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D.1 Introduction

The intention of this document is to record the requirements discovered for the system being developed. This document is an important part of the basis for the design and development of the system under discussion (SuD).

The SuD is a prototype driver information system that is being developed in cooperation with Revolve NTNU. The purpose of the system is to replace the traditional dashboard HDD with a HUD solution mounted or carried inside the helmet of a race car driver. This system is being designed to interact with the cars on-board sensor network, but also to be general enough that it can be used with other vehicles given hardware support.

This document will through use cases, system sequence diagrams and a domain model give a logical and conceptual description of the SuD and its interaction with other systems. All descriptions are black-box descriptions of the system and sub-systems.

D.1.1 Scope

This document does not describe details of external systems (like sensor network or CAN-bus, sensors, mechanical components). The purpose of this document is to describe the system that is to be developed and the requirements that the system need to meet.

D.1.2 Definitions and abbreviations

See project dictionary.

D.2 Use Cases

Use Case UC1	**Configure message format**
Scope:	Configuration system
Primary Actor:	Developer or system implementer
Stakeholders and Interests:	• System implementer: Wants to be able to move system into another vehicle without having to recompile source code and re-program the system. • System developer (developer): Wants to be able to easily adjust for changing message formats or if a sensor or message should need a special message format, also would like to avoid to have to recompile and program in new firmware if message format changes. • Revolve NTNU: Wants to have the possibility to change the message format without having to use big amounts of time to adjust the Driver Information System (DIS).
Preconditions:	
Postconditions:	A message format configuration is recorded by the system

Main Success Scenario:

1. Actor starts to create a new message format.
2. Actor defines the standard message frame format.
3. Actor defines what is accepted as a valid message.
4. Actor defines which part of the message contains the sensor identification or message detail.
5. Actor defines which part of the message which contains the raw data from the sensor.
6. Actor asks the system to record configuration.
7. System acknowledges that configuration has been recorded.

These steps can be repeated to create multiple message formats if needed

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Extensions:

7.a Error recording configuration:

1. System displays an error message explaining the error
2. Actor can retry step, ie. save to another location or try again (in the case of removable or network media)

Special Requirements:

- The message format should be general enough to accept frame formats for different types of communication networks/protocols.

Use Case UC2	**Configure sensors**
Scope:	Configuration system
Primary Actor:	Developer, system implementer or system owner (future)

Stakeholders and Interests:	• Future owner of system: Wants to be able to adapt and change the configuration of sensors (broken sensor, changing sensor, etc.) • System implementer: Wants to be able to choose which sensors are to be used for data collection and ignore others. To easily be able to turn sensors on and off. • System developer (developer): Wants to experiment with sensor usage and to easily choose which sensors are to be included, swap between different sensor configurations and choose different setups for testing and development. • Revolve NTNU: Wants configuration to be a process that can be done with minimal interfacing on the car so that other processes will not be disturbed. • Driver (competition): Wants a setup of sensors that are relevant for the competition at hand and can help increasing performance • Driver (training): Wants a setup of sensors that provide the information wanted during training and assist in assessing own abilities and possible improvement areas. • Driver (rental): Wants to get information that can show performance and make it easy to see progress between laps and learn where there is room for improvement.
Preconditions:	Requires one or more configured message formats (see UC1)

Postconditions:

- A sensor configuration is created and recorded by the system.
- Each recorded sensor has a valid input-output mapping

Main Success Scenario:

1. Actor starts to create a new sensor setup
2. Actor selects default message format.
3. Actor enters sensor identifier string.
4. System automatically chooses the default message format and displays this.
5. Actor enters the sensors expected message ID or address
6. Actor enters the sensors expected input unit
7. Actor enters the output unit (transformation of input value)
8. Actor enters the sensors linear calibration algorithm
9. Actor selects or enters the valid value-range for the sensor.
10. Actor gives priority to sensor display.
11. Actor may choose to add aggregation rule.
12. Actor may choose to add add trigger-event for sensor (can be triggered from other sensors)
13. System records the sensor information and shows the information from all registered sensors.

Actor repeats step 3 to 13 until done

14. Actor asks the system to record the sensor configuration and the system acknowledges.

Extensions:

4.a Actor wishes to use non-default format:

1. Actor chooses another predefined message format.
2. Actor continues with the next step.

4.b Actor wishes to use a yet undefined message format:

1. Actor chooses to define a new message format for use with this sensor configuration.
2. Actor follows the steps outlined in UC1.
3. Upon recording the message format the system returns to step 4 with the new format selected for the active sensor.
4. Actor continues with the next step.

9.a Sensor with multiple acceptable output units:

1. Actor can choose to add a unit to the value mapping that can be utilized by the display mapping (see UC3).

14.a Error recording configuration:

1. System displays an error message explaining the error
2. Actor can retry, eg. save to another location or try again (in the case of removable or network media)

Special Requirements:

- A sensor can also be a standalone subsystem communicating status of one or more sensors or actively controlled units.
- A sensor configuration must support having sensors with different formats.
- In the case a sensor or subsystem sends messages using different formats the system shall support having multiple instances of a sensor with varying frame formats.

