Software Requirements Specification (SRS)

FSRACC1

Authors: Yutaka Iwasaki, Carl Johnson, Usman Majeed, Nicholas Rutowski, Nicholas Saxton

Customer: Dr. Rami Debouk, General Motors

Instructor: Dr. Betty H.C. Cheng

1 Introduction

This document is the software requirements specification (SRS) for a Full Speed Range Adaptive Cruise Control (FSRACC) system to be used in vehicles designed and manufactured by General Motors. This document begins with the current section, the introduction, before moving on to a detailed look at the product, including an overall description of the system, its specific requirements, the requirements used in modeling it, and an overview of its prototype. More information regarding the organization and contents of this document may be found below in Section 1.4.

1.1 Purpose

The purpose of the SRS is to outline the requirements for the FSRACC system. FSRACC will be used as an operator convenience feature in vehicles designed and manufactured by General Motors. This document is intended for both the customer and developers of the system.

1.2 Scope

The product specified in this document is a FSRACC system. It is to be used as a operator convenience feature in General Motors vehicles. It functions as an embedded system in the automotive systems domain.

When engaged, the FSRACC system will allow the operator to set a speed and desired following distance from a forward vehicle, which will then be maintained by the FSRACC controller. The system is designed for the operator’s convenience and vehicles equipped with this system should not be considered automated in any way. Ultimately, the operator is expected to remain cognizant of what is happening while they are driving.
1.3 Definitions, acronyms, and abbreviations

The following is a list of definitions and acronyms used throughout the document.

- **ACC: Adaptive Cruise Control** - the precursor to FSRACC, adaptive cruise control allows the operator to set a follow distance between their vehicle and any forward vehicle, which is then maintained by the system.
- **Active** - the term used to denote that the FSRACC system is turned on and capable of being engaged.
- **Cruise speed** - the speed the subject vehicle will attempt to maintain, chosen when the system is engaged.
- **Controller** - the main module of the system responsible for taking input from the vehicle’s sensors and the operator and then using said input to determine forward threats and to maintain longitudinal control of the vehicle.
- **Operator Convenience Feature** - a feature intended to reduce the stresses of driving for the operator. These features do not remove the responsibility of driving from the operator.
- **DTC: Dynamic Trouble Call** - when an error in the FSRACC system occurs a message detailing what occurred and the conditions is issued to the controller.
- **Engaged** - the term used to denote that the FSRACC system is currently in use, maintaining the subject vehicle speed and follow distance as set by the operator.
- **Follow distance** - the distance between the subject vehicle and the forward vehicle, chosen by the operator when the system is engaged.
- **Forward radar** - a special sensor mounted on the front of the subject vehicle that is capable of detecting the position of forward objects up to 100m away.
- **Forward vehicle** - the vehicle in front of the subject vehicle from which the follow distance applies.
- **FSRACC: Full Speed Range Adaptive Cruise Control** - an enhancement of ACC, full speed range adaptive cruise control not only maintains the follow distance selected by the operator, but is also capable of bringing the vehicle to a full stop if the forward vehicle also comes to a full stop.
- **Go Notifier** - if the FSRACC brings the vehicle to a full stop the system will wait until it receives a go notifier from the operator. The operator tapping the accelerator pedal is a typical go notifier.
- **HMI: Human Machine Interface** - a sub-system of the overall system that allows the exchange of information between the operator of the subject vehicle and the controller of the system.
- **IMU: Inertial Moment Unit** - a special sensor inside the body of the vehicle that collects information used by the system’s path prediction algorithm.
- **Path prediction** - an algorithm taking input from the IMU and wheel sensors that determines the path that the subject vehicle is currently on, which is used in conjunction with the forward radar by the controller to determine forward threats.
- **Subject vehicle** - the vehicle containing the FSRACC system.
1.4 Organization

The remainder of this document provides a more detailed view of the different aspects of the project. Section 2 gives insight into the product whose requirements this document describes. This section includes discussion on the perspective of the product which examines how the product functions as part of a larger system. It goes on to discuss the intended functions of the product, the characteristics of the eventual user of the product, the constraints placed on the product, the assumptions that were made during the development of the product, and finally, the product requirements that were determined to be beyond the scope of this version of the product.

Section 3 of this document provides an enumerated list of requirements for the product. It introduces a hierarchy to better convey how requirements fit together and depend upon each other.

