CS445 Deliverable 3

Limited Autonomous Driving Software Specification

[redacted]

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1. Introduction

1.1 Purpose

This document describes the software requirements and specification for a Limited Autonomous Driving (LAD) system. In particular, this document will specify the four automated features: Basic Cruise Control (CC), Adaptive Cruise Control (ACC), Lane Centering Control (LCC), and Automatic Headlights. The document is intended for the customer and the developer (designers, testers, maintainers).

The reader is assumed to have basic knowledge of operating a car. Knowledge and understanding of UML diagrams is also required.

1.2 Scope

The software supports a Limited Autonomous Driving system. This system aims to automate four tasks that would normally be performed by drivers. More specifically, Cruise Control aims to maintain the car’s speed at a constant, driver-set value. Adaptive Cruise Control aims to perform the same functions as basic Cruise Control, but also reacts to traffic conditions by maintaining a safe distance away from cars ahead. Lane Centering Control detects and monitors lane markings and takes corrective action, if necessary, to keep the vehicle in its current lane. Automatic Headlights control the headlights on the vehicle based on the level of illumination outside as well as the presence of other vehicles in the area.

These features offer safety-critical functionality, and will not cause undesirable or unsafe actions to take place such as unintended braking or acceleration. The software will safely handle failures and alert the driver appropriately.

1.3 Acronyms, Abbreviations, Definitions

Acronyms:

- **ACC:** Adaptive Cruise Control
- **AHL:** Automatic Headlights
- **CC:** Basic Cruise Control
- **LAD:** Limited Autonomous Drivings
- **LCC:** Lane Centering Control

Definitions:

- **maxSpeedOfCar:** The maximum speed that the car can travel at.

For all of our models we will be using the official standard notational conventions as of April 1st 2012.

In the meeting minutes the colour red denotes corrections that the customer has made after the QA session.

1.4 References

For a detailed documentation of our meeting minutes please refer to the meeting minute section of the Appendix.

We also reference the Highway Traffic and Safety Act which can be found online at: http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90h08_e.htm

1.5 Overview

The rest of this document is organized as follows. Section 2 contains a general description of the LAD system software requirements. Section 3 identifies the specific requirements, including external interfaces, use cases, functional requirements, and behavioural requirements.

The minutes of meetings with customers do not constitute additional requirements for the software; all requirements arising from these minutes are incorporated into the specific requirements in Section 3.

2. Overall Description

2.1 Product Perspective

Below is a Use Case Diagram that illustrates the different high level features that the LAD system provides.

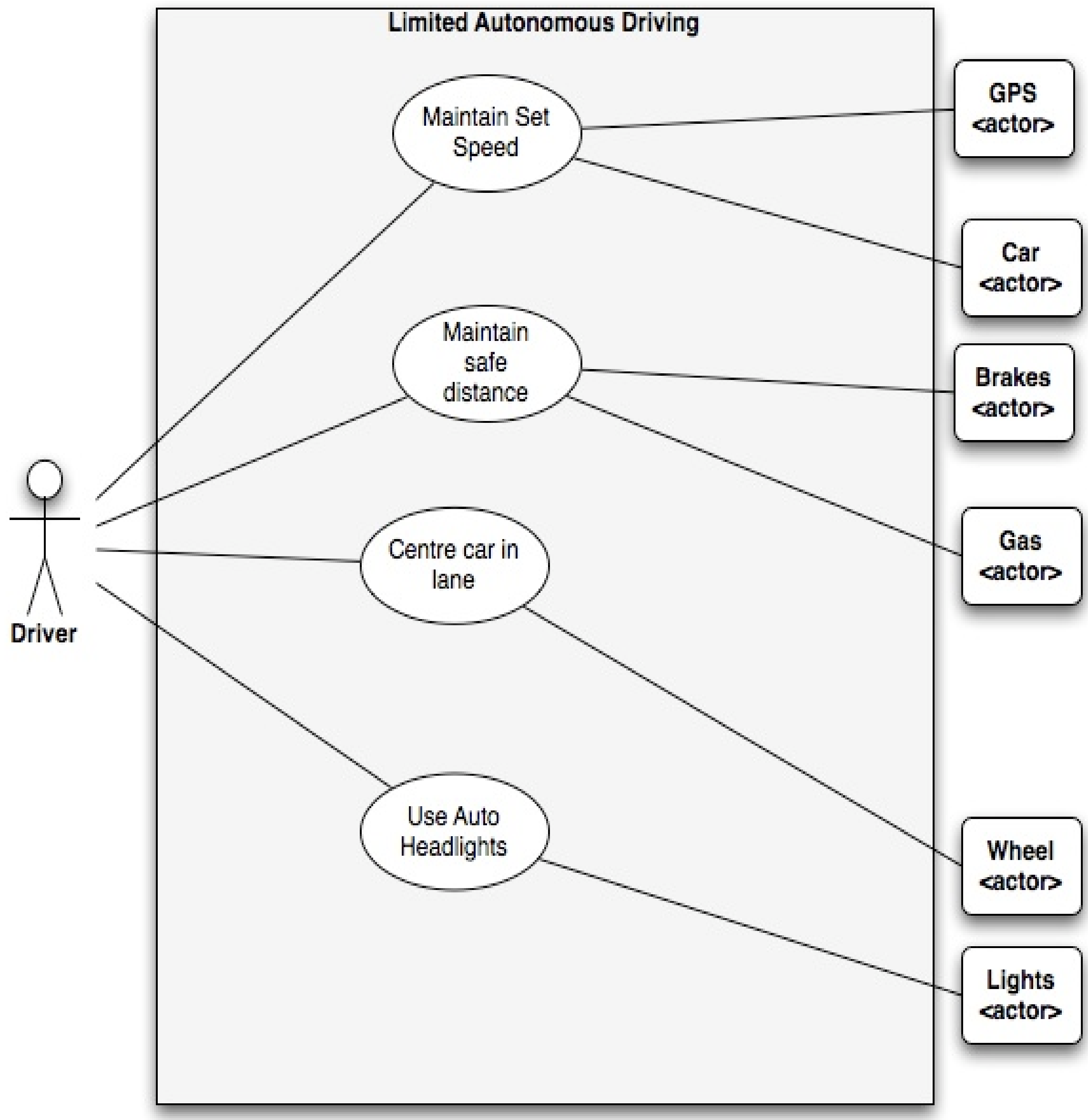


FIgure A: Use Case Diagram

The LAD does not work independently. It works together with the car’s brake system, engine system, steering system, location system, audio system and driver.

- Location interface
    - The LAD system communicates with the location system using a GPS protocol.

- Hardware interface
    - The LAD will need to have direct access to a number of hardware components within the car including the brakes, engine, audio and steering.
    - Communications between the electronic control units on which the software is installed are via the "controller area network" (CAN) protocol.

- User interfaces
    - Driver - The interface for the driver should be intuitive such that after reading the manual 90% of the users are able to correctly use the system.
    - Car Dealership - The car dealership is responsible for maintaining the system which includes fixing it when issues are reported and updating the software when new patches become available. The car dealership should be able to apply software updates within half an hour. These updates will be applied at the dealership and not wirelessly.