Technology and Data Variations List:

A If there is a duplex communication link between the car and radio and support team it should also be possible to receive messages.

Use Case UC3	**Configure display**
Scope:	Configuration system
Primary Actor:	Driver, Developer, system implementer or system owner (future)

Stakeholders and Interests:	• Future owner of system: Wants to be able to adapt and change the display of information from sensors (customer demand, new ideas) • System implementer: Wants to be able to adapt and change the display of information from different sensors based on preferences or requests. • System developer (developer): Wants to experiment with sensor display models, easily try out various configurations and have a quick deploy-time for a new configuration. • Revolve NTNU: Wants configuration to be a process that can be done with minimal interfacing on the car so that other processes will not be disturbed. Also wants to be able to vary the display for various circumstances and to be able to experiment with what works best to get the best performance out of the drivers. • Driver (competition): Wants a display configuration that is tailored to the event and displays the most relevant information. • Driver (training): Wants a display that is tailored for training and enables the driver to better assess own performance and areas of improvement. • Driver (rental): Wants to get information that can show performance and make it easy to see progress between laps and learn where there is room for improvement.
Preconditions:	There already exists one or more sensor configurations profiles (See UC2)

Postconditions: A display configuration is created and recorded by the system.

Main Success Scenario:

1. Actor creates a new display configuration.
2. Actor loads a sensor configuration.
3. Actor chooses a sensor.
4. System presents available representations for that sensor
5. Actor places the sensor.
6. Actor configures the sensor display size.

Actor repeats step 3 to 6 until done.

7. Actor chooses to record the display configuration and the system acknowledges.

Extensions:

7.a Error saving file:

1. The system displays an error message explaining the error
2. The actor can retry the step, for instance save to another location or try again (in the case of removable or network media)

Special Requirements:

- first applicable non-functional requirement
- second applicable non-functional requirement

Technology and Data Variations List:

1.a Alternative first action with other technology

Use Case UC4	**Upload configuration**
Scope:	System-wide
Primary Actor:	Driver, Developer, system implementer or system owner (future)
Stakeholders and Interests:	• Future owner of system: Wants to be able to adapt and change the display of information from sensors (customer demand, new ideas). Wants uploading of a new configuration to be a quick, easy and robust process. • System implementer: Wants uploading of a new configuration to be a quick, easy and robust process. • System developer (developer): Wants to experiment with sensor usage and to easily choose which sensors are to be included, swap between different sensor configurations and choose different setups for testing and development. • Revolve NTNU: Wants configuration to be a process that can be done with minimal interfacing on the car so that other processes will not be disturbed. • Driver (competition): Wants changing of setups to be a quick process. • Driver (training): Wants changing of setups to be a quick process, also wants to try different setups to find what works best. • Driver (rental): Wants configuration to be a transparent process, and the possibility to select the setup of his or hers choosing.

Preconditions:	There already exists one or more display configuration profile (see UC3)
Postconditions:	A display- and sensor configuration is uploaded to the driver information system.

Main Success Scenario:

1. Actor opens a display configuration profile.
2. Actor turns on the driver information system (DIS).
3. Actor creates a connection between the configuration system and the DIS.
4. Actor initiates an upload of the configuration to the DIS and the system displays progress during the process.
5. System completes the upload and displays a success message.
6. DIS loads the configuration profile and is ready for use.

Extensions:

2.a DIS lacks power:

   1. DIS does not indicate power or activity
   2. Actor gives DIS external power and continues with next step.

3.a No connection established:

   1. System shows failure message
   2. Actor can choose to abort or retry.

5.a Upload fails:

   1. System shows failure message with explanation of error.
   2. Actor can choose to retry or try to take action to rectify problem.

Technology and Data Variations List:

3.a Connection can be made using an applicable interface for the technology utilized, it may be wireless or wired. There is no predefined protocol.

Use Case UC5	**Send message to driver**
Scope:	Display system
Primary Actor:	Support team member or system owner
Stakeholders and Interests:	• Revolve NTNU: Wants ways to effectively communicate information during training (two-way communication not allowed during competitions). • Driver (competition): Wants to be able to receive textual messages in case radio-communication isn't feasible. • Driver (training): Wants to be able to receive messages or alerts from support team. • Driver (rental): Wants to be able to receive messages or alerts from system owner or other involved parties.
Preconditions:	• DIS is configured to receive messages. • DIS is running and communicating. • DIS has a way of establishing a wireless communication with the external system.
Postconditions:	DIS receives and displays a received message.

Main Success Scenario:

1. Actor tells system to create a new message.
2. (Support) System asks user to enter message and priority.
3. Actor enters message and sends it.
4. System sends message over wireless medium.
5. DIS receives message.
6. DIS evaluates priority of message.
7. DIS displays message in a timely manner based on priority.
8. DIS sends message back acknowledging message has been displayed.

Extensions:

5.a DIS does not receive message: See extension 8.

8.a Support system does not receive acknowledgment from DIS within 10 seconds:

1. System resends message.
2. DIS receives message.

3.a DIS has received first message, but awaiting display due to priority and therefore discards message

3.b DIS has not received first message, returns to step 6

Technology and Data Variations List:

2.a If vehicle has positioning actor might also select position for message to be displayed, for instance avoiding displaying messages in corners. This requires tracking vehicle in either DIS or support system.

