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Master Course
Distributed Computing Systems
Engineering

Workshop EE5620 :

Project Control and Management

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25th April 2017

Contents

List of Abbreviations

ADAS Advanced Driver Assistance Systems

Chapter 1

Introducing TSMW

Author: Wojciech Lesnianski

1.1 Company

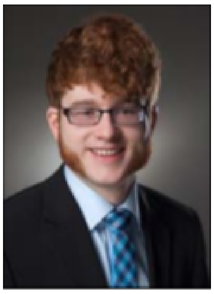
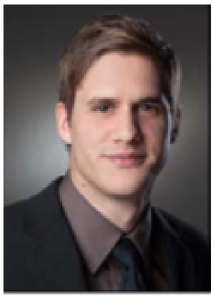
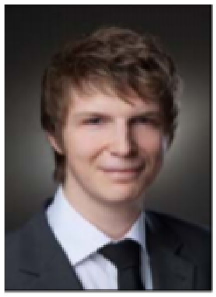
TSMW is a young company, which aims at the auto industry and provides own software solutions together with chosen hardware that is available on the market or provided by the customer, to build a system, supporting the car driver with a specific task. If needed, the company provides an analysis and a preselection of available hardware pieces, in terms of quality, availability and price to the customer, as well as an objective recommendation.

The aims and objectives of the company are:

- Development of support systems which satisfy the customer and the end user
- Creation of objectively fitting hardware selections for the customer
- Long terms binding of the customer to the company, through good price and quality of the required system.

1.2 Staff

The following chapter introduces the TSMW team. The young company consists of 4 members which share the tasks between each other to achieve the most with the given capacity, but also all have their special responsibility / role of their own. Especially for a small company, it is of high importance to coordinate the activities to meet the requirements of the customer.

Markus Just	Timo Acquistapace	Simon Schneider	Wojciech Lesnianski
			
Project Leader	Software Architect	Software Engineer	Designer

To make the coordination of the activities possible, we require a clear definition of roles and their interdependencies:

1.2.1 Project Manager

Project Manager is primary responsible for the communication with the customer and acquisition of requirements, as well their transformation into tasks and user stories. He supervises the development process and monitors the process flow.

1.2.2 Software Engineer

The primary task of the Software Engineer is primary responsible for the development of the system backend, decision making about the form of persistent data and the advisement of the software architect. The Software Engineer creates a selection of eligible hardware parts and together with the Project Manager, presents them to the customer.

1.2.3 Software Architect

The main task of the Software Architect is the creation of the architecture, as well as the consultation with all developers about the current development decisions.

1.2.4 Designer

The Designer is responsible for the creation of a user interface prototypes, as well as the development of the user interface throughout the development process. He is also in charge of the company's corporate design and its logo.

1.3 Product

The requested system should be built into the customer's cars and support the driver by bringing his car out of a parking position. Various sensors around the car should provide safety during the process and the driver should always be able to take control of the car. For the system, it should be of no matter, weather the parking position is parallel or perpendicular. In further development iterations, the process should also provide an external interface for third party systems to start or stop a parking process. The system should be capable of working with the traffic systems of all countries the customer's cars are sold to and take into account the countries rules including the orientation of the bidirectional traffic. For driver's convenience, the system should provide a graphical interface with an overview over the current state of the parking process, as well as the information received from the sensors.

Chapter 2

Aims, Objectives and expected Outcome

Author: Wojciech Lesnianski

In this chapter we will on the one hand discuss, what the overall aim of the project is, and what the objectives are, which we want to achieve either on the way through the project or in its end. Furthermore we will forecast, what our expected outcome of the project is and what the reasons for this forecast are.

2.1 Aim

The aim of the project is to create a system which helps the user to bring out his car from a parking position in the simplest, yet most convenient and reliable way possible.

2.2 Objectives

The project's objectives are:

- Satisfaction of the customer
  We measure our success rate with the satisfaction level of our customers.

- Satisfaction of the end consumer
  Since this is a system, our customer wants to make to provide support for his customers, his own satisfaction, and thus our success, will highly depend on this factor. We want to make his life easier, without asking too much of technical knowledge or making things so complicated to use, that he decides to do his actions without the help of our system.

- Creation of a satisfying hardware analysis
  Since the system is supposed to use third party hardware for significant parts of the functionality, it is an objective to create a good analysis on the state of art of the needed variety of sensors.

- Create a System that is significant on the market
  We want to create a system which other systems get compared to, when it comes to measuring the quality.

2.3 Expected Outcome

The expected outcome of this project is, due to the lack of time and hardware:

- A representative market analysis of current competition systems with the contrast to our product

- A representative market analysis on the needed hardware pieces for our system

- A solid and justified concept for a solution

- A proof of concept

Chapter 3

Requirement Analysis

Author: Markus Just, Wojciech Lesnianski

3.1 Top-Level-Requirement

The application should bring out a car from different parking positions automatically.

3.2 Functional Requirements

Required

- **3.2.1** The application should be able to bring out the car from a parallel parking position
- **3.2.2** The application should be able to bring out the car from a perpendicular parking position
- **3.2.3** The application should be able to bring out the car from an angled parking position
- **3.2.4** The application should be able to work on the road side
- **3.2.5** The application should be able to work in a parking facility
- **3.2.6** The application should provide relevant sensor information to the driver in an graphical overview
- **3.2.7** The application should provide information about the current action to the driver in an aerial car view

3.2.8 It should always be possible for the driver to intervene the current process

3.2.9 The application should be able to work with right-hand traffic

3.2.10 The application should be able to work with left-hand traffic

3.2.11 The application should consider the traffic rules and should act properly

3.2.12 The application should bring the car out of the parking system in a way that after that process it is possible to enter it from all sides

Nice-to-have

3.2.13 The application should work independent of the current weather conditions

3.2.14 The cars should have customizable skins, selectable by the user

3.2.15 The application should be remote-controllable by a mobile application if the user is within a defined range to the vehicle

3.3 Non-functional Requirements

3.3.1 The application must comply national safety regulations

3.3.2 The application should have a suitable design

3.3.3 The application should be integrated in the given car's entertainment system

3.3.4 The application's GUI should be easy to grasp for the user

3.3.5 The application should be easy to extend

3.3.6 The application should be secured against any kind of attack

3.3.7 The application should be integrateable in different sorts of vehicles

3.3.8 The application should be developed with C#/.NET

3.3.9 The applications GUI should be developed with WPF.

Chapter 4

Project Plan

Author: Markus Just

Chapter 5

Resource Allocation

Author: Wojciech Lesnianski

Available resources were always one of the biggest goods Project Managers had to work with, to keep customers happy. Especially with the growing agile approach popularity, where development iterations become smaller, it is of high importance to use all resources the most efficient way. Efficiency in this case, does not always mean, to put the most fitting developer on a task, but also consider where the other resources are allocated at the time. Putting a developer on a task that is not fitting him perfectly might still be a good idea if another developer would not be able to do anything otherwise.

5.1 Methodology of Resource Allocation

There are various methods which aim at the best possible resource allocation and they all first require the user, possibly the project manager, to break down jobs in tasks and classify the tasks and the resources in a specific way. The better the breakdown and the classification is, the better the project manager can allocate his resources.

For this project we will use the method described in the lectures of Dr. Ali Mousavi (see Mousavi [2017]).

This method focuses on classifying tasks and identifying the best possible human resource to fulfill the task. First the human resources get their Indicators of Capability:

- The Enablers (E) cognitive capabilities, skills and roles

- The Preferences (P) personal traits
- Past Attainments (A) past experience in similar roles

It takes an experienced project manager and good self-assessment of the developer to put together a representative and well-founded list of enabler properties.

In the following, we will calculate the impact and utilization of a specific human resource on a specific job as an example. Since we are a small company we take the job implementation as one big job which we separate into tasks (see figure 5.1.1). After writing down the most important skills needed for the single tasks, we can put them all together in a separate table, considering the highest X (see figure 5.1.2).

Considering the weight of a skill W and the availability of the human resource A we can calculate the values A' and A''. With those values we can calculate the Impact and Utilization of a Human Resource for a job:

Impact:	0.68
Utilisation:	0.81

Table 5.1.1: Impact and Utilization of a Human Resource

Those values would have to be compared to the values of other candidates, which would be too much for this assignment.