2.2 Product Features

Name: Maintaining set speed
Use Case Number: 1
Description: The driver engages CC/ACC and then sets the speed to maintain. The LAD system then maintains the speed set by the driver.

Name: Maintaining safe distance
Use Case Number: 2
Description: The driver engages ACC and then chooses what safe distance (1 second, 2 second) they want. The LAD system then continuously tracks the distance to the car ahead and will accelerate/decelerate accordingly.

Name: Centre car in lane
Use Case Number: 3
Description: The driver engages LCC (ACC already on) and the LAD system begins monitoring relative distances to lane markings. Keeps the car centered if they begin to veer towards either side too much.

Name: Use auto headlights
Use Case Number: 4
Description: The driver turns the headlights to auto mode. The LAD system then continues to monitor the illumination level to determine whether the headlights should be off or have low beams or high beams engaged.

2.3 User Characteristics

The driver must be legally allowed to drive based on the laws of the country they are driving in.

As far as training is concerned the driver can have any level of driving experience but they must read the LAD instruction manual prior to using the system. The driver must be alert and watching the road conditions.

The driver cannot be suffering from a disability.

The maintenance professional at the car dealership must be legally employed at the car dealership and be approved to perform maintenance tasks and upgrades on the vehicle. They must read the LAD instruction manual prior to updating the system. In addition to this, the maintenance professional must also have attended and passed the rigorous LAD upgrade and maintenance course.

2.4 General Constraints

- Regulatory policies
    - When the GPS speed limit feature is activated the car should not exceed the speed limit.
- Hardware limitations
    - The camera system will not be able to always detect the lane markings or all of the oncoming cars all of the time. For example they may be blocked by dirt or debris.
    - ACC and CC cannot be installed on the same car at the same time.
- Parallel operation
    - All of the components within LAD must be able to run concurrently.
    - The LAD system must be able to run in parallel with all of the other systems of the car.
- Audit functions
    - Checks for the integrity of stored data, as well as the correct functioning of the sensors and actuators.

- Control functions
    - The driver should be able to control which systems within LAD are active and have the ability to turn the entire system off completely.
- Criticality of the application
    - Proper functioning of the LAD system is extremely critical. Errors in the LAD system could seriously compromise the safety of the car's passengers
- Safety and security considerations
    - The LAD features will not engage if problems are detected with the sensors required for the feature to work
    - LAD will notify the driver when any of the features are disengaged or if a feature is unable to meet its requirement (i.e. safe distance cannot be maintained)
    - If the LAD system fails this could cause serious injury or even death
- Standards
    - The system must comply with all Canadian and American road standards
- Laws
    - The AHL system must comply with the Highway Traffic Act. Specifically, it must obey the regulations stated in Section 62 of the Highway Safety Act.

2.5 Assumptions and Dependencies

Assumptions about the input/environmental behaviour

- The vehicle has working brakes
- The vehicle has a working engine and can accelerate
- The vehicle has working headlights
- The vehicle is driving on an officially recognized road in Canada or the USA
- The road is flat, dry and made of asphalt
- The environmental temperature is between 40°C and -20°C

Conditions that could cause the system to fail

- If the lane marking on one of the lanes are unreadable then the LCC system will fail
- If the camera system or light sensors are blocked or obstructed in any way then system will fail

Changes to the environment that could lead to changes in the software requirements

- If the road system changes then the GPS maps in the SD card will need to be updated accordingly
- If the physical lane marking style of the road changes then the software will need to be updated accordingly

- If flying cars become mainstream then this software will need a total revamp

Dependencies

- The speed limit feature depends on having a working GPS system
- The LCC system depends on the ACC system
- ACC depends on ABS to prevent excessive skidding
- CC and ACC depend on traction control to limit excessive wheel spinning

3. Specific Requirements

3.1 External Interfaces

Below is the Domain Model which outlines the entities that constitute the LAD system.

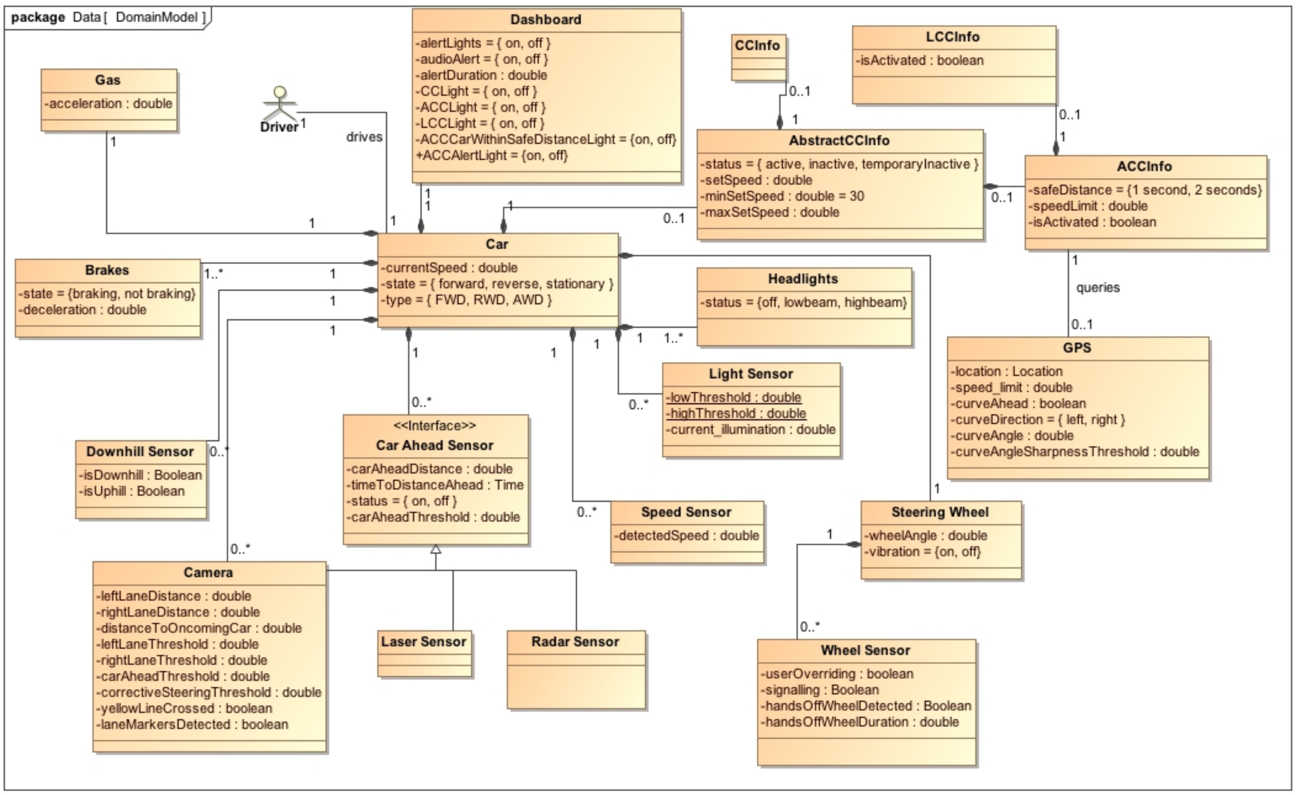


Figure B: Domain Model

<u>Inputs</u>

Input Name	**Wheel Steering**
Description	This input measures whether or not the driver is steering
Source	Driver
Valid Range	false or true
Data Format	Boolean

