Simple Vehicle Automation Control

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Simple Vehicle Automation Supplementary System

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Sometimes [you] try to take that big leap, and it doesn't work -Marc J. Dupuis

1 History of Revisions

Date	Version	Description	Publishing Author
February 1, 2017	1.0	• Document creation • Add elements from SRS • Add TODO markers	Timothy Elmer
February 2, 2017	1.1	• Add DOT Proposition • Add "Attack on SVASS Node" description	Thuan Tran
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March 14, 2017	4.0	• Add Implementation Team responses	Timothy Elmer

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4.1 Executive Summary

4.1.1 Introduction

What is SVASS?

The human element introduces error and inefficiency into traffic systems, slowing them down and making them more dangerous. This problem can be resolved by autonomous vehicle adoption, but autonomous vehicles are expensive and thus unobtainable for the middle and lower economic classes. SVAC's Simple Vehicle Automation Supplementary System (SVASS) is a *low-cost* alternative that can be *fitted to existing automobiles*, offering the benefits of new autonomous vehicles without the cost.

4.1.2 Stakeholders

Who is affected by SVASS, and how?

1. Traditional Vehicle Owners: Benefit from increased traffic efficiency and safety, may obtain autonomous vehicle at less cost by converting personal vehicle.
2. Businesses Reliant on Automobiles
    2.1. Car Rental Companies: Reduced chance of accidents resulting in damage to vehicle stock and/or litigation.
3. Government Entities
    3.1. Emergency Services: Fewer accidents allows for focus elsewhere, faster access to incidents via more efficient roadways.
    3.2. Departments of Transportation: Improved traffic efficiency allows funds used for congestion handling to be reallocated.
4. Insurance Providers: Fewer insurance claims for vehicular accidents.

4.1.3 Potential Risks

1. Communication Failure: SVASS can perform independently for a short time while attempting to reconnect to the Central Control Server, and will move safely to the side of the road if the connection cannot be restored.
2. Hardware Failure: SVASS utilizes redundant sensors in case of sensor failure, and robust hardware components. Should functioning sensors be insufficient or hardware components fail, the SVASS unit will command the passenger in the driver's seat to take control of the vehicle. SVAC servers will be georedundant in case of hardware failure or power loss.
3. Software Failure: Should SVASS experience a software failure from which it cannot recover, it will pull to the side of the road or command the passenger in the driver's seat to take control of the vehicle.
4. Malicious Actors: SVASS and its network connections shall be hardened against attackers. Should an attack be detected, SVAC staff will command the passenger in the driver's seat of all SVASS units to take control of the vehicle if necessary, and disconnect affected SVAC servers.
5. Unexpected Threats (such as natural disasters and acts of God): Local Emergency Services personnel or SVAC staff will command the passenger in the driver's seat of all SVASS units to take control of the vehicle. Individual SVASS units may also do so if they cannot safely handle a given situation. The SVAC servers will be georedundant to mitigate unexpected threats.

4.1.4 Conclusion

In short,

SVASS will improve traffic safety and efficiency by fast-tracking widespread autonomous vehicle adoption through affordable conversion of existing vehicles.

4.2 Stakeholders

4.3 Problem Addressed

Automobile transportation today faces a problem: the human element. As the primary users and beneficiaries of automotive transport, the inefficiencies we as humans introduce into the transport system affect us keenly. Our relatively slow reaction times, our fallibility, and our short attention span translate to inefficiencies and dangers in automotive transport, making vehicle trips both personal and business longer and more dangerous for our involvement.

4.4 Solution Proposed

The obvious solution to the human problem with vehicles, is the removal of the human element. Indeed, this transition is already becoming a reality, with the introduction of self-driving or autonomous vehicles. However, these autonomous vehicles are expensive and thus inaccessible to many in the middle and lower economic classes. To “bridge the gap” and offer autonomous vehicles – and thus their benefits – to those who could not otherwise afford them, SVAC proposes a transitional system; SVASS, which allows traditional non-autonomous vehicles to be converted into autonomous vehicles. By using existing vehicles, the benefits of autonomous vehicle technology are offered to those who cannot afford a new autonomous vehicle, and increases the spread of benefits to other users of vehicles, autonomous and non-autonomous alike, by making roads safer and more efficient.

4.5 Competitors

There are a few products on the market similar to SVASS.:

UBER

Uber provides transportation services similar to a taxi company. Currently, Uber is developing self-driving technology so that in the future, self-driving cars will be able to pick up passengers and drive them to their destinations without requiring the use of human drivers.

Tesla has become famous for its innovative electric vehicles, and its products are recognized and desired around the world. Tesla has begun to incorporate self-driving technology into its vehicles.

TESLA

While SVASS's competitors have advantages such as brand awareness and resources, they both suffer from a lack of accessibility to the general public. Tesla's vehicles have high prices prohibitive to many people. Uber's self-driving technology is only applicable to vehicles operated by Uber, and requires customers to sacrifice the use of their own vehicle to enjoy its benefits.

SVASS will surpass its competitors in accessibility to the majority of potential customers, thanks to its low price and flexibility in host vehicle.

4.6 SWOT Analysis

Strengths	Weaknesses
• Low cost alternative to autonomous vehicles • Can be installed in existing vehicles • Robust network to direct and inform vehicles and local authorities of traffic events and conditions	• Lack of brand awareness • Not tailor made to specific vehicles; lack of specialization and fine tuning
Opportunities	**Threats**
• Appeals to the majority of potential buyers • Takes advantage of a transition period between traditional and autonomous vehicles	• Safety concerns • Judicial barriers • Social unacceptance of autonomous vehicles • Large attack surface for malicious outsiders

4.6.1 Strengths

SVASS has a price advantage over other autonomous vehicles on the market. The high cost of autonomous vehicles (around $100k) renders them inaccessible to many. SVASS can provide the same functionalities at a more accessible price point.

SVASS, unlike originally autonomous vehicles, is generic and installable on a wide range of vehicles. This allows buyers to turn their current vehicle into an autonomous vehicle, rather than have to shop for a new car.

SVASS has a back-end network infrastructure that allows vehicles to be in constant communication with each other and a central control server. This allows for route-planning, traffic load balancing, and better emergency response.

4.6.2 Weaknesses

SVAC is a newly formed company, and is thus lacking in brand awareness and resources.

Because of the lack of standardization with different vehicles, installation must be performed by an authorized installer, temporarily rendering the customer's vehicle inaccessible.

4.6.3 Opportunities

Due to its accessible pricing, SVASS will be more attractive to customers than the alternatives.

The market for autonomous vehicles is still forming. By entering the market during this transitional period, SVAC offers early adopters a more flexible entry to autonomous vehicle ownership.

4.6.4 Threats

Vehicles are both highly regulated and highly dangerous. In order to succeed, SVASS will need to be sufficiently robust and documented to pass regulations, and designed with safety in mind to protect its users in a dangerous environment.

In order for SVASS to succeed, the public needs be accepting of autonomous vehicles.

Successful cyber-attacks could create bad press for SVASS.

4.6 Industry Research

Patent US6411328 B1 describes a system which can identify vehicles and traffic incidents via IR and visible light cameras and image recognition. SVASS will use a similar system, employing camera 'pods' with visual light, thermal, and LIDAR capabilities placed around the vehicle. This patent is intended for infrastructure deployment in static locations such as high-traffic intersections.

IEEE article 10.1109/MCOM.2008.4539481 describes the benefits and challenges of an ad-hoc network between vehicles. Such a network would allow forward warning of collisions, traffic lights, traffic speed changes, etc., via scheduled status messages and event-driven alerts. The article describes the challenges in wireless transmission and security between vehicles as well. SVASS will use a similar ad-hoc system via AC Wi-Fi to allow direct communication between nearby nodes without adding to CCS bandwidth requirements. SVASS will also incorporate the variable Tx power solution described in the article, as well as a system similar to the TESLA security system described in the article.

Article 10.1117/12.317537 describes the fitment of an ATV with a sensor/physical actuator/compute package that allows remote control of the ATV's control surfaces and independent path finding. SVASS will incorporate a similar system for physical actuation of control surfaces.

Patent US6185695 B1 describes a system for high availability of served resources, in which clients not designed for use with high-availability servers may be. SVASS will incorporate a failover system unlike that described in the patent, with a Primary appliance handling CCS instance synchronization and SVASS node assignment, and a Secondary appliance monitoring the Primary's heartbeat for failover.

Patent US20100179715 A1 describes a system for transitioning vehicle control to and from an autonomous system, testing for activation and deactivation safety. SVASS will incorporate a similar system of checking vehicle state for safety prior to system activation or deactivation.

Patent US4350970 A describes a system for routing traffic via static points at which traffic levels are monitored. This system would use hardware in the vehicles to record trip duration, pausing collection when vehicles are parked. SVASS will incorporate a similar system, with individual nodes responsible for collecting travel time and pausing collection when parked, but this data will also be incorporated with other sources, and provided to the CCS via the node's cellular connection.

4.7 Financial Summary

4.7.1 Revenue Analysis

Growth Rate: 50%

Year	Initial Customers	First Year Monthly Fee	Monthly Fee	Revenue	Hardware Cost	Profit
1	1000	$546	$106	$6,480,000	$4,100,000	$2,452,000
2	1500	$546	$106	$10,920,000	$2,050,000	$9,050,000
3	2250	$546	$106	$17,922,000	$3,075,000	$14,847,000
4	3375	$546	$10	$28,155,000	$4,612,500	$23,542,500

The figure above represents the profit of the company each year after the product is created. Note that these figures do not include the initial cost of the system.

Revenue is calculated by multiplying the expected number of customers by the monthly fee. Note that the revenue also takes into account customers who have finished their initial one-year contracts and new customers under their initial one-year contract.

Hardware cost is calculated by multiplying the cost of a SVASS unit ($4.1k) by the expected number of customers. Note that the hardware cost only takes into account new units manufactured for that year.

Profit is calculated by the revenue of that year minus the hardware costs of that year. Note that the cost for server maintenance is also take into account by the monthly fee.

We assume that our customer growth rate will be 50%. We have decided to offer SVASS to the customer without a large initial cost, but a subscription fee instead. This decision allows customers to enter ownership for a much lower initial price, and pay back the cost of the system over the course of their initial one-year contract. Further subscription fees will go towards server costs and profit. Looking at the profit for each year, we estimate that on the end of 1st year, SVAC's profit will surpass the initial cost of the system.

4.7.2 Cost Analysis

The estimated total initial cost is $3.77 million, with a hardware cost of $4.5K per physical unit, and a continuing cost of $200K per year for server hardware.

4.7.2.1 CCS Unit

The estimated total cost of the Central Control Server system is $2.22 million:

- $200K for server instance costs
- $20K for supporting software costs
- $2M for software development costs

4.7.2.1.1 Hardware

SVAC plans to leverage Amazon's AWS system to provide hardware instances for Central Control Server units to remove the costs associated with designing, constructing, and maintaining server farms. SVAC may decide to transition to independent data farms in the future if doing so is deemed to be cost effective.

SVAC has decided upon the m-series of computing unit from Amazon, as this unit is well suited to general purpose applications with the stable load[1] that will be generated by the SVASS system.

For the purpose of redundancy and disaster mitigation, the CCS software will run on at least two units each in at least two datacenters. AWS offers two m3 instances in their US-West (OR) or US-East (VA) datacenter over a 1-year term for $32,347.[2]

Thus, hardware for the CCS system will cost roughly $64,694 for one year.

Alternatively, a 3-year term is offered at $94,005[3] per datacenter, or roughly $188,010 for three years (versus $194,082 for three 1-year terms).

4.7.2.1.2 Software

Central Control Software will be a custom software package running on top of Microsoft Windows Server Standard and Microsoft SQL Server Standard.

Windows Server Standard costs $822[4] per license, and thus $3,288 for all four server instances, while SQL Server Standard costs $3,717[5] per license, and thus $14,868 for all four server instances.

The total cost of supporting software is thus $18,156.

The custom software package is estimated to cost $2M to develop, based on its complexity, interfacing and reliability requirements.[6]

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[1] "Amazon EC2 FAQs - Amazon Web Services."
[2] "EC2 Instance Pricing – Amazon Web Services (AWS)."
[3] Ibid.
[4] "Windows Server 2016 Licensing & Pricing | Microsoft."
[5] "SQL Server—Pricing an Licensing | Microsoft."
[6] Flackett, ""How Much Does It Cost to Build a Software Application?"

4.7.2.2 *SVASS Unit*

The estimated total cost of the SVASS Unit is $1.5 million for software development, $4,500 per physical unit for hardware.

4.7.2.2.1 Hardware

Estimated hardware costs for the SVASS Unit are $4,500 per-unit without taking bulk pricing into account. A preliminary breakdown of hardware components can be found in the Appendix.

4.7.2.2.2 Software

The SVASS Unit will run a custom stripped-down Android variant. The estimated cost to develop this software package is $1.5M, based on its complexity, interfacing, and reliability requirements.[7]

4.8 Risks

1. Link between SVASS and CCS is severed
   1.1. Link remains severed past NCA
2. Sensor failure
3. Vehicle power failure
4. Driver wake failure
5. Attack on CCS
6. Attack on SVASS node
7. Control surface actuator failure
8. Large scale road hazards (which cannot be reliably & safely handled by CCS & SVASS)
9. Small scale road hazards (which cannot be reliably & safely handled by CCS & SVASS)
10. SVASS local road hazard detection failure
11. CCS navigation data acquisition failure

4.9 Conclusions

With SVASS fitted on personal vehicles, stakeholders who depend on passenger vehicle transportation can expect large scale mitigation of traffic incidents on public roadways, especially high density, high speed roadways such as interstate highways. Investment in SVASS technology and infrastructure will effectively eliminate the uncertainty and congestion related to Human error in high speed motorways, thus mitigating the risk of abrupt financial loss for rental companies and insurance companies. SVASS infrastructure would also allow emergency services to save precious time when responding to an emergency. Most importantly, SVASS technology and infrastructure will decrease the likelihood of fatal, high speed accidents, thus reducing the loss of Human life.

5 System Requirement Specification

5.1 Introduction

5.1.1 Intended Audience and Reading Suggestions

This document is intended for anyone who is interested in purchasing a system to make their car autonomous, to detail how the system will affect traffic and how the system will work. The first section of this document will give a brief introduction to the system. The second section will describe what the system can provide. The remaining sections will discuss how the system will perform its functionalities.

To have a general understanding of the system, read the “Product Scope” below.

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[7] Ibid.

To deeply understand how the system is implemented in certain situations, read the entire document.

5.1.2 Product Scope

This product aims to address the issue of future mainstream autonomous vehicle adoption.

The product will be used in real time, interacting with other vehicles; autonomous and non-autonomous; on the road in an unpredictable and chaotic environment. It will not deliver a perfected product that maximizes transportation efficiency, given the imperfect nature of its environment, but will rather attempt to reduce delays in traffic resulting from human error and slow reaction time, as well as balancing traffic loads between corridors. This improvement will raise awareness for the benefits of autonomous vehicles, increasing adoption speed and eventually leading to a point where traffic is automated in entirety.

Road hazards such as weather, other vehicles, accidents, etc., will be handled by the SVASS unit, while large scale situations such as traffic routing, navigation, widespread disaster response, etc., will be handed by the CCS through commands to SVASS units.

5.1.3 References

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5.2 Overall Description

5.2.1 Product Perspective

The SVASS hardware and software system serves as a standalone vehicle automation solution. This system operates in conjunction with an automobile's existing ECU and associated hardware. The SVASS software control unit can be seen as a "piggyback" control unit supplementary to the existing ECU. The data from existing ECU is shared with the SVASS control unit, which then controls the automation of the vehicle based on both the ECU's data, and the SVASS hardware data.

The SVAC CCS is an independent product of SVASS, which is developed and run independently of any other system.

5.2.2 Product Functions

1. SVASS must control the vehicle autonomously without user assistance, except in extreme situations where the user must be given control of the vehicle.
2. SVASS must be able to detect and react to "road hazards".

5.2.3 Use Class and Characteristics

The SVAC system is intended for use by both individual vehicle owners and business vehicle owners, of all socioeconomic classes. Those who cannot afford an autonomous vehicle will benefit from affordable adoption of autonomous technology, while those who can afford autonomous vehicles but prefer their current vehicle can benefit from autonomous technology in the comfort of their personal vehicle of choice.

5.2.4 Operating Environment

1. The SVASS unit will be located in the customer's vehicle, and will interact with said vehicle physically and through electronic marriage of the SVASS unit and vehicle ECU.
2. The CCS units will be located in geo-redundant datacenters to reduce latency and provide failover capabilities.

5.2.5 Design and Implementation Constraints

1. The SVASS units will need periodic maintenance to ensure continued safe and efficient operation, much like the vehicle itself.
2. SVASS units must be able to interface physically and electronically with the majority of modern automobiles on the road.

5.2.6 User Documentation

	Paper copy distributed with SVASS unit	**Available on compact disk (by request)**	**Available as download from SVAC website**	**Available within SVASS UI**
User Manual	Yes	Yes	Yes	Yes
Quick-Start Guide	Yes	Yes (With manual)	Yes	No
Video Tutorial	No	Yes (With manual)	Yes	Yes
Installation Guide	No	For authorized installers	For authorized installers	No

5.2.7 Assumptions and Dependencies

The vehicle must satisfy the following requirements to be able to use SVASS:

1. The vehicle must be modern (as defined in glossary).
2. All hardware components of the vehicle should be in good shape and proper working order.
3. The vehicle must have physical space to house the SVASS unit.

5.2.8 Risk Assessment

Risk	Response	Probability (Low - High)	Severity (1 - 5)
SVASS and CCS Link Severed	Maintain navigation until navigation cache allowance reached.	High	1
Link Severed Past Navigation Cache Allowance	Pull over and return to manual drive mode.	Low	2
Sensor Failure	Varied types of sensor for each vehicle quadrant, use vehicle sensor data, use data from nearby SVASS units.	Medium	2
Vehicle Power Failure	SVASS has capability to actuate vehicle control surfaces without power for at least one minute, in which the vehicle can be moved to a safe state.	Low	3
Driver Wake Failure	Pull over and retry the process. If failed, contact emergency services.	High	3
Attack on CCS	SVAC staff can issue widespread driver wake and sever connection to SVASS units.	Low	4
Attack on SVASS Node	Nearby SVASS unit detect the attack. Report the attack to CCU. CCU ordered shut down of the system. Alert the driver then switch to manual mode	Medium	4
Control Surface Actuator Failure	Affected SVASS unit performs driver wake.	Low	3
Large-Scale Road Hazard (that cannot be reliably and safely responded to by CCS/SVASS)	CCU issues driver wake in affected area. SVASS unit self-issues driver wake if no connection to CCU.	Low	5
Small-Scale Road Hazard (that cannot be reliably and safely responded to by CCS/SVASS)	Driver wake issued in affected area to remain alert.	Medium	2
SVASS Local Hazard Detection Failure	Driver wake, vehicle pull over, manual override.	Medium	4
CCS Navigation Data Acquisition Failure	Temporarily disable autonomous drive, alert SVAC management and engineering, alert Google management and engineering.	Low	4

5.3 External Interface Requirements

5.3.1 User Interfaces

1. Allow user to view system information
2. Allow user to specify a destination (at origin or en-route)
3. Allow user to view map and location
    3.1. Allow user to search for location/point of interest

3.2. Display nearby points of interest
4. Allow user to view and set appropriate system settings
5. Allow user to view system manual

5.3.2 Hardware Interfaces

1. Allow the automobile's ECU to read diagnostic data from the automobile's OBDII sensors without interference from the SVASS control system.
2. Allow the automobile's ECU to control engine function.
3. Allow the SVASS control system to read diagnostic data from the automobile's OBDII sensors.
4. Allow the SVASS control system to read and record SVASS automation sensor data.
5. Allow the SVASS control system to control the automobile's control surface actuators.

5.3.3 Software Interfaces

1. Allow the SVASS control system to access read only data from the ECU.
2. Allow the SVASS control system to send data to and receive data from the SVASS user interface.

5.3.4 Communications Interfaces

SVASS units will connect to the local cellular data network via GSM to communicate with the CCS and other nearby SVASS units. The SVASS unit will have its own network hardware independent of any passenger's personal cellular devices.