Section 4 provides the modeling requirements for the product. This section contains several different types of diagrams related to the product: a use case diagram, a domain model for the system, multiple sequence diagrams, and several state diagrams. This section is intended to provide graphical representations of the components of the product along with specific scenarios that the product is expected to undergo.

Section 5 examines the prototype of the product. This section provides instructions on where to find and how to operate the prototype. It also gives several sample scenarios that have been demonstrated on the prototype.

Finally, Section 6 contains all of the information related to the documents referenced throughout this specification, while Section 7 provides a point of contact for individuals looking to garner further information about the product.
2 Overall Description
This section will discuss FSRACC in depth. It will cover the functionality of the system as well as the constraints, characteristics of users, assumptions, dependencies, and appropriating the requirements.

2.1 Product Perspective
FSRACC is a system that is developed to assist the users in speed control of a moving vehicle. It is developed to maintain a set distance between the forward vehicle automatically and to create more comfortable atmosphere for the user.

- Overall function of the system is explained in section 2.2.
- User characteristics when using the system is explained in section 2.3.
- The constraints for this system will be discussed in section 2.4.
- What is assumed and depended from the system is covered in section 2.5.
- Possible future version update is covered in section 2.6.

2.2 Product Functions
This section explains the overall functions of the system and what the system is capable of doing.

- The system has three states:
  - Off-state
  - Active-state
  - Engaged-state
- When FSRACC is engaged:
  - FSRACC maintains the cruise speed the user inputs.
  - The system will adjust the speed when the radar detects a car that is set distance away. The system will slow down so it maintains the set distance.
  - If the car that the user is following changes the lane, it means the car is no longer in front so the vehicle speeds back to the original speed until the radar detects a different car.
  - If a car merges between the user and the forward vehicle, the FSRACC readjusts the speed and the distance to the car that is newly in front of the user.
  - Applying the gas manually while FSRACC is engaged is considered a temporary override of the system. If the user is no longer manually accelerating, the FSRACC automatically makes the car go back to the speed the user set initially.
  - Applying the brakes is considered a full override and deactivates the system.
  - The system will display the cruise speed and the trailing distance to the user.
- When the FSRACC fails, the system will notify the operator by buzzing the seats/handle and turn off automatically.
- Path prediction is achieved using the radar and the car in front.

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2.3 User Characteristics

This section covers what is expected from the user when using the FSRACC.

- The user must be legally able to drive.
- The user must be capable of driving the vehicle.
- The user must fully understand the system prior to use.

2.4 Constraints

This section covers the limits and constraints of the system and explain how the system will respond.

- The front sensor detection range is a maximum of 80 meters.
- The front sensor only detects objects that are in the frontal path of the car.
- If the radar detects something that is blocking the readings, the FSRACC will shut down and notify the operator.
- If radar returns unsafe results to the system when the user presses the activate button, the system does not activate.
- If the radar returns unsafe results to the system when the system is on engage mode, the system turns off, giving the user an error message.
- When FSRACC is engaged and the forward vehicle goes stationary, the user needs to hit gas or hit button in order to start accelerating when the forward vehicle moves forward.
- The system will not go above the cruise speed the user sets when he/she engages the FSRACC.

2.5 Assumptions and Dependencies

This section explains what users should expect from the system, mainly for safety precautions.

- FSRACC only works if the radar returns safe results. It cannot operate under environment that causes the radar to give false results.
- It is assumed that the user is attentive to the road. This system is created to assist the operator, but it is the operator’s judgement in all cases.
- Deactivating the FSRACC will not result in the car stopping.

2.6 Appropriating the Requirements

This section covers what can be expected from future update of the system.

- Only the front of the vehicle is being focused for this project. For future versions, the project may focus on rear/side of the car to enhance the awareness of surroundings.
- The vehicle does not stop when it detects an object that is stationary or driving in low velocity that might lead to an accident. Future versions might prevent potential collisions by slowing down or stopping beforehand.
3 Specific Requirements

The following section enumerates the requirements of the system. High level requirements form the roots of the list and composed of more specific component requirements.