Basic Tasks	Capability Indicator	Skill Description	X (How much capacity of resource is required)	
Setup a development environment	C_{111}	.Net Knowledge	X_{111}	0.8
	C_{121}	Vehicle Knowledge	X_{121}	0.7
	C_{131}	Simulation Software Knowledge	X_{131}	0.5
	C_{141}	Database Knowledge	X_{141}	0.7
	C_{211}	Likes working in teams	X_{211}	0.4
	C_{221}	Extroverted	X_{221}	0.3
	C_{231}	Adapting to new situations	X_{231}	0.5
	C_{311}	Experience with car systems	X_{311}	0.8
	C_{321}	Experience with .Net projects	X_{321}	0.6
Implement the frontend	C_{112}	.Net Knowledge	X_{112}	0.8
	C_{122}	Design skills	X_{122}	0.85
	C_{132}	Layouting Knowledge	X_{132}	0.85
	C_{212}	Likes to design	X_{212}	0.85
	C_{222}	Likes working with layouts	X_{222}	0.8
	C_{232}	Understanding in customers needs	X_{232}	0.6
	C_{312}	Experience with GUIs	X_{312}	0.7
	C_{322}	Experience with WPF	X_{322}	0.6
	C_{323}	Experience with CarComp. Layouts	X_{323}	0.7
Implement the backend	C_{113}	.Net Knowledge	X_{113}	0.9
	C_{123}	Database Knowledge	X_{123}	0.7
	C_{133}	Sensor/Microcontroller Knowledge	X_{133}	0.5
	C_{143}	C# Programming Skills	X_{143}	0.8
	C_{213}	Likes working in teams	X_{213}	0.5
	C_{223}	Can work independently	X_{223}	0.4
	C_{233}	Adapting to new situations	X_{233}	0.6
	C_{313}	Experience with C#	X_{313}	0.7
	C_{323}	Experience with car systems	X_{323}	0.6
	C_{333}	Experience with .Net Projects	X_{333}	0.75
	C_{343}	Experience with databases	X_{343}	0.6
Test the system	C_{114}	Vehicle Knowledge	X_{114}	0.6
	C_{124}	Simulation Software Knowledge	X_{124}	0.5
	C_{134}	Writing Skills	X_{134}	0.3
	C_{214}	Understanding in customers needs	X_{214}	0.4
	C_{224}	Can work independently	X_{224}	0.7
	C_{314}	Experience with car systems	X_{314}	0.8

Figure 5.1.1: Task-Resource Matching

C'		X'	W (Weight)		A (Availability)		A' (MIN(X';A)/X')		A'' (MIN(X';A)/A)	
C'_{11}	.Net Knowledge	0,9	W_{11}	0,2	A_{111}	0,7	A'_{111}	0,78	A''_{111}	1,00
C'_{12}	Vehicle Knowledge	0,7	W_{12}	0,1	A_{112}	0,6	A'_{112}	0,86	A''_{112}	1,00
C'_{13}	Simulation Software Knowledge	0,5	W_{13}	0,08	A_{113}	0,3	A'_{113}	0,60	A''_{113}	1,00
C'_{14}	Database Knowledge	0,7	W_{14}	0,09	A_{114}	0,1	A'_{114}	0,14	A''_{114}	1,00
C'_{15}	Design skills	0,85	W_{15}	0,17	A_{115}	0,5	A'_{115}	0,59	A''_{115}	1,00
C'_{16}	Layouting Knowledge	0,85	W_{16}	0,17	A_{116}	0,6	A'_{116}	0,71	A''_{116}	1,00
C'_{17}	Sensor/Microcontroller Knowledge	0,5	W_{17}	0,06	A_{117}	0,4	A'_{117}	0,80	A''_{117}	1,00
C'_{18}	C# Programming Skills	0,8	W_{18}	0,1	A_{118}	0,8	A'_{118}	1,00	A''_{118}	1,00
C'_{19}	Writing Skills	0,3	W_{19}	0,03	A_{119}	0,5	A'_{119}	1,00	A''_{119}	0,60
C'_{21}	Likes working in teams	0,5	W_{21}	0,13	A_{121}	0,8	A'_{121}	1,00	A''_{121}	0,63
C'_{22}	Extroverted	0,3	W_{22}	0,09	A_{122}	0,5	A'_{122}	1,00	A''_{122}	0,60
C'_{23}	Adapting to new situations	0,6	W_{23}	0,15	A_{123}	0,6	A'_{123}	1,00	A''_{123}	1,00
C'_{24}	Likes to design	0,85	W_{24}	0,2	A_{124}	0,4	A'_{124}	0,47	A''_{124}	1,00
C'_{25}	Likes working with layouts	0,8	W_{25}	0,2	A_{125}	0,9	A'_{125}	1,00	A''_{125}	0,89
C'_{26}	Understanding in customers needs	0,6	W_{26}	0,13	A_{126}	0,4	A'_{126}	0,67	A''_{126}	1,00
C'_{27}	Can work independently	0,4	W_{27}	0,1	A_{127}	0,5	A'_{127}	1,00	A''_{127}	0,80
C'_{31}	Experience with car systems	0,8	W_{31}	0,2	A_{131}	0,1	A'_{131}	0,13	A''_{131}	1,00
C'_{32}	Experience with .Net projects	0,75	W_{32}	0,19	A_{132}	0,5	A'_{132}	0,67	A''_{132}	1,00
C'_{33}	Experience with GUIs	0,7	W_{33}	0,15	A_{133}	0,9	A'_{133}	1,00	A''_{133}	0,78
C'_{34}	Experience with WPF	0,6	W_{34}	0,1	A_{134}	0,8	A'_{134}	1,00	A''_{134}	0,75
C'_{35}	Experience with CarComp. Layouts	0,7	W_{35}	0,13	A_{135}	0,5	A'_{135}	0,71	A''_{135}	1,00
C'_{36}	Experience with C#	0,7	W_{36}	0,13	A_{136}	0,7	A'_{136}	1,00	A''_{136}	1,00
C'_{37}	Experience with databases	0,6	W_{37}	0,1	A_{137}	0,6	A'_{137}	1,00	A''_{137}	1,00

Figure 5.1.2: Individual Availability

A'		A''	
A'_{11}	0,70	A''_{11}	0,99
A'_{12}	0,85	A''_{12}	0,87
A'_{13}	0,72	A''_{13}	0,94

Figure 5.1.3: Normalisation

Chapter 6

Risk Analysis

Author: Simon Schneider
Contributor(s):
Risk analysis is a process which enables the analysis of risks, associated within a project. A Risk can be generally defined as the probability of something going wrong, and the negative consequences if it does. However, it is hard to find all the risks, which can occur, in a project. At first it should be recognised that a risks exists as a consequence of uncertainty. For this reason the risk analysis process will help to identify potential problems that may occur. Such a risk analysis can be useful in several situations:

- To help to anticipate and neutralise possible problems when planning projects.
- To decide wether to continue with the project or not.
- To improve safety and manage potential risks in the workplace.

6.1 Identifying the Risks

As one of the first steps in Risk Analysis it is to identify the existing and possible problems occur. Some of these areas and threats, which might have an impact on this project, are listet below:

- Project Members – Illness, injury, or another reason leading to a loss of a project member.

- Operational - Delays in deliveries.
- Reputational - Loss of customer or employee confidence.
- Project - Taking too long on concluding key tasks, or experiencing issues with product or service quality, goal not achieved.
- Financial - Budget exhausted, Business failure or non-availability of funding.

6.2 Estimate Risks

After some of the possible threats has been faced, the risk can be calculated with both the likelihood of these threats being realised, and their possible impact. One way of doing this is to make a estimation of the probability that this threat occurrs multiplied by the amount it will cost. This leads to the following equation which quantifies the risk:

$$Risk = Probability\, of\, Occurance \cdot Cost \tag{6.1}$$

Additionally there are two possible kinds of processes:

- The total value of a risk of a series of processes that are executed successively can be calculated as follows:

$$R_{Total} = R_n \cdot R_{n+1} \tag{6.2}$$

- The total value of a risk of parallel processes that are executed concurrent can be calculated as follows:

$$R_{Total} = 1 - (1 - R_n) \cdot (1 - R_{n+1}) \tag{6.3}$$

As an example the risk value of an illness of a project member will be calculated. The estimated propbillity will be set to 0.4. Lets assume that the member is ill for about a week. One day has 8 working hours and the salary for this member would be 50£ per hour.

$$Risk = Probability\, of\, Occurance \cdot Cost = 0.4 \cdot 5 \cdot 8 \cdot 50£ = 800£ \quad (6.4)$$

So the risk value for this threat would be 800£.

In order to determine what risks to focus on, an Impact / Probability Chart can be very useful. An Impact / Probability Chart is a two dimensional diagram whereat on the axis of ordinates the probability of Occurrence will be plotted and on the axis of abscissas the impact on the project. For this purpose, a probability and the associated impact are assigned to the identified risks. However, this is carried out only by way of example at a respective risk from each area and then drawn into the diagram. The assigned probabilities and impacts can taken from the following table.