5.4 System Features

1. SVASS must be able to physically interface with the driving controls (steering wheel, brake pedal, and accelerator pedal) for actuation,
2. SVASS' physical interface with the driving controls must be relatively transparent; allowing the "driver" to operate said controls similarly to how they would if SVASS were not in place.
3. SVASS must be able to connect via cellular network to a CCS.
   3.1. This CCS must provide all SVASS units with accurate navigation directions.
   3.2. CCS must coordinate SVASS units to balance traffic loads between routes via SVASS unit and DOT/Google provided real-time traffic data, minimizing the travel time of all SVASS units.
   3.3. SVASS must be able to independently reach a "safe state" (such as pulled to the side of the road) -- where the "driver" can take control of the automobile without endangering themselves, any passengers, any other vehicles, or any pedestrians -- if SVASS can no longer function autonomously for any reason.
   3.4. SVASS must maintain a cache of navigation directions in case of connection failure.
      3.4.1. SVASS units must self-issue a driver wake if the navigation cache time allowance has expired
         3.4.1.1. The navigation cache time allowance must be calculated based on the vehicle's geographical location and expected duration of interruption (e.g. passing through long tunnel).
4. SVASS must be able to react to "road hazards" such as (but not limited to) road construction, past or in-progress accidents, non-autonomous vehicles, and non-SVAC autonomous vehicles. This reaction must minimize damage to the SVASS vehicle and its occupants as well as other vehicles and their occupants, and pedestrians.
5. The CCS must provide an API for emergency services so that SVASS vehicles can be automatically moved out of the way of an emergency vehicle or situation by emergency services personnel.
6. Each SVASS unit must have a black box that will record the eternal statistical data of the vehicle every 100 milliseconds or less.
7. SVASS must not interfere with the vehicle's performance or safety.
8. SVASS must support over the air firmware updates.
9. The CCS will be an open system that can connect to and support other vehicle conversion systems or fully autonomous vehicles.
   9.1. A standard will be published for other systems to follow (automobile be a modern vehicle).

   9.2. Systems not following this standard may not use the SVAC control system.
10. The CCS must be able to command any set of SVASS units to perform a driver wake.
11. SVASS units must be able to alert the driver in the event of a driver wake via audio-visual notification.

5.5 Other Nonfunctional Requirements

5.5.1 Performance Requirements

1. SVASS must be able to actuate a driving control within 1/16th second of the control module's output.
2. SVASS must be able to respond to sensor input by initiating driving control actuation within 1/16th second of sensor input.

5.5.2 Safety Requirements

1. SVASS must be able to operate independent of vehicle power for at least three minutes.
   1.1. SVASS must be able to actuate steering and braking driving controls in at least 99% of consumer vehicles without vehicle power.
2. SVASS must pass all DMV safety regulations.
3. SVASS-equipped vehicles must prevent the primary passenger from taking control of the vehicle except in the event of a driver wake.

5.5.3 Security Requirements

1. SVASS must be hardened against bad actors attempting to intercept or interfere with communications between SVASS and the CCS.
2. The CCS must segregate network traffic for SVASS node communication and external service communication.

5.5.4 System Quality Attributes

1. SVASS must be installable in all automatic transmission left-driving vehicles within 24hrs by a qualified mechanic.

5.5.5 Business Rules

1. SVASS units will be granted software support for 7 years.

5.6 Stakeholder Propositions

5.6.1 Owners of Non-Autonomous Vehicles

By installing SVASS in your vehicle, you will have an autonomous vehicle that will do the driving for you. This will allow you to spend your time doing something else, decrease accidents, and increase traffic efficiency. In short; you get where you're going faster, safer, and more comfortably.

5.6.2 Businesses Reliant on Automobile Transportation

Car transportation is no longer constrained by work hours

5.6.2.1 Car Rental Companies

By investing in SVASS, rental companies will mitigate the risk of financial loss due to the decreased probability of Human error, particularly in high risk situations.

5.6.3 Government Entities

5.6.3.1 Emergency Services

SVAC allows for a seamless, simultaneous pull over of cars at the site of an emergency. This synchronized merging of SVASS automobiles to the right lane allows emergency vehicles to quickly reach their destination with reduced blockage from traffic.

5.6.3.2 *Departments of Transportation*
SVAC promotes a new way of driving that soon will be used by everyone. Using the system will improve the safety while driving hence reduce the effort of making regulations for safety. Furthermore, less accidents will occur hence the road facilities will be preserve.

5.6.4 Insurance Companies
SVAC promotes a safer driving experience for everyone. By automating the driving process, there will be fewer accidents. Furthermore, insurance companies will be able to obtain relevant data from SVAC in the event of an insurance claim. In short, fewer accidents and instances of insurance fraud will occur.

5.7 User Experience

5.7.1 Expected Scenarios

5.7.1.1 *Drive to Destination*
- SVASS Unit
    - Autonomously drive vehicle
    - Route the vehicle to destination
    - Communicate with CCS to update status and receive traffic/navigation updates
    - Communicate with other SVASS units for location and hazard awareness
- Primary Passenger
    - Specify destination and begin navigation
    - Do not interact with control surfaces
    - Stay seated with seat belt engaged
- Secondary Passengers
    - Stay seated with seat belts engaged

5.7.1.2 *Change Destination En-Route*
- SVASS Unit
    - Autonomously drive vehicle
    - Route vehicle to new destination
    - Communicate with CCS to update status and receive traffic/navigation updates
    - Communicate with other SVASS units for location and hazard awareness
- Primary Passenger
    - Specify new destination and begin navigation

5.7.1.3 *Car Enters Cellular Dead-Zone*
- SVASS Unit
    - Continue driving on cached route
    - If NCA expires, unit initiates driver wake
    - If signal is reestablished before allowance expiry, regular operation continues

5.7.2 Emergency Scenarios

5.7.2.1 *Detect Emergency Vehicle on Road*
- SVASS Unit
    - Detect Emergency Vehicle
    - Notify nearby SVASS units
    - Pull vehicle to side of road
    - Wait for Emergency Vehicle to pass before resuming normal operation
- Passengers
    - Remain seated in vehicle

5.7.2.2 *Notified of Emergency Vehicle on Road*
- Receive notification from nearby SVASS units OR from CCS

- o Pull vehicle to side of road
- o Wait for Emergency Vehicle to pass before resuming normal operation
- Passengers
  - o Remain seated in vehicle

5.7.2.3 Driver Wake

- SVASS
  - o Driver wake
  - o Audio notification
  - o Visual notification
  - o Relinquish control to driver when pressure detected on control surfaces
- Primary Passenger
  - o Engage control surfaces and take control when alerted by SVASS

6 Wireframes

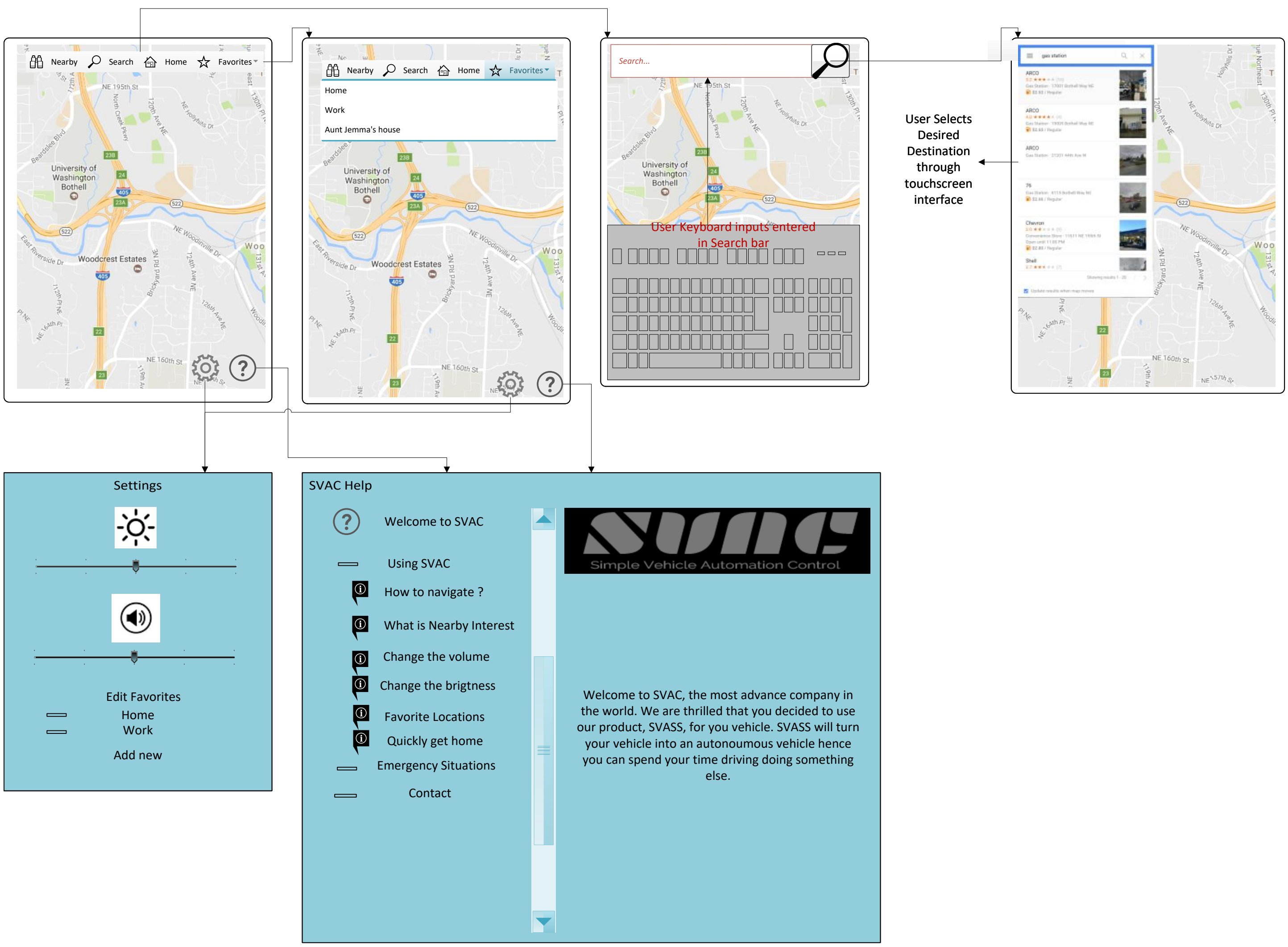


Figure 1: UI Wireframe

6.1 Design Rationale

- UI will be viewed and interacted with on a phablet-sized touch screen, as it must be mounted within the vehicle with minimal intrusion upon the potentially limited space and with minimal blocking of vehicle controls.
- This screen will have a capacitive "Back" button, as the "Back" action will be relevant in all UI activities (with the exception of the main map view)
- This screen will be portrait-oriented, as this allows greater temporal depth of information in a compass-oriented map.
- There will be a labeled menu bar at the top of the screen in the main map view, as there are several main functions a user can be expected to desire: listing nearby points of interest to navigate to, searching for a specific point of interest or address to navigate to, navigating directly home, and navigating directly to a preset favorite.
- There will be "Settings" and "Help" icon shortcuts in the bottom corner of the main map view, as these shortcuts are less frequently used, and can be recognized by the icon.
- The "Help" section will contain basic information about the system. Some of the basic information include: How to use the functionalities, What to do in Emergency Situation and who to contact if something happen. The "Help" Section will allow expand a category into subcategories by clicking on the symbol " - " next to the text description. It features half of the side of the screen to show the categories and other half to show the description
- The "Settings" will allow the user to change the volume of the interaction between the vehicle vs the user (driver wake). It will also allow the user to adjust the brightness of the UI. The user can click to the " - " Icon next to a favorite description to remove it or can add a new favorite location. The new added favorite location can be reached from the "Favorites" tab on the main screen.
- The settings and Help tabs are colored light blue to be easy on the eye and differentiate them from the main user view.
- Current SVAC UI and font follows the same guideline standards as Google Maps to create one uniform seamless package.
- Navigation display is designed to be as minimalist as possible with less clutter and more open viewing area for the GPS map.