1. System has three states of normal operation  
   a. Off  
   b. Active, disengaged  
   c. Engaged  
2. In the event of a DTC that signifies failure FSRACC returns control to the operator  
3. If the system must return control to operator unexpectedly it will issue a warning  
4. The system has three primary sensors available to it  
   a. Front mounted Radar/Lidar returns forward object distance data  
   b. Speedometer returns the speed of the subject vehicle  
   c. Inertial Moment Unit  
5. The system runs diagnostic tests  
   a. When the system moves from disabled to active a diagnostic check will be run  
   b. When the system is active sensors periodically run diagnostics  
   c. If no diagnostic errors are returned proceed to enabled state, the light by the button turns green  
   d. If any diagnostics return errors do not enable system  
   e. If the system is enabled and diagnostic errors are returned disable the system  
   f. In the event of an error a DTC will be submitted to the controller  
6. FSRACC controller gathers decision making information  
   a. Detect Forward Vehicle  
      i. Detect forward vehicle distance  
      ii. Calculate forward vehicle speed  
   b. Receive input from several sensors placed throughout the vehicle  
   c. Collect operator input through HMI  
      i. Activate FSRACC  
      ii. Engage/Disengage FSRACC  
         1. The system will not engage if the vehicle is traveling above a speed threshold of 90 mph  
         2. system can be disengaged via the engage toggle switch  
         3. system can be disengaged via braking  
      iii. Disable FSRACC via activate toggle switch  

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iv. cruise speed
   1. System is set to the speed the vehicle was traveling at when system was engaged
   2. While engaged the speed may be increased or lowered via console buttons
v. operator accelerating while system is active is considered a temporary override and will not disable the system or change the cruise speed
vi. Set trailing distance
vii. The trailing distances available for selection will allow adequate space for the vehicle or operator to react to unexpected deceleration of the forward vehicle

7. FSRACC controller uses decision making information to make control decisions
   a. Predict Subject Vehicle Path
   b. Maintain operator specified speed
   c. Match speed of forward vehicle
      i. Maintain operator specified distance
         1. Decelerate to increase follow distance
         2. Accelerate if the subject vehicle is traveling slower than the forward vehicle and is farther than the follow distance
      ii. Return to maintaining operator specified speed if forward vehicle speed is greater or no forward vehicle is present
d. Bring vehicle to cruise speed from stop
e. Bring vehicle to a stop behind forward vehicle
   i. If the subject vehicle is held at stop beyond a threshold of 3 seconds, hold vehicle at stop until the operator provides a Go Notifier
   ii. If the vehicle is held at stop for less than the 3 second threshold resume forward motion when forward vehicle accelerates
f. Detect failure condition and change to failure state

8. FSRACC carries out control decisions using the vehicles actuators
   a. Brakes provide rapid deceleration
   b. Throttle provides acceleration/deceleration by being engaged/disengaged

9. System displays system status variables to the operator
   a. Notify operator when FSRACC is enabled
   b. Display cruise speed
   c. Display trailing distance
   d. Notify operator of component failure
      i. The system must be able to detect the failure of the forward-facing radar system
      ii. The system must be able to detect the failure of the path prediction algorithm and its requisite sensors
      iii. The system must be able to detect the failure of the actuators necessary in controlling the speed and trailing distance of the subject vehicle
4  **Modeling Requirements**

This sections models the system using common Unified Modeling Languages diagrams. First, the high level requirements are related using a use case diagram. Next, a class model captures the functional relationships of the components of the system. Next, common scenarios are modeled using sequence diagrams. Finally, state diagrams of key components are provided to further describe their functionality.

The use case diagram, shown in Figure 4.1, describes high level requirements of a system. The use case diagram is followed by a text description of each use case detailing its dependencies and what requirements it satisfies. The components of a use case diagram are as follows:

- System boundary - represented by a shaded rectangle - a container that represents what content is part of the system
- Actors - represented by stick figures - an entity outside the system boundary that interacts with the system
- Use case - represented by an oval - a high level usage requirement
- Association - represented by a straight line - relates an actor to a use case
- Include - represented by a dotted arrow line labeled “include” - relates a use case to another use case that is part of its functionality
- Extend - represented by a dotted arrow line labeled “extend” - relates a use case to another use case that extends its functionality

Template based on IEEE Std 830-1998 for SRS. Modifications (content and ordering of information) have been made by Betty H.C. Cheng, Michigan State University (chengb at chengb.cse.msu.edu)
Figure 4.1: The use case diagram for the FSRACC