Risk	Probability	Impact
Illness of Project Member	0.4	3
Delay in Deliveries	0.35	8
Loss of Customer Confidence	0.5	7
Specified Goals not achieved	0.7	9
Budget exhausted	0.2	10

Table 6.2.1: Frequency analysis Novel

The following figure shows an exemplarily Impact / Probability Chart with the estimated probabilities and associated impacts on the project:

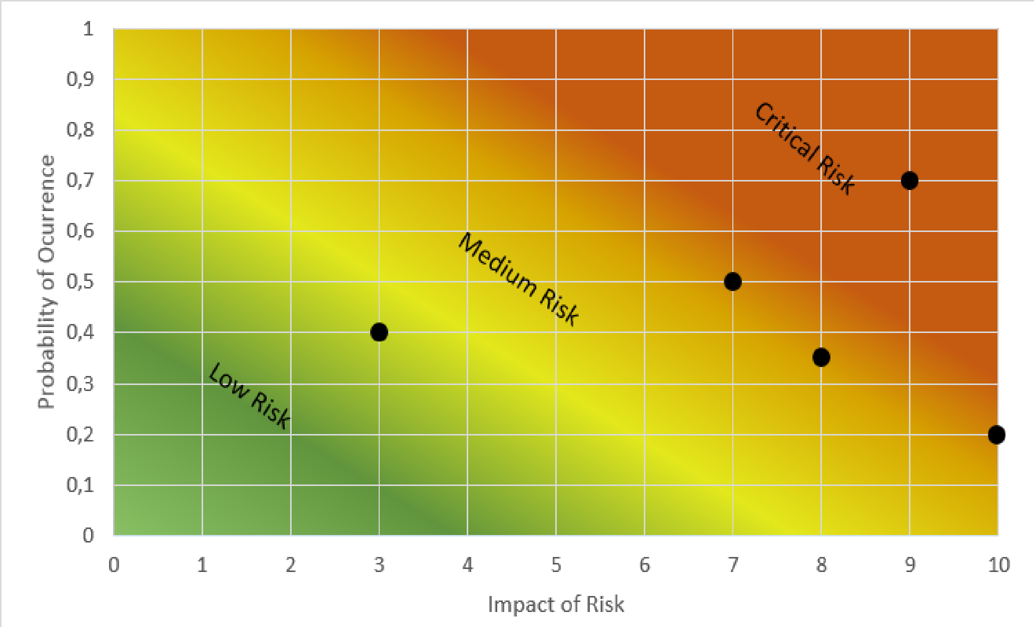


Figure 6.2.1: Impact / Probability Chart

As it can be seen, the chart has several areas. With help of this areas it can be figured out, if the the risk has priority or not. The characteristics of these areas will be explained subsequently:

- Low impact/low probability - risks in this area can often be ignored.
- Low impact/high probability these risks are of moderate importance but they have to be noticed and it should be tried to avoid that they occure
- High impact/low probability - these are of high importance and should not occure because the probablility is very low. If so, a contingency plans should be available.
- High impact/high probability risks in this area are of critical importance and have the highest priority.

On the basis of this Impact / Probability Chart, the main focus should be on the achievement of the goals, as these have the highest priority.

6.3 Dealing with Risks

To successfully execute a project, the risks has to be identified. Afterwards the focus has to be on the middle and high-priority risks. Otherwise resources on unecessary risks will be a waste. Since the risks has been identified and prioritised, the next step is how to deal with them. The following is a brief discussion of four different ways of dealing with risks.

6.3.1 Risk Avoidance

The aim of risk avoidance is to avoid any risk, even if they are very small. The suggestion of maximum safety through very strong differentiation and a high control is at the expense of free processes. An example related to the project is the early planning of the tasks and the associated aims. Through very strict planning it is already tried in the run-up to avoid all risks, to transfer them or to turn activities so that risks can not occur. All these actions are at the expense of project budgets and scheduling but in favor of quality.

The idea of risk avoidance: “do not take any risks” means maximum security while at the same time avoiding opportunities, including rejecting cooperation with certain partners and a longer project run-time with higher costs.

6.3.2 Risk Reduction

Risk reduction means that through various procedures in the field of personnel organisation and workplace organisation attempts are made to keep the specific probability of occurrence of the risks as small as possible. Examples for this could be, point explicitly to the risks of the respective task to the project members and communicate the risks transparent to all project members so that a shared understanding can be achieved.

The idea of risk reduction: by means of personnel processes (training, qualification, involvement of experts) and technical processes (only processing quality materials, making processes and optimising them), permanently reduce the probability of occurrence of risks.

6.3.3 Risk Transfer

During the transfer, risks are passed on to third parties through contracts and / or the assignment of service providers. If, for example, many risks occur during a project phase, it can be considered to outsource the entire task to a partner.

The idea of risk transfer: through service-level agreements, contracts or outsourcing, the risks and any related tasks are completely and in writing passed to third parties, which can then be made liable for a risk entry.

6.3.4 Risk Acceptance

The idea of risk acceptance: risks with very low scope and very low probability of occurrence, as well as risks that can not be circumvented, should be accepted as such.

6.4 Conclusion

In this chapter it has been worked out what risks are and how they can be identified. It was then shown how the risk value can be calculated from the costs and the probability of the occurrence. Afterwards, the identified risks were prioritized using the Impact / Probability Chart and the handling of risks was dealt with most recently.

Finally, the further the project progresses, the lower the risk.

Chapter 7

Market Analysis

Author: Timo Acquistapace

An important step in the development of a new product is to analyse the market. This analysis not only includes the identification of competitors and their offered technologies, but also the investigation of the demand on the product to develop and its future progression. Another part of the market analysis is to determine which hardware might be necessary for the product to develop. After the identification of the needed parts, the offered products on the market are compared regarding their capabilities and their price.

7.1 Analysis of Competitors

The analysis of competitors provides an overview of the available products on the market, of their capabilities and of how widely these products are already used. The following analysis is done by querying the internet and putting altogether the relevant information. It not only focuses on well-known manufacturers but also on scientific projects that might be in competition with our company.

7.1.1 Current Systems implemented in today's Cars

There are only a few systems available that help the driver in leaving a parking space. These systems exhibit a huge variety of autonomy. The manufacturers Volvo, Audi and Lincoln sheet park assistance systems that take control over the steering wheel when leaving a parking lot (see Volvo Cars Support [2016], Lincoln Motor Company [2014] and Audi Espana). While the steering is done autonomously, the driver has to operate the pedals on its own. This kind of systems is mostly restricted to parallel parking.

Mercedes-Benz offers a more autonomous, but also more restricted way of assisted parking. The Mercedes-Benz “Parking Pilot” is able to park and leave a parking site autonomously. The quitting of the parking site is restricted to those scenarios in which the Parking Pilot was also used to park the car (see Daimler AG [2016]).

Tesla offers the “Summon” functionality implemented in its Model S and Model X. It allows a driver to leave its car and park as well as retrieve it autonomously. This feature is restricted to perpendicular parking only (see Tesla Inc. [2016]).

7.1.2 Current Systems available from Suppliers

The development of systems assisting a driver in parking and leaving a parking lot can be illustrated by the evolution of the products originating from Robert Bosch GmbH. While the early systems act as it was described for the manufacturers Volvo, Audi and Bosch (see Robert Bosch GmbH [2013a]), the current systems are now able to drive a car into and back out of a parking site autonomously (see Robert Bosch GmbH [2013b]). Another future application of park assistants is the Bosch “Home Zone Park Assist”. It enables a driver to train its car for certain parking situations (see Robert Bosch GmbH [2016]). The car records a route that is driven and it is able to reproduce it even if the starting point of the route to drive and the one of the recorded route are slightly different. On its trained way, the car is able to detect impediments and to react to them.

7.1.3 Scientific Projects

The earliest work on the current topic that could be found is the one of Braun and Katsev [2004]. This team presents some analytical work as well on the system design as on the necessary hardware to implement the desired functionality. In addition, they also provide a detailed analysis on the structure of the needed algorithms.

While it couldn't be determined if this project was brought to termination, Roland Doloczki and Don Kevin Gaubitz produced a working prototype of an RC-Car that autonomously leaves a parking space (see Doloczki and Gaubitz [2015]). To achieve their goal, Doloczki and Gaubitz used ultrasonic and infrared sensors to sense the environment around parked vehicle.

7.2 Future Development of the market

It is obvious that the demand on systems that perform certain manoeuvres autonomously will increase with the success of autonomous cars. But also in the meantime till these cars make the breakthrough, there might be an increased need for Advanced Driver Assistance Systems (ADAS) like parking assistants. Following McKinsey Inc., there will be three eras in the revolution of self-driving cars (see Bertoncello and Wee [2015]). The first era, starting from now and lasting till the late 2020s, is characterised by the first autonomous vehicles being produced and by their impact on the established car manufacturers. McKinsey states that the premium makers will take an incremental approach to autonomous vehicles by implementing more sophisticated ADAS. This assumption is supported by Statista, assuming that the shipment of ADAS units will increase by more than 500% in the time from 2012 to 2020 (see Statistica Inc.).

One of the buzz words regarding future driver assistance systems is "Valet Parking" which means that a car parks itself after the driver has left it and that the car can be retrieved from its parking position without active control of the driver. Therefore, "Valet Parking" needs the possibility of a car autonomously leaving its parking site. A research project targeting on this technology was announced by Daimler, Bosch and Car2go in the year 2015 (see Daimler AG [2015]).

