Accident warnings during edge case traffic events
Requirements Specification

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Abstract. This requirements document specifies a new traffic accident warning app designed to handle accident warnings during edge case traffic events. The IEEE recommended practice for software requirements specifications (IEEE 830) is used throughout. The scope, vision and subsidiary goals are deduced accordingly. Furthermore, the standpoint of a potential contracting authority is used to define an overall project description. The goals then are further examined and yield 40 different requirements, which are proposed, grouped, rated and prioritized. The key is to deliver requirements as a foundation of a mobile application, that can identify hazardous situations in traffic and warn the driver beyond what an automated in-car sensor-based system would provide. This serves to further the interactive mobility and proactively increase the safety of driver and passengers.

Keywords: accident warning, traffic system, interactive mobility

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1 Introduction

1.1 Purpose

1.1.1 Vision

Our vision is the reduction of fatal traffic accidents during edge case events.

1.1.2 Project Mission

The overall project mission is the usage of data from a large group of collaborating drivers to create an app, that can identify dangerous situations and warn the car driver if no counteraction by autonomous systems within the car or the driver itself have been measured.

1.1.3 Project Goals

This project aims hereby at two primary objectives:

1. Accumulation of a large database of heterogenous traffic, driver and car situations, so even very uncommon events can be reliably predicted.
2. The creation of an autonomous warning app, e.g. by the usage of neural networks, that can.:
    A) reliably predict imminent accidents of the current car *A*.
    B) reliably assess the current car movements and the car drivers' counteractions *B*.
    C) reliably evaluate if *B* counteracts the event of *A* and warn the user adequately otherwise.

1.2 Definitions, acronyms, and abbreviations

Autonomous System	Autonomous systems refer to systems capable of operating in a real-world environment without any form of external control for extended periods of time.
Counteraction	An activity performed by the driver (e.g. steering, breaking) to prevent the collision of the car with other cars, objects or living organisms.
Edge Case Events	„An edge case is a problem or situation that occurs only at an extreme (maximum or minimum) operating parameter.“.
General Data Privacy Regulation	This term (short: GDPR) is a general term for 99 articles of the european legislation, that specifies requirements for the processing of personalized data.
Global Positioning System	The term (short: GPS) refers to a satellite-based navigation system, which provides accurate information about the current position of the receiver-device. In this project, this term refers especially to the GPS function of current smartphones.
Gyroscope	Gyroscope, device containing a rapidly spinning wheel or circulating beam of

	light that is used to detect the deviation of an object from its desired orientation.[8]
Heavy Traffic	In this project, this term is regarded as very dense (a lot of movement prohibiting moving objects) traffic around the users' car, which prerequisites a more complex environment analysis of autonomous systems and the driver, to ensure an accident-free transportation.
Neural Network	„A computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs.". [7]
Traffic	In this project, the term traffic is defined as the normal flow of movable objects (e.g. cars or living beings) around the users' car.
Traffic Congestion	In this project, the term is defined as a total stop of traffic flow at a certain place, due to cars inhibiting each other's movements. The term is meant as an extension to heavy traffic, where at least a minimal flow of traffic is observable.

1.3 References

[1] A. Takacs, I. J. Rudas, D. Bosi, T. Haidegger (2018), “Highly Automated Vehicles and Self-Driving Cars”.

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[6] A. Blair-Early & M. Zender (2008), “User Interface Design Principles for Interaction Design”.

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[8] Encyclopedia Britannica, “Gyroscope”, url: https://www.britannica.com/technology/gyroscope (last visited at 21.01.2020).

1.4 Overview

The app is expected to be used in the same manner, as a navigation app in the car, apart from that it must be positioned in a way that the smartphone camera has an unobstructed field of view through the windscreen.

Through the extensive usage of user data (video-feeds of the camera, gyroscope data and GPS data), that has been captured by their smartphones, a predictive model (e.g. a neural network) shall be trained. This heterogenous data (different smartphone camera angles, weather conditions, cars, etc.) shall improve the accuracy and robustness during the training phase of the predictive model and lead ultimately to appropriate warnings (visually and acoustically) for the driver.

2 Overall Description

This chapter covers the exploration phase, in which possible specifications of this app are examined. The result of this examination is a written consent in the form of specifications for the final requirements.

2.1 Context Model

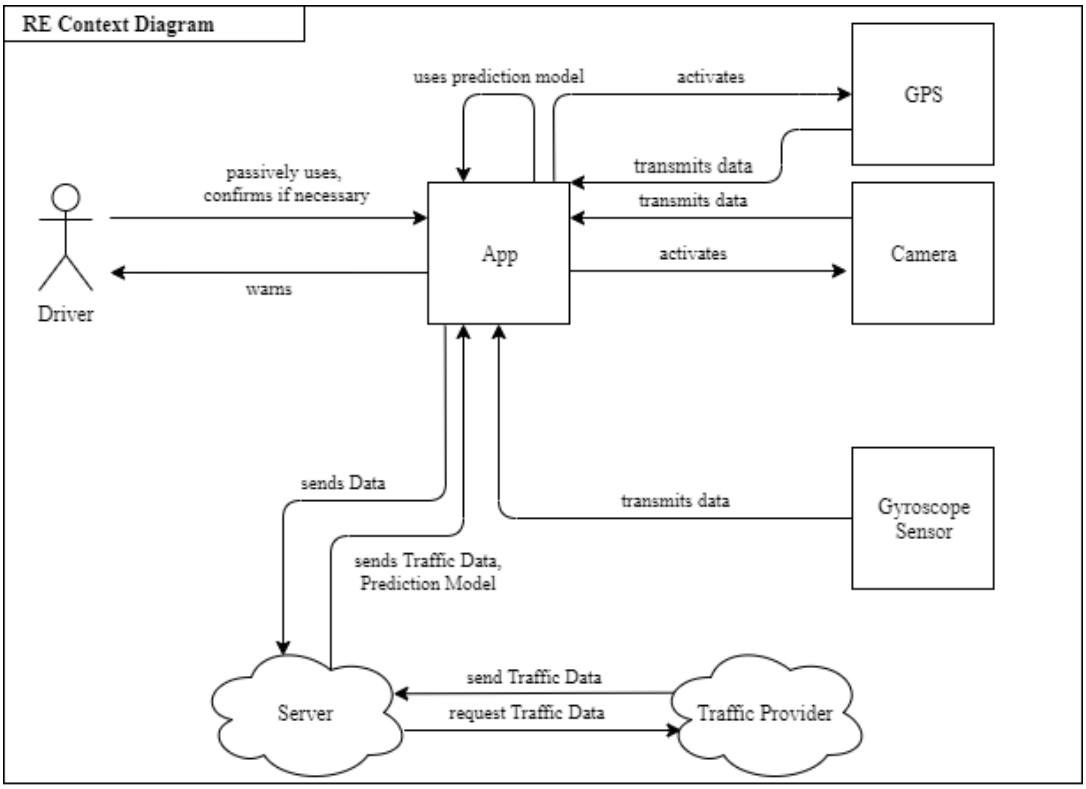

Figure 1: An abstract visualization of the app, the users, the direct technical environment and its ties to one another.

2.2 Stakeholder Analysis

The first step is to identify the stakeholders. [4] Both internal and external stakeholders are considered. [4] The internal stakeholders represent the stakeholder groups within the company and include management and operative staff members. [4] Once

all stakeholders have been identified, an evaluation has been conducted, using the stakeholder matrix. [4]

2.2.1 Identified Stakeholders

Internal Stakeholders

- Software developer
- Software tester
- Project manager
- Executive board

External Stakeholders

- Manufacturer of the components
- User
- Traffic provider
- Investor
- Politician
- Competitors

2.2.2 Evaluation

For the evaluation of the stakeholders, they were first assessed in terms of their attitude to the project and their influence on the project. An evaluation scale of one to five was used in each case:

- **1:** negative attitude / very little influence
- **2:** slightly negative attitude/ little influence
- **3:** neutral setting / medium influence
- **4:** slightly positive attitude/ high influence
- **5:** positive attitude/ very high influence

The result of this evaluation is the stakeholder matrix and visualized (see: Figure 2).

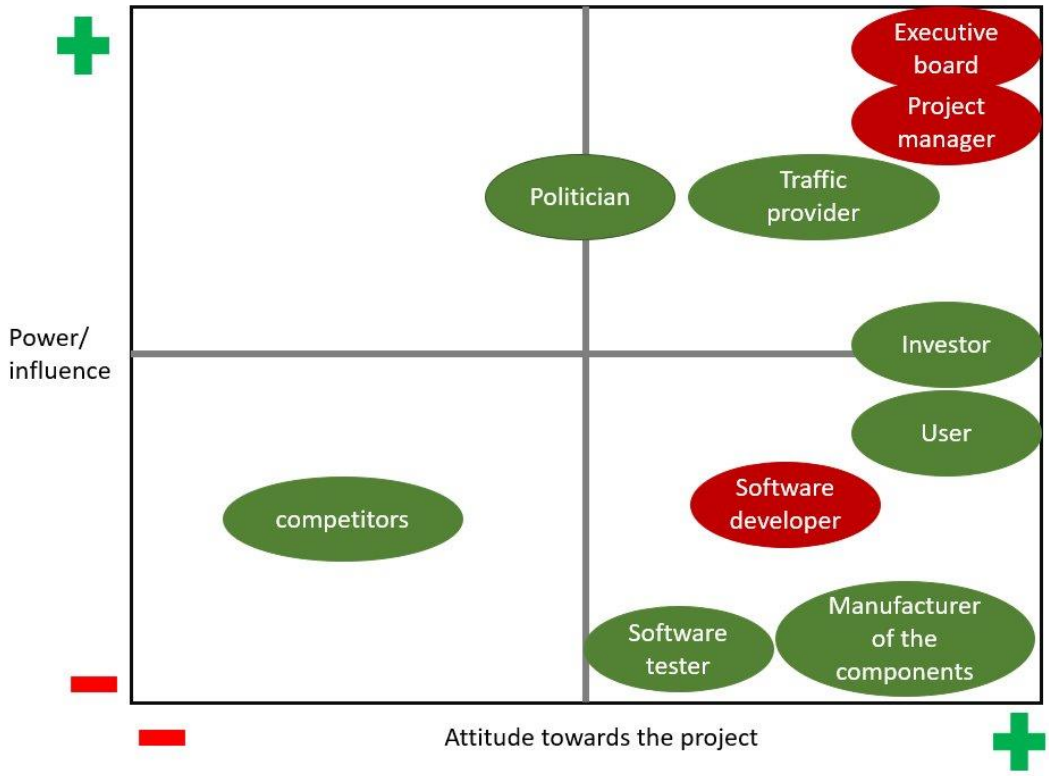

Figure 2: Stakeholder-Matrix of the identified Stakeholders.