4.a Depending on technology chosen DIS should be able to receive messages from vehicle sub-systems and/or a dedicated communications channel.

Use Case UC6	**Display real-time information**
Scope:	Display system
Primary Actor:	DIS
Stakeholders and Interests:	• Revolve NTNU: Wants the system to be effective and correct to give advantages during training and competitions • Driver (competition): Wants to be able to get a hold of essential and/or critical information without losing focus of the driving. • Driver (training): Wants to be able to easily get information about own performance and possible areas of improvement. Would also like to get alerted when receiving messages (see UC5) from support team and monitor vehicle status. • Driver (rental): Wants to be able to easily get information about own performance and possible areas of improvement.
Preconditions:	• DIS is configured for the cars sensor load-out. • DIS is configured with the correct display layout. • DIS is powered up (operational), awaiting data. • Driver is seated in the vehicle. • Vehicle is powered up and the sensor network is active.
Postconditions:	DIS works without problems during the driving.

Main Success Scenario:

1. Driver adjusts the position of the DIS if applicable.
2. DIS reads sensor information at given intervals or when received through the sensor network.
3. DIS processes the raw sensor data and transforms it into real world data using the settings in the configuration profile (see UC2)
4. DIS evaluates importance of information compared to sensed activity and priority rules.
5. DIS transforms the calibrated sensor data into graphical output.

System repeats step 2 to 5 until powered down or it stops receiving data

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Special Requirements:

- DIS automatically loads the last configuration.
- DIS does not distract the driver.
- DIS should deliver information from sensors with less than 200ms delay.
- DIS should not process information from sensors not configured.
- DIS shall not obstruct the drivers entry or exit from the vehicle.

Technology and Data Variations List:

5.a DIS might also use sounds if technology allows it and found as an appropriate means of giving information.

D.2.1 Additional requirements

The system shall:

- deliver information to the driver with less than 200 ms delay 90% of the time.
- not negatively affect the drivers performance.
- not obstruct the drivers entry or exit from the vehicle.