Input Name	**Braking**
Description	This input detects the rate at which the driver is braking
Source	Driver
Valid Range	0 .. 100
Units	m/s^2
Data Format	Double

Input Name	**Accelerating**
Description	This input detects the rate at which the driver is accelerating
Source	Driver
Valid Range	0 … 100
Units	m/s^2
Data Format	Double

Input Name	**Signalling**
Description	This input detects whether or not the driver is signalling
Source	Driver
Valid Range	false, true
Data Format	Boolean

Input Name	**Lighting Level**
Description	This input detects the current illumination level to update AHL functionality

Source	Light Sensor
Valid Range	low, medium, high
Accuracy	The light sensor will be able to detect changes in light levels 90% of the time
Data Format	Double

Input Name	**Lane Distance (Left/Right)**
Description	This input detects the current distance to the (left/right) lane marker to update LCC functionality
Source	Camera
Valid Range	0cm .. 200cm
Units	centimetres
Data Format	Double

Input Name	**Driver Sets Speed**
Description	This input detects the speed set by the driver to update the CC/ACC functionality
Source	Driver
Valid Range	30km/h .. maxSpeedofCar
Unit	km/h
Data Format	Double

Input Name	**Toggle CC Button**
Description	This input is when the driver turns CC on or off
Source	Driver
Valid Range	Off or On
Data Format	Boolean

Input Name	**Toggle ACC Button**
Description	This input is when the driver turns ACC on or off
Source	Driver
Valid Range	Off or On
Data Format	Boolean

Input Name	**Toggle ACC Safe Distance Button**
Description	This input is when the driver changes the safe distance to be maintained
Source	Driver
Valid Range	1 second or 2 second
Data Format	Enumeration

Input Name	**Toggle LCC Button**
Description	This input is when the driver turns LCC on or off
Source	Driver
Valid Range	Off or On
Data Format	Boolean

Input Name	**Toggle AHL Button**
Description	This input is when the driver turns AHL on or off
Source	Driver
Valid Range	Off or On
Data Format	Boolean

Input Name	**GPS Speed Limit Sensors**
Description	This input is the speed limit of the current road detected by the GPS
Source	GPS
Valid Range	0 .. 100
Accuracy	Up to 30 metres ahead
Units	km/h
Data Format	Double

Input Name	**GPS Curve Ahead Sensors**
Description	This input is the radius of the curve ahead on the current road detected by the GPS
Source	GPS
Valid Range	0 .. 250
Accuracy	Up to 30 metres ahead
Units	metres
Data Format	Double

Outputs

Output Name	**Toggle CC Light Display**
Description	This output shows the driver the status of CC
Source	LAD
Valid Range	Off or On
Data Format	Boolean
Timing	Update after driver toggles CC

Output Name	**Toggle ACC Light Display**

Description	This output shows the driver the status of ACC
Source	LAD
Valid Range	Off or On
Data Format	Boolean
Timing	Update after driver toggles ACC

Output Name	**Toggle LCC Light Display**
Description	This output shows the driver the status of LCC
Source	LAD
Valid Range	Off or On
Data Format	Boolean
Timing	Update after driver toggles LCC

Output Name	**Toggle AHL Light Display**
Description	This output shows the driver the status of AHL
Source	LAD
Valid Range	Off or On
Data Format	Boolean
Timing	Update after driver toggles AHL

Output Name	**Toggle Warning Light Display**
Description	This output displays a flashing warning light to the driver
Source	LAD
Valid Range	Off or On
Data Format	Boolean

Timing	Update if driver accelerates, brakes, steers, or signals to override systems

3.2 Functional Requirements

3.2.1 Fully Dressed Use Case Descriptions

Below are the fully dressed Use Case Descriptions of the LAD system.

Name: Maintaining set speed
Use Case Number: 1
Authors: Robert Laks, Yat Choi, Justin Pasqualini
Event/Precondition: Driver engages CC/ACC at speed (>=30 km/h)
System: Limited Autonomous Driving
Actors:

- Driver
- GPS
- Car

Overview: This use case describes how the driver can set the speed to maintain for CC/ACC
Related Use Cases:

Driver	LAD	Car	GPS
1. Driver toggles CC/ACC on			
	2. CC/ACC is activated		
		3. Get current speed	
	4. Speed is set to current car speed 5. Driver notified 6. Car maintains set speed		
7. Driver toggles CC/ACC off			

	8. CC/ACC is deactivated 9. Driver notified via alert		
Alternative 1: Driver restores previously set speed (Step 2)			
2. Driver toggles the resume button			
	3. CC/ACC is activated 4. Set speed is set to previously stored speed		
		5. Accelerate/ decelerate to set speed	
	6. Go to main scenario step 5		
Alternative 2: Driver increases set speed while CC/ ACC engaged (step 6)			
6. Driver increases set speed			
	7. CC/ACC set speed updated 8. Go to main scenario step 6		
Alternative 2: Driver decreases set speed while CC/ ACC engaged (step 6)			
6. Driver decreases set speed			

	7. CC/ACC set speed updated 8. Go to main scenario step 6		
Alternative 4: Driver steps on gas pedal during step 6.			
6. While gas pedal is pressed.			
	6.1 Engine speed change overridden. 7. Go back to Main scenario step 6.		
Alternative 5: Driver steps on brake pedal during step 6.			
6. Driver steps on brake pedal.			
	7. Go back to main scenario Step 8.		
Alternative 6 (ACC only): Driver chooses to use speed limit option (step 4)			
			4. Get current road speed limit
	5. Set stored speed to min(current speed, speed limit) 6. Go to main step 5		

Name: Maintaining safe distance
Use Case Number: 2
Authors: Robert Laks, Yat Choi, Justin Pasqualini
Event/Precondition: Driver sets ACC safe distance, car ahead within safe distance specified
System: Limited Autonomous Driving
Actors:

- Driver
- Brake
- Gas

Overview: Describes how the user can set the safe speed distance and how the system works
Related Use Cases:

Driver	LAD	Gas	Brake
1. Driver toggles ACC on			
	2. ACC is activated		
3. Driver turns “maintain safe distance” on			
	4. System begins to maintain safe distance		
5. Driver turns “maintain safe distance” off			
Alternative 1: Car ahead is beyond safe distance range (Step 4)			
		4. Accelerate 5. Go to main scenario step 5	
Alternative 2: Car ahead is within safe distance range (Step 4)			
			4. Decelerate 5. Go to main scenario step 5

Name: Centre car in lane
Use Case Number: 3
Authors: Robert Laks, Yat Choi, Justin Pasqualini
Event/Precondition: Driver engages LCC, ACC is on

System: Limited Autonomous Driving
Actors:

- Driver
- Wheel

Overview: Describes how the driver interacts with the LCC system
Related Use Cases:

Driver	LAD	Wheel
1. Driver engages LCC		
	2. LCC is activated 3. Driver is notified via alert 4. System detects car is veering into other lane	
		5. Wheel turns in opposite direction
	6. System detects car is centering	
		7. Wheel turns to middle
8. Driver disengages LCC		
	9. LCC is deactivated 10. Driver notified via alert	
Exception 1: LAD cannot detect lane markings (step 2)		
	2. LCC cannot be activated 3. Go to main scenario step 9	

Name: Use auto headlights
Use Case Number: 4
Authors: Robert Laks, Yat Choi, Justin Pasqualini
Event/Precondition: Driver turns headlight mode to auto
System: Limited Autonomous Driving
Actors:

- Driver
- Lights

Overview: Describes how the automatic headlight system works
Related Use Cases:

Driver	LAD	Lights
1. Driver turns headlights to AHL mode		
	2. System detects current illumination level	
		3. Headlights turn to the matching level
4. Driver turns headlight off of AHL mode		
Alternative 1: Low level of illumination (step 2)		
	2. System detects low illumination level	
		3. Headlights switch to low beams
Alternative 2: High level of illumination (step 2)		
	2. System detects high illumination level	
		3. Headlights switch to off
Alternative 3: Very low illumination level (step 2)		
	2. System detects very low illumination level	
		3. Headlights switch to high beams
Alternative 4: High beams on oncoming (or car ahead) car detected (step 4)		
	4. Oncoming car detected	
		5. Headlights switch to low beams
	6. Oncoming car passes 7. No more cars detected	

		8. Headlights switch to high beams

3.2.2 Extended Finite State Machines

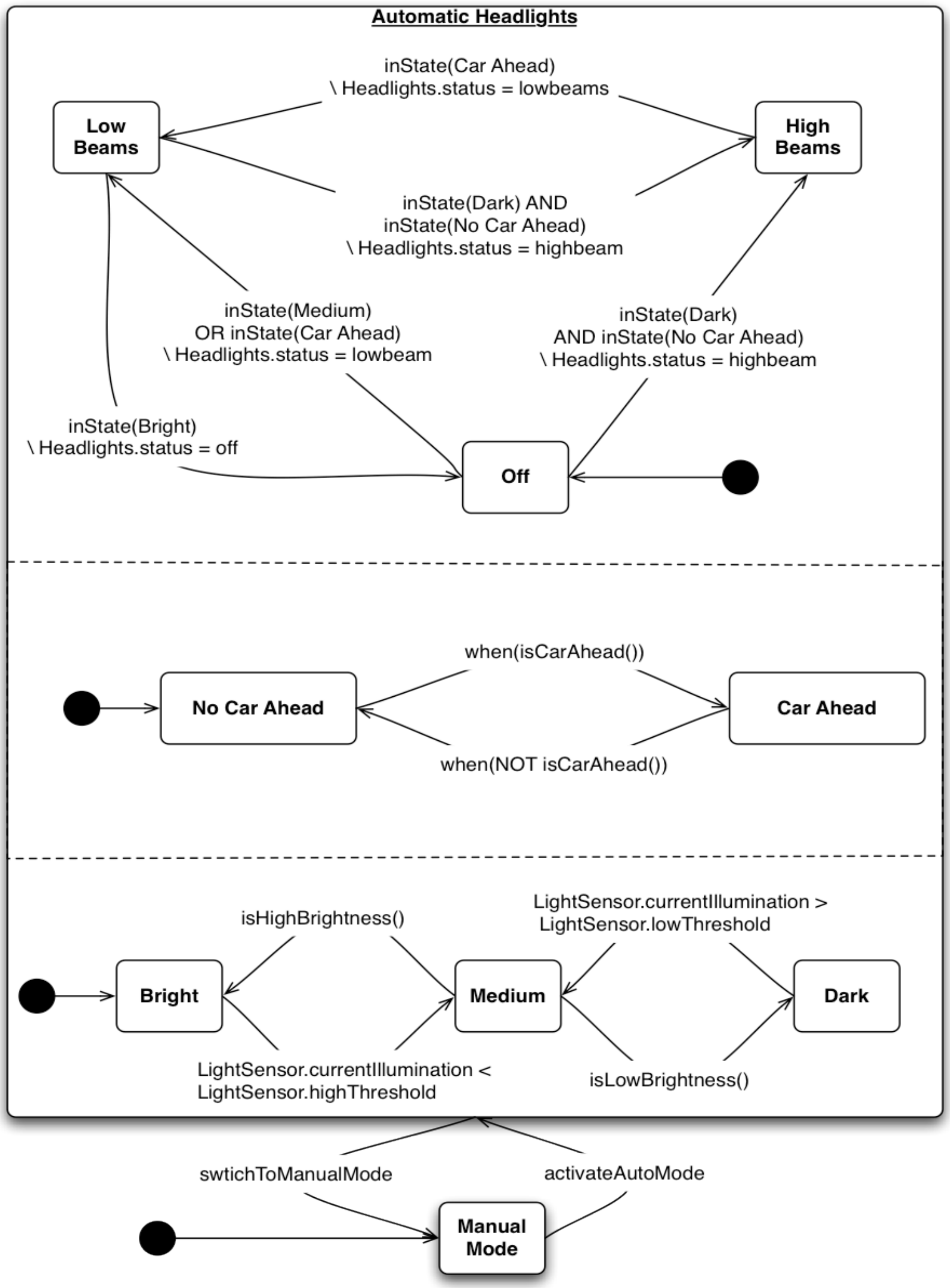


Figure C: AHL State Machine

Functions:

within1()->boolean: [currentSpeed/3600 > safeDistance]

within2()->boolean: [currentSpeed/1800 > safeDistance]

inReverse()->boolean: true if car is in reverse

Variables:

currentSpeed(double):0...200

setSpeed(double): 30...200

carAheadDistance(double): >=0

Events:

SpeedChange(speed): triggers when the car's speed changes

Sensor(distnace): triggers when the distance to the car ahead changes

ACC Switch(): triggers when the driver toggles the ACC Switch

Safe Distance Switch(): triggers when the driver toggles the safe distance switch