Stakeholders located in the lower left quadrant should be monitored. [5] These include competitors, as they have a rather small influence on the project and have a rather negative attitude. [5] In addition, it is recommended to regularly inform and keep the stakeholders in the lower right quadrant up to date, as they are positive or rather positive towards the project and have an influence on the project. [5] The politicians who are more likely to be in the upper left quadrant should be satisfied so that they do not block the project in the worst case. [5] The stakeholders in the upper right quadrant are the most important and they must be closely managed as they have the most influence and are positive towards the project. [5] A close cooperation with these stakeholders is strongly recommended.

2.3 Use Case Diagram

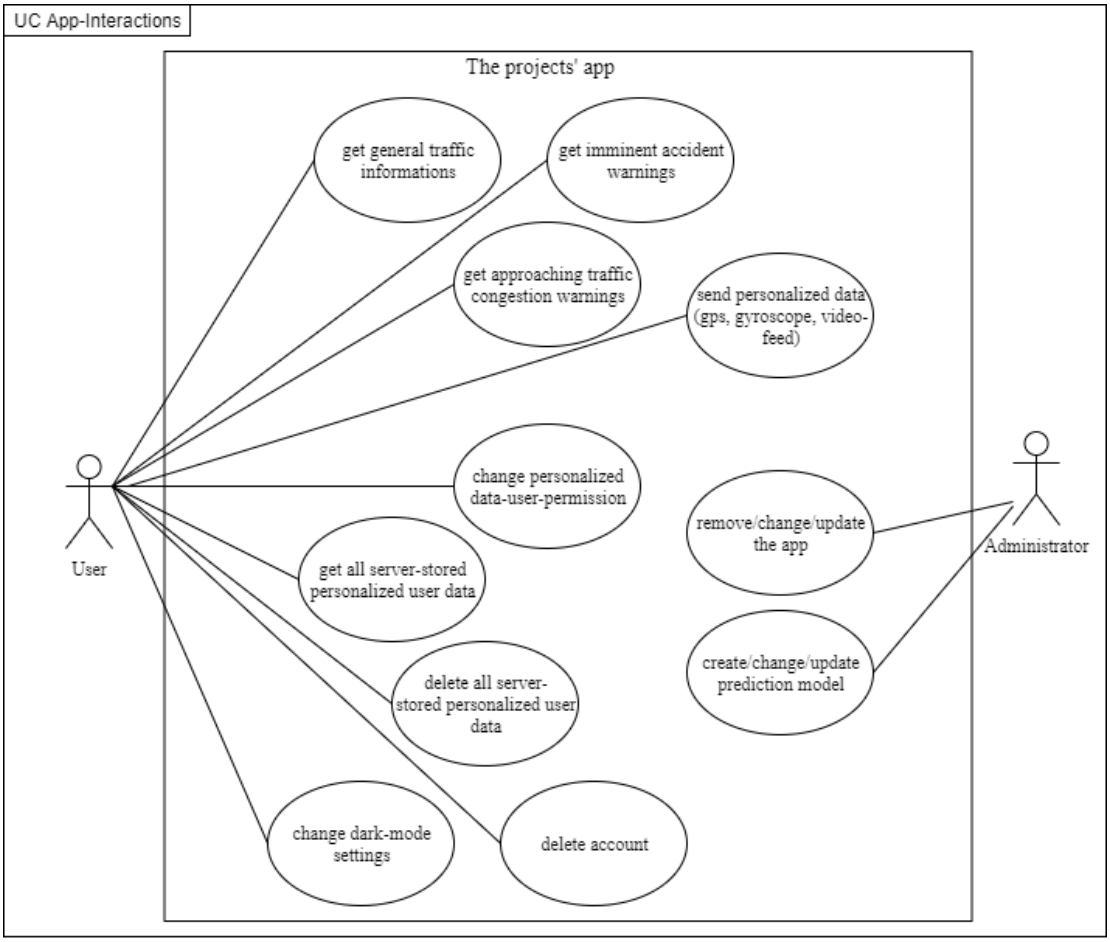

Figure 3: Use Case Diagram of the primary desired interactions, that users shall experience with the app.

2.4 Goal Model

Due to its size, the goal model of this project has been deferred to appendix 1.

2.5 Mockups

The following illustrations are first concepts of desired primary functionalities and thus suspect to change. In the following subchapters, the views have been separated by the two characteristic handling situations of smartphones (vertical and horizontal).

2.5.1 Horizontal View-Mode

Figure 4: Vertical Default-View of the app, while monitoring the traffic data, camera-feed and the gyroscope.

Figure 5: Vertical view of the warning state within the app. More detailed informations are blurred out and the attention of the driver is raised by the usage of warning colors. In conjunction with this visual signal, a warning signal shall occur.

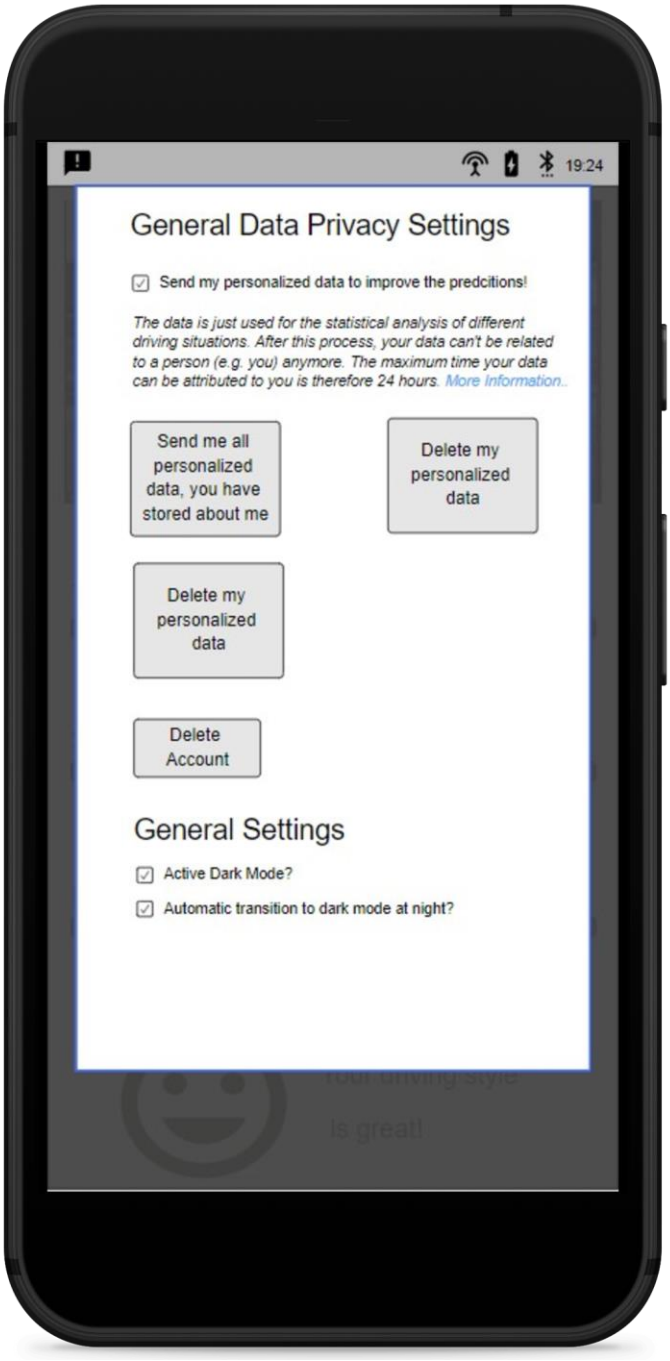

Figure 6: The vertical view of settings page. The user can access multiple data privacy options, as well as the configuration of the dark mode.

2.5.2 Vertical View-Mode

Figure 7: Horizontal Default-View of the app, while monitoring the traffic data, camera-feed and the gyroscope.

Figure 8: Horizontal view of the warning state within the app. More detailed informations are blurred out and the attention of the driver is raised by the usage of warning colors. In conjunction with this visual signal, a warning signal shall occur.