D.3 Conceptual model

D.3.1 System sequence diagrams

D.3.1.1 SSD - Configure Message Format

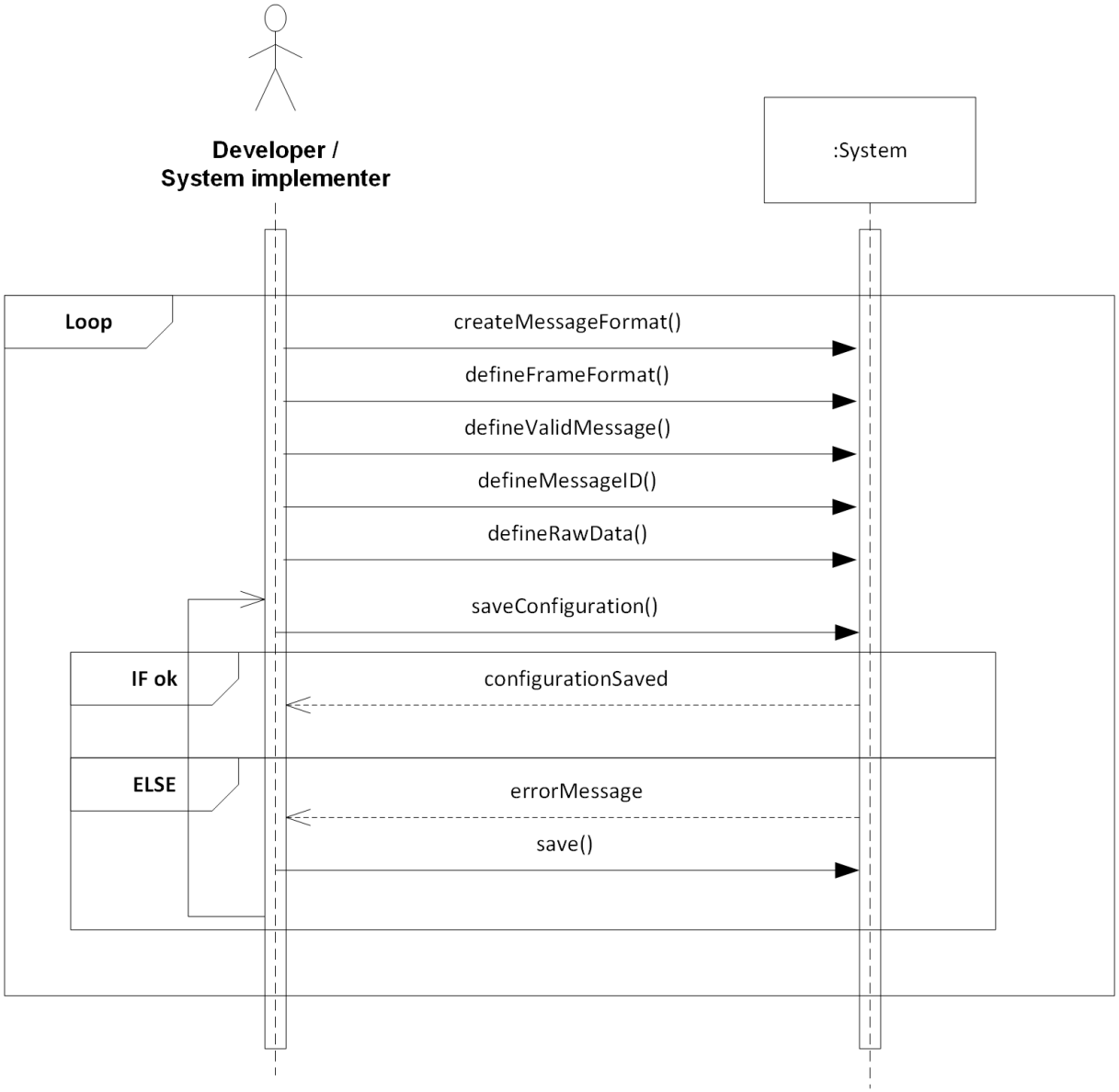


Figure 1: SSD for UC 1 on page 57

D.3.1.2 SSD - Configure Sensors

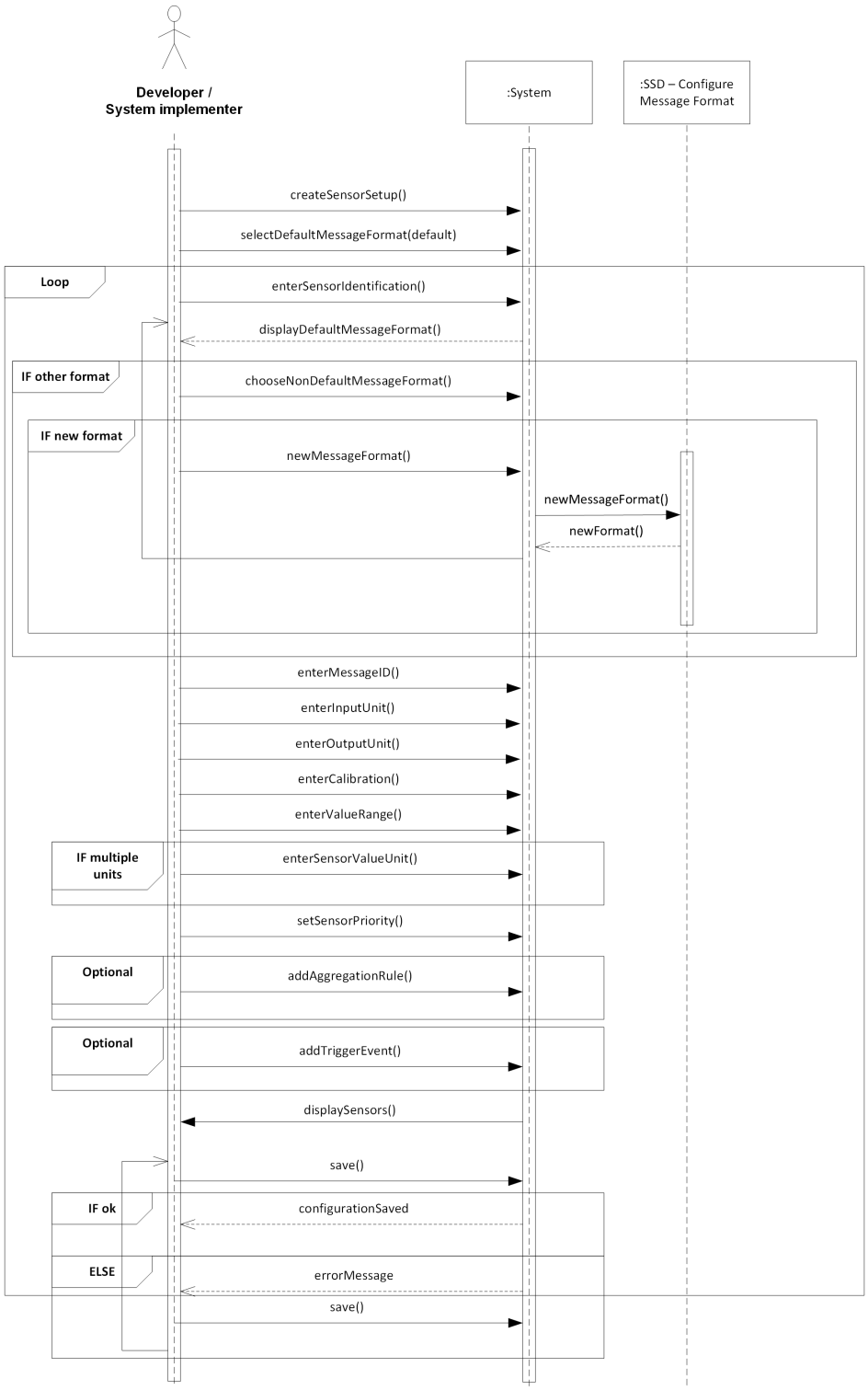


Figure 1: SSD for UC 2 on page 59

D.3.1.3 SSD - Configure Display

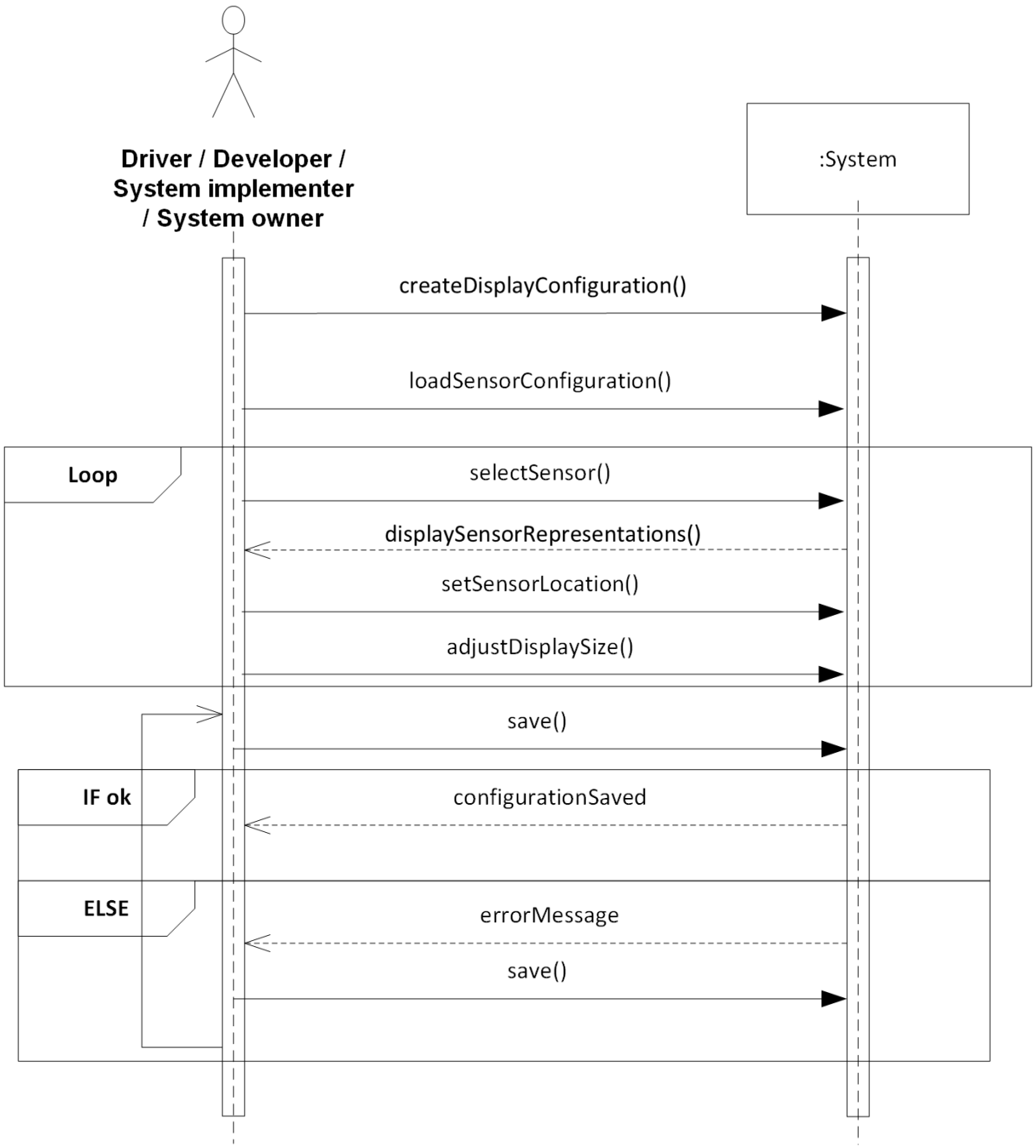