7 Architecture Design

7.1 Use Cases

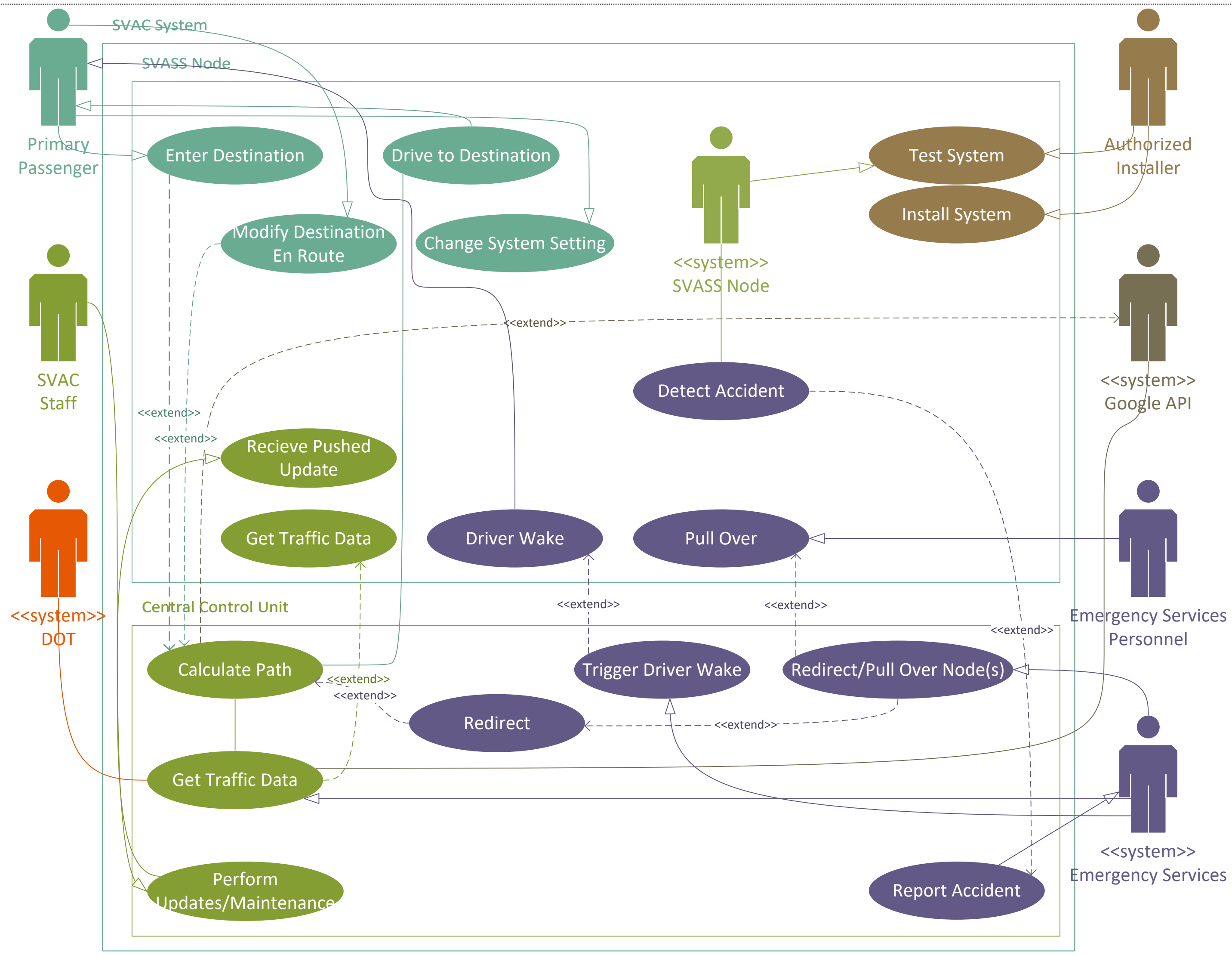


Figure 2: Use Case; Overarching Use Cases

7.2 Domain Models

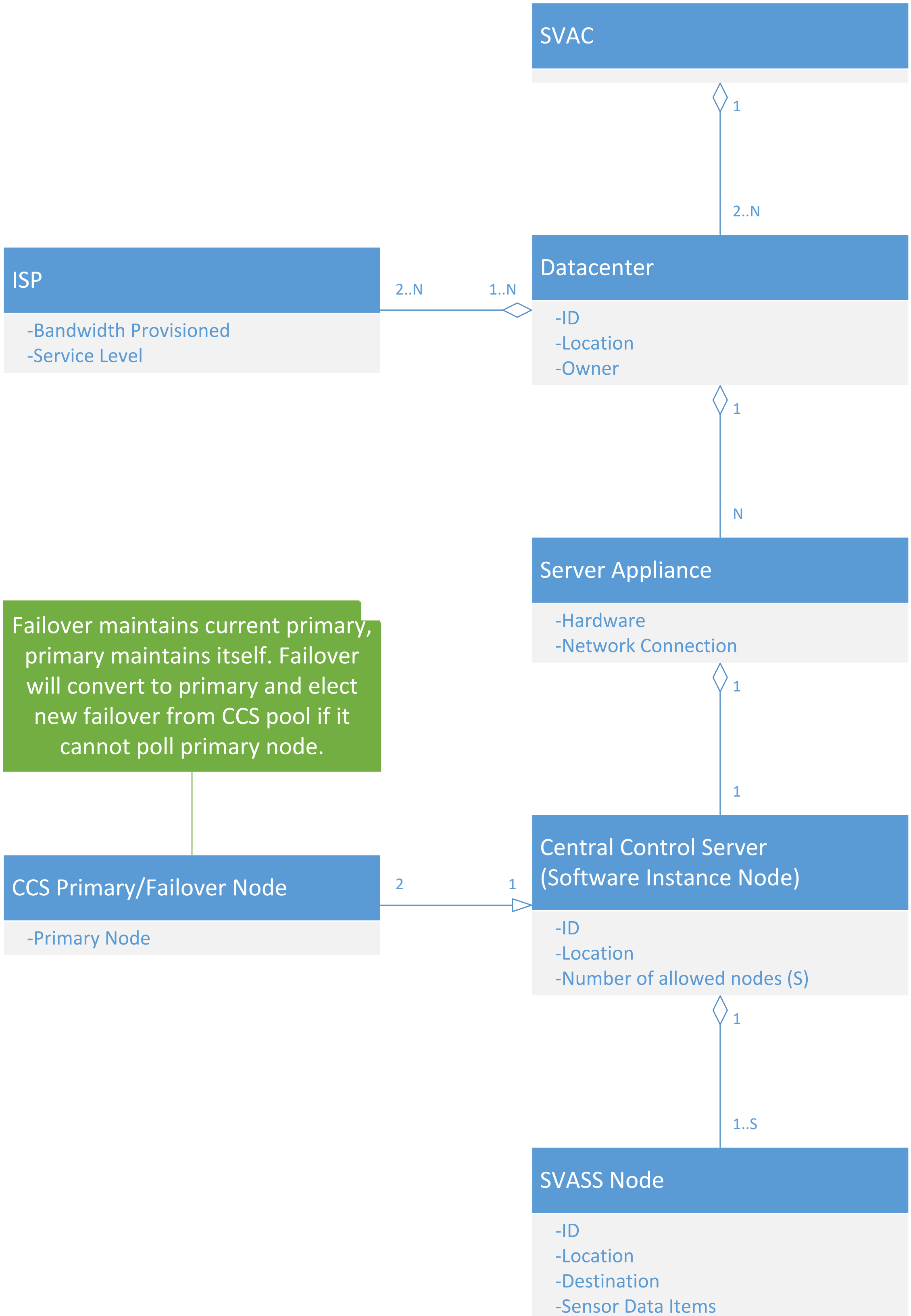


Figure 3: Domain Model; CCS

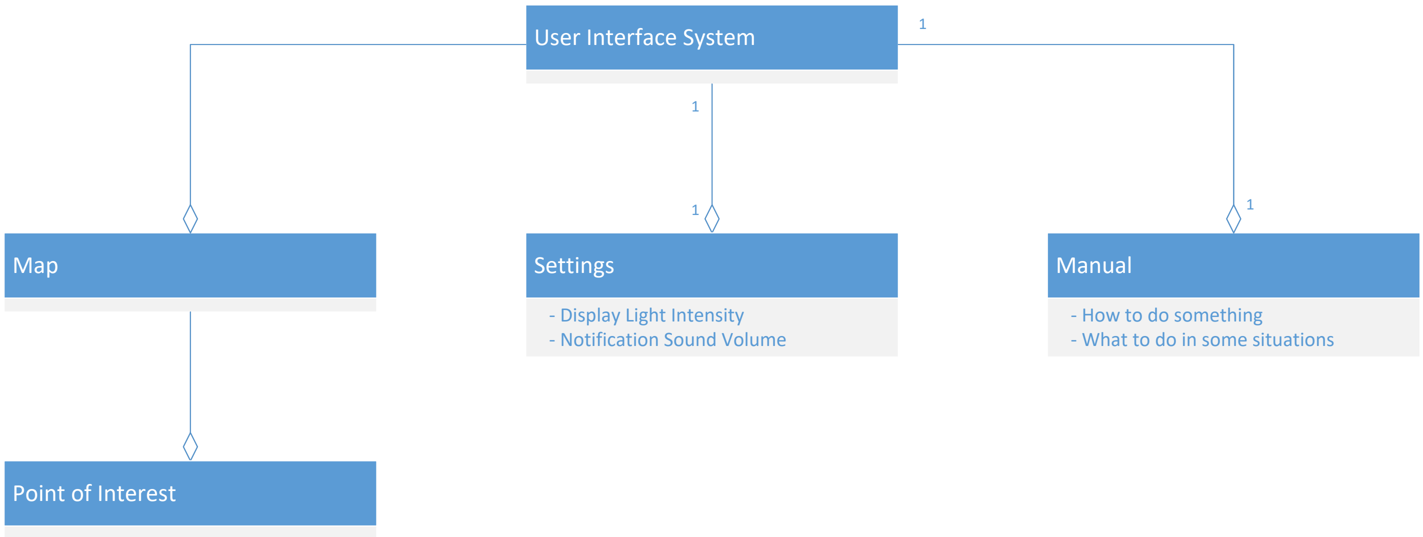


Figure 4: Domain Model; UI

7.3 Additional Artifacts

7.3.1 Activity Diagrams

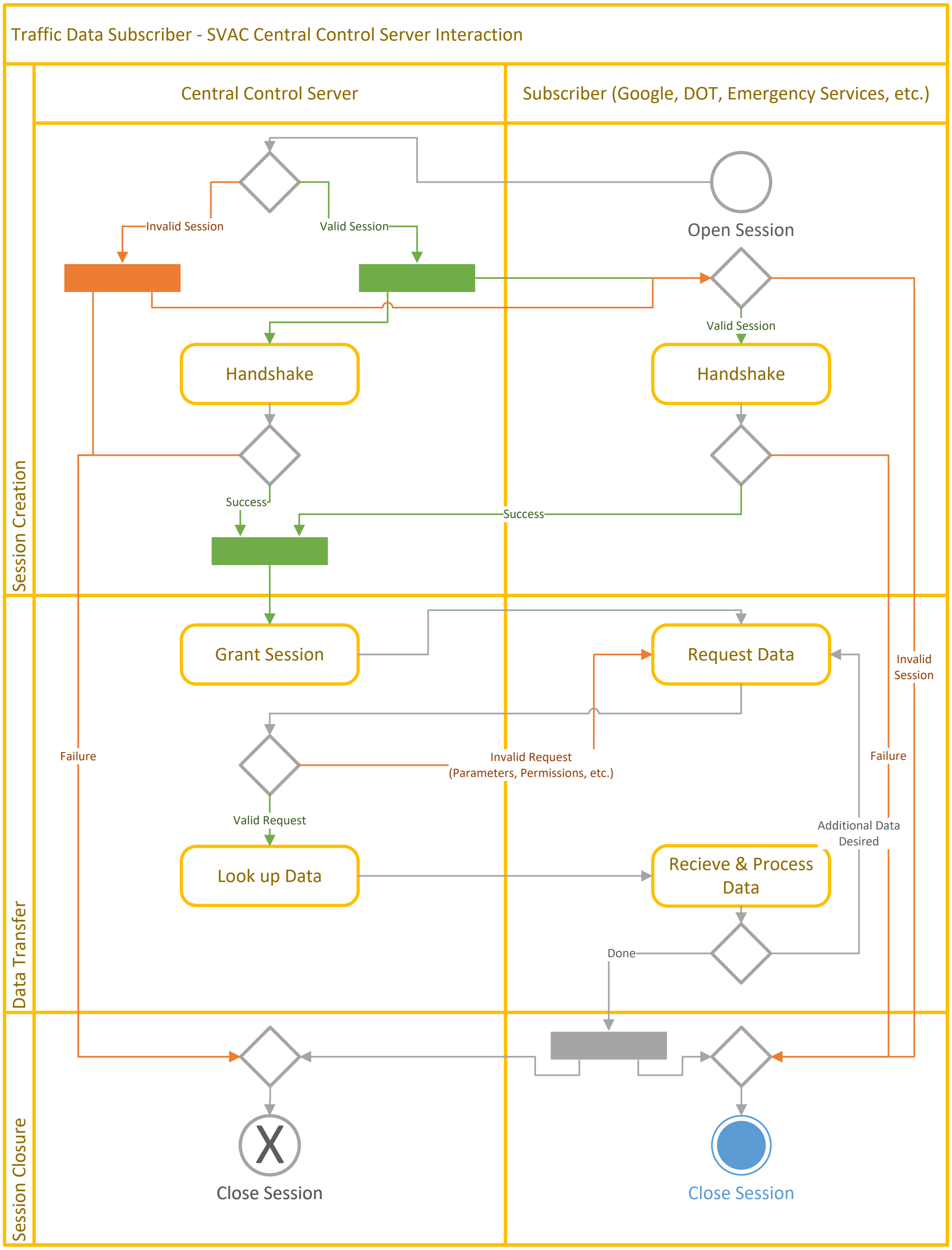


Figure 5: Activity Diagram; Data Subscriber & CCS

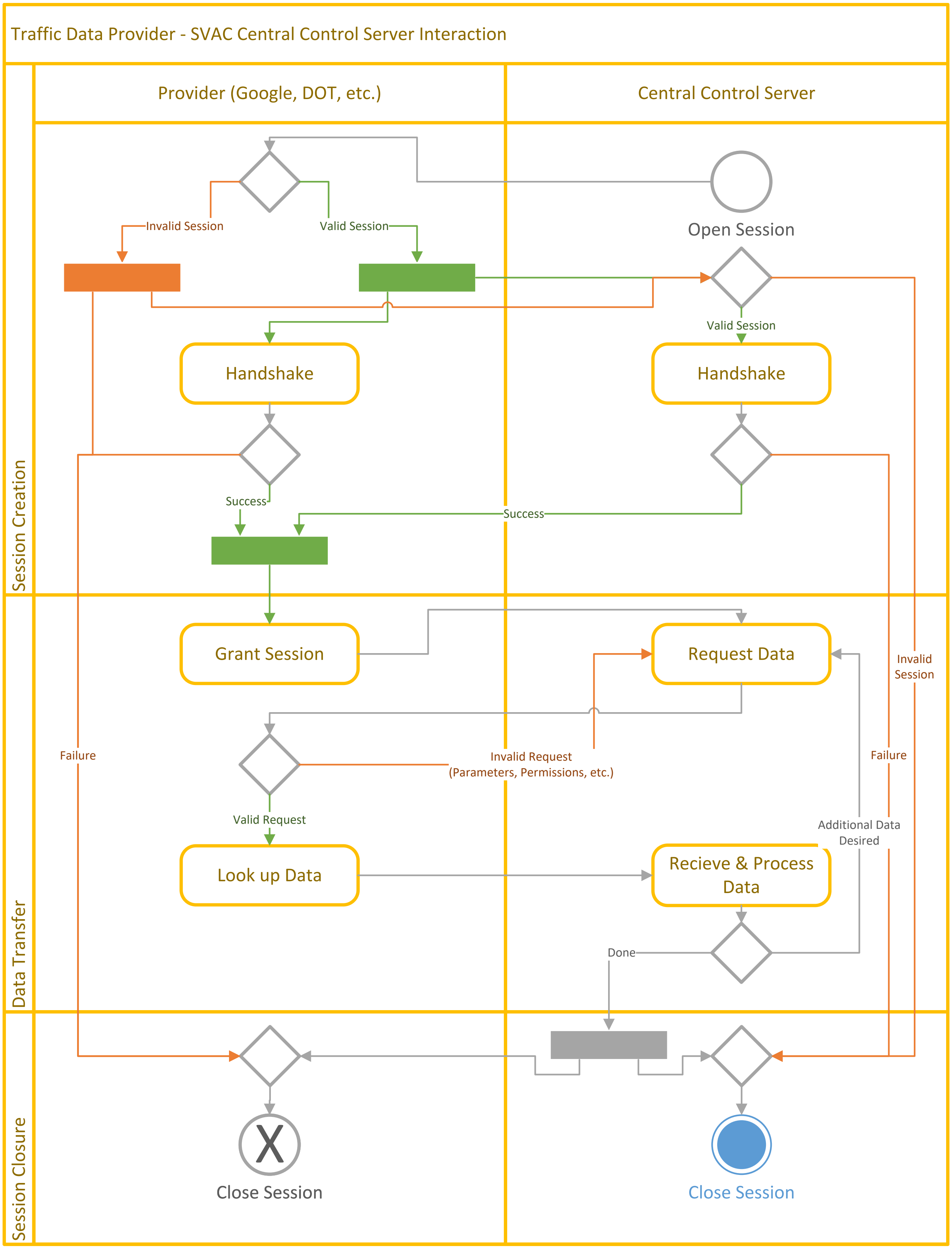


Figure 6: Activity Diagram; Data Provider & CCS

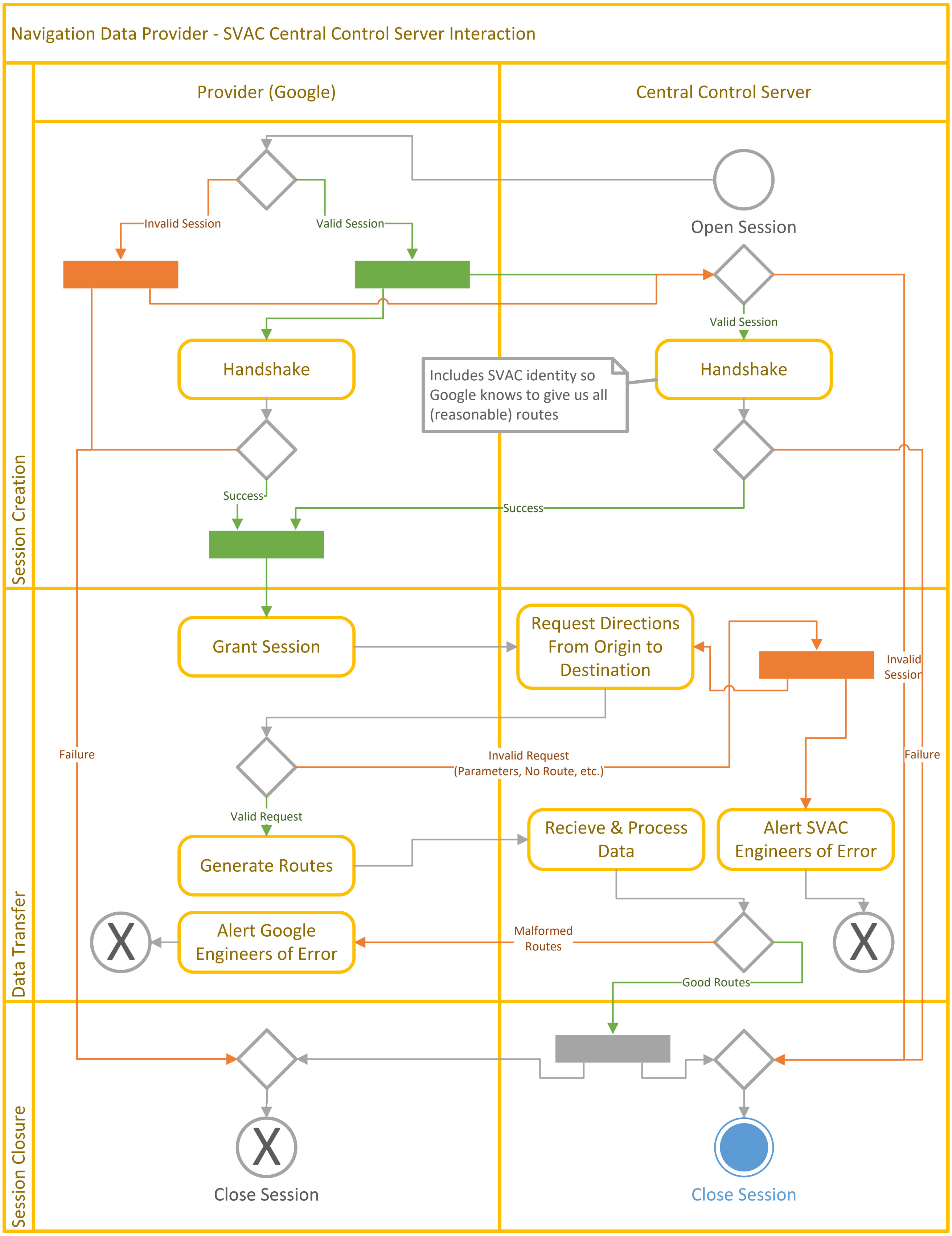


Figure 7: Activity Diagram; Navigation Data Provider & CCS

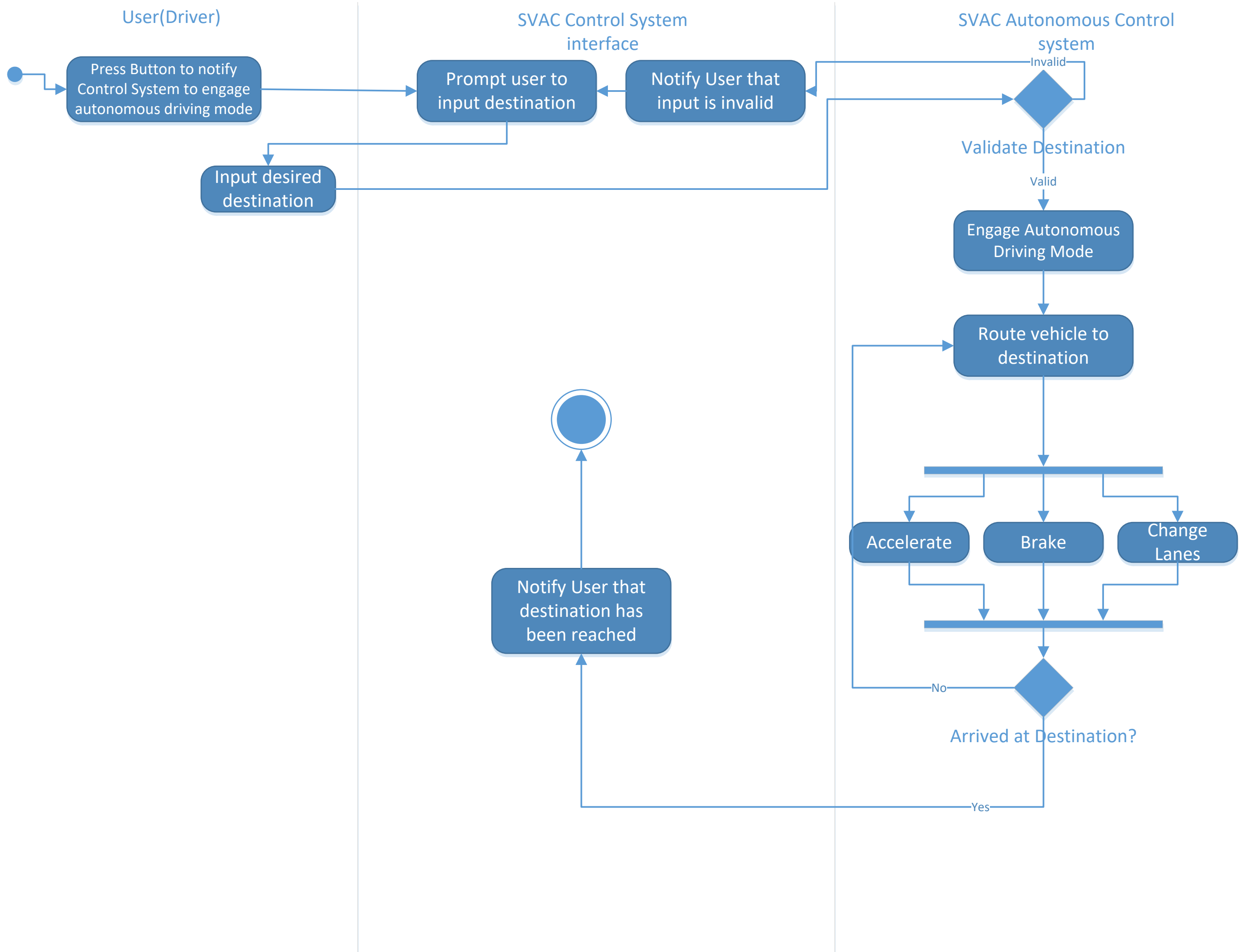


Figure 8: Activity Diagram; Drive to Destination

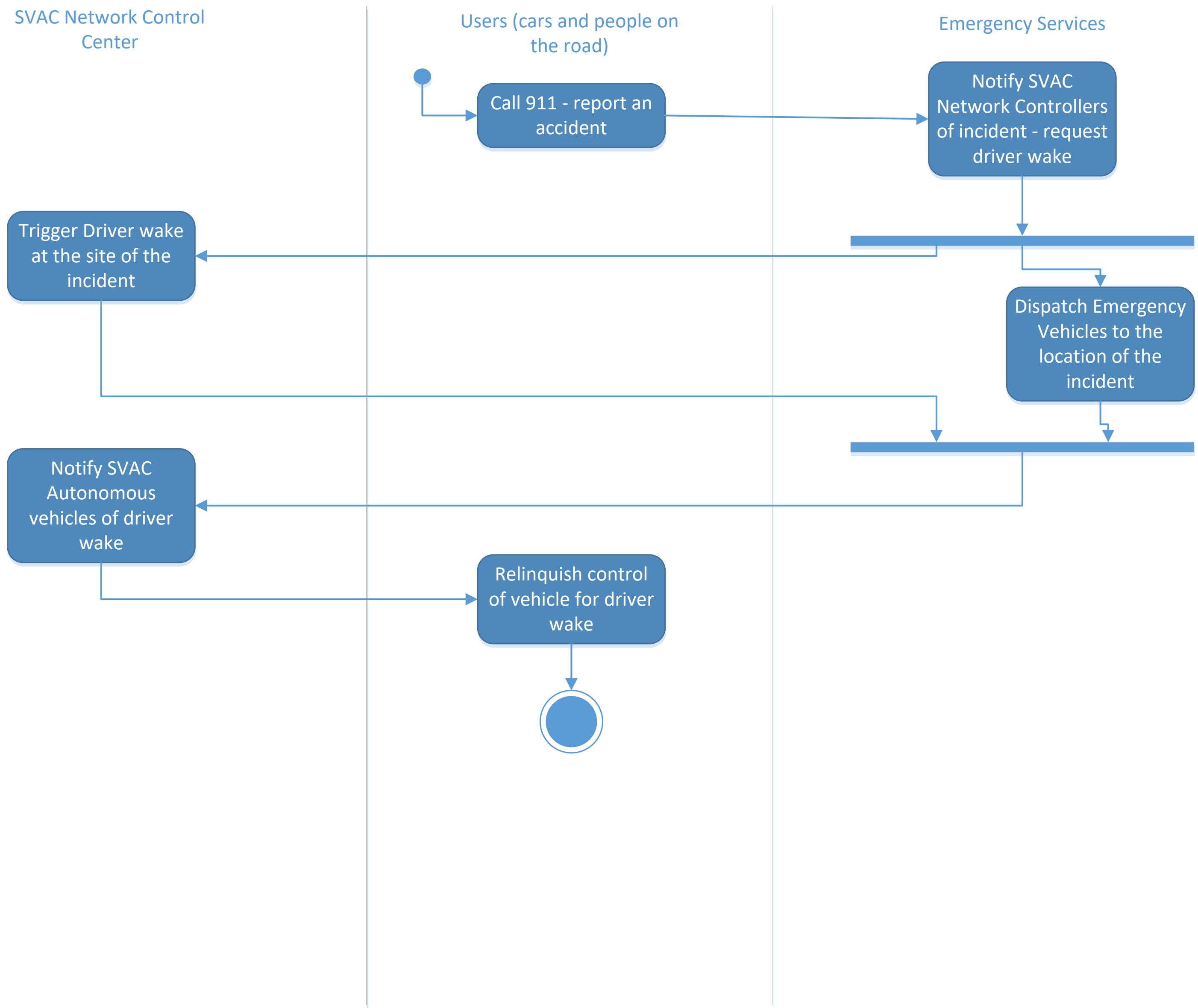