Template based on IEEE Std 830-1998 for SRS. Modifications (content and ordering of information) have been made by Betty H.C. Cheng, Michigan State University (chengb at chengb.cse.msu.edu)
Use Case: HMI allows operator to interact with system
Actors: operator
Description: operator can adjust settings and check the status of the FSRACC
Type: Primary
Includes: Set Trailing Distance, Set Cruise Speed, Operator can control system state
Extends: N/A
Cross-refs: 6.c
Use cases: N/A

Use Case: Set Trailing Distance
Actors: N/A
Description: HMI allows operator to select a trailing distance for the system to use
Type: Primary
Includes: N/A
Extends: N/A
Cross-refs: 6.c.vi, 6.c.vii
Use cases: HMI allows operator to interact with system

Use Case: Set Cruise Speed
Actors: N/A
Description: HMI allows operator to select a cruise speed for the system to use
Type: Primary
Includes: N/A
Extends: N/A
Cross-refs: 9.c.iv
Use cases: HMI allows operator to interact with system

Use Case: Operator can control system state
Actors: N/A
Description: HMI allows operator to Enable and Disable the system as well as Engage/Diengage its functionality
Type: Primary
Includes: Enable system, Disable System, Engage system, Disengage system
Extends: N/A
Cross-refs: 6.c.i, 6.c.ii, 6.c.iii
Use cases: HMI allows operator to interact with system

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Use Case: Disable system
Actors: N/A
Description: Take the system offline, the system cannot be engaged. If system is engaged, disengage it.
Type: Primary
Includes: Disengage system
Extends: N/A
Cross-refs: 6.c.iii, 1.a
Use cases: Operator can control system state, System failure

Use Case: Disengage system
Actors: N/A
Description: Return control of vehicle to the operator, controller no longer commands actuators.
Type: Primary
Includes: N/A
Extends: N/A
Cross-refs: 6.c.ii, 1.b
Use cases: Operator can control system state, Disable system, Brakes engaged by operator

Use Case: Activate system
Actors: N/A
Description: Make system available to be engaged, run diagnostics
Type: Primary
Includes: Run Diagnostics
Extends: N/A
Cross-refs: 6.c.i, 1.b, 5.a
Use cases: Operator can control system state

Use Case: Engage system
Actors: N/A
Description: Allow controller to use actuators to affect vehicle motion
Type: Primary
Includes: Make control decisions
Extends: N/A
Cross-refs: 6.c.ii, 1.c
Use cases: Operator can control system state

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Use Case: System failure
Actors: N/A
Description: A DTC indicating an error is detected, disable system, return control to operator, and sound an alarm.
Type: Primary
Includes: Disable system, Sound Alarm
Extends: N/A
Cross-refts: 2, 9.d
Use cases: Submit DTC

Use Case: Sound alarm
Actors: Alarm
Description: Sound a warning alarm to alert operator
Type: Primary
Includes: N/A
Extends: N/A
Cross-refts: 3, 9.d
Use cases: System failure

Use Case: Run Diagnostics
Actors: Sensors
Description: Run diagnostics on sensors and issue a DTC if errors are detected
Type: Primary
Includes: Submit DTC
Extends: N/A
Cross-refts: 5.c, 5.d, 5.f, 7.f
Use cases: Enable system, Make control decisions

Use Case: Make control decisions
Actors: N/A
Description: Use gathered data to determine which actuators to enable to affect vehicle motion
Type: Primary
Includes: Run Diagnostics, Stop vehicle, Maintain cruise speed, Display status to operator, Predict subject vehicle path, Detect forward vehicle
Extends: N/A
Cross-refts: 6.b, 7
Use cases: Engage system

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Use Case: Detect forward vehicle
Actors: Sensors
Description: Query sensors to detect the forward vehicle speed and distance
Type: Primary
Includes: N/A
Extends: N/A
Cross-refs: 6.a, 4.a
Use cases: Make control decisions

Use Case: Predict subject vehicle path
Actors: Sensors
Description: Query sensors to detect subject vehicles speed and projected path
Type: Primary
Includes: N/A
Extends: N/A
Cross-refs: 4.b, 4.c, 7.a
Use cases: Make control decisions