Product	Key Features	Price	Retailer
SICK UM18-218161101	Range: 0.12 - 1.0m Operation temp.: -25°C - 70°C Switching freq.: 10Hz	152.32$	TME
PING))) Ultrasonic Distance Sensor	Range: 0.02 - 3m Operation temp.: 0°C - 70°C Switching freq.: 10Hz	24.99$	Parallax
LV-MaxSonar-EZ1	Range: 0.0 - 6.45m Operation temp.: - Switching freq.: 20Hz	23.36$	Sparkfun [a]
AU003	Range: 0.08 - 1.2m Operation temp.: -20 °C - 70 °C Switching freq.: 5Hz	112.94$	Autosen [a]

Table 7.3.1: Compared Ultrasonic Distance Sensors

7.3 Market Analysis regarding the needed Hardware

The product to develop is based on the recognition of obstacles in the vehicle's surroundings. The most common used sensors to gain an overview of a car's ambiance are ultrasonic and laser sensors as well as cameras. Some representatives of these sensors are introduced and compared in this chapter.

7.3.1 Comparison of Ultrasonic Distance Sensors

There exist a lot of ultrasonic distance sensors on the market that are intended to be used in automotive applications. The chosen representatives of these all exhibit a detection range of $1m$ or above. Their switching frequency, operation temperature and price are compared in table 7.3.1.

While the low-cost sensors are appropriate for a proof of concept, they are not suitable for an application under real conditions because either their operation temperature lies only above freezing or it is not indicated in the datasheets. The prices of the high-cost sensors are based on the ordering of small amounts and might be renegotiated if higher volumes are commissioned.

Product	Key Features	Price	Retailer
OID200 - OIDLCPKG/US	Range: 0.03 - 2.0m Operation temp.: -25°C - 60°C Switching freq.: 11Hz	115.69$	Auto- mation24
Lidar Lite v3	Range: up to 40m Operation temp.: -20°C - 60°C Switching freq.: 10Hz	159.15$	Sparkfun [b]
AL003	Range: 0.03 2m Operation temp.: -25°C - 60°C Switching freq.: 11Hz	110.05$	Autosen [b]

Table 7.3.2: Compared Laser Distance Sensors

7.3.2 Comparison of Laser Distance Sensors

Laser distance sensors are especially popular in the context of the obstacle detection that is implemented by Google's self-driving car (see Whitwam [2014]). Different representatives of this kind of sensor are contrasted in table 7.3.2.

All of the presented sensors are designed for the use in automotive applications and therefore fulfil the requirements for our project. In contrast to the ultrasonic sensors, there are no low-cost laser distance sensors that are suitable for the use in a proof of concept.

7.3.3 Review on available Camera Sensors

Comparing available camera sensors on the market is very difficult. Most of the available sensors are designed to be used in model making. The prices of the ones that are intended for automotive applications (e.g. sensors of Ambarella and ON Semiconductor) have to be inquired from the manufacturers. Table 7.3.3 shows two camera sensors that are suitable for a proof of concept and that could also be tested under the condition of extreme temperatures.

Product	Key Features	Price	Retailer
32KM NTSC	Resolution: 0.35MP Operation temp.: -20°C - 70°C Scanning freq.: 60Hz, night vision: no, angle: up to 120°	31.95$	Sparkfun [c]
LinkSprite JPEG Color Camera TTL Interface - Infrared	Resolution: 0.3MP Operation temp.: -20°C - 70°C Scanning freq.: 60Hz, night vision: yes, angle: up to 120°	49.95$	Sparkfun [d]

Table 7.3.3: Sampled Camera Sensors

Part	Price/Unit	Pcs	Sum
32KM NTSC	31.95$	2	63.90$
LV-MaxSonar-EZ1	23.36$	4	93.44$
Arduino Mega 2560	37.18$	1	37.18$
Total			194.52$

Table 7.3.4: Calculation of Costs for a POC

7.3.4 Calculation of Costs

If a hardware proof of concept is implemented, the costs can be calculated like it is done in table 7.3.4. The amount of sensors that are used in a final system and the actual prices might differ in the moment of the system's final realisation.

7.4 Conclusion

The analysis of our company's competitors worked out that the planned product is more sophisticated than those systems that are used in today's cars. Nevertheless, the idea of autonomously leaving a parking space is not new and there has been some research in this area at least since 2004.

The Robert Bosch GmbH is estimated to be the major competitor to our company since they are well connected to important car manufacturers like

Audi and Mercedes-Benz. Bosch is involved in research projects that target on “Valet Parking” and it also already demonstrated a product that is similar to the one of our company using a real car. Due to the prognostication of the market’s development, there might however be the possibility to get a significant market-share if the competitors like Bosch could be overcome by additional functionality or improved safety and reliability.

The investigation of available hardware on the market gave a first estimation of how much a hardware proof of concept might cost. It is certainly difficult to derive the costs of the final product from this estimation since the used prices pertain to the ordering of a small amount of sensors. Especially in the case of camera sensors, there have to be some inquiries to the sensors’ manufacturers to get additional information about the capabilities and the prices of the offered sensors.

Chapter 8

Process Flow, Critical Path Identification and Predictive Models

Author: Markus Just

Chapter 9

Customer Reports and Analysis

Author: Timo Acquistapace

Giving the customer the possibility to participate in the development of a product by providing him transparency regarding the overall progress and by implementing its feedback is one of the most important success factors. Especially if the final results of the collaboration are not explicitly clear or if the project is some kind of research work, it is of highest importance to gather the customer's feedback continuously. The gained feedback serves as an input in adapting the product or even the whole process of development.

Especially in the area of software development, the need for constant interaction between a manufacturer and its customer is widely acknowledged. This fact can be demonstrated by the adoption of agile methods (see figure 9.0.1). These methods, like XP, Scrum and FDD, offer the possibility of high transparency, short feedback-cycles and increased flexibility regarding changes in the requirements or in the market - characteristics that proved themselves good and that are strongly wanted by the manufacturers adopting agile methods (see figure 9.0.2).

9.1 Determining the Modalities of Collaboration

To embed a process that as well satisfies the customer as it provides the manufacturer the possibility to get as much useful input and feedback as

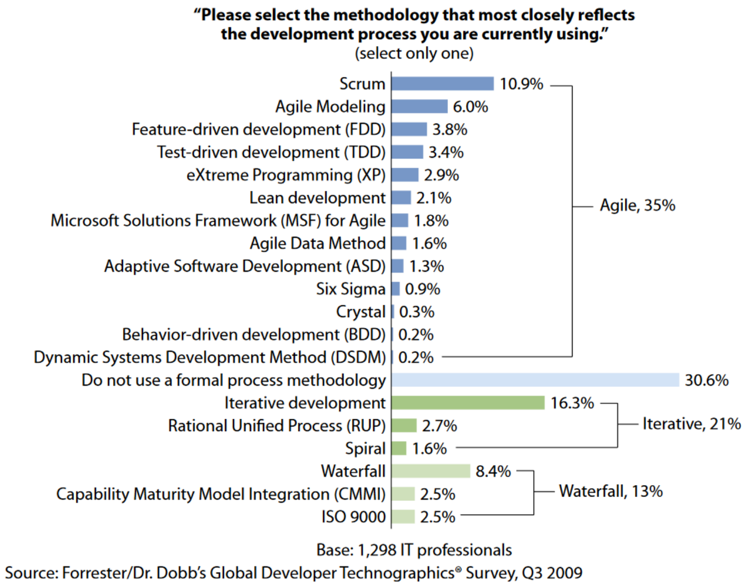


Figure 9.0.1: Adoption of agile Methods in Software Development (West and Grant [2010])

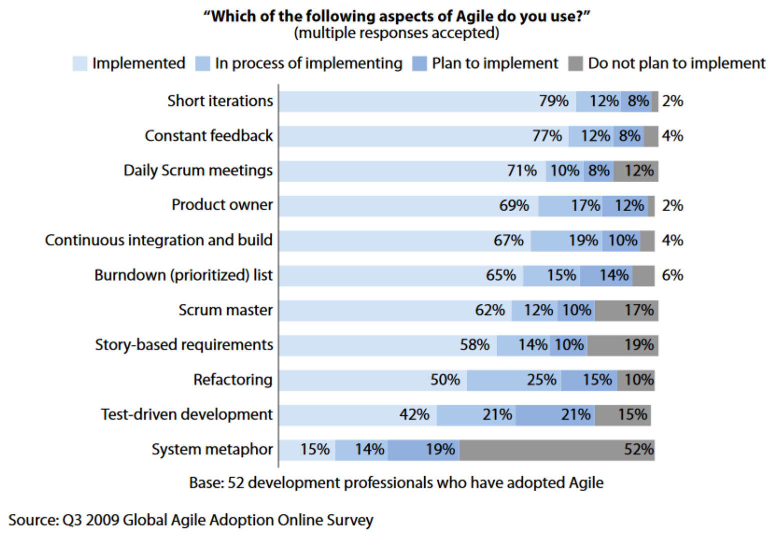


Figure 9.0.2: Adoption of agile Methods in Software Development (West and Grant [2010])

possible, the modalities of collaboration are negotiated as a first step. The salient points in this negotiation are:

- Who is the customer's specialist contact person and how should the communication with him/her take place?
- Who is the customer's technical contact person and how should the communication with him/her take place?
- In which way will the customer contact our company if necessary?
- What are the customers preferences regarding the reports on the project's progress?