Figure 2: SSD for UC 3 on page 64

D.3.1.4 SSD - Upload Configuration

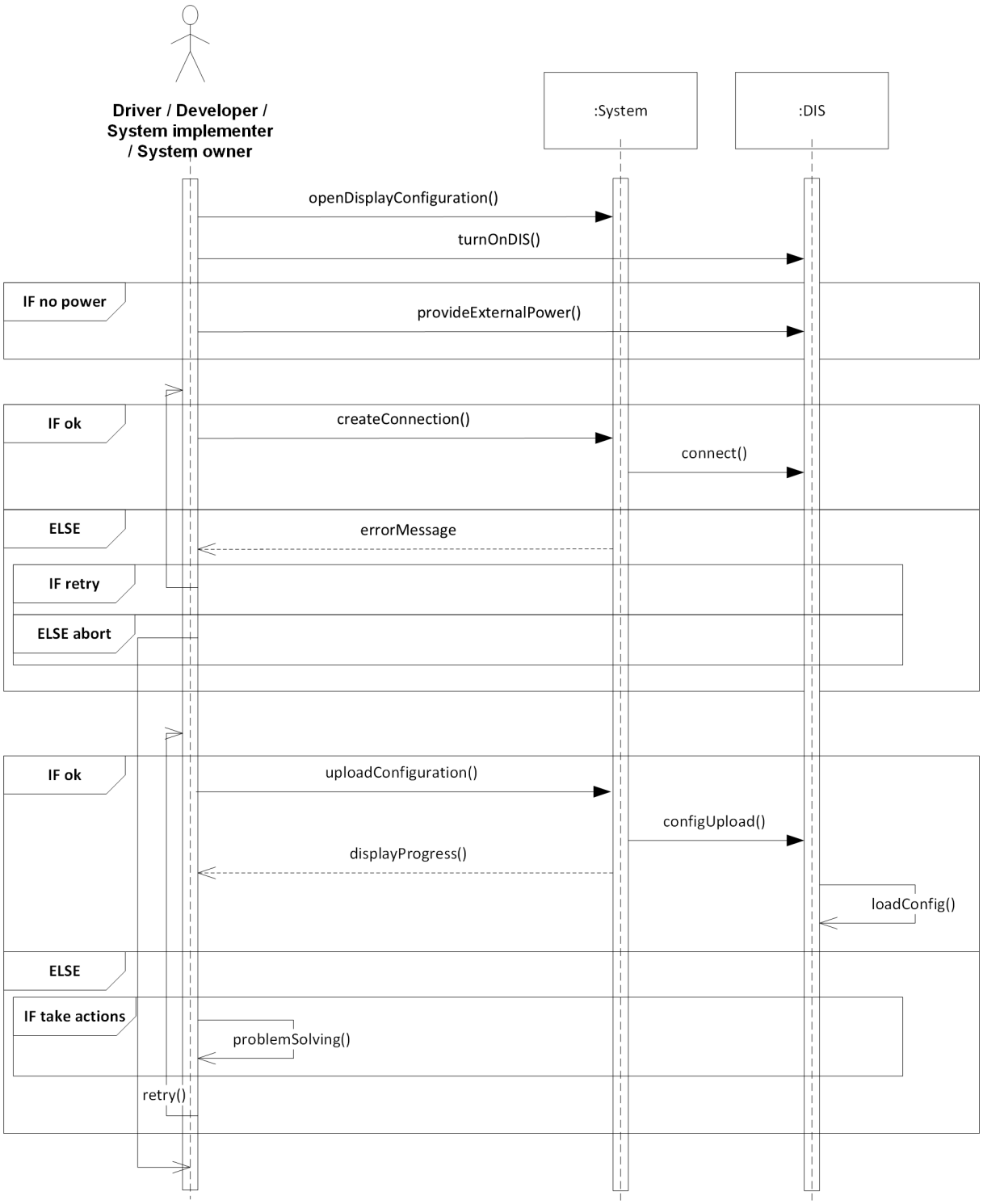


Figure 3: SSD for UC 3 on page 64

D.3.1.5 SSD - Send message to driver

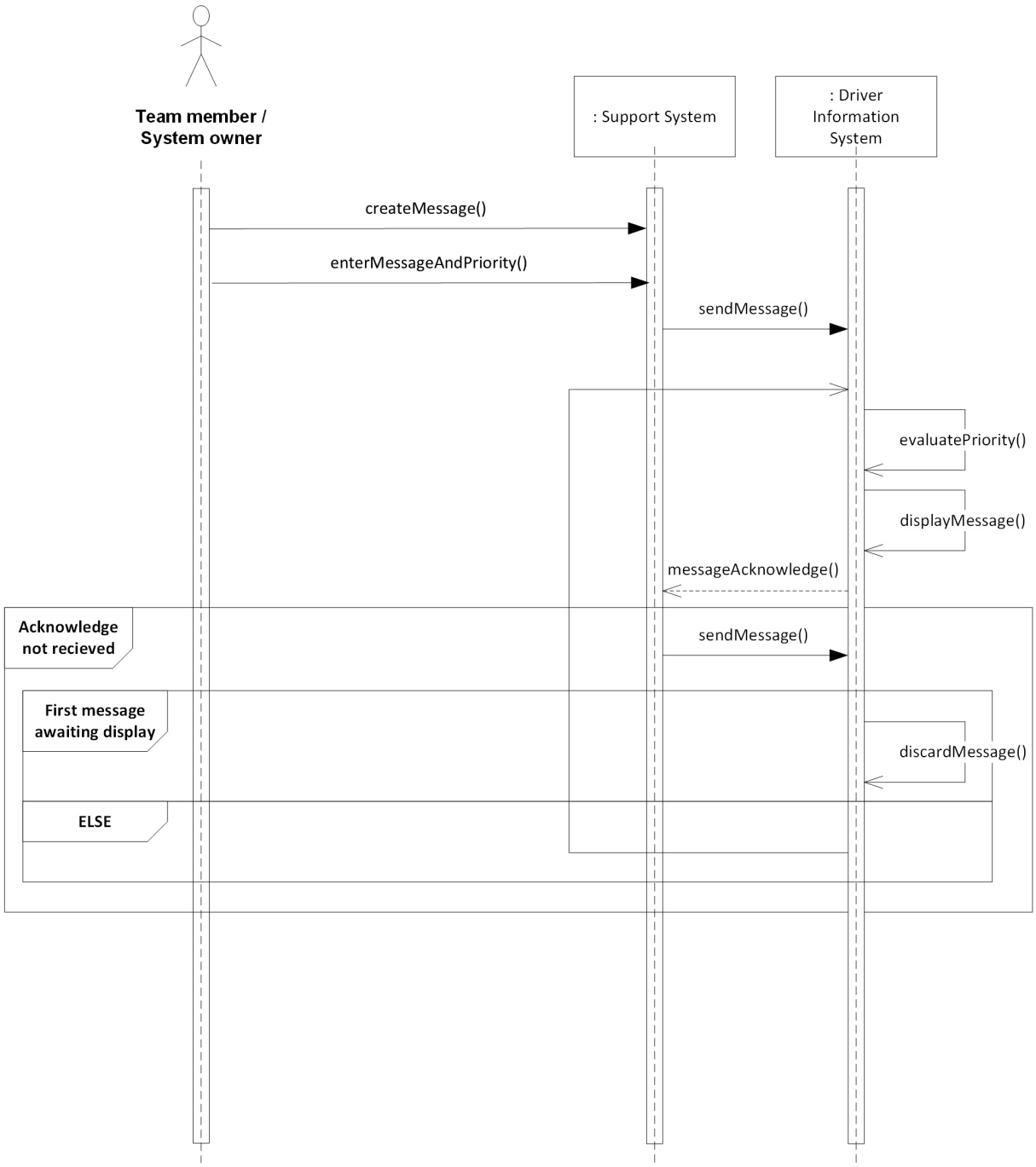


Figure 4: SSD for UC 3 on page 64

D.3.1.6 SSD - Display Real Time Info

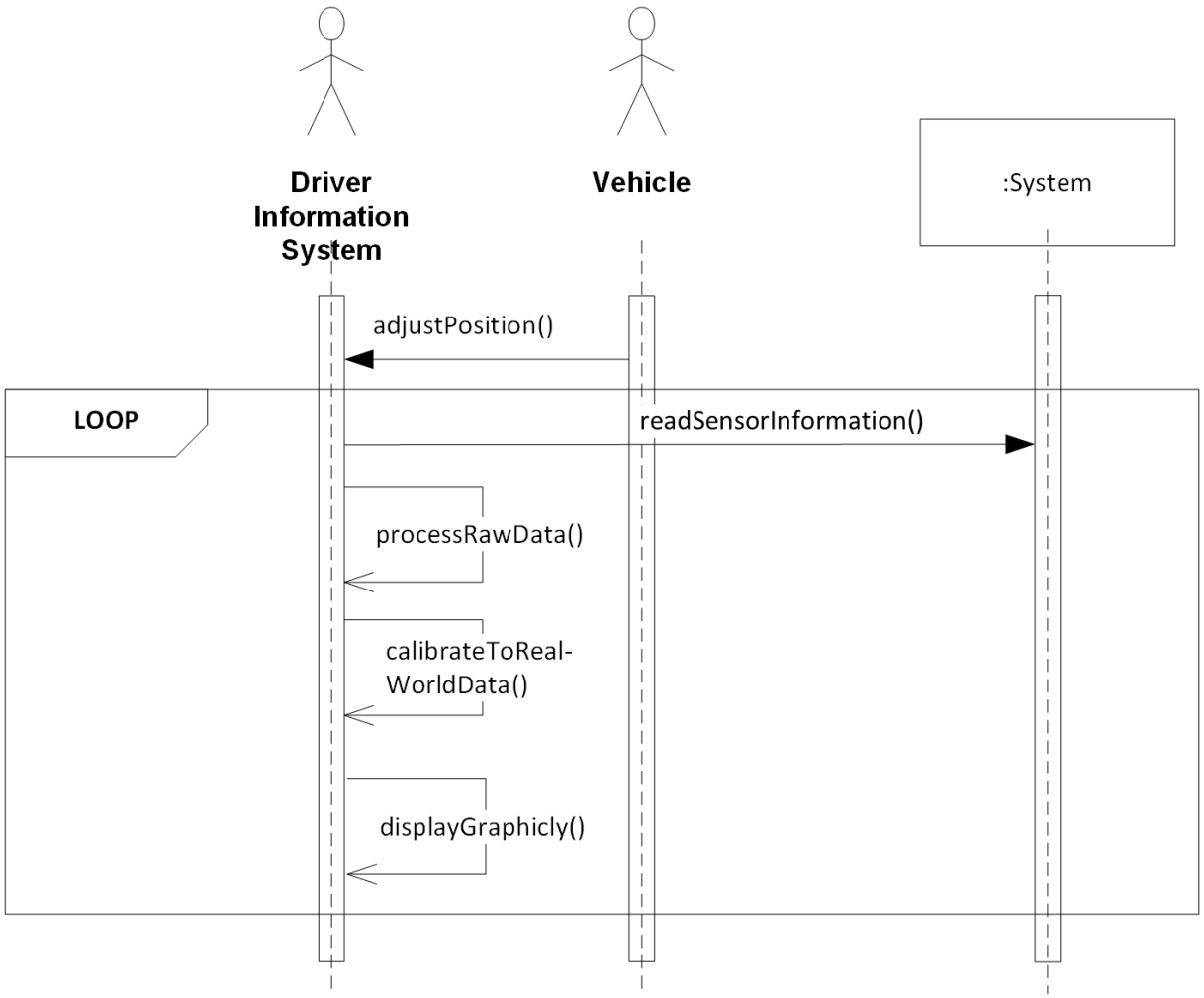