Figure 9: Activity Diagram; Accident Response

7.3.2 Robustness Diagrams

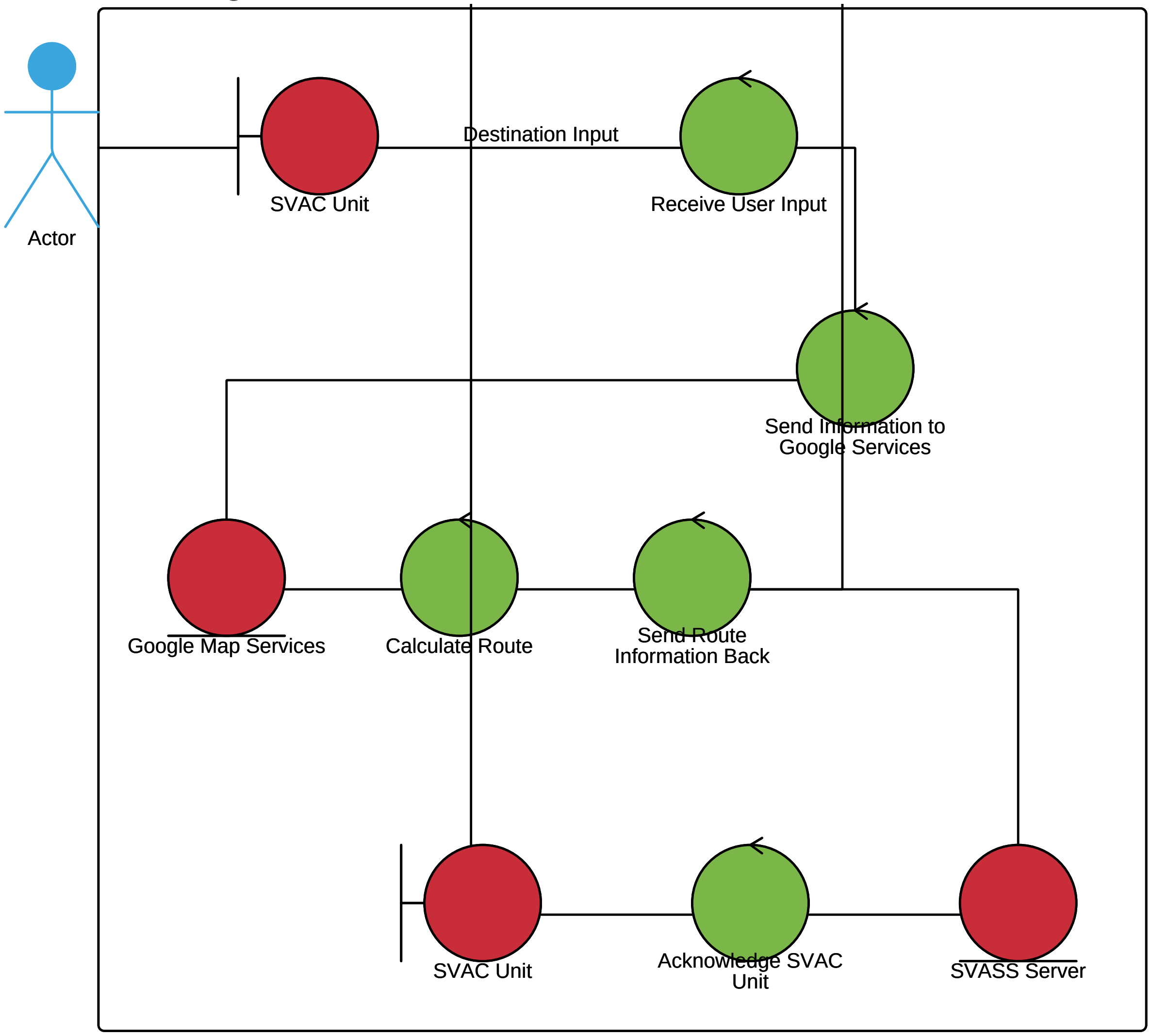


Figure 10: Robustness Diagram: Drive to Destination

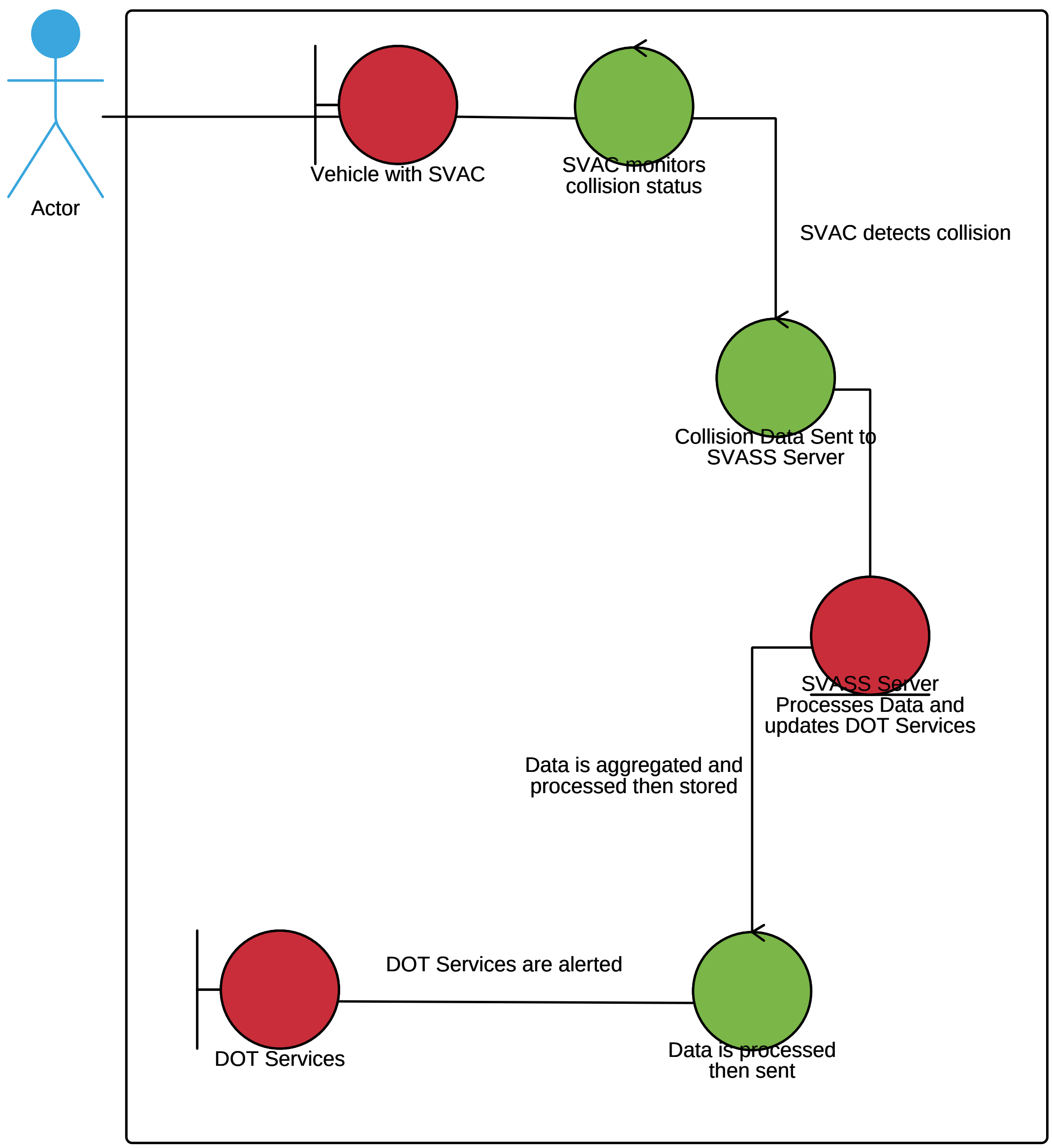


Figure 11: Robustness Diagram: Report Accident

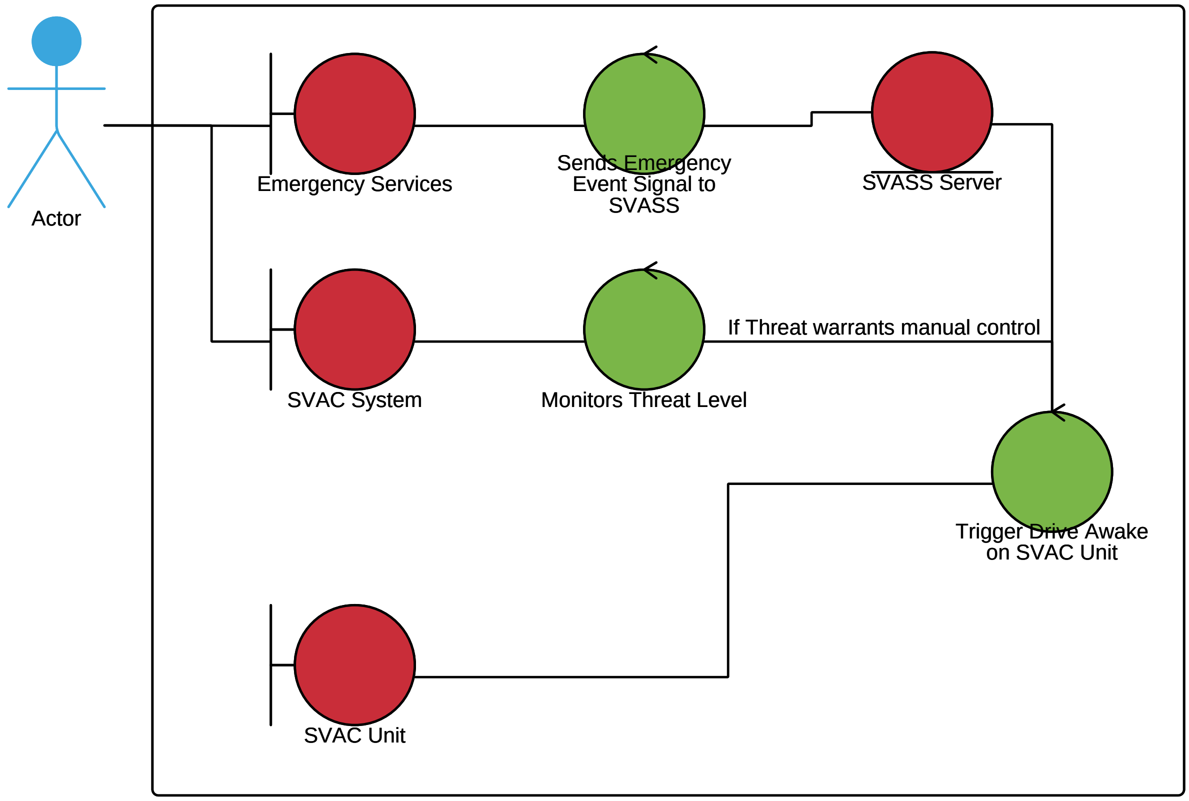


Figure 12: Robustness Diagram: Driver Wake

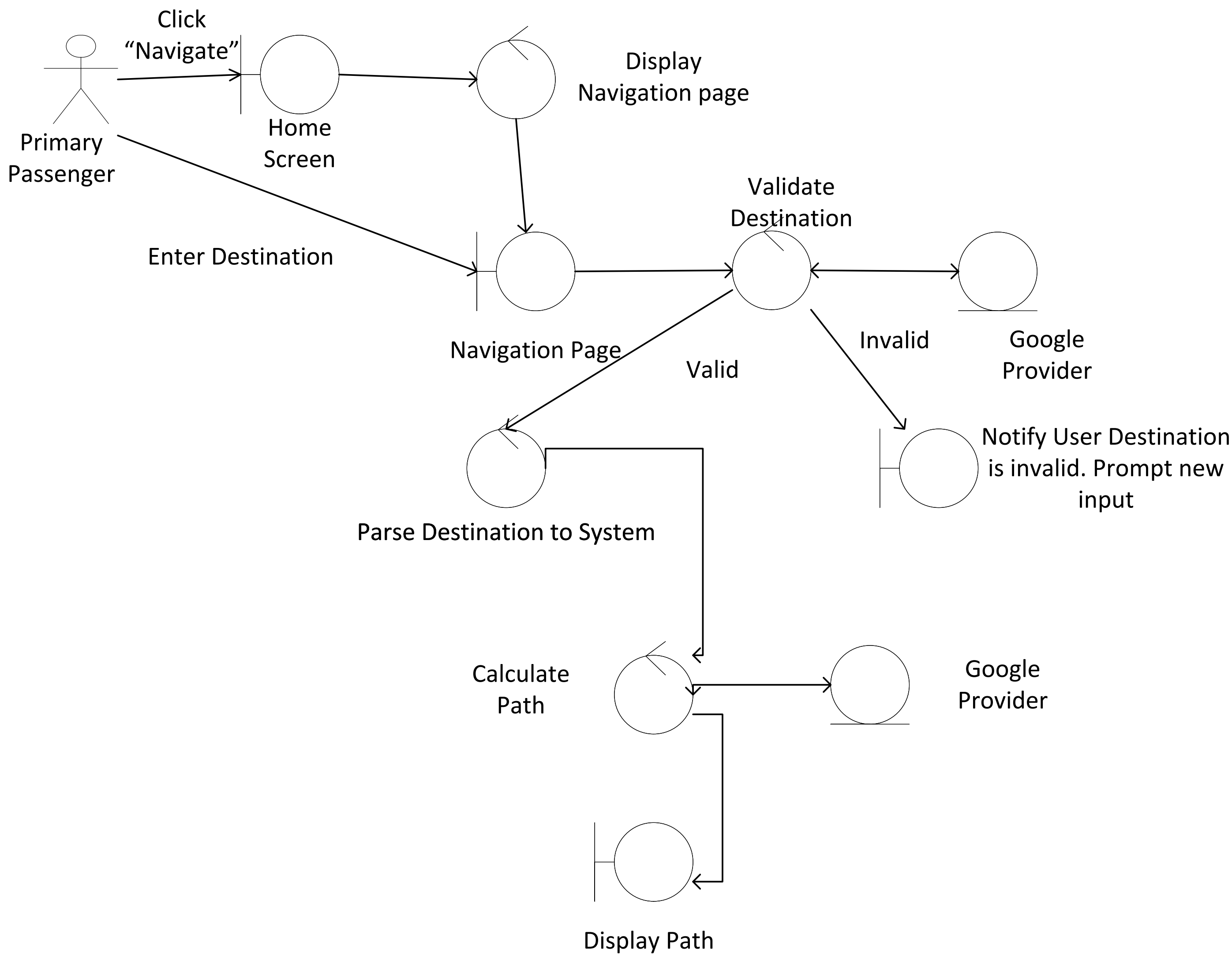


Figure 13: Robustness Diagram: Enter Destination

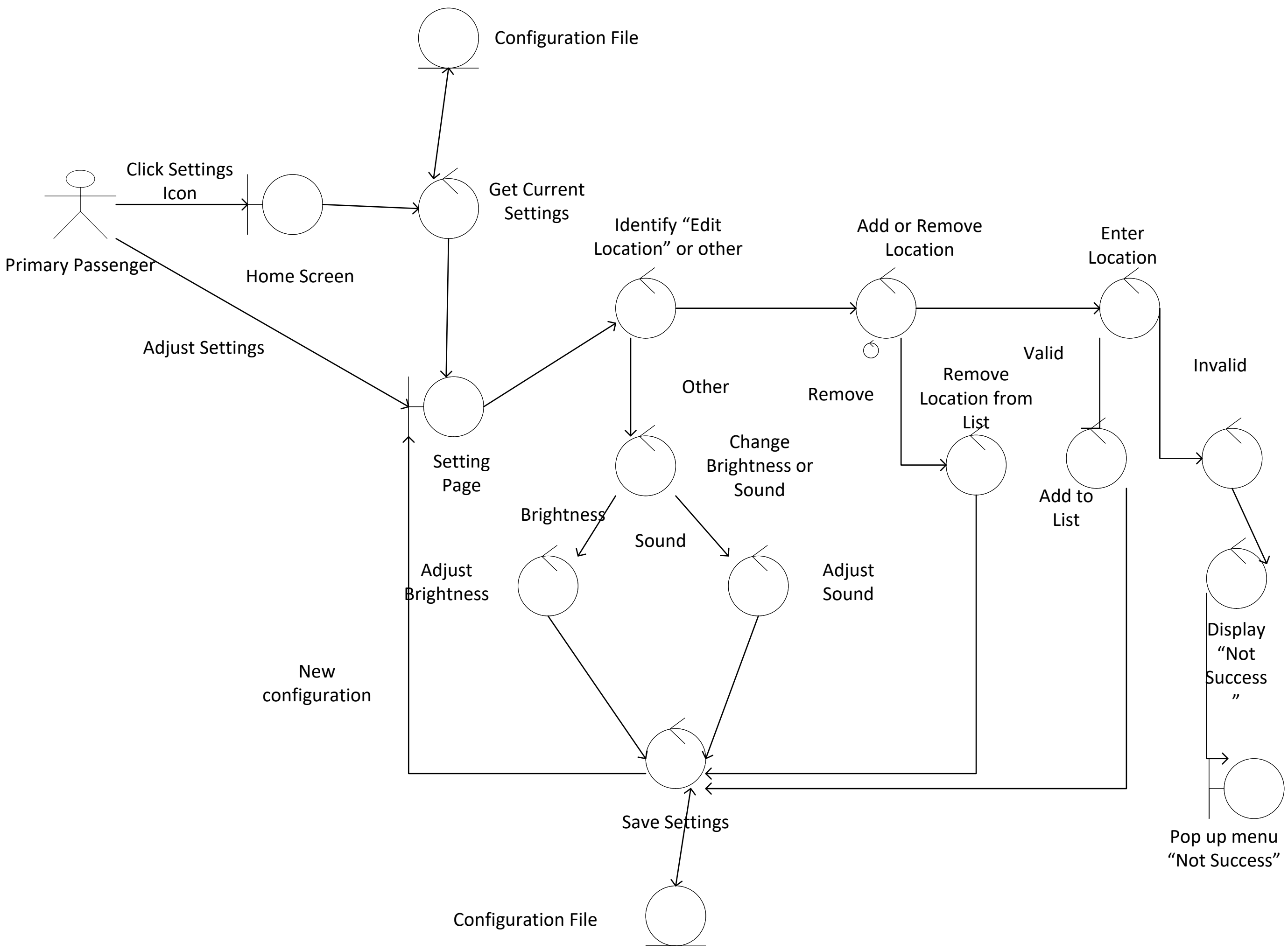


Figure 14: Robustness Diagram: Change Settings

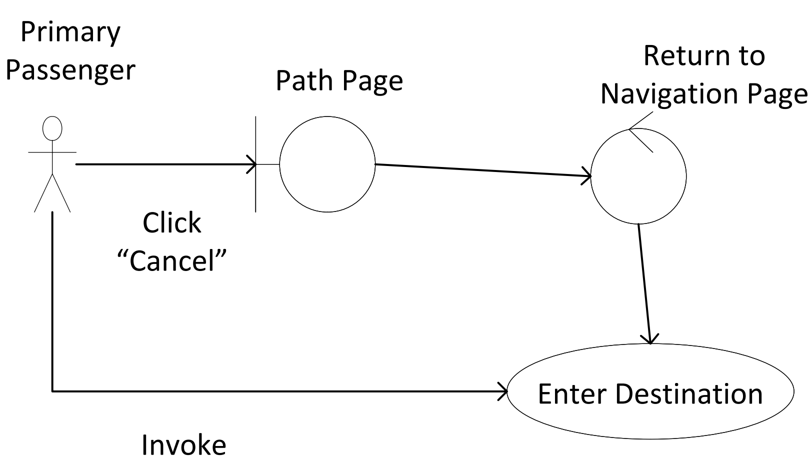


Figure 15: Robustness Diagram: Modify Destination

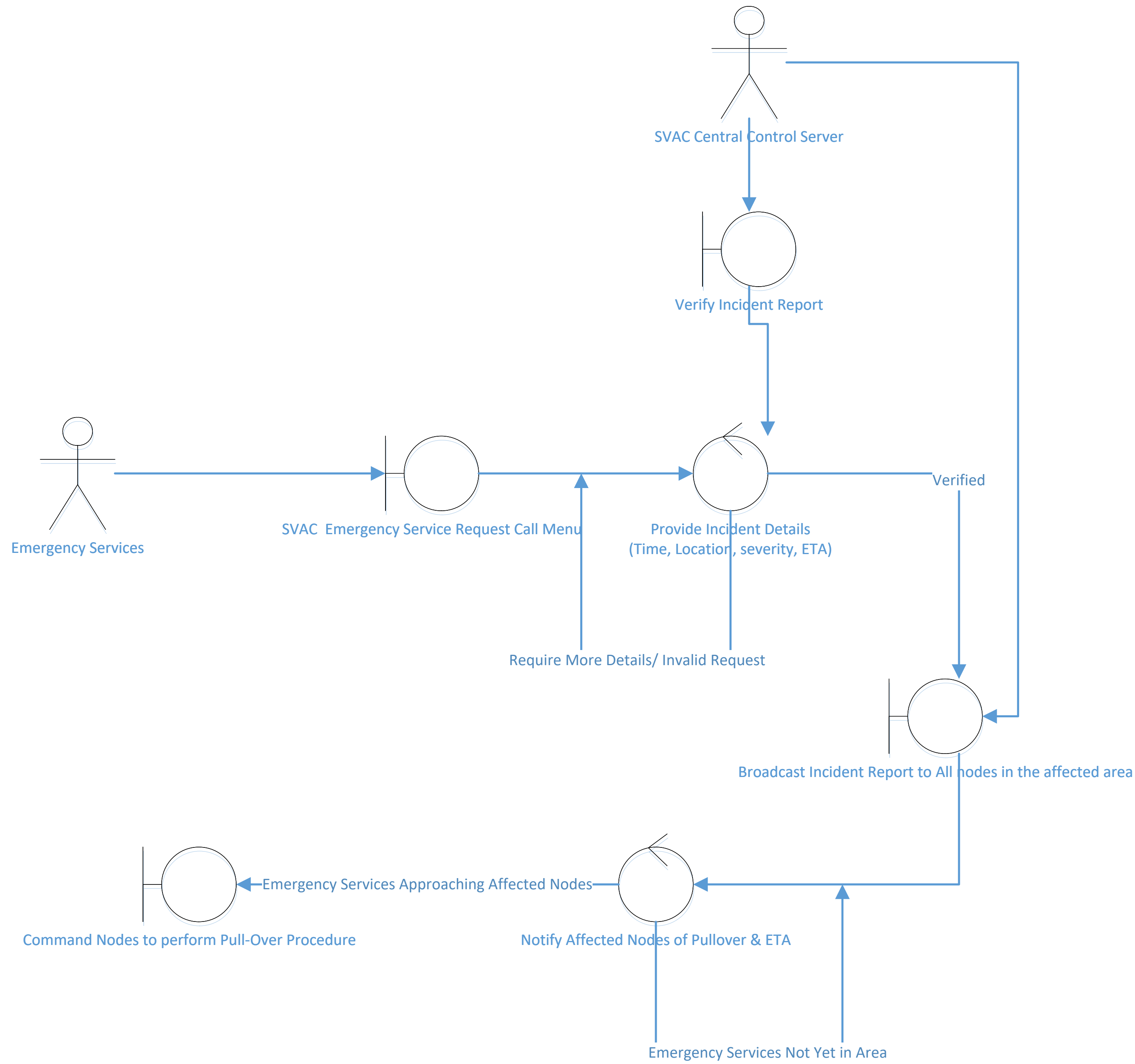


Figure 16: Robustness Diagram: Pull Over Vehicle

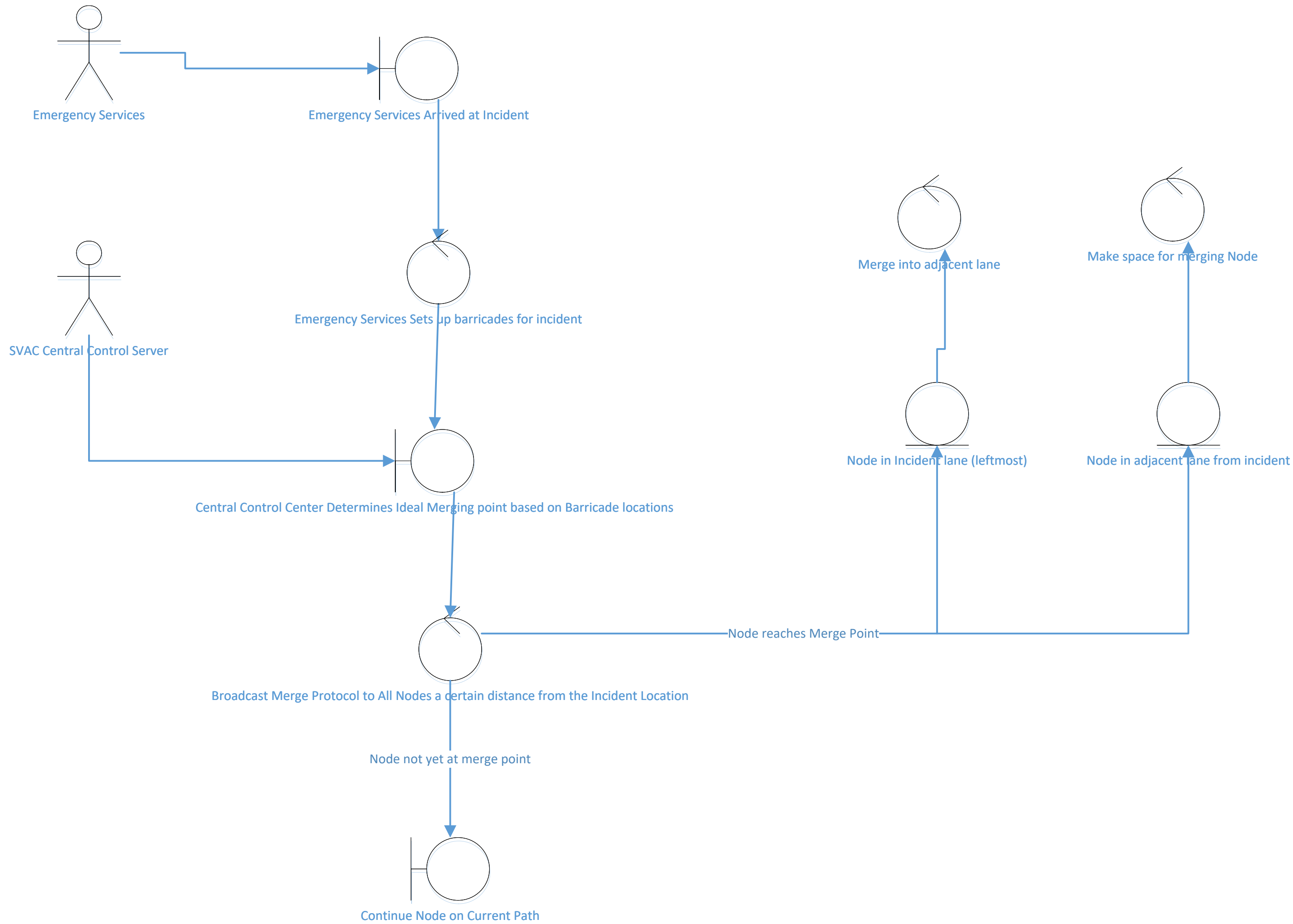


Figure 17: Robustness Diagram: Redirect Vehicle