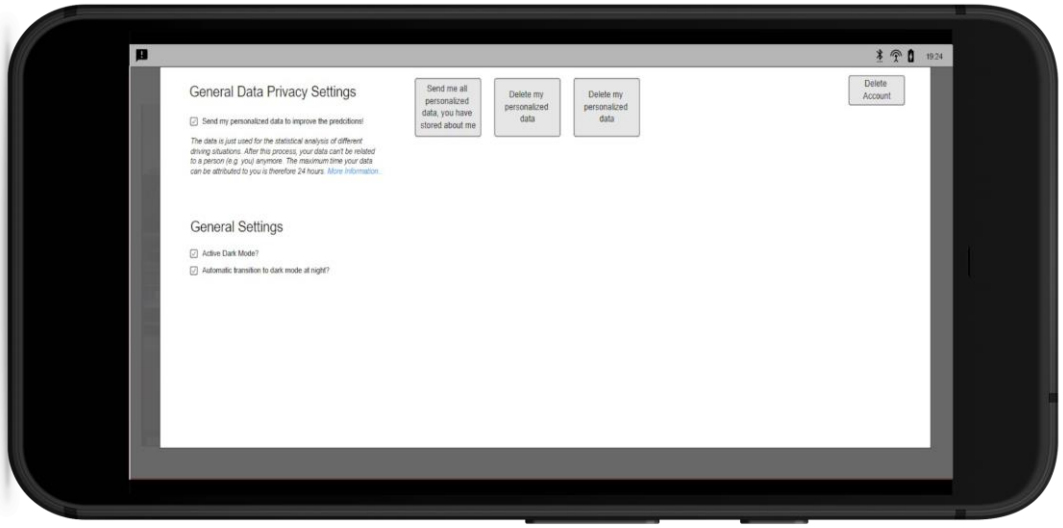

Figure 9: The horizontal view of the settings page. The user can access multiple data privacy options, as well as the configuration of the dark mode.

2.6 Identified Situations

In this chapter, we introduce and specify four different situations, that are expected to be either very complex or common, in context of the apps' usage.

2.6.1 Incident ahead

Name: Unidentified incident ahead

Information Source: Smartphone

Major functionality: Detection of incidents and the warning of the user

Short description: An incident is about to happen within the next 10 seconds and neither the car or the driver seemed to have made any attempts to prevent the impact. An acoustic and visual emergency warning occurs.

Representation of the environment:

- **External Environment:**
    - Driver as the user

- Surrounding traffic
- Smartphone
- Current drivers' car

- **Internal Environment:**
  - functions: monitorEnvironment, monitorUserReaction, AccidentWarning
  - components: videoFeed, GyroscopeData

Constraints:

- **Environmental** :
  - Incidents, that can only be detected outside the field of view of the smartphone-camera.
  - Incidents, that don't require an active acceleration/deceleration or steering.
  - Unknown situations for the prediction model, possibly because of an insufficient amount of sent user data for the project in general.
- **Non-functional**:
  - The time between the first registration of the possible accident event (external accident source and check of the drivers' behaviour) and it's warning to the user shall not exceed 1/10 seconds.
  - The warning that is scheduled to appear, shall be prompted as soon as possible to the driver.
  - The acoustic warning signal is the primary information source for the driver and thus shall have a characteristic, unambiguous sound.

2.6.1.1 Situation Model

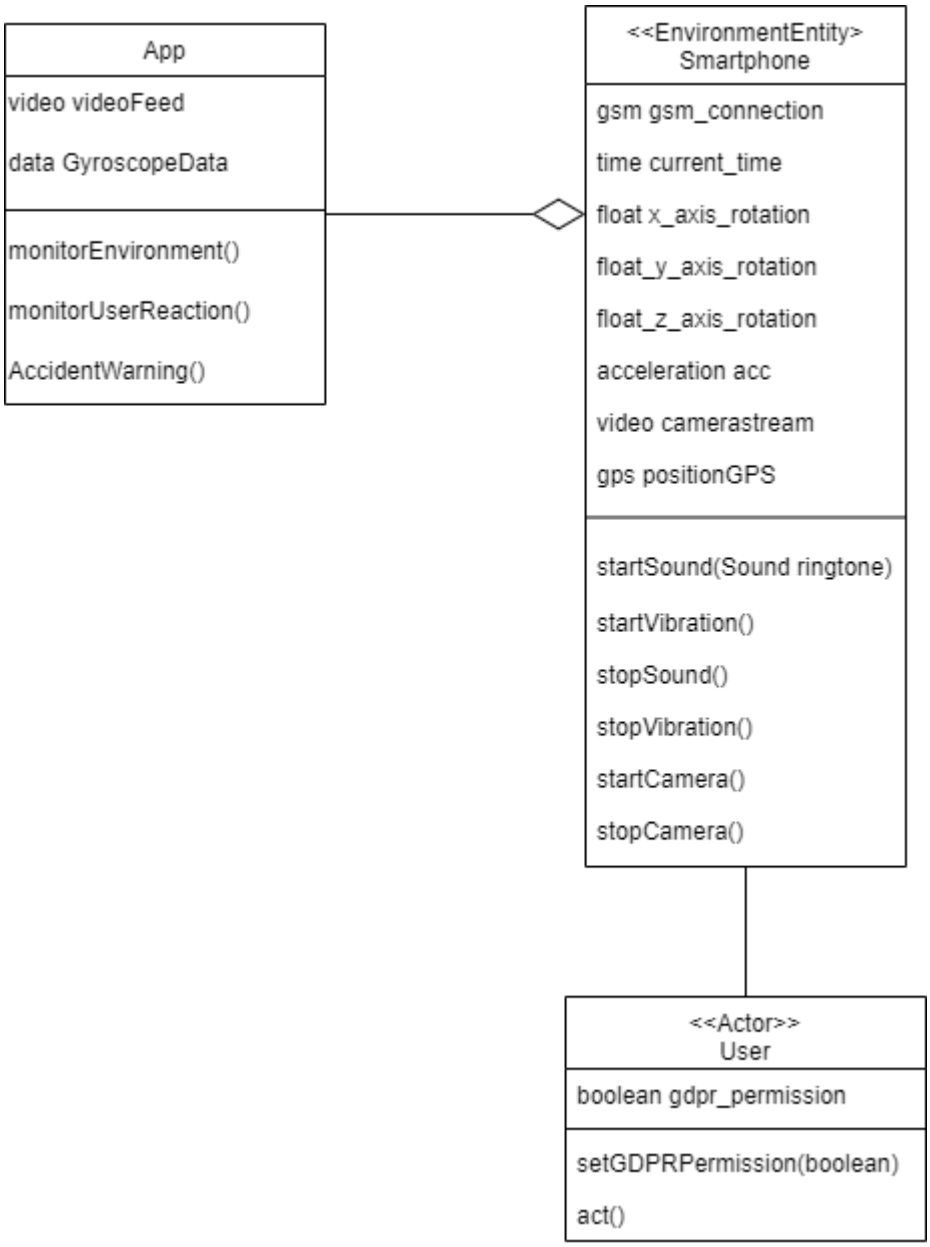

Figure 10: Model of the information system for the first identified situation: "Unidentified incident ahead".