Use Case: Submit DTC
Actors: N/A
Description: Submit and evaluate a DTC, if it indicates a failure condition initiate system failure.
Type: Primary
Includes: System Failure
Extends: N/A
Cross-refs: 5.e, 9.i, 9.ii
Use cases: Run diagnostics

Use Case: Display status to operator
Actors: operator
Description: Output status information to a display for operator consumption
Type: Primary
Includes: N/A
Extends: N/A
Cross-refs: 9.a, 9.b, 9.c
Use cases: Make control decisions

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**Use Case:** Maintain cruise speed  
**Actors:** Throttle  
**Description:** Maintain the speed selected by operator as along as it does not conflict with the forward vehicle speed  
**Type:** Primary  
**Includes:** N/A  
**Extends:** N/A  
**Cross-refs:** 7.b, 7.d, 8.b  
**Use cases:** Make control decisions, Match forward vehicle speed

**Use Case:** Match forward vehicle speed  
**Actors:** Throttle  
**Description:** If forward vehicle speed is less than cruise speed, match it  
**Type:** Primary  
**Includes:** N/A  
**Extends:** Maintain cruise speed  
**Cross-refs:** 7.c  
**Use cases:** N/A

**Use Case:** Stop Vehicle  
**Actors:** Brakes  
**Description:** Bring the subject vehicle to a stop behind the forward vehicle  
**Type:** Primary  
**Includes:** Hold vehicle at stop  
**Extends:** N/A  
**Cross-refs:** 7.e, 8.a  
**Use cases:** Make control decisions

**Use Case:** Hold vehicle at stop  
**Actors:** Brakes  
**Description:** Hold the vehicle at stop until a go notifier is received  
**Type:** Primary  
**Includes:** N/A  
**Extends:** N/A  
**Cross-refs:** 7.e.ii  
**Use cases:** Stop vehicle

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Use Case: Hold vehicle at stop
Actors: Brakes
Description: Hold the vehicle at stop until a go notifier is received
Type: Primary
Includes: Disengage system
Extends: N/A
Cross-refs: 6.c.ii.3
Use cases: N/A
The class diagram, shown in Figure 4.2, captures the functional capabilities and relationships of the system. Its components are:

- **Class** - represented by a rectangle, class name is represented by the bold text at its top, attributes are prefixed by a “-” and functions are prefixed by “+”.
- **Associations** - represented by a straight line, at either end of the line the multiplicity and relationship that relates the 2 classes.
- **Inheritance** - represented by a line capped by an arrow, denotes that the class that is on the non-arrow end inherits the properties of the class on the arrow end.
- **Aggregation** - represented by a line capped by an empty diamond, denotes that the class on the capped end is an element that can compose the other class.
- **Composition** - represented by a line capped by a filled diamond, denotes that the class on the capped end is an element that is an essential component of the other.

![Class Diagram](image)

**Figure 4.2**: The class diagram for the FSRACC

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The sequence diagrams capture the relationship of classes over the passage of time. The components are as follows:

- Lifeline, represented by a rectangle with a dotted line extended downwards, denotes the instantiation of a class over time.
- Message, represented by a line capped with an arrow, denotes a message from one class life line to another.

Enable and Engage FSRACC

![Enable and Engage FSRACC Diagram]

Maintain follow distance

![Maintain follow distance Diagram]

Figure 4.3A : Enable and engage sequence diagram for the FSRACC

Figure 4.3B : Maintain follow distance sequence diagram for the FSRACC

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Display system status

Figure 4.3C: Display system status sequence diagram for the FSRACC

Handle a DTC

Figure 4.3D: Handle a DTC sequence diagram for the FSRACC

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State diagrams capture all possible behavior of a single class. The notation is as follows:

- **State** - represented by a rectangle with rounded corners, denotes a state that the class can occupy. Can contain entry, do, and exit statements that denote what functions should be called in that state.
- **Transition** - represented by a line capped by an arrow, the transition shows a movement from one state to another. It is labeled with a function or condition that causes the condition. Additionally, a guard condition can be enclosed in square brackets “[]” and messages sent during the transition appear after the condition and a “/”.
- **Initial state** - represented by a filled circle with an arrow to a state, shows the state that the system begins in.