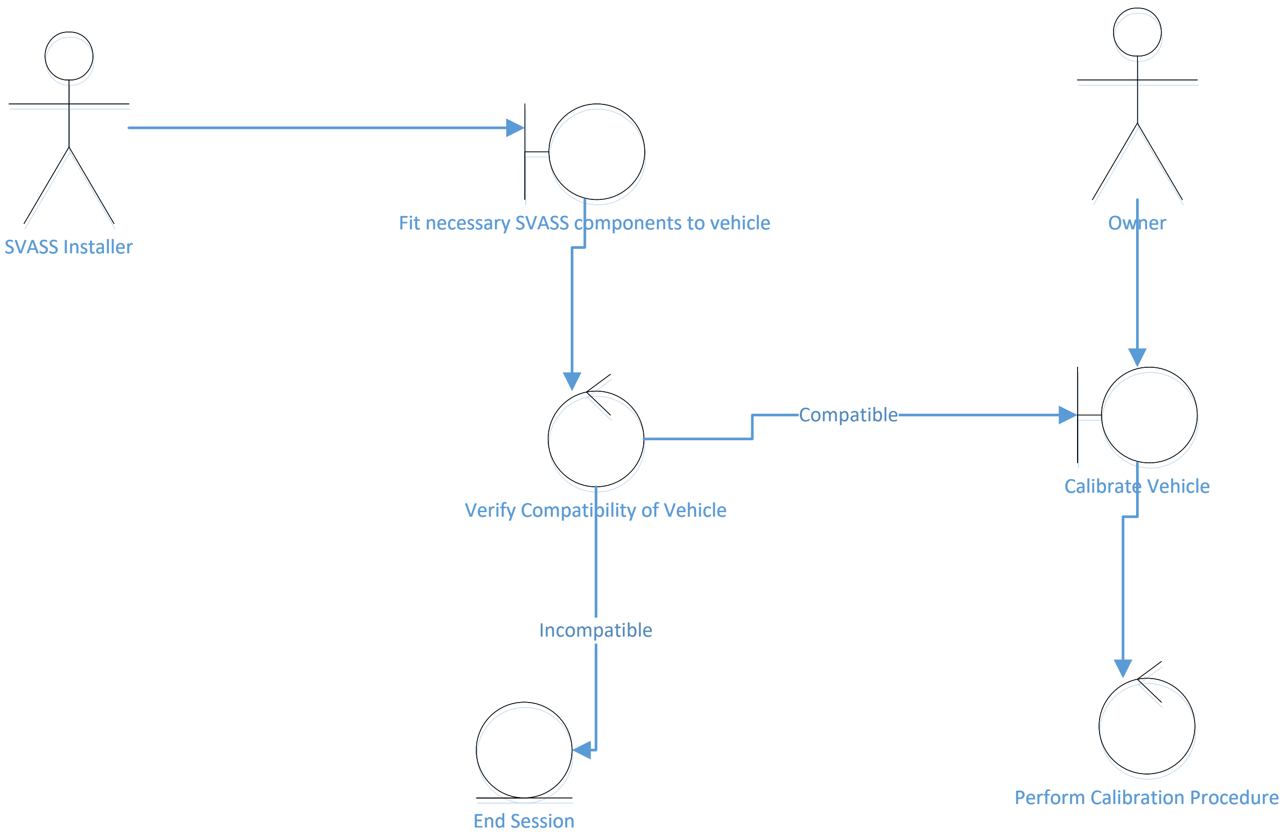


Figure 18: Robustness Diagram: Install SVASS

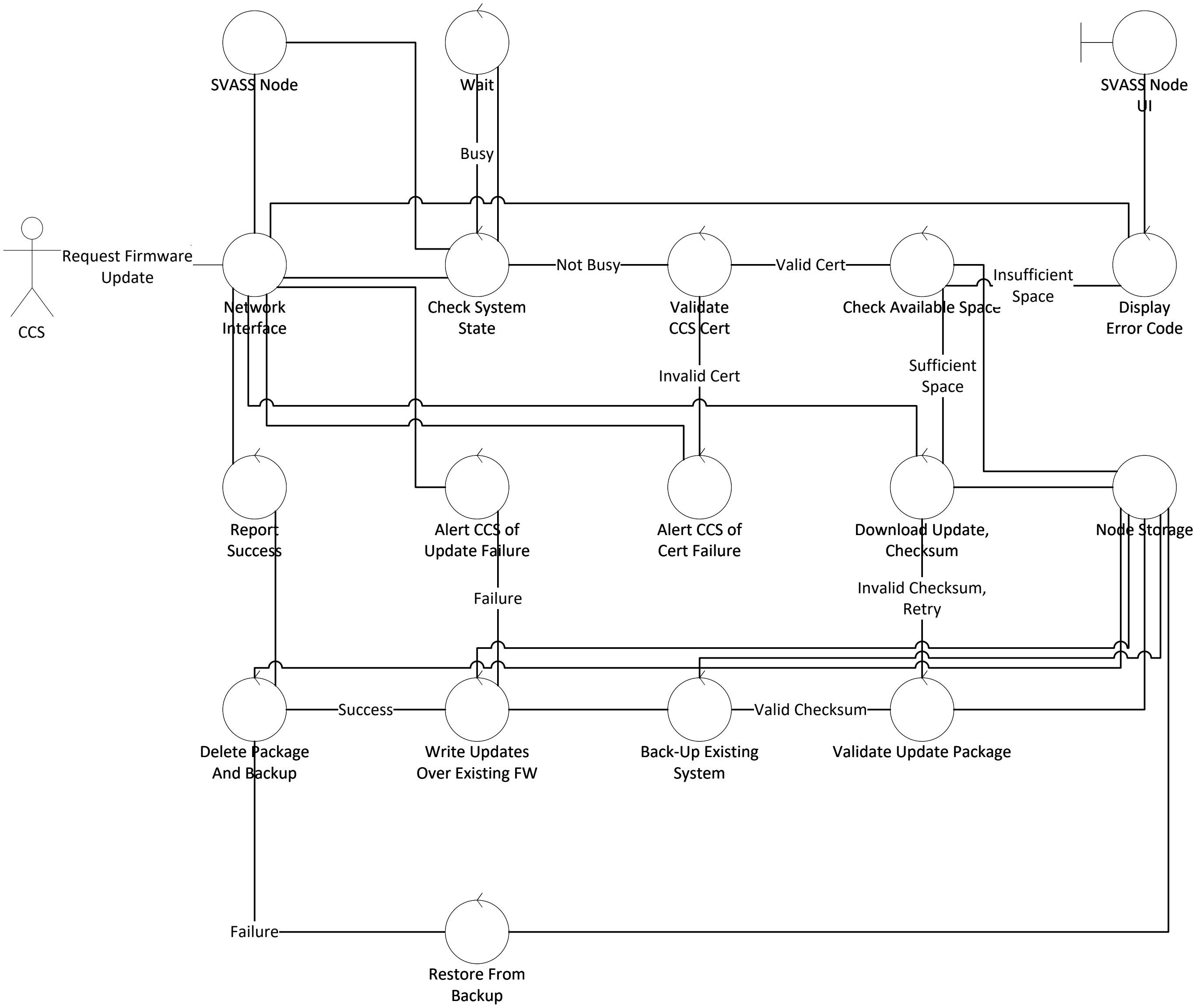


Figure 19: Robustness Diagram: Receive/Apply Pushed Updates

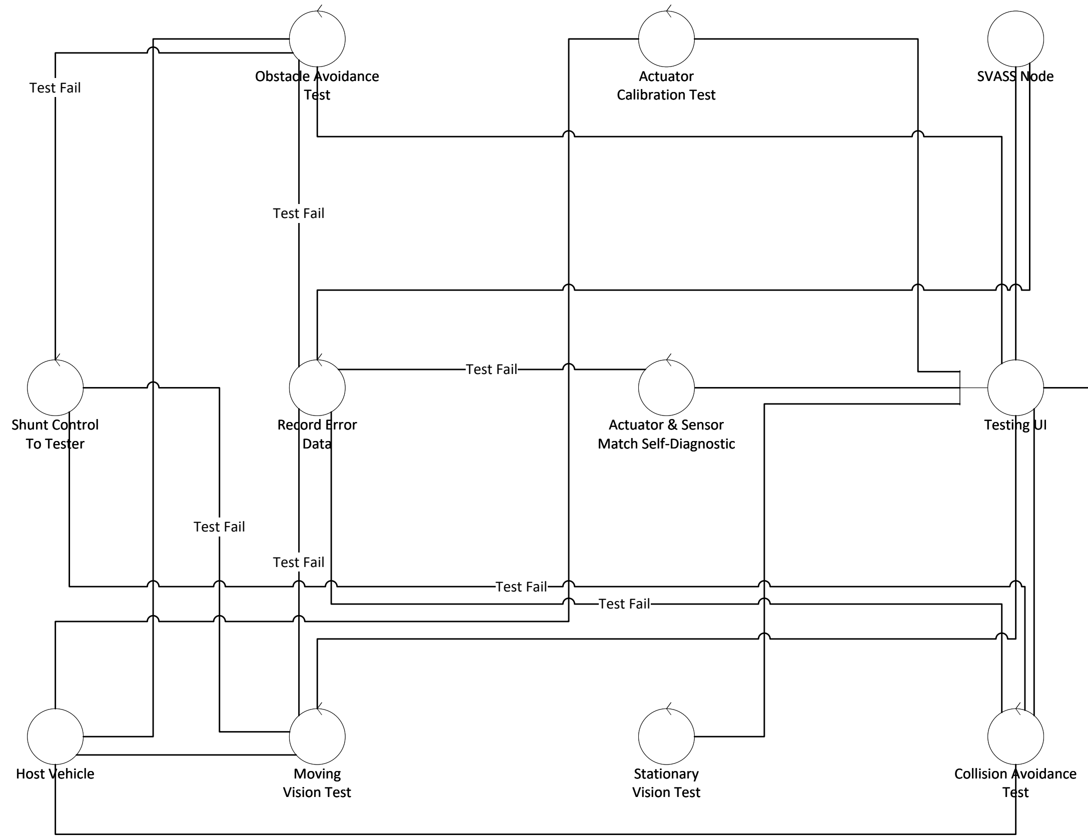


Figure 20: Robustness Diagram: Test Installed System

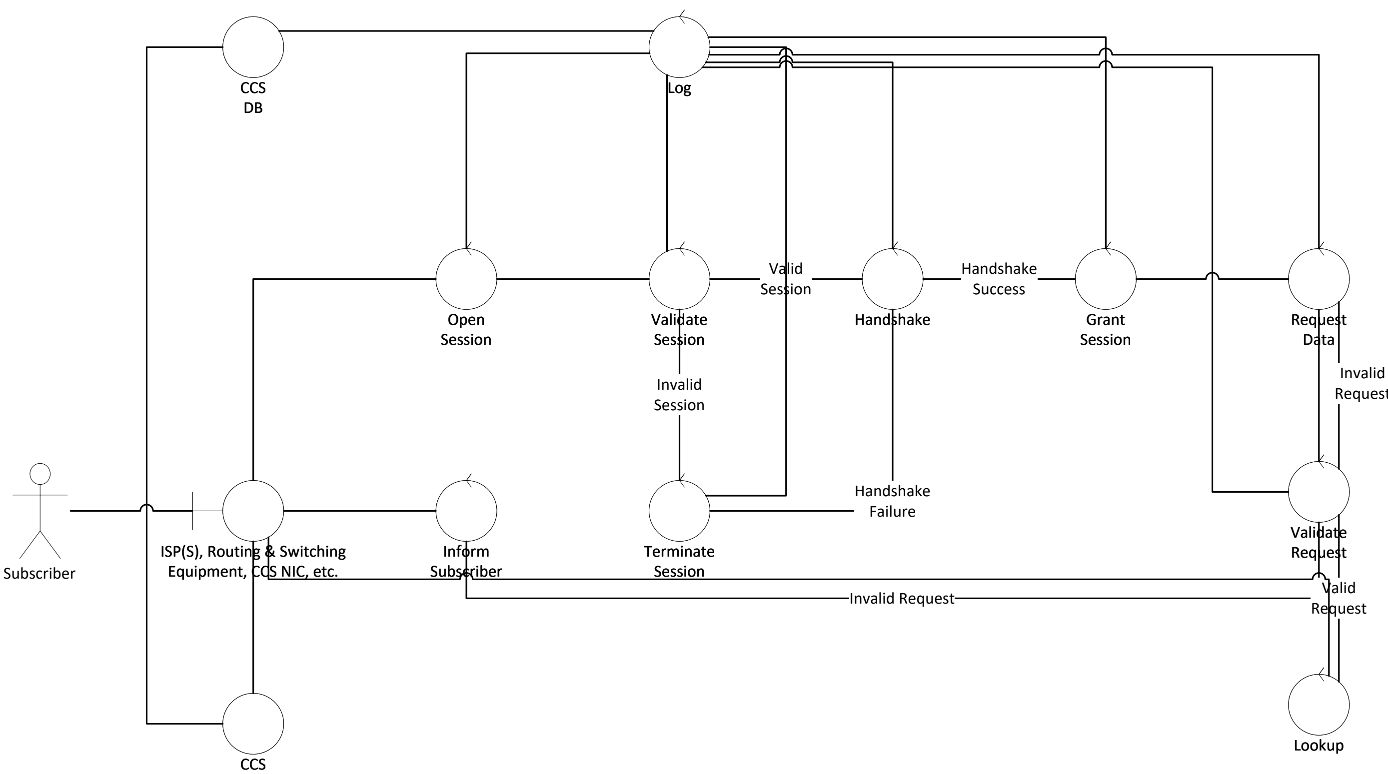


Figure 21: Robustness Diagram: Traffic Data Subscription

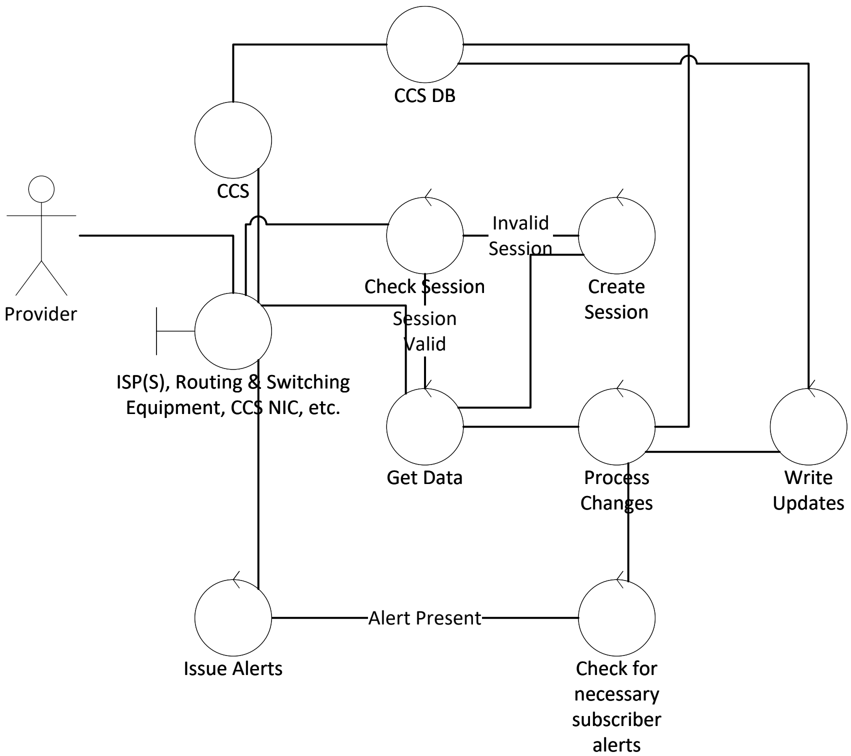


Figure 22: Robustness Diagram: Traffic Data Provision

7.3.3 Sequence Diagrams

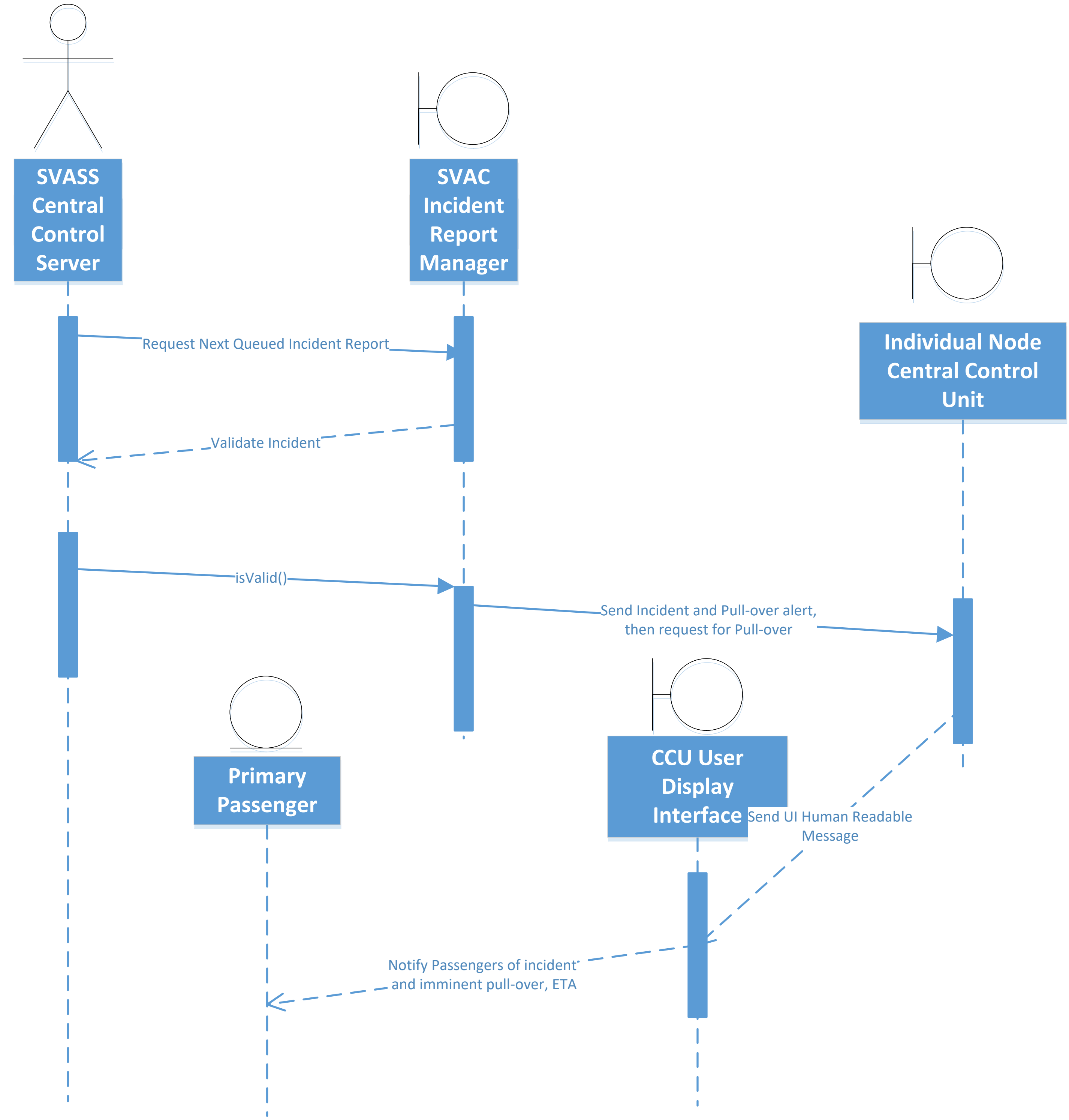


Figure 23: Sequence Diagram: Pull Over Vehicle

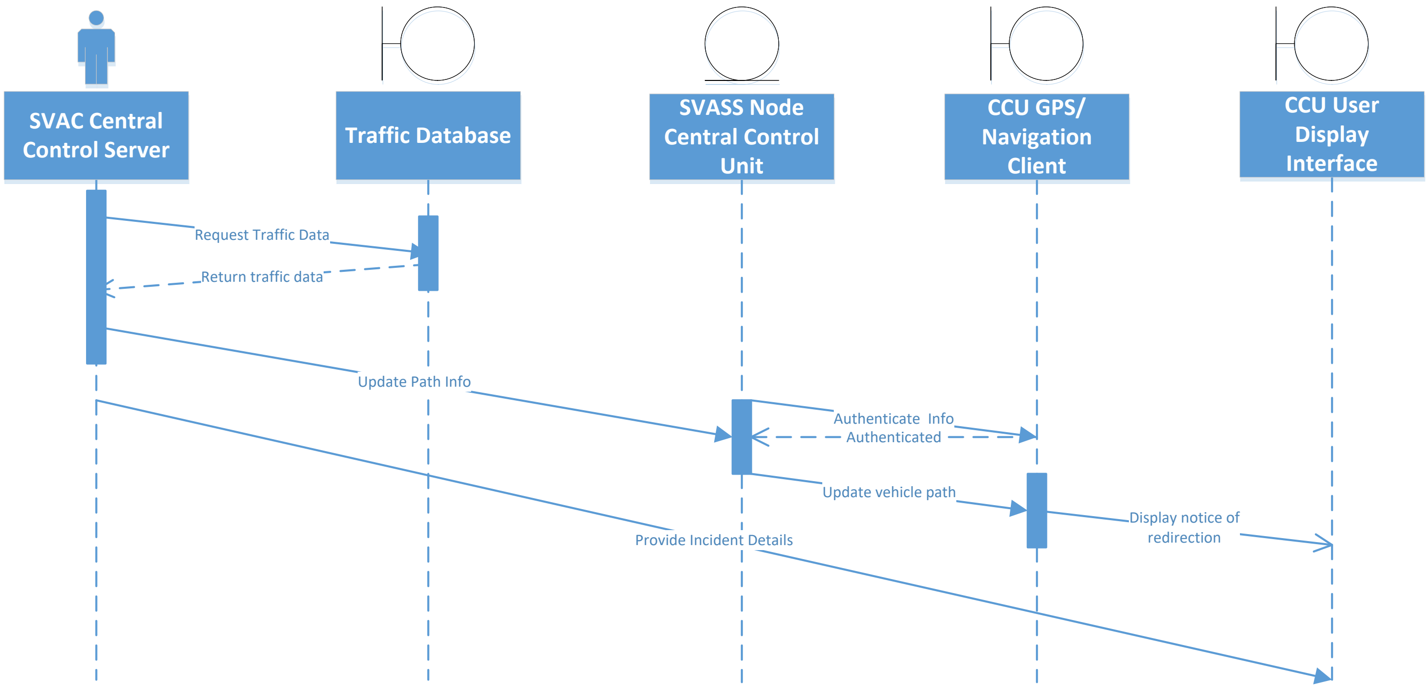


Figure 24: Sequence Diagram: Redirect Vehicle

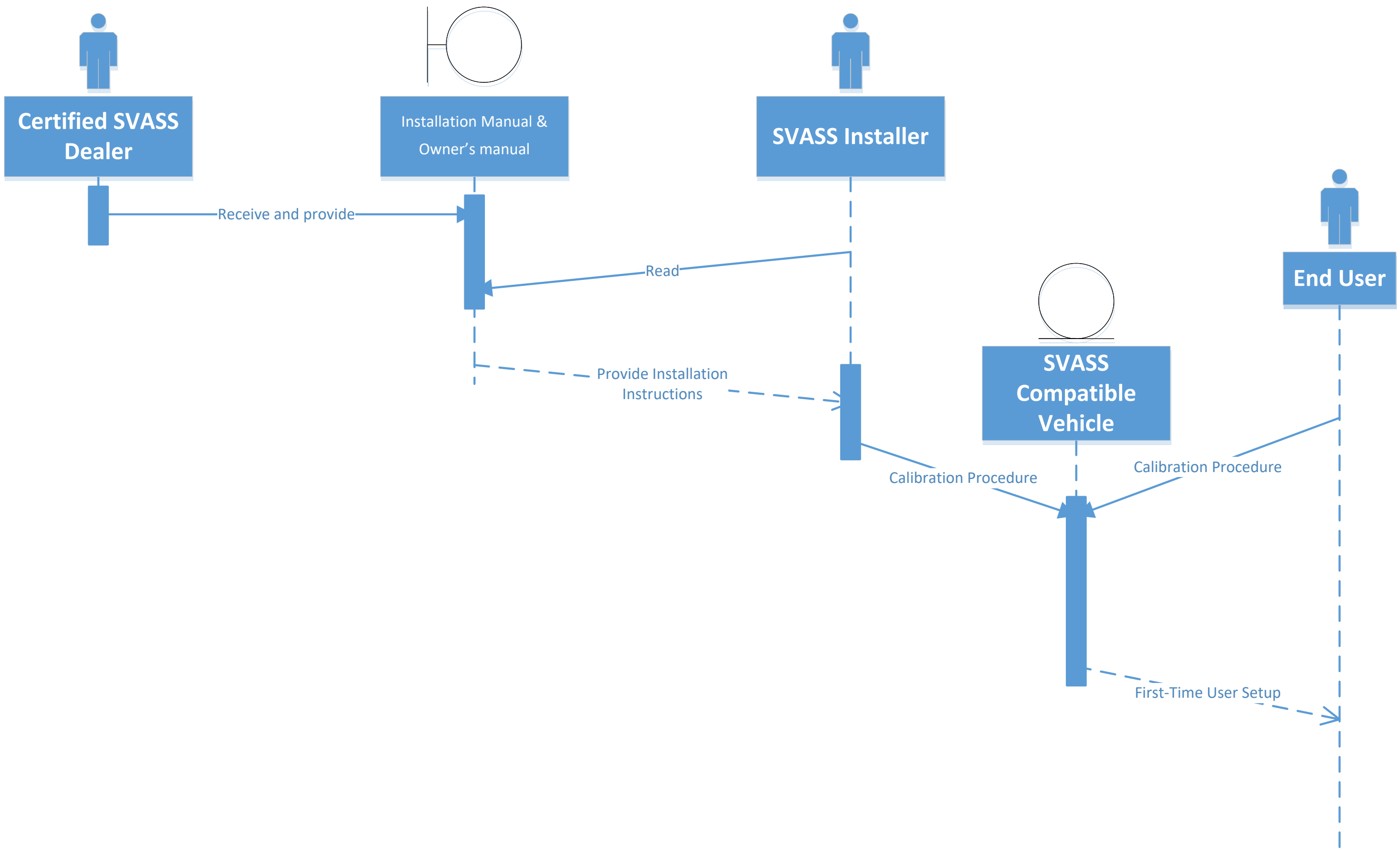