2.6.1.2 Sequence Diagram

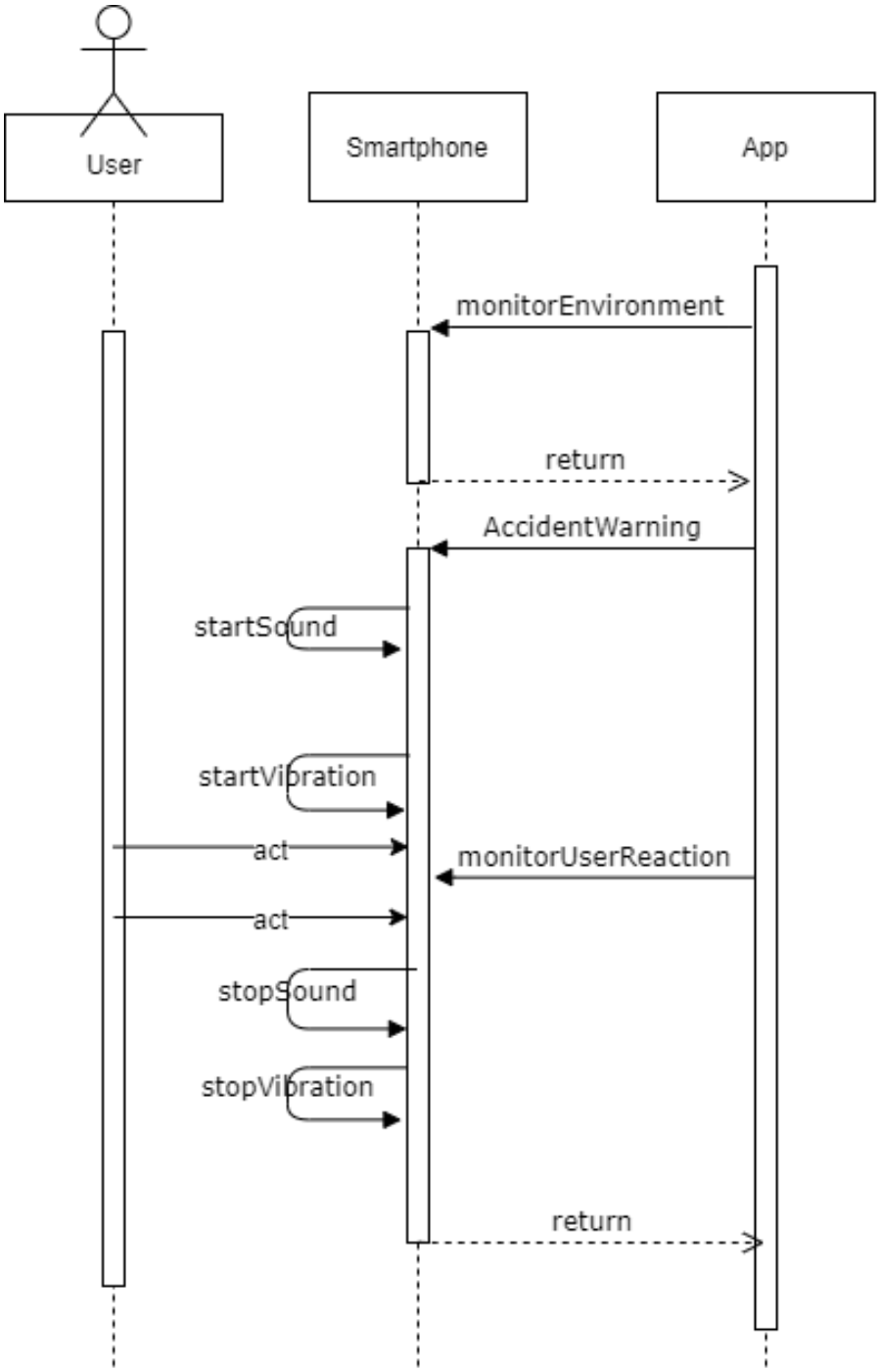

Figure 11: Sequence Diagram of the first scenario: “Incident ahead”.

2.6.2 Traffic congestion ahead

Name: Traffic congestion ahead.

Information Source: Smartphone and Traffic Information Provider

Major functionality: Warning in case of traffic congestions on the current cars' route within the next 5km.

Short description: Traffic Jam Data from a third-party provider shall be utilized and matched with the current geocoordinates of the users' smartphone. If on the current estimated route, a traffic has been registered by the system within the next 5km, a notification signal shall occur.

Representation of the environment:

- **External Environment:**
  - Driver as the user.
  - Current drivers' car
  - Traffic Data Provider
  - Smartphone
- **Internal Environment:**
  - functions: monitorTrafficJams, TrafficJamWarning, monitorUserReaction
  - components: videoFeed, GyroscopeData, GPSSignal

Constraints:

- **Environmental**:
  - Traffic jams, that haven't been reported yet.
  - Inaccurate traffic congestion information by the external Source.
  - Not enough users that have given permission to use their data-feed.
- **Non-functional**:

- The time between the first registration of the possible traffic jam start-position and it's warning to the user shall not exceed 1/10 seconds.
- The warning that is scheduled to appear, shall be prompted as soon as possible to the driver.

2.6.2.1 Situation Model

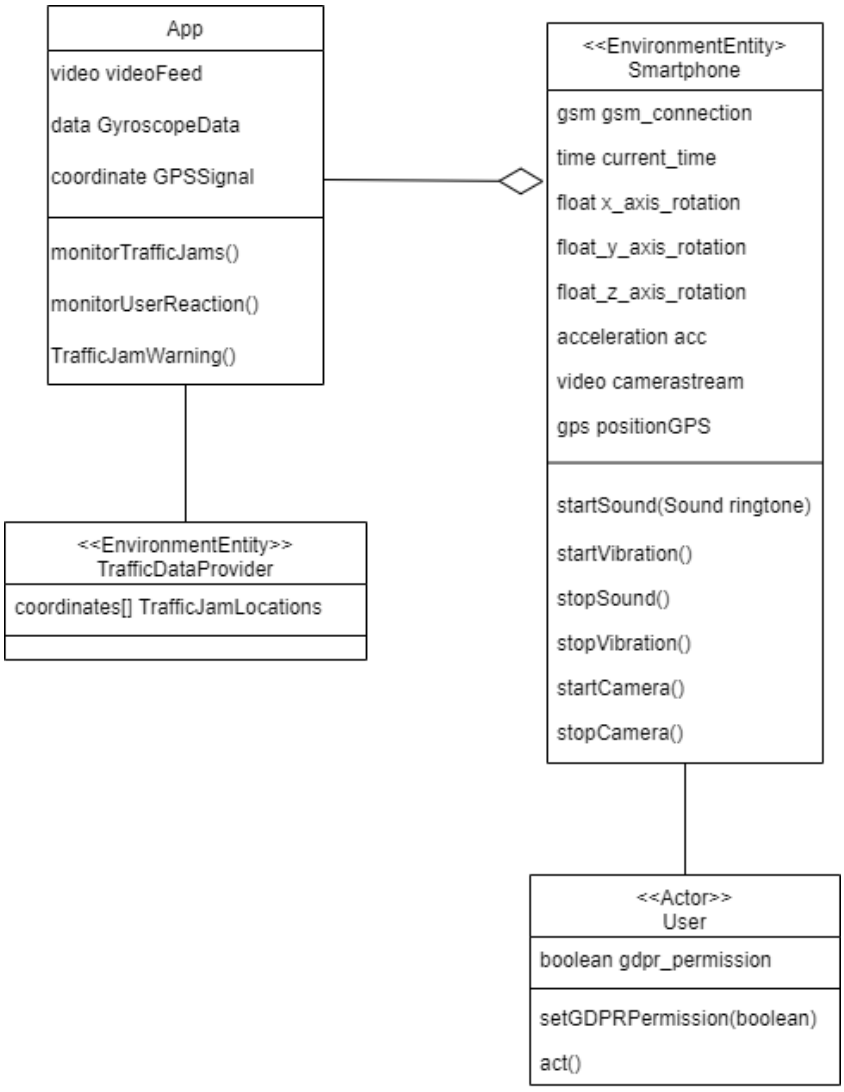

Figure 12: Model of the information system for the second identified situation: "Traffic congestion ahead".

2.6.2.2 Sequence Diagram

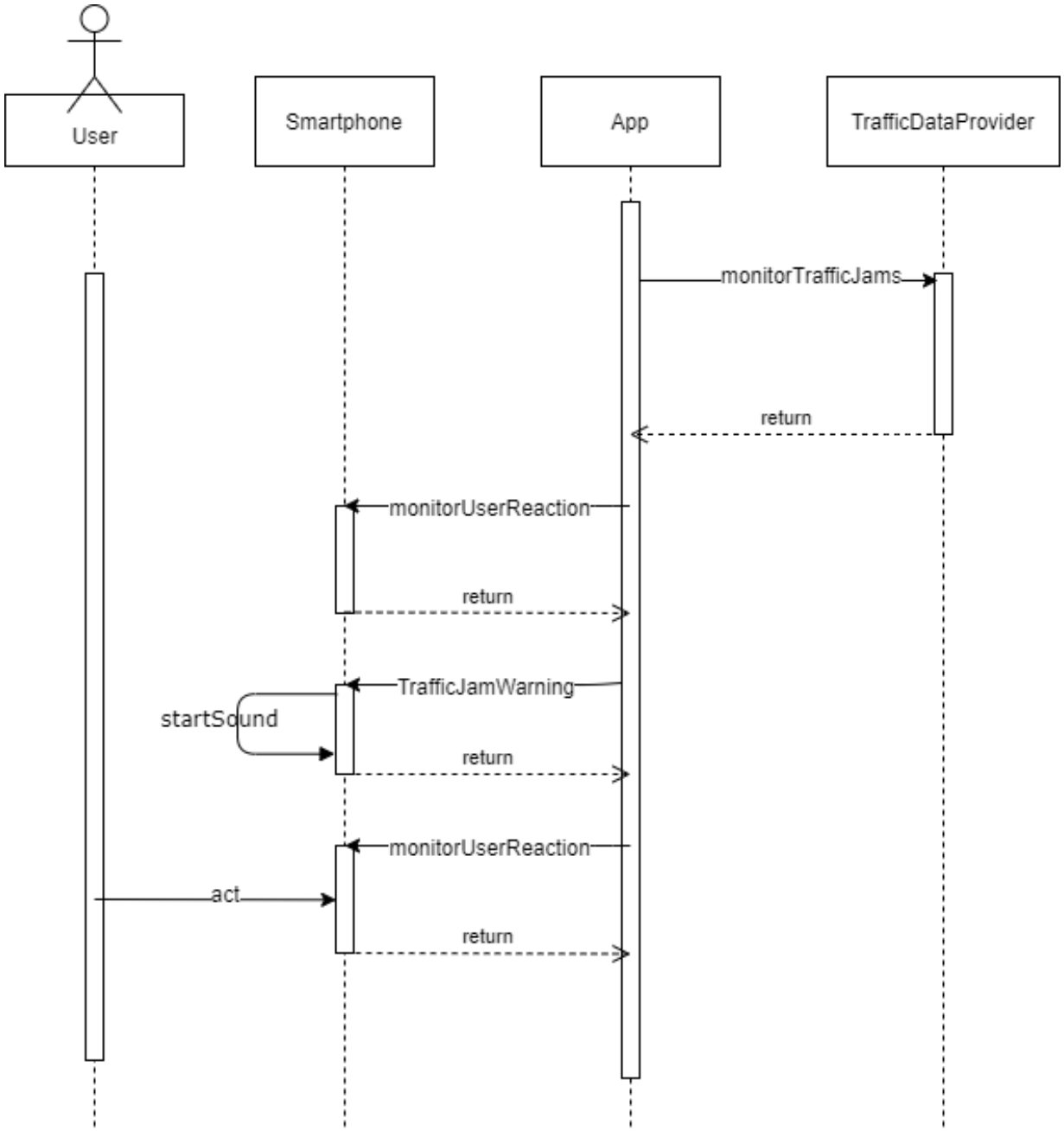

Figure 13: Sequence Diagram of the second scenario: "Traffic congestion ahead".