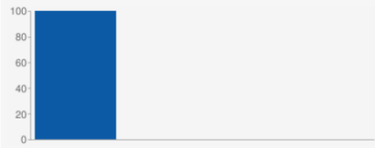
While some of these points like the contact information of a certain person in charge are only of informational kind, other points like the desired way of communication are of high importance. Since there are certain preferences in our company regarding the length of the iterations and the way how the communication should take place, the CORE value of the customer's answers in respect of our company's preferences is calculated.

9.1.1 Results

The results of the first questionnaire that serves to determine the modalities of collaboration between our company and our customer are presented in this section. The analysis of the results can be found in section 9.1.2. Answers that contain personal data like contact information are omitted.

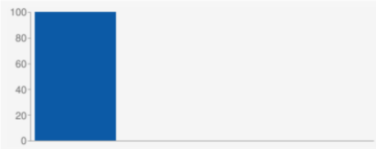
Section	Question title	Question average Satisfaction Value by CORE	Type	Mandatory	CORE	Median	Standard deviation	Mode	CORE verbal range	CORE colour
How we may reach your specialist contact person:	What ways of communication would be acceptable for you?	-	Multiple choice	Yes	No	1	0	1/	-	

- Email (1)
- Phone (0)
- WhatsApp (0)
- Skype (0)



Section	Question title	Question average Satisfaction Value by CORE	Type	Mandatory	CORE	Median	Standard deviation	Mode	CORE verbal range	CORE colour
How we may reach your specialist contact person:	Please tell us the contact information of your specialist contact person:	-	Textual	Yes	No	-	-	-	-	
Please tell us the contact information of your technical contact person:	What ways of communication would be acceptable for you?	-	Multiple choice	Yes	No	1	0	1/	-	

- Email (1)
- Phone (0)
- WhatsApp (0)
- Skype (0)



Section	Question title	Question average Satisfaction Value by CORE	Type	Mandatory	CORE	Median	Standard deviation	Mode	CORE verbal range	CORE colour
Please tell us the contact information of your technical contact person:	Please tell us the contact information of your technical contact person:	-	Textual	Yes	No	-	-	-	-	
How you want to reach us:	Your preferred way of communication:	-	Multiple choice	Yes	No	3	0	3/	-	

- Email (0)
- Phone (0)
- WhatsApp (1)
- Skype (0)

Section	Question title	Question average Satisfaction Value by CORE	Type	Mandatory	CORE	Median	Standard deviation	Mode	CORE verbal range	CORE colour
How you want to reach us:	Who do you want to reach in the case of a problem or a change of scope?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding	

- The project manager (1)
- The person responsible for the change / problem (0)

Exchange of information about the project's progress	How often do you like to be informed about the progress of the project?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding

- Daily information (0)
- Weekly information (0)
- Biweekly information (1)

Exchange of information about the project's progress	How much technical detail do you expect from these regular informations?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding

- Deep level of detail (including decisions on the implementation) (0)
- Medium level of detail (used technologies and justification about the decision why use these technologies) (0)
- Low level of detail (only used technologies) (1)

Exchange of information about the project's progress	What is your prefer way of communication the project's progress?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding

- Email (1)
- Phone (0)
- WhatsApp (0)
- Skype (0)

Future use of questionnaires	How much time do you want to spend on answering a future questionnaire at a max?	44	Exclusive choice	Yes	Yes	44	0	44/	Poor

- 2 minutes (0)
- 5 minutes (1)
- 10 minutes (0)
- 15 minutes (0)
- 20 minutes (0)

Future use of questionnaires	How long did you spend on answering this questionnaire?	65	Exclusive choice	Yes	Yes	65	0	65/	Satisfactory	

Future use of questionnaires	Do you have some other important points regarding our collaboration that this questionnaire didn't cover?	-	Textual	Yes	No	-	-	-	-	

no

9.1.2 Gained Knowledge

The result of the questionnaire is as well important as it is satisfactory to our company since the most answers given by the customer reflect the preferences of our company. This is especially true regarding the questions on the way our company will contact the customer, on the interval that is used for reporting and on the reporting's level of detail.

While the fact that our customer wants to contact the project manager and not any other team member complies with our company's preferences, the way of contacting him is suboptimal in our opinion. Nevertheless, our company will attend the customer's wished in this point.

To be able to gain honest and serious feedback from following questionnaires and not to overstrain our customer's willingness to collaborate, the last section deals with questionnaires in general. It is determined how long it took to answer the current questionnaire and how much time our customer is willing to spent in answering future questionnaires. For the simple reason that it was estimated that answering the current questionnaire would take 10 minutes, the CORE value retrieved from the answers on these questions is not highest achievable value. However, the result shows that the questionnaire's length perfectly fit the customer's preferences. Future questionnaires will therefore be designed in a way that they nearly have the same length

Form title	Form average Satisfaction Value by CORE	Number of sections	Number of questions	Number of answers	Last answered by	Last answered on	CORE verbal range	CORE colour
CollaborationQuest	85	5	13	1	Taeg5Customer	2017-04-01	Outstanding	

Section title	Form average Satisfaction Value by CORE	Number of questions	CORE verbal range	CORE colour
How we may reach your specialist contact person:	None	2	-	
Please tell us the contact information of your technical contact person:	None	2	-	
How you want to reach us:	100	2	Outstanding	
Exchange of information about the project's progress	100	4	Outstanding	
Future use of questionnaires	55	3	Fair	

Figure 9.1.1: Overview of first Questionnaire's Results

and the CORE values for the options on the question how long it took to answer a questionnaire will be adapted.

9.2 Clarification of the Requirements and Assessment of the first Design

Prototype Gathering and writing down requirements for a product requires high prudence. Young [2004] defines 15 characteristics of good requirements. Even if high effort is expended in the process of requirements engineering, there are mostly requirements that don't exhibit all of these characteristics. In the most cases, these requirements lack clarity and expressiveness.

The unclear requirements as well as a first mockup are the basis of a second questionnaire. Its aims are to inform the customer how the vague requirements were interpreted in the first step, to offer the customer the possibility to give a feedback on this interpretation and to provide him a first sense of the product that will be developed. The mockup that was created for the purpose of this questionnaire is depicted in figure 9.2.1.

9.2.1 Results

The results that help to clarify the requirements and to get a first feedback on the planned design are depicted below and interpreted in the next section

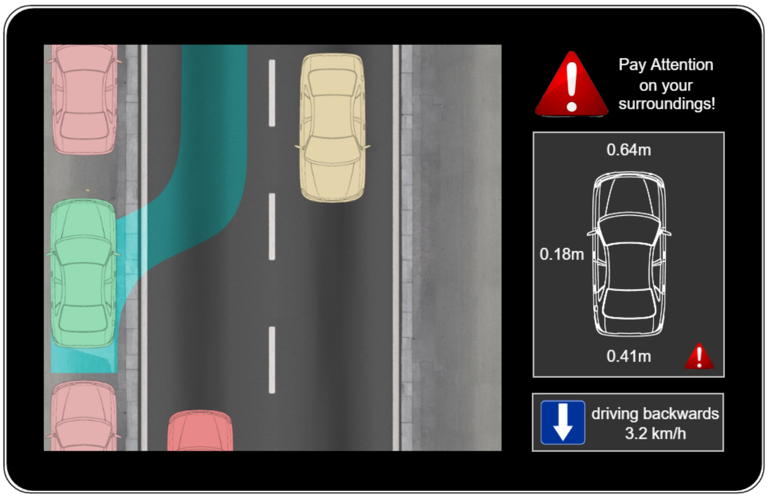


Figure 9.2.1: Initial Mockup of the System

(see section 9.2.2). Since a mistake has been made on the creation of the questionnaire, the assessment how long it took the customer to answer it had to be done in an additional form. The results of the initial survey and the additional form are assembled together.

Questions on the mandatory functional Requirements	Requirement 2.6 states: "The application should provide relevant sensor information to the driver in a graphical overview". We identified the distance to any impediment on any side of the car, approaching cars and the current state of motion (speed, direction) as "relevant information" that could be retrieved from the sensors. Do you identify any other relevant information?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding	
Yes (0) No (1)										
Questions on the mandatory functional Requirements	If yes: Which sensor information do you want to be added to the graphical overview?	-	Textual	No	No	-	-	-	-	

Questions on the mandatory functional Requirements	Requirement 2.7 states: "The application should provide information about the current action to the driver in an aerial car view". We identified the current state of motion (speed, direction) and the planned trajectory as important information. Do you identify any other relevant information about the current action?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding	

Questions on the mandatory functional Requirements	If yes: Which information on the current action do you want to be added to the graphical overview?	-	Textual	No	No	-	-	-	-	

Questions on the mandatory functional Requirements	Requirement 2.11 states: "The application should consider the traffic rules and should act properly". The traffic rules of which country should be implemented in a first step?	-	Exclusive choice	Yes	No	1	0	1/	-	

Questions on the mandatory functional Requirements	If you chose "Other": Which country should we chose?	-	Textual	No	No	-	-	-	-	

Questions on the mandatory functional Requirements	Do you have any further comments on the mandatory requirements?	-	Textual	No	No	-	-	-	-	

- Please inform us early if some of these requirements can not be implemented

Questions on the Design Prototype	Requirement 3.2 states: “The application should have a suitable design”. Since “suitable” is a very generic term: How much are you satisfied with the general structure of our mockup?	76	Exclusive choice	Yes	Yes	76	0	76/	Excellent

- Very satisfied (0)
- Satisfied (1)
- Mostly satisfied (0)
- Mostly unsatisfied (0)
- Unsatisfied (0)

Questions on the Design Prototype	Are there any improvements regarding the general structure? If yes, please feel free to tell us about it!	-	Textual	No	No	-	-	-	-

- Currently, the structure is good. But please do not make the area for the sensor information smaller.