Figure 25: Sequence Diagram: Install SVASS

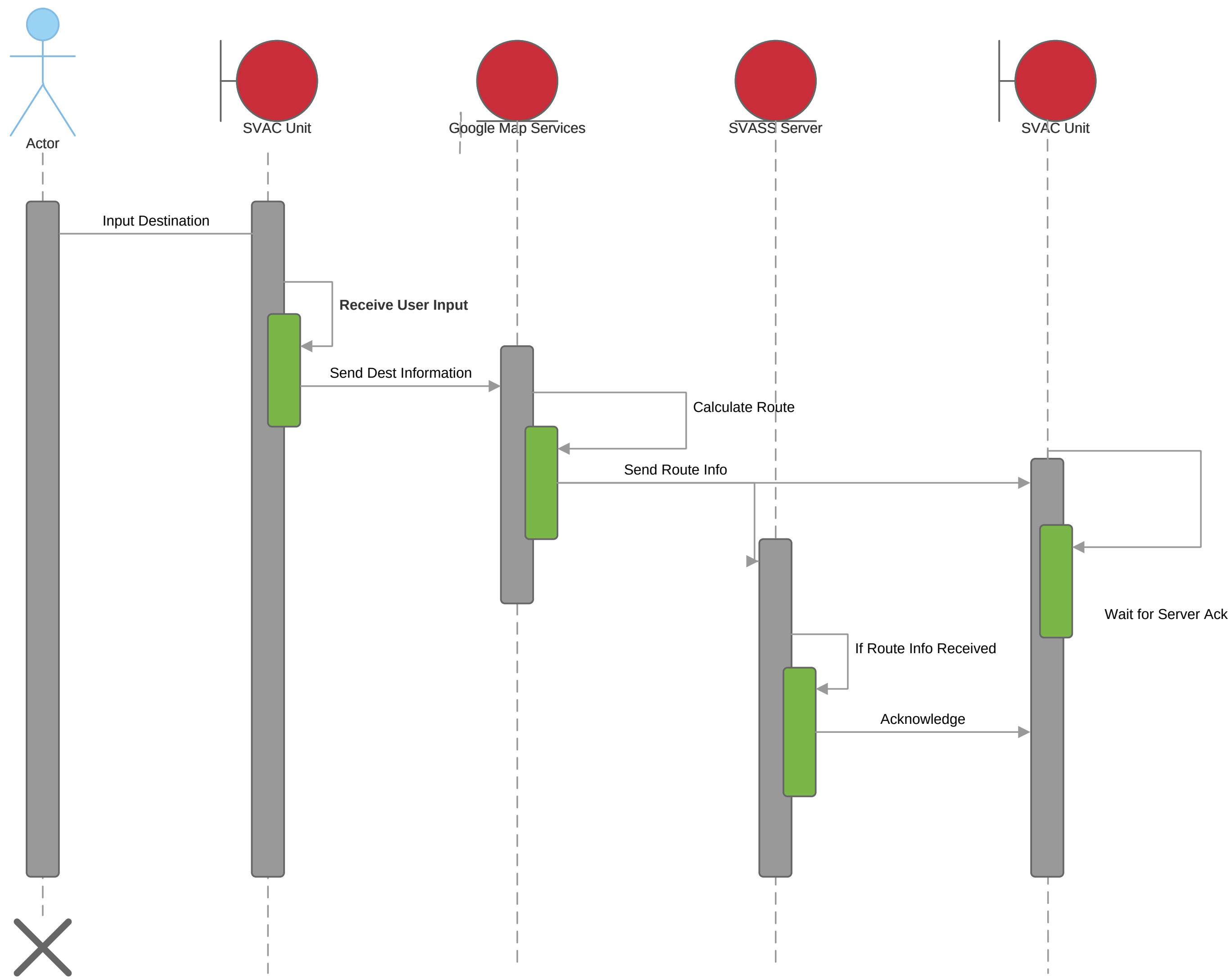


Figure 26: Sequence Diagram: Drive to Destination

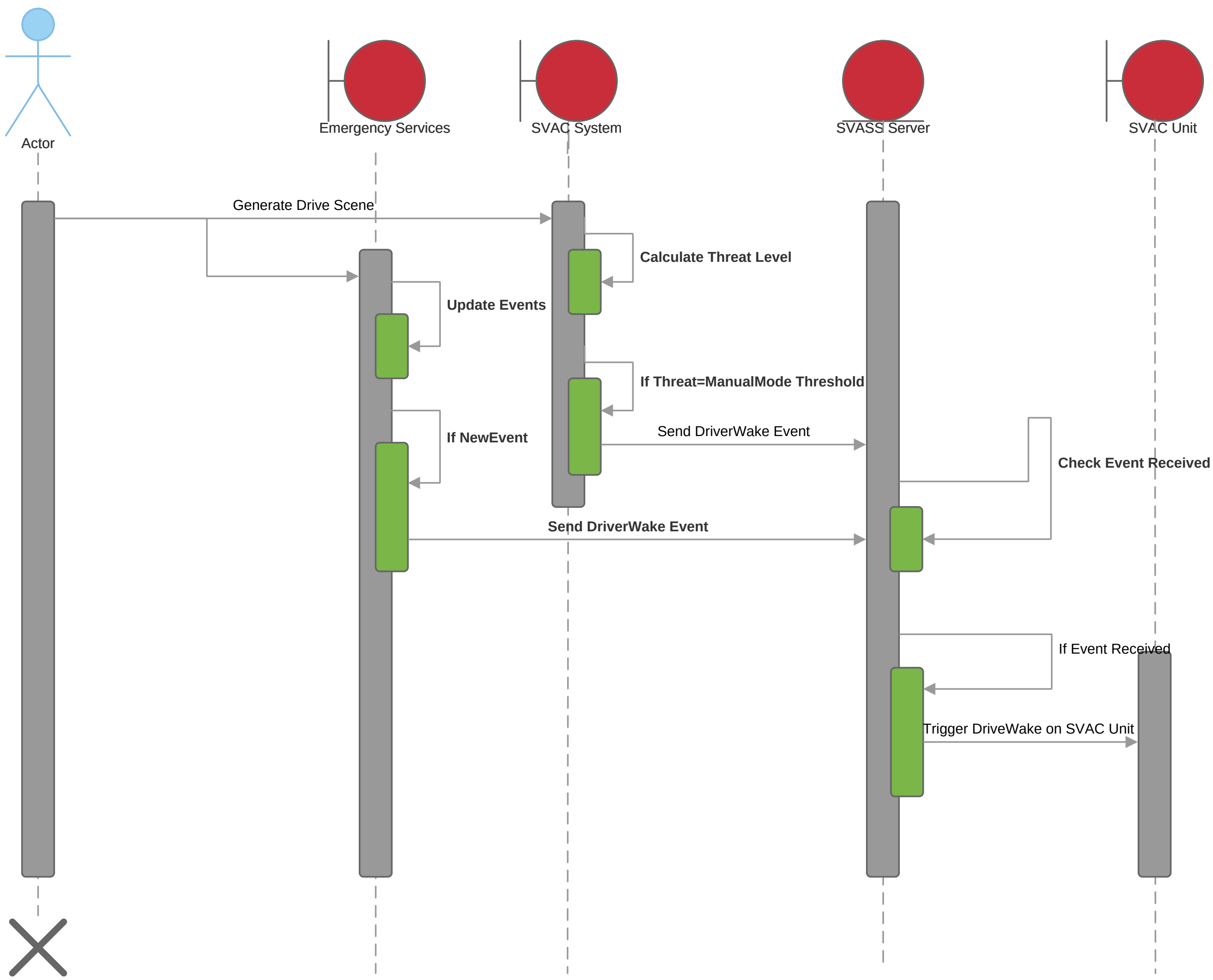


Figure 27: Sequence Diagram: Driver Wake

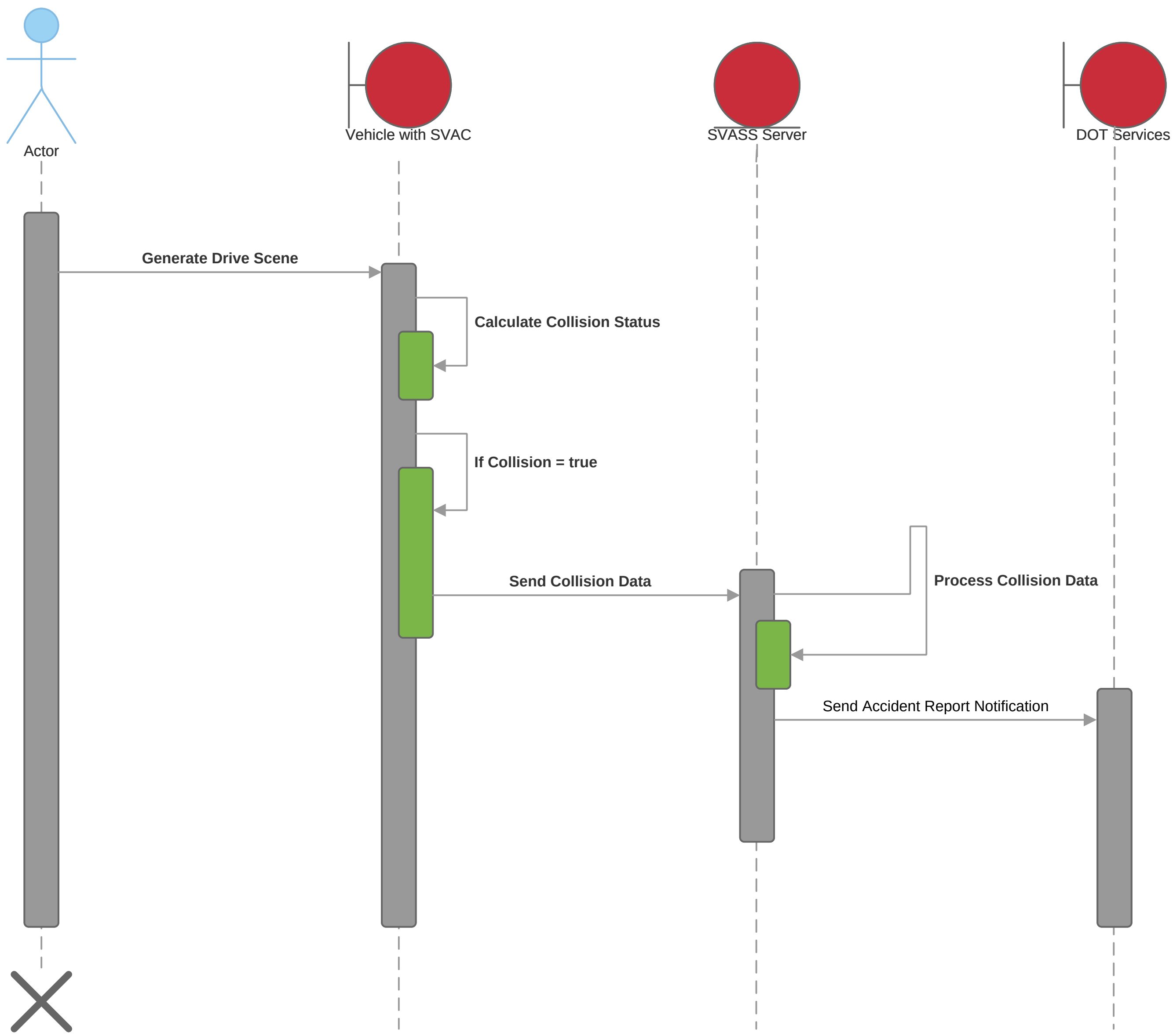


Figure 28: Sequence Diagram: Report Detected Accident

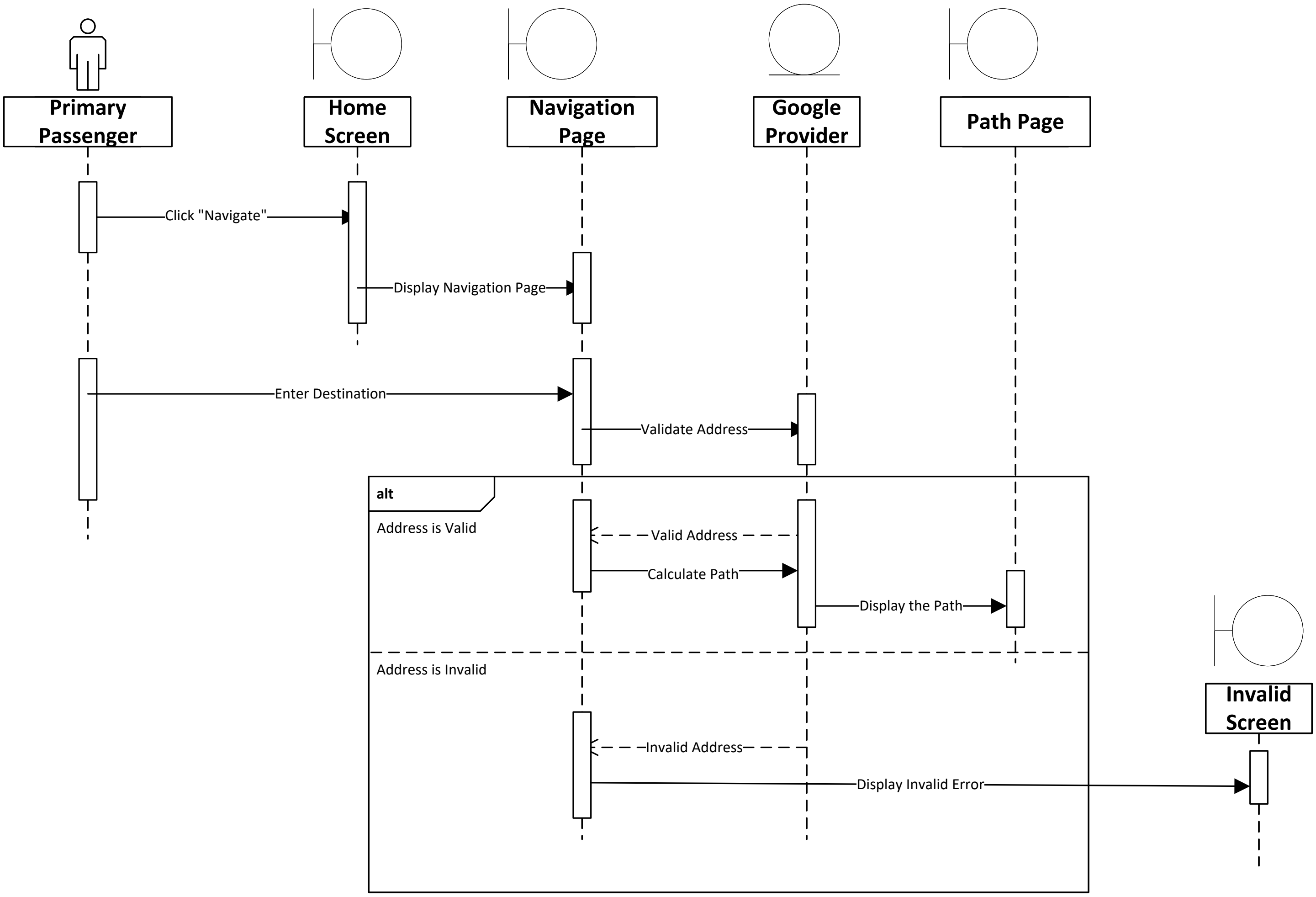


Figure 29: Sequence Diagram: Enter Destination

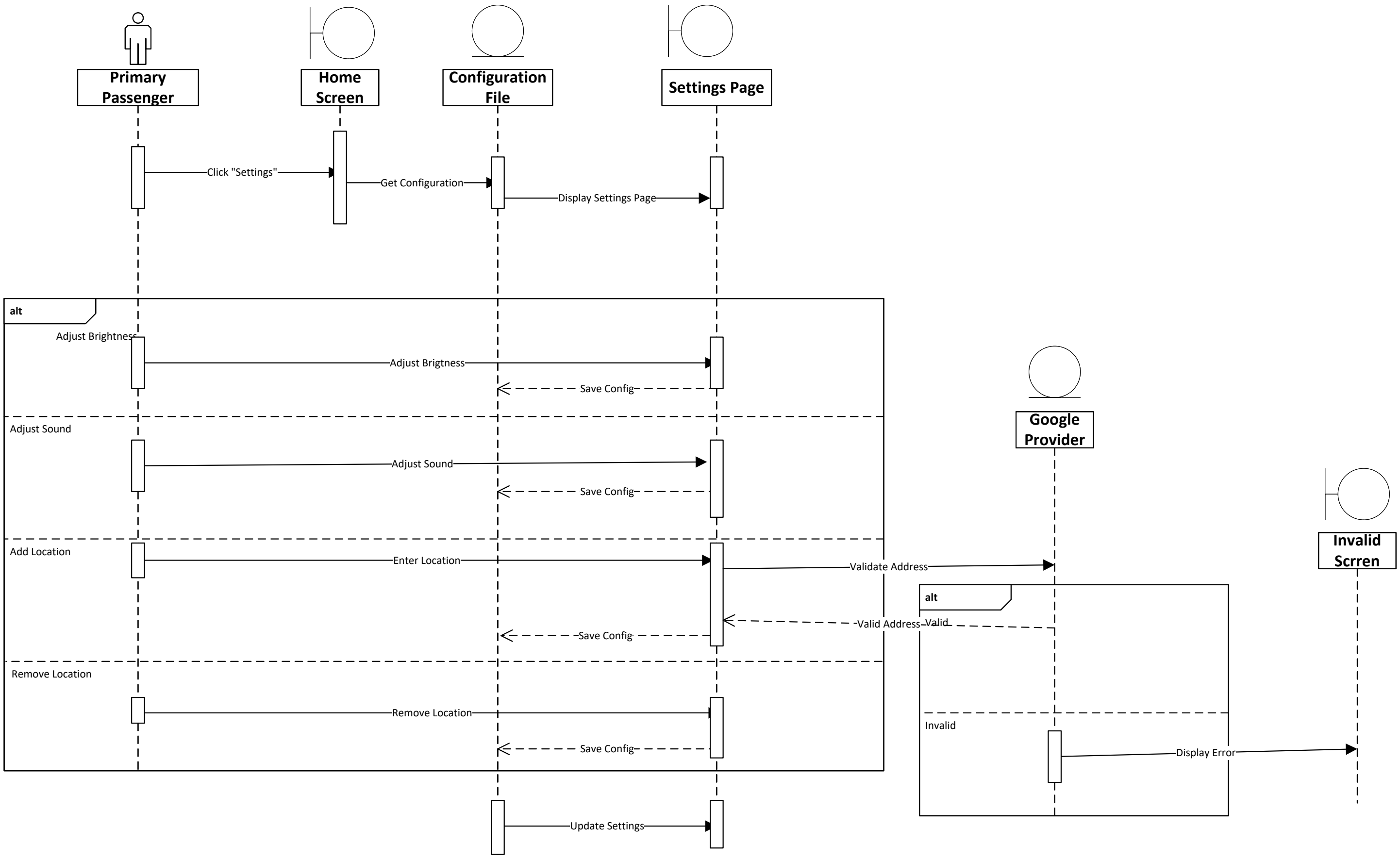


Figure 30: Sequence Diagram: Adjust Settings

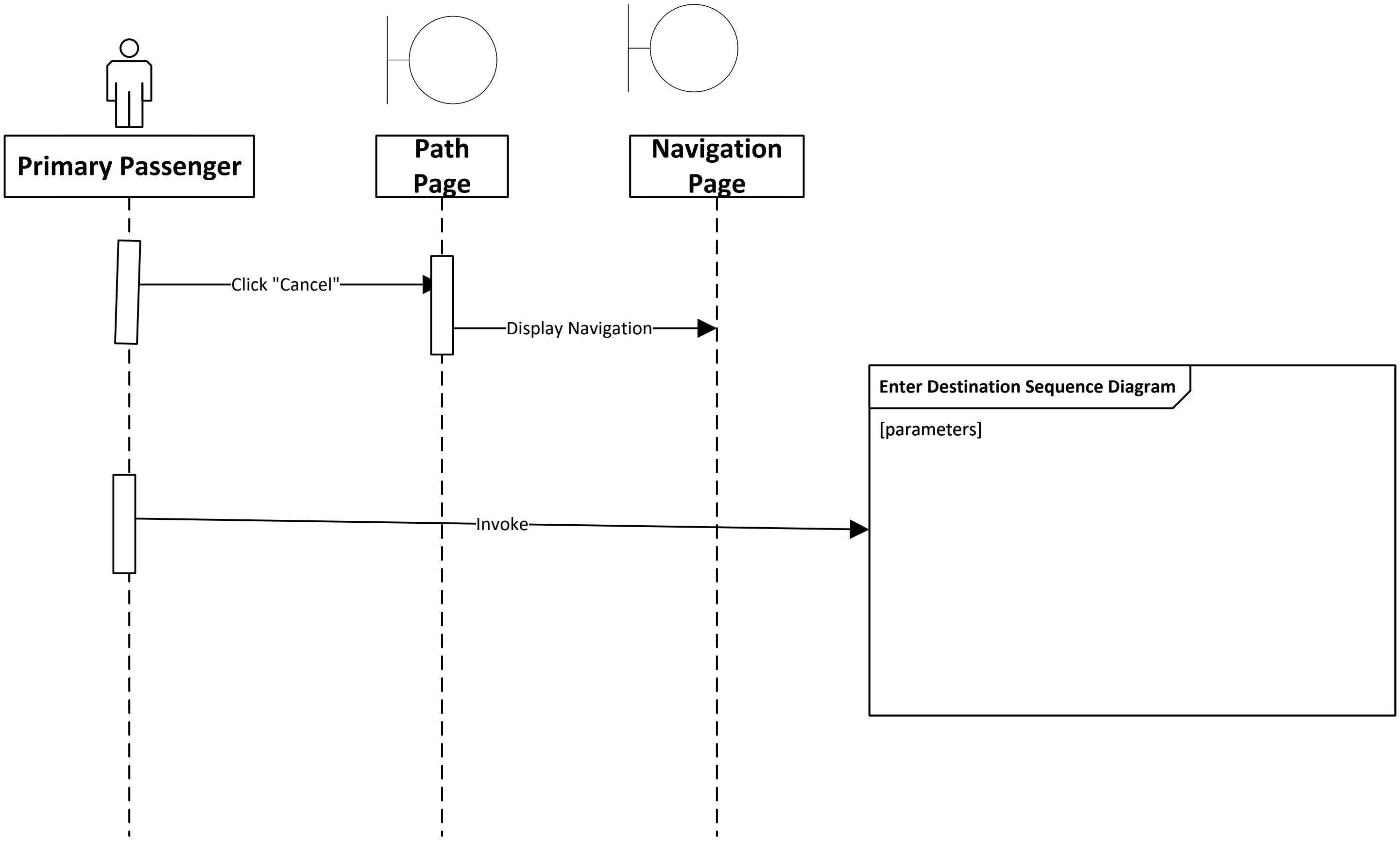


Figure 31: Sequence Diagram: Modify Destination

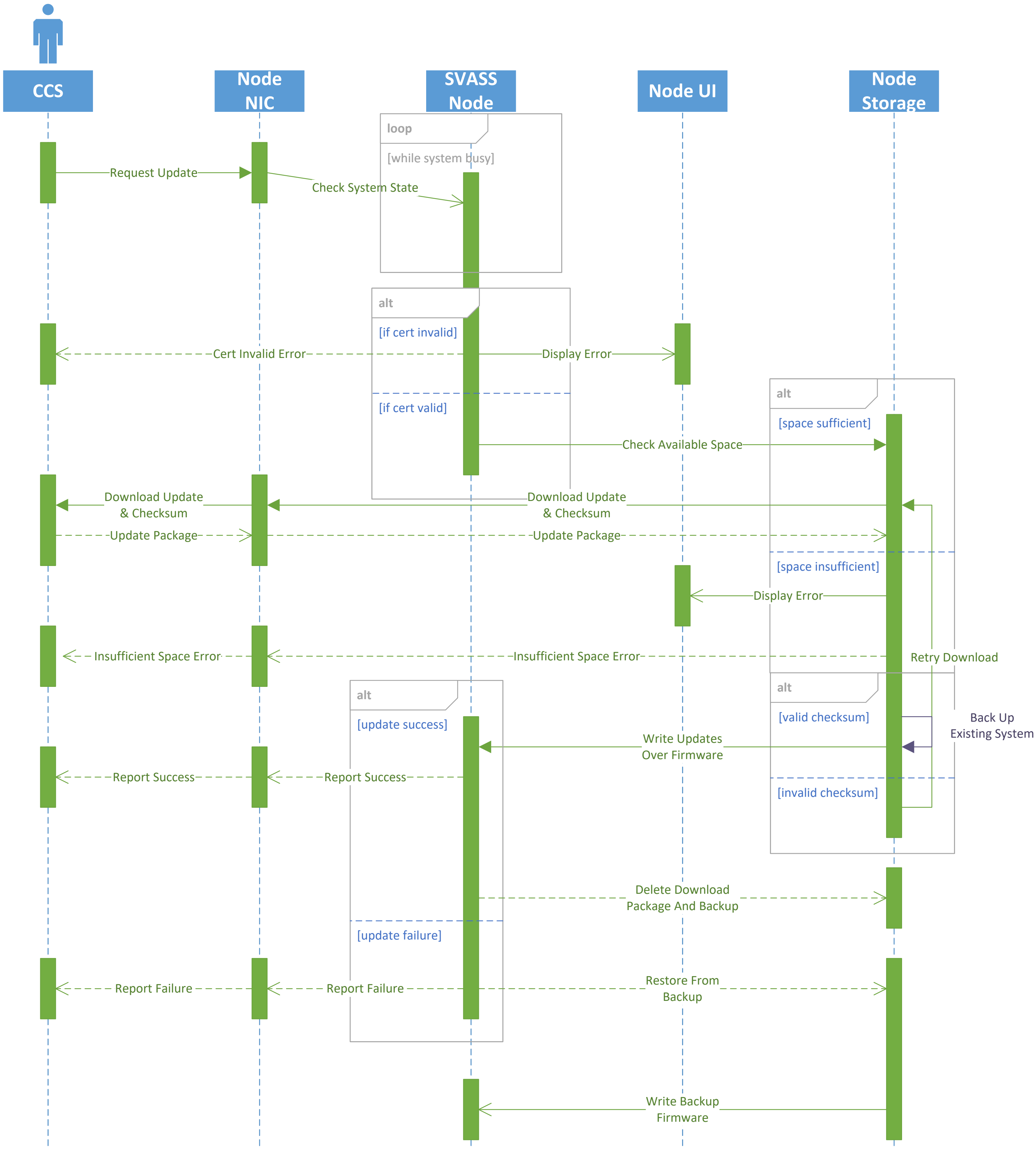
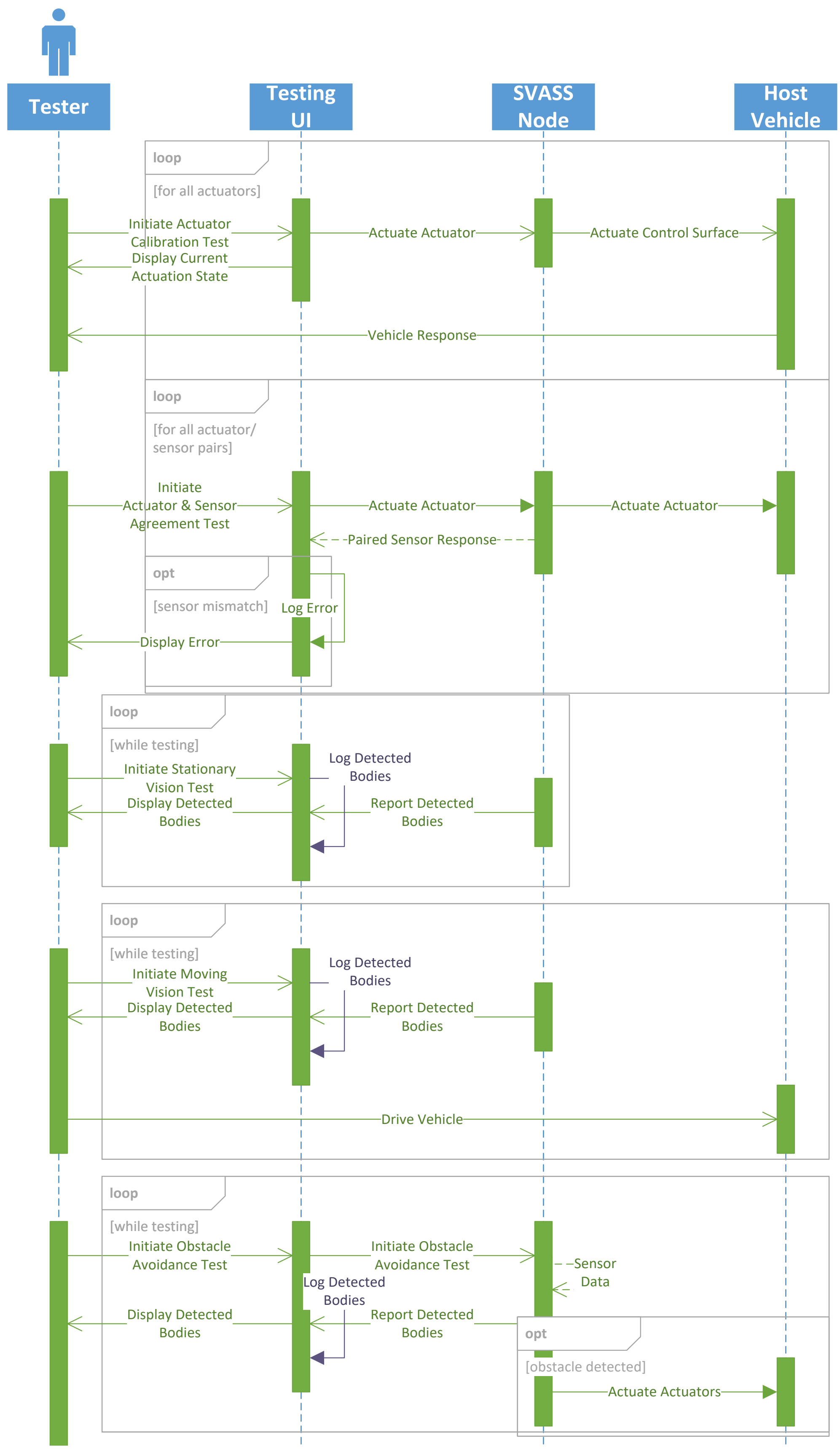


Figure 32: Sequence Diagram: Receive/Apply Pushed Update


Tester
Testing UI
SVASS Node
Host Vehicle
loop
[for all actuators]
Initiate Actuator Calibration Test
Actuate Actuator
Actuate Control Surface
Display Current Actuation State
Vehicle Response
loop
[for all actuator/ sensor pairs]
Initiate Actuator & Sensor Agreement Test
Actuate Actuator
Actuate Actuator
Paired Sensor Response
opt
[sensor mismatch]
Log Error
Display Error
loop
[while testing]
Initiate Stationary Vision Test
Log Detected Bodies
Display Detected Bodies
Report Detected Bodies
loop
[while testing]
Initiate Moving Vision Test
Log Detected Bodies
Display Detected Bodies
Report Detected Bodies
Drive Vehicle
loop
[while testing]
Initiate Obstacle Avoidance Test
Initiate Obstacle Avoidance Test
Sensor Data
Log Detected Bodies
Display Detected Bodies
Report Detected Bodies
opt
[obstacle detected]
Actuate Actuators