2.6.3 Normal Driving without accidents or warnings

Name: Normal Driving without accidents or warnings

Information Source: Smartphone and Traffic Information Provider.

Major functionality: Monitoring of traffic without interruption of the driver

Short description: During the usual traffic flow, the system is still monitoring the traffic and video feed events but doesn't provide a warning to the user unless a certain probability threshold of a collision is imminent or a traffic warning from a third-party traffic information provider has been transmitted.

Representation of the environment:

- **External Environment:**
  - Driver as the user.
  - Current drivers' car
  - Surrounding traffic
  - Traffic Data Provider
  - Smartphone
- **Internal Environment:**
  - functions: monitorEnvironment, monitorTrafficJams, monitorUser-Reaction
  - components: videoFeed, GyroscopeData, GPSSignal

Constraints:

- **Environmental**:
  - Not enough users that have given permission to use their data-feed.
- **Non-functional**:
  - The user shall have a feeling of security, although no active interference of the system is present.

2.6.3.1 Situation Model

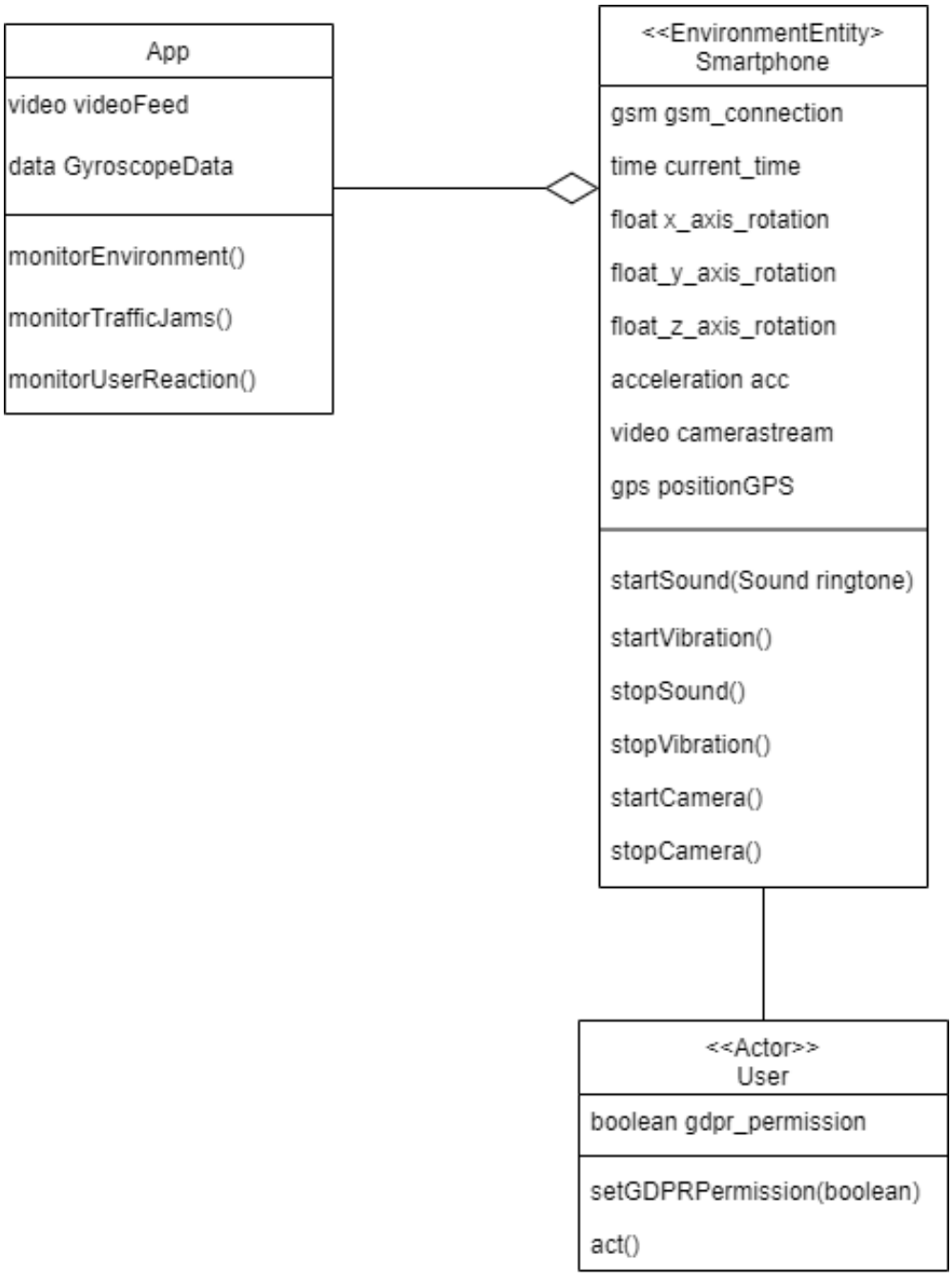

Figure 14: Model of the information system for the third identified situation: "Normal driving without accidents or warnings".

2.6.3.2 Sequence Diagram

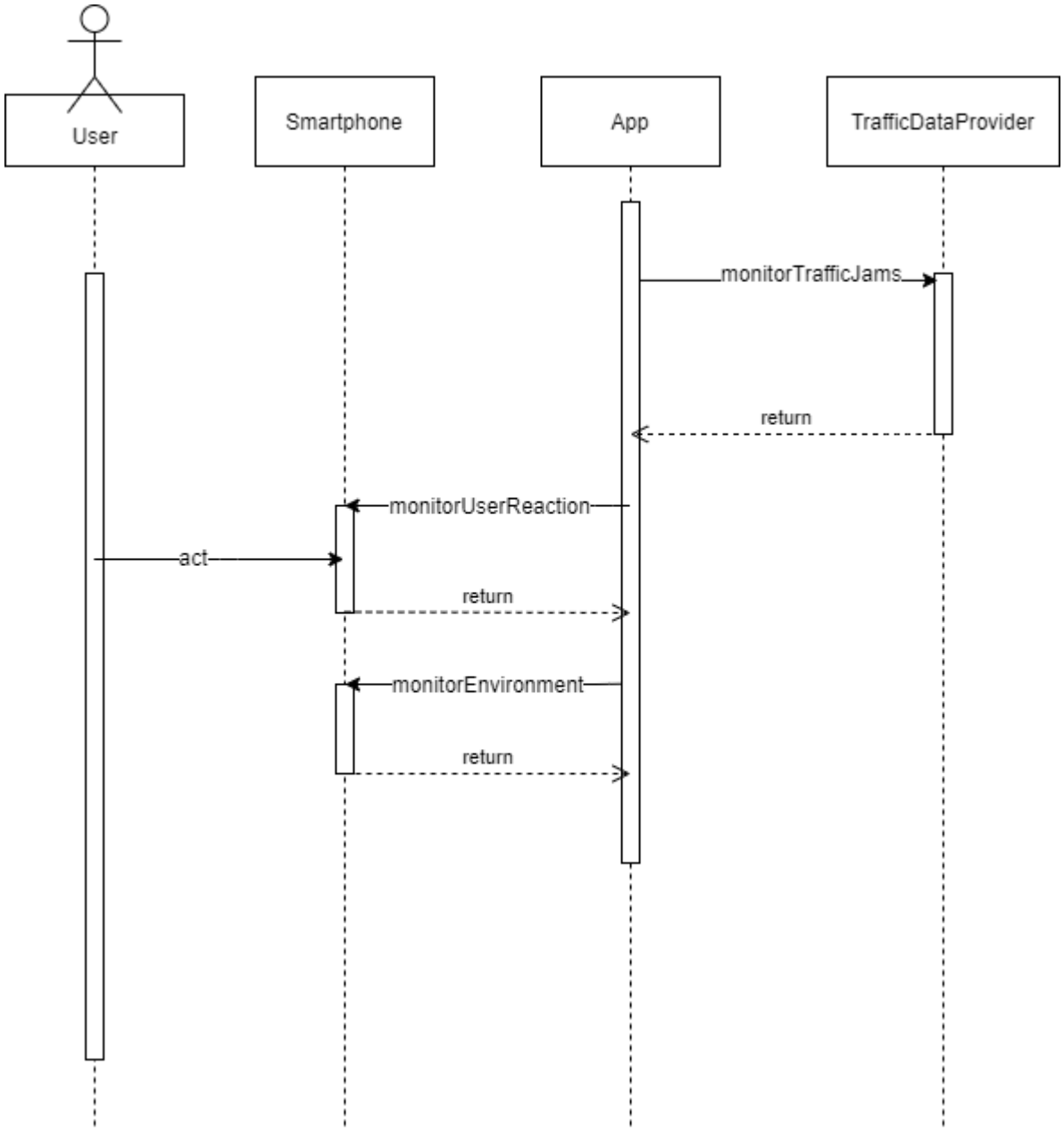

Figure 15: Sequence Diagram of the third scenario: "Normal driving without accidents or warnings".

2.6.4 Driving during heavy traffic conditions

Name: Driving during heavy traffic conditions

Information Source: Smartphone and Traffic Information Provider.

Major functionality: Monitoring of heavy traffic without interruption of the driver, unless the drivers' actions pose an inappropriate risk for him-/herself and/or others.