Set(): triggers when the driver attempts to set speed

Resume(): triggers when the driver resumes ACC

Brake(): triggers when the driver hits the brake

ReleaseBrake(): triggers when the driver releases the brake

Gas(): triggers when the driver steps on the gas

ReleaseGas(): triggers when the driver releases the gas

Increment(): triggers when the driver hits the increment button

Decrement(): triggers when the driver hits the decrement button

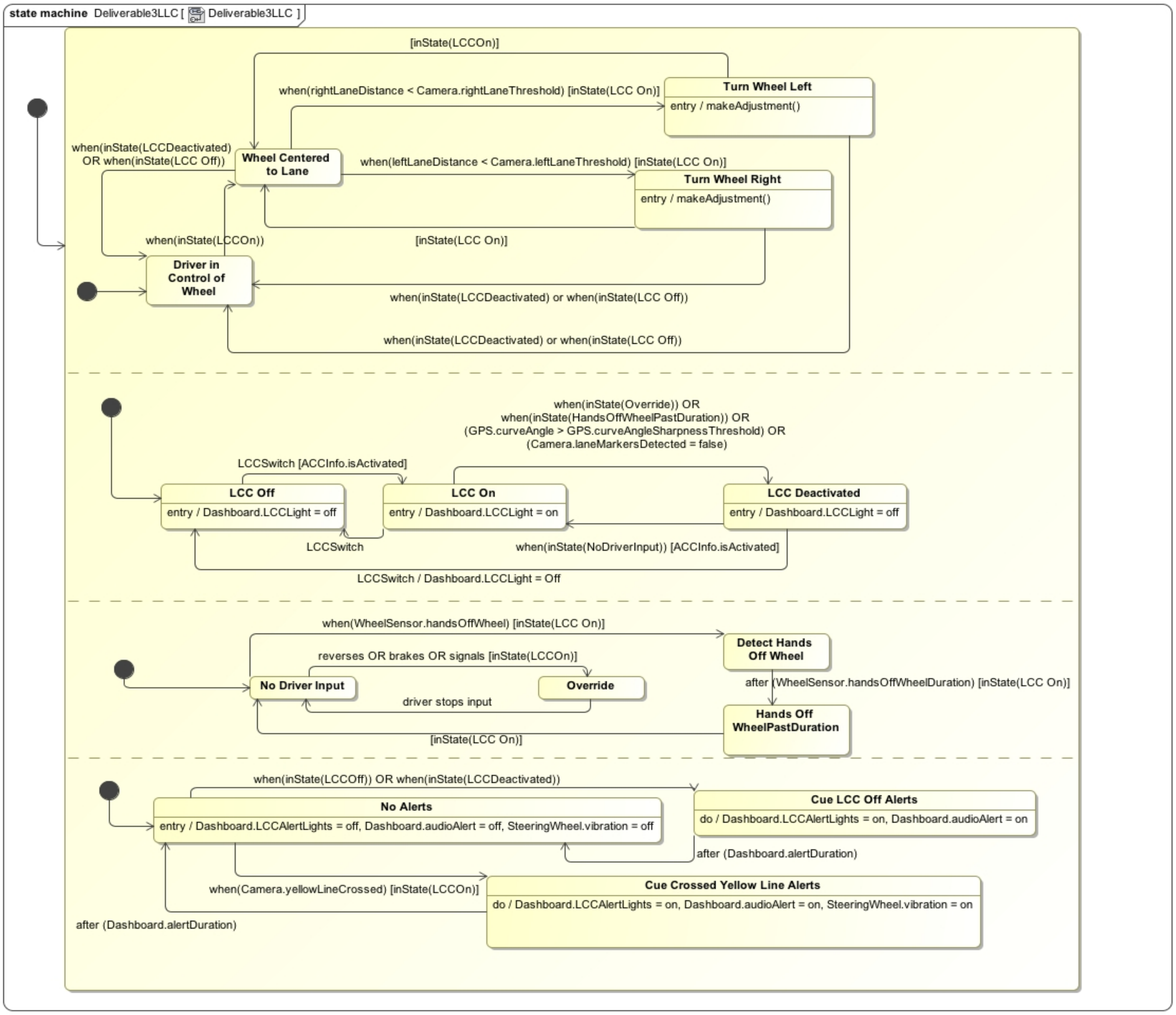


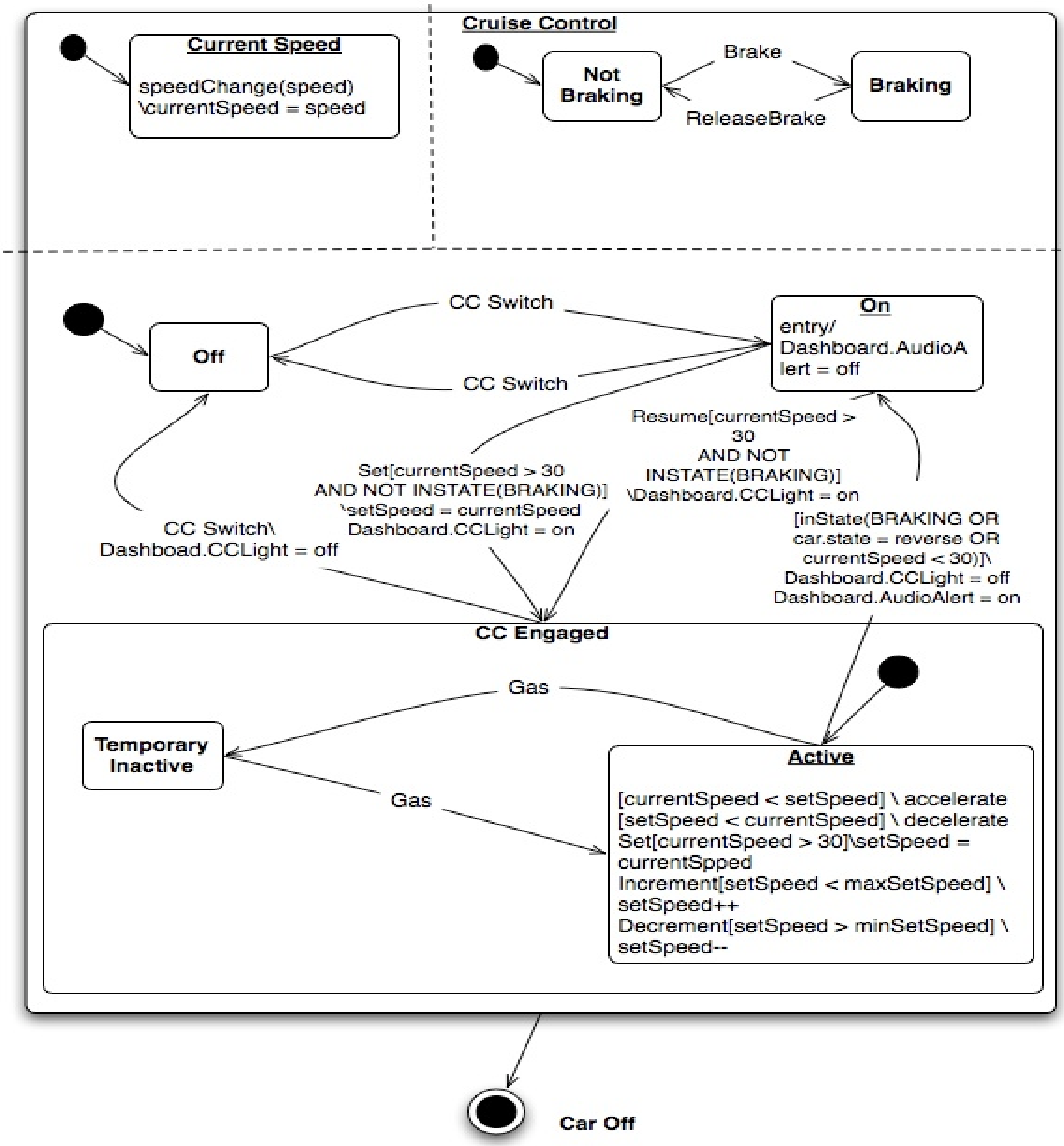
Figure D: LCC State Machine

__Variables__
rightLaneDistance: Camera.rightLaneDistance
leftLaneDistance: Camera.leftLaneDistance

__Functions__
makeAdjustments(): function that calculates the angle with which to turn the steering wheel, and then after completing the turn, counter-steers so that the vehicle is moving centered in lane.