Questions on the Design Prototype	Are the sensor information (distances to impediments and speed) presented clearly enough in the mockup?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding

- Yes (1)
- No (0)

Questions on the Design Prototype	If not: Do you have any suggestions for a better representation?	-	Textual	No	No	-	-	-	-

Questions on the Design Prototype	Are the information about the current action that is taken presented clearly enough?	35	Exclusive choice	Yes	Yes	35	0	35/	Poor

- Yes (0)
- No (1)

Questions on the Design Prototype	If not: Do you have any suggestions for a better representation?	-	Textual	No	No	-	-	-	-

- Please write only \"Backwards\". To much text distracts the driver

Questions on the Design Prototype	Are the symbols that we used self-explaining enough?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding	

- Yes (1)
- Most of them are (0)
- No (0)

Questions on the Design Prototype	Do you have any suggestions on how to improve the used symbols?	-	Textual	No	No	-	-	-	-	

- Please make sure that you have the rights to use these symbols.

Questions on the Design Prototype	Are you satisfied with the coloring of our mockup which might be the first standard template?	100	Exclusive choice	Yes	Yes	100	0	100/	Outstanding	

- Yes (1)
- No (0)

Questions on the Design Prototype	Do you have any suggestions on how to improve the coloring of the standard template?	-	Textual	No	No	-	-	-	-	

- You should provide another standard template that is not that dark. May be one template for night-mode (the presented) and one for day-mode (the brighter one)

Questions on the Design Prototype	Do you have any further comments regarding the first draft of our design?	-	Textual	No	No	-	-	-	-

- No.

Assessment of your Effort	How long did it take you to answer the previous Questionnaire?	54	Exclusive choice	Yes	Yes	54	0	54/	Fair	

- 2.5 min (0)
- 5 min (0)
- 7.5 min (0)
- 10 min (1)
- 12.5 min (0)
- > 12.5 min (0)

9.2.2 Gained Knowledge and further Steps taken

As it can be seen in 9.2.2, the results are very satisfying and the interpretation of the requirements fits the customer's expectations. More detailed feedback could be gathered regarding the design of the system. In the further development, our company will focus its attention to simplify the design e.g. by shortening the presented texts and by trying to scale up the area that presents the sensor information.

Unfortunately, the customer was not able to answer the questionnaire within 5 minutes as preferred, although the open questions on the optional requirements were already omitted. Since this was expected and the clarification of the requirements is a very important point, it is acceptable in the case of the current survey. Nevertheless, there has to be some effort made in the future to keep the questionnaires as short as possible for not deceiving the customer again in this regard.

9.3 Interim Report about the Project's Progress

As it was determined in the first questionnaire (see section 9.1), our customer wishes to get biweekly information about the project's current progress. The information included should exhibit a low level of technical detail and only reflect the relevant design decisions. A sample report can be found in the following pages.

TSMW

Interim Report on the Project's Progress

Dear Customer,

we'd like to present you the information about our current progress. Please let us know if there are any questions or remarks on the recently made decisions or on the progress itself.

Recent Activities

The recently completed activities include:

- Refinement of the Scope according to our most recent agreements (see the email, 7th April, 2017)
- Refinement of the final Requirements according to you feedback
- Finalisation of the market analysis regarding the competitors on the market as well as regarding the available hardware parts
- Finalisation of System Analysis including the gained knowledge from your last feedback form
- Finalisation of the needed algorithms' analysis
- Creation of improved skins for day- and night-mode
- Implementation of the data storage

Current Timeplan

Unfortunately, as you were informed by the email of the 13th April 2017, we ran into some problems regarding the implementation of the data storage. These problems, causing an initial delay of 3 days on this tasks, could now be overcome. Since the implementation of the depending systems could nevertheless be continued with only little overhead of abstracting the real data storage, the total delay is currently only about one day and will be compensable by time buffer we included in our project plan.

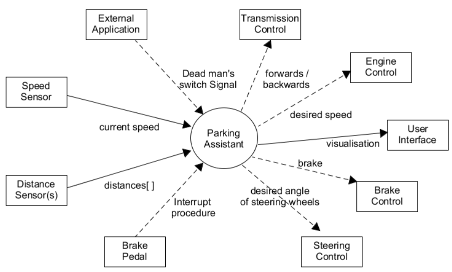
Cost Estimation for a Hardware - PoC

As you required, we made an estimation about the costs to create a Hardware-PoC. Please let us know if you are interested in the justification of the used components.

Part	Costs
2x 32KM NTSC	63.90$
4x LV-MaxSonar-EZ1	93.44$
1x Arduino Mega 2560	37.18$
Total	194.52$

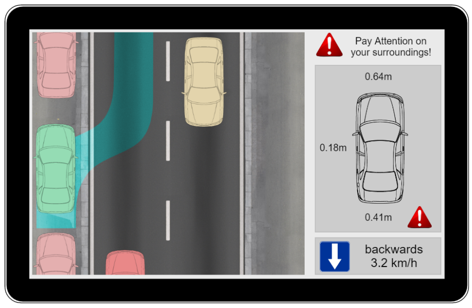
Final Results of the System Analysis

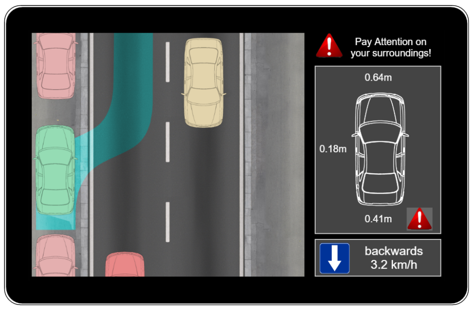
The context of the system is depicted below. It shows you all the systems that we expect to get input from and all the components we plan to actuate. If you need further insights into the analysis we conducted, we will send you the complete analysis in a separate document.



Improved Skins

According to your feedback, we improved the available skins of the system. In addition to the first presented skin, we created a brighter skin that might be used in the day-mode. We also included your feedback regarding the simplification of the outputs and extended the area where the relevant sensor information is represented.





Next Steps

Our next steps will be the final inclusion of the data storage as well as the enhancement of testing. In parallel, we will refine the current documentation and prepare the review / presentation of the developed product.

Form title	Form average Satisfaction Value by CORE	Number of sections	Number of questions	Number of answers	Last answered by	Last answered on	CORE verbal range	CORE colour
Clarification on the Requirements and the Design	91	2	18	1	Taeg5Customer1	2017-04-08	Outstanding	
Clarification on the Requirements and the Design II	54	1	1	1	Taeg5Customer1	2017-04-08	Fair	

Figure 9.2.2: Overview of second Questionnaire's Results

Chapter 10

Product Development and Production Life Cycle Analysis

Author: Simon Schneider, Timo Acquistapace

In the present section, the steps that were taken in analysing the system to develop are described. These steps include:

- Determination of the system's use cases
- Investigation of the required sensors
- Bounding of the system's context
- Visualisation of the needed algorithms via activity diagrams

The presented system analysis does not lay a claim on completeness but it reflects all the standardised methods of analysing a system that were estimated helpful in order to develop the system.

10.1 Use Case Diagram

Based on the requirements that were agreed on with the customer, two main use cases of the system can be found:

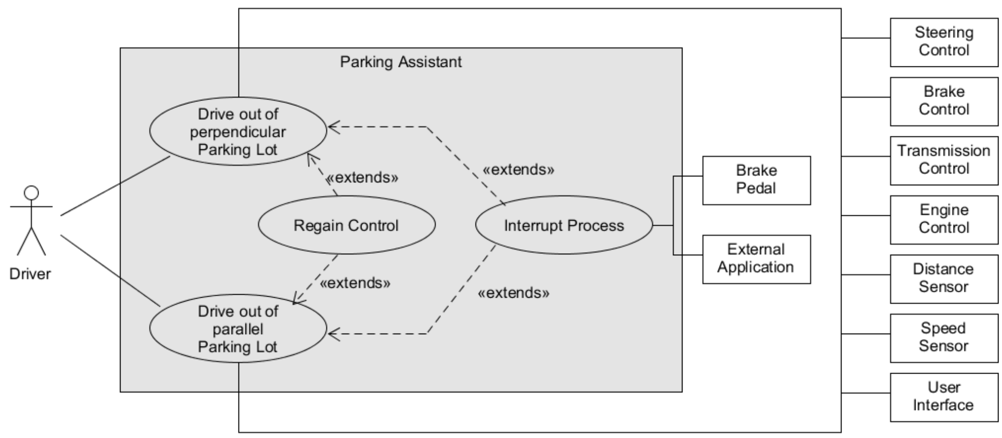


Figure 10.1.1: Overview of the System's Use Cases

- Drive out of a perpendicular Parking Lot
- Drive out of a parallel Parking Lot

Both use cases have in common that at the end of the successful process, the user has to regain the control over its vehicle in a defined way. Additionally, the user should always have the possibility to interrupt the process and regain the control over the car, even if the process has not yet finished. Each of the use cases are triggered by the driver as well as they are supported by various sensors and control systems.