Short description: No warning prompt for the user, although heavy traffic around the car, implies a lot of possible near-collisions around the car. If the drivers' actions pose an irrational amount of risk for him-/herself and/or others, a visual feedback for the user shall be provided.

Representation of the environment:

- **External Environment:**
  - Driver as the user.
  - Current drivers' car
  - Surrounding traffic
  - Smartphone
- **Internal Environment:**
  - functions: monitorEnvironment, monitorUserReaction, setVisualFeedback
  - components: videoFeed, GyroscopeData

Constraints:

- **Environmental**:
  - Incidents, that can only be detected outside the field of view of the smartphone-camera.
  - Incidents, that don't require an active acceleration/deceleration or steering.
  - Not enough users that have given permission to use their data-feed.

- **Non-functional**:
    - False positives may happen frequently due to heterogenic video feed capturing angles or an insufficient amount of training data for the neural network.

2.6.4.1 Situation Model

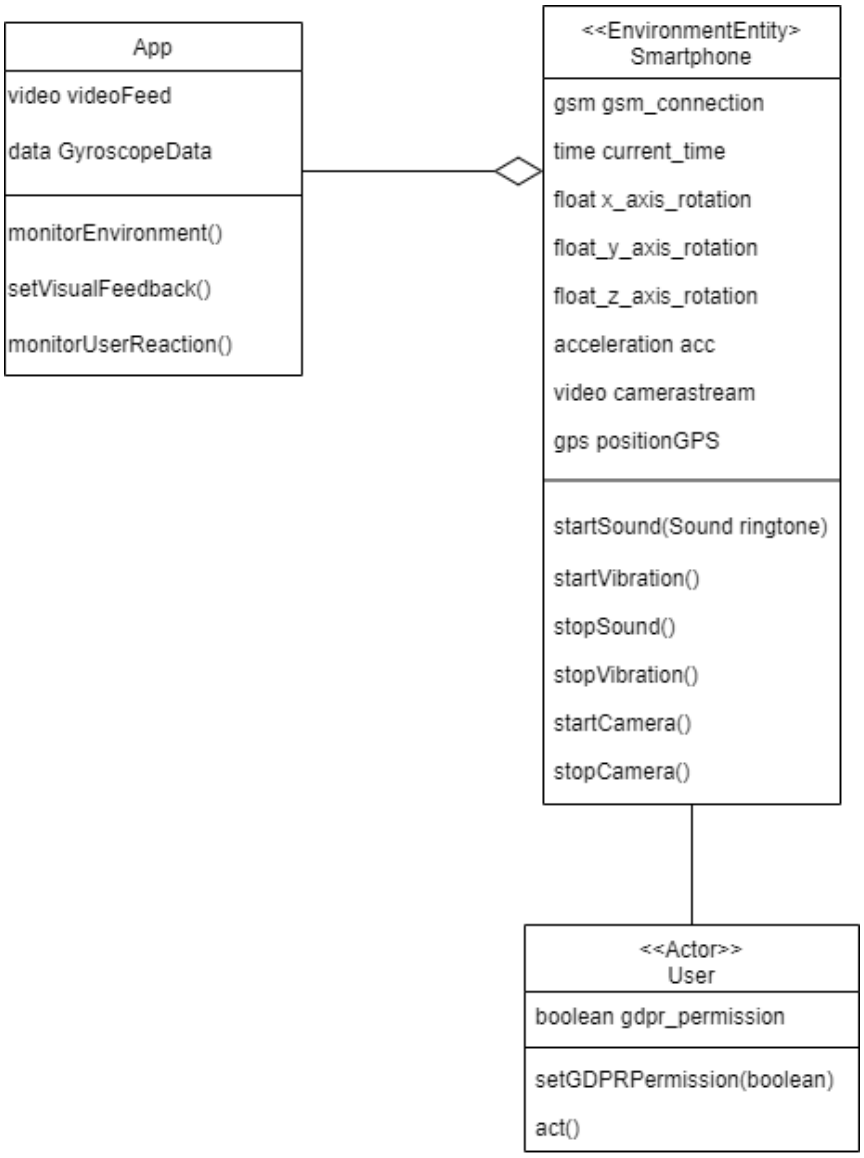

Figure 16: Model of the information system for the fourth identified situation: "Driving during heavy traffic conditions".

2.6.4.2 Sequence Diagram

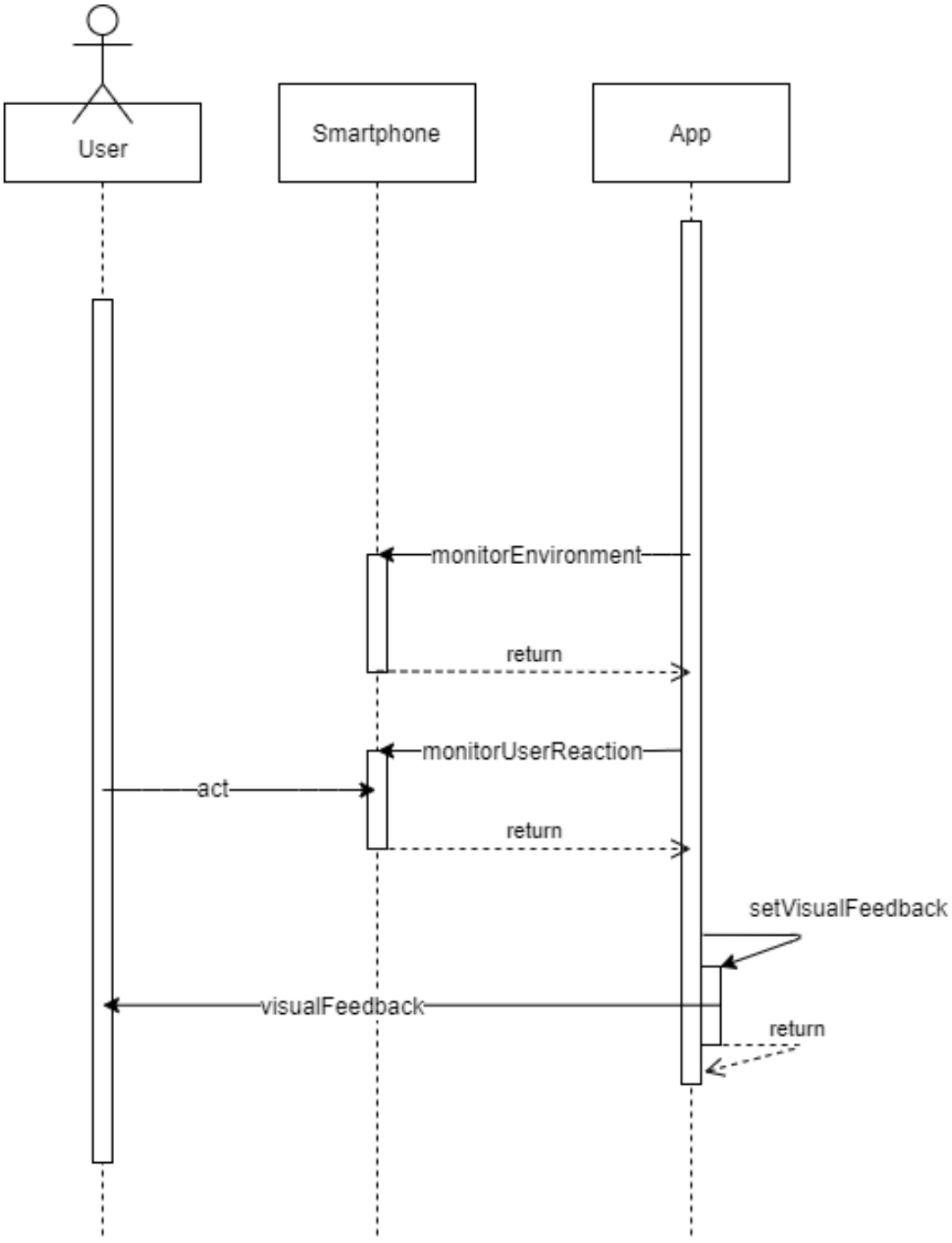

Figure 17: Sequence Diagram of the fourth scenario: "Driving during heavy traffic conditions".

2.7 Requirements

2.7.1 Product Perspective

1. The app requirements must be intuitively understandable
    - **ID:** PP_1
    - **Priority:** Normal
    - **Difficulty:** Normal
2. The app must effectively reduce the number of incidents (in relation to cars without the app).
    - **ID:** PP_2
    - **Priority:** Very High
    - **Difficulty:** Very High
3. The app must warn the driver adequately for the situation acoustically and visually.
    - **ID:** PP_3
    - **Priority:** Very High
    - **Difficulty:** High
    - **Comments:** Similar problems arise with support systems within planes and existing standards could be used as a guideline for this project.
4. The app must comply to GDPR-regulations
    - **ID:** PP_4
    - **Priority:** High
    - **Difficulty:** Medium
5. The app shall provide the driver with a feeling of security.and influence the driving style of the user positively.
    - **ID:** PP_5
    - **Priority:** High
    - **Difficulty:** Medium

2.7.1.1 User Interface / Visual Expectations

This subchapter relates especially to the mockups of chapter 2.5, in which a first visual expression of the desired final product has been outlined. The following requirements detail these impressions further.