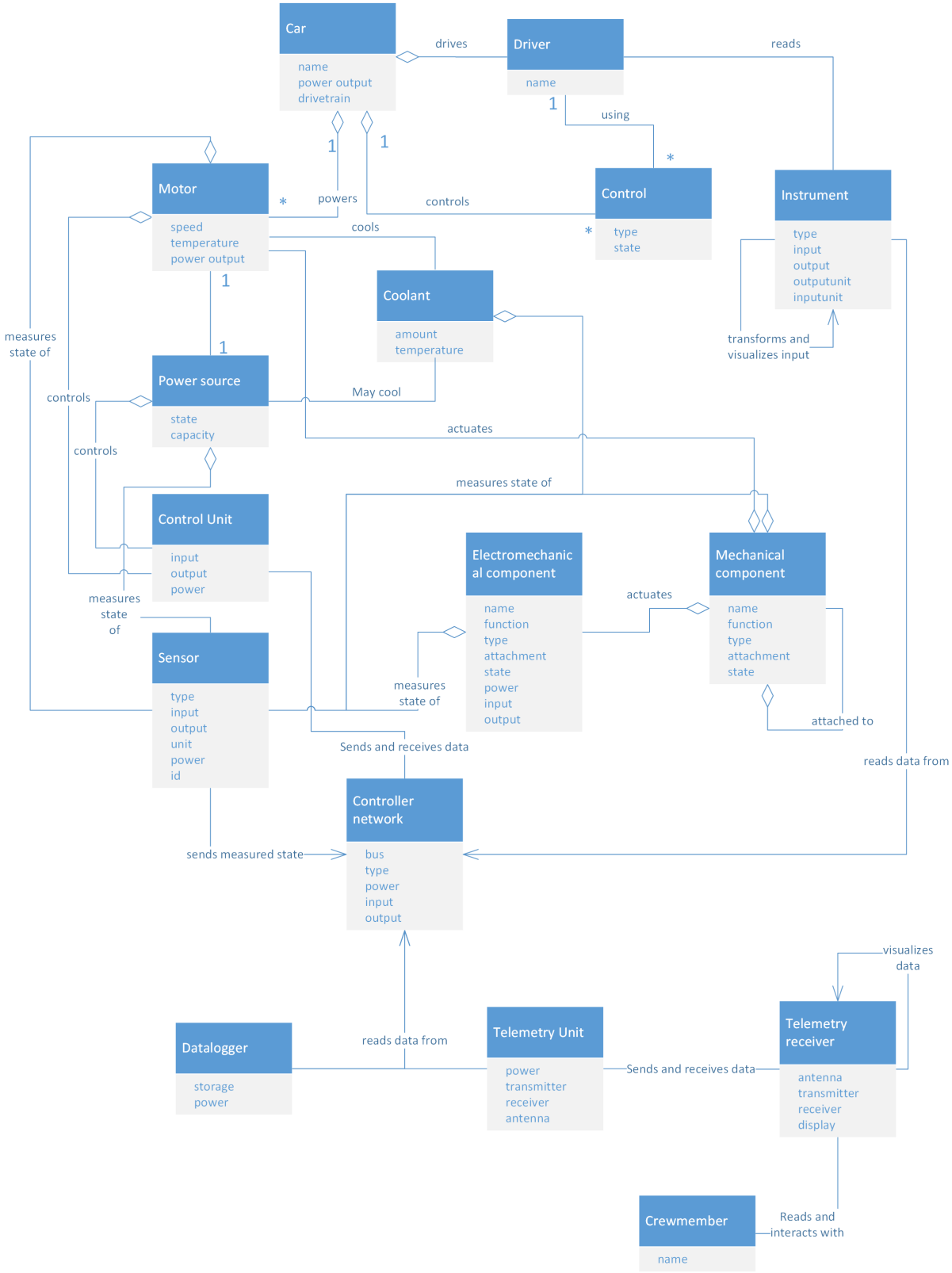


Figure 5: SSD for UC 3 on page 64

D.4 Domain model


Car
name
power output
drivetrain
drives
Driver
name
reads
1
using
*
1
1
Motor
speed
temperature
power output
*
powers
controls
Control
type
state
*
Instrument
type
input
output
outputunit
inputunit
cools
1
Coolant
amount
temperature
measures
state of
1
Power source
state
capacity
controls
May cool
transforms and
visualizes input
controls
actuates
measures state of
Control Unit
input
output
power
Electromechanic
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function
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state
power
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attached to
Sends and receives data
reads data from
Controller
network
bus
type
power
input
output
sends measured state
visualizes
data
Datalogger
storage
power
reads data from
Telemetry Unit
power
transmitter
receiver
antenna
Sends and receives data
Telemetry
receiver
antenna
transmitter
receiver
display
Crewmember
name
Reads and
interacts with