**Controller**

![State diagram for the controller](image)

Figure 4.4: State diagram for the controller

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Figure 4.4A: State Diagram when the system is engaged

Throttle

Figure 4.5: Throttle state diagram

Brake

Figure 4.6: Brake state diagram

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Figure 4.7: Sensor state diagram.
5  Prototype

This section describes the FSRACC prototype, including an in depth procedure of how to run it and it’s features. The main point of the prototype is to provide a rough outline of how the final product will function, so that the client can clear up any miscommunication or flaws.

Our prototype is a web application, and it has two main parts. On the left side of the page it will show the dashboard, and the right side will show the demo, which includes a road divided by yellow stripes. The subject vehicle and the forward vehicle will be driving on the right side of the road.

5.1 How to Run Prototype

This section describes all of the tools and dependencies needed to run the prototype. Fortunately, it is a web application, so there are very few technologies needed. To run the prototype, go to https://www.cse.msu.edu/~cse435/Projects/F2014/Groups/FSRACC1/web/prototype.html in an updated version of a modern browser (Chrome, Firefox, Internet Explorer).

The figure above is the dashboard that is used to run the prototype. These inputs and outputs are correlated directly with the demo. The following enumerated list below depicts the functionality of each aspect in the dashboard.

1. **Speed Up:** Increases the speed of the subject vehicle (Maximum is 90mph)
2. **On:** The engage button turns on the FSRACC System, and when this button is pressed it turns yellow, indicating the system is on, and portrays a radar graphic on the subject vehicle, signaling the radar is on.
3. **Speed Down:** Decreases the speed of the subject vehicle (Minimum is 60mph)
4. **Car Length:** These three buttons specify how far the driver wants to trail the forward vehicle when FSRACC is turned on. Default is one car length.

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5. **Actual Speed:** The current, real-time, speed of the subject vehicle (initial is 65mph)
6. **Cruise Speed:** The user-input set cruise control speed (initial is 65mph)
7. **Forward Car Speed:** The constant speed of the forward vehicle. This does change throughout the demonstration.
8. **Change Lane:** Moves the subject vehicle into the left lane. A prototype limitation has been created that disables this button until the demonstration starts.
9. **Start Demo:** Starts the prototype demonstration. All buttons and features remain active after the demo is started.
10. **Reset Demo:** Reloads the page, which resets all variables and inputs.
11. **Add Forward Car:** Initially, there is no forward car shown. Once this button is pressed, a forward car appears in front of the subject vehicle. This button disables after use, as a prototype limitation is that there cannot be more than one forward vehicle.

### 5.2 Sample Scenarios

This section depicts the scenarios that can be drawn from the prototype, to better understand the system. There is no menu for selecting a set scenario, but the user has a wide variety of inputs he/she can use to create one. There are many more scenarios that can be created using the demo, these are only few to show some basic functions of the prototype.

This scenario is made with driver speed at any speed higher than the initial setting, clicking the On button, the Add Forward Car button, choosing the 1 car length button, and hitting Start Demo. The subject vehicle appears to be moving at a constant speed until it sees the forward vehicle and slows down to the forward vehicle’s speed. On the dashboard, it changes the actual speed to 65 mph, where the cruise speed is still the same as what it was set at, in case the forward car ever gets out of the view, the subject vehicle can revert back to it’s set speed.

This scenario is a continuation of the first. On the dashboard the change lanes button controls the subject vehicle, switching lanes and leaving it with nothing in it’s radar. Remember that the subject vehicle has the same actual speed as the forward, but it’s cruise speed is higher. Once the forward vehicle leaves the radar’s view, the subject vehicle is free to revert back to the cruise speed. In the figure to the right, the forward vehicle is shown losing ground to the subject vehicle.

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This scenario is also a continuation of the first. This shows what occurs when the operator of the subject vehicle decreases his speed lower than the forward vehicle, but is trailing the vehicle by a set car length. Although the subject has a trailing car length set, the cruise speed overrides this. The subject car will not go faster than the set cruise speed, so in the figure to the left the subject vehicle is shown backing off of the forward vehicle.

6 References
The following is a list of documents referenced throughout the document. Additionally, a link to our team’s project website can be found in this section.


7 **Point of Contact**

For further information regarding this document and project, please contact **Prof. Betty H.C. Cheng** at Michigan State University (chengb at cse.msu.edu). All materials in this document have been sanitized for proprietary data. The students and the instructor gratefully acknowledge the participation of our industrial collaborators.

Mercedes-Benz provides closer look at its Intelligence Drive System