1. The app shall support a horizontal and vertical orientation mode, to provide more possible installation options for the driver within the car.
    - **ID:** VE_1
    - **Priority:** High
    - **Difficulty:** Low
    - **Reference(s):** e.g. Figure 4 + Figure 7.
2. The app shall show the driver, when very important aspects within the video feed have been detected by the app.
    - **ID:** VE_2
    - **Priority:** High
    - **Difficulty:** Very Low
    - **Reason:** This ensures, that the driver can verify him-/herself, if the smartphone is positioned correctly in front of the windshield and contributes to a sense of security due to an intuitively understandable detection pattern.
    - **Reference(s):** e.g. the displayed video-feed with object detection within Figure 4.
3. If a warning for the driver must be displayed (e.g. due to an imminent accident), all other subsidiary function shall be hidden.
    - **ID:** VE_3
    - **Priority:** Normal
    - **Difficulty**: Very Low

- **Reason:** Ensure minimal distraction due to the app and intuitively alarm the driver of the forthcoming event.
- **Reference(s):** e.g. Figure 5 + Figure 8.

4. The warnings shall be framed by red emergency indicating colours and an easily readable large font.
    - **ID:** VE_4
    - **Priority:** Normal
    - **Difficulty:** Very Low
    - **Reason:** The warnings must be subconsciously understandable within a minimal amount of time.
    - **Reference(s):** e.g. Figure 5 .
5. The warnings must be easily readable in horizontal and vertical orientation mode.
    - **ID:** VE_5
    - **Priority:** High
    - **Difficulty:** Low
    - **Reference(s):** e.g. Figure 5 + Figure 8.
6. The settings of the app must be displayed if the user clicks on a random point within the apps' view space, if this is not the settings page itself.
    - **ID:** VE_6
    - **Priority:** Low
    - **Difficulty:** Very Low
    - **Reason:** This minimal user interaction, ensures that the driver is not interested with an active interaction with the app during the ride. This further supports the ride safety enhancing capabilities of this app.
7. The settings page of the app shall follow a minimalistic approach to its possible user interactions, so the driver has no incentive to click on the app and get distracted during the ride.

- **ID:** VE_7
- **Priority:** Very Low
- **Difficulty:** Very Low
- **Reference(s):** e.g. Figure 6 + Figure 9.

8. The settings page of the app shall distinguish between GDPR-related functions and general settings for the user.
    - **ID:** VE_8
    - **Priority:** Low
    - **Difficulty:** Very Low
    - **Figure(s):** e.g. Figure 6 + Figure 9.
9. The app must provide an intuitively understandable feedback for the current driving style of the driver, e.g. with smileys representing the range from upset to happy.
    - **ID:** VE_9
    - **Priority:** High
    - **Difficulty:** Normal
    - **Figure(s):** Figure 7.
10. The app's feedback for the driving style, must be intuitively comprehensible by the driver, as such its indicators are clear for the driver and possible counter-measures to comply with a better feedback, are obvious for the driver. The environment perspective "Traffic-Density" of the drivers' surrounding traffic, the drivers' current appropriateness to the traffic density and speed regulations, and the subconscious reaction time of the driver (shrinking due to fatigue) shall be displayed. These three factors shall be the only ones, contributing to the app's feedback (the smiley).
    - **ID:** VE_10
    - **Priority:** Normal
    - **Difficulty:** Normal

- **Reference(s):** Figure 4 + Figure 7**.**

2.7.1.2 Use Cases

Within this project two primary actors have been identified, which interact with either the administrative part of the app (administrators) or the frontend functionalities (user / driver) (see: chapter 2.3).

Because the use cases of the administrator largely depend on the technical implementation of the app, two broad assumptions will be made. Apart from the programming of the app, an administrator should be able to fulfil two primary tasks: administration of the app itself (updates, bug fixes, etc.) and the administration of the apps' prediction model, as it is the most important, novel, and complex part of the app and as such likely to be updated regularly. All other activities, such as the administration of users for example, should be automated as far as possible, if no regulatory necessities prevent this endeavour.

The identified use cases for the user (driver) have been identified as follows:

1. Get general traffic information: The user wants to be informed about the general driving conditions, surrounding the driver such as Traffic Density (relative number of cars around the cars, in contrast to a theoretical maximum number of cars).
    - **ID:** UC_1
    - **Priority:** High
    - **Difficulty:** Very High
    - **Reference(s):** Chapter 2.6.3.
2. Get imminent accident warning: The main purpose of the system is to prevent accidents through the usage of appropriate warnings of the user prior to accidents. The "get" doesn't imply, that the user has to proactively demand the warning, but the warning are presented in appropriate situations automatically.

- **ID:** UC_2
- **Priority:** Very High
- **Difficulty:** Very High
- **Reference(s):** Chapter 2.6.1.

3. Get approaching congestion traffic warning: A rather optional part of the system, as that it should provide warnings, if a traffic congestion has been identified by the system, on the cars' current road within the next few minutes.
    - **ID:** UC_3
    - **Priority:** Normal
    - **Difficulty:** High
    - **Reference(s):** Chapter 2.6.2.
4. Send personalized data: The user should be able to automatically send personalized data. This data (GPS, gyroscope, time and date, etc.) is the analytical foundation, on which this apps' prediction system will be trained. However, this task must only be executed, if the user agrees to.
    - **ID:** UC_4
    - **Priority:** Very High
    - **Difficulty:** Normal
5. Change personalized data-user-permissions: As the user can contribute personalized data for this app, he/she should be able to withdraw or give this permission any time.
    - **ID:** UC_5
    - **Priority:** Normal
    - **Difficulty:** Very Low
6. Get all server-stored personalized user data: All personalized information that have been stored by the app on the smartphone or our server, can automatically be requested / downloaded by the user within the app.
    - **ID:** UC_6

- **Priority:** Normal
- **Difficulty:** Low

7. Delete all server-stored personalized data: All personalized information which have been stored by the app on the smartphone or our servers, can be deleted automatically by the user with a function within the app.
    - **ID:** UC_7
    - **Priority:** Normal
    - **Difficulty:** Very High
8. Delete account: The user can freely choose to delete his/her account and all information associated with it, at any time within an automatic function within the app.
    - **ID:** UC_8
    - **Priority:** Normal
    - **Difficulty:** Low
9. Change dark-mode settings: The user can choose (automatically or manually) if the app shall be displayed in the usual way or a theme that resembles a dark mode. The dark mode implies a dark background with a white font, which reduces the overall brightness of the smartphone screen during the apps' usage.
    - **ID:** UC_9
    - **Priority:** Very Low
    - **Difficulty:** Very Low

2.7.2 Product Functions

1. The app shall have warnings for situations, that naturally emerge from the traffic and foreseeable traffic congestions
    - **ID:** PF_1
    - **Priority:** Very High

- **Difficulty:** Very High
- **Reference(s):** Chapter 2.6.2.

2. The app shall provide information about the current drivers' driving style.
    - **ID:** PF_2
    - **Priority:** Normal
    - **Difficulty:** High
    - **Reference(s):** Chapter 2.6.4 and Figure 7.
3. The app shall provide GDPR compliant functions for users like: deletion, request and update of their personalized data (see: Figure 6 and Figure 9).
    - **ID:** PF_3
    - **Priority:** Normal
    - **Difficulty:** Dependent on the function (see: chapter 2.7.1.2)
4. The app shall comply with current design standards of Android A and IOS-devices.
    - **ID:** PF_4
    - **Priority:** Low
    - **Difficulty:** Very Low
    - **Reference(s):** Chapter 2.2.

2.7.3 User Characteristics

The main target of this app is the driver of a car. The function, design and subsidiary aspects of the final product shall comply to this user.

Some characteristics that we assume for the common user or the following:

1. Fear of missing out on early indicators of an accident
2. Fear of slow or inadequate reaction to dangerous events
3. About the own driving style and its adequacy in relation to the current traffic circumstances.

4. Aware of the GDPR-related value and rights of their own data.
5. Willingness to provide data for the sake of statistical analysis and the further improvement of driving security of the public.
6. Ability to hear acoustic warning signals from an app.

2.7.4 Constraints

1. We assume that the user has a smartphone with market common functionalities, especially a camera, gyroscope, GPS and UMTS technology.
2. We assume the abilities and behaviour of a typical driver.
3. We initially don't assume any disabilities. Further support of special needs will be included in future releases.
4. We assume, that the smartphones (especially their cameras) are positioned in a way that allows the prediction of accidents from this cameras-angle.

2.7.5 Assumptions and dependencies

1. A reliable prediction model can only be built if enough users share their data (camera-feed, gyroscope data and GPS).
2. The smartphone-camera is not purposefully blocked by objects within the car during the ride.
3. A warning, seconds before the accident positively effects the chances of accident prevention by the driver.
4. We assume that an adequate source for traffic congestions can be found (3rd party source).
5. The app depends on the functions of the smartphones and thus expects their normal behaviour without extraordinary malfunctions.

3 Specific Requirements

This chapter utilizes the project customer orientated requirements from chapter 2.7 to specify these requirements further. These requirements have been grouped into the four dimensions “User Interactions and Trust”, “Warnings”, “Prediction and Evaluation” and “Reliability”.

3.1 User Interactions and Trust

This requirements group covers the visualization of information for the user, its interactions with the app and the overall concept of usability in context of the user interface.