10.2 Sensor Overview

To support the presented use cases, the system needs an overview of the cars surrounding. Six sensors, two of them cameras and 4 of them distance sensors, are placed in the car to provide this overview. The placement of the sensors can be retrieved from figure 10.2.1.

The sensors that are placed in the middle of the car's front and rear are cameras. In many cases cameras are already integrated in the car and provide the user a realistic image of its surrounding. The distance sensors at the corners of the bumpers might be radar- or ultrasonic-sensors. Radar

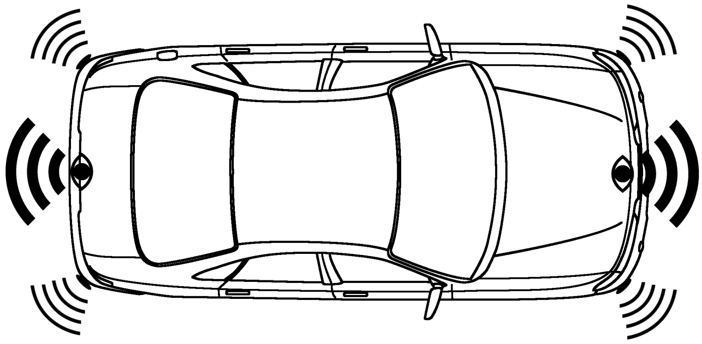


Figure 10.2.1: Overview of the System' Sensors

sensors have the advantage, that they might be placed within the bumper and that they are therefore not visible.

10.3 Context Diagram

After the use cases and the required sensors have been found, the context of the system to develop can be determined (see figure 10.3.1). Dataflows are depicted with solid arrows while signals that are used to control the systems are sketched with dashed arrows.

Beside the sensor information, the graphical representation of the process and the information that is sent to the car's control systems, there exist two systems that are used to interrupt the process of leaving a parking lot. If a driver sits in the car and presses the break pedal, the process will be interrupted immediately and the driver will regain the control over its vehicle. If the whole process is controlled remotely without the driver sitting in its car, the external application that controls the process should act as a dead man's switch that is operated by the user. If the signal from this application is no more retrieved by the system, the process should be interrupted.

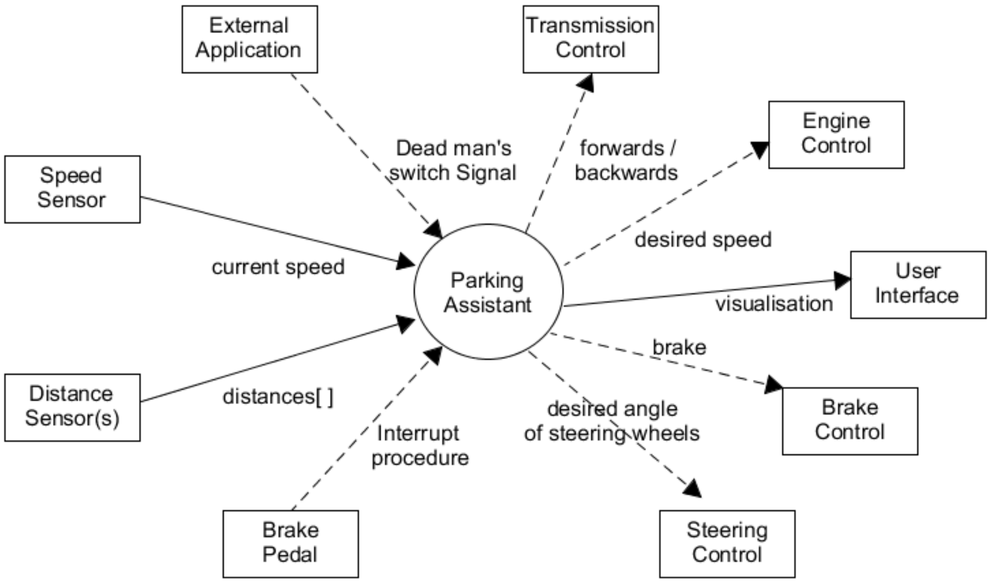


Figure 10.3.1: Context Diagram of the System

10.4 Activity Diagrams

After the previous sections presented the use cases as well as the involved sensors and actuators, the current section presents the progress of leaving from a perpendicular and a parallel parking situation. This presentation is done with the help of activity diagrams that reflect the algorithm that has to be implemented. Activity diagrams visualise the dynamics and the behaviour of a system and therefore serve for a better understanding of the process.

10.4.1 Activity Diagram Reverse Perpendicular Parking

When leaving a perpendicular parking situation, there exist different cases affecting the process that have to be analysed. This cases might impede the system from successfully performing its action. Additionally, there are different starting situations a car might be in before starting the process of leaving a parking space. To analyse these cases and to develop an algorithm that is able to deal with the possible cases and starting situations, the Best-

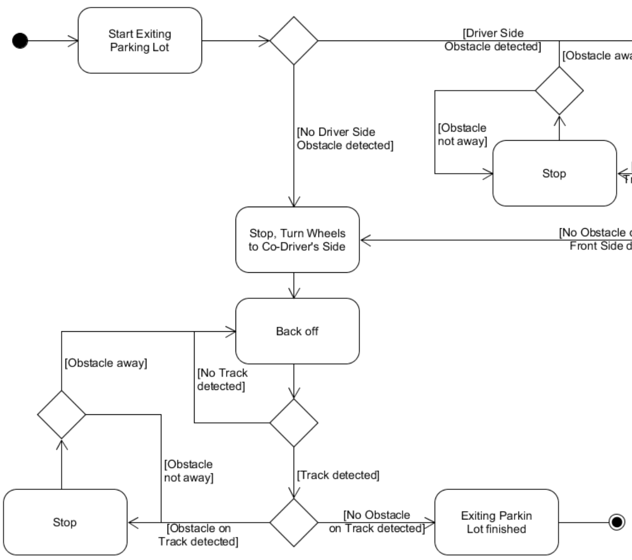


Figure 10.4.1: Algorithm for leaving a perpendicular Parking Situation

as well as the Worst-Case for the system are described. The activity diagram of the whole process can be seen in figure 10.4.1.

Best Case

The initial situation of the best case is the situation of there being no obstacle on the driver's side. The presence or absence of an obstacle is determined with the help of the car's sensors that have been introduced in section 10.2.

If there is no obstacle on the driver's side, the car is able to turn its wheels in the needed direction and start to drive backwards. For the case of leaving a reverse perpendicular parking situation it is of no importance if there is an obstacle on the passenger side because this won't affect the process of leaving the parking space.

The car now drives backwards till the moment it recognizes the roadway with the help of the built-in camera. Additionally, the roadway is scanned for moving obstacles like other cars, bicycles or persons during the whole process. If such an obstacle is detected, the car stops and waits for the moving obstacle to leave the safety-critical area. If there is no obstacle, if the detected obstacle has disappeared of it has stopped approaching the car, the process can be resumed and be completed.

Worst Case

In opposition to the previously described initial situation, the worst case is given if there is an obstacle on the driver's side. The process then changes in a way that the car has firstly to drive back some distance before it can turn its wheels safely without the risk of there being a crash with the detected obstacle.

In the same way as it was described for the best case, the car scans its surroundings while driving backwards if there are moving obstacles. In the case of there being none of the possible obstacles, the car drives back until the obstacle on the driver's side is no more critical to the process and the car is able to safely turn its wheels. The process that follows is now identical to the previously described best case.

10.4.2 Activity Diagram Parallel Parking

Leaving a parallel parking situation also includes different initial situations that have to be reflected. Analogously to the process of reverse perpendicular parking, the best- and the worst case are described within this section. The activity diagram of the whole process can be retrieved from figure 10.4.2.

Best Case

The best case in the current scenario is given if there is no obstacle in front of the car that should be brought out from a parallel parking situation. In this case, the car is able to turn its wheels towards the road side and to drive forward safely. During the process of driving forwards, the system continuously checks if there are either obstacles occurring in front of it or approaching from the roadside. If an obstacle is detected, the process is again stopped and only resumed if the detected obstacles have disappeared or if they do not approach anymore.