__Events:__
LCCSwitch(): Driver switches LCC on or off
reverses(): Car.state = reverse
steers(): WheelSensor.UserOverriding = true && SteeringWheel.wheelAngle != 0

signals(): WheelSensor.signalling = true
driverReleaseInput(): Driver's manual input has stopped (brakes, steering wheel, gas etc.)



Variables:

currentSpeed(double):0...200
setSpeed(double): 30...200

Events:

SpeedChange(speed): triggers when the car's speed changes
Sensor(distnace): triggers when the distance to the car ahead changes
CC Switch(): triggers when the driver toggles the CC Switch
Set(): triggers when the driver attempts to set speed
Resume(): triggers when the driver resumes CC
Reverse(): triggers when the car is put in reverse
Brake(): triggers when the driver hits the brake
ReleaseBrake(): triggers when the driver releases the brake
Gas(): triggers when the driver steps on the gas
ReleaseGas(): triggers when the driver releases the gas
Increment(): triggers when the driver hits the increment button
Decrement(): triggers when the driver hits the decrement button

Figure E: CC State Machine

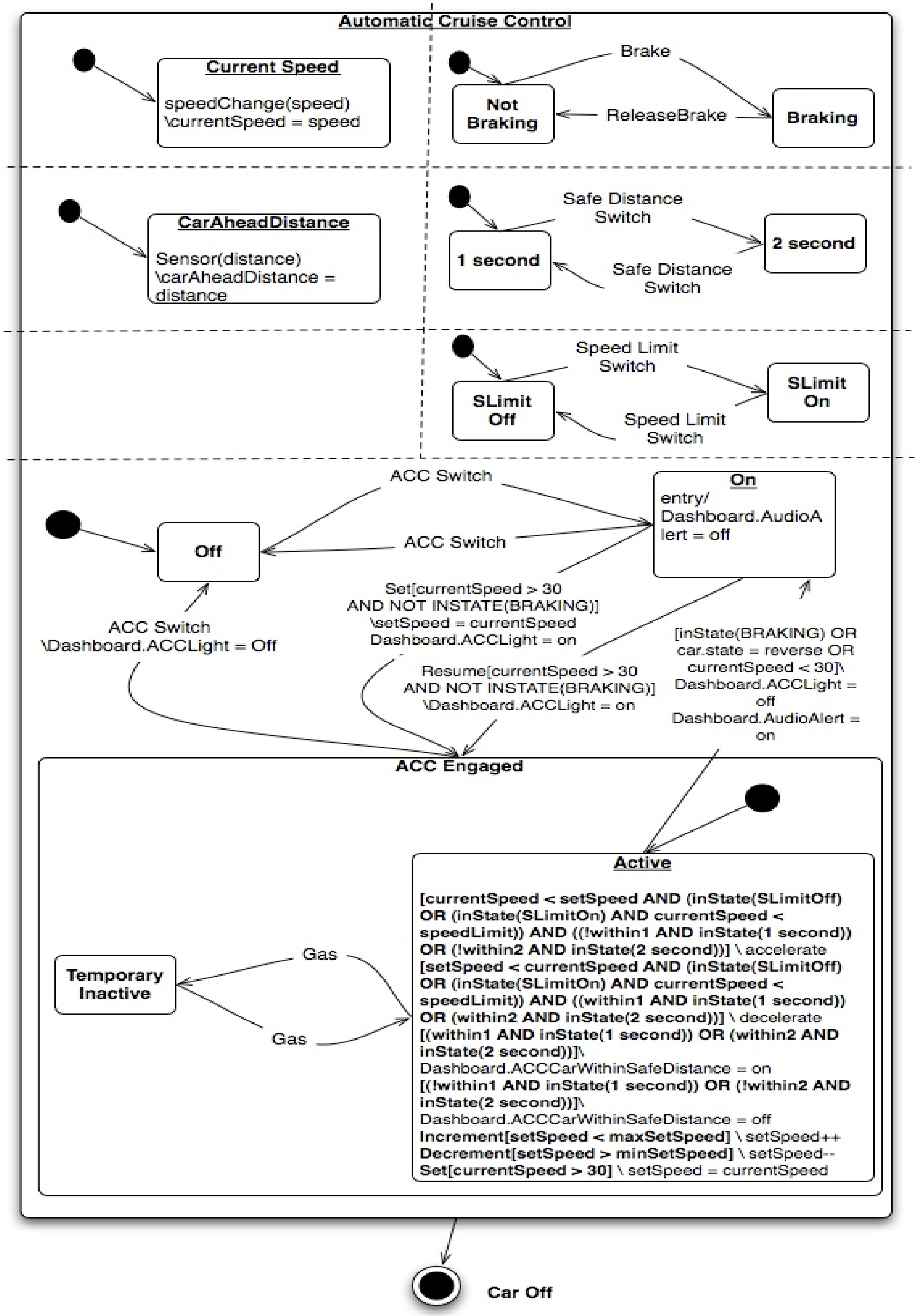


Figure F: ACC State Machine

Functions:
within1()->boolean:[currentSpeed/3600 > safeDistance]
within2()->boolean:[currentSpeed/1800 > safeDistance]

Variables:
currentSpeed(double): 0...200
setSpeed(double): 30...200
carAheadDistance(double): >=0
speedLimit(double): 30...200

Events:

SpeedChange(speed): triggers when the car's speed changes
Sensor(distnace): triggers when the distance to the car ahead changes
ACC Switch(): triggers when the driver toggles the ACC Switch
Safe Distance Switch(): triggers when the driver toggles the safe distance switch
Set(): triggers when the driver attempts to set speed
Resume(): triggers when the driver resumes ACC
Brake(): triggers when the driver hits the brake
ReleaseBrake(): triggers when the driver releases the brake
Gas(): triggers when the driver steps on the gas
ReleaseGas(): triggers when the driver releases the gas
Increment(): triggers when the driver hits the increment button
Decrement(): triggers when the driver hits the decrement button

3.3 Performance Requirements

<u>Overall</u>

- The LAD system is not concerned with any other users besides the driver
- The LAD system is designed to operate between the external temperatures of -20°C and 40°C

<u>ACC</u>

- If the ACC system is braking automatically and the driver intervenes then the system should respond immediately. The driver intervention of the accelerator pedal should not create a significant delay in the response.
- ACC deceleration brake pressure should not exceed $3m/s^2$ and acceleration shall not exceed $2m/s^2$.
- Automatic Braking should not lock brakes longer than ABS allows
- Automatic Throttle should not allow for excessive positive wheel spin for periods of time longer than allowed by the vehicle’s Traction Control.