The formulated requirements are as follows:

1. The app shall not transmit personalized data to our servers, unless permission from the user has been given.
    - **ID:** SR_1
    - **Priority**: Very High
    - **Difficulty**: Low
    - **Comments**: The action must be GDPR-compliant. More detailed requirements must be evaluated, since there is no definite jurisdiction to this matter, yet.
    - **Dependencies**: SR_5, SR_9
2. The app should show a notification (at turn on) to fix the device into a mount in order to ensure operation conformable to the law.
    - **ID:** SR_2
    - **Priority**: Low
    - **Difficulty**: Low
    - **Comments**: Responsibility for realization is on the end user side.
    - **Dependencies**: SR_9

3. The user should be able to create a personalized account.
    - **ID:** SR_3
    - **Priority**: Low
    - **Difficulty**: Low
    - **Comments**: SR_9
4. There must be a restriction for user accounts (one account for one e-mail address).
    - **ID:** SR_4
    - **Priority**: Low
    - **Difficulty**: Low
    - **Dependencies**: SR_3
5. Users should have access to a website in order to self-administrate their accounts and have an insight to their user data and statistics.
    - **ID:** SR_5
    - **Priority**: Medium
    - **Difficulty**: Low
    - **Dependencies**: SR_3
6. The user should be able to choose if a warning should be displayed in case of: traffic congestions, accidents or both.
    - **ID:** SR_ 6
    - **Priority**: Medium
    - **Difficulty**: Low
    - **Dependencies**: SR_9
7. The App must be available for the smart phone platforms iOS and Android.
    - **ID:** SR_7
    - **Priority**: High
    - **Difficulty**: Medium

8. The app should show the most important functionalities in a tutorial at first use.
    - **ID:** SR_8
    - **Priority**: High
    - **Difficulty**: Low
    - **Dependencies**: SR_ 2, SR_ 9
9. The user interface must be intuitive and clear to not distract the driver.
    - **ID:** SR_9
    - **Priority**: Low
    - **Difficulty**: Low
    - **Comments**: As a general guideline the user interface design principles by [6] are implied.
10. The app should support a dark mode.
    - **ID:** SR_10
    - **Priority**: Low
    - **Difficulty**: Low
    - **Dependencies**: SR_ 7
11. The app should only use current traffic data, that's not older than 15 minutes.
    - **ID:** SR_11
    - **Priority**: High
    - **Difficulty**: Medium
    - **Comments**: Depending on third party service.
12. The traffic data (Server-Side) should be updated as soon as a new event has been recorded (Push-Notifications).
    - **ID:** SR_12
    - **Priority**: High
    - **Difficulty**: High
13. The user should be able to use automatic GDPR-related services.

- **ID:** SR_13
- **Priority**: High
- **Difficulty**: Low

14. The apps' business process should be GDPR-compliant (e.g. ensure recurrent backups on servers)
    - **ID:** SR_14
    - **Priority**: Medium
    - **Difficulty**: Medium
15. The user should be able to send his data as possible training data for the prediction model.
    - **ID:** SR_15
    - **Priority**: High
    - **Difficulty**: Medium
    - **Dependencies:** SR_14
16. The app must document the user permissions' regarding the usage of their personalized data.
    - **ID:** SR_16
    - **Priority**: Medium
    - **Difficulty**: High
    - **Comments:** GDPR-Compliance must be achieved, which covers additional requirements for the whole App Business Process, including the documentation of infrastructure, data processing of cooperating companies and more. Depending on realization.
    - **Dependencies:** SR_14

3.2 Warnings

17. The app must warn the driver in a way, that doesn't irritate the user with too many warnings.

- **ID:** SR_17
- **Priority**: High
- **Difficulty**: High
- **Comments**: A suitable working example of this requirement, would be warning signals for pilots, since they have multiple decades of experience with automated warning systems, their impact on the pilot's attention and their documentation in international standards.
- **Dependencies**: SR_9, SR_11, SR_12, SR_15

18. The app shall differentiate warnings for the user based on its importance for the user.

- **ID:** SR_18
- **Priority**: Medium
- **Difficulty**: Medium
- **Comments**: At the time of this writing, there are only two distinctions covered within the specifications: "Traffic Congestion Ahead" and "Accident Imminent". Depending on usage.
- **Dependencies**: SR_9, SR_11, SR_12, SR_15

19. After an accident, the app should show an option to call an ambulance.

- **ID:** SR_19
- **Priority**: Low
- **Difficulty**: High
- **Comments**: High challenges of an accurate registry of accidents.
- **Dependencies**: SR_9

20. The app shall not differentiate too many warnings for the user, so a fast reaction time of the driver is retained.

- **ID:** SR_20
- **Priority:** Medium

- **Difficulty**: Medium
- **Comments**: At the time of this writing, there are only two distinctions covered within the specifications: “Traffic Congestion Ahead” and “Accident Imminent”.
- **Dependencies**: SR_9

21. If the user drives more than 3 hours at once the app should prompt a warning that the accident risk is increased and suggest taking a break.
    - **ID:** SR_21
    - **Priority**: Medium
    - **Difficulty**: Low
    - **Comments**: Accident prevention.
    - **Dependencies**: SR_9
22. The app shall have the ability to rate accidents and use this data to improve the prediction accuracy of the model.
    - **ID:** SR_22
    - **Priority**: Medium
    - **Difficulty**: Medium
    - **Comments**: Additional help for the user in order to estimate the situation.
    - **Dependencies**: SR_1
23. The app shall report low battery of the used device in order to ensure a full-time protection.
    - **ID:** SR_23
    - **Priority**: Medium
    - **Difficulty**: Medium
    - **Comments**: If the Battery is lower than 20%, prompt a message to plug in the charger.

- **Dependencies**: SR_ 9

3.3 Prediction and Evaluation

24. The app shall be able to detect potential accidents and evaluate their potential impact and probability.
    - **ID:** SR_24
    - **Priority**: High
    - **Difficulty**: High
    - **Dependencies:** SR_1
25. Due to collection of data of multiple users (if allowed) the app should be able to calculate high risked routes due to accidents or traffic potential.
    - **ID:** SR_25
    - **Priority**: Medium
    - **Difficulty**: High
    - **Comment**: Implementation of a predictive algorithm necessary.
26. The predictive data should be actualized live depending on the actual traffic data.
    - **ID:** SR_26
    - **Priority**: Medium
    - **Difficulty**: Medium
    - **Comments**: Depending on third party provider.
27. The quality of the provided traffic data has to be very high (nearly 100% correct).
    - **ID:** SR_27
    - **Priority**: High
    - **Difficulty**: Medium
    - **Comments**: Depending on third party provider.

28. When a situation occurs that does not fit in to the clusters of recognition there should also be a prompt with unidentified situation.
    - **ID:** SR_28
    - **Priority**: High
    - **Difficulty**: Medium
    - **Comments**: Fault tolerance out of the cluster. Depending on implementation.
29. Score of the driver depending on his driving skills.
    - **ID:** SR_29
    - **Priority**: Low
    - **Difficulty**: Low
    - **Comments**: E.g. watching for speeding. Depending on realization.

3.4 Reliability

30. The app shall work reliably under all circumstances, thus warn before every imminent crash-event, warn before reported traffic congestions.
    - **ID:** SR_30
    - **Priority**: High
    - **Difficulty**: High
    - **Comment**: Depending on implementation and third-party data.
31. The app shall be able to detect situations reliably and separate potentially harmful events from normal heavy traffic.
    - **ID:** SR_31
    - **Priority**: Medium
    - **Difficulty**: Medium
    - **Comments**: Depending on implementation.

32. The app shall warn the driver reliably if an accident will occur without an active counter-reaction of the driver.
    - **ID:** SR_32
    - **Priority**: High
    - **Difficulty**: High
    - **Comment**: Depending on realization.
33. The app shall work even if the functionality of an information resource (video-feed, third party traffic information, GPS signal) has been interrupted.
    - **ID:** SR_33
    - **Priority**: Low
    - **Difficulty**: High
    - **Comments**: Depending on implementation.
34. The detection, analysis and warning of the driver, shall occur in real time. Under no circumstance this process shall take longer than ¼ seconds.
    - **ID:** SR_34
    - **Priority**: High
    - **Difficulty**: High
    - **Comment**: The performance of the smartphones, which this app uses as a platform is very heterogenous. The proposition of minimum requirements for the user and a high priority on performance efficiency is advised.
35. The app shall not transmit personalized data to our servers, unless a permission from the user has been given and documented.
    - **ID:** SR_35
    - **Priority**: High
    - **Difficulty**: Low
    - **Comments**: Depending on permission.

36. The app shall be able to detect current movements patterns of objects, and predict if an accident will occur, in relation to our own predicted path.
    - **ID:** SR_36
    - **Priority**: Medium
    - **Difficulty**: Medium
    - **Comments**: Ensure the correct functionality. Depending on implementation.
37. The app shall be able to predict the trajectory of moving objects.
    - **ID:** SR_37
    - **Priority**: High
    - **Difficulty**: High
    - **Comments**: High importance to ensure timely driver reaction. Depending on implementation.
38. The sensor of the App shall have the ability to recognize and explicitly differentiate between different objects (differentiate the blue sky from truck tarpaulin or advertisements on trucks)
    - **ID:** SR_38
    - **Priority**: High
    - **Difficulty**: High
    - **Comment**: High challenge to the implementation of the functionality. Depending on implementation.
39. The sensor of the App shall have the ability to recognize objects during bad weather conditions (rain, snow), during the night or in tunnels.
    - **ID:** SR_39
    - **Priority**: High
    - **Difficulty**: High
    - **Comment**: High challenge to the quality of the sensor. Depending on implementation.

40. Necessary updates of the App must be explicitly confirmed in order to avoid completion during the ride.
    - **ID:** SR_40
    - **Priority**: High
    - **Difficulty**: Low
    - **Comment**: Functionality must not be disturbed due to updates. Depending on implementation.

Appendixes

Appendix 1: Goal Model