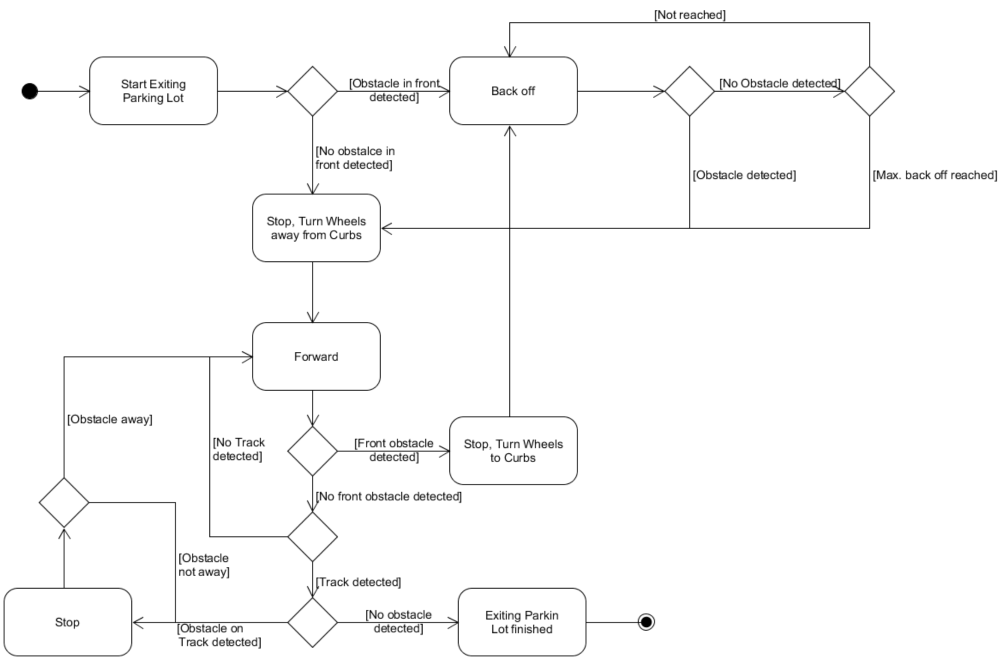


Figure 10.4.2: Algorithm for leaving a parallel Parking Situation

Worst Case

The worst case is characterised by there being an obstacle both in front and behind the car that should be brought out of the parking lot. The car then starts to drive slowly backwards until it has reached the minimum safety distance to the obstacle behind it. The wheels are then turned towards the roadside and the car starts to drive forwards.

In the case that the car then detects an obstacle in front of it, it stops, turns its wheels towards the curbs and starts to drive backwards. It continues with its motion till it reaches the minimum safety distance either to the rear obstacle or to the curbs. The car then turns it wheels to the roadside again and drives forwards. These steps are repeated until the car is able to leave the parallel parking situation and detects the roadway. Within the whole process, the car's surroundings are again checked for steady and for moving obstacles respectively.

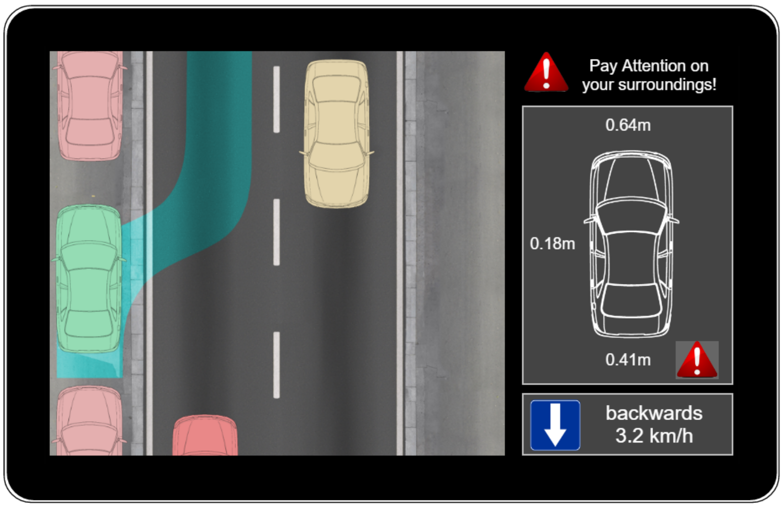


Figure 10.5.1: Dark Skin of the final Design Sketch

10.5 Design Sketches

A first design sketch has been developed (see figure 9.2.1) and the customer's feedback on the design has been gathered, this feedback is used to create refined mockups. Since the customer requests two designs – one for the day and one for the night-mode – two of these refined designs are developed.

These newly designed mockups also take the customer's feedback into account that some outputs should be simplified and that the area where the sensor information is presented should not be reduced. Instead, the area presenting the aerial view is reduced and the sensor information are presented in a wider area.

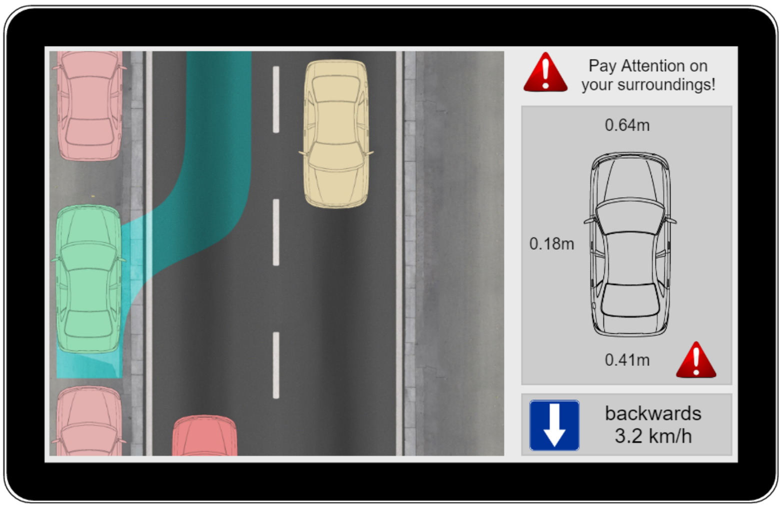


Figure 10.5.2: Bright Skin of the final Design Sketch

Chapter 11

Facilitation and Monitoring of the Process

Author: Hans
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Chapter 12

Conclusions

Author: Markus Just, Timo Acquistapace, Simon Schneider, Wojciech Lesnianski

12.1 Conclusion - Markus Just

12.2 Conclusion - Timo Acquistapace

This project was the first one in my educational experience that included a detailed process of project management. As a consequence, it was on the one hand very interesting to get an insight into the steps that could help to run a project successfully. On the other hand, there are some points that would be done in a different way the next time a similar project is set up, e.g. the assignment of roles. The roles were initially assigned to the team members with regard to their technical skills and knowledge. Since every team member was also assigned to do some work in the area of project management, there occurred some interdependencies that were not considered in the assignment of roles. An exemplary interdependence in the current project is the following: To evaluate the customer's satisfaction with the first drafts of the system, it is very helpful if a design sketch is available. However, the designer was not entrusted with the task of evaluating the customer's satisfaction. To avoid additional overhead for synchronization and waiting times, the initial assignment of roles was defined down and the creation of mockups as well as their enhancement according to the customer's feedback was assigned to the person that was responsible for the involvement of the customer.

Embedding the customer's voice itself is proved itself expensive. After having collected some experience with agile methods and their regular, but non-formal events to collect feedback on a product or process, the way of using questionnaires to determine the customer's satisfaction appears nonelastic and complicated at the first glance. But over the course of the project, the advantages of documented feedback became clear. The used tool to create the questionnaires – Satistica – proved itself very helpful. Gathered feedback is diagrammed clearly by Satistica and single questions as well as whole sections of questions can be evaluated easily regarding the point if the answers fit the expectations. It is therefore very easy to determine the areas of work where some improvements have to take place. Nevertheless, written feedback that does not offer the possibility to make a query directly could also be misunderstood like every written document. It has to be kept in mind that creating good questionnaires is a part of social science and there are many points to consider. Concluding, I would value direct discussions over feedback questionnaires. If this is not possible, Satistica anyway offers good support in collecting a customer's feedback.

The market analysis conducted exhibits the greatest deviation from the way it would be done in a commercial project. Whilst the prices of needed hardware parts are only gathered by a research on the internet, contacting the different manufacturer would be inevitable in a commercial project. The manufacturers may provide more favourable conditions if a larger amount of pieces is ordered and they may also counsel our company on the selection of the products. If the analysis is done in a very early stage, even before the project team is chosen, the persons that already published research projects like Katsev and Braun might be contacted and asked to contribute to the project by bringing in their experience. The greatest weakness of the conducted market analysis is the way how the competitors' products were analysed. While the information was again gathered by research on the internet, a commercial project would require to test the products that are already available on the market. Only this it is possible to get an impression of how these product might be improved and how the competitors could thereby be overcome.

12.3 Conclusion - Simon Schneider

12.4 Conclusion - Wojciech Lesnianski

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