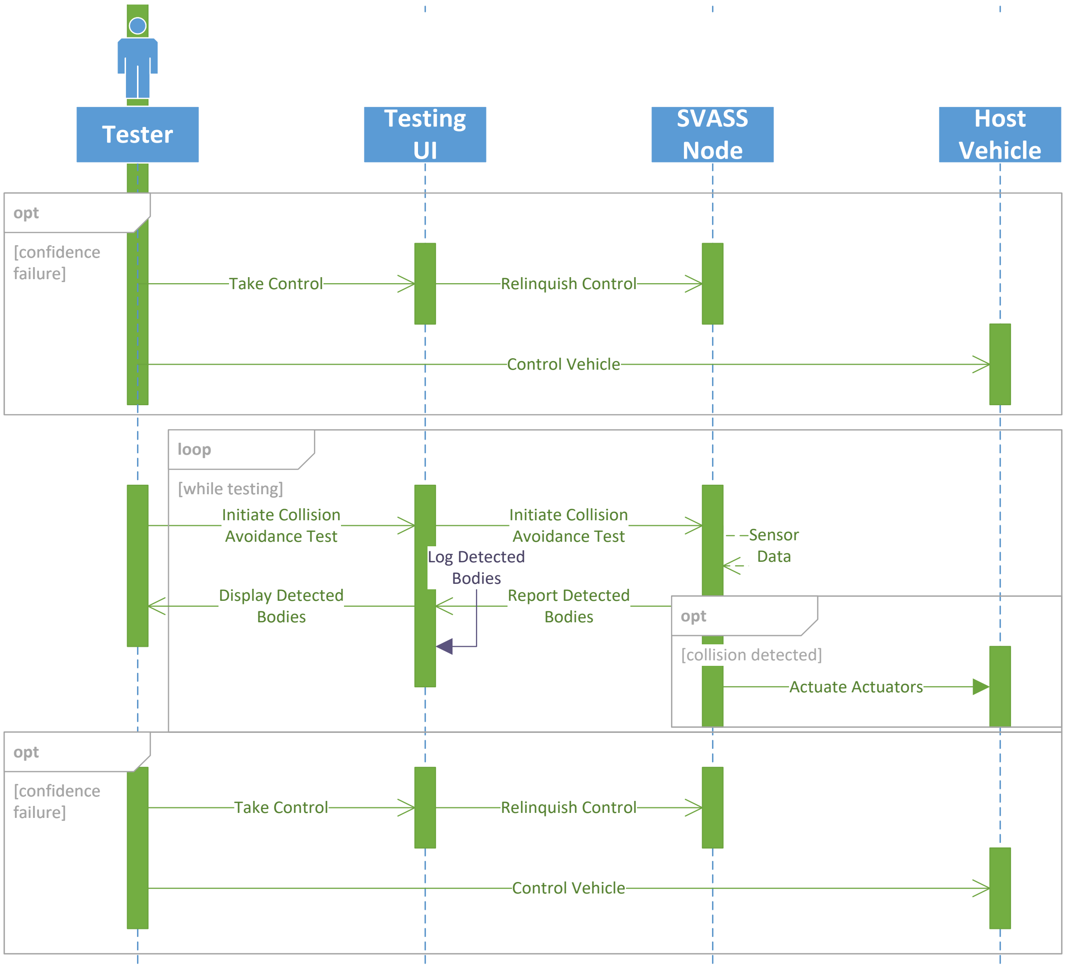


Figure 33: Sequence Diagram: Test Installed System

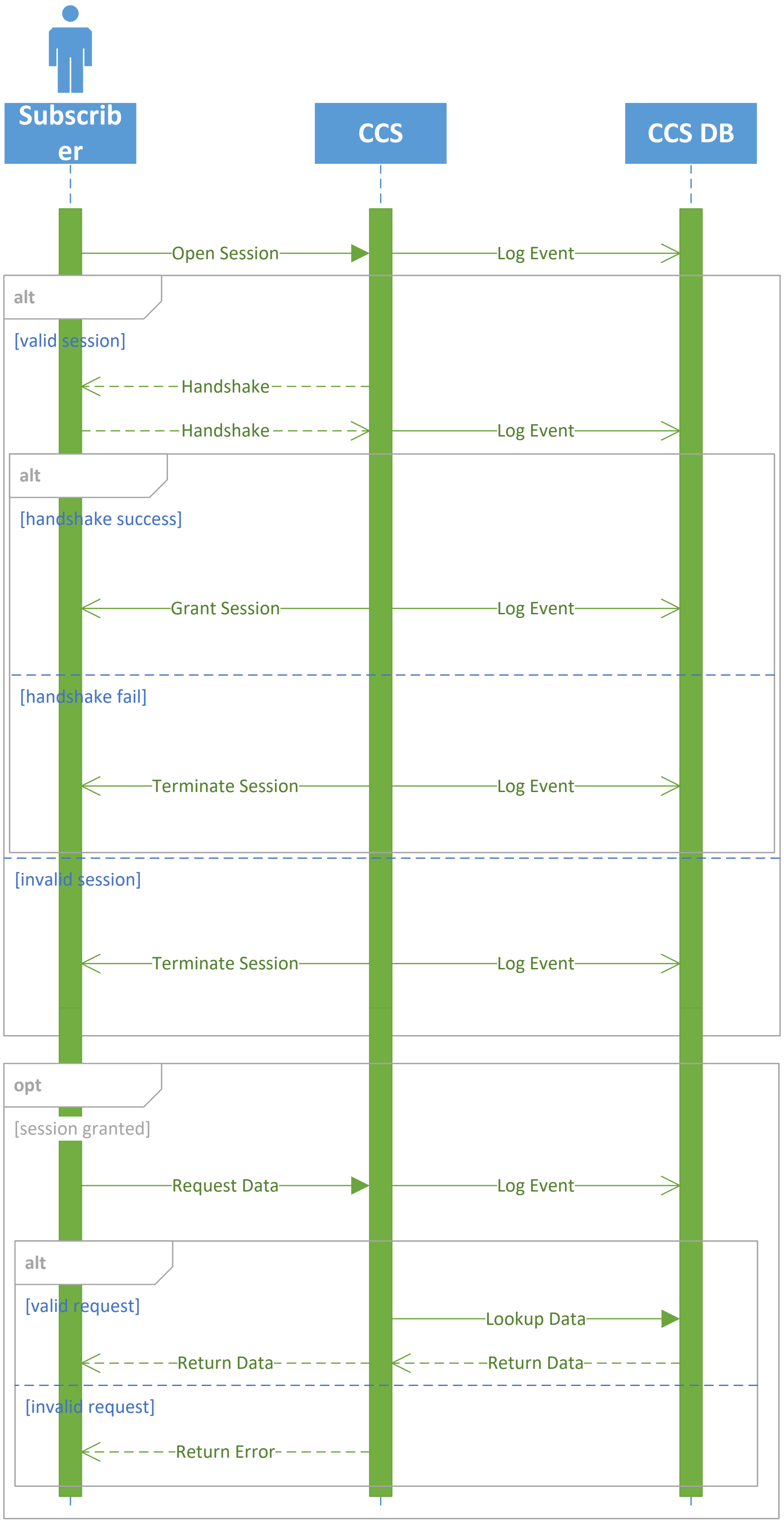


Figure 34: Sequence Diagram: Traffic Data Subscription

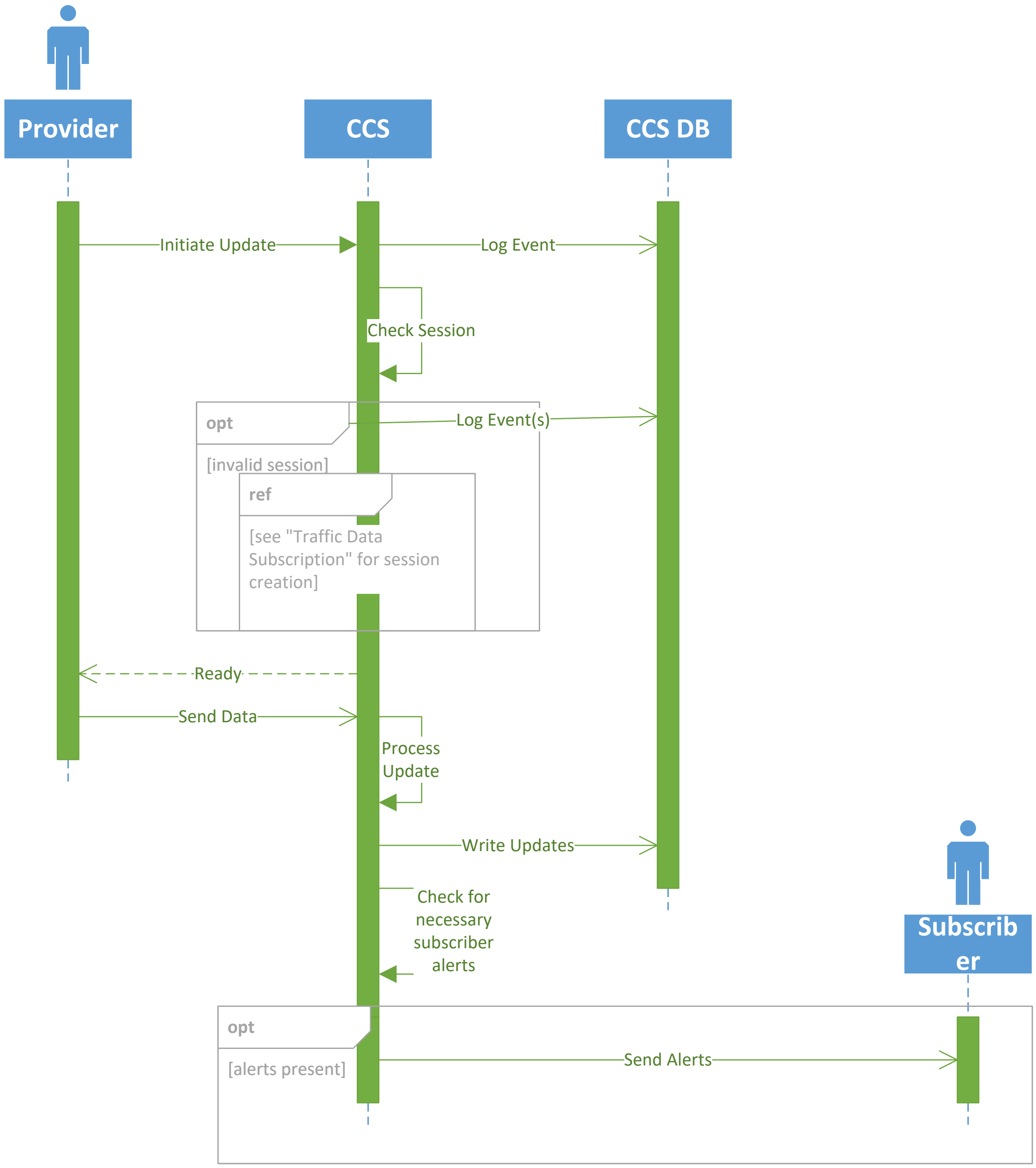


Figure 35: Sequence Diagram: Traffic Data Provision

Appendix

Appendix 1 Glossary

Allowance, Navigation Cache (NCA):
How long the SVASS unit may navigate via its onboard cached data without connecting to the CCS.

Central Control Server (CCS):
SVAC server system which interfaces with SVASS units and external services.

Control Surfaces:
Physical controls used to operate the automobile:

- Steering wheel
- Brake pedal
- Accelerator pedal
- Turn signal

Driver Wake:
In a situation where it is determined that the SVAC system is incapable of safely controlling a SVASS unit, the SVASS unit will be directed to “wake” the primary passenger of the vehicle, gaining their attention via audio-visual notification, and subsequently granting them control of the vehicle. This event may also be triggered by the SVASS unit itself.

Simple Vehicle Automation Control (SVAC):
The Simple Vehicle Automation Control company.

Simple Vehicle Automation Supplementary System (SVASS):
Hardware package purchased by an end user and installed in their vehicle. The SVASS uses its own sensor and actuator packages in conjunction with those leverageable from the host vehicle to drive said vehicle with complete autonomy.

External Service:
Any data system not directly affiliated with SVAC that provides data to, receives data from, or otherwise interacts with SVAC systems in a permitted manner. This includes (but is not limited to) Google Maps navigation and traffic data, Departments of Transport traffic data, and Emergency Services.

Modern Vehicle:
SVAC considers modern vehicles to be those equipped with fully automatic (or optionally so) transmission, an electronic control unit, and an onboard diagnostic port (OBD-II standard or better).

Navigation Cache:
Storage local to SVASS unit maintaining copy of navigation data for current route.

Primary Passenger:
The passenger of a SVASS-equipped vehicle sitting in the seat directly behind the control surfaces. This passenger will be expected to take control of the vehicle in any situation requiring a driver wake, and must therefore be legally and physically capable of driving (has a valid driver’s license, not under the influence of any substance, etc.).

Secondary Passenger:
The secondary passenger unlike the primary passenger, sits in the seat that is not the driving seat. Secondary passengers are not expected to manually drive the vehicle in event of a manual override.

Appendix 2 Records on Interactions with Stakeholders

Dear *Simple Vehicle Automation Supplementary System* Design team,

After thoroughly looking over your design documents and proposal I have decided to bid for the project. Your proposal document gives me a very clear and understandable view of what needs to be implemented and my team feels comfortable enough with your specifications and requirements documentation that they could build the product to specifications.

There are however two things that I wished to comment on. First of all, the title of your document refers to the "Simple Vehicle Automation Control" (SVAC) whereas the rest of your document refers to the "Simple Vehicle Automation Supplementary System" (SVASS). Is the SVASS a subset of a larger system (the SVAC), or has there been a change in the name at some point throughout the project's history that hasn't been caught completely by version control?

My other concern is that in our research into autonomous vehicle control and its effects on the flow of traffic, it seems the the benefits of faster flowing traffic (one of your major marketing points) will only come to be when and only when the vast majority of vehicles on the roads are autonomously controlled, or there are specific lanes on roads and highways for autonomous vehicles. We wanted to make sure that you had considered if and how this may affect the rate of the initial uptake for this product.

Sincerily,
Jesse Llona
jbllona@uw.edu

I thought this document was really well written and have a very professional look and template. I really like the table of figures section and would defiantly like to include one in our document. I had one thought on page 6, 4.1.3 number 3. If there was a software malfunction where the system could not recover, would it still be able to pull of the road? The references were very thorough. It is hard to find things wrong with document, if I had to knit pick it would have to be the different use of software for the sequence diagrams and use cases. -Austin Abeyta

Appendix 3 Implementation Team Review

Pros

+ Good introduction and shareholder interests documented.
+ Well-explored risks.
+ Overall, good research and documentation for the executive summary.
+ Great risks assessment.
+ Well-explored requirements.
+ Great diagrams.

Neutral

* What happens if the vehicle starts driving down an unmarked road? Can the vehicle even plot a course using an unmarked (e.g. gravel) road or will it simply avoid the road? What if the user lives on an unmarked road?
* Grey headings appear washed out, the document can appear condensed at times.
* Use case could appear convoluted; color helps.
* Yellow color is slightly distracting in the activity diagrams.

Cons

- Lacks strong parallelism between robustness diagrams and sequence diagrams. Not all scenarios and/or alternate courses of action are documented in sequence diagrams.
- Inconsistency between title page and document content

Summary Decision

Overall, the problem space is well-researched and documented. The document is organized and easy to navigate. The business proposal and risk analysis/assessment are thorough with appropriate solutions. The requirements specification is good, and each requirement translates into a unique use case scenario. No requirements are passive or ambiguous. Good assumptions. Wireframes are simple and effective. I can easily understand the expected interface. The activity diagrams are easy to understand and effectively communicate the program logic. The robustness analysis lacks ambiguity and extends the understanding of each use case. The only problem is that each sequence diagram lacks strong parallelism between its complementary robustness diagram. We found in our research that the benefits of faster flowing traffic (one of your major marketing points) will only come to be when and only when the vast majority of vehicles on the roads are autonomously controlled, or there are specific lanes on roads and highways for autonomous vehicles. We wanted to make sure that you had considered if and how this may affect the rate of the initial uptake for this product.

Final Verdict: BID with CONDITIONS – The sequence diagrams should be better rooted in their respective robustness diagram. The sequence diagrams are good and it is evident the designers know how the elements of a sequence diagram interact with each other. They just need to be strongly tied to each robustness diagram. Overall, great work!

Appendix 4 SVASS Unit Hardware Cost Sheet

Note: This parts list is preliminary, and should be taken as a rough guide for pricing and necessary parts. This list does not account for tax, shipping, or any applicable bulk discounts. Sourcing information is listed in the following section.

Description	Manufacturer	Part #	Unit Cost	Quantity/Unit	Subtotal
OBD II Female Housing	Molex	0511151601	1.37	1	1.37
OBD II Connector	Molex	0504208000	0.17	16	2.72
GSM Module	Multi-Tech Systems	MTSMC-EV3-N3-SP	184.68	1	184.68
GSM/GPS Ant.	Taoglas	MA203W.AB.002	33.37	1	33.37
ADHOC Wi-Fi Module	Murata Electronics	LBEE5ZZ1CK-TEMP-DS-SD	125	1	125
User Interface Panel	Adafruit Industries	2354	47.5	1	47.5
User Interface Back Button	Visual Communications	CTHS15CIC04	6.59	1	6.59
GPS Module	Skyworks Solutions	SE4150L-R	3.2	1	3.2
Accelerometer	STMicroelectronics	LIS2HH12TR	1.32	1	1.32
Video Camera	OmniVision Technologies	OV07740-A32A	4.96	4	19.84
Thermal Camera	FLIR	500-0643-00	175	4	700
LIDAR Camera	SparkFun Electronics	SEN-14032	150	4	600
Stepper Motor	Delta-Line	86SH156-6204A.000	244.43	3	733.29
Compute Unit	VersaLogic Corporation	VL-EPU-3310-EBP	1017.01	1	1017.01
Battery	B B Battery	MPL155-12-I3	374.14	1	374.14
Misc. Housing					200
Misc. Wiring					50
				Rough Total:	4100.03

Appendix 5 SVASS Unit Hardware Source Sheet

Note: This parts list is preliminary, and should be taken as a rough guide for sourcing and necessary parts.

Manufacturer	Part #	URL
Molex	0511151601	digikey.com/product-detail/en/molex-llc/0511151601/WM3342-ND/2405201
Molex	0504208000	digikey.com/product-detail/en/molex-llc/0504208000/WM3324CT-ND/2405657
Multi-Tech Systems	MTSMC-EV3-N3-SP	digikey.com/product-detail/en/multi-tech-systems-inc/MTSMC-EV3-N3-SP/591-1228-ND/4553627
Taoglas	MA203W.AB.002	digikey.com/product-detail/en/taoglas-limited/MA203W.AB.002/931-1239-ND/3945612

Manufacturer	Part #	URL
Murata Electronics	LBEE5ZZ1CK-TEMP-DS-SD	digikey.com/product-detail/en/murata-electronics-north-america/LBEE5ZZ1CK-982/490-13810-ND/6051980
Adafruit Industries	2354	digikey.com/product-detail/en/adafruit-industries-llc/2354/1528-1870-ND/6618721
Visual Communications	CTHS15CIC04	digikey.com/product-detail/en/visual-communications-company-vcc/CTHS15CIC04/CTHS15CIC04-ND/6556979
Skyworks Solutions	SE4150L-R	digikey.com/product-detail/en/skyworks-solutions-inc/SE4150L-R/863-1354-1-ND/2745473
STMicroelectronics	LIS2HH12TR	digikey.com/product-detail/en/stmicroelectronics/LIS2HH12TR/497-15069-1-ND/5043075
OmniVision Technologies	OV07740-A32A	digikey.com/product-detail/en/omnivision-technologies-inc/OV07740-A32A/884-1005-ND/2123256
FLIR	500-0643-00	digikey.com/product-detail/en/flir/500-0643-00/500-0643-00-ND/5215151
SparkFun Electronics	SEN-14032	digikey.com/product-detail/en/sparkfun-electronics/SEN-14032/1568-1437-ND/6204382
Delta-Line	86SH156-6204A.000	delta-line.com/86sh156-6204a-000-P73365.htm
VersaLogic Corporation	VL-EPU-3310-EBP	digikey.com/product-detail/en/versalogic-corporation/VL-EPU-3310-EBP/1241-1271-ND/5250512
B B Battery	MPL155-12-I3	digikey.com/product-detail/en/b-b-battery/MPL155-12-I3/MPL155-12-I3-ND/5886037