LCC

- The camera detection method should be able to detect lane marking 90% if the time.
- The cameras should be able to process at least 15 frames per second.
- The GPS Sensors should be accurate within 30 meters
- GPS data is updated via SD card and all location information should stored locally

AHL

- The camera detection method should be able to detect changes in illumination 90% of the time
- The AHL system should responds to changes in then illumination level within 1 second

3.4 Design Constraints

- Alert lights should be red
- Buttons should have lights
- Life expectancy for the system should be the average life expectancy of a car

3.5 Quality Attributes

- After a single reading of the user manual, 90% of users should be able to correctly utilize the system

Name: ACC Deceleration
Overview: Automatic braking will only apply deceleration of up to 3 m/s^2
Maximum: 3.0m/s^2
Minimum: 3.0m/s^2
Importance: High

Name: ACC Acceleration
Overview: Automatic Cruise Control will only apply acceleration of up to 2 m/s^2
Maximum: 2.0m/s^2
Minimum: 2.0m/s^2
Importance: High

Name: LCC Lane Detection
Overview: Rate at which LCC Camera correctly determines lane markings.
Outstanding: 100%

Target: 90%
Minimum: 85%
Importance: High

Name: Light Switch Off
Overview: Time for light to switch off
Outstanding: 30 seconds
Target: 1 minute
Maximum: 5 minutes
Importance: Medium

Name: Camera FPS Rate
Overview: Rate at which cameras process frames
Outstanding: 45 fps
Target: 15 fps
Minimum: 5 fps
Importance: High

Name: GPS Distance
Overview: Distance at which GPS sensors are accurate
Target: 30 meters
Minimum: 30 meters
Importance: High

Name: AHL Sensor Response Time
Overview: Response time for sensors to detect switches in illumination
Outstanding: Fractions of seconds
Target: 0.25 seconds
Minimum: 1 second
Importance: High

Name: AHL Camera Detection Rate
Overview: Rate at which cameras correctly detect changes in illumination
Outstanding: 100%
Target: 90%
Minimum: 85%
Importance: High

Name: Curve Handling Radius
Overview: Capability of cruise control on curves with radius
Outstanding: 300m
Target: 275m
Minimum: 250m
Importance: High

Name: Alert Beep Volume

Overview: Volume of alert beeps
Target: 85 decibels
Minimum: 80 decibels
Importance: Medium

Name: LAD temperature range
Overview: Range of temperature in which LAD operates
Minimum: -20C
Maximum: 40C
Importance: High

Name: Horizontal Visibility
Overview: Horizontal visibility range
Minimum: 1km
Importance: High

Glossary

EFSM: Extended Finite State Machine

Appendix

Meeting Minutes

QA Session 1

Questions:

1. How does the driver set their cruise control value? A: Multiple methods
2. What is the allowed deviation from the cruise control speed, before CC reacts? A: 10% of the set speed is allowed overshoot
3. 'In addition, ACC reacts to traffic conditions, maintaining a safe distance from the vehicle ahead.' - What mechanisms does it use to detect traffic conditions? What is a safe distance and how does the system determine this? Can the ACC differentiate between a traffic jam (where you can afford to be closer to the next car) and regular traffic conditions? A: Radar sensor or laser sensor. Some cars can have multiple sensors. Distance is either user-set or 1-2 seconds.
4. Does the user need to initiate LCC? If not, how does LCC differentiate a lane change from accidental shifting into a lane?
5. How does LCC detect the lines on the road? A: Camera on windshield
6. When is LCC expected to react? When they are on the line or before? Should the car's speed be lowered when LCC kicks in?
7. What mechanisms are used to detect the illumination level?
8. At what level of illumination should automatic headlights be turned on/off?
9. What is closest a car may be for which the high-beams are allowed to be on A: Illumination threshold is constant and cannot be set by driver. Distance is 150m for approaching car or car driving in front
10. Is the same mechanism for determining distance with ACC used for detecting distance to the vehicle ahead or nearest oncoming car (when considering high-beams)? If not, how are the mechanisms used for automatic headlights different?
11. What are the realtime constraints for each of the systems?
12. Can all of the systems be used at once? A: no, ACC cannot be used if CC is turned on
13. What should happen when there are no lane markings, and other unexpected conditions (like snow)?
14. If something fails, how does the system alert and return control to the user?
15. Does the ACC maintain the car's speed at the speed limit or traffic speed? What if traffic is moving faster than the speed limit? A: minimum of speed limit and set speed
16. If the lane ends up ahead, how does the LCC correctly predict this and merge into another lane safely? A: It doesn't

Question:

Q: How should the car behave with slippery road conditions in relation to CC and ACC?
A: The CC and ACC systems do not take weather conditions into account. LCC and automatic headlights use cameras for detection. Cameras maybe affected by weather conditions

Q: What is the allowed deviation from the cruise control speed? It's called overshoot.
A: 10% of desired speed is the overshoot threshold. Cruise control can be temporarily overridden by the driver when they step on the pedals/brakes

Q: What knowledge does the car have of things like signs etc.
A: There s a version of adaptive CC that takes speed limits into account. It's called dynamic set speed. Uses GPS. If you reach a point where the set speed is higher than the speed limit then it will use the speed limit. Always picks minimum of set speed and speed limit. Road signs are not taken into account.

Q: What would happen if there is an emergency vehicle present.
A: CC and ACC do not detect emergency vehicles.

Q: Does the camera do anything other than detecting the vehicle ahead.
A: Yes it detects lane markings. Front, top of the windshield.

Q: What if you can only see one side of the lane marking?
A: Does not require both lane markings. If only one side is known, the lane centering is based on whatever is visible

Q: If the driver decides to change the lanes how does that affect CC?
A: Neither CC or ACC take steering into account. Lane centering is affected. Lane centering will deactivate. If they use their left or right lane change signals it deactivates lane centering until the signals are turned off.

Q: Does LCC recognize lane closures.
A: No.

Q: Do any of these features exist on a manual transmission car?
A: CC does but not ACC.

Q: What is the sensor for the lighting feature and where is it located?
A: Photo-electric sensor located at the base of the windshield under defogger grill.

Q: Are there any other special conditions?
A: CC downhill taken into account.

Q:
A: Optional ON/OFF button for whether or not CC can be enabled. To activate it there are multiple methods. Braking disables it.

Q: Will ACC stop your car completely?
A: ACC will detect when a car is stopping and within distance that is specified by driver

Q: How is ACC distance tracked?
A: By time. 1 second or two seconds.

Q: Should CC or ACC or LC work in reverse?
A: No. 60km/h minimum speed as well (LCC only).

Q: What level of illumination will cause the sensors to turn on the lights?
A: Sensor sensitivity is constant and not adjustable by the driver. The lights should switch on when it's dark around dusk.

Q: How far does an approaching car have to be for it to turn off the high-beams?
A: 150m. Both oncoming and cars driving in front

Q: What kind of output interfaces are there?
A: CC and ACC have a visual display as well as audio warning tones. The display for basic CC it shows you the set desired speed for 5 seconds. When CC is deactivated it will sound a tone and it will also display the message for 5 seconds again. For ACC, it will visually warn you if a vehicle is ahead. It also has forward collision warning. This happens if it can't maintain the distance you specified. It will warn you with both sounds and display. LC there is both an audio warning and a visual warning and a vibration warning (through the steering wheel if you pass a solid yellow line). For automatic headlights they just turn on/off when a vehicle is approaching.

