a complete vehicle system failure, the vehicle must come to a stop within 10cm

8.3.6 Capacity Requirements

A: The intersection controller must be able to manage at least one intersection at a time

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

8.3.7 Scalability or Extensibility Requirements

- N/A

8.3.8 Longevity Requirements

A: Components should be functional for up to one year

8.4 Operational and Environmental Requirements

8.4.1 Expected Physical Environment

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

B: The vehicle must be able to operate on a track in a lab setting

8.4.2 Requirements for Interacting with Adjacent Systems

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

8.5 Maintainability and Support Requirements

8.5.1 Maintenance Requirements

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

8.5.2 Supportability Requirements

- N/A

8.5.3 Adaptability Requirements

- N/A

8.6 Security Requirements

8.6.1 Access Requirements

A: All stated stakeholders have full access to the product

8.6.2 Integrity Requirements

A: The system will not be altered by external malicious Bluetooth signals

8.6.3 Privacy Requirements

A: Image data gathered by the vehicle controller will not be stored

B: Image data gathered by the intersection controller will not be stored

C: Information passed between the vehicle and the intersection must not include sensitive information

D: All message passing between subsystem will be encrypted

8.6.4 Audit Requirements

- N/A

8.6.5 Immunity Requirements

- N/A

8.7 Cultural and Political Requirements

8.7.1 Cultural Requirements

- N/A

8.7.2 Political Requirements

- N/A

8.8 Legal Requirements

8.8.1 Compliance Requirements

- N/A

8.8.2 Standards Requirements

- N/A

9 Project Issues

9.1 Open Issues

- None

9.2 Off-the-Shelf Solutions

9.2.1 Ready-Made Products

A: OpenCV - existing software used for image processing

B: BlueZ - a Bluetooth library

9.3 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.

9.4 Costs

The general budget for the major components are as follow:

A: 1/10th model car (x2) $240.00 each

B: Cameras and sensors $50.00

C: Vehicle Battery (x2) and Charger $90.00

D: Raspberry Pi (x2) $150.00

Total Cost : $530.00

9.5 Waiting Room

A: Having the system work with other autonomous car models