Q: For LC, does it matter how big the size of the vehicle is?
A: No.

Q: Can the driver update the speed limit data?
A: Yes.

Q: CC that deals with curves?
A: Yes, it will get it's data from GPS to slow you down before turning.

Q: For CC, can you set it to any speed?
A: No, 30km/h is the lower limit.

Q: ACC from stationary?
A: Press brake until you stop behind a car. If you release your foot off the break. If the car ahead of you starts moving and you hit the gas you'll follow the car.

Q: How does the vehicle detect the distance ahead?
A: Uses a sensor. Two kinds: radar (150m) and laser (unknown range), and camera. Could have one or multiple sensors.

Q: How can the sensors work when you turn?
A: Could be errors. Sensors are limited.

Q: What are the conditions under which LCC activates?
A: LCC deactivates when: you change lanes, turn, markings become unclear, speed goes under 60km/h.

Q: Does LCC it affect the cars speed?
A: Yes.

Q: Can LCC and CC be activated at once?
A: Yes. And you must have ACC to have LCC. LCC automatically enables ACC.

Q: Is the automatic headlight feature weather dependent or dependent or any other feature?
A: yes for weather, no for the rest.

Q: What is the sensitivity involved with LCC?
A: LCC warns you if your hands are off the wheel.

Q: When are high-beams allowed to be used?
A: When moving forward. Automatic headlights enables low beams when moving in reverse.

Q: If the car ahead of you speeds up will ACC speed up?
A: Yes, but only to the minimum of the speed limit or set speed

QA Session #2

Q1. What alerts does LCC give to the driver?
There will be a light on the dashboard when LCC is on. When LCC turns off, the light will turn off as well as audio alerts to driver

Q2. Do adaptive lights turn on right when the ACC turns on?
Lights will still turn on based on sensor

Q. The range of ACC lasers?
A. unknown right now

Q3. What dependencies exist between the system?
A. ACC must be active for LCC to work

Q4. Are there different thresholds for turning on low-beams vs high-beams
A. low beams will always be on between dusk and dawn. High-beams are only turned on when visibility is low.

Q5. When automatic headlights is initiated are low-beams are set by default?
A. No, the low-beams will only turn on when they are needed and similarly for high-beams. If neither situations are met, neither are turned on

Q6. How to represent thresholds for low-beams and high-beams?
A. use low_threshold and high_threshold (variables)

Q7. What is the interface for turning on different features of ACC?
A. Option for recognizing speed limits and option for using curve control feature of ACC

Q8. Two ways to set CC?
A1. Accelerate to a certain speed (Above 30 km/h) and then set cc to that speed (it will now maintain that speed)
A2. Accelerates (decelerates) to previously set CC speed.
A2. Is not correct. Resume from a stored speed. If the resume stored speed functionality is invoked and there is not set speed, CC will assume you want to set the current speed as the CC speed

Q9. If ACC slows down to below 30km/h to adapt to a slower car will ACC accelerate when the car ahead speeds up.
A. It will accelerate back up to the set speed or whatever it can

Q10. Will ACC stop the car if it detects a car ahead slowing down?
A. Will react to a car slowing down and issue a warning to the driver and stop if necessary. It will not issue a warning or react if the car ahead is completely stopped.

Q11. Can ACC be engaged when you are stopped?

A. Yes, activate ACC and accelerate causes ACC to be engaged

Note: Some cars have on/off switch for ACC/CC, cars without this switch are assumed to have ACC/CC always on.
Note: When ACC/LCC are engaged, the pedals and or steering wheel may move on their own

For ACC/CC/LCC any user action will temporarily pause the features.
Not entirely true. Steering is not an input to LCC. Pressing brake pedal while (A)CC is engaged will deactivate it (unlike trottle that will temporarily deactivate it.)

Q12. If LCC is engaged and the driver takes their hands off the wheel what happens?
A. LCC alerts driver and disengages
I hope you know how to model this answer, :D. Please get the right answer to this questions as was stated in the meeting.

Q13. How does the automatic headlight feature differentiate between a oncoming car and daylight illumination?
A. Camera used for detecting oncoming cars. Some error threshold for which it will incorrectly diagnose daylight illumination for an oncoming car.

Q14. Are the sensors isolated to their respective feature?
A. Some may or may not depending of the information being sensed.

Q15. What happens when you start ACC with speed limit option and there is no saved speed?
A. Speed limit option cannot be started until there is a stored speed
Speed limit of a road is obtained from a GPS when available. There is nothing like a saved speed for speed limit functionality.

Notes: LCC will not operate on: tight curves, poorly visible or non-visible lanes, user’s hand are off the steering wheel

QA Session 3:

Disabled drivers? No

Assumption that the driver will read the manual before using the system.

Are there any performance requirements imposed on the system? ACC. 1 - If the ACC system is braking automatically and the driver intervenes then the system should respond within The driver intervention of the accelerator pedal should not create a significant delay in the response.

ACC response time for braking reaction time - not specified

ACC deceleration shall brake pressure should not exceed 3m/s^2 and acceleration shall not exceed 2m/s^2.

For LCC - The camera detection method should be able to detect lane marking 90% if the time.

It can take up to 5 minutes for the light to switch off.

Are we concerned with any other users besides the driver. No.

Can we assume that the hardware will react to the software commands? Yes.

Should we be designing the system to be modular and upgradable? Yes.

Upgrades happen at the dealership.
Are there any specific instructions on fault tolerance?

Highway Traffic Act Section 62 - specifies restrictions on lights.

Restrictions on the cost of the system - No restrictions.

Life expectancy of the system - whatever the life expectancy of a car is for both the software and the hardware.

On average the cameras process 15 frames per second. Some do 45 per second.

GPS sensors - How accurate? 30 meters.

What’s the maximum response time for the auto headlights? Sensor can detect the change within fractions of a second but the switching has a 1 second allowable response time.

Assumption: All of these systems should act concurrently. (Except ACC and CC)

Response time for automatic headlight camera sensors? 1 second

GPS and updating - Data updated via sd card. Storing the data locally.

How accurately will the light sensor be able to detect changes in light? 90% of the time.

How many decibels should the beeping sound be - 85

How easy is it for the driver to learn to use the features? After a single reading or the manual 90% of the users are able to correctly use the system

Driver assumptions:
- driver is alert
- watching road conditions
-can brake or accelerate at any time
-knows how to use the features

AHL - LCC
- only an aid, driver is ultimately responsible

The capability of cruise control on curves is for curves of radius >= 250m

Automatic braking should not lock brakes longer than ABS allows

Same for automatic throttle on ACC, shouldnt allow for excessive positive wheel spin for periods of time longer than traction control allows.

ACC and CC
- road is flat, dry or asphalt
- temperature range is 40C and -20C
- horizontal visibility range is greater than 1km

Aesthetics of the interface
- lights should be red
- buttons with lights for other features